



Danish Agency for Science, Technology and Innovation

# Evaluation of Danish Industrial Activities in the European Space Agency (ESA)

Assessment of the economic impacts of the Danish ESA-  
membership

March 2008

## **Foreword**

The Danish Agency for Science, Technology and Innovation has launched an evaluation of the Danish space activities, intending to set a platform for recommendations for developing a national space strategy, enabling a strengthening of the Danish space activities.

The overall evaluation is divided into two parts. The first part of the evaluation has its primary focus on the scientific value of the ESA membership and is evaluated by an international peer review panel. The second part analyses the economic impacts of Danish companies' involvement and cooperation with the European Space Agency (ESA).

The Danish Agency for Science, Technology and Innovation has asked Rambøll Management to conduct the analysis and evaluation of the industrial involvement, including the economic impacts of the Danish industrial cooperation with ESA. This publication reports the findings of the analysis and evaluation of the Danish membership for Danish companies.

The evaluation comprises Danish companies who in the period from 2000 to 2007 have obtained an ESA-contract or who in another way have contributed to Danish ESA-activities, e.g. as subcontractors to Danish companies with ESA-contracts. In addition, the evaluation comprises Danish companies involved in space-related activities, but without contracts with ESA.

## **Table of contents**

<b>Executive Summary .....</b>	<b>1</b>
<b>SECTION ONE: Introduction.....</b>	<b>3</b>
<b>SECTION TWO: Methodological approach and design .....</b>	<b>4</b>
1. Study design.....	4
2. The Space Economy and spinoff .....	5
3. Assessing the economic impact of Danish ESA-activities .....	9
4. Assumptions and delimitations .....	10
<b>SECTION THREE: ESA and the Danish ESA-commitments.....</b>	<b>13</b>
1. About ESA .....	13
2. Danish Space Policy and main actors .....	15
3. The Danish ESA-engagement.....	16
<b>SECTION FOUR: Findings .....</b>	<b>24</b>
1. Turnover and employment among Danish ESA-contractors .....	24
2. Turnover and employment among Danish subcontractors .....	28
3. Danish companies without direct access to ESA-contracts.....	30
4. Impacts of ESA-contracts on Danish Economy (spinoff) .....	31
5. Sensitivity analysis .....	33
<b>SECTION FIVE: Conclusions and recommendations .....</b>	<b>35</b>
<b>ANNEX: List of interviewed companies .....</b>	<b>37</b>

## Executive Summary

The Danish Agency for Science, Technology and Innovation has asked Rambøll Management to conduct an analysis and evaluation of the industrial involvement, including the economic impacts of the Danish industrial cooperation with ESA.

The evaluation comprises Danish companies who in the period from 2000 to 2007 have obtained an ESA-contract or who in another way have contributed to Danish ESA-activities, e.g. as subcontractors to Danish companies with ESA-contracts. In addition, the evaluation comprises Danish companies involved in space-related activities, but with out contracts with ESA.

As formulated in the ESA-Convention ESA contracts are distributed in competition between industries in all member states but taking into account a fair geographical distribution compared to participation and contribution.

The Danish contributions to ESA are after being subject to competition returned to Denmark as contracts with Danish companies and institutions. In that way, the Danish companies and institutions get a direct turnover through ESA-contracts. Moreover, the contracts are expected to bring about indirect effects through developed technology, competencies, etc. The present study assesses the size of these direct and indirect effects compared to the size of the Danish ESA-contribution. Consequently, a spin-off factor is defined, which measures total amounts of EUR created in direct and indirect turnover by the Danish ESA-contribution. The analysis takes into account that the Danish companies forward some of the turnover to foreign sub-suppliers.

The study clearly indicates that the Danish ESA membership is very important for enhancing the possibilities for the Danish companies to maintain and accelerate Danish knowledge-intensive competences within the space sector and other (closely related) industrial sectors. Across the Danish ESA-priorities, each million EUR of Danish contribution to ESA generates a total turnover of 4.5 million EUR, which is a clear result of Danish companies' direct involvement in ESA-projects and through further commercialisation of products and technologies developed through ESA-contracts.

The geographical return on ESA-contributions ensures an increased turnover in Danish companies. Only a small fraction of the turnover is spent on foreign sub-suppliers and the major part of the ESA-contributions returns in that way to the Danish economy. With regard to total generated direct turnover, the analysis shows that the ESA-contracts have generated a total turnover of 99.3 million EUR among the Danish companies covered by the study.

The largest direct impacts on Danish ESA-contracts in terms of turnover are found within the ISS-Programme and the General Budget. Together, the associated direct turnover amounts to 51.1 million EUR in the period from 2000 to 2007, equalling approximately half the generated direct turnover among Danish ESA-contractors in the period. Similarly, the Scientific Programme, the Earth Observation Programme, the Launchers Programme, and the Microgravity Programme have generated a relatively high turnover among Danish ESA-contractors in the period.

With regard to employment, the turnover has directly generated a total employment equal to 192 full-time employees in the period from 2000 to 2007. Compared to the generated direct turnover the analyses show that a contractsum of 1 million EUR on average generates 1.9 full-time employees.

With regard to total generated indirect turnover, the analysis shows that the ESA-contracts have generated a total turnover of 462.6 million EUR. The largest indirect impact from Danish ESA-contractors in terms of turnover is found on contracts related to the General Support Technology Programme, from which the associated indirect turnover amounts to 121.4 million EUR in the period from 2000 to 2007, equalling approximately 25 % of the total generated indirect turnover in the period. Similarly, ESA-contracts related to the Launchers Programme, the Navigation Programme, the Telecommunications Programme, the Earth Observation Programme, and the Microgravity Programme have generated relatively high indirect turnovers in this period. However, the General Budget, the Scientific Programme and the ISS-Programme all have generated a relatively low turnover in this period. With regard to employment, the analyses show that the turnover indirectly have generated a total indirect employment equal to 355 full-time employees in the period from 2000 to 2007. Compared to the generated direct turnover the analyses show that a contractsum of 1 million EUR indirectly generates 0.8 full-time employees on average.

Apart from the quantitative assessment of the direct and indirect effects, the report also includes qualitative descriptions of companies' impressions of the Danish ESA-activities. The companies generally have a positive attitude towards the ESA-involvement. The contracts with ESA lead to improvements in technology and quality management etc. In addition, several companies experience a "branding effect" giving them an advantage with potential clients and employees. In some cases, it is possible to identify which effects follow directly from the ESA-contracts while it may be difficult in other cases.

## SECTION ONE: Introduction

The overall evaluation is divided into two parts. The first part of the evaluation has its primary focus on the scientific value of the ESA membership and is evaluated by an international peer review panel. The second part analyses the economic impacts of Danish companies' involvement and cooperation with the European Space Agency (ESA).

The Danish Agency for Science, Technology and Innovation has asked Rambøll Management to conduct the analysis and evaluation of the industrial involvement, including the economic impacts of the Danish industrial cooperation with ESA. This publication reports the findings of the analysis and evaluation of the Danish membership for Danish companies.

The evaluation comprises Danish companies who in the period from 2000 to 2007 have obtained an ESA-contract or who in another way have contributed to Danish ESA-activities, e.g. as subcontractors to Danish companies with ESA-contracts. In addition, the evaluation comprises Danish companies involved in space-related activities, but with out contracts with ESA.

In addition to this introduction, the report contains the following sections:

- **Section two** provides an overview of the applied methodological approach and design of the evaluation, including an overview of the main phases of the evaluation, an outline of the methodological approach, and an outline of the main assumptions and delimitations of the assessment.
- By outlining the main characteristics of ESA, Danish space policy, and the Danish ESA-engagement in the period from 2000 to 2007, **section three** aims to provide a general background for the evaluation.
- **Section four** presents the findings of the evaluation, containing an analysis of the economic impacts of the Danish industrial cooperation with ESA on Danish companies with ESA-contracts and Danish suppliers to Danish companies with ESA-contracts.
- Finally, in **section five**, the conclusions on the importance of the Danish ESA-membership for Danish companies are reported.

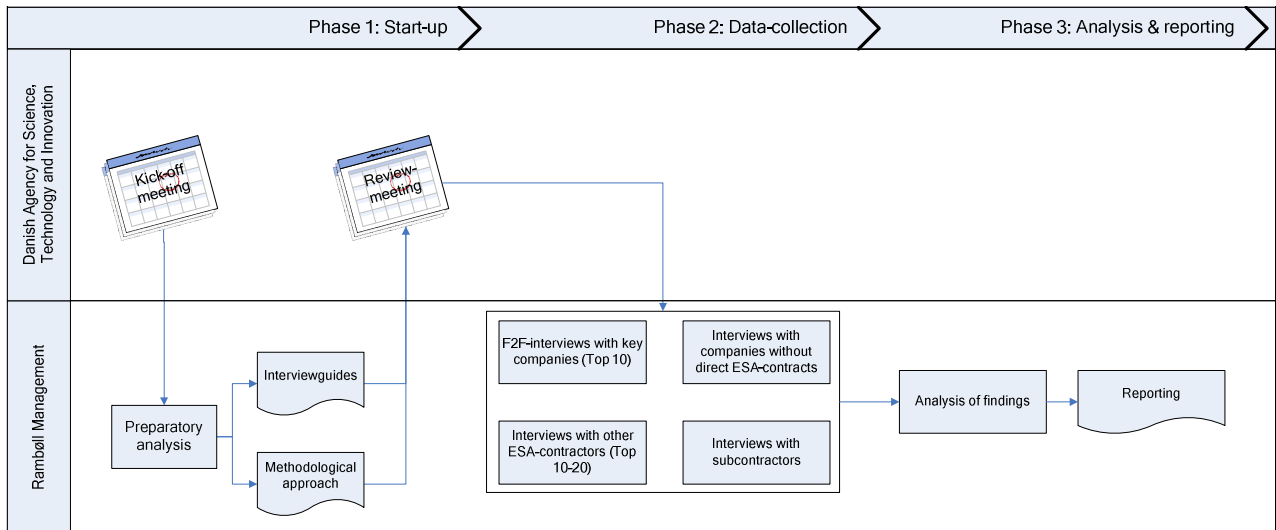
## SECTION TWO: Methodological approach and design

As outlined above, this section provides an overview of the applied methodological approach and design of the evaluation. First, this section provides an overview of the main phases of the study. Second, this section outlines the methodological approach chosen for assessing the economic impact of the Danish involvement and cooperation with ESA. Finally, this section provides an outline of the main assumptions and delimitations of the assessment.

### 1. Study design

As illustrated in the flowchart below, the study has been designed around three main phases.

**Figure 1: Study design**



In the start-up phase, the settings for the study have been agreed at a kick-off meeting between the Danish Agency for Science, Technology and Innovation and Rambøll Management. Following the kick-off meeting and preliminary research and analysis, drafts for the guidelines for interviews with companies have been discussed and agreed.

The second phase covers the collection of data, including:

- In-depth interviews (face-2-face) with the Danish companies who have obtained the largest ESA-contractsums in the period from 2000 to 2007 (top 10)
- Interviews (telephone) with other Danish companies who have obtained the largest ESA-contractsums in the period from 2000 to 2007 (between top 10 and 20)
- Interviews (telephone) with suppliers to Danish companies with ESA-contracts
- Interviews (telephone) with other Danish companies engaged in space-related activities, but who do not have direct contracts with ESA

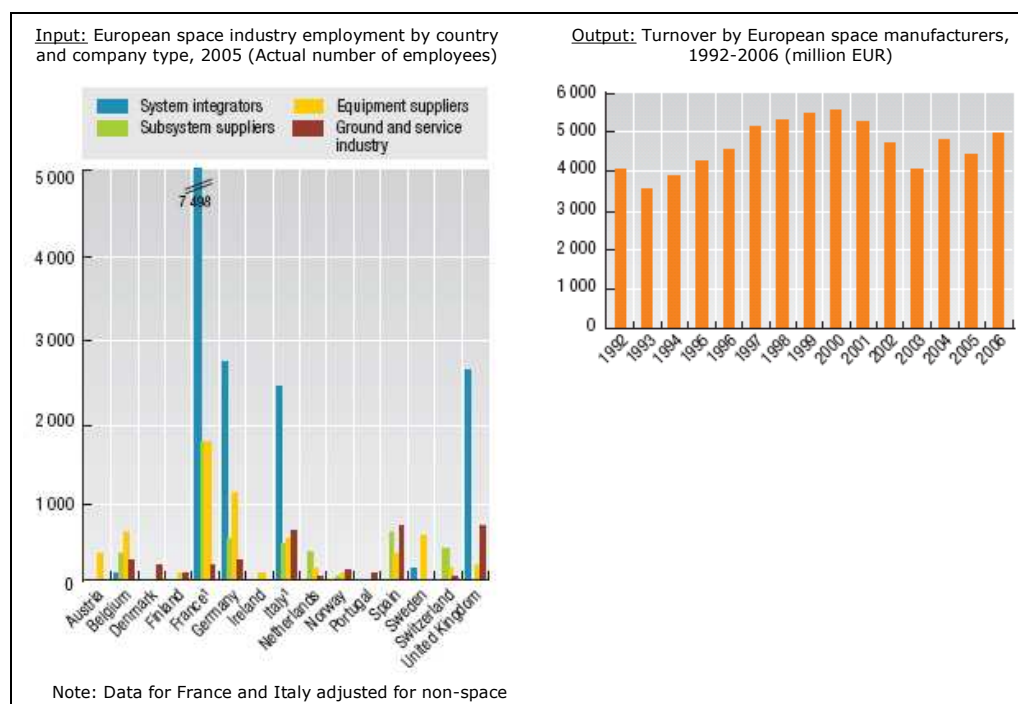
In the third and final phase, the findings from the data-collection are analysed and reported.

## 2. The Space Economy and spinoff

During recent years, an increasing number of countries and organisations have increased attention to the space sector’s contributions to national economic activities. The increased attention is based on the basic assumption that space-related activities have positive impacts on society and is of critical importance for modern technical infrastructure etc.

While assessments of the impacts of the space economy on society mostly have been qualitative rather than quantitative, OECD recently published the first ever overview of economic inputs to and outputs from space activities. Figure 2 below includes examples of these inputs to and outputs from the space economy.

**Figure 2: Input to and output from the space economy**



Source: OECD, the Space Economy at a Glance 2007

Even though the OECD also has attempted to frame the space economy in quantitative terms, assessments of the economic impacts of space-activities on society remain more qualitative than quantitative. The OECD-assessments of the impact consist of the “societal value-added” created by space activities, in terms of new jobs, new revenues, and efficiency. Table 1 below illustrates how space-derived effects may affect other sectors:

**Table 1: Selected types of impact of space investments**

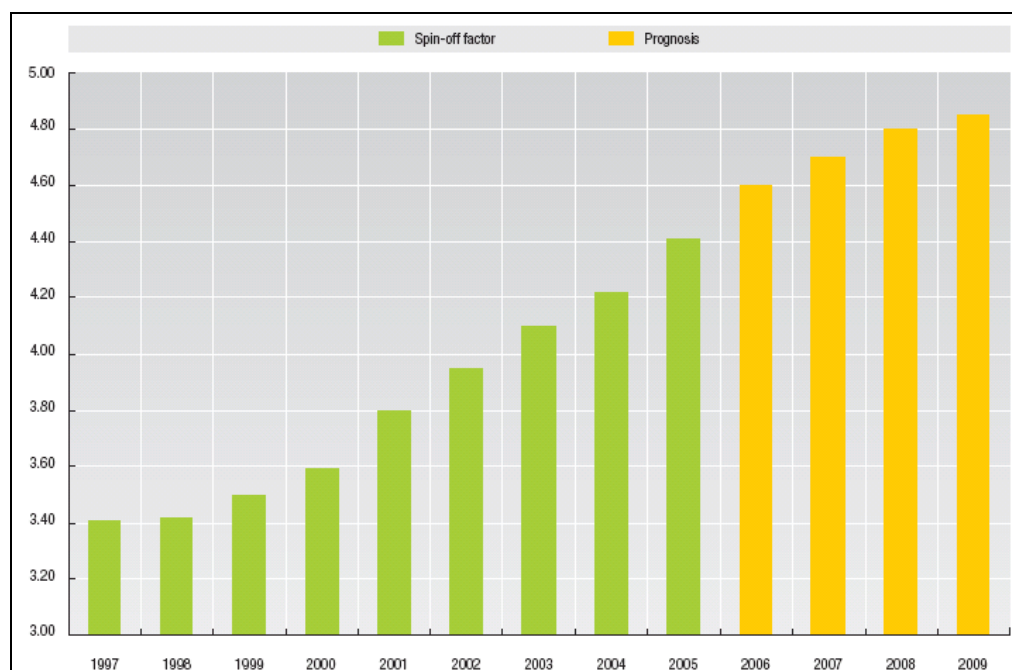
Category of impact	In the space sector	In other sectors
New jobs	Workforce in the space sector	Employment locally, regionally serving the space sector workforce (e.g. local shops, industries). Employment in companies, organisations, using space-related products or services to create new products or services (e.g. imagery in geospatial equipment, satellite signals in navigation equipment).
New revenues	Revenues from new services	Revenues coming from new services, based on space-based elements (telecommunications, navigation, geospatial services).
Efficiency	Increased competitiveness of some space firms	Productivity gains achieved by improving space assets users' production and distribution. Cost savings.
Cost avoidance	-	Reduced damage to properties and lives.
Social inclusion	-	Satellite communications infrastructure projects contribute to addressing the problem of social exclusion by improving accessibility.

Source: OECD, the Space Economy at a Glance 2007

Even though issues concerning economic data definitions and methodologies still have to be resolved to allow benefits to be identified and quantified fully, the main message in the OECD-assessment is that many space-based activities have positive impacts on society.

Focusing on the economic outputs from space activities, a study done by Euroconsult in 2002 shows that every EUR invested into the space applications generates a turnover of 7-8 EUR, due to development of industries that need the satellite infrastructure. Similarly, a recent Norwegian study shows that for each million EUR of governmental support through ESA or national support programmes, the Norwegian space sector companies on average attained an additional turnover of 4.4 million EUR. In addition, the Norwegian study expects this spinoff-factor of 4.4 to climb even further, c.f. figure 3 below:

**Figure 3: Norway space industry spinoff-factor**



Source: OECD, the Space Economy at a Glance 2007

Even though the space industry spinoff-factor may vary widely from country to country, the study from Euroconsult and the Norwegian study indicate the potential positive economic impacts of space-investments.

## **2.1. The European and Danish Space Sector**

The European space manufacturing industry is a niche strategic sector, embedded in the wider European AeroSpace and Defence industrial complex. The sector operates at the higher end of the value chain, and supplies to service providers and public institutions, spacecraft and launchers to their requirements.

The largest industrial holdings (EADS-Astrium, Snecma and Thales-Alenia) are directly responsible for more than 80 % of the total space industry employment in Europe (including both service employment and manufacturing employment). Small and medium-sized enterprises (SMEs) represent significantly less than 5 % of the total space industry manufacturing employment, whereas small space units (within larger companies) represent around 20 % of the total space industry manufacturing employment. The industry is distributed across all Europe, with the main industrial sites located in France, Germany, Italy, and, to a lesser extent, United Kingdom, Spain and Belgium.

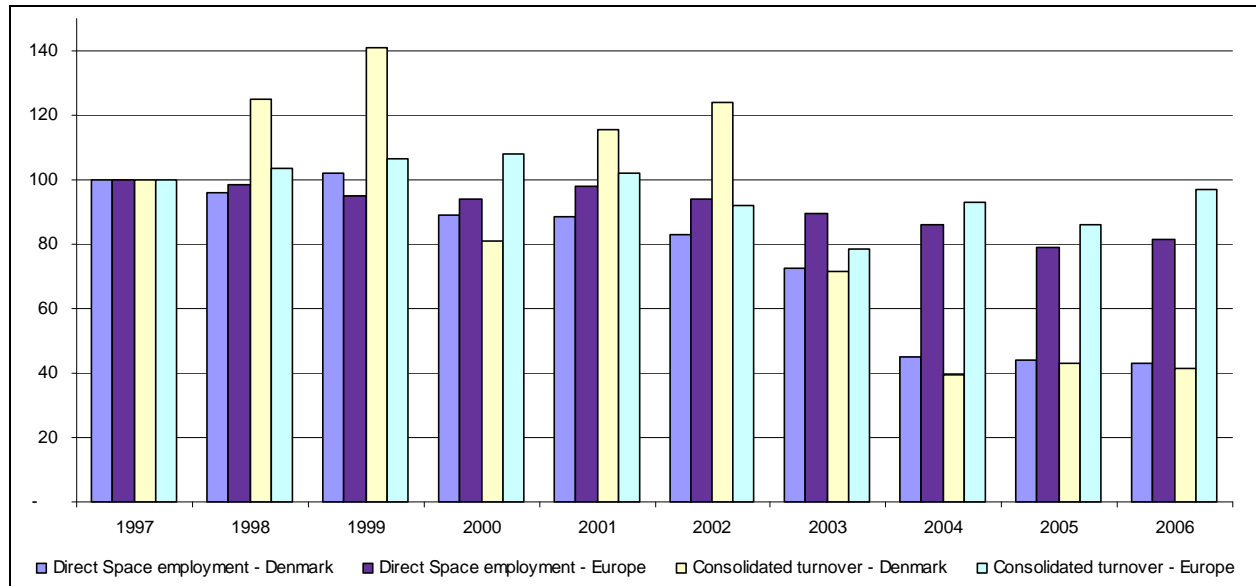
As illustrated in figure 4 below, the situation of European space manufacturing industry has changed significantly in the past decade. With regard to both employment and turnover, the European space manufacturing industry has witnessed a decrease since 1997. According to Eurospace, the reasons for the overall European development are two-fold:

1. Mergers and acquisitions have restructured the manufacturing sector, starting at the higher level of the value chain (system integrators) pursuing strategies of vertical and horizontal integration.
2. Industry restructuring explains some of the employment reduction suffered by the sector since the mid-nineties, but market factors apply as well.

Since 1997, the European space industry turnover has more or less been equally driven by institutional and commercial customers. In this period, the global commercial market has been characterised by a fierce, technology-driven competition, very high reliability, timeliness requirements and cyclical evolutions (the space industry is currently suffering from a particularly low phase of the cycle).

With average lead production cycles of 18 to 36 months for operational space systems, the competitive environment of commercial activities involves high technical and financial risks, not to mention market uncertainties and the hazards related to the launch phase.

**Figure 4: Employment & turnover in space manufacturing industry, 1997-2006 (Index 1997=100)**



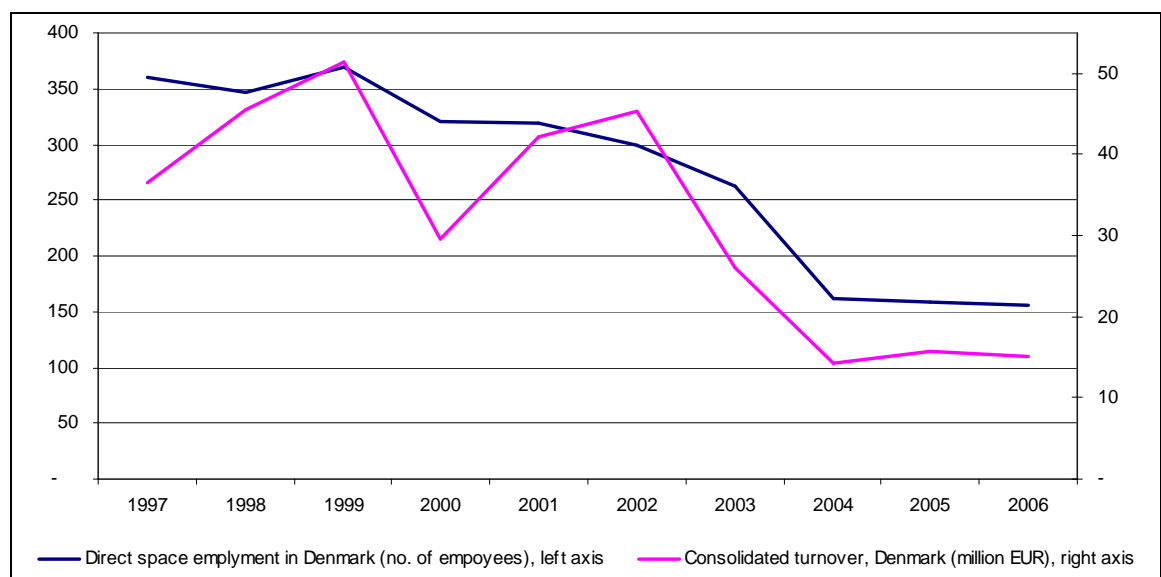
Source: Eurospace 2007

Note 1: In this context, Europe covers the following countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

Note 2: The data from Eurospace survey focuses on industrial manufacturing activities, i.e. the identification of development and production activities of space launchers and spacecraft and the associated (professional) ground segment. The figures do not include revenues and employment related to service activities such as provided by launch services providers (Arianespace) or satellite operators (e.g. Eutelsat).

As figure 4 above also illustrates, both employment and turnover in the Danish space-manufacturing industry have decreased to a higher extent, compared to the overall European development. Figure 5 below details the development of employment and turnover in the Danish space-manufacturing industry in the period from 1997 to 2006, and shows that in both cases the decrease amounts to approximately 55 %:

**Figure 5: Employment & turnover in Danish space-manufacturing industry, 1997-2006**



Source: Eurospace 2007

The significant decreases from 2002 are mainly due to the close down of activities in Alcatel Space Denmark (in 2003) and to a number of acquisitions and consolidations made by Terma A/S.

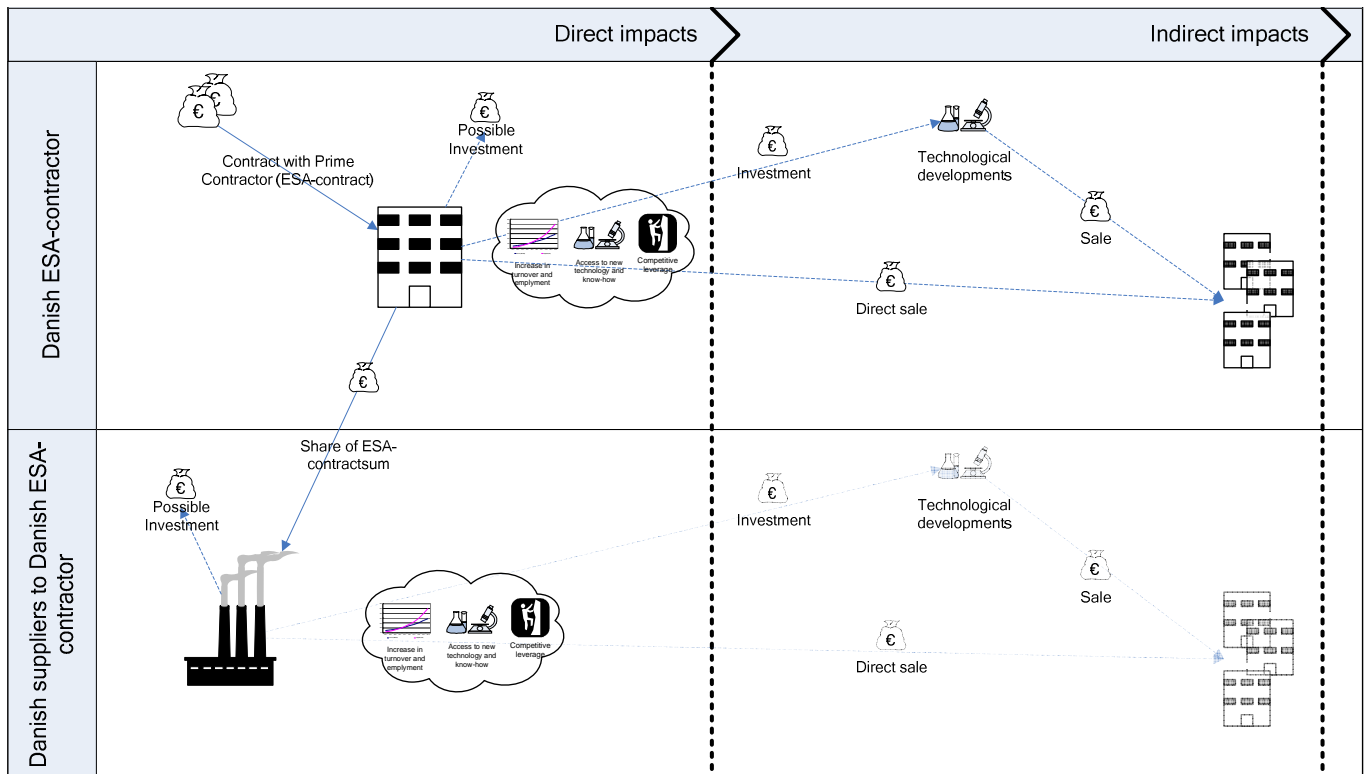
### 3. Assessing the economic impact of Danish ESA-activities

The starting point of this analysis is the assumption that the Danish investments in ESA have a positive economic impact on Danish companies through their involvement in ESA-contracts. Following this basic assumption, the analysis of the economic impacts distinguishes between direct and indirect impacts:

1. The direct impacts are the increased turnover and employment, which follows directly from entering into an ESA-contract.
2. In the process of fulfilling the ESA-contract, the company may develop new technology or competencies. These may gain competitive advantage and leverage in existing markets and be way to facilitate market penetration; both leading to higher turnover and employment.

Both the direct and indirect impacts will benefit the subcontractors of the companies, which enter into ESA-contracts.

**Figure 6: Model for assessment of the economic impacts of ESA-contracts**



The quantification of the direct impacts is more precise than the indirect impacts, since the direct impacts of the ESA-contracts are relatively easy for the companies to identify, while the quantification of the indirect impacts by its nature is based mostly on the companies' own assessments.

The analyses of economic impacts are based on information from the companies, which are a part of the ESA-activities. The direct impacts are evaluated using the following data:

- The size of the ESA-contracts and the number of employees demanded to fulfil the contracts in the period 2000-2007.
- The proportion of the contracts channelled to suppliers in the period 2000-2007 and identification of these suppliers.

This information makes it possible to calculate the socio-economic impact of the ESA-contracts. The impact of the contracts is determined by a spinoff-factor, which regards the Danish ESA contribution as an investment and shows the return on that investment.

Optimally, it would be possible to calculate the Internal Rate of Return (IRR) on this investment. This, however, requires a well-specified cash flow over the observed years. Due to limited data material, this is not possible. The investments and the return on investments are therefore defined as the total amount invested in the period and the total return in this period. All amounts are deflated to 2008-prices using the GDP-deflator.

For private companies, a given initiative is favourable if the present value of the income is higher than the present value of the expenses. However, for public initiatives, a convergence between operating economic impacts and socio-economic impacts will rarely exist. A given public initiative may be socio-economic favourable while having an operating economic deficit. If a public initiative, which is considered to be socio-economic favourable, entails an operating economic deficit, then it is necessary to finance a part of these costs through taxation of other parts of society. However, such redistribution through the taxation-system is not without costs, as taxation usually entails a distortion of the activities in the economy<sup>1</sup>. Assumed that the Danish contribution to ESA is financed by imposing a tax, a tax distortion factor of 20 % should be included in the calculations, which entails that the cost of the investment (in this case the Danish ESA-contribution) increases by 20 %<sup>2</sup>.

#### **4. Assumptions and delimitations**

The analysis covers the period between 2000 and 2007. The Danish companies' ESA-contracts in this period therefore represent the investment. Any additional investments made by the company or others are regarded neither as investment nor return.

The return on the investment includes the direct impact of the ESA-contracts on the Danish companies corrected for the proportion of the contracts channelled to foreign subcontractors. The indirect impacts are only included for the companies receiving the ESA-contracts, that is, any indirect impacts on these companies' subcontractors are not included.

---

<sup>1</sup> Consider a situation where a person is willing to work for a yearly salary of 100 EUR, but not for 90 EUR, and a company is willing to pay a salary of 100 EUR. If there is no income tax, the company will hire the person and society will benefit from the activity. However, if the government introduces an income tax of 10%, the person will not be hired even though the company is willing to pay a salary of 100 EUR. This causes a dead-weight loss.

<sup>2</sup> The tax distortion factor is set to 20 % in the publication *Vejledning i udarbejdelse af samfundsøkonomisk konsekvensvurderinger* – Danish Ministry of Finance, 1999.

As mentioned above, operational space systems are characterised by an average lead production cycles of 18 to 36 months, imposing a time lag between investment and return. However, the analysis does not include a time lag between investment and return, whereby it is implicitly assumed that the indirect impacts of the ESA-contracts can be observed in the same year as the contracts are given. Indeed, there may be a time lag before the indirect impacts are realised, but introducing this in the analysis would further limit the observed period. Assuming that the total contractsum to Danish companies is relatively constant, it makes little difference whether a time lag is included or not. Therefore, the direct and indirect impacts of the ESA-contracts in the period 2000-2007 are regarded as a return on the ESA-contracts in the same period. Consequently, some of the effects of the indirect impacts will actually stem from ESA-contracts before 2000 while there may be indirect impacts of ESA contracts, which will be realised after 2007.

#### 4.1. Definition of spinoff-factor

The spinoff-factor indicates the return on the ESA-contracts to Danish companies in the period 2000-2007. The spinoff-factor represents the size of the return compared to the investment, where:

- *The investment* is the Danish ESA-contractsums among the companies included in the analysis in the period 2000-2007.
- *The return* is the turnover created by these contracts and the indirect impacts. The indirect impacts can be the additional turnover generated by these contracts on new or existing markets. Furthermore, turnover of spinoff-companies is included in the case a technology is created under an ESA-contract and thereafter exported to another company. Any increased turnover among foreign subcontractors to Danish ESA-contractors is not included in the return.

To summarize, the spinoff-factor (SF) is defined as follows:

$$SF_{2000-2007} = \frac{DirectTurnover(ESA - contractsum, excl. costs to foreign subcontractors)_{2000-2007} + IndirectTurnover_{2000-2007}}{1.2 \times DirectTurnover(ESA - contractsum)_{2000-2007}}$$

Hence, a spinoff-factor of 0.83 means that there are no indirect impacts. If the spin-off factor is above 1, the turnover from the indirect impacts is larger than the dead-weight loss caused by tax distortion.

#### 4.2. Comments on central assumptions

*Expenses to Danish suppliers are included in the return on investment:*

- Since these expenses will benefit the Danish society, they are included in the return. The Danish suppliers channel a very small fraction of their turnover to foreign suppliers.

*Expenses to subcontractors are disregarded when looking at new contracts and spinoff-companies. Turnover from these contracts is included 100 %:*

- It would require an even more detailed investigation to quantify these expenses. The analysis indicates that only a very small fraction of the turnover in the Danish space industry is channelled to foreign suppliers.

*Development capital from the company itself and foreign investors etc. is neither included as investment nor return on investment:*

- The participating companies find it difficult to quantify their own development costs and it the size of this capital is therefore very difficult to measure.

*Spinoff-companies' turnover is included 100 %:*

- Since these companies would not have existed without the Danish ESA-contributions, their turnover is regarded as return *on investment*.

*Assessment of indirect impacts by programme:*

- In some cases, it has not been possible clearly to ascribe the indirect effects to a single programme. In these cases, the impacts have therefore been distributed among the programmes proportional to the distribution of the relevant company's contractsum.

*No time lag. Investments are the Danish ESA-contracts in the period 2000-2007 and the return is the direct and indirect impacts in the same period:*

- The data is limited to this period. Assuming that the Danish ESA-contribution is relatively constant, the results would probably change very little with the introduction of a time lag.

## SECTION THREE: ESA and the Danish ESA-commitments

### 1. About ESA

The European Space Agency (ESA) was founded in 1975 by the merger of the European Launcher Development Organisation (ELDO) and the European Space Research Organisation (ESRO), both established in 1964. Denmark was among the founding members, which also include Austria, Belgium, Finland, France, Germany, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom, who all signed the Convention on the establishment of ESA in 1975.

ESA's mission is to shape the development of Europe's space capability and ensure that investments in space deliver benefits to the citizens of Europe and its Member States. By coordinating the financial, technological and intellectual resources of its members, ESA undertakes programmes and activities beyond the scope of a single European country.

ESA's objective is to draw up a European space programme and carry it forward. ESA's programmes are designed to find out more about Earth, its immediate space environment, our Solar System and the Universe, as well as to develop satellite-based technologies and services, and to promote European industries. ESA also works closely with space organisations outside Europe and with the EU.

The ESA-Council is the Agency's governing body between councils at ministerial level, and provides the basic policy guidelines within which the Agency develops its space programmes. Each Member State is represented on the Council and has one vote, regardless of its size or financial contribution.

#### **ESA Member States, cooperating states and relations to the European Union**

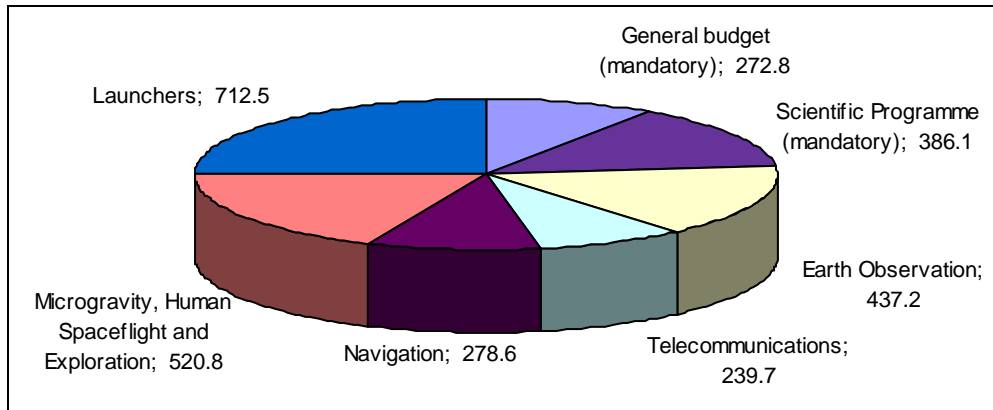
ESA has 17 Member States: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal Spain, Sweden, Switzerland and the United Kingdom.

Canada has been a Cooperation Partner since 1979. The Czech Republic, Hungary, Romania and Poland are participating in the Plan for European Cooperating States (PECS), while other countries are in negotiation about joining ESA.

Not all Member States of the European Union are members of ESA and not all ESA Member States are members of the EU. ESA is an entirely independent organisation although it maintains close ties with the EU through an ESA/EC Framework Agreement. The two organisations share a joint European Strategy for Space and together they developed the European Space Policy, work together on specific initiatives such as the European navigation programme Galileo, and Global Monitoring of Environment and Security (GMES).

ESA's budget for 2006 is an estimated 2,904 million EUR. The agency operates on basis of geographical return, i.e. it invests in each Member State, through industrial contracts for space programmes, an amount more or less equivalent to each country's contribution. Figure 7 below shows ESA's 2007 budget by programme:

**Figure 7: ESA budget 2007 by programme, million EUR**



Source: University of Stuttgart

ESA's activities fall under two categories: "mandatory" and "optional" programmes. The General Budget and the Scientific Programme budget are mandatory, and include the Agency's basic activities and facilities (studies on future projects, technology research, shared technical investments, information systems and training programmes). All Member States contribute to these programmes according to a scale based on their GDP.

The optional programmes may only be of interest to some Member States, who are free to decide on their level of involvement. Optional programmes cover areas such as earth observation, telecommunications, satellite navigation and space transportation. Similarly, the International Space Station (ISS) and microgravity research are financed by optional contributions.

About 90 % of ESA's budget is spent on contracts with the European industry, mainly for research and development activities. The companies involved in ESA's activities fall mainly into two categories:

- prime contractors, mainly acting as system integrators, and
- a wide range of companies, including subsidiaries of "primes", independent equipment suppliers, small system integrators, fully independent SMEs, R&D institutions, etc.

### ESA-programmes

#### **The General Budget and the Scientific Programme (mandatory programmes)**

The General Budget and the Scientific Programme cover the Agency's basic activities, including studies on future projects, technology research, shared technical investments, information systems and training programmes. The objective of the Scientific Programme is among other, to enhance European capability in space science and to bring together national space programmes.

#### **Earth Observation (optional)**

ESA has been dedicated to observing the Earth from space ever since the launch of its first meteorological mission METEOSAT in 1977. Following the success of this first mission, the subsequent series of METEOSAT satellites, ERS-1, ERS-2 and Envisat have been providing invaluable data about the Earth, its climate and changing environment. ESA's Living Planet Programme is comprised of two main components: a science and research element, which includes the Earth Explorer missions and the Earth Watch element designed to facilitate the delivery of Earth Observation data for the eventual use in operational services.

**Telecommunications (optional)**

All telecommunication-activities are based on a long-term plan covering the main strategic areas of the Telecommunications department. Any work undertaken with ESA comes under a financial framework called ARTES (Advanced Research in Telecommunications Systems). There are five ARTES programme elements. Each ARTES element defines a set of budgetary rules and regulations.

**Navigation (optional)**

Galileo is a joint effort between ESA and the EU. The global satellite navigation system aims to put Europe at the forefront of this important strategic and economic sector as GPS is today. Galileo is expected to generate countless applications and more than 100,000 highly qualified jobs in Europe. The first Galileo satellite, GIOVE-A, has been in orbit since December 2005. The system is expected to fully operational in 2013.

**Human Spaceflight (optional)**

The International Space Station (ISS) is a partnership with the United States, Russia, Japan and Canada. The ISS-Programme enables scientific research in space and supports the industrial utilization of space. ESA is exclusively responsible for the Columbus laboratory and the Automated Transfer Vehicle (ATV). In the framework of the ISS-Programme, several highlights are scheduled for the near future including launch of the first ATV Mission in March 2008 and the successful delivery of ESA's main contribution to the ISS, the Columbus laboratory in February 2008.

**Launchers (optional)**

ESA's launcher strategy aims to ensure that Europe has the launchers present and in the future to meet institutional and commercial demands, and ensuring that Europe's Spaceport remains a byword for excellence and reliability. Among others, the European Guaranteed Access to Space Programme aims to ensure that Ariane 5 launchers will be available for future European missions.

**Exploration (optional)**

Europe's Space Exploration Programme is called Aurora. Preparations are underway for robotic - and in the future human - missions, targeted primarily at Mars and the Moon. ExoMars is the first Aurora Flagship mission under preparation, with the aim of better characterising the biological environment of Mars.

**Technology (optional)**

ESA's Technology Programme provides the basis for future developments of launchers, satellites and orbital infrastructure. The Technology Programmes focus more and more on ensuring autonomous access to technologies.

Source: [www.esa.int](http://www.esa.int) and University of Stuttgart

## 2. Danish Space Policy and main actors

The intention of the current evaluation of the Danish space policy is to set the platform for developing recommendations for a national space strategy strengthening the Danish space policy.

During the last years, a series of initiatives have however been taken to facilitate the Danish space-prioritisations and activities. Among others, this includes the formation of the Danish Space Consortium in 2005 and the creation of a Danish Space-industry Cluster in 2007.

### **The Danish Space Consortium**

Through coordination and cooperation, the Danish Space Consortium aims to maximise the industrial and scientific benefit of Danish space activities. The aim of the Consortium is to ensure an optimal utilisation of the Danish resources benefitting science, education and industry with the purpose of creating value for society and additional employment. To reach this objective, the Consortium aims to:

- Develop and implement a joint national strategy for space-science
- Advise the Danish Ministry on space-initiatives and –prioritisations
- Activate Danish potentials and possibilities related to the industrial and scientific utilisation of space
- Develop and implement activities strengthening the cooperation between Danish companies and educational and scientific institutions
- Ensure the optimum utilisation of the Danish ESA-engagements

The Consortium advises the Danish Agency for Science, Technology and Innovation with regard to the formulation of the Danish space policy and the prioritisation of the Danish financial investments in ESA.

The Consortium was formed in 2005 and is organised in a steering committee and a series of forums, among others dealing with astronomy, the solar system, earth observation and ISS. The secretariat of the Consortium is hosted by the Space Centre at The Technical University (DTU-Space), which is also the national contact point for the Danish space sector.

### **The Danish Space Cluster**

The Danish Space Cluster was established in 2007 with the purpose of collecting and extending existing Danish knowledge on the industrial possibilities of space-activities. In addition, the cluster aims to build-up knowledge on the application-procedures for the various space-projects in Denmark and abroad.

One of the main reasons behind the establishment of the cluster is to attract political attention to Danish space-industry and to increase the financial contributions to the Danish space-sector.

Currently, the Danish Space Cluster involves 20 Danish companies, and 7 universities and scientific institutions.

## **3. The Danish ESA-engagement**

As mentioned, Denmark was among the founding members of ESA in 1975. Below, an overview is provided of the Danish ESA-engagement during the period from 2000 to 2007.

### **3.1. Danish ESA-contributions from 2000 to 2007**

ESA's mandatory activities are funded by a financial contribution from all Member States, which is calculated in accordance with each country's GDP. The annual Danish ESA-contributions are based upon the agreements between Member States on the general ESA-budget.

With regard to the optional programmes, each Member State decides in which optional programme they wish to participate and the amount they wish to contribute. Although the ESA Convention states that participating states in optional programmes should participate on GDP-level, there is a mutual understanding between the member states that especially smaller countries participate on a lower scale than GDP. Denmark participates in all major optional ESA programmes, including Earth Observation, Launchers, ISS, Microgravity, Aurora (The European Space Exploration Programme), Telecommunications, and Navigation.

Figure 8 below shows the Danish financial contribution to ESA in the period from 2000 to 2007. In this period, Denmark has contributed with a total annual average of 25.5 million EUR, split approximately equally between contributions to the mandatory programmes and the optional programmes.

**Figure 8: Danish financial contribution to ESA from 2000 to 2007, million EUR (2008-prices)**



Sources:

For 2000: The Danish Ministry of Finance, the State Account for the Financial Year 2000  
For 2001 to 2007: The Danish Ministry of Finance, the Finance Act Database

On average, the Danish financial contribution to the mandatory programmes in the period from 2000 to 2007 amounts to 12.5 million EUR. As illustrated in figure 8 above, the Danish contributions to the optional programmes are given granted by the Government every second or third year. On average, the Danish financial contribution to the optional programmes in the period from 2000 to 2007 amounts to 13.1 million EUR.

Table 2 below shows the Danish contribution to the various ESA-programmes (both mandatory and optional) in the period from 1/1-2000 to end of September 2007. The table also shows the total ESA-budget, the Danish share of the total ESA-budget, and the overall status of geographical return of each programme and in total.

**Table 2: Danish ESA-contributions from 2000 to 2007 (million EUR)**

Programme	Danish contribution	Total ESA-budget	Danish share	Surplus	Geographical return
General Budget (mandatory)	10.8	591.6	1.83 %	-2.63	76 %
Scientific Programme (mandatory)	29.4	1,569.9	1.87 %	-11.90	59 %
Earth Observation (optional)	13.5	1,560.8	0.86 %	10.53	178 %
Microgravity (optional)	8.9	295.3	3.03 %	1.25	114 %
International Space Station (optional)	19.7	1,701.1	1.16 %	2.44	112 %
Navigation (optional)	0.5	366.4	0.14 %	0.14	127 %
GSTP & Prodex (optional)	3.8	485.1	0.78 %	0.02	100 %
Launchers (optional)	9.6	3,614.6	0.27 %	-1.18	88 %
Telecommunication (optional)	1.2	1,125.3	0.10 %	0.36	131 %
<b>Total</b>	<b>97.4</b>	<b>11,310.0</b>	<b>0.86 %</b>	<b>-0.97</b>	<b>99 %</b>

Source: The Danish Agency for Science, Technology and Innovation

As the table shows, the Danish contribution to the total ESA-budget on the mandatory programmes amounted to 1.86 % and 0.63 % on the optional programmes. Across mandatory and optional programmes, the Danish contribution constituted 0.86 %. Across programmes, the table shows that Denmark has a surplus of approximately -1.0 million EUR or equivalent to a geographical return of 99 %.

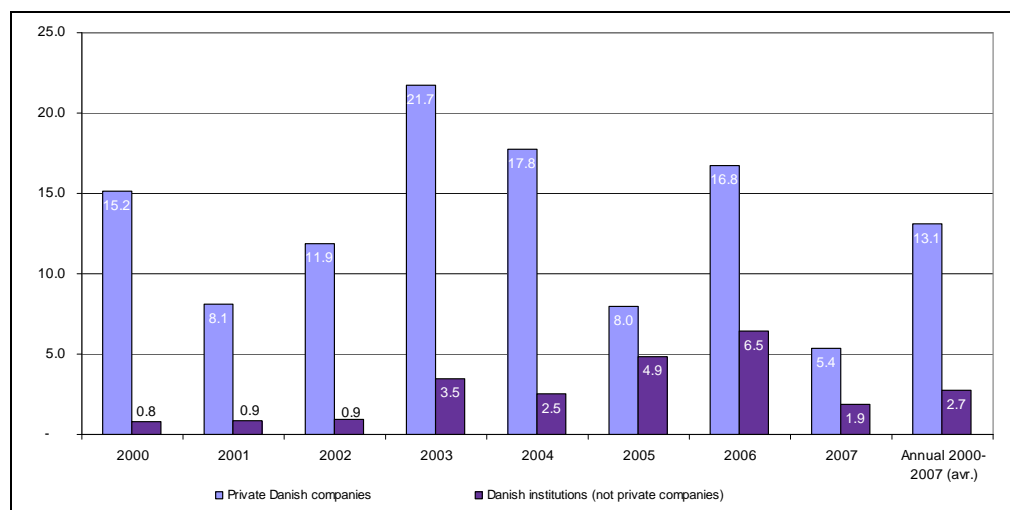
Table 2 above also shows that the Danish contribution to the mandatory programmes in this period amounts to 40 % of the total Danish ESA-contribution. Among the optional programmes, the largest contribution has been given to the ISS-programme, the Earth Observation-programme, and the Launchers Programme. In this period, the Danish contribution to the Microgravity Programme amounts to 9 % of the total Danish contribution, while the contribution to the Technology Programme amounts to 4 % of the total Danish contribution. The contribution to the Telecommunications Programme amounts to 1.2 % of the total Danish contribution, while the contribution to the Navigation-programme amounts to 0.5 % of the total Danish ESA-contribution in this period. It should be noted, that the Danish commitments to Telecommunication Programme and the Navigation-programme GNNS began in 2005/2006, making the Danish contributions to these programmes in the period from 2000 to 2007 relatively small.

### 3.2. Danish ESA-contracts from 2000 to 2007

#### 3.2.1. Contractsums for Danish companies and institutions

In the period from 2000 to 2007, Danish companies and institutions achieved ESA-contracts equivalent to a total sum of 126.7 million EUR, of which 82.7 % were assigned to private companies and 17.3 % were assigned to institutions (public authorities and agencies, universities etc.). On average, this is equivalent to a total annual contractsum on 13.1 million EUR to Danish private companies and a total annual contractsum on 2.7 million EUR to Danish institutions.

**Figure 9: ESA-contracts for Danish companies and institutions (2000-2007), million EUR (2008-prices)**



Source: The Danish Agency for Science, Technology and Innovation

#### 3.2.2. Contractsums for Danish companies by programme

Focusing on the contracts achieved by private Danish companies, the main part of the contracts relate to the Launchers Programme, the General Budget, the Scien-

tific Programme, and the Earth Observation Programme. For each programme, table 3 below shows the total number of contracts assigned to Danish private companies in this period, the total contractsum in millions of EUR, and the average contract-size in EUR.

**Table 3: Contracts assigned to Danish companies from 2000 to 2007 (2008-prices)**

<b>Programme</b>	<b>Number of contracts</b>	<b>Total contractsum (million EUR)</b>	<b>Avr. contractsum (EUR)</b>
General Budget (mandatory)	172	25.6	148,564
Scientific Programme (mandatory)	61	15.9	259,962
Earth Observation (optional)	95	15.0	157,858
Microgravity (optional)	29	9.7	334,012
International Space Station (optional)	92	26.0	282,962
Navigation (optional)	7	0.3	46,358
General Support Technology Programme & Prodex (optional)	13	1.2	94,417
Launchers (optional)	364	10.2	27,961
Telecommunication (optional)	6	0.9	150,318
<b>Total</b>	<b>839</b>	<b>104.8</b>	<b>124,860</b>

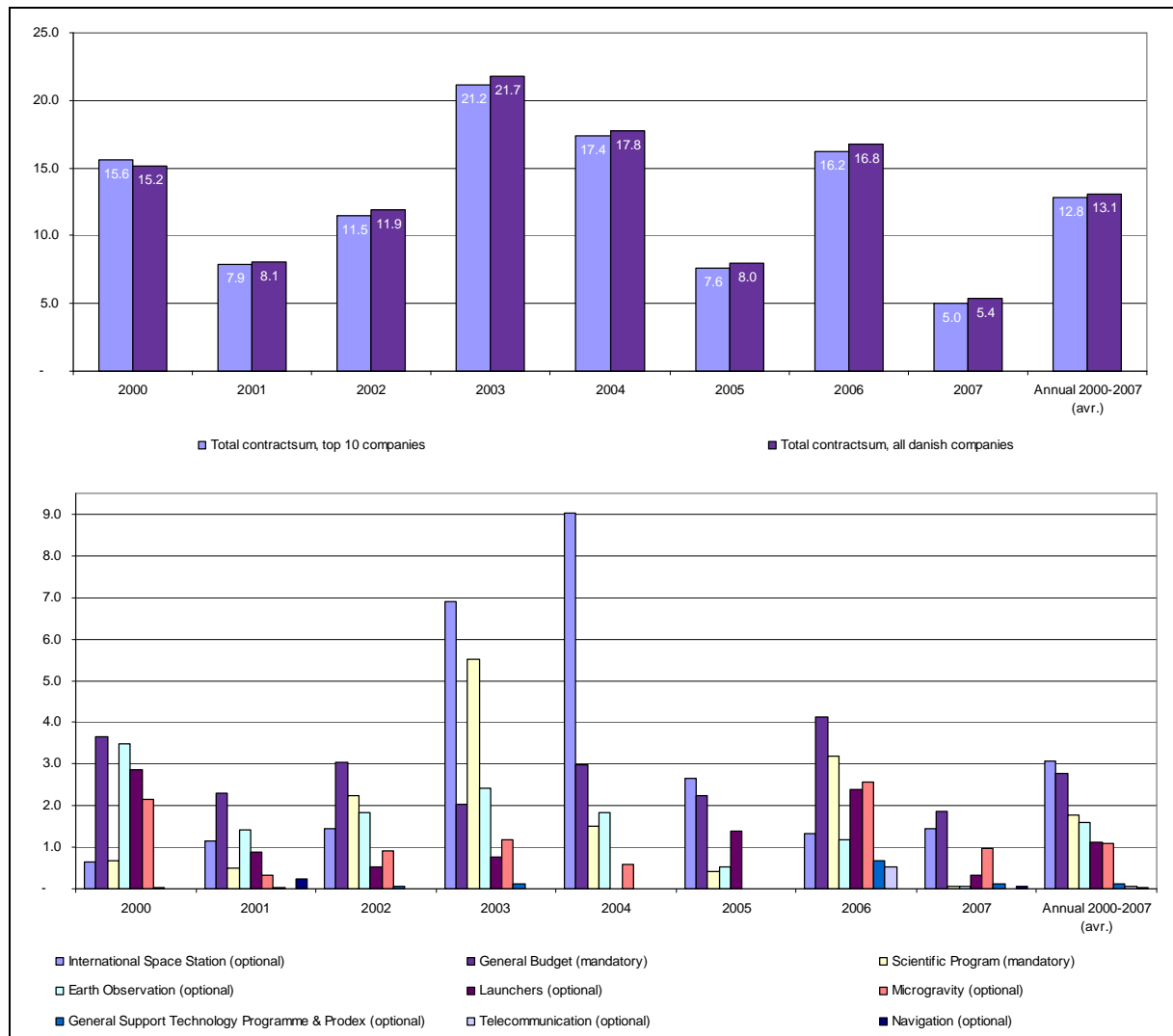
Source: The Danish Agency for Science, Technology and Innovation

In the period from 2000 to 2007, Danish companies were assigned with 839 ESA-contracts amounting to a total contractsum of 104.8 million EUR, corresponding to an average contractsum of approximately 124,860 EUR. The highest total contractsum relate to contracts on the ISS-Programme (26.0 million EUR) and the general budget (25.6 million EUR). Together the contractsums for these two programmes amount to approximately half the total ESA-contractsum among Danish companies in this period. Data from the Danish Agency for Science, Technology and Innovation also show that Danish companies have been assigned with contracts related to ISS corresponding to an average annual amount of 3.3 million EUR, and contracts related to the general budget corresponding to an average annual amount of 3.2 million EUR in this period.

During the period, approximately 30 Danish companies have obtained ESA-contracts, but the data on Danish ESA-contracts also show that the largest contracts are assigned to a limited number of companies. As illustrated in figure 10 below, an average of 98 % of the total contractsum to private Danish companies in this period has been assigned to ten companies, most of which have been assigned to contracts related to ISS, the General Budget, and the Scientific Programme.

Denmark has received contracts worth 14.8 million EUR on the Galileo In Orbit and Validation (IOV) phase and has generated 56 new jobs in Danish industry. The Danish participation in Galileo IOV where covered by a juridical document in 2002 on 5.3 million EUR and is a cooperation between ESA and EU. The Galileo activities are however, not yet covered in the general ESA statistics on contract distribution and therefore not covered in this report.

**Figure 10: Contractsums to top 10 Danish companies from 2000 to 2007, million EUR (2008 prices)**



Source: The Danish Agency for Science, Technology and Innovation

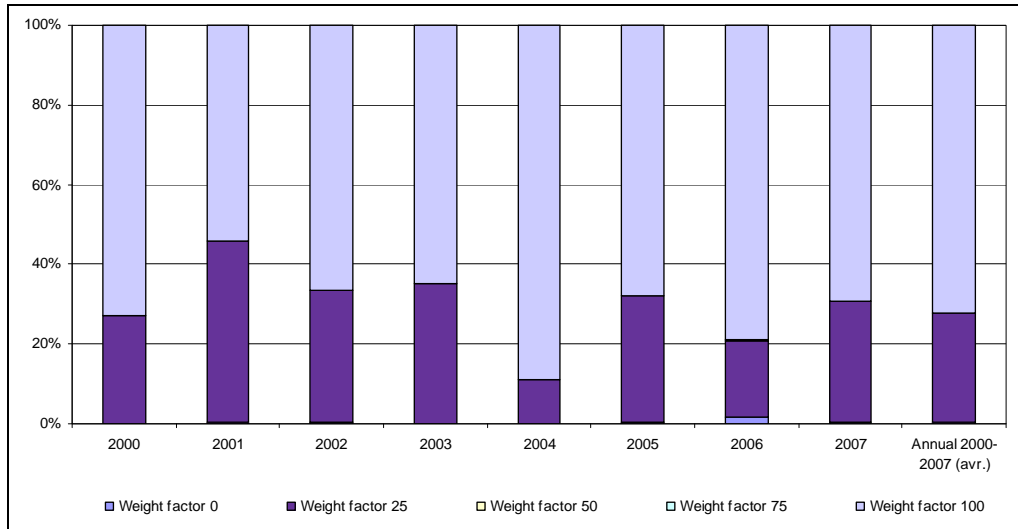
### 3.2.3. "Value" of contracts for Danish companies

All ESA-contracts are assigned with a certain weight-factor, representing the degree of "noble work" required for completing the contract:

- Contracts with a weight-factor of zero, have no space-relevance, and represent for instance contracts related to operating canteens and operating cleaning at ESA-facilities.
- Contracts with a weight-factor from 25 to 75 represent contracts, where the tasks are space-related and require knowledge-skills to some degree. These contracts are typically related to development of software to observation- or administration systems.
- Contracts with a weight-factor of 100 represent tasks, which are considered noble and require development of new technologies.

Figure 11 below shows how contracts have been allocated to Danish companies in the period from 2000 to 2007, according to this weight-factor:

**Figure 11: ESA-contractsums for Danish companies according to weight-factor from 2000 to 2007 (2008-prices)**



Source: The Danish Agency for Science, Technology and Innovation

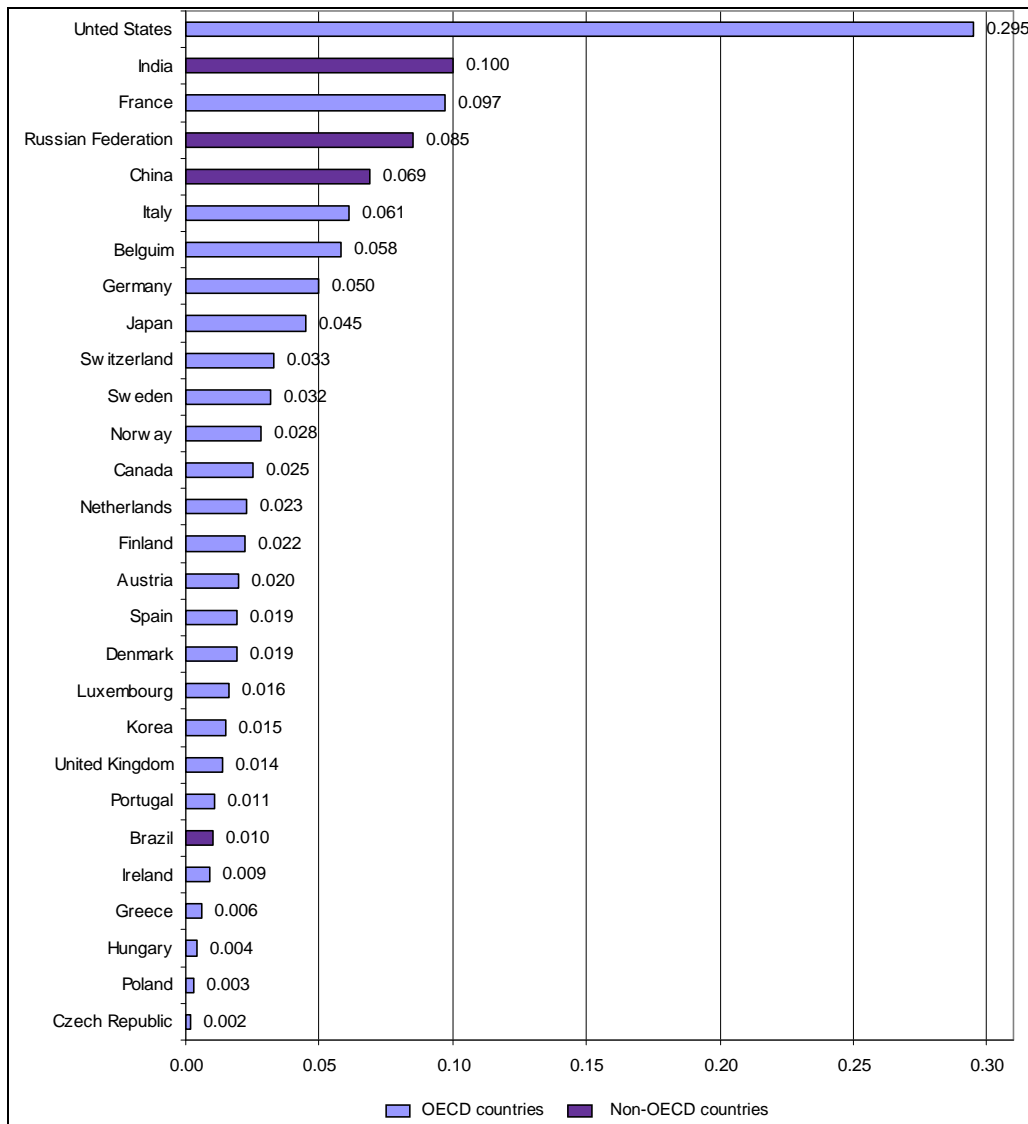
As figure 11 illustrates, approximately 70 % of the contracts (calculated on basis of contractsums) allocated to Danish companies in this period are considered noble and require development of new technologies (weight-factor 100), while approximately 25 % of the contracts represent tasks which are space-related and require knowledge-skills to some degree (weight-factor 25 to 75).

### 3.3. Danish space-budget and ESA-contributions compared to other countries

The Danish space-budget covers the financial contribution to ESA, the financial contribution to the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), and financial contributions to national programmes (civil, military and other programmes (EU, etc.).

In 2005, the total Danish space-budget was equivalent to approximately 0.2‰ of the national GDP. In comparison, the Swedish space-budget was equivalent to approximately 0.3‰ of the Swedish GDP in 2005 and Norway to 0.28‰. Figure 12 below shows the national space-budgets for various OECD- and non-OECD countries as percent of the national GDP in 2005.

**Figure 12: Public space budgets as percent of national GDP, 2005**

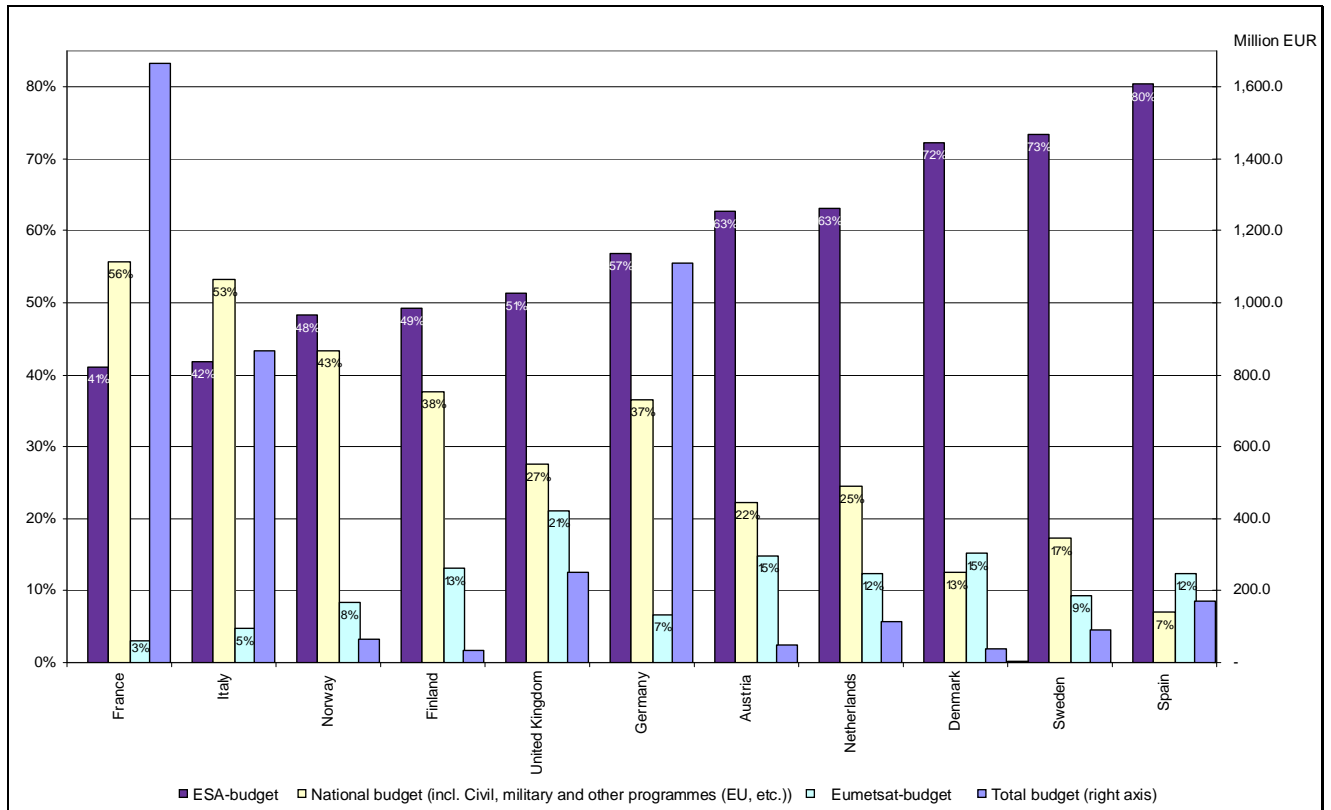


Source: OECD, the Space Economy at a Glance 2007

As mentioned, the estimated annual ESA-budget amounts to 2,904 million EUR (in 2006). Figure 13 below shows the total space budget for 2004 for selected European countries, including Denmark<sup>3</sup>. As figure 13 shows, 72 % of the total Danish space-budget for 2004 was allocated to ESA, while 15 % were allocated to EUMETSAT and 13 % were allocated to national programmes. The allocation of the Danish space-budget is much like the Swedish, where 73 % of the budget was allocated to ESA, 17 % was allocated to EUMESAT, and 9 % was allocated to national programmes. However, it should be noted, as is evident from figure 13, that the Swedish space-budget in 2004 was 2.3 times higher than the Danish budget. In Norway, where the total space-budget is 1.6 times higher than the Danish budget, 48 % of the budget was allocated to ESA, 8 % was allocated to EUMETSAT, and 43 % was allocated to national programmes. The Danish national programme mainly covered the budget for the Danish Space Centre when it was still a governmental research institution and the now closed Small National Satellite Programme.

<sup>3</sup> The figure include only European countries with a budget greater than 25 million EUR

**Figure 13: Breakdown of selected European Space budgets for 2004**



Source: European Space Technology Platform (ESTP), Strategic Research Agenda, 2006

In 2004, France had the highest space-budget (approximately 1,650 million EUR), followed by Germany (approximately 1,110 million EUR) and Italy (approximately 870 million EUR). Among the selected European countries, these three countries also had the highest contribution to the ESA-budget in absolute terms. In 2004, France contributed with approximately 685 million EUR, while Germany contributed with approximately 630 million EUR. Italy contributed with approximately 360 million EUR. The Danish contribution to the ESA-budget in 2004 was mostly comparable to the Finnish and Austrian contributions.

Compared to other European countries, the Danish ESA-contribution takes up a relative large share of the total space-budget. However, compared to other European countries, the total Danish space-budget is relatively low.

## SECTION FOUR: Findings

As mentioned in section two, the analysis of the impacts of ESA-contracts on Danish economy are categorised into direct and indirect impacts, where the direct impacts cover increases in turnover and employment following ESA-contracts, and where indirect impacts cover the effects on turnover and employment following access to new technologies and knowhow, and an increased competitiveness. In this section, the findings from the collection of data from Danish space-companies are presented and analysed according to this model.

### 1. Turnover and employment among Danish ESA-contractors

#### 1.1. Direct impacts

The direct impacts of ESA-contracts on the Danish economy are assessed using the size of Danish ESA-contracts in the period from 2000-2007 and the number of employees required to fulfil these contracts.

With regard to the total contractsum for Danish ESA-contracts, the proportion of the contracts forwarded to foreign subcontractors, is left out in the assessment of the impacts on turnover and employment among Danish ESA-contractors.

Information about the direct impacts of ESA-contracts on the Danish economy have been collected using figures from the Danish Agency for Science, Technology and Innovation on ESA-contracts and contractsums obtained by private Danish companies in the period from January 2000 to end of September 2007.

In addition, the direct impacts have been assessed by conducting in-depth interviews with the Danish companies who have obtained the largest ESA-contractsum in the period from 2000 to 2007. Table 4 below shows the findings with regard to direct turnover and employment among Danish ESA-contractors.

**Table 4: Direct impacts among Danish ESA-contractors from 2000-2007 (2008-prices)**

	<b>ESA-contract-sum/turnover (million EUR)</b>	<b>Employment (FTEs)</b>
International Space Station (optional)	26.3	43
General Budget (mandatory)	24.8	57
Scientific Programme (mandatory)	15.4	35
Earth Observation (optional)	13.7	31
Launchers (optional)	8.3	16
Microgravity (optional)	8.7	6
General Support Technology Programme & Prodex (optional)	1.2	4
Telecommunication (optional)	0.6	1
Navigation (optional)	0.3	1
<b>Across programmes</b>	<b>99.3</b>	<b>192</b>

With regard to total generated direct turnover, the analysis shows that the ESA-contracts have generated a total turnover of 99.3 million EUR. However, as table 4

also shows, the largest direct impacts on Danish ESA-contractors in terms of turnover are found within the ISS-Programme and the General Budget. Together, the associated direct turnover amounts to 51.1 million EUR in the period from 2000 to 2007, equalling approximately half of the generated direct turnover among Danish ESA-contractors in this period.

Similarly, the Scientific Programme, the Earth Observation Programme, the Launchers Programme, and the Microgravity Programme have generated a relatively high turnover among Danish ESA-contractors in this period.

However, it is also clear from table 4 above, that the General Support Technology Programme, the Telecommunication Programme and the Navigation Programme due to low contributions all have generated a low turnover among the Danish ESA-contractors in this period.

With regard to employment, table 4 above shows that the Danish ESA-engagements in these programmes have generated a direct total employment equal to 192 full-time employees in the period from 2000 to 2007. Compared to the generated direct turnover the analysis shows that a contractsum of 1 million EUR on average generates 1.9 full-time employees.

The analysis also shows that some programmes generate a higher number of employees than others, however the information on generated employment following ESA-contracts are in some cases very limited, making analyses at programme-level highly sensitive to the information provided by the companies on relations between turnover and employment.

However, a correlation may exist between the type of contract according to required knowledge-skills and the generated employment, in such a way that knowledge-intensive contracts require high-level expertise and employees with a higher salary, generating a relatively low number of employees.

However, on the other hand, contracts that do not require high-level expertise may also have a relatively low contractsum, making such a correlation invalid. The data provided by companies in this study do not allow for such analyses, making conclusions on relations between contractsum, type of contract and employment unfeasible.

The interviews with Danish ESA-contractors show that some companies primarily base their business on the ESA-contracts and do not base the business to a high degree on the possibilities of utilising competencies acquired through the ESA-assignments to obtain contracts outside ESA.

Other companies however consider ESA-contracts and the direct impacts of the contracts as less important compared to the possibilities of commercialising the competencies acquired through the ESA-assignments on markets outside ESA.

Below two, examples are given on companies who are less focused on the possibilities of utilising competencies on markets outside ESA. An example of a company who focuses on further commercialisation is given in section 1.2 below.

### **Innoware A/S: Further commercialisation is not within focus until now**

Innoware A/S is an independent company established on basis of comprehensive experience from participation in various space programmes. The company was founded 1. June 1995, under the name ARCOM Space, by Bent Christensen, who is the sole owner of Innoware A/S. The company, under the present name, became active late summer 2001.

Innoware produces test-equipment for earth observation missions (primarily software). In May 2007, ESA gave go-ahead to proceed with the first phase in the development of an engineering model of the Lamda (Laser Anemometer and Martian Dust Analyzer) instrument, which can measure wind speed/direction and dust deposition on the surface of Mars.



Innowares involvement in ESA-contracts has until now been highly dependent on alliances and networks, where Innoware mostly participates as subcontractor to other ESA-contractors. The LAMDA-project is the first project, where Innoware acts as ESA-contractor and where Innoware has subcontractors.

The main objective of Innoware has until now been to focus on the ESA-assignments as such, and not on the possibilities of utilising competencies acquired through the ESA-assignments to obtain contracts outside ESA.

### **DAMEC Research: Primary focus is to provide space research and engineering**

Damec Research is a high technology company operating in the area of advanced medical instrumentation and other engineering fields primarily with in Space applications. Damec employs engineers and technicians.

Damec Research ApS was founded in August 1988. The purpose of Damec Research ApS was to support space medical and human physiological research. In April 2003, Innovision A/S transferred all Space related activities into Damec Research ApS and hereby refocused the purpose of Damec to a general space engineering company.



Damec has developed respiratory equipment in several versions, bicycle ergometers and participated in freezer development for Space Shuttles and Space Stations. The various space equipments have led to commercial products used in every day hospital life. This commercialisation is accelerated through Innovision A/S and not through Damec Research ApS, where the primary focus is to provide space research and engineering.

Another characteristic among the interviewed Danish ESA-contractors is that the implementation of the contracts does not involve subcontractors outside Denmark to a notable degree. The use of subcontractors is required in some cases, but the interviews show that these subcontractors are mainly located in Denmark.

## **1.2. Indirect impacts**

The indirect impacts of ESA-contracts on the Danish economy have been assessed using the data on the size of other contracts obtained by Danish ESA-contractors due to access to new technologies and know-how obtained through ESA-contracts, and due to the increased competitiveness achieved through involvement in ESA-contracts.

The assessment also includes the number of employees required to fulfil these contracts. With regard to the total contractsum achieved by Danish ESA-contracts because of increased competitiveness, this includes both contracts obtained on the same market as the ESA-contracts and contracts obtained on other markets.

Information about the indirect impacts of ESA-contracts on the Danish economy has been assessed by conducting in-depth interviews with the Danish companies who have obtained the largest ESA-contractsum in the period from 2000 to 2007. Table 5 below shows the findings with regard to indirect turnover and employment.

**Table 5: Indirect impacts among Danish ESA-contractors from 2000-2007 (2008-prices)**

	<b>Turnover (million EUR)</b>	<b>Employment (FTEs)</b>
General Support Technology Programme & Prodex (optional)	121.4	64
Launchers (optional)	89.1	118
Navigation (optional)	73.8	39
Telecommunication (optional)	66.0	41
Earth Observation (optional)	53.5	62
Microgravity (optional)	49.1	27
General Budget (mandatory)	7.4	2
Scientific Programme (mandatory)	1.3	1
International Space Station (optional)	1.0	0
<b>Across programmes</b>	<b>462.6</b>	<b>355</b>

With regard to total generated indirect turnover, the analysis shows that the ESA-contracts have generated a total turnover of 462.6 million EUR. As table 5 also shows, the largest indirect impact from Danish ESA-contractors in terms of turnover is found on contracts related to the General Support Technology Programme, from which the associated indirect turnover amounts to 121.4 million EUR in the period from 2000 to 2007, equalling approximately 25 % the total generated indirect turnover in this period.

Similarly, ESA-contracts related to the Launchers Programme, the Navigation Programme, the Telecommunication Programme, the Earth Observation Programme, and the Microgravity Programme have generated relatively high indirect turnovers in this period. It is also clear from table 5 above, that the General Budget, the Scientific Programme and the ISS-Programme all have generated a relatively low turnover in this period.

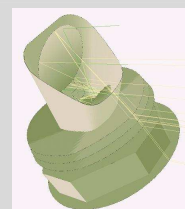
With regard to employment, table 5 above shows that the turnover indirectly generated through the Danish ESA-engagements in these programmes have generated a total indirect employment equal to 355 full-time employees in the period from 2000 to 2007. Compared to the generated direct turnover the analysis shows that a contractsum of 1 million EUR indirectly generates 0.8 full-time employees on average.

As mentioned above, the interviews with Danish ESA-contractors show that some companies consider ESA-contracts and the direct impacts of the contracts as less important compared to the possibilities of commercialising the competencies acquired through the ESA-assignments on markets outside ESA. Below an example is given of a company with focus on further commercialisation.

### **TICRA Engineering Consultants: ESA-contracts enhance competencies**

TICRA was founded in 1971. The company, which is organised as a commercial foundation, mainly supplies software and advisory services regarding e.g. calculations on the transmission of electromagnetic waves from antennas. TICRA has its origin in The Electromagnetic Institute (EMI) at the Danish Technical University. EMI had finished one ESA-contract around 1970, but rejected a second contract since they felt it was too similar to the previous contract and therefore was of limited scientific interest. Three employees from EMI therefore decided to offer their expertise commercially and founded TICRA.

In the first years, the company based its business solely on ESA-contracts concerning the development of numerical methods for electromagnetic modelling. However, since then TICRA has expanded its businesses to other markets and today, the turnover from ESA-contracts represents only a minor part of the total turnover (about 20 %). TICRA has obtained contracts with companies like Boeing and Lockheed Martin – delivering software for reflector antenna design, as well as customized modifications of this software.



ESA-contracts are important to TICRA even though they are not the main source of turnover. The contracts give capital to conduct important research and ESA supplies innovative ideas and the opportunity to consult skilled ESA-scientists. The contracts are rarely a source of direct profit, that is, the costs are often higher than the contractsum. Yet, the contracts can be profitable since they enhance TICRA's general knowledge and competencies, which can indirectly bring about profits. The involvement in the space industry further facilitates the recruitment of qualified employees.

TICRA is an example of a company, which was based on ESA contracts in the beginning, but has become increasingly independent of these contracts. The company has successfully used its competencies to obtain contracts outside ESA. Moreover, the company displays the positive indirect effects of the ESA-contracts on the companies' general qualifications.

The inclusion of turnover and employment from spinoff-companies in the model has a significant impact on the calculations of the economic impacts of the Danish ESA-engagements. However, it is clear from the interviews with these companies, that the very existence of these spinoff-companies is rooted in the ESA-engagement.

As these spinoff-companies never would have been founded without the Danish ESA-engagements, the turnover and employment generated in these spinoff-companies have been included in the assessment. However, it is also clear from the interviews that the developments of these spinoff-companies after the establishment, also depend on other factors than the ESA-engagements. Current turnover and employment in these spinoff-companies cannot be 100 % credited to the ESA-contracts.

## **2. Turnover and employment among Danish subcontractors**

As mentioned above, the direct impacts of ESA-contracts on the Danish economy are assessed using the size of Danish ESA-contracts in the period from 2000-2007 and the number of employees required to fulfil these contracts. With regard to the total contractsum for Danish ESA-contracts, the proportion of the contracts forwarded to foreign subcontractors, are left out in the assessment of the impacts on turnover and employment among Danish ESA-contractors.

Companies generally use suppliers when the activity is expensive or difficult to perform in-house and a more specialised company sells it at a low price. In the space

industry, many components are highly specialised. Therefore, no or few companies can produce these at a low cost.

Broadly, two types of suppliers to Danish space companies have been identified:

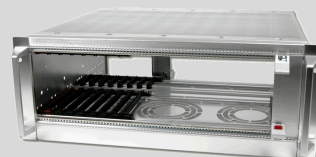
- First, some suppliers have specialised in delivering components for the space industry and similar industries. These companies gain competencies through deliveries to Danish companies with ESA-contracts, and these competencies are an advantage when delivering to foreign companies with ESA-contracts and companies on other markets.
- Second, some companies deliver components, which are not specialised for the space industry and similar industries. This means that the companies gain no additional competencies from deliveries to companies with ESA-contracts.

A few companies have specialised in deliveries to the space industry and have therefore gained a spinoff effect from delivering to the Danish companies with ESA-contracts. However, some companies have very few orders with the space industry and gain no spinoff from these orders. Below, examples of each of these types of companies are given.

#### **JJ Elektronik & JJ Mekanik: Design, test and production of tailored cabinets**

JJ Elektronik & JJ Mekanik has more than 30-years of experience as supplier, partner and co-manufacturer of electronics packaging, such as cabinets and system integration. Clients cover both Danish and foreign companies working in electronics. Using these experiences, the company develops individual solutions based upon sub-components from Elma Electronic. Through these experiences, the company has developed unique competencies with regard to vibration, chock, cooling etc. but also with regard to quality management.

In 2007, a Danish space-company ordered JJ Elektronik to design, test and produce a 19" cabinet, on basis of a series of complex specifications charted by the Danish space-company. In 2007, this cabinet provided a sale of approximately 23,000 EUR.



The total space-related sale in 2007 amounted to approximately 1 % of the company's total turnover in 2007. This assignment provided an employment equivalent to 2 man-months. The company does not expect the assignment to generate additional space-related assignments, but acknowledge the branding-value in developing products suitable for space. The company expects to use these cases in their marketing activities, but do not expect further spinoff of these projects in the near future.

### **Eltronic: Production of a new robot lane system, enhancing manufacturing practices**

Eltronic works in four areas of business: manufacturing engineering (design and construction of new machines and technologies), manufacturing service (daily operation and maintenance of the production machinery), manufacturing intelligence (decision-making based on validated data directly from the lines of production), and manufacturing automation (automation of processes, optimizing and adjustment of workflows).

In 2005, Eltronic was ordered by Force Technology Denmark (ESA-contractor) to design and construct a new robot lane system, which could provide a high accuracy for welding of rocket nozzles. The result is a robot welder, which can position with an accuracy of 0.05 mm on all three levels over a length of 6 metres. The design and construction of the robot provided Eltronic with a total contractsum of approximately 400,000 EUR, requiring an employment equivalent to approximately 4 man-years.



Through this assignment, Eltronic was able to enhance existing capabilities with regard to manufacturing practises, enabling Eltronic to enhance the Danish model for Good Automated Manufacturing Practice (GAMP). Consequently, Eltronic has since 2005 been able to promote its capabilities regarding manufacturing practises, which have resulted in new assignments. The company is currently in negotiation with a Spanish company on design and construction of a new robotic system. According to Eltronic, these negotiations were not possible without having completed the assignment to Force Technology and not having increased its capabilities regarding manufacturing practises. It is expected that these negotiations will result in a total order worth approximately 1.5 million EUR.

### **3. Danish companies without direct access to ESA-contracts**

As mentioned in the introduction, the current evaluation also comprises Danish companies engaged in space-related activities, but who do not have direct contracts with ESA. A series of interviews with such Danish companies have been completed in order to collect information about their assessment of the Danish ESA-engagement as such, and what it means for the space-activities in these companies that they do not have direct access to ESA-programmes and -contracts.

A number of factors make it difficult for Danish companies with space-activities to obtain access to ESA-contracts:

- Most of the interviewed companies have space-activities outside the ESA-programmes supported by the Danish ESA-investments, excluding these companies from access to ESA-contracts.
- Even though some of the interviewed companies have space-activities covered by the Danish ESA-engagement, their access to ESA-contracts is still very limited as the Danish ESA-market, similar to other ESA-markets, is limited by national contributions and characterised by a fierce, technology-driven competition. Some Danish companies do not have sufficient references from previous space-projects to obtain future ESA-engagements.
- In some cases, the interviewed companies find the administrative procedures related to tendering of ESA-contract very resource demanding, making the access to ESA-contracts through the tendering-procedure too overwhelming.

- In addition, some of the interviewed companies find the ESA-market so complex that the companies do not have the resources needed to engage the market in an effective way.
- Finally, some of the interviewed companies are excluded from ESA-contracts, as production-facilities are geographically located outside the ESA-coverage.

Some of the interviewed companies also note that other markets than ESA can be difficult to access. For instance, one of the interviewed companies mentions that local barriers restrain access to Asian markets.

The limited direct access to ESA-contracts for these companies has different impacts on the interviewed companies. Most companies mention that the limited access to ESA-contracts entails a lower turnover and growth than otherwise forecasted, and that limited access to ESA-contracts makes it difficult to compete against other European companies engaged in similar activities, as these companies gain a competitive advantage through increased research and development activities due to their involvement in ESA-activities. Some of the interviewed companies also mention that the limited access to ESA-contracts makes it difficult to obtain space-related references, which is otherwise seen as an important brand when accessing other markets.

To overcome the difficulties of acquiring direct access to direct ESA-contracts, these companies choose other means to get access to the European space-market. Most of the interviewed companies engage in partnerships with other European institutions or companies with ESA-activities.

Some of the interviewed companies engage in partnerships or projects with universities around Europe with proven ESA-credentials, while other companies cooperate with European companies engaged in activities related to space, for instance companies engaged in the aircraft industry.

Some of the interviewed companies also make use of other institutional settings, such as the Danish Space Cluster, in order to enhance contacts to other Danish companies engaged in space-activities and to learn from experiences from these companies.

Finally, some of the interviewed companies have had contact with the Danish Agency for Science, Technology and Innovation to learn about Danish ESA-engagements and possibilities. In this context, some of the interviewed companies express the need for additional support systems for small space-companies, as more information is needed on the ESA-system as such and on Danish ESA-possibilities for small companies.

#### **4. Impacts of ESA-contracts on Danish Economy (spinoff)**

The economic impacts of the Danish industrial cooperation with ESA are determined by a spinoff-factor, which regards the Danish ESA-contribution as an investment and shows the return on that investment. The spinoff-factor goes across direct and indirect impacts on Danish ESA-contractors and direct impacts on Danish subcontractors to these companies.

For each programme and across programmes, Table 6 below shows the ESA-contractsum obtained by Danish companies included in the analysis from 2000 to 2007 including dead-weight loss from tax distortion, the total turnover generated

by these contracts (direct and indirect) from 2000 to 2007, and the determined spinoff-factor, representing the size of the return compared to the investment:

**Table 6: ESA-contractsum, generated turnover and spinoff-factors, by programme (2000-2007)**

<b>Total</b>	<b>Direct impacts</b>	<b>Indirect impacts</b>	<b>Total spin-off</b>	<b>Investment</b>	<b>Spinoff-factor</b>
General Support Technology Programme & Prodex (optional)	1.2	89.1	90.4	1.5	60.0
Launchers (optional)	8.3	53.5	61.8	12.1	5.1
General Budget (mandatory)	24.8	121.4	146.2	29.8	4.9
Scientific Program (mandatory)	15.4	73.8	89.2	18.5	4.8
Earth Observation (optional)	13.7	66.0	79.7	16.6	4.8
Navigation (optional)	0.3	1.3	1.6	0.4	4.1
International Space Station (optional)	26.3	49.1	75.4	32.8	2.3
Telecommunication (optional)	0.6	1.0	1.6	0.7	2.2
Microgravity (optional)	8.7	7.4	16.1	11.6	1.4
<b>Across programmes</b>	<b>99.3</b>	<b>462.6</b>	<b>561.9</b>	<b>124.0</b>	<b>4.5</b>

First, table 6 shows that **across programmes**, the ESA-contractsum obtained by Danish companies included in the analysis from 2000 to 2007 amounts to 124 million EUR<sup>4</sup>, that the turnover created by these ESA-contracts (direct impacts) and the turnover generated by these contracts on new or existing markets (indirect impacts) amounts to approximately 562 million EUR. The analysis shows that each million EUR of Danish contributions to ESA generate a total turnover of 4.5 million EUR.

Second, table 6 shows that the economic impacts differ according to the **various ESA-programmes**, as some types of contracts facilitate higher spinoff-possibilities than other types of contracts. As table 6 clearly shows, the analysis shows that each million EUR of Danish contributions to the General Support Technology Programme generate a total turnover of 60 million EUR.

This spinoff-factor, and the total spinoff-factor, is strongly influenced by the fact that the model includes turnover from spinoff-companies. However, as mentioned in the findings above, it is clear from the interviews, that the very existence of these spinoff-companies is rooted in the ESA-engagement, and that these spinoff-companies never would have been founded without the Danish ESA-engagements.

However, it is also clear from the interviews that the developments of these spinoff-companies after the establishment, also depend on other factors than the ESA-engagements. In this case, it should be noted that the Danish ESA-contribution to this programme is relatively small, making the additional turnover generate a striking spinoff-factor for this programme.

An exclusion of spinoff-companies in the analysis shows that the spinoff-factor across programmes will drop to 3.7, while the spinoff-factor related to the General Support Technology Programme will drop to 6.7.

<sup>4</sup> This includes the dead-weight loss from tax distortion.

In addition, table 6 shows that the Launchers Programme, the General Budget, the Scientific Programme, and the Earth Observation Programme all generate a relatively high spinoff-factor. On the other hand, the Navigation Programme, the ISS Programme, the Telecommunication Programme and the Microgravity Programme generate a relatively low spinoff-factor, as the Danish companies commercialise ESA-contracts on these programmes to a relatively low extent.

Regarding the assessment of the indirect impacts by programme, it should be noted that in some cases, it has not been possible clearly to ascribe the indirect effects to a single programme. In these cases, the impacts have therefore been distributed among the programmes proportional to the distribution of the company's contractsum.

Third, the analysis shows that the dead-weight loss of tax distortion has a significant impact on the total spinoff-factor. To get a picture of the overall effect of including the dead-weight loss of tax distortion, table 7 below summarises the spinoff-factor with and without this dead-weight loss, and with and without inclusion of spinoff-companies:

**Table 7: Spinoff-factor with and without spinoff-companies and tax distortion**

	<b>With spinoff-companies</b>	<b>Without spinoff-companies</b>
<b>With tax distortion</b>	4.5	3.7
<b>Without tax distortion</b>	5.4	4.5

As table 7 shows, the total spinoff-factor (taking spinoff-companies into the analysis) will rise from 4.5 to 5.4 if the dead-weight loss of tax distortion is excluded from the analysis. If the spinoff-companies are excluded from the analysis, the total spinoff-factor will rise from 3.7 to 4.5 if the dead-weight loss of tax distortion is excluded from the analysis.

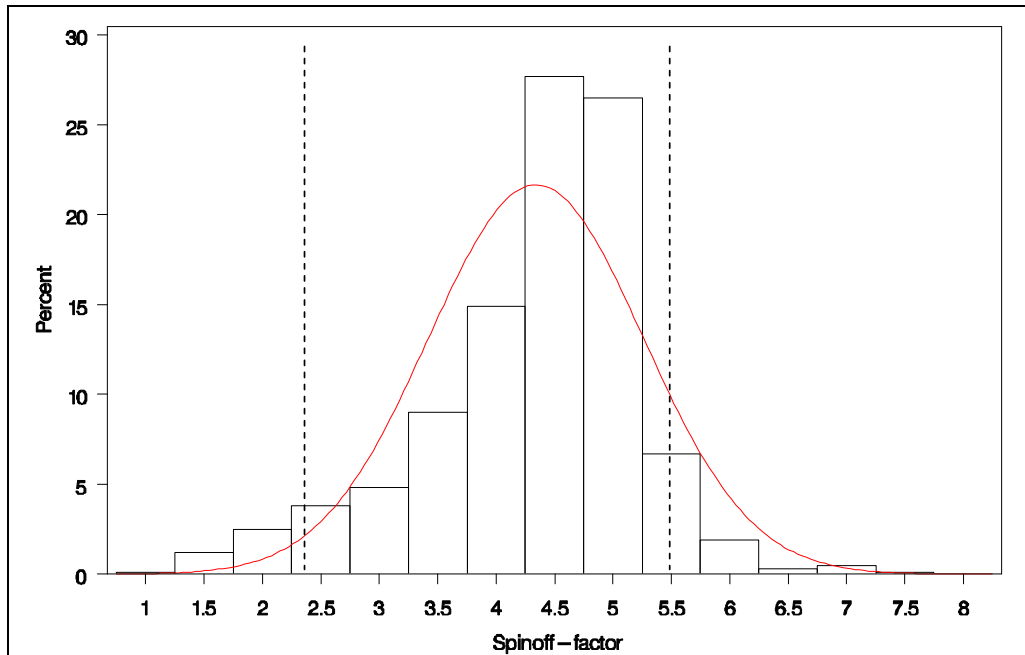
## 5. Sensitivity analysis

The input used in the assessment of the economic impacts is of course subject to some sources of uncertainty, in this case with regard to the estimations of indirect impacts in terms of increased turnover and employment. The analyses show substantial differences in the spin-off factor across programmes, making the size of the spinoff-factor dependent on perhaps a few companies. For this reason, a sensitivity analysis has been conducted to understand how dependent the spinoff-factor is on the composition of companies in the Danish ESA-engagement.

One way of assessing the sensitivity of the data is through a bootstrap analysis. The bootstrap analysis creates new samples based on the existing sample, by a random draw of existing observations (companies), with replacement, from the original sample. In this case, this means that each company can appear more than once in any new sample, while other companies are left out of some of the new samples. The variable analysed in this case is the sum of the spinoff-factors, weighted by the relative size of the company's ESA-contracts. In the original sample, this sum is equal to the overall spinoff-factor.

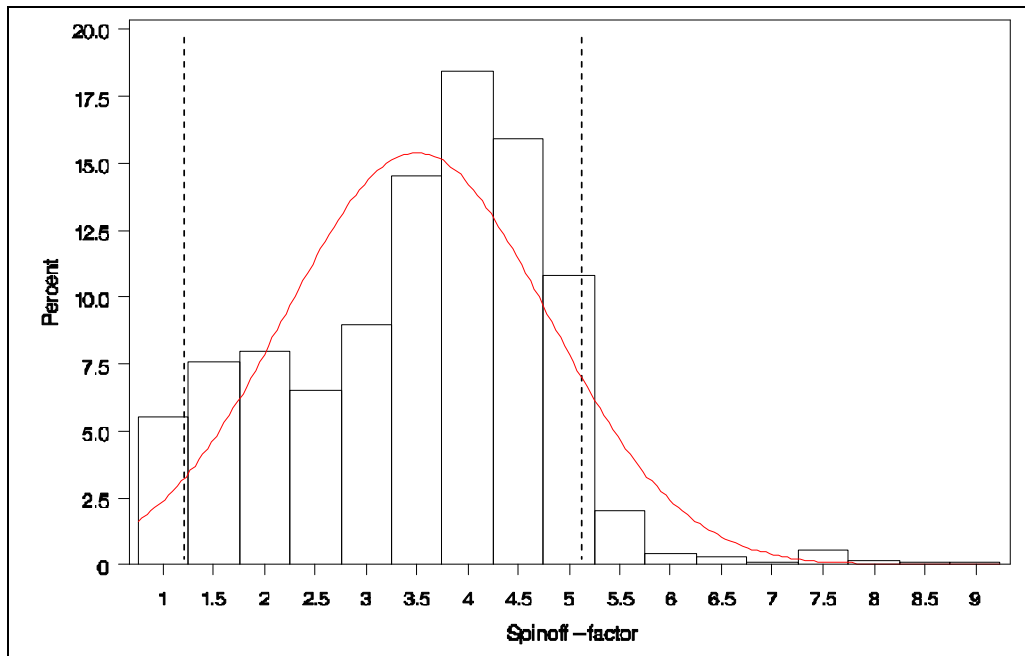
In figure 14 below the block diagram shows the empirical distribution of the spinoff-factors in the bootstrap resampling, while the red line shows a normal distribution with the same mean and standard variation. Formal tests shows that the empirical distribution is not normal distributed on a 5 percent confidence level. Therefore, the dotted lines represent the 5 and 95 % confidence interval from the empirical distribution.

**Figure 14: Distribution of spinoff-factor in bootstrap resampling (1,000 replications)**



As figure 14 illustrates, it is evident that there is some variation in the spinoff-factor when the companies are randomly sampled. However, as figure 14 also shows that the spinoff-factor with 90 % confidence lies between 2.4 and 5.5. Figure 15 below show the same analysis, but without including spinoff-companies.

**Figure 15: Distribution of spinoff-factor in bootstrap resampling without spinoff-companies (1,000 replications)**



As figure 15 illustrates, the spinoff-factor excluding influence of spinoff-companies with 90 % confidence lies between 1.2 and 5.1.

## **SECTION FIVE: Conclusions and recommendations**

It is clear from the study that the Danish involvement and cooperation with ESA is very important for enhancing the possibilities for the Danish companies to maintain and accelerate Danish knowledge-intensive competences within the space sector and other industrial sectors. Across the Danish ESA-priorities, each million EUR of Danish contributions to ESA generates a total turnover of 4.5 million EUR, which is enabled through Danish companies' direct involvement in ESA-projects and through further commercialisation of products and technologies developed through ESA-engagements.

These findings are in line with a Norwegian study, showing that each million EUR of Norwegian contributions to ESA generate a total turnover of 5.4 million EUR (in 2006). Considering the tax distortion, which is not included in the Norwegian study, the Norwegian findings are even more similar to the Danish findings.

For Danish companies operating primarily in the space sector, the Danish involvement and cooperation with ESA provides a platform for developing and advancing existing competencies due to the involvement in ESA-projects. Excluding the effects from spinoff-companies mainly operating in other sectors than the space sector, the analysis shows that each million EUR of Danish contributions to ESA generate a total turnover of 3.7 million EUR.

The return of ESA-contributions to Danish companies ensures an increased turnover in these companies. Only a small fraction of this turnover is spent with foreign suppliers and therefore almost all of the ESA-contributions are returned to the Danish economy. With regard to total generated direct turnover, the analysis shows that the ESA-contracts have generated a total turnover of 99.3 million EUR among the Danish companies covered by the study in this period. The largest direct impacts on Danish ESA-contractors in terms of turnover are found within the ISS-Programme and the General Budget. Together, the associated direct turnover amounts to 51.1 million EUR in the period from 2000 to 2007, equalling approximately half the generated direct turnover among Danish ESA-contractors in this period. Similarly, the Scientific Programme, the Earth Observation Programme, the Launchers Programme, and the Microgravity Programme have generated a relatively high turnover among Danish ESA-contractors in this period. However, the General Support Technology Programme, the Telecommunications Programme and the Navigation Programme all have generated a relatively low turnover among the Danish ESA-contractors in this period. With regard to employment, this turnover has directly generated a total employment equal to 192 full-time employees in the period from 2000 to 2007. Compared to the generated direct turnover the analysis shows that a contractsum of 1 million EUR on average generates 1.9 full-time employees.

The analysis also shows that increased competencies within space activities through involvement in ESA-projects facilitate the development of competencies in other sectors than the space sector. Interviews with Danish space-companies have shown some examples, where the involvement in ESA-projects provides a platform for commercialising competencies in other sectors through establishment of new companies (spinoff-companies). The Danish involvement and cooperation with ESA not only facilitates a platform for maintaining and accelerating Danish knowledge-intensive competences within the space sector. It also provides a platform for generating competencies in other sectors.

The larger Danish companies (mainly ESA-contractors) experience positive impacts of the Danish ESA-engagements through their involvement in ESA-projects. More-

over, the study shows that these companies often use the participation in ESA-projects as a platform for marketing and branding of the competencies of the company. While the Danish ESA-activities has a positive impact on larger Danish companies, smaller Danish companies (mainly suppliers to Danish ESA-contractors) also experience a positive impact, as the involvement in ESA-projects often facilitates or even requires development of high-end competencies and products, generating further possibilities for these companies on other markets. Interviews with Danish subcontractors have shown some examples, where the involvement in ESA-projects provide a platform for commercialising competencies in other sectors through development of high-end products and high-quality management processes.

With regard to total generated indirect turnover, the analysis shows that the ESA-contracts have generated a total turnover of 462.6 million EUR. The largest indirect impact from Danish ESA-contractors in terms of turnover is found on contracts related to the General Support Technology Programme, from which the associated indirect turnover amounts to 121.4 million EUR in the period from 2000 to 2007, equalling approximately 25 % the total generated indirect turnover in this period. Similarly, ESA-contracts related to the Launchers Programme, the Navigation Programme, the Telecommunications Programme, the Earth Observation Programme, and the Microgravity Programme have generated relatively high indirect turnovers in this period. However, the General Budget, the Scientific Programme and the ISS-Programme all have generated a relatively low turnover in this period. With regard to employment, the analysis shows that ESA contracts indirectly have generated a total employment equal to 355 full-time employees in the period from 2000 to 2007. Compared to the generated direct turnover the analysis shows that a contractsum of 1 million EUR indirectly generates 0.8 full-time employees on average.

The analyses conducted in this study also show that the model chosen for assessing the importance of the Danish membership for Danish companies, has provided sufficient information to analyse the economic impacts of the Danish industrial cooperation with ESA. However, further developments of the model may provide additional information in areas, which have a significant influence on the overall estimation of the impacts. For instance, information on the influence of company-specific circumstances may provide a more detailed assessment of the economic impacts, especially with regard to indirect turnover and employment. It is recommended that further developments of the model are conducted in order to provide more detailed assessments of impacts at programme-level.

Furthermore, continuous updates of the economic impact of Danish ESA-investments should be conducted in order to monitor the economic impacts of changes in Danish ESA-investments and developments in Danish space-companies.

## **ANNEX: List of interviewed companies**

**ESA-contractors participating in in-depth interviews – companies who have obtained the largest ESA-contractsum in the period from 2000 to 2007:**

- Alcatel Space Denmark A/S (Chresten Overbeck)
- Damec Research ApS
- FORCE Technology
- Innoware A/S
- Rovsing A/S
- Terma A/S
- TICRA

**ESA-contractors participating in telephone interviews – companies who have obtained the largest ESA-contractsum in the period from 2000 to 2007:**

- DHI Water & Environment
- Gatehouse A/S
- GRAS A/S
- Kirkholm Maskiningeniører A/S
- Xperion ACE A/S

**Danish sub-contractors to ESA-contractors (telephone interviews):**

- Eltronic A/S
- Flux A/S
- JJ Elektronik A/S
- GPV Printca A/S

**Danish companies engaged in space-related activities, but who do not have direct contracts with ESA (telephone interviews):**

- Thrane & Thrane A/S
- Gomspace ApS
- Ohmatex ApS
- IR Denmark ApS
- Arla Foods AmbA