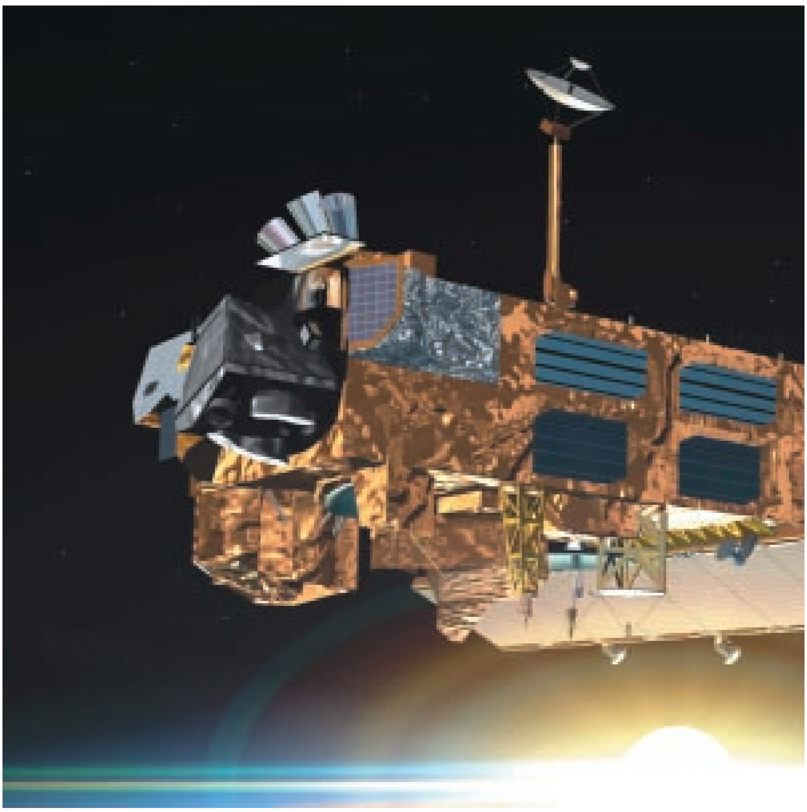
Space technology programmes 1995–2000

Bernhard F. Fabis, Preben Gudmandsen

Technology Programme Report 11/2001 | Evaluation Report



TEKES

Space Technology Programmes 1995–2000

Evaluation Report

Bernhard F. Fabis
Preben Gudmandsen

TEKES

National Technology Agency

Technology Programme Report 11/2001
Helsinki 2001

Tekes – your contact for Finnish technology

Tekes, the National Technology Agency of Finland, is the main financing organisation for applied and industrial R&D in Finland. Funding is granted from the state budget.

Tekes' primary objective is to promote the competitiveness of Finnish industry and the service sector by technological means. Activities aim to diversify production structures, increase productivity and exports, and create a foundation for employment and social well-being. Tekes supports applied and industrial R&D in Finland to the extent of some EUR 390 million, annually. The Tekes network in Finland and overseas offers excellent channels for cooperation with Finnish companies, universities and research institutes.

Technology programmes – part of the innovation chain

The technology programmes for developing innovative products and processes are an essential part of the Finnish innovation system. These programmes have proved to be an effective form of cooperation and networking for companies and the research sector. Technology programmes promote development in specific sectors of technology or industry, and the results of the research work are passed on to business systematically. The programmes also serve as excellent frameworks for international R&D cooperation. Currently, a total of about 50 extensive national technology programmes are under way.

ISSN 1239-1336
ISBN 952-457-037-8

Cover: Oddball Graphics Oy
Page layout: DTPage Oy
Printers: Paino-Center Oy, 2001

Foreword

Finnish universities and research institutes, together with industry, have participated in international projects in space science, technology and remote sensing since the mid-1980s. In 1995, Tekes launched two space technology programmes: Globe 2000 and Space 2000.

The Globe 2000 technology programme was aimed at developing entrepreneurship in the remote sensing industry, implementing operative remote sensing techniques and developing remote sensing technologies and methods. Remote sensing is an effective tool for producing information about the state of the environment as well as changes to it. The total volume of Globe 2000 was about FIM 54 million (EUR 9 million) during 1995–2000.

The Space 2000 programme concentrated on the technology of space satellites and their ground support equipment. Its main target was to increase the opportunities of the Finnish space industry to carry out ESA projects, thus, enabling Finnish companies to be competitive. Space 2000 also ran from 1995 to 2000 and its volume was FIM 98 million (EUR 16 million).

It was decided to evaluate these two programmes at the same time, because they were implemented simultaneously and, together, they cover a remarkable share of the R&D activities in the space sector. However, they have different technological backgrounds and different applications.

Two prominent experts were invited to conduct the evaluation. Bernhard Fabis has much versatile experience in space technology. He has been responsible for German research in satellites, launchers and other space infrastructure. Preben Gudmandsen is Professor Emeritus of Microwave Techniques at the Technical University of Denmark. He has had a number of international duties with regard to remote sensing and has garnered much recognition for his research.

The evaluation was carried out during April-October 2000. Both evaluators concentrated on one of the programmes according their own expertise.

Tekes wishes to express its gratitude to the evaluators for their systematic and thorough work. Tekes wishes to thank the participants of the space technology programmes for their contribution.

Helsinki, April 2001

Tekes, the National Technology Agency

Contents

Finnish Space Technology Programmes

1 Globe 2000 – Remote Sensing 1996–2000

Information about the environment

Remote sensing is an effective tool for airborne instruments producing information about the state of the environment as well as changes to it with the help of satellite and airborne instruments. Satellite remote sensing is especially useful for obtaining data quickly from a wide or distant area. Combining remote sensing data from several different sources usually provides the best results.

Remote sensing data is often part of a knowledge-based service. The technology needed to produce this service consists of data acquisition equipment, an efficient data communications solution, a geographic information system, and an application-specific expert system for data interpretation. Remote sensing methods can be utilised in many ways in the information society of the future, both in Finland and in the export market.

Thanks to high-quality research, Finnish remote sensing expertise is top level. Approximately 20 research organisations and groups, as well as several companies, participate in research activities and the utilisation of the results.

The Globe 2000 technology programme helps to develop the remote sensing industry by intensifying the use of research data for operational and commercial applications as well as deepening the co-operation between the participants.

Utilisation opportunities of the remote sensing industry

During the years 1995–2000, over 50 remote sensing satellites were launched. They cover the optical, short-range infrared, infrared, and microwave wavelengths. Satellite images with a resolution of 1–2 metres will also become available for civilian use. Over thirty new instruments will be introduced for atmospheric survey only.

Sophisticated optical, infrared, and microwave frequency instruments for airborne use are available from many different manufacturers.

All this, along with the development of information technology, increases the utilisation opportunities of remote sensing. There is a shift in the focus of application development from using the data of an individual instrument to using satellite data from many sources.

Objectives of the programme

Developing entrepreneurship in the remote sensing industry.

Implementing operative remote sensing techniques to gain considerable economic and commercial benefits as well as benefits related to the monitoring of the state of the environment.

Developing remote sensing technologies and methods that enable a technological leap forward, or are related to top-level international research co-operation.

International co-operation

The Globe 2000 technology programme was co-ordinated with the remote sensing programmes of the European Space Agency (ESA) and the remote sensing programme of the European Union (CEO). The success of Finnish participants in the EU's and ESA's remote sensing programmes is evidence of good competitiveness.

Projects

Four kinds of projects were launched in the technology programme:

- *Companies' product development projects* for commercialising remote sensing methods and supporting companies' technology projects.
- *Applied technological research projects* for obtaining internationally significant new information about remote sensing.
- *Demonstration projects* for presenting a remote sensing instrument, method, or data set to the end users.
- *Operative remote sensing implementation projects*, during which remote sensing methods with significant economic or commercial value are implemented.

Duration and budget of the programme

The Globe 2000 programme ran for five years. The budget of the programme was approximately FIM 54 million, of which Tekes financed approximately 50 percent.

2 Space 2000 – Space Equipment Technology 1996–2000

Background

Planning of the Space 2000 programme began in 1995, when Finland became a full member of the European Space Agency. Membership increased the opportunities of Finnish researchers to participate in space research and benefit from the data produced by ESA satellites. Full membership also offers companies and research institutes an opportunity to provide research services to ESA and supply subsystems, units and sub-units of satellite systems to be launched into space. A national space technology development activity was seen to be necessary to increase the level of know-how to participate in, and utilise, ESA programmes and become competitive in the international space markets.

The Space 2000 programme concentrates on the technology of space satellites and their ground support equipment. Space technology covers a broad spectrum of challenging technologies. However, it is often based on the same technological solutions as earthbound applications. Space technology offers companies and research institutes opportunities to further apply and develop their expertise and products and to extend their markets to new, challenging fields of application.

Objectives

The main target of the Space 2000 programme was to increase the opportunities of the Finnish space industry to carry out ESA projects with a content and subject suitable to the technology strategies of the companies. As a result of the Space 2000 measures, Finnish companies should be competitive with the European space industry in 2000, when ESA's special measures to channel orders to Finland come to an end.

The first sub-goal of the Space 2000 programme is to transfer the technological expertise, acquired in conjunction with the building of these scientific instruments, to an industrial environment. This will create a sound foundation for the ESA's industrial delivery projects.

In the ESA delivery projects, one company provides the leadership and the other companies (or research institutes) serve as subcontractors. The second sub-goal of the Space 2000 programme is the creation of a functional network of companies to facilitate the execution of ESA delivery projects.

Focus areas of the programme

The themes of the Space 2000 programme were limited to the flight and ground segments of satellite systems and did not include interpretation of the data collected or transmitted by the satellites.

The first focus area of the Space 2000 programme concentrated on running-in by the Finnish companies and research institutes of the qualified technologies and processes needed for the equipment and software projects of the satellite systems. In addition, an attempt was made to create a network of companies and research institutes that would also be able to take total responsibility for extensive delivery projects.

The second focus area in the projects of the Space 2000 programme is the development of core competencies for each company so that a certain satellite subsystem can be realised efficiently (size, mass, power consumption, telemetry, schedule, costs). The goal is for companies participating in the Space 2000 programme to develop the kind of competence that would make them competitive with European companies in selected space sector products. This also means that the subsystem or unit in question would suit several satellites, so that the initial outlays could be justified by continuity.

Projects

The Space 2000 programme consisted of the companies' product development projects and the research-based joint projects of companies and research institutes. Many projects were closely related to the ESA's or NASA's future satellite projects and the ESA technology programmes.

The total number of projects in the Space 2000 technology programme was 51, of which 23 were company projects and 28 joint projects between companies and research institutes.

Company projects concentrated on developing key technologies and processes, which a particular company needed. The research projects consisted of pre-defined topics, which were needed to improve technological know-how in various areas and which are needed by companies and institutes. Definition and development projects of science and earth observation instruments were also included in the programme. This led to a remarkable increase of the total programme budget and Tekes' share.

List of the projects and participants can be found in Annex 1.

Duration and budget of the programme

The duration of the Space 2000 programme was five years. The total budget of the programme was FIM 97.8 million, of which Tekes financed approximately 76 percent.

The biggest project was the development and building of the Ozone Monitoring Instrument for the NASA EOS Aura satellite. This project was exceptional, because it was a flight model delivery project not a technology development project, or a study like the other projects in the programme. If this project is excluded from the programme budget, the total budget of Space 2000 will be FIM 49.9 million and the corresponding Tekes' financing 54 percent.

International co-operation

Co-operation within the European Space Agency plays a central role in the Finnish space activities. In the area of technology, Finland participates strongly in the technology development programmes of the ESA, especially the Basic Technology Research Programme TRP, the General Support Technology Programme GSTP and the Advanced Research in Telecommunications Systems ARTES programmes. Therefore, the Space 2000 programme is also closely linked with the ESA technology programmes and satellite projects.

Evaluation of Globe 2000

Preben Gudmandsen

Executive summary

An evaluation of the Globe 2000 programme has been carried out based on reports submitted by participants in the programme and a number of interviews with companies and government organisations and universities. A total of 17 reports on projects in companies and 33 reports on projects in organisations/universities were involved.

The evaluation attempts to answer questions such as (1) to what extent are the Tekes programme objectives achieved, (2) what is the technical and commercial relevance of the work undertaken and (3) how successful is the programme. In addition, points raised during the interviews and in e-mails were included.

With the Tekes programme initiated on the occasion of Finland becoming a member of the European Space Agency, EUMETSAT as well as the European Union, it may be stated that all programme objectives have been met. It has increased the awareness of remote sensing in private companies, government organisations and universities, and the interest in exploiting the capabilities this techniques offer. The programme includes almost all Finnish entities known to have such interests. It has sponsored a variety of projects related to observations from satellites as well as from aircraft, and the development of methods for data utilisation.

However, in one respect, related to increased co-operation between industry and research organisations, it has not reached the same level of fulfilment. The number of contracts involving such co-operation is limited. A project has been launched with the purpose of creating co-operation between remote sensing activities in private companies including *inter alia* transfer of technology from research centres to industry. It was initiated in early 1998 so the impact of this important project may only be seen upon completion. It has been operated by way of information meetings, but a more proactive undertaking may prove useful in order to reach the project goal.

The work undertaken under the programme is almost invariably related to the mission of the entities involved, so that the relevance is ensured almost from the outset. The co-financing of the organisation in question is a strong indication of this and, in the case of private companies, even more so, considering that a contribution of the order of 50 percent or more is required. From an application point of view, many of the satellite related projects are highly relevant considering the large and relatively uniform areas of Finland that may be monitored.

The success of the programme has been judged by the success of the work undertaken. The result is a very positive one in the way that, except for one case, the projects have largely reached their goal. This is remarkable for projects that involve the development of new techniques or the demonstration of applications by way of field campaigns. Delays have occurred in some of the latter cases and extensions granted to conclude the projects properly.

It was noted the small and medium-size enterprises concentrate on aerial photogrammetry where a market exists rather than satellite observations.

In conclusion, Globe 2000 may be characterised as a highly successful programme that has achieved its goals, in so far that it has raised interest for, and developed applications of, remote sensing data. It has created projects of high calibre, some of them of an international level. Greater efforts are needed, however, in order to overcome the dichotomy between private companies and research institutions to sustain and develop, especially small and medium-size companies.

1 Brief description of the GLOBE 2000 programme

The Globe 2000 programme was established in 1996 on recommendations formulated by a group of Finnish scientists and presented in a Tekes publication entitled 'Technology Program for Remote Sensing'[1]. The group was formed in connection with the decision by Finland to become a full member of the European Space Agency (ESA) and the European Union (EU) in January 1995. The programme should ensure (1) 'the integration of research and development operations' and (2) 'increased co-operation between research institutions', and is co-ordinated by Tekes.

The objectives of the programme are as follows[2]:

- Developing entrepreneurship in the remote sensing industry
- Implementing operative remote sensing techniques to gain considerable economic and commercial benefits as well as benefits related to the monitoring of the state of the environment
- Developing remote sensing technologies and methods that enable a technological leap forward or are related to top-level international research co-operation.

The programme shall include various types of project such as

- Technology and Research Projects
- Demonstration Projects
- Implementation Projects for Operational Remote Sensing Methods
- Business Projects.

The latter Business Projects are of interest to private companies including small and medium-size enterprises (SMEs). They may be funded by up to 60 percent in the case of research projects, whereas prototype development may be supported by up to 35 percent. Furthermore, the programme assumes internal funding at the research and educational institutions.

The programme calls for co-ordination that is established by creating a Co-ordination Group which advises Tekes in judging the calibre of the proposals issued for support within the programme based on various criteria.

The Tekes calls for proposals are issued once per year for institutional research. The praxis has been that a continuation of a multi-year project requires a new application that is judged not only on its merits and the results previously obtained, but also on its merits related to new proposals that are submitted at that time.

Proposals for business projects may be submitted at any time and are handled solely by Tekes and treated as confidential.

Associated with each project, a Management Group or Steering Group is appointed to oversee the work undertaken and to advise Tekes. These groups include people with knowledge in the field in question and people with experience in managing research projects plus a Tekes representative.

As an indication of the operation of the Tekes programme, it is interesting to note the sequence of the project initiation of institutional/university and industrial research, respectively:

Year	Institute/ University	Business	Note
1995	3	1	December
1996	9	2	
1997	6	6	
1998	11	6	
1999	7	1	
2000	5	2	until April
Total	41	18	
Continued projects	8	2	

1 A Look at the Earth – Significance of Earth Observation in Finland, 1998. Tekes publication, 58 pp.

2 GLOBE 2000 – Remote Sensing 1996–2000, 1998. Tekes information leaflet, 2 pp.

The last row indicates projects that continue(d) over two or three years. It is noted that seven projects were initiated this year so that no results could be presented at the time of the evaluation.

2 Description of the evaluation task

The evaluation of the Globe 2000 programme was carried out in three steps:

- In a one-day visit to Tekes, the Globe 2000 programme was introduced with a brief overview of the projects that are funded by Tekes and of the institutions and companies involved. A so-called virtual tour was conducted by a Tekes employee. Since part of the material available is in Finnish, this introduction was essential.
- Brief reports written by the principal investigators of the projects were forwarded and studied in preparation for the interviews. In all cases, only one or half a page of report was submitted – according to the suggestion by Tekes employees. In some cases, more elaborate reports and/or copies of relevant articles were attached. A total of 41 projects have been initiated with government-supported organisations and university institutes and 18 projects with private companies. Thirty two reports of the first category and fifteen (confidential) of the other were received for review.
- Twelve interviews were conducted in a four-day period. Of these, eight interviews involved government-supported and university entities and four were held with private companies. In addition, questionnaires were submitted by e-mail to some companies that could not come for interview and were considered important for the evaluation. These questionnaires were adapted to the projects in question, mainly addressing 'administrative matters'. The interviewed entities were selected by Tekes at the recommendation of the reviewer, but concentrated, for logistic reasons, on organisations and companies in the vicinity of Helsinki.

In most cases, the technical contents of the report gave a good overall description of the work carried out and its progress as well as the results obtained. In the case of companies, the perspective of the work undertaken and the marketing possibilities were expressed. Questions of a technical nature were, therefore, often for clarification, or addressed issues that would satisfy the curiosity of the reviewer and/or widen his horizon. In some cases, the interviews dealt with matters related to the application procedures, the management of the work carried out, the relationship with Tekes and the industrial policy adopted in Finland.

It shall be stated that in all cases the questions of the reviewer were well accepted and resulted in a frank and open discussion that is reflected, to some extent, in this report.

3 Fulfilment of the technology programme

The programme objectives may be expressed in a short form as follows

- Development of industry
- Implementation of operational remote sensing technologies
- Develop remote sensing techniques and methods to an international level.

In the subsequent paragraphs, an overview of the projects, funded under the Tekes programme, shall be given with reference to these objectives. Firstly, projects with private companies will be dealt with followed by a review of projects in the public domain.

3.1 Company contracts

The range of companies involved in Tekes-related activities is wide, from small software companies, medium-size value-added companies to relatively large companies or branches of large companies. This also applies to companies developing hardware ranging from one small company to another very large one.

Considering the projects carried out by companies, it can be stated that all three objectives have been met, although to a varying degree.

The majority of the projects may be considered directly related to the first objective, comprising six software development projects. They increase the competence of the companies and improve the marketing situation in Finland and abroad. However, it is interesting to note that the majority of the software projects are planned for use in connection with aerial photogrammetry. Only two projects developed the use of satellite data for mapping purposes. Two projects related to mapping and to agriculture in third-world countries may be regarded as part of this category. One of these companies obtained the next highest score of support from Tekes within this programme.

Another six projects comprise hardware design and construction of advanced equipment. Among them one hardware design project has scored the largest support of all Tekes funds within this programme.

Only one project is concerned with operational monitoring aspects. No report is available from this project, however.

Three of the development projects included above may be regarded as fulfilment in part of the last objective with the design of units for advanced instruments. To this may be added another explorative project related to satellite flight opportunities of an instrument (COALA). Although inconclusive, the latter project has clearly increased the awareness of Finnish research and industrial capabilities internationally.

It is observed that a small number of the projects have been carried out together with government-supported institutions or with potential users of the techniques or methods developed. In some cases, the list of parties involved is long and may have required appreciable time to establish, and manage, when efficient co-operation is aimed at.

One project relies heavily on a contribution from a university laboratory in the form of a Finnish-based model that complements satellite and ground observations in third-world countries.

Companies that are related as to subject apparently do not need to co-operate, or do not want to for reasons of competition, as it was argued in some interviews.

3.2 Public projects

The range of public projects covers a very wide field of interests as indicated above and as it will appear from the following list of public institutions:

- Finnish Geodetic Institute (FGI)
- Geological Survey of Finland (FTK)
- Finnish Institute of Marine Research (FIMC)
- Finnish Environment Institute (FEI)
- Finnish Forest Research Institute
- Helsinki University of Technology (HUT)
- National Land Survey of Finland (NLS)
- University of Joensuu
- Technical Research Centre of Finland (VTT)
- Novosat Oy (this company is a spin-off of NLS, Space Image Centre, and continued work begun under that regime).

It is interesting to note that the list is almost identical to the Directory of Remote Sensing Organisations in Finland included in the Tekes publication 'A Look as the Earth', 1998, p. 51. Apparently only a few organisations did not respond to the call for proposals.

The majority of research in remote sensing in Finland is carried out in universities and government-supported institutions and organisations. It is a characteristic of many Tekes-supported projects that they are carried out by the institutions individually; in only a few cases was co-operation with other institutions established. Only in a few (5) cases did the projects involve Finnish industry that has supported the projects with smaller funds or by contributions in kind.

In general, the many public projects represent a mixture of technology and research projects, as well as demonstration projects. Some of them fulfil the two objectives of development of operational methods and the advancement of the techniques, or form the basis for such activities.

Four projects are clearly software-development projects for various applications. Two of them involve private companies. One three-year project is concerned with the development of an advanced instrument for environmental research. Two other projects are related to the processing and application of data from GOMOS, the ozone instrument on Envisat to be launched in 2001, and future missions organised by EUMETSAT.

Otherwise, the majority of the other projects – seven in all – are related to applications in forestry, of which five will apply satellite data. One of them is directed towards forestry and land cover studies in Finland and Borneo. Only one of these projects has an industrial partner while another has obtained support from an EU programme.

Other fields of application are: two projects on snow monitoring (one with a contribution from industry), two on geology (one with support from the mining industry), two on sea ice monitoring and classification, and two on coastal and lake water monitoring.

It is interesting to note that most satellite data-related projects are carried out at VTT (see the list above). Other SAR-related projects were carried out or are in progress at FIMR, FEI and Novosat. In the case of snow monitoring, one project, that was carried out successfully in one institute (FGI), continues, and is further elaborated, in another (FEI) apparently with a smooth transfer from one institution to the other.

It is noted that some of the projects extend over two or three years with annual grants, but are considered in this report as one project if carried out within the same organisation.

3.3 Project on 'Support to increase industrial activity in remote sensing'

One programme is clearly directed towards the development of Finnish industry, namely the project, 'Support to increase activity in remote sensing'. The project is of a very different nature and, therefore, deserves special attention – and did so in connection with the interviews.

In the period 1998–99, the project was operated by Novosat, a spin-off of the Satellite Image Centre under the National Land Survey. When this centre was privatised, the three-year programme was transferred to the Finnish Geodetic Institute on the recommendation of the project's Steering Group. It was considered essential that the guiding entity could be regarded as absolutely neutral when dealing with private enterprises.

In the initial period, a 'Finnish Space Affairs Negotiation Group' was established to foster a dialogue between private companies. Five meetings were held and were well-attended. The interviews, held as part of the evaluation process, gave the impression that, although the initiative is regarded as very useful from the point of view of gathering information on the latest development and programmes, it was less successful in establishing co-operative projects. One reason could be that companies are reluctant to reveal information about current activities from the point of view of competition – or even of buy out. By the same token, information about long-term plans is not disclosed.

A brief report was issued, on the occasion of this evaluation process, by the Finnish Geodetic Institute. It defines the content of the project somewhat broader as '1) technology transfer, 2) informatics (to give information on capabilities), 3) education and 4) international contacts'. The activities of the project, under its new guidance, will still take place, but may result in improved co-operation. It is understood that, with the broader line of objectives, the activities will also include research institutions.

The project will run for an additional two years, but it was questioned whether this would be sufficient to ensure a larger impact on the state of affairs considering the difference in 'culture' in the two camps. It was suggested in one interview with a private company that the project be supplemented with sub-projects that deal with actual cases of 'technology transfer' with in-depth studies of areas of common interest. Elsewhere, it was stated that small companies may not have the necessary manpower to be able to take advantage of the actions offered. The software project may constitute an exception, however.

The impression gained from further remarks made during the interviews is that proactive work is needed to fulfil the goal of the project regarding 'technology transfer' and 'informatics'. The project could be supplemented by actions that will create, or even enforce, direct interaction between the parties. It could take one or several of the following forms: a) Ph.D. studies carried out in a company and a research institute/university laboratory on a subject of common interest, b) the same could be the case for post-doctoral work, c) call for proposals on projects that require a mutually binding agreement between a research institute and the company on a joint development programme, and d) a periodic publication of running contracts and intermediate results as the case may be. The suggestion a) will educate scientists who understand the conditions prevailing in private companies, whereas b) and c) may interest scientists in research organisations and will increase the co-operation between the entities involved thus ensuring technology transfer. The suggestion d) could lead to direct negotiations between companies and research institutes about co-operation. The activity a) and b) may require a special programme managed by Tekes and funded jointly with the company involved.

In conclusion, it should be mentioned that there are cases of co-operative projects created without such actions. A good example is the pilot project on the estimation of rice yield in Vietnam based on remote sensing and meteorological data. It is lead by Finnagro Oy and involves Finnish public institutions and a university in Vietnam. The outcome of the project is very much dependent upon a crop growth model developed at Helsinki University of Technology.

3.4 Further discussion

The preceding section has dwelt on the 'Industry support' project, because it is thought to be an important part of the Tekes programme. The project may be considered a must if the good intentions, reflected in the document entitled 'Technology Program for Remote Sensing'[3] for the development of small and medium-size enterprises (SME's), are to be fulfilled. It may be added that many European governments, as well as the European Union, are concerned about this development – or lack thereof.

It should be added that in almost all interviews and contacts with companies the benefit of the 'Finnish Space Affairs Negotiation Group' established in the first part of the 'Industry support' project was underlined. It was described as a useful forum for gathering information about new activities in Finland and abroad, and for an exchange of views giving private enterprises in the field of remote sensing an opportunity to present their thoughts *vis-à-vis* Tekes.

The review of the many reports gives the impression of great and interesting activity in the field of remote sensing in Finland. It covers a wide field of applications and data acquisition including several projects undertaken to ensure that present and future satellite data may be applied in forestry, snow and sea ice monitoring and monitoring of coastal waters and larger lakes. The continued development of advanced airborne microwave equipment at the Helsinki University of Technology is worth mentioning.

From the reports issued, especially the attachments, and from the interviews held, the conclusion is that, generally, the work is carried out very professionally and with enthusiasm. In several cases, the work has lead to papers in recognised international journals or to a Ph.D. thesis, and this applies equally to institutional, as well as industrial, research and development. It is worth mentioning that the ESA ERS-Envisat Symposium saw three presentations from industry, as well as research entities based on Tekes grants, and two originating from ESA contracts. Many 'public projects' are carried out in the framework of co-operation between research institutions exploiting the expertise that is necessary for carrying out the task. There seems to be a good network.

3 A Look at the Earth – Significance of Earth Observation in Finland, 1998. Tekes publication, 58 pp.

The Tekes programme calls for activities that are related to the investments made in connection with Finland's membership of the European Space Agency and EUMETSAT, concentrating on Envisat ASAR data applications and the GOMOS activities, where Finland's Meteorological Institute plays a major role. The vast majority of projects initiated fulfil this goal. On the other hand, experience shows that, generally, there is a gap between the research work and the system that is needed for operational, that is, day-to-day application of data which has to be filled. This is not a negligible task to be conducted by the unit responsible for the monitoring in question. Tekes may participate in the funding of this type of work.

On the one hand, it is striking that private companies in almost all cases emphasise aerial photogrammetry, whereas satellite-related work is carried out almost entirely in government-supported organisations. On the other hand, the interviews confirmed that airborne remote sensing is an important market that is exploited with success by private companies ('the market is there'), whereas satellite observations are considered useful for large-scale monitoring that, in general, is the responsibility of governmental institutions. In one interview with a mapping company, it was pointed out that for local or regional remote sensing, aerial technology is at premium with many customers that require fine-scale data. The recently launched satellites with their very fine spatial resolution of optical/near-infrared images are not considered great competitors since they cannot provide three-dimensional scenes which is currently a trend.

From a technical and applications point of view, there is no doubt that the Tekes activities fulfil the objectives of Globe 2000. It comprises a relatively large component of support to government institutions and universities but has, as it appears to the present observer, only to a smaller extent fulfilled the objective of transferring technology from research to private companies. It is the impression that the participation by companies has been passive and perhaps more consulting in nature and/or consisted of delivering ground information. Undoubtedly, such contributions are very useful, assisting the direction of the details of the project in question, but it is questionable as to what extent a 'technology transfer' has taken place. Admittedly, the five projects with company partners may be seen as a first step to be followed by further action. The above-mentioned co-operative project, where a private company exploits a model developed in a university laboratory, is an excellent example.

The distribution of funds between contracts to private enterprises and public contracts is reflected by the following amounts that have been granted in the period December 1995 to April 2000:

Company contracts:

Sum:	FIM 14.8 million (EUR 2.5 million),
Range:	FIM 0.1 to 7.5 million (EUR 0.02 to 1.3 million),
Average:	FIM 0.78 million (EUR 0.13 million)

Public contracts:

Sum:	FIM 27.1 million (EUR 4.6 million),
Range:	FIM 0.1 to 1.8 million (EUR 0.02 to 0.3 million),
Average:	FIM 0.66 million (EUR 0.11 million)

These numbers do not give the full picture, since the numbers for companies include two relatively large contracts. If these projects are disregarded, the sum becomes FIM 5 million (EUR 0.8 million) and the average only FIM 0.35 million (EUR 0.05 million), that is, about half of that for public contracts.

It should be mentioned that some of the companies have obtained a loan in addition to the direct support, ranging from FIM 0.1 to 8.0 million (EUR 0.01 to 1.3 million).

The sum of contracts for the five-year period 1996 to 2000 that involve ESA-related work is FIM 7.8 million (EUR 1.3 million) that may be compared with the Finnish contribution to the Earth Observation programme of the ESA. In the five-year period 1995–1999, this amounted to about FIM 137 million (EUR 23 million). Thus, the investment of public money in industry and institutions is about 6 percent of the contribution to the ESA. However, it shall be recalled that, in almost all cases, companies and public institutions, including university laboratories, contribute financially to the projects so that the total national investment is larger.

The company contributions are only known in a number of cases. It is, therefore, only possible to make an estimation using some examples, which show that when Tekes contributed FIM 10.9 million to seven projects, the companies invested FIM 13.5 million themselves, it being understood that the last figure, in some cases, includes smaller contributions from outside companies that were interested in the development in question. Thus, industry contributes on average about 55 percent of the programme costs, which is the order of magnitude set out in the recommendations by the Planning Group.

Likewise, university laboratories and public organisations contributed to their project – as defined at the out-set of the programme. Considering the amount of work carried out on some of the projects, it seems that this contribution has been of a sizeable magnitude.

These numbers are food for thought. It is not the task of the present reviewer to discuss whether these numbers strike the right balance between contracts to companies and public organisations, but they reflect, undoubtedly, a policy of Tekes decided at a high level. This is, probably, also the case with contracts related to the ESA remote-sensing programme. Or perhaps, it reflects the level of interest in Finland and the relationship between industry and organisations/universities.

To the reviewer, it was interesting to note that university laboratories apparently have relatively large funds available to invest in the projects and to cover unforeseen expenses in connection with work undertaken, expenses that are not covered by Tekes.

4 Project successes

From the reports delivered, it appears that, in almost all cases, the work has been performed approximately as planned. This applies first of all to the software projects. However, through the interviews, it was found that, in some cases, the work encountered difficulties – not unusual for research and development projects. Generally, Tekes agrees that the work period be extended, but within the same budget. In some of these cases, the project management shall have to secure/provide additional funds.

In projects demonstrating new technology, difficulties were met – not surprisingly – so campaigns have to be repeated. This results in an extended period of work and additional expenses that have to be covered within the budget and/or with separate funding. It may be an appreciable burden to small companies.

In only one case has a company been unable to fulfil demanding specifications for special equipment. Apparently, the company had difficulties, initially, in purchasing suitable components, but problems attracting qualified people were also encountered. The university laboratory that drafted the specifications undertook, at a later date, to develop a prototype that meets the specifications. The time lapse might have been advantageous. The laboratory will cover the expenses incurred by this extra work. The company will subsequently produce the 36 units needed, so that the overall goal of the project can be fulfilled. However, problems may well be encountered later. Experience tells that development of a prototype might not take into account the tolerances of the components purchased, so that the production may not fully satisfy the specifications set out initially – a well-known problem in industry. (The Envisat ASAR active antenna suffered from this problem, resulting in a major delay of the programme).

Problems of this nature are likely to occur when creating advanced and/or new equipment and means should be available to overcome them financially. Otherwise, a programme like Globe 2000 will not be able to live up to the objective of 'developing technologies and methods that enable a technological leap forward' since scientists will only propose ideas that are considered safe.

Another difficulty has arisen in some of the contracts stemming from the delay of the launch of the Envisat, where some laboratories are preparing utilisation of various sets of data. This has been tackled by temporarily reducing the work pace foreseen, thus stretching the available funds. However, from the interviews, it appeared that in some cases this leads to additional expenditures that have to be covered by the project management. This tactic also has built-in manpower problems, in some cases, as experienced people may have left the entity when data finally arrives.

The interviews leave the impression that in such situations, and in other cases of unforeseen difficulties, the responsible person did not expect additional funds could be obtained from Tekes to cover these contingencies. It is unclear whether this is a policy of Tekes, but, if so, it seems unreasonable to the present reviewer. Such incidences are likely to be encountered – often with major consequences – when dealing with the development of new types of advanced equipment, when field campaigns are involved or the traditional delay of a satellite launch occurs.

It seems unfair to discuss the issue of project successes using examples of projects that were not fully successful. However, the small number involved underlines the observation of the reviewer that impressive work of high standing has been, and is being, carried out in companies as well as institutions and universities, in most cases to a high international standard. Many results have been published in recognised technical and scientific journals emphasising this fact. Moreover, the reviewer got the impression from the reports that there are reasons for increasing the latter activity and advocated such during the interviews.

5 Technological and commercial relevance

The subject of relevance of the Tekes-supported activities in technical and commercial terms will be dealt with, in the same way as before, under the headings of Company contracts and Public projects.

5.1 Company contracts

The way these contracts are handled by Tekes ensures that they are relevant for the company applying for support. A general rule is that Tekes can support such proposals with 60 percent of the total sum and that the company shall cover the remaining 40 percent. Since this contribution to a development project may be regarded as high by many smaller companies, examples show that they make great efforts to interest other parties – mostly potential customers – in the project in question and eventually contribute to its budget.

No doubt, this time-consuming procedure places great strain on the smaller companies, but may be seen as an advantage to Tekes since the list of contributors indicates that eventually there will be a market after the work has been successfully completed. This was foreseen at the outset of the Tekes programme.

The application process requires an estimate of the future market for the product developed, which, according to interviews, involves the participants' own experience and discussions with experts in the field in question. This may be a time-consuming process; one company interviewed claimed that the process of market analysis and lining up partners could easily take the greater part of a year. Without this, the company would not risk the investment. It is understood that market aspects are part of the discussion with Tekes prior to submitting a proposal.

5.2 Public projects

In the case of public contracts, the question of commercial relevance is generally not important. However, it appears from the report that the VTT organisation does reflect on this issue in some of their reports, indicating that it considers itself a commercial entity in part. This is certainly due to the fact that the budget for running the organisation has to be supplemented by income from external services, a trend which is also observed in other Nordic countries.

As to the technical relevance, the projects do reflect Finnish interests from the point of view of the organisations, researchers/engineers and applications of remote sensing data. The researcher has a genuine interest in advancing the 'know-how' within his/her field of expertise and to compete with other researchers with original and advanced results. This applies to original research, as well as development tasks of improved methods and/or adaptation of known techniques to new or local/regional phenomena.

This view is reflected in the previously mentioned document entitled 'Technology Programme for Remote Sensing' (1995), which gives a broad list of subjects that could form the basis for proposals. The many projects supported by Tekes match this list. From the interviews held, albeit only eight, it became clear that knowledgeable people have submitted proposals in their field of expertise and interest, and the interest of the institution, and that good results have been obtained.

With projects covering the many special features in Finland in the fields of forestry, geology, snow, sea ice, and water quality in lakes and coastal waters, relevance is fully ensured. To this list, we may add the great interests in ozone measurements, where Finnish scientists play a major role. The fact that many projects are also related to space activities, to which Finland contributes and participates actively in, makes the work highly relevant in the context of the ESA and EUMETSAT.

6 Observations from interviews

In the previous discussion, reference was made to the interviews whenever remarks were made that were relevant to the issue discussed. The following paragraphs are an attempt to summarise other remarks made about the Tekes handling of the programme, as well as aspects of competition and product development.

It is a pleasure to report that, in all cases, when the subject was discussed, it was stated that the Tekes staff is highly competent and open for discussion and comments, as well as providing good guidance in the preparatory phase of proposals.

It was argued, however, that the staff is too small considering the many tasks to be performed: proposal and contract handling as well as contract negotiations, participating in international meetings, etc. The consequence is that the handling of contract proposals appears to take a long time. The time lag from submission of a proposal to contract confirmation may easily become four to five months which, in the case of a university laboratory, often gives rise to concern. Thus, a project that was planned to begin 1 January may first be initiated in April which may lead to manpower problems, particularly when the continuation of a project is at stake. In the case of contracts with companies, such delay appeared of less concern and one reason could be that applications may be submitted at any time.

The problem of handling proposals that cover work running over more than one year was questioned. It is fully accepted that the continuation of a project depends on the performance of the work carried out as described in the annual report. However, the prevailing principle, that the size of the support the subsequent year may eventually depend upon other proposals that are received for consideration, is felt to be very unfortunate. The fact that a project, already accepted as worthy for support, shall have to compete with new projects makes planning difficult and may curtail a good project. This is unsatisfactory. However, it seems to work, as exemplified by the cases where projects were extended over two and three years, but at the expense of the institution in question.

Competition is another subject that was raised in the interviews. Concern was expressed over what appears to be unfair competition from government-supported institutes that receive support from Tekes in addition to government funding. The concern was expressed covering the whole range from the diplomatic:

- 'because the state-supported organisations have developed their operative systems with government financial support it is necessary for industry to have support from Tekes in order to maintain the competence of private industry' to the more brutal criticism:
  - 'VTT activities in the market are perhaps the reason why there are so few value-added companies. It was founded 60 years ago to help establish Finnish industry and has now fulfilled its commitments and should be closed'.

It is interesting to note that VTT is the only public organisation that reflects in its report on the market aspects of the work undertaken.

Discussion also covered the marketing problems of small and medium-size enterprises in remote sensing including value-added companies. One company provocatively expressed it as: 'The market does not really exist'. It was pointed out that most Finnish government institutions want to build their own expertise, so as to carry out work that could just as well be carried out in a private company, and that they appoint new personnel when the need arises. This appears to be a common problem in the Nordic countries and may only be overcome by introducing the principle of outsourcing all work that may be carried out equally well by private industry. This principle is enforced in USA and Canada governmental organisations.

The first objective of 'development of industry' has only been met marginally. One reason is the late start of the project with this in mind. However, it is questioned whether the approach adopted is the correct one. It is suggested that a more proactive way of furthering small and medium size enterprises is to create projects that require research institutions and private companies to work together with the goal of creating a new 'product'. Examples of this approach may be found elsewhere. A very recent one is the announcement by the Ministry of Science in the United Kingdom[4] of a scheme of university groups working with companies (SME's) or a user entity to develop a new product – 'to transfer technologies pioneered in academia into real-world applications'. The scheme is related to the field of photonics, but could easily be adapted to remote sensing applications. Other suggestions are presented in Section 3.3.

One interview lead to considerations as to product development and marketing. It is a three-phase operation and it was pointed out that, in general, the support obtained by, for example Tekes, would, at best, lead to development of a prototype. After this, further development is needed before a commercially viable product is available. A third phase is the actual marketing including the design of sales material and advertisements. These considerations apply to hardware as well as software although the costs may be different. In smaller companies, the last two phases may be an appreciable load, and it was argued that these two phases should also obtain support (from Tekes, for instance) to ensure a reasonable return on the initial investment. Material presented by the larger companies for the evaluation includes a number of examples of good, instructive brochures reflecting an established marketing policy. Presentations of new equipment or software at international scientific and commercial meetings is another useful, and relatively cheap, way of advertising company activities – exemplified by two companies.

7 Postscriptum

It should be pointed out that this evaluation formally constitutes two weeks of work carried out by only one person. Although attempts have been made to present the views expressed at the interviews, and otherwise in the right spirit, the review unavoidably reflects the understanding of the author.

4 Opto & Laser Europe Magazine, June 2000.Posted 16 June as Industry News, http://optics.org.

Evaluation of Space 2000

Bernhard F. Fabis

Executive summary

This evaluation was performed to answer the question: "Are the objectives of the Space 2000 Technology Programme, defined in 1995, met at as the programme nears the end?"

The Space 2000 Technology Programme, which concentrates on space equipment technology, is designed to increase the opportunities of the Finnish space industry to carry out ESA projects with a content and subject suitable to its technology strategies. As a result of the Space 2000 Technology Programme measures, Finnish companies should be competitive with the European space industry in 2000, when the ESA's special measures to channel orders to Finland come to an end.

Input into the evaluation came from short written reports, sometimes supported by detailed project reports, as well as interviews.

The programme included 50 projects of very different sizes and was valued around FIM 75 million (in May 2000), of which Tekes shouldered around 75 percent.

The first goal of the programme, to raise the international competitiveness of the Finnish space players, was largely met, mostly by supporting different ESA engagements of the industry and institutes concerned. The more intensive exchange between space technology and other industry sectors, defined as the second programme goal, was demonstrated in different projects. Taking the moderate amount of money involved, (in comparison to other countries), into account, the very good performance in this field cannot be assessed high enough. On the other hand, it is felt that the third goal, to intensify the know-how transfer from research to industrial entities, is not quite satisfactory. One reason may be sought in the kind of competing situation concerning fund raising between industry and institutes. The fourth goal was to create a functional Finnish space network. Comparing this desired network with a control loop, it can be said that the components in the loop are of high quality but the loop is not yet tuned. A common project with strong guidance may help to get the network working.

The projects performed were quite well chosen matching the technical abilities of the Finnish industry and institutes. They helped to create the very first steps in entering the international space market. Whereas the commercial influence of the projects regarding some terrestrial application is seen to be very positive for space application, the big bargain has still to be demonstrated.

The overall effect of the Space 2000 Technology Programme on the Finnish economy and space industry was positive. It should continue in the same direction to help the excellent players get a foot in the commercial space market.

1 Introduction

In the beginning of 1995, Finland became a full member of the European Space Agency (ESA). At that time, Finnish space industry and research institutes could hardly compete for ESA flight hardware contracts with similar entities in other European countries.

The reasons for this included the very special ESA culture of administrative and quality assurance management, as well as the missing label of "flight proven hardware" for Finnish space products.

These deficiencies were very well understood by the national Finnish Technology Agency, Tekes, which convened a working group in the last quarter of 1994 to set up a frame for the "Space 2000 Technology Programme" (henceforth 'Space 2000'). Industry and institutes delegated high-ranking people to this group.

The first projects of Space 2000 started at the end of 1995, and some projects are still running in 2000.

Near the end of the programme, Tekes wanted to know the real output of its initiative and its financial investments, regardless of the final results of the projects still running.

The envisaged evaluation should avoid conflicts of interest and result in an objective assessment. Therefore, Tekes appointed an external expert for this task.

Chapter 2 introduces the structure of Space 2000 and the reasons for such a programme. The evaluation procedure and criteria are described in Chapter 3. This chapter includes an assessment of the evaluation process. Different points of the overall Space 2000 assessment are discussed in Chapter 4. A summary of the assessment and some recommendations conclude the report.

2 Programme structure and justification

Space 2000 included pure company projects and projects in which institutes and industry co-operate. The institutes had to apply to Tekes in regard to the latter projects. All projects were scrutinised by Tekes.

Space 2000 was monitored by a steering committee consisting of the main players within the Finnish space community including Tekes personnel. The steering committee could comment on proposals for research projects but not on company projects. The steering committee defined the main objectives and emphasis of Space 2000 and followed the management of the programme, which was handled by Tekes. Furthermore, it monitored the progress of Space 2000 as well as of individual projects. The steering committee met around five times a year.

Within Space 2000, the opportunity was given to engage external advisors for consultation services concerning the international space market and technology developments. This option has not yet been used. On the other hand, the ESA consultation services for technology matters and technology transfer were called on frequently.

The scale of work reached from system-, component- and process-studies through basic technology research, predevelopment of components/instruments and building of flight hardware up to the set-up of a test station for radiation tests. Some projects concentrated on software applications for process development as well as on studying management tools.

A classification of the 50 projects along the TRP (Basic Technology Research Programme) technology tree shows that

- 5 of the 6 areas of product level 0
- 3 of the 4 areas of product level 1 and
- 8 of the 15 areas of product level 2

were touched by Space 2000. The TRP product tree is shown in Annex 3.

Research institutes in co-operation with industrial companies performed 27 projects. The remaining 23 projects were company projects with only limited control by Tekes.

The total money approved for the 50 projects approached FIM 75 million (EUR 13 million) (in May 2000). In reality, the figures of Tekes changed a little, because some granted funds were cut back during the running time of the projects. On the other hand, funding by companies was sometimes higher than planned because of cost overruns.

It is interesting to note that for one project alone Tekes funded FIM 46 million (EUR 7.7 million). The total for all funds added, for activities in the field of ozone- measurement, amounts to FIM 48 million (EUR 8 million). Around FIM 6 million (EUR 1 million) was invested by Tekes in projects in the field of structure and material. As a consequence, only FIM 16 million (EUR 2.6 million) was spent on the remaining 33 projects, including two projects around FIM 3 million (EUR 0.5 million) for ESA consultation services, that is, the average support of Tekes for 31 projects was FIM 0.4 million (EUR 0.06 million) or around one person-year. This fact must be kept in mind when judging the project performances.

Space technology has the reputation of being highly sophisticated, as indeed it is in very many areas. To keep pace with the technological development in the other ESA countries, Tekes did very well to launch Space 2000 upon becoming a full member of the ESA. The working group of Space 2000 formulated the main target in 1994/95 as follows: "The main target of Space 2000, which concentrates on space equipment technology, is to increase the opportunities of the Finnish space industry to carry out ESA projects with a content and subject suitable to its technology strategies. As a result of Space 2000 measures, Finnish companies should be competitive with the European space industry in 2000, when the ESA's special measures to channel orders to Finland come to an end."

In other words, the Finnish industry and research institutes must gain ESA and other European agencies' contracts from 2000 onwards in open competition, in order to receive a good return on the money the Finnish Government is transferring to the EU, ESA, EUMETSAT and other European agencies.

The justification for Space 2000 is that it will help Finnish entities reach this goal. Furthermore, a good functioning space technology can exercise a very positive influence on terrestrial technologies.

3 Evaluation procedure and criteria

3.1 Evaluation procedure

The evaluation was conducted by Bernhard Fabis, M.Sc. Dipl.Ing., who has around 40 years experiences in aero- and astronautics, and is now head of the consultant company Ingenieur-Diensleistungs-Service (IDS). A kick-off meeting in Helsinki was held, in which Tekes mainly presented the structure of Space 2000 and the main participating companies and institutes in form of a virtual visit via the Internet. A survey of the general working of Tekes as the Finnish Technology Agency was also given.

In the second half of May 2000, Tekes provided short, one to two page descriptions in English of most of the projects. These short papers were supported by more comprehensive reports in so far as they were available in English. Some of the short papers arrived just at the beginning of the interview period, which was conducted from June 5 2000 to June 9 2000. No information was received for at least four projects.

The basis for the interview session was a review plan, which was sent to Tekes one week in advance. This review plan described

- the aim of the review
- the topics to be worked out in the evaluation
- the participants of the review
- the time table, and
- the definition of the output.

A questionnaire was delivered as an annex to the review plan. All participants of the interviews should have received the review plan.

Interviews were performed with representatives of 14 out of 18[1] industrial and research entities involved and they covered 42 projects, including the ESA consultation projects by Tekes. 90 to 180 minutes were spent on each interview, depending on the number of projects to be evaluated.

1 Patria Finaviatec Systems and Patria Finaviacomp as well as VTT Automation and VTT Electronics are each regarded in this report as two separate entities; Tekes is included because of the ESA consultancy projects

During the interviews opinions how to develop space adminisration in Finland were presented. However the purpose of this evaluation was to evaluate the Space 2000 technology programme and therefore these opinions are not discussed in this report.

3.2 Evaluation criteria

The objectives of the Space 2000 are inherently contained in the report of the working group of 1994/95. These objectives can be used as criteria, and read in condensed form as follows:

- Developing the international competitiveness of the Finnish space equipment industry, especially in the satellite projects of the European Space Agency (ESA).
- Intensifying technology synergy between space technology and other industry sectors.
- Transmitting the expertise, acquired in connection with the development of nationally financed SCIENTIFIC space equipment, to an industrial environment.
- Creating a functional network for space technology to enable the realisation of more extensive space technology projects in Finland.

Additionally, answers should also be found to the following questions, which were used as criteria.

- What has been the technological and commercial relevance and the calibre of the project portfolio?
- How did the projects succeed within the technology programme?

3.3 Assessment of the evaluation process

In general, the auditor felt that the preparation of the evaluation process was quite satisfactory, especially concerning the effective way in which the most important information, for checking the projects against the criteria, was received in such a very short time.

The written information was of variable quality, depending on the author. In most of the short summary reports, a common structure was visible. But even in this structure, some signs of inferior quality were seen, and some of the short reports failed to clarify matters.

It has already been mentioned that four reports were totally missing while some were really late. Verbal commentaries were given on three projects for which the reports were missing.

The atmosphere in the interviews was always friendly and, in general, very open. The auditor never had the impression that anyone wanted to hide anything. Sometimes a very positive statement from the interviewee changed after additional questions to a less positive one. No concrete answer could be given to certain questions for projects that had already finished some years ago. Two interviewees proposed that Tekes should include their intention to perform a final programme evaluation in the contract and define the necessary documentation.

The performance of an interviewee depends on his character and his momentary mood. In general, the interviewees were very competent people who gave straight and precise answers. Some were a little shy. Two of them gave the impression that they do not identify themselves with their jobs or their projects, but the author attributes that to their momentary condition during the interviews.

4 Overall programme assessment

The overall programme assessment weights the results of the projects against the criteria defined in Section 3.2. This will not be done project by project but more globally. Certainly this will not exclude the fact that sometimes special projects are mentioned within the different chapters. This global assessment is chosen because an individual judgement needs more time in order to get more comprehensive information.

4.1 Compliance between the Space 2000 and the requirements of the working group

In general, the approved projects over the last five years comply with the frame given by the working group. The exceptions are two projects concerning ground data processing for scientific data. The Space 2000 working group explicitly excluded this task.

Most of the money went into the development of ozone measuring instruments or subsystem studies. This work belongs, more or less, to the earth observation sector, which had its own development programme, the 'Globe 2000 Programme'. Such work was not excluded by the working group, but for transparency reasons this work should have been carried out by only one programme.

In Chapter 2, it was shown that many projects were funded for less than one personal year and, as a one shot support, were not continued by a follow-on contract. Astonishingly, very good performances were delivered in some of these tiny projects.

Tekes should reflect about the concentration of funding in the fields in which Finnish industry and institutes are already very strong. The motto applied in other industrial countries "to make the strength still stronger and do not support the weaknesses" should also be used by Tekes.

4.2 Competitiveness in ESA projects

The ESA is relaxing the strict rules of the geo-return in favour of more open competition from the beginning of year 2000. The flight hardware projects of the science directory, in particular, may be in danger for the Finnish industry in an unprotected market. On the other hand, Finnish companies can gain contracts in other fields, till now not open to them, such as the field of launchers, manned space or telecommunication and navigation.

Concerning the competitiveness of Finnish companies/institutes, the author got the impression that

- at subsystem/equipment level — two companies
- at equipment level — one company
- at instrument level — one research institute
- at component level — two companies
- for test services — one research institute
- for GSE — two companies

are in a position to win competitive international tenders.

Compared to 1995, the situation for Finland today concerning competitiveness in the space business has very much improved thanks to Space 2000. Therefore, it can be stated that the objective of making Finland competitive in certain space business fields was largely fulfilled. To be competitive does not mean to win a contract. In the older ESA-countries, networks of specialised companies have grown up. The Finnish companies have to find ways to become part of these networks. Furthermore, the large space system companies often try to keep the subsystem and equipment work as much as possible in house. The companies concerned welcome any kind of State support in finding an entry into the networks, and in the customer lists of the system companies.

Nowadays, delegates have only a very small influence on the allocation of contracts for ESA satellites. But there is still the chance of channelling small projects of the ESA GSTP and TRP research programmes to Finland. It seemed to the auditor that, in the past, Space 2000 often supported the same topics as were financed by the ESA research programmes. By doing this, the quality of the Finnish research work became known to the ESA and, thus, to the world-wide space community. In this aspect at least, the state investment was a big success.

The consultancy services of the ESA got different ratings from the receivers. Sometimes, the lectures were judged to be too theoretical and not immediately applicable, sometimes they helped to solve a special problem and at times these services even help develop new business relations. The success of such consultancy services depends very much on the choice of the clearly defined topic and the correct lecturer.

One company reported co-operation with a well-established foreign company that was functioning quite well. This co-operation included an exchange of residents. The advantage of such an exchange is described in Section 4.4.

As mentioned above, the ESA culture for doing business is difficult and very costly. In regard to quality assurance, the market produced a good solution in the form of a small company, which sells its services to small and medium sized enterprises (SME) and institutes. Maybe such a service firm dealing with administrative matters could write the proposal to the ESA and, thus, could partially take a heavy burden off the SME and motivate them to continue in the space business. Two companies, which transferred the knowledge of space technology in terrestrial applications, abstain from writing proposals to the ESA ITTs. The reason is that for a fraction of the expense involved in preparing proposals, they can earn many times the money in the terrestrial application business.

Only rare examples were found, which showed the successful winning of non-ESA space contracts on a commercial or nearly commercial basis. Therefore, these businesses cannot be used as criteria for deducing the competitiveness in commercial space projects.

But being competitive in ESA projects – even with some administrative support – means that at least the technological competitiveness is also available for commercial projects. Thus, the above table can be applied to the technological competitiveness of commercial space projects.

The competitiveness of financial matters is quite another issue and not the subject of this evaluation report.

In concluding this chapter, it can be said that the objective of competitiveness in certain space business areas is fulfilled, but administrative and financial help is still needed.

4.3 Intensifying the exchange between space technology and other industry sectors

It is well understood that Space 2000 supported the companies and institutes which had a sound basis through doing similar work in the past for terrestrial applications. This heritage is used, as far as possible, as a kind of 'spin-on' to space technology. With the new space technology know-how (software-tools, processes, QA/PA and management rules, technologies, etc.) a spin-off effect from space technology was expected.

It should be recorded that nearly all the interviewees stated that they would not have entered a new space technology field without the support of Space 2000. A certain fear of the technical and financial risk in the companies/institutes may be deduced from this kind of statement. On the other hand, they put their own money in the projects, which finally showed that outside support could overcome such a fear.

In Section 4.2, it was mentioned that two companies would not participate at the time in ESA tender actions, though they felt, they could totally comply with the requirements. These two companies were the ones to apply the knowledge gained in Space 2000 very successfully to commercial terrestrial work.

In another case, a company became a strategic telecom R&D partner of Finland's most important company by using the space know-how.

One company already had a good reputation world-wide before engaging in the space business. The new environment for space application called for new solutions in the very same technology field. These new processes and parts are, nowadays, integrated in components used in terrestrial applications. Thus, this company is a world leader in this field.

One research and one university institute reported a clearly defined exchange of terrestrial and space know-how.

A very effective know-how transfer is one where qualified personnel change the work place. These people apply the same principles used in the old environment to solve problems in the new one. This kind of know-how transfer also took place in Space 2000; sometimes to the disadvantages of the programme, because there was nobody available to fill the gap. Compared to other countries, Space 2000 produced a very high know-how exchange between space and terrestrial technologies bearing in mind the limited money involved. Therefore, it can be stated that the goal of the second objective was also reached.

4.4 Know-how transfer from research to industrial entities

Before 1995, Finland was primarily engaged in the development of space science instruments. This work was performed in research institutes as well as in universities. A wealth of know-how was gathered. The fathers of Space 2000 wished a transfer of this know-how into industrial entities where it could be applied commercially.

Therefore, all approved Space 2000 projects initiated by research entities are somehow co-operative projects with industrial partners. For some survey studies, industry delivered only its technological status and their needs as inputs. Other projects had a classical prime-/sub-contractor relationship, where only deliveries were discussed in meetings. This obviously brought no great transfer. A good example of know-how transfer was reached in projects where industrial residents were in the research institutes or *vice versa* researchers were residents in industry.

The most effective know-how transfer was gained by a migration of personnel. This sometimes caused problems for the institutes, because there were no immediate replacements available.

The auditor got the impression that the know-how transfer was fairly good in the beginning of Space 2000 and worsened towards the end. Today, it only about two well functioning transfer examples can be reported.

In the interviews, industry accused the university and research institutes of keeping the most qualified personnel for themselves so that industry got only second rate personnel. On the other hand, the researchers lamented that industry hanged them out to dry by not placing any contracts with them. This is not a good climate for getting this objective fulfilled.

A similar trend as in other European countries can also be seen in Finland, that is that the bigger space promoting industry is trying to become autonomous and independent from the “smaller space entities”. Such things as financial arguments were used for this move, for example, the research institutes would offer their services at much too high a price. On the other hand, one company told of the engagement of 42 SMEs for a 15–20 percent share of the project. Maybe these SMEs were not specially engaged in the space business and they delivered support equipment for terrestrial use.

With the above said only a partial fulfilment of this objective can be identified.

4.5 Creation of a functional Finnish space network

This objective is very closely related to that of Section 4.4. It asks for co-operation, which is a prerogative for the know-how transfer. The realisation of a “more extensive space project” was defined as the goal for getting a functional network. Although no clear definition of this “more extensive project” was given, it could be, for example, a complete scientific instrument or a smaller satellite. One of both objects may fit into the financial frame of the Finnish space budget. Whereas scientists may easily find arguments for a new instrument, a customer (user) for a small but sophisticated and meaningful satellite is not easy to spot.

Anyhow, it seems that Finnish research institutes and industry are well prepared to start the definition, design and realisation of such a scientific instrument with all its mechanical electrical, optical and software subsystems as well as to do the corresponding testing.

Not all the subsystems can be designed and built in Finland for a small satellite performing a sophisticated mission. For example, AOCS with OBC or power generation subsystem have to be provided from abroad.

Although Finnish space entities may be in a position to build, without important foreign help, a complex scientific instrument, no functioning space business network exists in Finland. A functioning network is more than just a dozen highly specialised space units. These units have to communicate with, and help, each other to enlarge the strong capability of the corresponding units.

The interviews revealed that in a preponderant number of cases, there was almost no communication, and everybody was looking for a bigger slice of the ESA and Tekes financial cake. This rivalry exists not only between companies, but also between companies and research institutes.

One reason is certainly that the research institutes have to bring in outside money to get projects started. In one research institute, 70 percent of the project cost has to be financed by outside money.

The competition between industrial firms is a natural phenomenon but for the sake of national success, the different participants of the network should start to play together and not against each other. A national project with a strong customer would certainly help to bring the players together.

Comparing this desired network with a control loop, it must be said that the components in the loop are of good quality, but the disturbance variable is very high and the loop is not yet tuned. Therefore, this objective was only a partial success.

4.6 Technological relevance of the projects

Each project should have been separately examined concerning its technological relevance, because of the very different technologies supported by Space 2000. But, as said at the beginning of this chapter, only a global assessment will be given. Another reason is that the project plans were not seen by the evaluator. Such plans are necessary in order to make a profound assessment about the success.

Market studies and survey studies were included in the programme. These studies will be disregarded in this chapter. The projects with technological content partially covered basic research, but most of them dealt with applied research and development topics. Another classification is the division into good tasks with high innovation potential and not so good tasks, to which modern and new, but elsewhere already existing, tools were applied for the first time in Finland. All the projects got their legitimisation by reaching the goals of the above-defined objectives.

Taking into account the findings of Section 4.2, it can be stated that in some cases Space 2000, together with other measures by ESA contracts, brought Finnish industry up to the same technological level as other space industry nations. This is mainly valid for one subsystem, three to four pieces of equipment and some components. In four cases at the component level, Finnish enterprises/institutes maintain world leadership. But examples were also found in which the technological level is lower than the world standard.

4.7 Commercial relevance of the projects

Real business starts with a series production or with customised niche. This law is also valid for space business. Series production at the system level in space business is seen world-wide only for launchers, telecom satellites and the upcoming navigation satellites. Subsystems not used in series satellites are submitted to more or less severe modifications when used in single event satellites. But existing flight-proven equipment can very often be reused only with minor adaptations. The chance of a series production at the equipment and component level is very much higher.

The commercial effect of Space 2000 on the space business is of a limited nature. No series production of any part of a regular satellite system breakdown-structure can be seen. Finnish companies/institutes have won some ESA contracts as a consequence of Space 2000 support and, for the moment, they can survive, but a breakthrough in the free commercial market has not taken place.

On the other hand, it became obvious that for at least four companies, the application of space technology know-how to solutions to terrestrial problems developed into a success story. Unfortunately, two of them are doing so well in the terrestrial business that they currently have no opportunity to participate in the ESA ITTs.

The biggest market resulting from space activities is that for consumer end-equipment, such as satellite receiving stations, hand-held-telephones or GPS-receivers. The participants in the development of the space equipment of these systems are well-placed to influence, via standardisation, the design of the consumer mass-products. This can be an advantage for the Finnish consumer industry. Maybe the data of the EOS-OMI follow-on instruments can be developed for the consumer market.

The Space 2000 programme can be considered a success when the overall commercial results are taken into consideration.

4.8 Calibre of the programme

Most of the financial support went into projects related to the ozone measurement. Maybe, in the long run, this investment will pay off handsomely. At present, it strengthens the reputation of Finland as the leading country for ozone measurement equipment. Tekes and all the other concerned parties should be more emphatic about making this fact known to a wider audience. Otherwise, EOS-OMI may be regarded as purely a Dutch instrument.

In the previous chapters, the success story of Space 2000 was assessed. The calibre of Space 2000 was found to be very well tailored for Finland, when the limited financial possibilities, and the technological heritage of the Finnish companies, are taken into account. Maybe more should have been done in the area of system engineering and system management. A subsystem can be managed like a system and even complicated equipment can be managed as a system. In general, managers will use the same tools at the system, subsystem or equipment level. The tools may differ only in complexity. It seems that some deficits exist here.

4.9 Success of the projects

In general, the reviewed projects can be regarded as successful. Although an immediate application of the new know-how is to be not seen in all cases. One of the items this refers to is software work.

Running and keeping a mechanical test installation up to date is a very expensive undertaking. If these test installations are only used to test Finnish space products they cannot be run profitably. Getting more users out of the non-space business can lower the financial burden. If this is not possible, a trade-off should be made either to continue the expensive use of these installations and give Finland a little more autonomy in space technology or stop the support and do the testing abroad.

The solar cell technology is one of the most advanced in the world. But big, maybe too big, investments have to be made to bring these cells to a series production. It is interesting to mention the world-wide trend towards developing medium efficient cells with almost no degradation over the lifetime. Tekes should evaluate the situation in this field very carefully.

5 Summary of the programme assessment and recommendations

Taking into account all the findings of Chapter 4, which weighted the programme/project successes against the criteria defined by Tekes and the working group of 1994/95, it can be stated that the overall programme was very successful in the sense of raising the competence level of Finnish space institutes and companies in certain predetermined fields to a European level.

Space 2000 produced a very high know-how exchange between space technology and other industry sectors in both directions. This has to be seen in the light of the limited amount of money involved.

While the fulfilment of the first two criteria was positive, the next two, that is the transfer of know-how from institutes to industry and building a functional network, were only a partial success.

Concerning the technological relevance, it can be stated that the projects were very well chosen so as to build up mosaic stones for a Finnish space network. Working on this premise, not all the projects could cover topics with a very strong innovative potential. Space 2000 was of great importance for Finnish institutes and companies.

Space 2000 helped Finnish space entities enter the protected space market. (The ESA contracts are meant for a protected market, because of the strict geo-return regulation prior to 2000.) This is regarded as positive. Its influence on terrestrial business fields is seen even more positively in cases where companies successfully enlarged their business volume, based on technologies and methods applied in space projects.

The calibre of Space 2000 was well tailored to the Finnish possibilities.

One of the objectives of Space 2000 was to prepare Finland for "more extensive space projects". This topic has been discussed in Section 4.5. Without saying anything about the mission profile of such "more extensive projects" it is highly recommended that such a project besides EOS-OMI be considered. Such a project will achieve positive effects such as, for example, raising the acknowledgement of space technologies in Finland, bringing all Finnish space players together, gaining more know- how in system engineering and system management, underlining Finland's ability to produce flight hardware at a system level.

When a meaningful mission is found, a market survey should be made for the mission product, as well as for subsystems and components of the flight hardware. Strategic alliances with foreign companies/institutes should be sought. This can help Finland bring its companies, with their competencies, into the real commercial space market. Furthermore, an alliance may accelerate the realisation of the project. In today's fast-paced world, the project should be completed within 3 years. Otherwise some positive effects may get lost.

Annex 1

List of projects

Globe 2000 Projects

Research, co-operative and institutional projects

Participant	Project title
Finnish Geodetic Institute	Ilmasta ja avaruudesta otettujen kuvien orientointien määrittäminen ilman signaloituja maastopisteitä
Finnish Geodetic Institute	Lumikartta
Finnish Geodetic Institute	Yritysten kaukokartoitustoiminnan lisääminen
Finnish Geodetic Institute	Pellon ja metsän BRDF-arvojen määrittäminen satelliitti-kuvauksia varten
Geological Survey of Finland	Kaukokartoitetun heijastuneen valon ja infrasäteilyn g eologinen tulkinta
Geological Survey of Finland	Hyperspektrinen malmi- ja teollisuusmineraaliviitteiden kaukotunnistus ja -kartoitus
Finnish Meteorological Institute	Satelliittitietojen käyttö otsoni- ja UV-tutkimuksessa ja operatiivisiin sovelluksiin
Finnish Meteorological Institute	COALA flight opportunities study
Finnish Meteorological Institute	GOMOS-datan validointi ja hyödyntäminen
Finnish Meteorological Institute	EUMETSAT Otsoniosaamiskeskus
Finnish Meteorological Institute	GOMOS-datan validointi ja hyödyntäminen
University of Joensuu	Metsikkötunnusten arvioiminen optical flow -menetelmällä tarkennetulta videokuvalta hahmontunnistusmenetelmää käyttäen
National Land Survey of Finland	Automaattisen satelliittikuvien oikaisujärjestelmän tuotantoon saattaminen
National Land Survey of Finland	Satelliittikuvien siirto tietoverkon välityksellä
National Land Survey of Finland	Operatiivisen maastomallilaskennan kehittäminen perustuen SAR-interferometriatekniikkaan
National Land Survey of Finland	Satelliittikuvien puoliautomaattinen tukipistemittaus
National Land Survey of Finland	Kaukokartoitusmarkkinoiden laajentaminen satelliittikuva-keskuksen avulla
Finnish Institute of Marine Research	SAR-kuvan häviöllinen sekä geofysikaalinen kompressointi jäänmurtajia ja kauppalaivoja varten (SARKOMP)
Finnish Institute of Marine Research	ENVISAT ja Itämeren jääolot (ESSI)
Finnish Forest Research Institute	Valtakunnan metsien inventoinnin (VMI) ajantasaistus kaukokartoitusaineiston avulla
Finnish Environment Institute	Sääsatelliittikuvien operatiivisen käytön apuohjelmat (SOKA)
Finnish Environment Institute	Operatiivinen vesialueiden seuranta- ja valvontajärjestelmä
Finnish Environment Institute	Assessment of the usability of ENVISAT MERIS, AATSR, ASAR data in monitoring of coastal waters and lakes in Finland (ENVISAT-Vesi)
Finnish Environment Institute	Envisat-Lumi

Participant	Project title
Finnish Environment Institute	ENVISAT- Vesi - DLR vierailu
Helsinki University of Technology	Lentokäyttöinen mikroaaltoradiometri
Helsinki University of Technology	Uudet menetelmät metsien kaukokartoituksessa
Helsinki University of Technology	Lentokäyttöinen mikroaaltoradiometri
Helsinki University of Technology	Retrieval of boreal forest and surface characteristics from Envisat multisensor data
Helsinki University of Technology	Uudet mikroaaltoradiometriteknologiat ympäristön kaukokartoituksessa
VTT Automation	SPOT VEGETATION datan käyttö pohjoisten metsien tutkimuksessa (SPOTVEGE)
VTT Automation	INDOSAR
VTT Automation	Korkeusmallin automaattinen tuottaminen digitaali-ilmakuvista PC-klusterilla (KADIP)
VTT Automation	ENVISAT boreaalisen metsän kartoituksessa ja lehtialaindeksin arvioinnissa (=ENBOR FORMAL)
VTT Automation	Development of generic models for forest biomass estimation using multi-resolution optical data and JERS L-band SAR data

Industrial projects

Participant	Project title
Diware Oy	Significance of earth observation for Finland
ESPA Systems Oy	Digitaalisten ilmakuvien käyttö: ohjelmisto- ja kehityshanke
FG-Shipping Oy Ab	ICEPILOT: Reaaliaikaisen jäätilannetiedon hyödyntäminen kauppamerenkulussa - pilottihanke
FM-Kartta Oy	LIDAR
Genimap Oy	SAR interferometry derived DEM's for Cellular network planning
Maa ja Vesi Oy	Kaukokartoitusaineistojen käytön tehostaminen Maa ja Vesi Oy:ssä
Metsäteho Oy	Kaukokuvat metsän inventoinnissa ja seurannassa
Novo Group Oyj	HUAFIN ohjelmistoprojekti
Novosat Oy	Korkeusmallien tuottaminen satelliittitutkakuvilta
Oy Finnagro Ab	Satelliittikuvatulkintaan ja paikkatietojärjestelmiin perustuva riisisadon ennustemalli
Space Systems Finland Oy	COALA flight opportunities
SPECIM, Spectral Imaging Oy Ltd	Kuvantavan lentokonespektrometrin teknologiakehitys
SPECIM, Spectral Imaging Oy Ltd	Kuvantavan lentokonespektrometrin 3-akselisten asentoanturointiratkaisujen kokeellinen evaluointi
Stora Enso Forest Consulting Oy Ltd	Korkearesoluutioinen videokuvaus metsätietojärjestelmässä
Stora Enso Forest Consulting Oy Ltd	Digitaalinen mosaikointi suuralueelle
Vaisala Oyj	Ilmakehän remote sensing-mittausmenetelmien kokeellinen tutkimus
Ylinen Electronics Oy	Uudet mikroaaltoradiometriteknologiat ympäristön kaukokartoituksessa

Space 2000 Projects

Research, co-operative and institutional projects

Participant	Project title
Finnish Meteorological Institute	Development and construction of the ground segment for Odin satellite OSIRIS instrument
Finnish Meteorological Institute	Ozone Monitoring Instrument (OMI) for NASA EOS-Aura I
Finnish Meteorological Institute	Ozone Monitoring Instrument for NASA EOS-Aura II
Finnish Meteorological Institute	Ozone Monitoring Instrument for NASA EOS-Aura III
Finnish Meteorological Institute	NetLander 2005 definition Phase A
Finnish Meteorological Institute	NetLander Mission Study Phase B
Helsinki University of Technology Laboratory of Light Weight Structures	Experimental analysis of composite materials thermal and humidity transformation
Helsinki University of Technology Metsähovi Radio Observatory	Evaluation of the TRW MMIC process and its upper frequency limits
Tampere University of Technology Optoelectronics Research Centre	Processing and characterisation of cascade space solar cells
Tekes	ESA consultation co-operation I
Tekes	ESA consultation co-operation II
University of Jyväskylä Department of Physics	Development of space radiation testing facilities and service marketing
VTT Automation	Environmental testing of space equipment
VTT Automation	Structural and thermal design of space equipment
VTT Automation	Space equipment structures, materials and surface treatments
VTT Automation	Improvement of environmental testing facilities in space equipment testing
VTT Automation	COALA Ozone instrument flight opportunities
VTT Automation	OMI-Ims Phase B 2.4 Study
VTT Automation	Environmental testing of integrated circuits pilot and development
VTT Automation	Definition of the micro systems in space applications
VTT Automation	Low shock separation mechanism for small satellite
VTT Automation	Management and system engineering in space projects
VTT Automation	Thermal vacuum testing in Finland
VTT Automation	COALA Ozone monitor flight opportunities II
VTT Electronics	Surface mount technology
VTT Electronics	Software production methodologies and tools in space applications
VTT Electronics	Dynamic gain control method and device for time-of-flight imaging lidar

Industrial projects

Participant	Project title
AL Safety Design Oy	Development of PA/QA for space instruments
CCC Systems Oy	Software markets within space
Coherent Tutcore Oy	Development of radiation resistant GaInP/GaAs cascade solar cells
Detection Technology Oy	Business activities development in space programmes
Metorex International Oy	Development of large area gas sensors for x-ray detection and quality improvement
Patria Finavicomp Oy	Development of space structure technologies for commercialisation
Patria Finavicomp Oy	Technology package for structure lead status
Patria Finavicomp Oy	Space structure development for commercial projects
Patria Finavitec Oy Systems	Development project for space instrument technologies
Patria Finavitec Oy Systems	COALA Ozone monitor flight opportunities
Patria Finavitec Oy Systems	COALA Ozone monitor flight opportunities II
Patria Finavitec Oy Systems	OMI-ImS B2.3 FEE PDR-status
Patria Finavitec Oy Systems	DEBIE particle detector definition study
Patria Finavitec Oy Systems	Research on fast data processing and modular power supply for GSE equipment
Patria Finavitec Oy Systems	Technology definition for DEBIE small particle detector
Patria Finavitec Oy Systems	Surface mount technology evaluation and implementation
Patria Finavitec Oy Systems	Space electronics development for commercial projects
Rejlers Oy	Rejlers Space 2000
Smartech Oy	Space qualified ASIC design
Space Systems Finland	Onboard flight software development
Space Systems Finland	COALA Ozone monitor flight opportunities II
Space Systems Finland	New markets for space technology
Ylinen Electronics Oy	Ground station technologies for mm-waves

Annex 2

Curriculum Vitae

Bernhard F. Fabis

Name:	Bernhard Franz Fabis
Date of birth:	October 9, 1934
Place of birth:	45670 Herten/Westfalen
Nationality:	German
Personal status:	married to Annemarie Fabis, née Krischer, four children, aged 30, 29, 28, 23

Schools: 1941–1946, Primary schools in Herten, Westerholt, Burschen
1946–1955, Mathematics and Science High School, Herten
Graduated with the overall mark: good

University education:

1955–1962 Aeronautics at the RWTH Aachen
Practical work (overall one and a half year)
Mannesmann steel factory in Gelsenkirchen
Bischoffwerke in Lüdinghausen
Weser-Flugzeugbau, Einswarden
Valmet Oy, Tampere
Graduated Diplom-Ingenieur with the mark: good
1964–1966, NASA scholarship, Control and human engineering in the aerospace department of the Massachusetts Institute of Technology,
Graduated Master of Science

Professional career:

1959–1962	Work in the supersonic wind tunnel of DVL
1962–1964 and 1966–1967	Assistant professor for flight guidance at the Technical University of Braunschweig
1967–1969	Engineer, “Gesellschaft für Weltraumforschung”, responsible for the component development of satellite orbit and attitude control systems
1969–1975	Delegated from the Ministry of Research to the project “SYMPHONIE” in Brétigny, France; responsible for all mechanical subsystems
1975–1980	Deputy to the department head for communication satellites at DFVLR-PT in Köln; responsible for the programmes “ARCOMSAT, ZKS, National TV-SAT”
1980–1988	German project manager for the development of the German-French project “TV-SAT/TDF”; Mission manager for launch and in-orbit commissioning

1988–1991	In DLR management division responsible for the space plane “HERMES”
1991–1997	Manager for all research work within DLR concerning space infrastructure (launcher, propulsion systems, intelligent structures, robotics, aero-thermodynamics, etc.)
1997–1999	Head of the division “Space Infrastructures” within the German Space Centre, that is, responsible for all State-financed projects in the field of space and ground based infrastructure in German industry
since Nov. 1999	Free-lance consultant and head of “Ingenieur-Dienstleistungs-Service (IDS)”

Points to be mentioned: Trilingual (German, English, French)
Wide experience in foreign relations
Many publications in the area of aerospace
Aerospace expert for ISO 14001- and EMAS-certification
Holder of the German Cross of Merit

Preben Gudmandsen

Born: October 5, 1924 Solbjerg, Denmark.

M.Sc. in Electrical Engineering, 1950, from the Technical University of Denmark (TUD). Thesis: Theoretical/numerical investigation of waveguide structures.

He has worked as a research engineer at the Microwave Laboratory of the Academy of Technical Sciences, Denmark from 1950 to 1957 (design of microwave equipment for tropospheric propagation experiments carried out in Denmark, field measurements and data analysis). From 1957 to 1960, he was a research scientist, and later Section Head, at SHAPE Air Defense Technical Center, The Hague, The Netherlands, (projects related to tropospheric scatter communication systems and ionospheric propagation). From 1960 to 1961, he was employed as a development engineer at TITAN A/S, Copenhagen (large-current rectifier plants). From 1961 to 1994, he joined the Technical University of Denmark, Lyngby (Electromagnetics Institute), first as Assistant, later (1964) as Associate Professor, and from 1972 as Professor of Microwave Techniques. He has taught a number of subjects including microwave techniques, radio communications, optical fibre communications system, remote sensing techniques and digital image processing. Throughout the years, he has initiated and led a number of Ph.D. studies in these fields of research. He was Head of the Electromagnetics Institute for a period and of the Remote Sensing Unit until he retired from the office of Professor in October 1994. After retirement, he continues research mostly related to the Greenland region, the ice sheet and Greenland waters, exploiting remote sensing data.

In 1967, he initiated remote sensing activities in Denmark by carrying out airborne radio echo sounding of the Greenland Ice Sheet with a small group. It was a ten-year project of equipment design, profiling from aircraft, analysis of data for compilation of a map of the bed under the ice sheet. This work was carried out under the framework of Éxpéditions Glaciologique Internationales au Groenland (EGIG) with participation from Austria, Denmark, France, Germany and Switzerland. Later, it was continued under the framework of the Greenland Ice Sheet Program with substantial support from the National Science Foundation, Washington D.C. and the Commission for Scientific Research in Greenland. Satellite remote sensing was initiated through work with passive microwave remote sensing in connection with the NASA NIMBUS-7 programme, where he served on the NIMBUS Experiment Team related to work on the Greenland Ice Sheet and sea ice in Greenland waters. In 1981, he succeeded in securing funds for the first digital image processor in Denmark which was installed in his laboratory and used by Danish scientists, at large, exploring remote sensing data in their research. He initiated and lead the East Greenland Current Project (development of methods in geophysics), 1984-86, and the Greenland Sea Project (1987–95), including participation in the Marginal Ice Zone experiments. He was Principal Investigator in an ERS-1 Announcement Opportunity project related to research in the Greenland Sea carried out by the Remote Sensing Unit as part of the North East Water Polynya Project initiated by the Arctic Ocean Sciences Board.

In addition to his university duties, he has contributed to a number of contracts with the European Space Agency (ESA) and participated in various ESA study groups since 1972, several of them being forerunners for ERS-1. For a three-year period, he was Chairman of the ESA Remote Sensing Advisory Group. Until the end of 1994, he was Danish delegate to the ESA Council and the Programme Board for Earth Observation and was active in a number of working groups under this Board: EOPAG, EOSTAG and EDEN-WG (Chairman). He was an official representative to the EU initiatives concerning an environmental data network under the name of Centre of Earth Observation, CEO. He is a member of the Advisory Committee for the European Microwave Signature Laboratory (EMSL) at the Joint Research Centre at Ispra, acting as its Spokesman. He was a member of the National Committees on Oceanographic and Climate Research until February 1996. He is co-founder (1985) and the European Chairman of PIPOR (Programme for International Polar Ocean Research), related to exploitation of ERS-1 SAR data in polar research. He was a member of the Danish Space Research Board for the period 1984–94, and a member of the Commission for Scientific Research in Greenland for the period 1973–94. He was the Danish delegate to the Arctic Ocean Sciences Board from its start in 1984 until 1999. He is a member of the Danish Academy of Technical Sciences.

He is a co-founder of the European Association of Remote Sensing Laboratories (EARSeL, 1977) now comprising about 250 laboratories, and its first Chairman for the first seven years. In 1994, he was awarded the title of Honorary President of EARSeL. In 1982, he founded the now-dormant Danish Remote Sensing Society. He is Honorary Member of the Danish Society for Space Research, the Remote Sensing Society (England) and the European Geophysical Society.

In 1985, he founded, with two colleagues, the company, RS-Consult ApS, to carry out research and studies on contract based on the experiences gained through previous research. In this context, he has been responsible for studies of future satellite missions for the ESA and within the EU Centre for Earth Observation programme. Research in remote sensing in various disciplines is also carried out in the framework of NPOC-Denmark, a registered, privately owned company.

He received the ESSO Prize for his research in microwave and antenna techniques, and the Hans Egede Medal (by the Royal Danish Geographical Society) for his research in Greenland. The Hartmann Reward was granted in recognition of his scientific work and the promotion of technical-scientific research in Denmark. He received the ESA Medal and the Remote Sensing Medal in recognition of his work in connection with the ESA Earth Observation Programme for 20 years.

Annex 3

Product Tree vs. TRP Preliminary selection

Preliminary Selection Headings	**Product level 2**	**Product level 1**	**Product level 0**
Technologies related to Application Payloads	Earth Observation P/L	Payload & Instruments Technologies	Space Segment
Man in Space / Microgravity	Man in Space / Microgravity		
Technologies related to Application Payloads	Navigation		
Science	Science		
Technologies related to Application Payloads	Telecommunication		
Spacecraft Bus Technologies, Ground Segment & other Generic Technologies	AOCS Technologies	Spacecraft Bus Technologies	
	Mechanism Technologies		
	OBDH Technologies		
	Payload Data Processing Technologies		
	Power Technologies		
	Propulsion Technologies		
	Structure Technologies		
	Thermal Control Technologies		
	TTC Technologies		
SpaceTtransportation	Propulsion Technologies		Space Transporta-tion Technology
Spacecraft Bus Technologies, Ground Segment & other Generic Technologies			Components & Materials Technologies
		Spacecraft Operations	Ground Segment
		Payload Data Exploitation Technologies	
			Systems Architecture
Spacecraft Bus Technologies, Ground Segment & other Generic Technologies			Engineering Tools, Facilities & Services Technologies

Source: ESA/IPC(2000)3

Tekes Technology Programme Reports

11/2001	Space Technology Programmes 1995–2000. Evaluation Report, 36 p.
10/2001	Competitive Reliability 1995–2000. Evaluation Report. 2001, 42 p.
9/2001	Transport Chain Development Programme KETJU 1998–2000. Final Report.
8/2001	Tutkimuksesta liiketoimintaa, Tekesin TULI-toiminnan arviointi. Arviointiraportti. 2001, 50 s. Bjarne Peth, Anne Mäkinen
7/2001	Finnsteel Technology Programme 1995–2000. Final Report. 2001, 63 p.
6/2001	Finnsteel Technology Programme 1995–2000. Evaluation Report. 2001, 95 p. Mark Lawson, Bassam Burgan
5/2001	Competitive Reliability 1995–2000. Final Report. 2001.
4/2001	Mallitehdaskonseptin kehittäminen 1996–2000. Loppuraportti. 2001, 93 s.
3/2001	Nopeat tuotantojärjestelmät 1997–2000. Loppuraportti. 2001, 142 s.
2/2001	Keskiraskas ja raskas kokoonpanotoiminta 1998–2000. Loppuraportti. 2001, 129 s.
1/2001	Huomisen koneet ja järjestelmät SMART 1997–2000. Loppu- ja arviointiraportti. 2001, 125 s.
21/2000	Digitaalisen median teknologiaohjelmat 1996–1999. Arviontiraportti. 2000, 43 s. Petri Rouvinen, Pekka Ylä-Anttila, Ulf Lindqvist, Timo Siivonen
20/2000	Oppivien ja älykkäiden järjestelmien sovellukset 1994–1999, Adaptive and intelligent systems applications. Arviointiraportti, Evaluation Report. 2000, 54 s.
19/2000	Finnsteel-teknologiaohjelma 1995–2000. Loppuraportti. 2000, 63 s.
18/2000	Adaptive and Intelligent Systems Applications 1994–1999. Final Report. 2000.
17/2000	Nanotechnology Research Programme 1997–1999. Final Report. 2000
16/2000	Virtausdynamiikan teknologiaohjelma 1994–1999. Arviontiraportti. 2000, 44 s. Raimo J. Häkkinen, Lasse Kivikko, Tarmo Lemola
15/2000	Light Assembly Industry LASSI 1996–1999. Evaluation Report. 2000, 61 p. Kamal Youcef-Toumi, Antti Soini
14/2000	Light Assembly Industry LASSI 1996–1999. Final Report. 2000, 105 p. Reijo Tuokko
13/2000	Marketing Molecules Technology Programme 1997–2000. Evaluation Report. 2000, 31 p. John H. Prophy, James H. Clark
12/2000	Puurakentaminen 1995–1998. Loppu- ja arviointiraportti. 2000, 101 s.

Subscriptions: www.tekes.fi/eng/publications