ESTEC's value to The Netherlands

final report

Triarii, The Hague, 27 June 2005

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MANAGEMENT SUMMARY

This report provides the results of the study of the added value of ESTEC for the Netherlands. The study focused on the value of ESTEC for the Dutch knowledge society and on the macro-economic value of ESTEC. It was assigned by ESTEC and the Dutch Ministry of Economic Affairs, to be presented at the celebration of the 30th anniversary of the European Space Agency (ESA) in June 2005. The principal conclusions of the report are the following.

Conclusion 1: ESTEC's direct value for Dutch knowledge society is high.

ESTEC, ESA's prime technology centre, is the sixth largest knowledge institute in the Netherlands, employing 2010 permanent staff and contractors, among which some 1200 engineers and scientists. ESTEC's volume of research and technology development is estimated at 212 M€ (6% of its total spending). Most of its activities are internationally outsourced, allowing European industry and public research to share in its knowledge development.

A significant share of the Dutch space cluster benefits from this knowledge development. The Dutch upstream space sector (producing hardware for ESA's space missions) consists of approximately 40 parties, employing 1100 people and has an annual turnover of M€ 170. A much larger part of Dutch space sector indirectly benefits from ESTEC as user of space hardware (e.g. telecom industry, earth observation). Their turnover in this field is estimated at B€ 2. They particularly benefit in an indirect way, from the universities around ESTEC that have acquired ESTEC knowledge.

Conclusion 2: ESTEC's interaction with Dutch space cluster is substantial but leaves ample room for improvement.

There are many mechanisms through which ESTEC and the Dutch space cluster benefit from each other's investment in knowledge development. Some of these hold significant opportunities for further development.

1: Exchange of knowledge workers between ESTEC and Dutch space cluster is not intense. For permanent staff this is related to the attractiveness of the challenging international ambiance at ESTEC. The many contractors usually have a long contract duration. It is a major challenge to embed mechanisms in the ESTEC organisation for the exchange of knowledge workers with the European universities and industry, in the space sector as well as the non-space sector. It would have the benefit of mixing company cultures and would provide an intense knowledge exchange.

2: Outsourcing of work by ESTEC is a very important mechanism through which Dutch industry acquires ESTEC-knowledge. The Dutch space sector in general does very well as it gets more than its share of the outsourced work, most of which has a very high technological content: development and production of (sub-) systems, studies and technology development. There are however only a few fast growing Dutch newcomers: it is a relatively stable group of industries that benefits from ESTEC's knowledge.

3: Sharing ESTEC test facilities and laboratories with Dutch industry and universities is not well developed partly because ESTEC only recently reinforced its efforts to open them up to third parties. Sharing facilities could create interaction and technology transfer as well as a cost advantage. Because of proximity, Dutch industries can be expected to benefit most. Currently however, use by Dutch industry is only limited.

4: Conferences, workshops and briefings aimed at aligning industry and science with ESTEC's needs and activities are a well developed channel for knowledge exchange and networking. ESA conferences and workshops, mostly targeted at the technological and scientific community, are mostly held in the Netherlands: 25% of participants is Dutch. Conferences, and in particular workshops, allow participants to acquire detailed in depth knowledge from ESA specialists on specific subjects.

5: Dedicated initiatives regarding technology transfer at ESTEC are small, young and fruitbearing however there is a lot of potential for improvement. The main initiatives are the Space Incubator and Technology Transfer Programme. The latter has third party financing and despite its young age is already showing tangible results. The Space Incubator manages to create a steady flow of incubatees. The incubator however is only small and the funding of incubatees is also small. Follow-up funding of incubatees, necessary to mature them to a level that venture capitalists demand, is not yet secured but is under investigation.

6: Cooperation with public knowledge infrastructure is in some areas very well developed. Educational cooperation is particularly developed with the University of Delft and its ESA professor's chair and the Space Tech masters programme. Research cooperation is very well developed with several Dutch universities (Universities of Amsterdam, Leiden, Utrecht, Delft, Nijmegen, Groningen). Development of scientific payload instruments by Dutch public research also is very well developed as the high number of principal investigators of Dutch origin demonstrates. Exchange of personnel between ESTEC and Universities is not well developed. There are very few Dutch research fellows and only a single part time professorship. This is not dissimilar to other countries.

7: The Erasmus User Centre is dedicated to the International Space Station and research in micro-gravity. In this particular field it has a high indirect value for Dutch society. It is a very effective,

appealing and appreciated means of attracting and informing new users and decision makers on utilisation of ESA missions. Most of its capabilities are used for providing information to international guests, news agencies, hosting events and helping scientists. Although it is not particularly used by Dutch industry, its appeal and its closeness to the Dutch Capital has resulted in many high level political visits, for example when the Netherlands was chairing the European Union. It has also contributed significantly to the image of the region (technology region).

8: The use of the ISS in general, hence also by Dutch industry is not yet significant. Thirty percent is reserved for commercial use. However because of the delays in the ISS programme, main ISS-modules such as the science module Columbus are not yet operational. As a consequence the market for commercial use of ISS is still nascent, only few industries are involved so far. One Dutch manufacturer of electronics has undertaken a pathfinder mission.

9: The impact of ESTEC on Dutch education is significant. ESTEC functions as the appealing face of the desired knowledge based society and is able to capture attention and interest of school pupils and to influence their educational choices. The combination of a committed Dutch government, given the policy paper ?plan ßtechniek and the efforts of ESTEC is seen as an example approach for other countries. Indirectly ESTEC provides a strong educational stimulant through the 80.000 visits per year to the ESA visitors centre “Space Expo” of which about one third are school children.

Conclusion 3. Dutch spending on ESTEC still very good value for money

Over the period 1994 – 2004 the Dutch contribution to ESA increased in absolute and relative sense from 2,8% to 3% of total contribution. In absolute numbers this was a rise of 33 % (from M€ 66 to M€ 88). In addition The Netherlands spent a significant amount on incidental investments at ESTEC.

The ESA expenditure in the Netherlands in the period 1994-2004 rose significantly in absolute figures, a rise of 29% (M€ 221 to M€ 284). Because of the growth of the Dutch economy, the ESTEC spending as a share of the Dutch Gross Domestic Product decreased from 0,054% to 0,047%.

The added value, i.e. expenditure minus Dutch contribution, in the period 1994-2004 rose 12% (in absolute figures from M€ 180 to M€ 202: 22 M€).

The total spending of ESA in the Netherlands in 2004 amounted to M€ 284 Thus, every Euro of the Dutch contribution of M€ 88, produces a return spending of €3.4 for the Dutch economy. In this respect the Dutch contribution of 88 M€ can be considered as a very good investment.

1 INTRODUCTION

1.1 Study background: knowledge exchange focus in this edition

Since 1967 the European Space Research and Technology Centre (ESTEC), the largest site and the technological heart of the European Space Agency (ESA), is located in Noordwijk, The Netherlands. Presently it employs 2010 people: a permanent staff of 1064 and 946 contractors. In the summer of 2005 ESA celebrates its 30th anniversary. ESA and The Netherlands, i.c. the Ministry of Economic Affairs, decided to present a report at this event describing the value of ESTEC to The Netherlands. Previous estimates of ESTEC's value to the Netherlands have been made in 1991 and 1995. Those reports focused on the economic value. This report in addition provides a description of the value of ESTEC to the Dutch knowledge society.

1.2 Study approach: internal and external perspectives

The current study was carried out in two phases. In the first phase ESTEC's perspective was investigated. For this, a desk study was carried out and 35 interviews inside ESTEC were held. These are shown in exhibit 1 below.

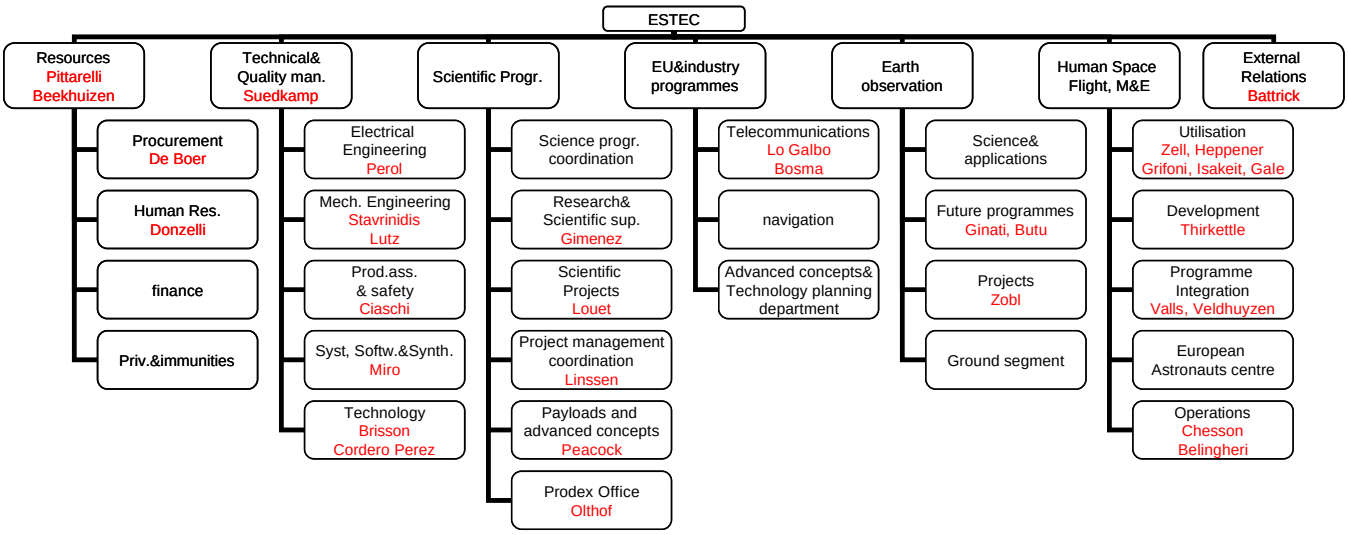

exhibit 1, ESTEC interviewees phase 1

In the second phase the inward looking perspective was investigated. Interviews were held with selected organisations outside ESTEC. These interviews are shown in the following exhibit 2[1].

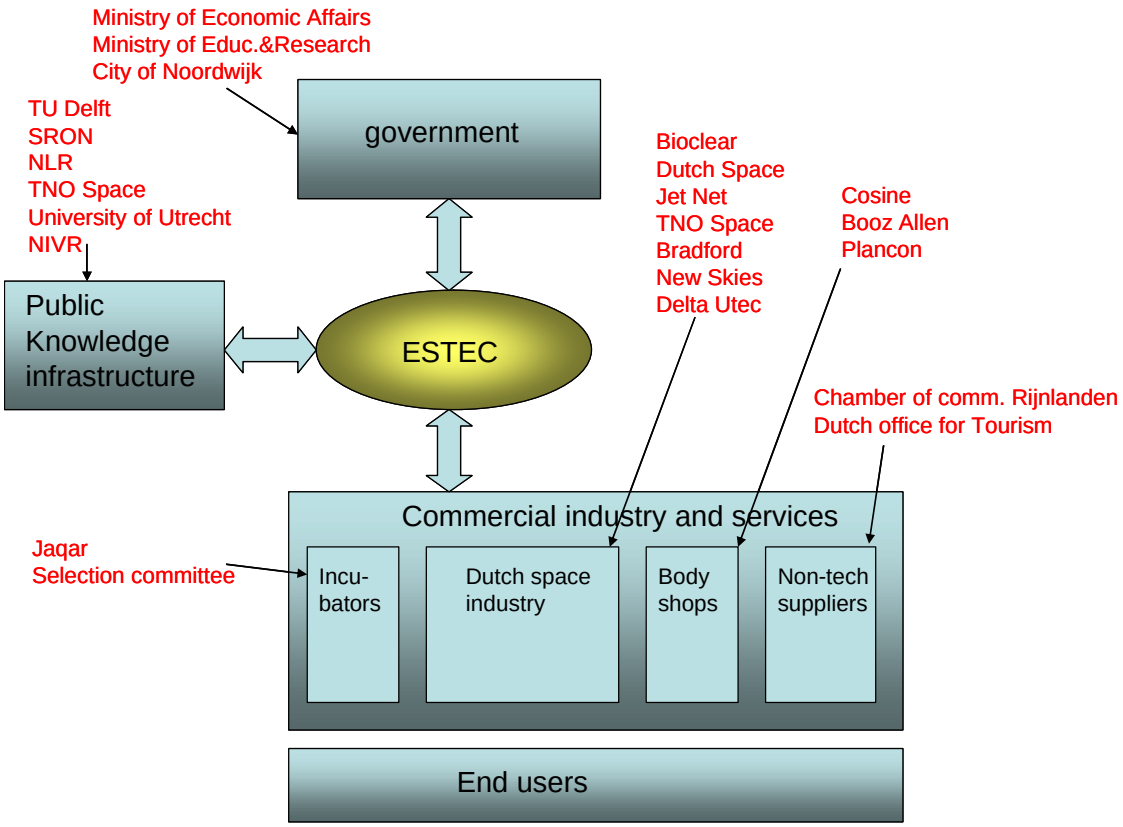

exhibit 2, interviews outside ESTEC in phase 2

1.3 Reporting structure: separate analysis knowledge value&economic value

The combined information from each phase was used as basis for the two analyses, i.e. that of the value of ESTEC's knowledge to Dutch knowledge society and that of the macro-economic value of ESTEC for the Dutch economy in general. The first is described in section 1 of this report (chapters 2-6) and the latter in section 2 (chapter 7).

[1] Exhibit 2 aims to structure the actors according to their primary role. It is however well understood that actors may assume other roles. For example the difference between industry and body shop is not very sharp as in the case of Jaqar Space Engineering. Also SRON in some cases acts as a body shop to ESTEC.

Section 1 "Knowledge exchange" is structured following exhibit 3 below.

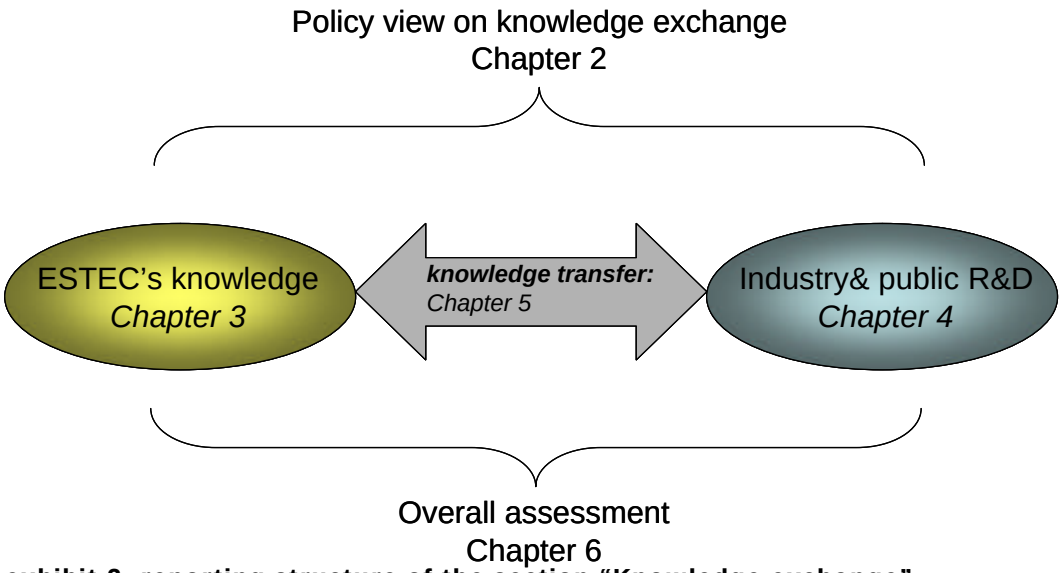

exhibit 3, reporting structure of the section "Knowledge exchange"

The general components earlier introduced in exhibit 2, also constitute the reporting framework that will be employed in the analysis of the knowledge exchange. The framework organises the relevant actor categories in this respect by the principal nature of their interaction with ESTEC.

Section 2 "Macro-economic perspective" presents the analysis of the expenditures and contributions to determine the economic value of ESTEC to the Dutch economy in general.

SECTION 1: KNOWLEDGE EXCHANGE

Analysis of the interaction between ESTEC and the Dutch knowledge society

2 ESTEC AS PART OF DUTCH KNOWLEDGE SOCIETY IS UNIQUE OPPORTUNITY

2.1 Knowledge is main determining factor of economic growth EU

Nowadays innovation is seen as an important factor that determines economic growth. The development of new knowledge is essential to innovate. In many advanced economies the importance of the development and use of knowledge for economic growth is well appreciated. With the Lisbon agreement (within 10 years the European Union has to develop into the most competitive and dynamic knowledge economy in the world) the European Union has chosen the knowledge economy as a cornerstone of its economic policies) not withstanding that it is generally acknowledged that its target is very ambitious.

2.2 Innovation requires collaboration and efficient knowledge exchange

An innovative and entrepreneurial private sector is a key constituent of a knowledge economy. The industry and services sector will have to be highly innovative and move to new products and markets with a higher added value.

But industries cannot do it on their own. Innovation is increasingly a team effort, in which industries identify opportunities and develop new products and technologies together with their suppliers and clients, public research and sometimes their competitors. Increasingly innovation processes are not confined to the limits of one organisation but cross borders between organisations and are driven by sharing ideas, knowledge, ambitions and activities. The strength of a nation's economy is determined by the cooperation and interaction between each of the actors. Naturally, such cooperation does not stop at national borders and has also international dimensions.

In general the European economies appear to be less innovative compared to for example the economy of the USA. Too often knowledge at public research organizations (e.g. universities) is not used to its potential. Too often industries insufficiently collaborate with their clients and suppliers in order to create new knowledge, new products for new markets. Too often organizations still follow a "linear innovation model" in which organisations restrict themselves to their own stage of the R&D process and have insufficient interaction with the other members of the innovation chain, the consequences of which are that research efforts are insufficiently tuned to, and used by, eachother. It is much better to follow an open or "dynamic innovation model" with frequent interaction with other stakeholders in each phase of the knowledge cycle. This dynamic innovation model has distinct advantages; sharing knowledge is more effective as organisations learn from eachother and it is more efficient.

2.3 ESTEC is important building block for Dutch innovation policy

The Netherlands are recognizing the importance of innovation, the role of knowledge development and the importance of a dynamic innovation system. The policy document “the innovation letter” (de innovatiebrief) presents the prime policy initiatives to support innovation in the Netherlands:

- *improvement of climate for innovation*, by fiscal stimulation of the R&D activities, by supporting cooperation in the field R&D and by educating and training technology-oriented workforce (“?-plan ß/techniek”).
- *More innovative companies*, by supporting innovative technology oriented start-ups, unleashing the innovative potential of small and medium-sized enterprises and by attracting foreign knowledge intensive industries to The Netherlands
- *focus on specific areas* in which Netherlands is able to compete globally, by stimulating R&D in particular areas, connect with international clusters of knowledge development.

In its recently formulated industrial policy (de industriebrief) the lack of interaction between public research and Dutch industry is recognised and specific policy actions are announced to address this.

Hence both the “innovatiebrief” and the “industriebrief” see it as a major objective for the next few years to bring interaction between industries, universities and research institutes on a higher level and on an international level. Because of its size, location and knowledge intensity ESTEC presents a unique opportunity to Dutch industry and public research for this desired cooperation and interaction, of benefit to all involved. Tapping into the knowledge of ESTEC potentially provides Dutch industry with a competitive advantage.

3 ESTEC'S KNOWLEDGE IS SIZABLE AND NOT RESTRICTED TO SPACE

3.1 ESA spends substantial technology related budgets through ESTEC

The space systems of ESA are built under 10 major programme lines (see exhibit 4) either under the ESA mandatory programme (16% of budget) or under the optional programme (remaining 84%). The ESA budget to finance these programmes amounted to M€ 2893 in 2004 (payments). Except for launchers, nearly all ESA projects are managed by ESTEC as a result of which ESTEC controls well over M€ 1600 p.a.

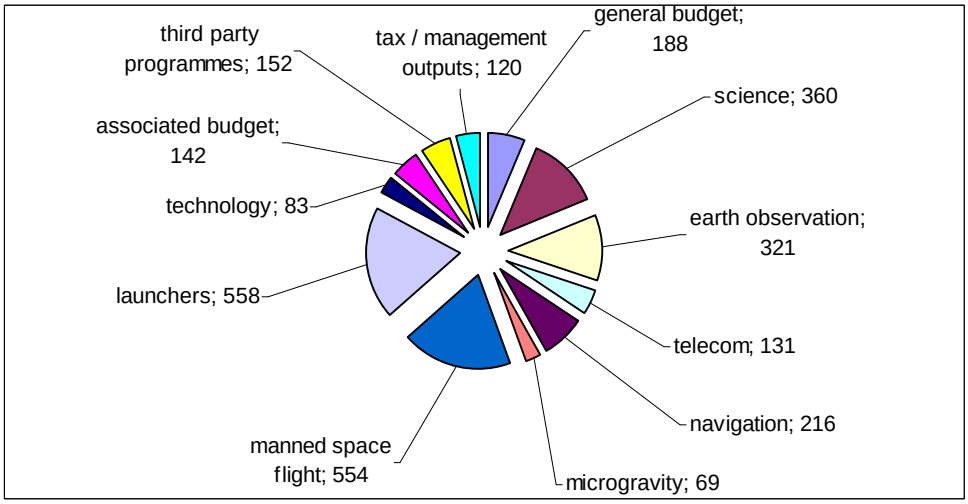

Exhibit 4, expenditures ESA in 2004 (M€)

A significant part of ESA's expenditure is spent on research and technology development: M€ 212[2], 6% of its budget. Most of this R&D is managed by ESTEC in the Netherlands. The programmes that involve R&D components are shown in exhibit 5.

[2] ESTMP, figure 11

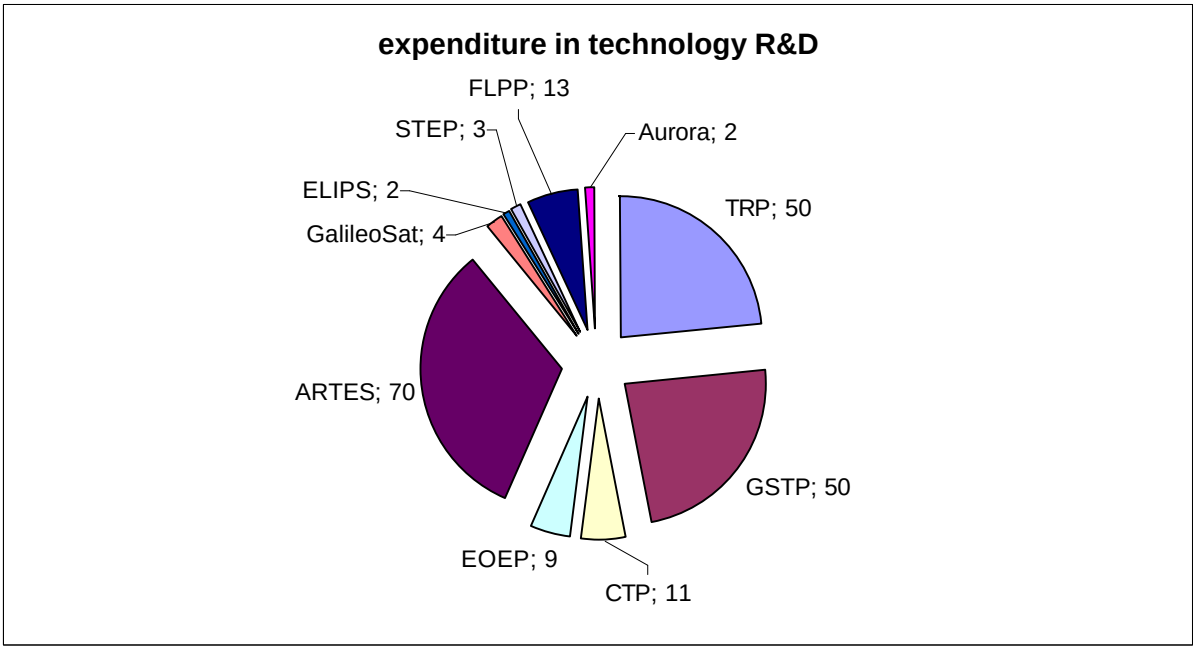

exhibit 5, annual expenditure on technology stimulation in ESA programmes (M€, 2002-2004)[3]

Table 1 lists short descriptions of these R&D programmes.

TRP	Basic technology research programme: backbone of ESA's innovative efforts
GSTP	General support technology programme: pre-development&qualification of technologies
CTP	Core technology programme: aimed at achieving a higher level of technological maturity
EOEP	Earth observation envelope programme: R&D focused on sensor technologies and algorithms
ARTES	Advanced Research in Telecommunication systems
GalileoSat	This programme contains some user equipment and application developments
ELIPS	Research in the area of life and physical science & applications for ISS exploitation
STEP	Human space flight studies, technology and evolution preparation programme aimed at ISS
FLPP	Future launchers preparatory programme: aimed at next generation launchers
Aurora	Set to pave the way for human exploration of the Moon, Mars and asteroids

table 1, summary of ESA programmes with an R&D component

3.2 ESTEC is one of the largest knowledge developers in the Netherlands

Total employment at ESTEC in May 2005 amounted to 2010 people, consisting of permanent staff and contractors.

[3] European space technology master plan, table 1, par. 2.1.2

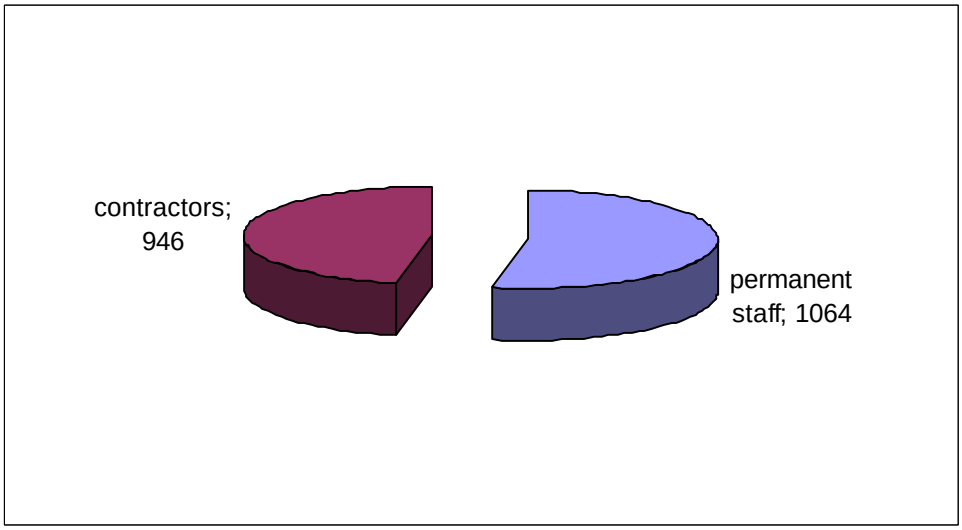

exhibit 6, permanent staff and contractors at ESTEC[4]

The majority of the workforce of ESTEC is highly educated. At present, of the total permanent staff of 1064 persons, 933 are A-grade[5]. Of these, approximately 800 are scientist or engineer. Also the majority of contractors is highly educated. In absence of accurate figures it is estimated that some 400 work as scientist/engineer, bringing the total number of scientists/engineers at ESTEC to approximately 1200.

Based on 2002 company data of technology-intensive industries in The Netherlands, the most recent data available from Statistics Netherlands (CBS), this number makes ESTEC rank about the 6th, i.e. among the majors.

3.3 ESTEC's knowledge portfolio in line with Dutch high tech industry

Most of the technologies of ESTEC's technology-portfolio are quite common for hightech industries, as can be deduced from the organisational structure of ESTEC shown in exhibit 7.

[4] may 2005, excluding 88 young graduates and 21 internal research fellows

[5] A-grades generally have an academic background

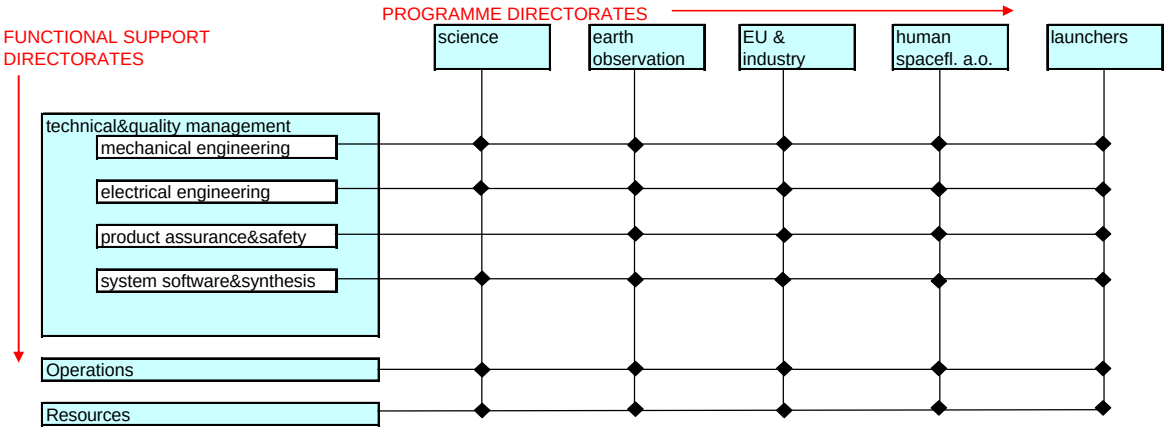

exhibit 7, matrix structure of ESA / ESTEC

Particularly the technical and quality department makes up for a lot of the ESTEC staff. Similar organisation and activities are common for many high tech industries. However what does distinguish technology at ESTEC from other industries is

- the high complexity of the systems for space;
- the fact that space applications require a very high standard of quality and reliability;
- The small series that are needed, making the final products very expensive.

The complexity and the high standards make that space industry is an excellent area for practice for students and a learning environment for industries that work for ESTEC.

3.4 ESTEC is oriented towards an open innovation process

ESTEC is in essence an R&D-organisation. ESTEC concentrates on defining a mission, awarding contracts, project management and testing. Implementation of research and technology development is mostly done by industry. So by nature, ESTEC must do business with industry, universities and research organisations.

Recently ESTEC has reinforced its policy to be more transparent to the professional public. The visibilty of the activities and results should be increased among industry, users, decision makers and the public at large. Important elements of this policy are:

- to increase the use of the ESTEC laboratories by non-ESA organisations;
- the establishment of the Erasmus User Centre that, amongst other functions, links ESTEC with the ISS user community at large and makes it aware of the possibilities of the ISS and microgravity, creates a tangible interest with them and provides tailor-made advice to users. More than any other part of ESTEC the Erasmus User Centre is the appealing face of ESTEC in which stakeholders can get a good impression of the products and technologies ESTEC is developing.

- To reinforce the exchange of staff personnel with external institutions and organisations in the space sector as well as in the non-space sector

3.5 In changing environment[6], strategic importance of ESTEC activities is high

ESTEC, as a part of ESA, has a very wide range of activities that offers a lot of opportunities for industry. It is one of the few space agencies world wide to combine the responsibility for:

- basic activities, required to develop and maintain access to space, the technology base, industrial capabilities, ground facilities;
- inspirational activities: science (earth, space, life and physical sciences), and human and automatic exploration;
- utilitarian activities: developing space systems to support public services (meteorology, environment, disaster management, education, energy, agriculture etc.) and commercial offerings (telecom, navigation and imagery) for the benefit of citizens.

ESA/ESTEC will in the future have to adapt its activities to the major changes that are currently taking place. At a global level the major changes discernible at present include the overhaul of the American space policy and the increasing involvement in space of large and fastgrowing economies of particularly India and China . At a European level major drivers of change are the enlargement of the European Union, expansion of the competences of the European commission in the field of space, the investments of the European commission with respect to working towards its Lisbon goal (stepping up R&D), a common foreign and security policy and the restructuring of the European space industry.

These changes present significant opportunities for ESA as well as industry. In 2003 ESA launched its Agenda 2007. Its principal objectives are:

- to increase the volume of total ESA activities by 30 percent in 2007, jointly with the European Commission;
- to increase the inspirational activities, science and exploration;
- to improve the benefits of ESA technology programmes
    - o by improving the competitiveness of the European satellite industry
    - o by implementing a plan for innovation, strategic technology and preparation for the future. ESA must provide the bedrock on which Europe can build its future space missions.
- To establish an education programme, able to attract the best people to space development.

[6] agenda 2007, by ESA director General

All these developments and objectives show that the space scene in general and ESA in particular are in a constant process of change and renewal that holds many opportunities, particularly for The Netherlands as the homebase of ESTEC.

4 DUTCH SPACE CLUSTER: TOP CLASS SCIENCE AND LARGE ECONOMIC SIGNIFICANCE[7]

The Dutch space cluster is relatively well developed. The scientific work of Dutch academic institutes is renowned in the world, widely acknowledged to be of impressive quality and quantity especially for a small country. Turn over of the Dutch space industry, about a third of which directly related to ESA/ESTEC, is equally significant. Although exact figures are not available, it is estimated to be close to B€2, with many jobs, directly or indirectly dependant on space technology and –activities.
The value chain of space technology can be subdivided in an upstream and a downstream segment, each of which will be elaborated in more detail in the following.

4.1 The upstream segment: subcontractors and strong research groups

The upstream segment consists of organisations that are directly involved in the production of the hardware and software needed for space missions themselves: launchers, satellites, ground stations and so on. The Netherlands has some 40 industries and institutions that are involved in this, employing some 1100 people and with an annual turnover of approximately M€ 170. The major Dutch Industries are Dutch Space and Stork. The major Dutch institutions are NLR, TNO-TPD, TUD and SRON.

In this paragraph illustrative descriptions of some Dutch upstream parties with ESTEC relations are provided to give an impression of the sector: Dutch Space as the largest Dutch industry in the commercial space sector, SRON as the national centre of expertise for the development and exploitation of satellite payload instruments, Bioclear as a young industry having diversified to working for ESTEC and Bradford Engineering as a dedicated equipment supplier.

Illustration of a major space industry: Dutch Space

Dutch Space (DS) is the Dutch company with the largest turn over at ESTEC. Its annual turn over amounts to M€ 60, of which 90% is attributed to space. 70% of total turnover is related to ESTEC, either as a prime contractor (10%) or as a subcontractor (60%). In the longer term DS wants to diversify to other sectors, in particular the defence industry. DS produces:
- Solar arrays;
- Structures and mechanical systems, with the main product being engineering of Ariane 5 engine frame;
- Advanced systems and engineering, with projects such as Herschel / Planck attitude control, European Robotic Arm (ERA), ConeXpress payload adaptor and the ATV-ISS docking simulator Eurosim.

[7] ruimtevaart foto

Illustration Academic institution: National Institute for Space Research (SRON)

As a part of the Netherlands Organization for Scientific Research (NWO) SRON is the national centre of expertise for the development and exploitation of satellite instruments in astrophysics and Earth system science. It acts as the Dutch national agency for space research.

SRON is credited for developing and producing excellent payloads. It employs about 250 people at Utrecht and Groningen together. About 70% are academically trained. The divisions for high and low energy astrophysics and earth system sciences set the course for research strategy. These divisions are complemented by R&D divisions for sensor research & technology and engineering.

SRON maintains excellent contacts with ESTEC on all levels, mainly enabled by its proximity to ESTEC. This is demonstrated by agreements to exchange personnel, both temporarily (refresh knowledge, experience with hands-on R&D) as well as on a permanent basis (better carreer prospects in another organisation). Due to its well developed contacts, the influence of SRON on the ESA programmes tends to be well above average. For example in the Scientific Programme, the relative influence of The Netherlands is comparable with the top 3 in this area, being Italy, France and Spain.
Also the well developed contacts allow SRON technicians to obtain easy access to specific test equipment, e.g. electron microscopy for ASIC development.

Illustration Non core space industry: Bioclear

Bioclear is a young, highly specialised developer of environmental and sustainable biotechnology, with a staff of 23 people, most highly educated. Its main product is biological clean-up technology for soil remediation. Over the years Bioclear managed to get ESTEC contracts for biological air filters and, later, for quantitative detection and monitoring methods based on DNA techniques to determine the presence of undesirable micro-organisms in airfilters. The ESTEC work enabled Bioclear to set up a much larger department that uses the technology in other markets such as the agricultural sector and the soil remediation sector. Hence Bioclear is able to create leverage from its activities at ESTEC. This is important because the products and technologies it developed in the past are losing their competitiveness

Illustration Dedicated equipment supplier: Bradford Engineering

Currently grown to a company employing 70 people, Bradford was founded in 1984 as a manufacturer of high quality instruments for nuclear power plants. In the period following the Chernobyl disaster this was a very difficult market. At about the same time the company was able through ESA to win several contracts. The first major success was the USML-1 glove box which went into space in 1992. As a result of the contracts with ESTEC and other Space agencies (NASA,

JAXA etc), the company developed into a supplier of subsystems. Prime examples of the latter are the glove boxes destined for use in ISS, i.e. ISS Microgravity Science Glove Box, Life Science Glove Box, Biological Glove Box.

A spin off has been created by applying the sterilisation process for equipment inside glove boxes for space use, for medical purposes. Particularly dentists have shown interest in this sterilisation technology as a promising solution for the serious issues they still face in cleaning their instruments thoroughly. Other medical applications are envisaged.

4.2 The downstream segment: diversity with significant start-up contribution

The downstream segment consists of all industries that directly or indirectly use the space hardware for commercial purposes (use operators of satellites, the value adders, the services sector) or that supply goods and services to these industries. In this segment, there have been quite a few start-ups over the recent years.

This downstream segment can be subdivided in five themes:

1. Telecommunication: in this field several Dutch SatCom operators are active such as New Skies Satellites and Xantic. Total turnover in the Netherlands in this field is estimated at B€ 1, which is however unlinked to ESA/ESTEC.
2. Microgravity: Dutch organisations that are involved in this field are for example he AMC, TNO, Bradford, Pharmacia Biotech and Shell Research.
3. Navigation: many Dutch organisations are active in this field such as Fugro, Thales, HITT, TomTom as well as small start-ups like Ursa Minor. Turnover of these companies in this particular field is estimated at several hundreds of millions Euro, only the direct Galileo related part linkable to ESA/ESTEC.
4. Earth observation: an estimated 40 Dutch value-adders operate in this field. Examples are Argoss, Carthago, Imagem and SarVision. The commercial interests vary widely (management of infrastructure, ground research). Total turnover is estimated at M€ 200.
5. Others: this includes many industries that provide goods and services to the previous four fields. Examples are SKF, De Koningh, Sumipro and HAWO.

In this paragraph a short description is given of a member of the Dutch downstream space cluster: SarVision as an earth observation end user / start-up.

Illustration Earth Observation End User / Start-up: SarVision

With currently 6 employees, SarVision develops monitoring products and services based on radar satellite data. Notable examples include development of environmental security services and carbon offset trading schemes in collaboration with DGIS and monitoring of tropical rainforest in Indonesia to prevent illegal logging, a service carried out by a local daughter company. In addition and in cooperation with ESTEC, SarVision develops and maintains test sites for radar data calibration purposes, consisting of various areas with known properties, e.g. flat and homogeneous soils as well as areas with corner reflectors.

SarVision was founded 5 years ago as a spin off of the Dutch university of Wageningen in response to a specific request of the Indonesian government to supply such monitoring services. The university of Wageningen became involved in Earth observation when it was asked to develop and set-up a dedicated test site in Flevoland, as a preparation of the first radar satellite mission of ESA, ERS-1 launched in 1991. Proximity to ESTEC was an important factor in this project. This cooperation still continues with projects for successor satellites ERS-2 and ENVISAT.

SarVision in The Netherlands expects a gradual future growth because of similar needs in, and services requests from, South America and Africa. For eventual service operation and provision, local affiliates will be established following the Indonesian model.

5 ESTEC'S INTERACTION WITH SPACE CLUSTER: SUBSTANTIAL, ROOM FOR IMPROVEMENT

ESTEC interacts in various ways with each of the stakeholders in The Netherlands. The following main mechanisms of knowledge transfer have been identified:

- Job mobility;
- Outsourcing of research and technology development;
- Use of ESTEC's test facilities;
- Conferences, workshops and industry briefings;
- Start-up / Spin off support (Incubator, DTTP);
- Joint science activities;
- Erasmus User Centre;
- Use of ISS facilities;
- Education.

In the following paragraphs these mechanisms of knowledge exchange between ESTEC and each of the Dutch stakeholders will be evaluated in detail.

5.1 Limited mobility of knowledge workers to Dutch economy

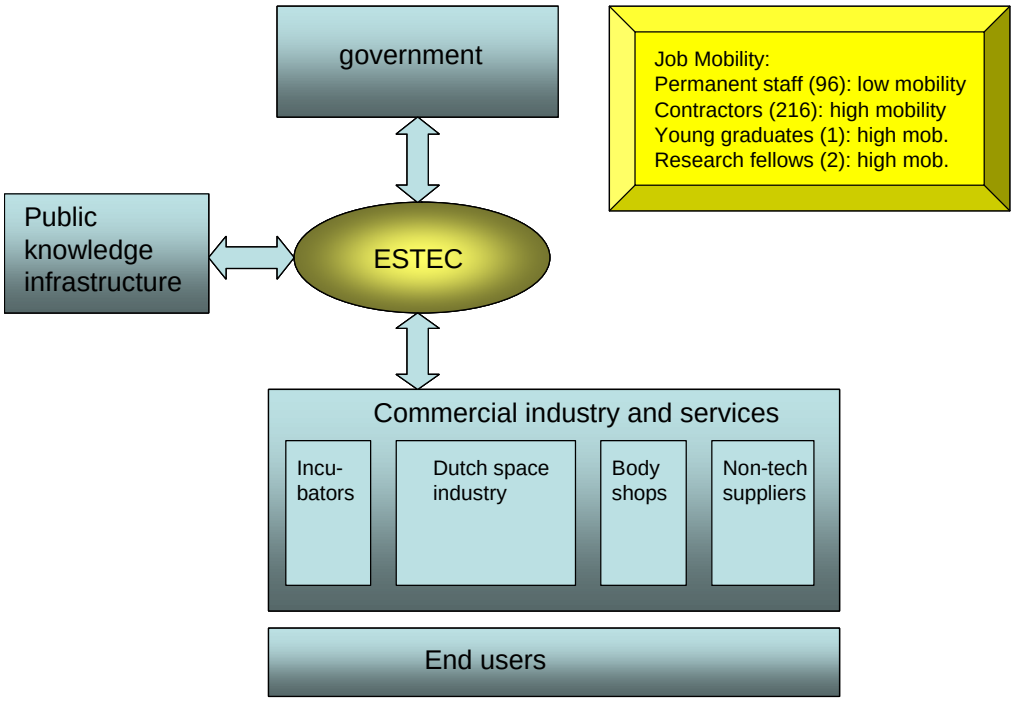

exhibit 8, key facts job mobility

In general, job mobility between knowledge intensive organisations is among the most effective mechanisms of knowledge exchange. The knowledge and experience that people collect in one working environment is used at the next employer. In the case of ESTEC, scientists and engineers obtain a thorough understanding of the knowledge and the processes at ESTEC that can prove to be very valuable to other Dutch organisations in the space cluster. More general skills like programme management and systems engineering will also be of relevance outside the space cluster.

Knowledge workers at ESTEC can be subdivided in the following categories:

- permanent staff;
- contractors;
- young graduates (contract of 1 or 2 years);
- research fellows (Postdoc, contract for 1 or 2 years);
- stagiairs (undergraduate, 6 months+);
- visting scientists (senior scientists on sabatical leave, 9-12 months)[8].

Permanent ESTEC staff in general has a negligible job mobility. For vacancies there is an enormous competition (approximately 1700 applications / year). By analogy with the general situation, no significant mobility of Dutch permanent staff at ESTEC to Dutch economy occurs. The small number of the Dutch knowledge-intensive workforce (only 55 out of 98 have an A-grade, thus have a university background) is one of the factors that contribute to the small significance of this mode of knowledge exchange.

Contractors by nature have a higher job mobility than permanent staff. After leaving ESTEC, they will carry out assignments elsewhere in industry. About 30% of contractors have the Dutch nationality. This reflects the Dutch financial advantage, with expats being more expensive. Job mobility of Dutch contractors is higher than permanent staff, but not impressive. Only some 50% of Dutch contractors have spent less than 5 years at ESTEC.

[8] *Scheme under development*

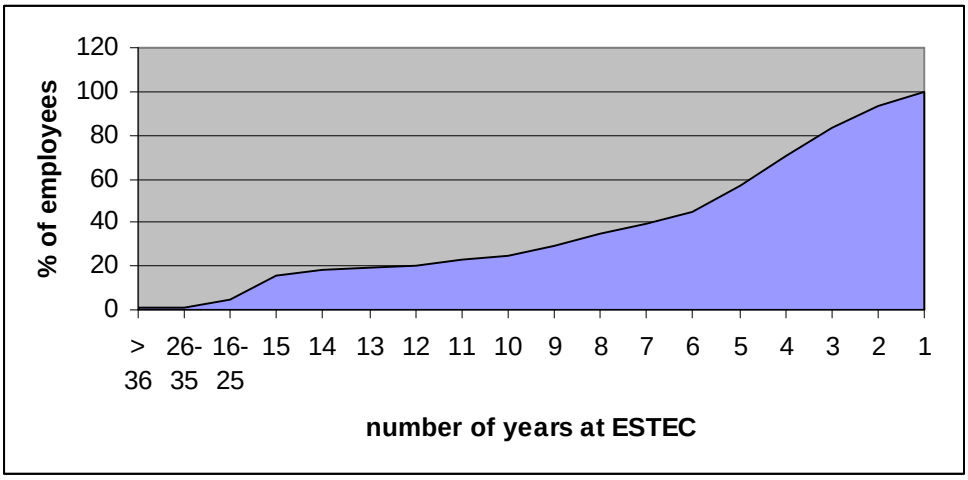

exhibit 9, duration contract Dutch contractors

Young graduates are temporary staff that have just graduated and get a contract of one or two years during which they are able to gather experience that they use in their home country after their return. In total there are 88 young graduates at ESTEC. By definition they have a high job mobility, although sometimes young graduates end up at ESTEC instead of elsewhere in industry. Dutch Young Graduates also have a high job mobility but there usually are not many. At the moment there is only one Dutch young graduate.
Several countries (notably Spain) have additional, nationally funded, programmes for young graduates at ESTEC and in this way are able to create an additional flow of knowledge to their national industries. The Netherlands do not have a similar scheme.

Research Fellows are scientists holding a PhD that are temporarily contracted by ESTEC to research scientific topics as preparation for an academic career. At present there are 37 Research Fellows which can be divided in two categories:

- Internal research fellows, scientists working at ESTEC on a scientific domain, on a two-year contract. ESTEC counts 21 internal research fellows.
- External research fellows, scientists working at a university, but paid by ESTEC. At present there are 16 external research fellows.

Research fellows by definition have a high job mobility. At present there is one Dutch external research fellow; a Dutch internal research fellowship just ended recently.

Visiting Scientists will be offered a scheme in the near future. It is based on the idea to offer more senior scientists a research oriented stay during their sabbatical (9-12 months), while still on the university pay roll. However, since this scheme is not yet on line, it has no impact yet on knowledge exchange.

Stagiairs (temporary staff, not graduated) get a contract of approximately 6 months during their study, during which they are able to obtain experience at ESTEC. By definition, they have a high job mobility. At present there are 64 stagiairs at ESTEC, 7 of which have the Dutch nationality (11%). The high number of Dutch stagiairs can be attributed to the proximity of ESTEC to Dutch Universities. For example Wubbo Ockels, in the period that he was a professor at the University of Delft at the ESA-seat, delivered some 20 engineers, all of which did their stage at ESTEC.

Options to improve the impact of job mobility

- Regarding permanent staff it is a major challenge to embed mechanisms in the ESTEC organisation for the exchange of knowledge workers with the European (and Dutch) universities and industry, in the space sector as well as the non-space sector. It provides the benefit of mixing company cultures and intensifies knowledge exchange.
- Regarding the temporary staff, particularly the numbers of Dutch Young Graduates and Research Fellows could be increased. For Young Graduates, it could be considered to implement similar schemes as Portugal and Spain have, both countries providing additional funding to allow Young Graduates. Although the relative share of Dutch Research Fellows is not bad, the absolute impact is limited. The best way to improve this is likely through ESA by increasing the total number of available Research Fellow positions.

5.2 Dutch space industry benefits well from outsourced work, few fast growers

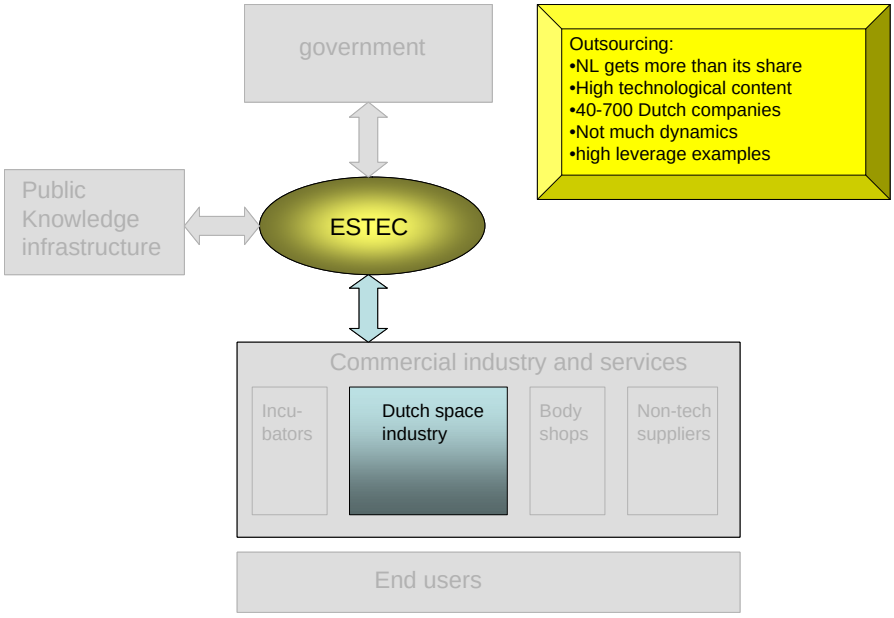

exhibit 10, key facts outsourcing to Dutch industry

The Dutch space sector gets more than its share of the ESA outsourcing. Exhibit 11 shows that in the period 2000-2004 the total value of ESTEC spending (total return) exceeded the Dutch contribution with 261 M€ (weighed and unweighed return minus juste retour) and that the value of contracts to Dutch industry (weighed return) exceeded the Dutch contribution with M€ 24.

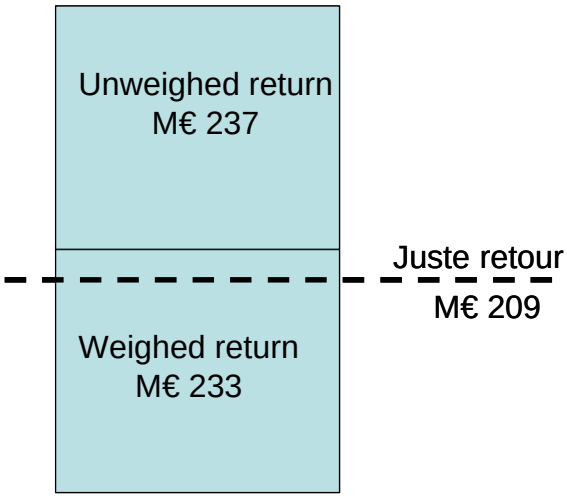

exhibit 11, financial figures outsourcing to dutch industry (total amounts 2000-2004)

A very large share of this work leads to substantial knowledge exchange with Dutch economy:

- Approximately half of the spendings (weighed return) concern contracts with a high technological content, relevant for the Dutch knowledge-based economy.
- Much of the remaining half of the spendings (unweighed return) concerns contracts for outsourcing to on-site and off site contractors (body shops). These contractors are likely to be used in other jobs after completing their contracts at ESTEC and hence are also very relevant for the Dutch knowledge society

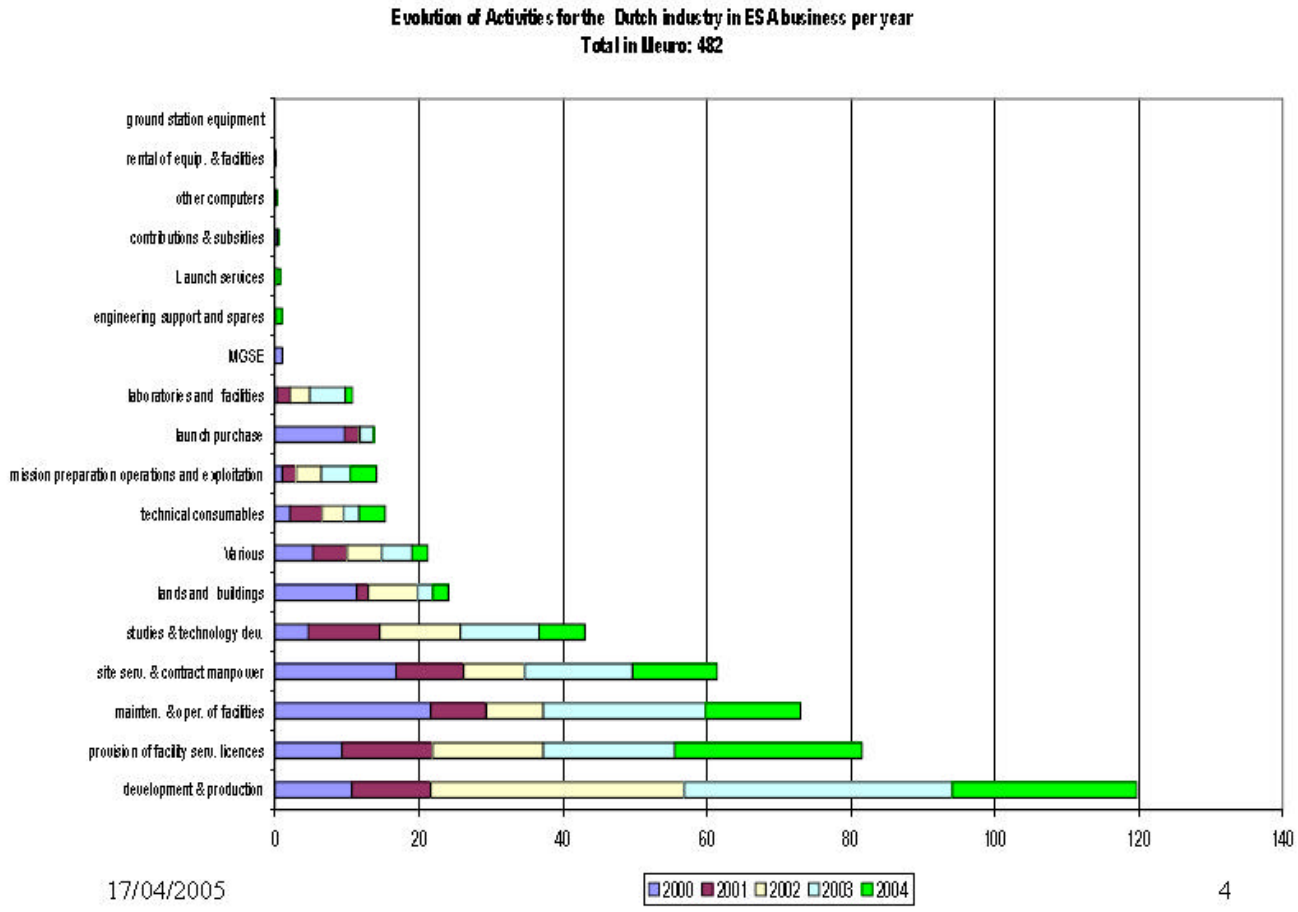

exhibit 12, Most contracts concern Development&production

Exhibit 12 shows that

- most of the Dutch contracts (weighed return) have a high technological value. The largest expenditure goes to development and production of (sub-)systems for ESTEC. The 5th largest category involves studies and technology development.
- But as can be expected there is also a significant amount of work that is non-technological. The 2nd, 3rd and 4th largest categories relate to the maintenance and operation of the ESTEC site.

The contracts for ESTEC are carried out by a wide group of Dutch firms. The EMITS-database that contains all bidders counts approximately 700 Dutch firms. However most of the work is done by a relatively small group of some 40 Dutch companies that are well established in the upstream space sector. The firms engaged in work with a high technological content (weighing factor = 1) with the largest contracts are shown in the following graph.

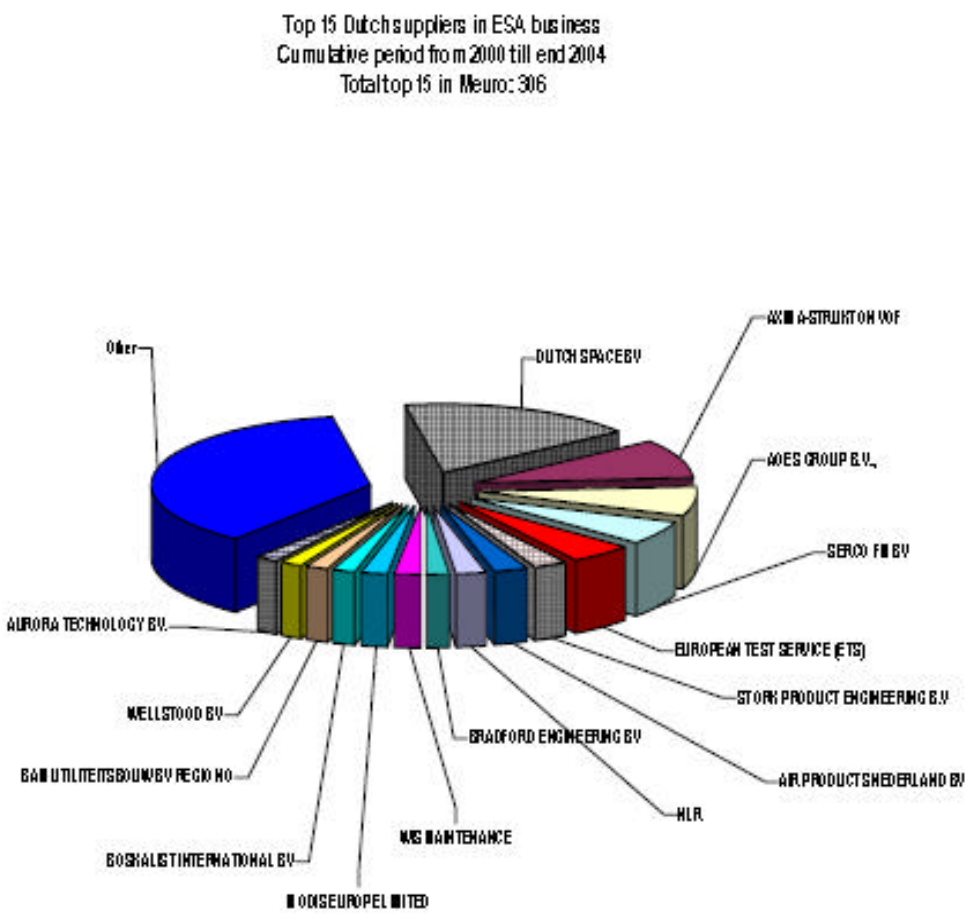

exhibit 13, Dutch suppliers of ESTEC with a large ESTEC-turnover

Under the large Dutch suppliers we find

- Industrial suppliers such as Dutch Space, Stork, Bradford, NLR
- Manpower suppliers such as Wellstood, Aurora, AEM, SERCO (software maintenance), AOES-group
- ETS: the commerical operator of the ESTEC test facilities
- Construction companies such as BAM utiliteitsbouw, BosKalis, Axima Structon

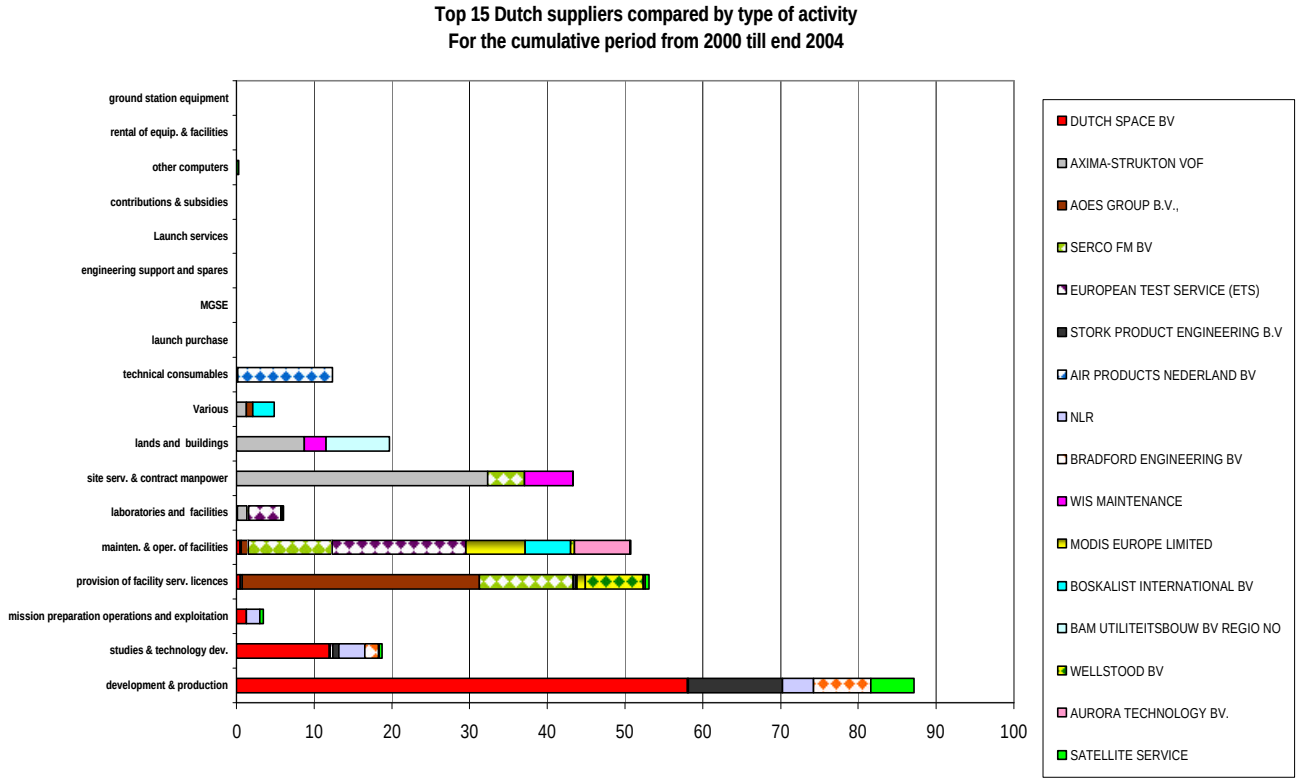

exhibit 14, Knowledge-intensive work done by Dutch space and group of smaller companies

Exhibit 14 demonstrates that the knowledge-intensive contracts are dominated by Dutch space and that there is a small group of other Dutch industries that also have sizeable turnover.

The Dutch organisations that are most involved in ESTEC activities are:

- Development and production: Dutch Space, Stork Product Engineering, Bradford, NLR
- Studies & technology development: Dutch Space, Bradford, NLRA, Cosine;

There are a few Dutch newcomers in the upstream space industry. Some examples: *Bioclear* made its inroads in the beginning of the Nineties in the field of air filters and now has a strong position. *Delta-utec* started in the late Nineties with its tether technology but still has to carve out its competitive niche. Overall it seems to be quite difficult for any small company, hence also for Dutch companies, to become part of the core space industry. *Ursa Minor Space & Navigation* is a young and innovative company that specializes in localization and (satellite) navigation. Ursa Minor has experience with *GPS*, *WAAS* and *EGNOS* and designs state of the art navigation solutions. With Cosine (cf Showcase Cosine) as the notable exception, these newcomers in the upstream Dutch space sector are not really fast growing.

Showcase Fastgrowing Newcomer: Cosine

After working for 2 years in research at ESTEC through a contractor, Mr Marco Beijersbergen in 1998 established Cosine, a small flexible research company with a laboratory to support ESTEC studies, at the time with 3 people and currently having grown to a staff of 12.

Cosine carries out research for ESTEC and strives for close cooperation. ESTEC keeps a good grip on the R&D activities and –choices that it often does not have when it outsources R&D to large organisations that are not located close to ESTEC. The ever increasing administrative overhead pressure on ESTEC staff, necessitates more and more that technology development is outsourced.

Cosine supports R&D and technological development at the borderline of physics, optics and IT. A typical example project would be “technology spin in”: use of a known technology from other markets for space application. Cosine coordinates the activities of the component manufacturer, who in general has no prior experience in space applications, and the academic institute taking care of the space dedicated analysis of the deliverables.

In the space research context, Cosine clients include SRON, Dutch Space, TNO and Kayser-Threde (D). The non-space market has not actively been explored yet, due to the attractivenes of the space market, both intellectually and commercially as ESTEC outsources R&D at commercial tariffs (whereas the Netherlands government only acts as co-financer, and large technology driven industries like Shell or Philips mostly outsource basic research to government institutes), as well as the intention to control growth. However, aAs a spin off of its activities for ESTEC, Cosine has carried out a software management project for Vodaphone. Several non-space projects in developing vision systems are being set up at the moment.

Showcase Bodyshop with non-space origins and non-space clients: Plancon

Plancon provides schedule and cost control services to ESTEC as well as clients in the oil & gas sector, waste incinerators and Schiphol.

Having its origins in the oil & gas sector, Plancon started working for ESTEC in 1988 as subcontractor of the producer of Artemis, a mainframe application for schedule control, to carry out implementation at ESTEC. In 1989, Plancon was contracted directly by ESTEC to continue the implementation. Also in 1989, Plancon started with supplying schedule control capacity to ESTEC for a variety of D/SCI projects, which under various contracts it has done to this very day.

The two contracts ran in parallel until 2000, involving on average 14 FTE then accounting for about 35% of Plancon’s turnover making ESTEC its number one client. In 2000 the PMIS contract (project Management Information System) was lost. The schedule capacity contracted was once more won,

involving on average 8 FTE yet now accounting for about 50% of Plancon's turnover due to less activity outside ESTEC.

The quality of the ESTEC-Plancon cooperation has always been excellent. The ESA project leaders based in ESTEC, having the final responsibility and doing cost based management, are supported by a Plancon supplied schedule controller. Together they run the project and as a consequence the Plancon contractor is a fully integrated team member, having access to all information and flying of to participants sites, e.g. Toulouse, or staying at launch sites, e.g. Baikonur, with the team when appropriate.

Options to improve the impact of outsourcing

The Netherlands gets more than its share of outsourcing (see also exhibit 11). In view of the "juste retour" this share cannot be augmented without compensation. However focus could be put on the leverage of outsourcing. Several of the Dutch industries (e.g. bioclear) have been able to use the knowledge obtained through ESTEC contracts in non-space activities. In these cases ESTEC enabled them to create new business. From an economical point of view this type of participation is preferrable and should be promoted.

5.3 Dutch industry does not use ESTEC test facilities to their potential

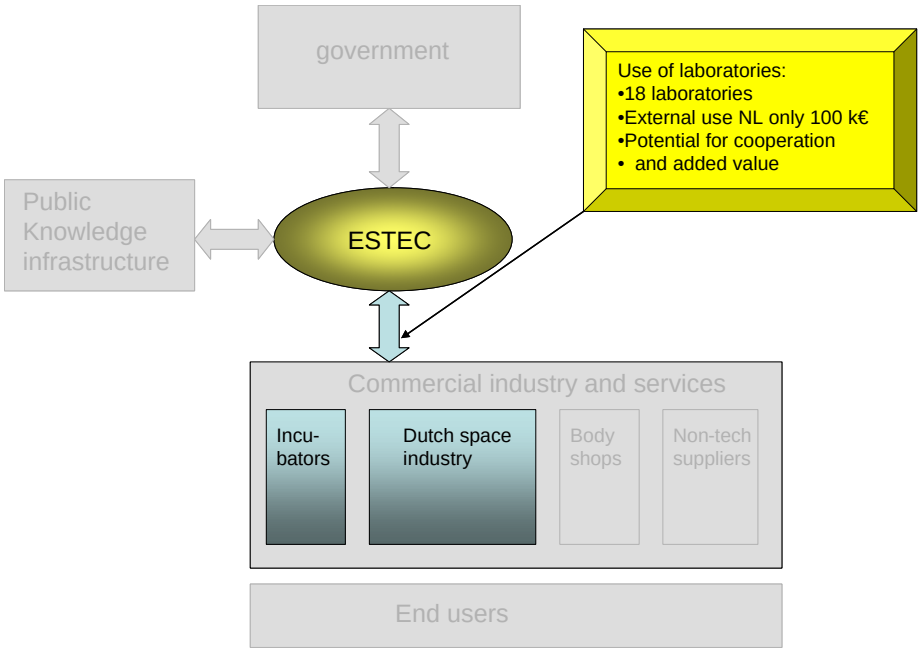

exhibit 15, key facts regarding external use of ESTEC's test facilities

Test facilities and laboratories can play a significant role in knowledge transfer and can have a large added value to Dutch industry. The test facilities at ESTEC have state-of-the-art equipment. The use itself creates contact between ESTEC and the user, which is also very important for the transfer of non-tacit knowledge. ESTEC's present strategy is to promote the use of its test facilities in general by commercial industry, particularly SMEs.

ESTEC avails of two types of test facilities, i.e. smaller and department specific laboratories as well as large scale and more general test facilities.

Smaller laboratories of which there are 17 at ESTEC, cf. table 2 often are an intrinsic part of the departments. Annually the cost of the laboratories (operational costs and replacement investments) amount to M€ 30.

Engineering laboratories

	compact antenna test range
	compact payload test range
	electromagnetics and space environment computing facility
	software and simulation laboratory
	Avionics control systems
	avionics data systems
	payload systems
	Power and solar generator laboratory
	European space battery test centre
	concurrent design facility
	ESA propulsion laboratory
	mechanical systems laboratory (including structure and thermal computing facility)
	automation and robotics
	Opto and opto electronics and sub m m laboratory

materials and processors laboratories

	materials and processors laboratory
	components laboratory

microgravity laboratory

	microgravity laboratory

table 2, laboratories at ESTEC

The laboratories are also available for the start ups at the Incubator Centre. To what extent they are actually used by incubatees is not known. A survey carried out at the end of 2004 shows that the laboratories are used by third parties only to a very limited extent. In 2004 the technical support to Dutch companies had a value of roughly 100K€ invoicing.

ESTEC has some particular bottlenecks that prevent the use of laboratories by non-ESTEC organisations.

- ESTEC's own business comes first. Other business is only allowed if this does not interfere with ESTEC work.

- The use of laboratories, specifically when support is required, is perceived as expensive.

The laboratories however do constitute an opportunity for Dutch industry. Notably sharing of clean room facilities might prove to be a cost saving solution, as these facilities are very expensive to implement and generally have a very low utilisation grade, i.e. are not used to capacity, if reserved for only one organisation.

Illustration small laboratory facility: Concurrent Design Facility

The concurrent design facility has developed a system and methodology for concurrent design and engineering, based on a similar tool of NASA (JPL). The facility is suited for highly complex engineering jobs such as defining missions. The concurrent design methodology aims to integrate all of the varying expertise required for a complex project in terms of know-how, logistics and time pressure, to come to consistent product specification. This is implemented through interactive sessions using a common software tool that integrates all knowledge and results. Outcomes of such sessions are full system design and trade off reports including cost engineering.

Large scale test facilities are grouped into the ESTEC Test Centre, which is managed by contractor ETS.

ESTEC Test Centre
Large Space Simulator (LSS)
Large European Acoustic Facility (LEAF)
Multishaker (MSH)
Multi Axis Hydraulic Vibration System (HYDRA)
Large Electromagnetic Facility (Maxwell)

table 3, large test facilities at ESTEC

The Test Centre provides 5 separate test facilities, cf. table 3, for large structures, focused but not limited to perform environmental tests on satellites at system level. The vast majority of the tests are carried out for ESA programmes through a variety of international space industries. Examples of Dutch users are Dutch Space, Bradford Engineering and TNO.

Some 5% concerns non-space related tests, recent examples including German (in relation to Airbus, automotive industry) and Norwegian commercial clients. Thus far Dutch non-space industry has not been very active in this respect, attributed to non-awareness of the opportunities. Only recently the marketing efforts needed for this have been reinforced. For example together with the Automotive Technology Centre, Eindhoven, a network is being established for the use of ESTEC Test Centre facilities, and engineering laboratories for Dutch industries e.g. the Electro Magnetic Compatibility (EMC) facility for verifying automotive products. More or more general networks

might help to bring further change. Therefore, ETS has recently invited KIVI/NIRIA to promote the Test Centre's potential.

Showcase External Use of Test Facilities: NASA Solar Array tests in LSS

At the end of the 90's, the NASA Hubble Space Telescope project suffered from a perturbation of the telescope's stabilisation. Suspected cause were micro-vibrations generated by the thermal effect on the solar panels when passing from day to night and vice versa. In search for a solution, NASA needed to simulate and measure this phenomenon on the ground.

NASA turned to ESTEC to use the Test Centre's Large Space Simulator (LSS) as none of the facilities available in the United States could provide the required low levels of seismic stability. LSS however is equipped with a seismic table, i.e. a table attached through the wall of the vacuum chamber to a large seismic block, which dampens any vibrations generated by the surroundings. Thus, the measurable vibration level is of the order of 1/10000th of the gravitational acceleration, which does allow the type of sensitive measurements NASA needed to carry out.

In the summer of 2000 therefore, a large NASA team came to ESTEC to conduct a multi-week series of tests in LSS on a large solar array, specifically flown in by a dedicated transport plane. The cooperation between the American and European teams proved extremely fruitful. Thanks to LSS the tests were a full success, leading NASA to advertise on their web site that "world class Hubble space hardware were tested in the LSS world class facility at ESTEC, Noordwijk, The Netherlands".

Options to improve the impact of ESTEC test facilities

- Regarding the laboratories, some interviewees have suggested that the added value can be significantly improved by simplifying the procedures for SMEs.
- Regarding the ESTEC Test Centre, more and more general industry networks might be established to bring further change. ETS's recent invitation of KIVI/NIRIA to promote the Test Centre's potential, is a first step but should be backed up by other activities to bring this about.

5.4 Dutch space cluster well served by conferences, workshops, briefings

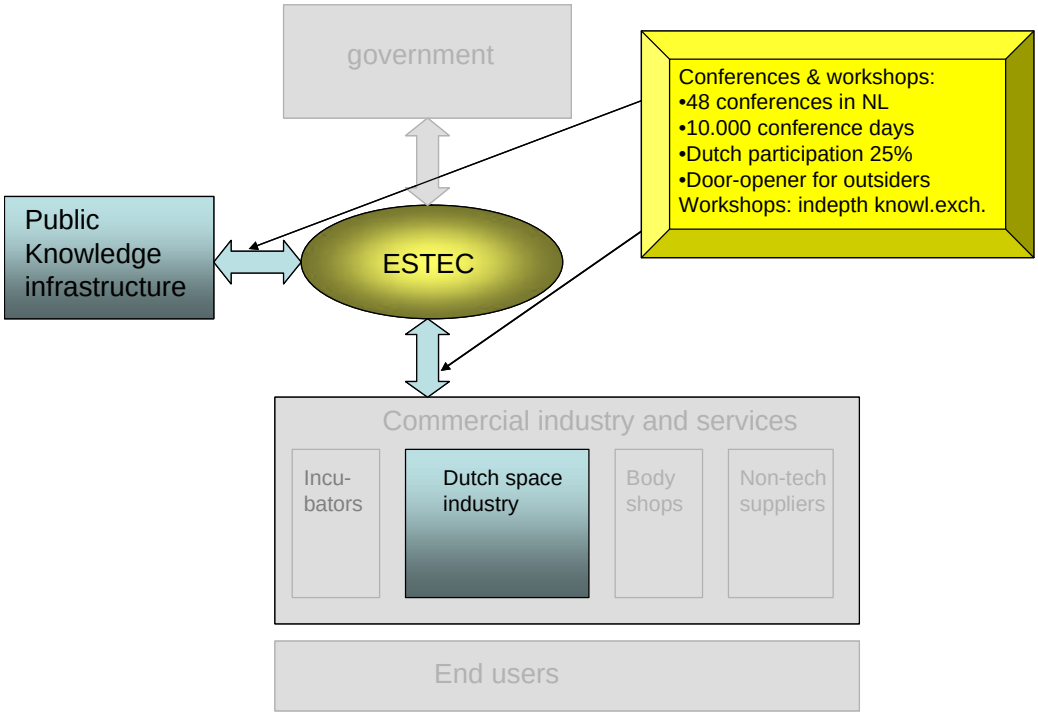

exhibit 16, key facts ESTEC's conferences, workshops and industry briefings

Conferences are regularly organised by many ESA departments. They often serve as a milestone at which a common understanding is obtained between ESTEC and the relevant stakeholders, particularly scientific ones, for the next three years.

Although workshops and conferences primarily target the technological and scientific community, they do also constitute an important tool for industries that do not regularly do business with ESTEC to establish personal contact and for getting a view on business opportunities. A good example of the use of the conferences is the Canadian company that participated in an earth observation conference: before the conference they had no business with ESTEC, after the conference they were able to get a market share of 11% at that department, despite the fact that this was much higher than Canada was entitled to with respect to geographical return.

In 2004 ESTEC organised a total of 73 conferences. The majority of these (48) were held at ESTEC, involving 9782 conference days. The Dutch participation at these conferences at ESTEC is very high: 25%. Likely the proximity of Dutch industry and knowledge infrastructure is the dominant factor in this. Also special arrangements made play a role that often are offered to students e.g.

Delft faculty for Aerospace to attend conferences at no conference fee. Dutch participation in the 24 ESTEC conferences abroad is lower but still relatively high (9%).

Industry briefings serve to inform industry of opportunities, well before the ITT's are announced in the official EMITS database. As a rule, the process is triggered by a request from / through a national delegation. A briefing for the industry of that specific country of origin is then organised and announced through the delegation, which in turn decides who to invite. Many countries, including The Netherlands, put in regular requests for these briefings as they have proven to be very efficient to involve the national industry.

5.5 Space Incubator&Technology Transfer Programme: potential to be realised

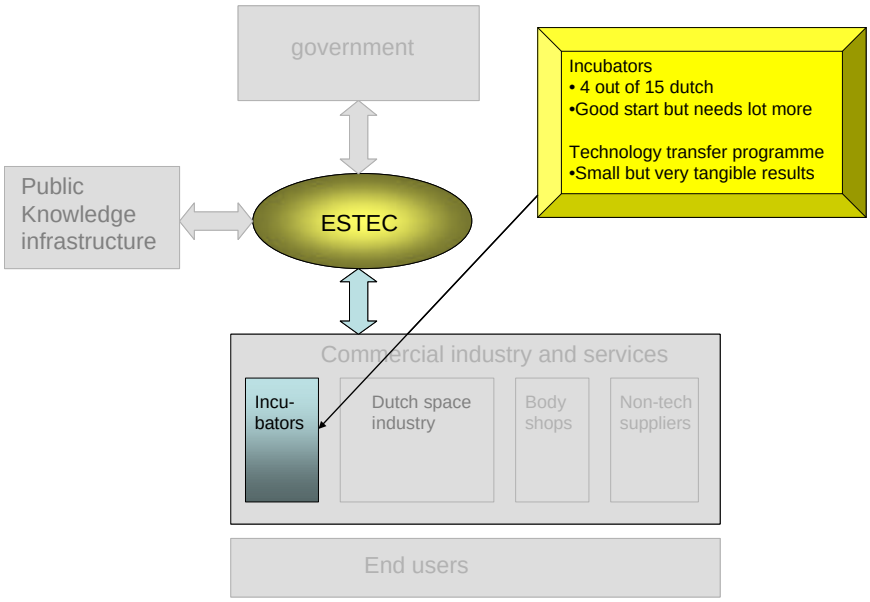

exhibit 17, key facts specific technology transfer initiatives ESTEC

The efforts of ESA/ESTEC to transfer its knowledge to Dutch organisations include:

- the establishment of the European Space Incubator (ESI)
- participipition in the Dutch Technology Transfer Programme (DTTP)

The European Space Incubator (ESI) established at ESTEC, and its associated network ESINET, is a recent initiative that started 18 months ago. € 50.000 is provided to proposals that are selected by a selection committee, chaired by ESTEC. The incubator not only finances spin outs of ESTEC (like Jaqar CDS, cf. Showcase Incubatee) but also finances ventures that link ESTEC technology to industry (like Bradford's ozoniser). The start-ups have access to ESTEC services and

expertise and also receive some management support. Sixty percent of funding is provided by the Ministry of Economic affairs. At the moment there are 15 incubatees:

- four Dutch
- three Portuguese
- one Italian
- three French
- two Belgians
- one UK
- one mixed.

The high percentage of Dutch incubatees is notable. Not all incubatees are located at the ESTEC site. ESTEC expects to have another 25 start ups by the end of 2005.

Showcase incubatee: Jaqar Concurrent Design Services

Jaqar CDS is a daughter company of Jaqar Space Engineering, a contractor established in 1999 by 2 Dutch former ESTEC young graduates, with a current staff of 4. Jaqar SE facilitates concurrent design sessions at ESTEC's Concurrent Design Facility (see Illustration laboratory: CDF) and manages as well as further develops the original ESTEC CD methodology under feed-back agreement with the CDF.

Jaqar CDS is set-up to commercialise the CD methodology outside the space industry, notably in oil & gas, ship building, construction, large infrastructure projects (transport, energy generation) etc. Its activities thus far have consisted of improving the robustness and user-friendliness of the software that incorporates the concurrent design methodology. The incubatee start capital is said to be indispensable for this software adaptation; without, there is essentially no marketable product. No clients have been landed yet, but promising negotiations are in progress. Jaqar CDS's aim is to grow to a staff of 7-10, to serve customers in at least 4 EU countries within the next 3 years by the end of 2007.

The incubator potential is estimated at 20 to 30 investments every year. It is anticipated that five of these will go bankrupt, five will return to their country, and and five will leave, which would still leave on the order of 15 survivors.

With a budget of M€ 3 the incubator at ESTEC is small compared to other well-known incubators. In view of the unique availability of space technology ESTEC's incubator would have deserved a significantly larger budget. However, despite the small size, ESTEC is putting much enthousiasm and effort into acquisition of incubatees. There now is a steady flow of ideas. It is also important to note that the incubator (together with DTTP, see below) has sparked off the thinking about commercial use of space technology, about the value of space technology.

The Dutch Technology Transfer Programme (DTTP) was initiated in 2000. It is based on an agreement between ESA, TNO and the Ministry of Economic Affairs that jointly set up a fund: DTTP.

The basic approach is that TNO actively searches for, and helps industry to use space related technology in other applications. In its first phase, the approach for finding and selecting projects was primarily “market pull”. The support, given by DTTP, is a subsidy of 50% for feasibility studies. If after a feasibility study support is needed for the implementation, TNO will assist in finding the appropriate funding from other sources, e.g. the TNO Co-financing Programme, Senter/Novem and/or EU Framework Programmes. In the first year TNO had to invest significant sums, engaged frequently with industry and also mobilised its own personnel in order to make them aware of the possibilities of DTTP. Only at the end of that year the results started coming. It was quite difficult to get started. At present the programme is in its second phase, lasting until 2008. Additional co-funding is obtained from NIVR, ASTRON, SRON and OCW. This co-funding changes in the approach slightly, because now - in addition to market pull - a technology push approach is required as well. The annual budget in the second phase amounts to K€450. Annually some five feasibility studies will be funded and some 2 implementation projects will be started. There are some successful examples:

- With the help of TNO, Dutch SME SmitsVonk is currently developing a new ignition system for energy plants. This development is based on a re-usable, acoustic ignition system for the future Ariane launchers. At present the company employs some 25 people. If these new application really takes off, the company might double in size;
- Telemetronics, a venture, started in Wageningen three years ago, has developed biometrical systems for use in space. The feasibility was investigated to convert their systems for application in animal research. If successful, the company, now still small, will become the market leader in this niche market and could grow to a size of several tens of employees.

Options to improve the impact of ESI

Although the incubator is still in its infancy and it is too early to make a judgment, serious doubts have been raised about the successrate of its incubatees. Several arguments have surfaced:

- Firstly the funding of the incubatees (50 K€ each) seems very small. In many cases this might be barely enough for analysis of feasibility, for the development of a business plan but not for a serious incubation. Funding of this magnitude might be better called a “pré-incubator”. For the actual incubation the funding is likely inadequate.
- Secondly, for the period after the incubation the funding appears to be uncertain to say the least and the relation between ESTEC and the incubatees is not very well defined. The path from an idea to a viable business is therefore not yet sufficiently covered by the ESTEC incubator initiative. We understand that at present, the possibilities are being investigated for additional funding that bridges the gap between the present funding of the incubatee and financing by commercial venture capitalists.

The impact of the ESTEC incubator could further be improved by choosing focus. It is advisable to concentrate the incubator on areas in which incubatees reinforce one another, e.g. materials technology, health care, etc.

5.6 ESTEC already well connected to the public knowledge infrastructure

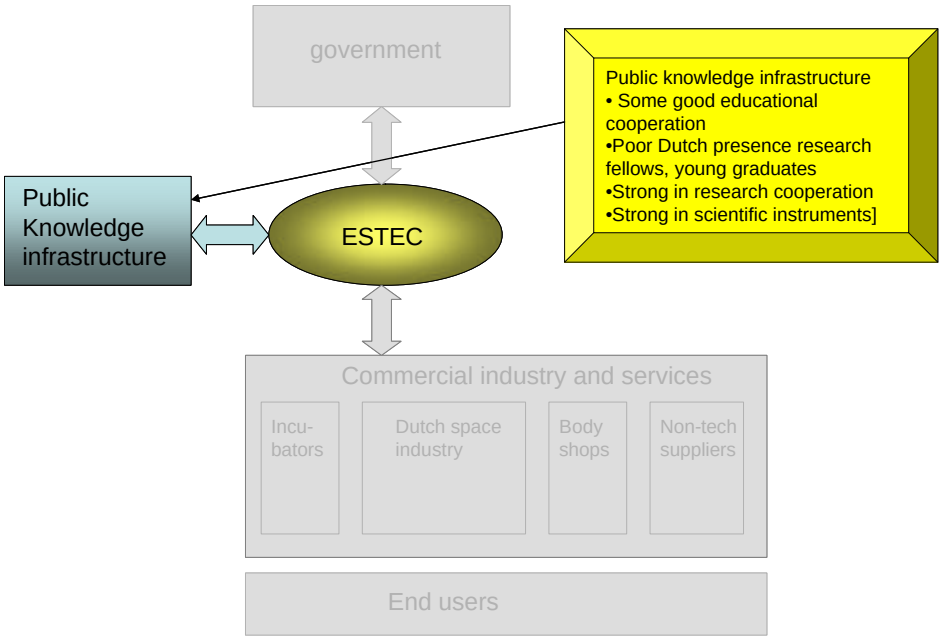

exhibit 18, key facts interaction ESTEC with Dutch knowledge infrastructure

There are several modes for science related knowledge exchange between the public knowledge infrastructure and ESTEC, the most important ones, sometimes partly overlapping, being:

- Educational cooperation through financial support (ESA chair) to in-kind support to educational programmes;
- Research cooperation to develop a joint knowledge base;
- Sharing of personnel while working in ESTEC (as opposed to taking over ex-ESTEC personnel which is dealt with in paragraph 5.1);
- Development of scientific instruments as payload to be delivered to ESTEC;
- Contracted services (e.g. university as a (sub) contractor, paid by ESTEC. This is dealt with in paragraph 5.2).

The educational cooperation between ESTEC and Dutch universities is particularly strong with the University of Delft, faculty of aerospace, at which ESA finances a professor's chair. The ESA-chair is a part time professorship (20%) set up with the intent to strengthen the relation between the University of Delft and ESA/ESTEC. The chair has directly and indirectly led to a lot of interaction. The main example is that relatively many students do their stage at ESTEC, theses for

PhD. Former astronaut Wubbo Ockels who held the ESA chair for many years delivered during this period some 20 engineers. All of them did their stage at ESTEC. Most of them went to industry, some of them started their own company (delta-utec), some of them are now amongst the contractors of ESTEC.
At the University of Delft in 1996 the TopTech / SpaceTech education was set up at the faculty of aerospace engineering: a master programme for engineers that already have a masters degree. It meets the needs for advanced systems engineering education. ESTEC is committed to sending 6 persons to this course on average every year.

Research cooperation

Research cooperation is strong with the Universities of Delft, Amsterdam, Utrecht and with NLR:

- At the *University of Delft* several professors have or have had intense research relations with ESTEC in the past, specifically prof. Jongkind (in charge of the microsat project: cooperation with TUE and UT), prof. Stoewer (now retired, but initiated the space tech master programme), prof. Ockels (ESA-chair, now full time professor in the field of sustainable areospace technology), Roederer (ESA-scientist, doctor honoris causa, faculty of electrotechnics).
- The *University of Amsterdam* has strong relations, amongst others through the microgravity lab, partially paid by SRON and the ministry of economic affairs;
- The *University of Leiden* and its bioparc have strong relations with ESTEC in the field of life sciences;
- *Utrecht University* and *SRON* recently embarked on a joint initiative backed by ESTEC to establish a Planetary Sciences group (Cf Showcase);
- *University of Nijmegen:* astrophysics.

Showcase: Set-up of academic Planetary Sciences group

Contrary to astronomy and earth observation, planetary sciences have no strong tradition in Dutch academia. In the last decade in the wake of an increased planetary focus of ESA (resulting in missions like Mars Express, Cassini/Huygens and upcoming Venus Express, Mercury oriented BepiColombo), essentially only astrobiology evolved into a dedicated research group at the university of Leiden (UL). Over the years, other relevant topics have been studied but mostly by scattered individuals and more often than not as side steps from their principal area of interest. Example topics include planetary atmospheres in UvA and planetary geodynamics at the University of Utrecht (UU).

In 2004, the National Platform Planetary Sciences, organised in the course of the development of the National Space Actionplan, (re)established the potential of the research area but stressed that real impact would require further integration.

As one of the Platforms results, a joint initiative of former ESTEC Research Fellow Ms Tanja Zegers of the UU and SRON, backed by ESA, now aims to create and foster conditions to set-up a dedicated surface/subsurface oriented planetary science research group. This opportunity arose when ESTEC decided to hire Ms Zegers through a contractor, following her Fellowship project on Mars Express, to continue some of the more operational tasks she had assumed in the mean time. Kindling interest of UU turned into a small part time contract that is combined with the bigger ESTEC contract and the willingness of SRON to act as contractor for the latter, now formally tie these crucial stakeholders since 1 May of this year. Proximity of ESTEC and UU is a crucial enabler in combining both assignments. In addition to a further intensification of the relation between the stakeholders, first concrete outcome of this initiative is the development of a planetary science course in UU to start shortly.

Sharing of personnel

Sharing of ESTEC personnel, particularly permanent staff, with the Dutch public research organisations does not have much volume and is overall rather weak despite the relatively strong position of Dutch science. The situation with temporary staff is somewhat better.

- One staff member of SCI-S, Mr Michael Perryman, holds a part-time professorship at the University of Leiden
- 21 Internal research fellows (may 2005) of which only 1 is Dutch: hence a relatively weak Dutch presence.
- 16 external research fellows (may 2005) are employed by ESTEC: 5 in the field of earth observation, 6 in the field of astrophysics, the others in a variety of fields.
    - One research fellow has the Dutch nationality, working in the telecom area at the university of Bath (UK).
    - Two research fellows are posted at Dutch universities: Departement of Environmental Sciences, Wageningen University and at the Astronomical Institute Anton Pannekoek, University of Amsterdam.

Development of scientific instruments as payload

In the mandatory scientific programme, ESA provides the opportunities to launch a mission. However, most of the scientific payloads are not paid and contracted by ESA/ESTEC but are separately financed by governments. The process through which these projects come about consist of the following steps:

- New issues for projects are identified by ESTEC's thematic teams.
- Through announcement of opportunities organisations are invited to submit proposals for projects and instruments. As a rule, proposals are based on international cooperations under management of a "principal investigator" (PI).
- ESA selects the best proposals that subsequently are executed under PI management, in close contact with the ESA mission management when appropriate, to be delivered to

ESA/ESTEC upon completion. But they are not managed or financed by ESTEC who just provides the opportunity to embark it on a spacecraft

Dutch institutions are doing relatively well in this area. The quantitative participation is naturally determined by the funding of Dutch government, directly or indirectly, but the qualitative contribution of Dutch science measured by the share of principal investigators that originate from Dutch public knowledge infrastructure, is well above average.

Options to increase the impact of Sharing of Personnel

- Regarding exploiting the presence of experienced ESTEC staff for science and education purposes, Dutch organisations could dedicate some means to achieve this. With ESA appearing open to these kinds of interactions, in many cases leading to a classic win-win, and the relatively modest sums involved with part time professorships, limited means could generate a significant impact.
- Regarding Research Fellows, the option parallels the one in paragraph 5.1 e.i. an increase of the total numbers through ESA.

5.7 The Erasmus User Centre

The User Centre was initiated in 1999, when the Dutch government supported ESTEC in setting up a demonstration centre for attracting new users for the International Space Station (ISS) and research in microgravity: the Erasmus User Centre. It has among others a replica of modules of the ISS, the Columbus module, a glovebox section and facilities for microgravity.

The primary objective of the user centre is to attract and inform new users regarding the utilisation of (ISS) and microgravity. In these fields it has the functions of:

- a matrimonial office: it links Estec with its user community. This user community is made aware of the possibilities ESTEC offers, creates a tangible interest with them and provides tailor-made advice to users.
- A support area. After selection of a project, the experiment needs to be prepared and executed. The user centre can serve as a place where lessons an be given, users can familiarize themselves with the experiment and the equipment, mission sequence tests can be carried out, dry runs can be carried out as a test.
- The appealing face of ESTEC. Visitors can get a good impression of the products and technologies ESTEC is developing in this particular field.

To this purpose, the Erasmus User Centre focuses on two distinctive groups of visitors:

- Scientists, to make them aware of the possibilities of micro-gravity research and have to develop the plans for this;

- Governments, ministries, decision makers who in the end are responsible for the funding. Over the last few years, ESTEC, and therefore also the User Centre, has received a large number of high-profile political visitors.

There is no quantitative information available regarding the tangible results, the value of the User Centre for Dutch industry. Setting overhead time apart, about 40% of its time is spent on providing background information on the space station. About 30 percent of its available time is spent on hosting events: visitors, workshops, mission sequence tests. About 20 percent is dedicated to helping scientists. The remaining 10 percent is used for internal customers.

5.8 Dutch use of ISS for commercial purposes: nascent but promising

Thirty percent of the ISS capacity is reserved for commercial use. Although the capacity and consequently the market is limited, it is a high profile one with spin-off potential. ESTEC is in the process of raising industry awareness of and interest in this opportunity. The market for this kind of services being nascent, it is essentially still a latent market. This is caused by several reasons:

- this kind of services is perceived as risky, expensive and complex
- The macro-economic situation (stagnating economy) is preventing industries from such unconventional ventures
- Industry researchers are not used to the kind of research that is suited for ISS (micro-gravity).

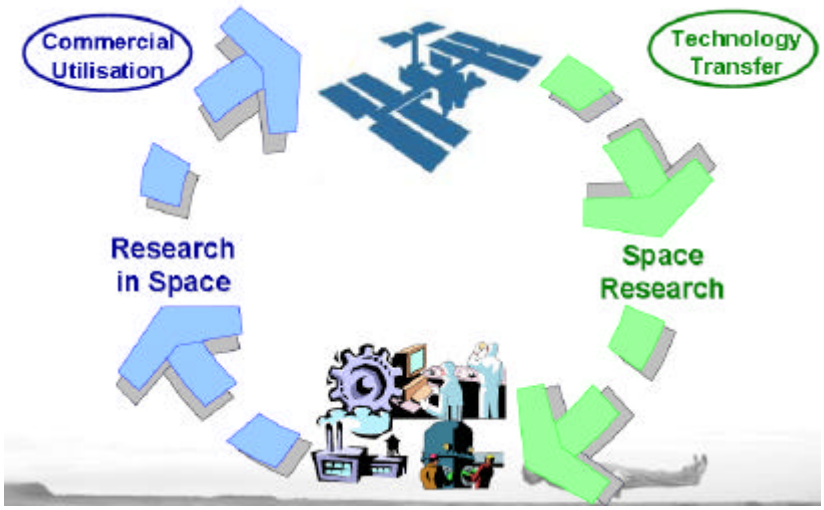

exhibit 19, commercial utilisation of the ISS is part of the objective in the human space flight directorate

In order to attract industries, ESA is taking several measures:

- reducing barriers for industry, e.g. in the field of IPR

- increased promotion, notably via the International Space Station Business Club that convenes 5-4 times annualy at various trade fairs to organise workshops etc.
- demonstration, through pathfinder missions

So far, only few industries have actually engaged with commercial pathfinder projects for the space station. Italian, Swiss and German industries have shown a pro-active interest.

Dutch participation has not really taken off yet. One pathfinder mission, partly financed by Dutch government, has been undertaken: the testing of a plasma lamp of Philips. Nevertheless the outlook for Dutch industry participation is promising:

- the Netherlands has several large multinationals for which ISS facilities are potentially very useful
- Dutch industry has shown an above-average interest
- at present, there are several commercial discussions taking place with Dutch industries

5.9 Exploitation of ESA/ESTEC in education is showcase for other countries

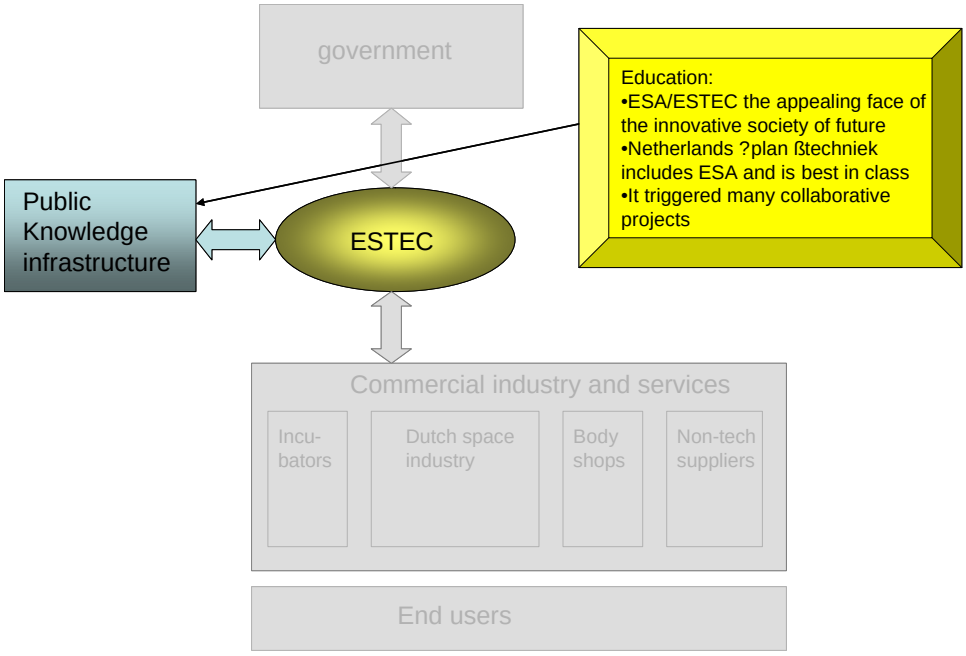

exhibit 20, key facts impact ESTEC's education activities on Netherlands

Over the last years ESA, and ESTEC in particular, have proven to be very valuable for the reorientation of the Dutch education system towards science and technology. ESTEC is the appealing face of the desired scientific/technological society.

Firstly through Space Expo the public at large is informed about space matters in general, conveying an overall and appreciated positive message. More than 1 million visitors have spent time in this independant foundation and have paid entrance fees for it.

Secondly, education itself is a specific and fundamental part of the mandate of ESA because it can contribute to a scientifically literate and aware society. For this purpose ESA has set up the International Space Station (ISS) Education Programme. This makes use of the ISS, as a means to capture the attention and the interest of primary and secondary school pupils, to attract them to study, in particular, scientific and technical disciplines, and to understand the importance of space for Europe. It is worth noting that a small part of the resources of ISS have specifically been allocated to education (see exhibit 21).

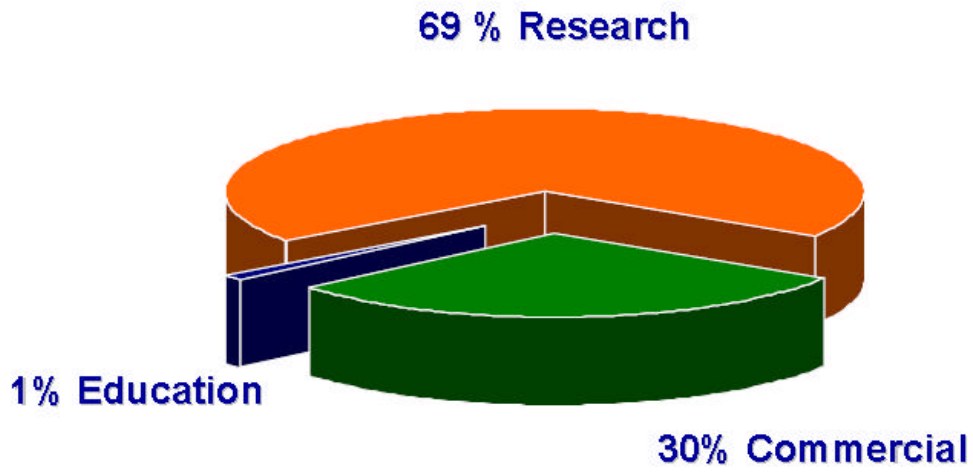

exhibit 21, The International Space Station is also used for education

The main focus of ESA in this field is on the development of educational activities and products (teaching material, as well as supporting student experiments on board of the ISS) for primary, secondary, and university students, and their teachers. ESA does not do this on its own but enters into strategic partnerships with governments.

In the Netherlands, government has developed a policy to promote technical studies: het “?plan ß/techniek”. In this plan ESA and the Dutch government work closely together.

exhibit 22, André Kuipers with "seeds in space" rocket

Part of this plan was the trip of astronaut Andre Kuipers to the ISS (DELTA-missie: Dutch Expedition for Life science, Technology and Atmospheric research). This involved projects like seeds in space, chats with the astronaut from public libraries and an educational kit.

It is not yet possible to show tangible results. It will take many years to see whether the activities lead to more children choosing technical profession. It is however clear that the Dutch "? plan ß/techniek" policy receives ample attention from other member states because of its coherence and funding. It is seen as "best practice". Some facts:

- all Dutch Primary Schools (approx. 6000) were involved in the experiment "Seed in Space", which had also large media resonance (Jeugd Journaal etc.);
- all Dutch Secondary Schools (approx. 1000) received from OCW a copy of the ISS Education Kit (educational material for science and technology based on space context)
- 40 Dutch Public Libraries opened the doors to children for a night of web chat with André Kuipers
- the two selected university student experiments (GraPhoBox and BUGNRG, from the Universities of Delft and Utrecht) received large public attention, including 2 hours of TV prime time (NOS Journaal, Netwerk etc)

The success of the education programme during the Delta mission was recognised by many actors in Dutch society and industry and kick-started a series of collaborative projects, such as:

- Delta Researchers School Programme (collaboration OCW/ESA/NASA, implemented by science centre NEMO: a programme to increase the interest and improve the quality of beta teaching in primary schools; first test of the results in 3 years);
- Establishment of a European Space Education Resource Office in the Netherlands
- Collaboration with JetNet (Network of companies such as Shell, Philips, AKZO, Unilever - that promotes Beta disciplines);
- Collaboration with CITO Group for the preparation of national exams;
- Collaboration with text book publisher Nijgh Versluijs, and publication of the pilot book for secondary schools (VMBO/HAVO/VWO) "Met André de ruimte in".

6 OVERALL ASSESSMENT INTERACTION ESTEC-DUTCH KNOWLEDGE SOCIETY

In the previous chapter, for each of the actors, the modes for knowledge exchange have been described as well as their value for Dutch society and industry. The most important identified options for improvement are listed in table 4.

options for improvement
exchange of knowledge workers
incubator
use of ESTEC labs
young graduates
professor chairs

table 4, summary of options for substantial improvement interaction with industry

6.1 Proximity ESTEC to Dutch actors adds value for The Netherlands

6.1.1 Proximity allows informal contacts leading to various advantages

In gaining new work, proximity is not a decisive factor. Indirectly however, the ease of establishing informal contacts during project execution is widely acknowledged, both by ESTEC and its collaboration partners, to contribute to productivity and efficiency. Furthermore, ESTEC collaboration partners stress that these same informal contacts and resulting common understanding from time to time do facilitate ad hoc collaborations (e.g. to use unique equipment) and in general increase the flow of ideas and speed up innovation.

While the impact of informal contracts vary widely between directorates, departments, divisions and persons, and are hard to quantify as the effects can seldom be isolated in these areas, the overall contribution is likely to be substantial.

In addition, there are several areas in which the added value is more concretely attributable to the proximity effect:

6.1.2 Proximity brings new scientific relations

Many foreign visitors to ESTEC, notably those with a scientific interest, do take the opportunity of their stay in The Netherlands for additional visit(s) to Dutch academic research groups. Especially TUD and SRON express profiting in this way, but it is likely that other institutions do benefit also. A prime example leading to many unplanned new interactions and relations is the large Solar Array test, NASA specifically came to ESTEC for (cf Showcase in paragraph 5.3). In the 2 months or so

the tests took, quite a few NASA scientists, being in the neighbourhood anyway, “hoped over” to nearby universities.

6.1.3 Proximity leads to the new scientific horizons

ESA’s research focus is by definition dynamic and new interests on the international level can spur dedicated activities on the national level.
A prime example is the planetary science area, that became a priority to ESA in the nineties, which UU and SRON now aim to establish firmly in Dutch academia using a collaboration project with ESTEC on Mars Express as the catalyst for integration and extension (cf. Showcase Set-up of Planetary Sciences group in paragraph 5.6).

6.1.4 Proximity leads to new business

Specific examples of Dutch R&D partners, winning business with ESTEC by a combination of specific competencies and proximity are:

- **Example new services market1**: Raad voor Accreditatie (Dutch Accreditation Council) / Utrecht. ISO 17025 certification of laboratories, including metrology, optics, microgravity and robotics.
- **Example new services market2**: Plancon / Purmerend (since 1990). Body shop with specialized knowledge on cost & schedule control of complex projects and related IT control instruments, originally from the oil & gas sector. Plancon contractors, currently 9 people, are fully integrated in project teams including 3 month Baikonur stays to prepare launches. Such a supplier is hard to beat by new entrants due to expertise, understanding ESTEC ways of work from existing relation and attractive price/quality ratio due to proximity (no expensive expats).
- **Example new product market**: Machinefabriek West-End / Lisse. Provider of machine/equipment products and services regarding development, engineering, manufacturing and maintenance. Employed by all ESTEC directorates for engineering support, in part selected because of the ease to maintain extensive contacts. Other clients of West-End include (petro)chemical, pharmaceutical, food and paper industries.
- **Example Start-up**: Cosine / Leiden (since 2001, cf. Showcase in paragraph 6.2). Research coordination services provider, offering ESTEC the possibility to outsource research: off loading of day-to-day management of research projects while staying in charge of strategic choices. The frequent contacts required in this type of work, make proximity a prerequisite.

6.2 Visibility of ESTEC knowledge assets can be improved

ESTEC is a large organisation. The technology and knowledge that is developed at ESTEC covers a wide spectrum. From the interviews it can be concluded that for insiders such as members of the core space industry it is quite clear what the activities of ESTEC in their respective domains are and how they can identify opportunities. However for relative outsiders it is much more difficult to get a clear understanding of the knowledge assets and facilities. The conferences that are organised regularly do mitigate this to some extent. However several of the organisations interviewed in the course of this study confirm that they consider ESTEC to be quite difficult to access by outsiders. The testing facilities and laboratories are a particularly valuable asset of ESTEC. They are however hardly used by Dutch industry. This is partly due to the fact that opening them up for industry has only just begun.

Options to improve the visibility of ESTEC among industry in general

ESTEC so far has not broadly marketed its capabilities. To make ESTEC more transparent for outsiders, it could be considered to develop short “Knowledge Profile Fact Sheets” for external distribution - preferaby no more than one sheet / two A4 leaflets - for each department (Draft proposal included as annex). This would both stimulate the ESTEC departments to make an inventory of their assets and would improve transparency of the quite complex ESTEC organisation, thus benefiting all parties involved.

SECTION 2: MACRO-ECONOMIC PERSPECTIVE

Economic value of ESTEC to The Netherlands

7 ECONOMIC VALUE OF ESTEC: STILL GOOD VALUE FOR MONEY

In the 1991 and 1995 studies, economic research was done related to the position of ESTEC in the Netherlands. This research pertained to the years 1989 and 1994. In both these studies ESTEC expenditure (not: commitments) was taken as the main indicator for its value. In order to be able to make comparisons this report also investigates expenditure.

7.1 Contribution of The Netherlands to ESTEC has risen

7.1.1 Contribution via ESA increased

The Dutch share of the annual expenditures of ESA increased from 2.8 % to slightly over 3 % in 2004. In absolute numbers the contribution of The Netherlands rose from M€ 47 in 1989, M€ 67 in 1994 to M€ 88 in 2004.

7.1.2 Significant additional investments by the Netherlands in recent period

The Netherlands has also invested on an incidental basis for special purposes, having in common the goal to reinforce ESTEC's position within ESA. The most important ones are:

- Funding of the Erasmus User Centre (M€ 4,5)
- For the new territory “ESTEC-2” the Dutch government will transfer the use of the lands (5 ha) to ESTEC.
- The Ministry of Economic Affairs provided about K€ 450 for refurbishment / upgrading to the Space EXPO over a period of 3 years.

Furthermore, the Netherlands and ESA, sharing the common objective to reinforce the scientifical and technical literacy of Europe/the Netherlands, have also joined forces in the education area, where collaboration programmes (e.g. establishment of education centres, Delta Researchers School Programme) have started between the Ministry of Education and ESA/ESTEC with a contribution by the Ministry of approx. 200K€ per year.

7.2 Total expenditures of ESTEC in The Netherlands has risen

The expenditure of ESA has increased with 14 % in the period 1994-2004 (without accounting for inflation). The spending of ESTEC increased by about 42 %. Hence the relative importance of ESTEC within ESA has grown strongly. It also underlines the importance of ESTEC within the ESA organisation. The ESTEC expenditure in The Netherlands also increased by 30%.

			1989	1994	2004
A	ESA expenditure	M€	1704	2537	2893
B	ESTEC total expenditure	M€	655	1159	1650
A/B	ESTEC percentage of ESA	%	38,4	45,7	57,0
C	ESTEC expenditure in Netherlands	M€	163	222	289
C/B	ESTEC percentage spending in Netherlands	%	24,9	19,2	17,5

Table 6, Expenditures of ESA and ESTEC (M€ / %)

Despite the fact that ESA spends more in Europe and ESTEC spends more in The Netherlands, the ESTEC expenditure in the Netherlands decreased from about 24,9 % of total ESTEC spending in 1994 to 17.5 % in 2004. However the percentage related to the relative value of ESTEC within ESA has increased, from 45 to 57 %.

			1989	1994	2004
A	**direct spending**				
	personnel		70	103	145
	contractors		53	75	130
	Buyings		26	29	
	Other		6	12	4
B	**indirect spending**				
	Visitors		2	2	5
A+B	**total spending**		157	221	284

Figures of ESTEC spending exclude travel expenses (non-comparable data).
In 2004 relevant travel expenses amounted to M€ 9

Table 7, Spending of ESTEC in The Netherlands (M€)

Table 7 shows that personnel costs increased faster than any of the other costs component. Over the period 1994-2004 the personnel costs have increased by more than 40 %, whereas the other costs components only have increased by about 16 %.

7.3 Added value of ESTEC to The Netherlands: still increasing

Table 8 lists the key figures to determine ESTEC's added value.

			1994	2004
A	Dutch contribution to ESA	M€	66	88
B	ESTEC expenditure in the Netherlands	M€	221	284
C	Other expenditure in the Netherlands from ESA	M€	25	6
D=B+C	Total expenditure	M€	246	290
D-A	Added value of ESTEC	M€	180	202

Table 8, Added Value of ESTEC to The Netherlands (M€)

Over the period 1994-2004, the added value of ESTEC for The Netherlands increased as a consequence of limited increase in the expenditure of ESTEC in The Netherlands and the reduction of expenditure by other ESA facilities in the Netherlands. The added value for the Netherlands increased with almost 29 %. This percentage is slightly less than the rise of the Dutch contribution to ESA which rose in the same period with a third.

Over the period 1994-2004 the size of the ESTEC spending declined relative to the Dutch economy. From 1994 onwards the share of ESTEC as percentage of the Gross Domestic Product decreased from 0.054 % to 0.047 %. This is on the one hand due to a stagnation in rise of ESTEC spending and on the other hand due to economic growth reflected in in the Gross Domestic Product and inflation. This development is a change in the trend since 1980 as can be deduced from table 9.

	1980	1984	1989	1994	2004
ESTEC share in GDP of the Netherlands	0.029 %	0.039%	0.05%	0.054%	0.047%

Table 9, ESTEC share in Dutch GDP

7.4 Summary and conclusion: Economic value of ESTEC still very important

A graphical summary of the key economic figures regarding ESA expenditure is given in exhibit 23 below.

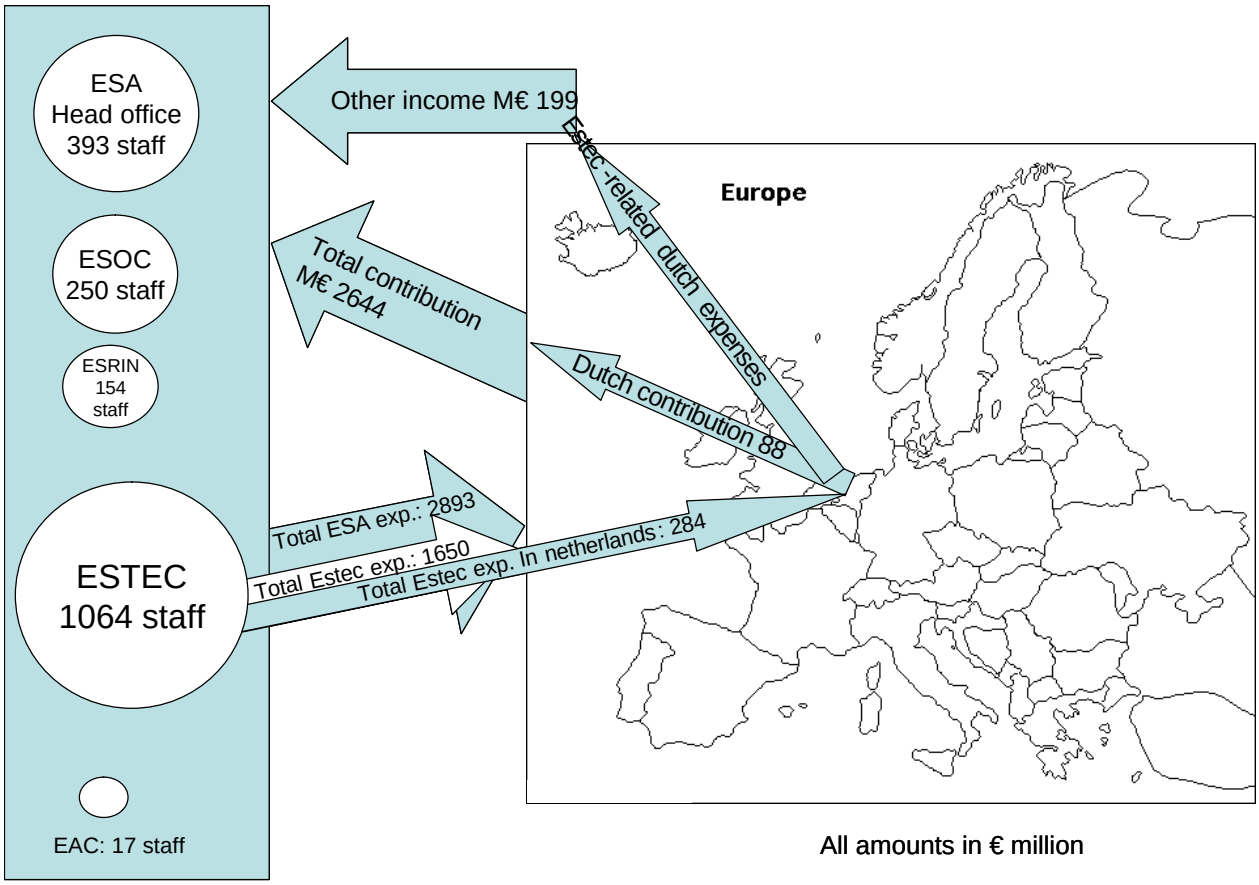

exhibit 23, expenditures versus contributions (M€)

It can be concluded that ESTEC economically is very important for the Netherlands. Every euro of the Dutch contribution of M€ 88, produces a return value of €3.4 for the Dutch economy. In this respect the Dutch contribution of 88 M€ can be considered as a very good investment. However the relative value in the Netherlands compared to 1989 and 1995 of ESTEC is declining slightly, which is caused mainly by stagnating ESA budgets and by inflation and economic growth.

ANNEX: KNOWLEDGE PROFILE FACT SHEET OF ESTEC DEPARTMENTS

Knowledge Profile Fact Sheet

The purpose of this proposal fact sheet is to make the organisation of ESA transparent for people outside ESTEC, in order to enable them to establish contacts with the right departments. Proposal lay-out partly elaborated for HME to illustrate the idea.

Directorate: "human space flight, microgravity and exploration " (HME)

Department: Utilisation (HME-G)

Main divisions: ISS utilisation and promotion;
Payload division;
Microgravity facilities for Columbus div.;
Utilisation P.A. & safety office;
Esrange/Andoya special project office;
HME utilisation strategy & education office.

Key figures:

- **Staff:** 42 scientists/engineers
- **Website:** http://www.esa.int/esaHS/ESAM1B0VMOC_index_0.html
- **contact person:** Martin Zell, head of department: telephone number

Key tasks&activities

Core task is payloads development. The framework for this is laid out in the "European utilisation plan for the International Space Station". Through topical teams new research subjects for the payloads are selected. Open calls are then used to select and contract research projects. The payload will then be built by industry.

Past: Main achievements over the last few years: <to be completed>

Present: Main present projects / programmes: <to be completed >

Future plans: <to be completed >

Opportunities for external parties: <to be completed >

Laboratories, conditionally open for outsiders: <to be completed >

Symposia organised by the department: <to be completed >