Economics

Evaluation of Norwegian Space Programs

A review of the economics and public policies for development of space capabilities in Norway

Evaluation commissioned by the Ministry of Trade and Industry

July 2012

pwc

The information used by PwC in preparing this report has been obtained from a variety of sources as indicated within the report. While our work has involved analysis of financial information and accounting records, it has not included an audit in accordance with generally accepted auditing standards, due diligence or agreed-upon procedure of the Company's existing business records, not a qualified legal opninion of compliance with applicable laws and regulations or a forensic investigations of detailed proceedings. Accordingly we assume no responsibility and make no representations with respect to the accuracy or completeness of any information provided to us.

By its very nature, evaluation work cannot be regarded as an exact science, and the conclusions arrived at in many cases will of necessity be subjective and dependent on the exercise of individual judgment. There is, therefore, no indisputable single value and we normally express our assessment as falling within a likely range. The statements in this report express PwC opinion at the time the evaluation was performed. We reserve the right to change opinion without notice.

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Objective of Norwegian space activities

To provide substantial and persistent contributions to:

- *wealth creation*
- *innovation*
- *knowledge development*
- *environmental- and public safety*

Executive summary

The objective is to evaluate the performance of Norwegian space programs and in particular participation in ESA, the Radarsat agreement and the national support funds. Its focus is on whether the programs contribute to the accomplishments of the space policy objectives; identifies impacts and socioeconomic benefits of the programs, and suggests areas of improvement. Scientific activities were not part of the assignment. The review is commissioned by the Ministry of Trade and Industry and delivered in July 2012. The main conclusions can be summarized as follows.

Important aspects of the model for public support work. The national service programs, matched with special initiatives such as Radarsat and AIS satellite deliver cost-efficient capabilities for public sector. There is a positive interaction between the important instruments such as national programs for industrial development and ESA programs. ESA participation also enhances capabilities of Norwegian business. There are ripple effects, meaning that contracts from ESA results in additional sales. There are differences between segments. Other services results in highest ripple effects and this is growing. The space center leadership and expert advisory capacities are widely appreciated among business and government alike. There are also several other areas of strengths and successes observed including positive contributions from the support schemes:

a) Considerable global market share in mobile satcom services and earth observation (largely optical and radar images tracking services).
b) Rapid growth and strength among several companies across all of the value chain and especially in the mobile satcom and earth observation services segments.
c) Growth and gaining share also for some companies in the space manufacturing segment. Albeit smaller as share of turnover in Norway and with low overall worldwide market shares. There are high levels of public support here.
d) Highly successful public sector programs to enhance marine monitoring and surveillance capabilities that shows real world impacts. Emerging valuable programs for land use and some are institutionalized.

At the same time, the evaluation points to a number of areas were developments are a concern and warrants rethinking and further deliberations. Adjustments and

a) Overall, sales are not increasing and world wide market shares are declining. The sector is declining as share of GDP, as share of service exports and product exports. There are few new entrants to the space segment over the last decade. Among those firms supported there is not growth in space related labor. Structural shifts in ownership to foreign conglomerates have uncertain impacts. Ground equipment producers have has lost much sales volume and market share. Public expenditure on space are rising faster than commercial sales.
b) Support is highly concentrated among few repeat actors. It is further concentrated in the space segment and for ground equipment producers. This is in accordance with classical technology development strategy to support early stage development, but is a more questionable match with growth potential and strength.
c) External political environment including EU/ESA convergence is likely to be more challenging with impacts both on access to decision making arenas in Europe and market access for business. External market developments show commercialization and growth of new service concepts worldwide. Norwegian policies are little adapted to this environment and a rethink of commercialization strategies and the public role could be helpful.

Summary

Report

This is the short version of the report. Important patterns of development, findings, analysis and observations are presented here over the next thirty pages.

More in-depth analysis and data work, and a more nuanced discussion is presented in a detailed analysis attached to this. Methodologies and appropriate references to data sources are also found in the detailed analysis.

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Objective, scope, and methodologies of the review

The objective

The objective is to evaluate the participation in ESA, the Radarsat agreement and the national support funds. The evaluation should also provide a basis for assessing the socio-economic benefits of the programs. The review is commissioned by the Ministry of Trade and Industry and delivered in July 2012. The ministry highlights three themes of particular importance:

-Whether the programs contribute to the accomplishments of the space policy objectives;

-Assess the socioeconomic benefits of participation in the programs, and

-Identify areas of improvement.

The scope

The request from the Ministry outlines a number of areas and detailed questions, all relevant to evaluate the past performance of the space programs, as well as to point the way ahead. There is a range of policy instruments to support space activities in Norway. This work is to focus on the following three:

1. Participation in the ESA. ESA mandatory and the Optional program, participation in which should reflect the Norwegian priorities.
2. The funds managed by the National Space Center for dedicated programs for industrial development and public service development including special initiatives such as AIS and Radarsat to enhance public sector capabilities.
3. Purchasing of radar satellite data through a separate agreement with Canadian firm MDA.

Interactions between these instruments are important and we will explore those when relevant to inform the analysis. The focus the last ten years and if data is available, even longer back. There are long lead times in development of space activities and the fruition of policies may not be seen for decades. The Ministry mandate focuses on the years 2004-2010. Science is an integral part of the space activities. There are many space science activities in Norway and meaningful analysis of this needs to be holistically. That is beyond this work.

Methodology and data

The evaluation combines indepth interviews with considerable quantitative analysis of the support schemes and the sector in general. This includes:

Administrative and business data: Considerable quantitative data have been used. The data are collected by the MoTI, NSC and ESA for different purposes but has some overlaps. As in all administrative datasets there are certain inconsistencies, broken time series and varying sample sizes. We have integrated this as best as possible and supplemented with information from corporate reports, financial statements and press and investor information. In total this is robust though there are minor unresolved inconsistencies. The evaluation also uses company specific information drawn from publically available sources. We have had access to non-public sensitive information of single companies and this has been important to calculate certain aggregate numbers.

Document analysis: Nearly 1500 pages of relevant documents has been reviewed. Important documents includes annual reports and budget proposals, company annual reports, international studies, and a range of market analysis. This also includes information from press releases, investor relation reporting, financial analysts, as well as quarterly and annual reports.

Interviews. The analysis is further strengthened by interviews of actors across all segments of the value chain, private and public alike.

The **value chain for** space related activities can be defined in several ways. We have based the analysis upon prevailing standards in market analysis and official publications. This is adapted to the Norwegian context where appropriate.

To utilize **international expertise** in the area and also to avoid any ties or conflict of interests with Norwegian space programs, the report has been develop din English. The report is translated into Norwegian and both versions made available.

Overview of developments

Activity has declined in real terms but may be reemerging. Turnover declined from 2003 but shown real growth in the last few years. Activities increased strongly prior to 2003 and have since leveled off. Total activity in this figure includes both institutional and commercial activities, but excludes consumer TV i.e.. Canal Digital and Viasat. The consumer segments has not been a focus of the Norwegian space programs.

Activity may have contracted as much as 25 percent between 2003 and 2007 if adjusted for producer price inflation (PPI). The extent of the decline depends upon how price inflation is adjusted for.

Services constitute the largest segment and has increased in significance over time. Product manufacturing is about 20 percent of total in 2010.

The decline is confirmed when comparing against other core economic parameters.

The sector constitutes a little over 0,2 percent of GDP in 2010, a reduction of about 33 percent from 2003. Measured against the less oil dependent GDP Mainland numbers we find the same pattern of decline albeit with slightly higher numbers.

The export ratio in this sector is quite high, but we find a decline measured against other Norwegian exports. Measured against other services exports we also find a decline of space related exports since 2003. Compared against other exports of manufactured goods, we find an even more significant drop of about 43 percent since 2003. This share has declined since the late nineties and is now at about 0,3 percent of total product exports.

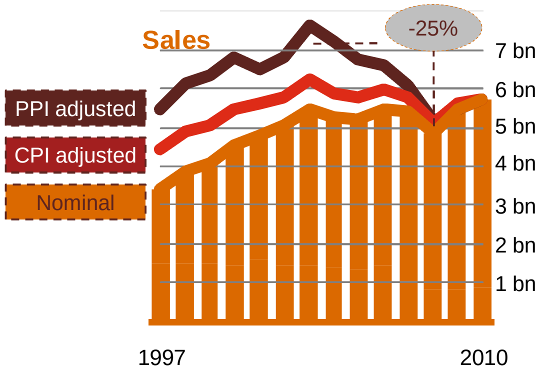
Norwegian firms gained global market share during the first five years of the decade. This was particularly driven by gains in the mobile satcom markets. Since then the share has declined and currently stands at about 2 percent.

The industry remains highly commercial with 75 percent of sales to maritime and offshore industries. It is more commercial than its peers in other countries.

In summary, this is a picture of an industry with declining sales, loosing share of the economy, and that looses global market share.

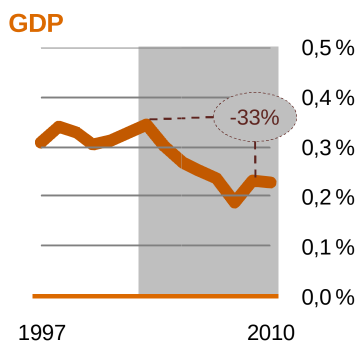
Turnover declined since 2003

Figure 1: Turnover space industries in Norway



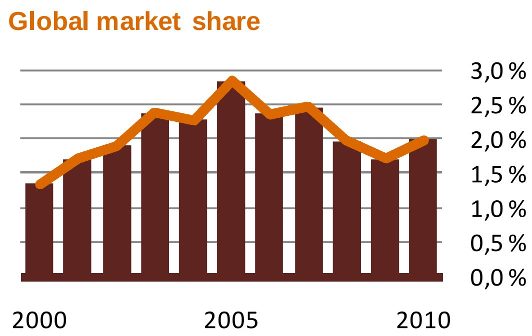
Declining share of the economy

Figure 2: Turnover as share of GDP



Loosing global market share

Figure 3: Global market share of Norwegian space business (excluding consumer markets)



Details and source information are available on pages 44 to 55 in the main report.

The value chain for space related activities

When assessing how space activities contribute to wealth creation and other objectives it is useful to define the scope and range of space activities in the economy. We do this by mapping a value chain, that is understanding how actors and stages interact. There are three distinct elements of the space value chain:

First, there is **the institutional segment.** Historically, developments have been much driven by military needs, i.e. communications and remote sensing needs. Scientific explorations of space also constitutes a core rationale and other public sector requirements such as environmental monitoring are important. These are often requirements for which there exist no private market or suppliers. New developments are necessary and these require significant investments and entails risks that few private enterprises are willing to embark upon alone.

There are also **commercial space segments**. We can divide this into its main value chain activities such as illustrated above. In principle, the institutional activities of governments can be grouped along the same dimensions but the commercial activities can be analyzed with more granularity mostly because of better availability of data and information. Many of the same private actors are also involved a contractors for developments of public systems and in some cases with mixed public and private financial involvement, it is not always possible to distinguish the institutional and commercial segments entirely.

Much of the commercial value chain is driven by the demand for communication services. This creates the demand for satellites, launchers and ground equipment. Most important is transmission of TV signals, but also for internet broadband and other communication services. Of increasing importance, albeit small yet, is also developments of remote sensing capabilities such as the images found on Google Earth. These service markets operate on pure commercial terms. There are international agreements governing use of frequencies and location of satellites but little other policy intervention. Much of the technological base has however been developed under institutional programs.

The satellite manufacturing and launcher segments are more captive. Most of the demand for their products stems from public sources. Nation states (and intergovernmental organizations such as ESA) typically prefer enterprises from their own countries. As such this market segment has more captive characteristics than the service segment. i.e. in the U.S government spending is estimated to constitute 85 percent of the demand for space manufacturing in the U.S. In Europe the ratio is closer to 50 percent. Yet, when a Satellite TV organization needs to increase their satellite capabilities, the manufacturing and business mechanisms around this are commercial.

The tail end of the value chain is the **consumer distribution**. This includes service provision such as TV or broadband access, and also equipment manufacturing of i.e. GPS hand- or vehicle equipment, chipsets for smart phones or TV set top boxes. These segments are the largest ones in economic terms but has not been a focus of Norwegian space programs and are not part of this analysis.

Illustration of the value chain for space activities

To understand the industry we review the following four value chain segments:

I. **Satellite components and launchers.** This includes all Norwegian manufacturers who deliver components for launchers or satellites. Most of these are private enterprises but one is affiliated with a university and included here.

II. **Ground equipment.** This includes all producers of ground equipment. Product offerings vary but all are involved in professional markets only. None sell to consumer markets.

III. **Satellite communications services.** These firms are service providers only. They may own an infrastructure, i.e. satellites or ground stations, but they do not manufacture equipment. This is the largest segment in Norway.

IV. **Other services.** These are also pure service providers. The range in offerings quite wide, from offshore surveying, met services and ground station operators. These do not produce hardware, but may own infrastructure i.e. ships or grounds stations.

The value chain stretches from scientific exploration of space to delivery of entertainment to consumers

Figure 4a: The value chain concept for space industries

The value chain and public support

The size and growth rates of different segments vary across countries and in Norway the **services** segment is particularly large. The figure to the right shows the distribution of institutional and various commercial segments.

Globally, we find that the **institutional** segment of the value chain is particularly large. This is mostly explained by the large U.S government expenditures estimated at nearly 65 billion dollars in 2010 equivalent to one- third of total turnover globally including consumer satellite TV.

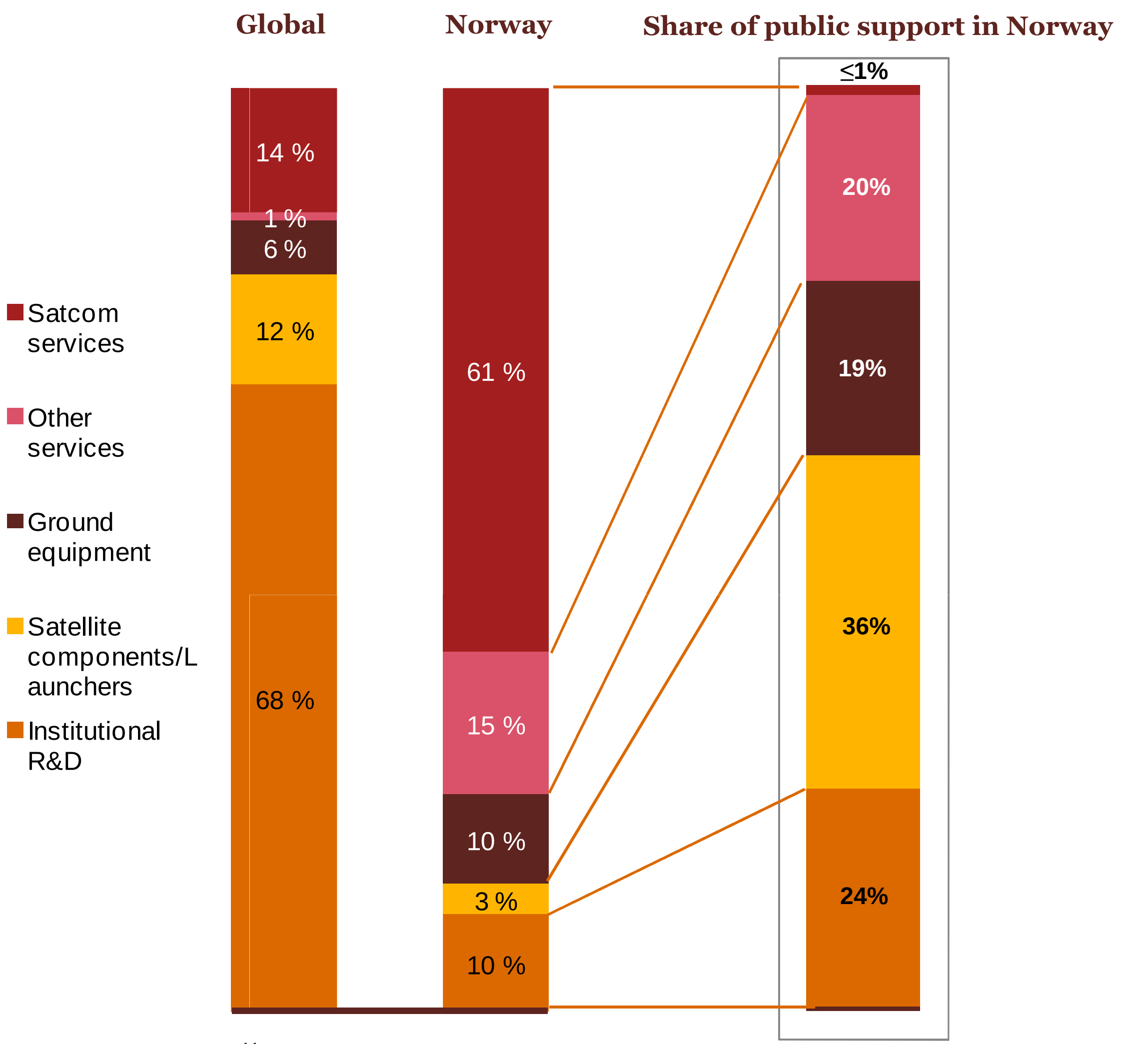
In Norway we find that the **institutional** side is much smaller than the commercial segments. This reflects the success of the industry in global commercial markets. The **commercial** value chain is characterized by a very large communication services segment. There are companies with large global market shares included in this. There is also a rapidly evolving earth observation community, as well as a small but specialized space manufacturing industry.

At the same time, the public support I Norway is focused on the upstream production of satellite components and ground equipment. This constitutes about 80 percent of total support. The difference between support and industry size is most marked for the satellite components segments where 36 percent of the total support is allocated yet the segment only constitutes about 3 percent of the space related turnover in Norway.

Satellite communications services, which is by far the largest segment in Norway, receives nearly no support with only about 1 percent of total over the last decade.

Norwegian space value chain is very different from global structures, and public support is directed towards the less commercial segments

Figure 4b: Turnover space value chain global and in Norway ex consumer TV- and electronics (2010 est.)



Manufacturing recieves most support but is loosing market shares

Launch and satellite manufacturing receives most of the Norwegian support, and is a small growing segment with a fractional global market share. **Launcher market** access is only through Ariane-5. Arianespace captures most of the commercial launch revenues but competition is escalating. Growth in demand for launchers, but even more rapid growth of supply from commercial, U.S. and Asian providers. It is unclear whether support for launchers is justified in light of the competitive positioning and the poor potentials for growth and wealth creation.

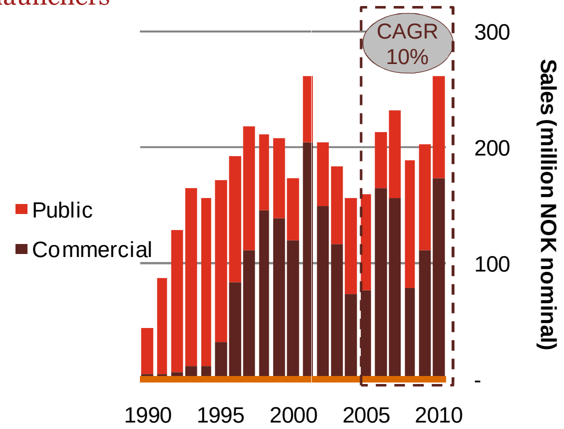
Norwegian **satellite component** manufacturing is mostly financed by public funds but commercial share has been increasing. High entry barriers for satellite components manufacturing but competition escalating. Access to European institutional markets will become more difficult in light of more open competition pushed by the EU. With one exception, the position of Norwegian manufacturers in commercial markets is not strong. Risk that they will be insufficient in size and scope to compete with integrated global conglomerates. Also in this segment there is reason to question the sustainability of the support schemes.

The once large **ground equipment** industry has seen much decline. The Norwegian strength is sales to maritime industries. There is strong growth of worldwide ground equipment markets. Norwegian producers have lost global market share. This is sensitive to the collapse of one large company, but remaining firms have not grown to cover the gap.

Sales have also developed at a much slower rate than the overall growth of electronics manufacturing in Norway. The overall electronics industry in Norway does well, and it is not evident why space sales are falling.

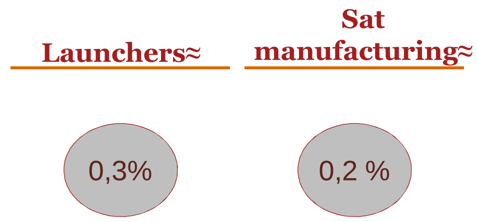
Space manufacturing shows growth and commercial sales

Figure 5: Turnover space manufacturing and launchers



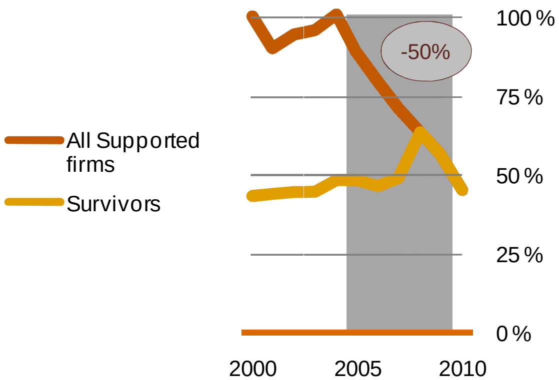
...and fractional global commercial market share but increasing

Figure 6: Estimated global market share 2009-2010



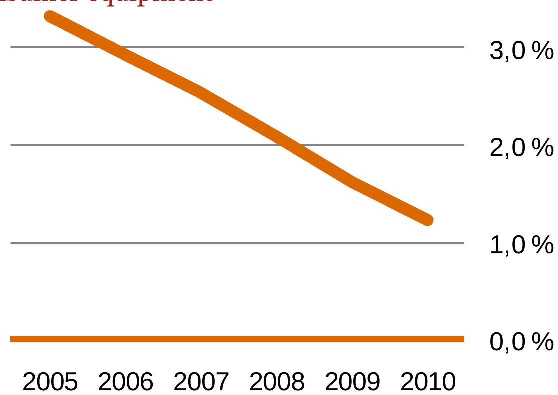
Ground equipment has much decline in sales and flat growth for survivors

Figure 7: Turnover ground equipment prod.



...and loss of global market share

Figure 8: Estimated global market share 2005-2010 ex consumer equipment



Details and source information are available on pages 56 to 87 in the main report.

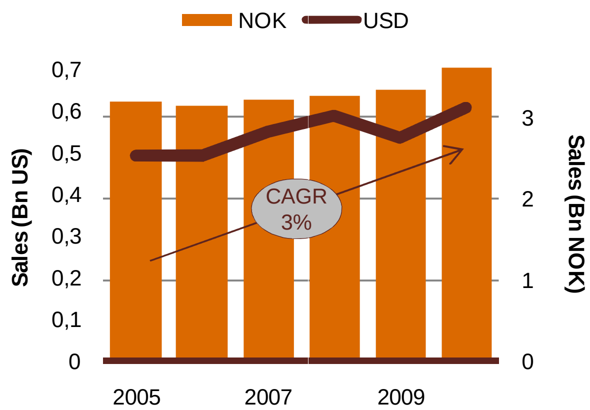
Satcom services are leading globally but loosing shares. Other servcies ahs growth potential.

SatCom services have lost some global market share but still accounts for two-thirds of commercial space sales in Norway. It operates nearly autonomous from the public support schemes. Relatively small public investments here have had big impacts. This segment has also seen new entrants with rapid growth. Fixed satellite operator Telenor goes strongly, but has divested most of its other large engagements in space. Norwegian firms are global market leaders. Firms in the fast growing mobile maritime segment have been attractive acquisition targets for global operators. New entrants may challenge the positions in maritime mobile markets including from Ericsson. Uncertain impact of foreign acquisitions on satcom service industry. There is a risk of dwindling satcom services activities and policy tools are not suited to redress the issue.

Other services are emerging with strong Norwegian capabilities and market shares. The supply side of this market is commercializing while demand remains mostly government. Image data sales market is growing rapidly after introduction of high resolution image and radar. Norway has no involvement in data acquisition and risks being locked out of the growing value added markets as value chains integrate. KSAT has a sweet spot in ground station and data distribution and a basis for expanding value added services. There are advanced commercial surveying and met services actors in Norway. Surveying off- and onshore increasingly using satellite information in addition to navigation. One of Europe's fastest growing commercial met services is based in Norway and operates in six countries. Government support is very selective and broader support for commercialization could be considered.

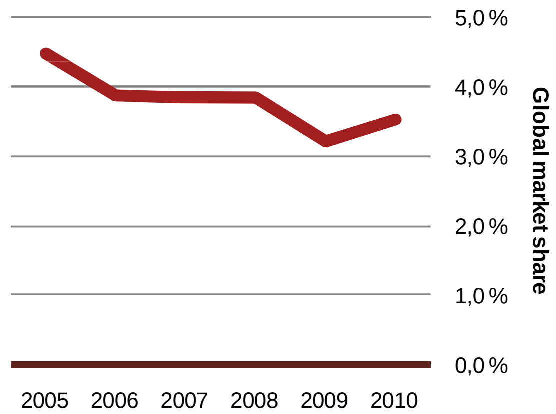
Satcom services growing albeit slowly…

Figure 10: Sales Satcom services ex TVDTH



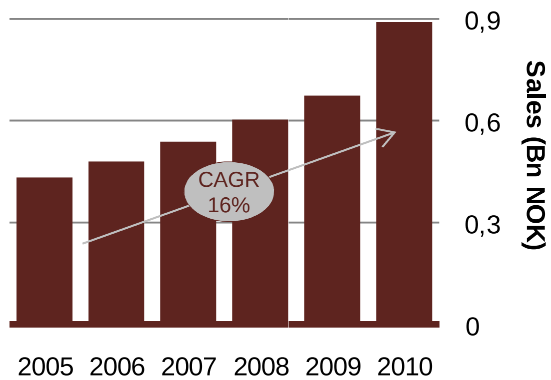
…but loosing ground in global markets

Figure 11: Estimated global market share 2005-2010



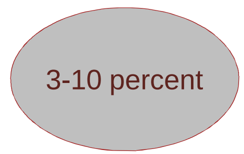
Other services has rapid growth…

Figure 12: Turnover other services



…and possible large global market shares

Figure 13: Estimated global market share 2010



Note: Robust estimates of total information services market volume does not exist. Better estimates exist of the EO and Met services markets and against those the Norwegian market share may be in the range of 3-10 percent.

External developments contributes to loss of competitiveness

Developments in the external institutional and political arena have implications for the relevance and effectiveness of the national space programs.

Five perspectives are important:

1. The U.S. 2010 space policy could be a game changer for commercialization. It is likely to impact markets and industry and also create opportunities for non-american government to acquire new and better services. The definition of commercialization implies capital risk for private actors and goes beyond previous practices of sub-contracting commercial vendors. U.S. business will continue to have anchor tenants in government but will also have stronger incentives to further commercialize products and services.

2. European issues. This is primarily about the reconfiguration of ESA and EU relationships with the implications this has for priorities and direction of policies, as well as governance structures, and access and opportunities for Norwegian firms and other interests.

This is an ongoing, and slow moving process, but certain emerging patterns can be ascertained. The important ramifications for Norwegian policy include: That the Commission wishes to better coordinate activities of member states, and space infrastructure is to be explored jointly.

The EU space policy involves continuation of the flagship programs Galileo and GMES, space exploration and military ambitions. It might entail restructuring of the EU/ESA relationship.

Future contract awards will be more competitive but likely not fully aligned with EU procurement directives in all ESA programs. Contracts under EU funded programs are likely to remain competitive. This will lead to reduces market access for Norwegian firms compared to today's more protected regime.

There is a considerable financing gap for the policy. EU has not provided financing for space activities in the Medium-term Financing framework thereby threatening the completion and operation of a.o the GMES Sentinel flagship program for earth observation. EU wants member states to cover. Future challenges for Norway include both access to decision making arenas in Europe and market access for business to institutional markets in Europe.

3. Peer country developments. Canada, Switzerland and Sweden are discussed. A common thread is that all are realigning policies due to changing environments. Canada has embarked upon a significant policy process, Sweden has called for one, while Switzerland completed its new policy in 2008.

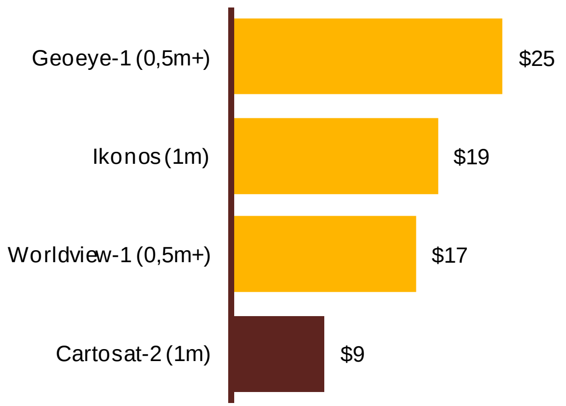
4. Commercialization and private risk. Increasingly national programs organized as partnerships with commercial orientation and private capital at risk. Boundaries between public and private roles are shifting. This is particularly seen within the earth observation image and radar segments but also in military communications. This is driven by U.S. and European concepts.

5. Emerging market countries expansion and signs of future of low-cost space, commoditization and service expansion will threaten Norwegian firms. Commercial capabilities are still limited. Those relate primarily to operation of SatCom services for domestic or regional markets; The launcher industries of Russia and China have significant market shares and especially China has begun to make inroads into the more profitable segment of launching commercial communications satellites directly in competition with a.o Arianespace. In India especially the image segment is semi-commercialized and they have gained shares in the global image sales markets.

The Asian space race is driving competition and launch of military and surveillance satellites.

Indian low-cost image challenger

Figure 14: Indicative market prices high resolution, fresh images, per Sq km



Details and source information are available on pages 88 to 111 in the main report.

Norwegian policy implementation is mostly about ESA, but fastest growth for national programs

The objective of this analysis is to review how the programs have been implemented. What has been the activities? Where has the monies been spent and to what effect?

There is real growth in public expenditure for space and 60 percent of it for Space Center managed programs. We also find that other spending, in particular on R&D is quite significant at about 30 percent of total.

The important dedicated space programs for this review includes:

•ESA participation which remains the primary instrument for developing capabilities; and

•National programs including special initiatives such as Radarsat and AIS satellite development.

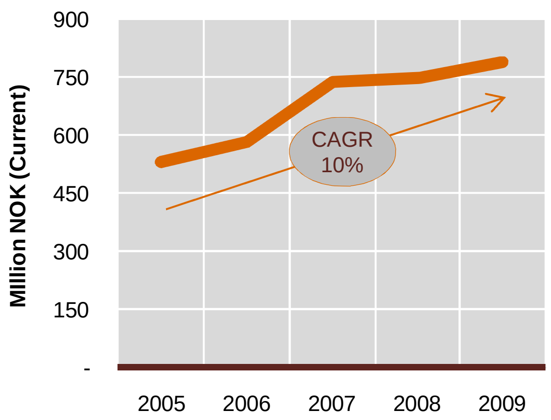
The core rationale for participation in the European Space Agency relates to access to pooled capabilities and development programs beyond what Norway could accomplish on its own. The ability to get access to "cost-efficient" systems that meets demand and requirements for public agencies is emphasized in addition to access to scientific programs and instruments for researchers. Another rationale is that Norwegian industry gets access to technology development programs and qualified ESA assistance, and opportunities to deliver into ESA development programs of satellites and other systems. Large segments of the space industry value chain is captive to government programs, and in absence of ESA access, Norwegian industry would not have access to important markets.

National program financing is increasing faster than ESA contributions. Financing has nearly tripled in monetary terms since 2005, and also more than doubled as share of ESA contributions. The increase has mostly been for special programs or initiatives. Prominent among these are the Radarsat agreement, The AIS Satellite program and infrastructure developments such as for maintenance at Andøya Rocket range, and support for the KSAT station in Antarctica.

The schemes for industry and earth observation service development have seen some increase in absolute terms. These programs have decreased in significance compared to other special programs.

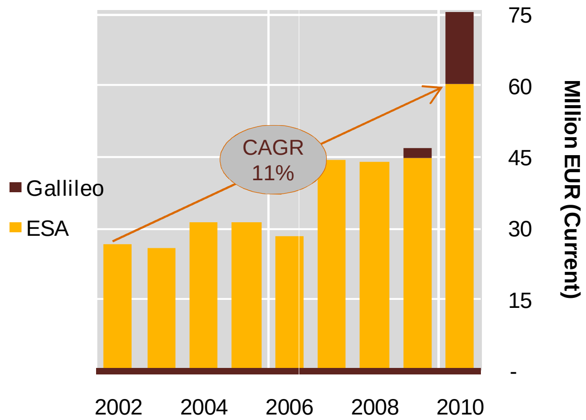
Top line growth in all public expenditure on space

Figure 15: All Norwegian expenditure on space including ESA, Space programs, science and government agencies



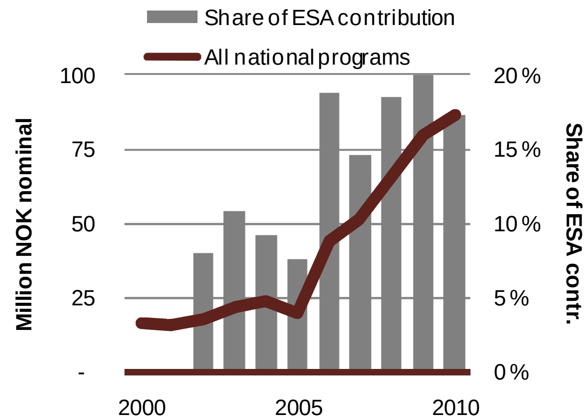
Contributions to ESA growing even faster

Figure 16: ESA and Galileo contributions from Norway



National programs growing faster than ESA contributions

Figure 17: All national funds including Radarsat, AIS, industry development, service development



Details and source information are available on pages 112 to 134 in the main report.

ESA contributions increases and most for the optional programs, but declining share returned as contracts to Norwegian firms

The European Union is now the largest single contributor to ESA at about 20 percent of the 2011 budget. ESA's expenditures have generally grown since 2002 albeit with a significant decline in 2010. Budgets for 2011 are higher but not as high as the 2009 record levels. There are some difficulties in matching incomes and expenditure and ESA has for the last two years recorded operational surpluses of 1 billion Euros.

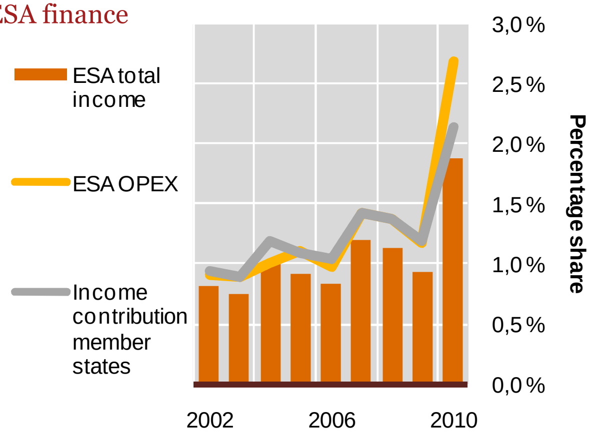
Norwegian contributions to ESA have increased at an annualized rate of 11 percent between 2002 and 2010. In nominal terms this implies more than a doubling. Contributions have risen faster than for many other ESA states and the share of the total financing envelope for ESA is increasing. The contribution was equivalent to 2,8 percent of actual ESA spending in 2010, and about 1,8 percent of total income.

About two-thirds of contributions have been for Optional programs. There is possibly a trend change whereby the share is increasing and the levels of Optional financing in 2010 reached nearly three-quarters. This seems to be sustained also in 2011.
The Galileo and GMES programs currently under implementation are not part of the numbers below but could possibly be considered Optional programs although the mechanisms are different given the involvement of the EU.
Norway is below mid-point in terms of ratio between mandatory and Optional programs. Some nations, both small and large have considerably higher Optional program weighting.
Norway participates in most Optional programs. Some other countries including Sweden, Switzerland and the U.K has a more selective participation.

Norway is an up-and-coming ESA player especially in Optional programs where the growth rate has been highest. Longer term, telecom has been the most favored Optional program. This constitutes of a number of smaller programs most of which are technology development programs whereby industry gets 50 percent financing and access to qualifies ESA assurance of their work. Earth observation sees almost as high share at about 16 percent of total financing. Much has happened over time. A shift can be observed from 2007 whereby a significant share was allotted to the general technology program. This now encompasses about 25 percent of total Optional contributions.
Over the last nine years we observe that the volume of contracts returned is 58 percent of accumulated contributions to ESA. The ratio has been declining.

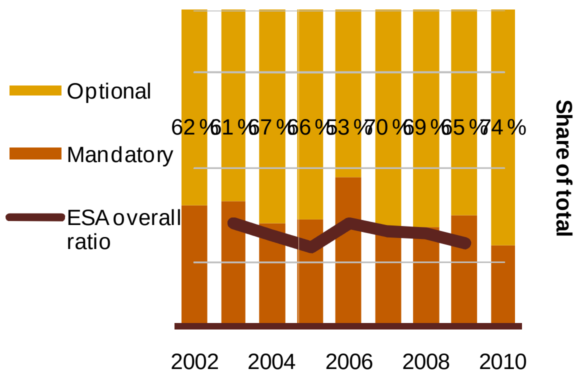
Gaining share of ESA financing

Figure 18: Norwegian contribution as share of ESA finance



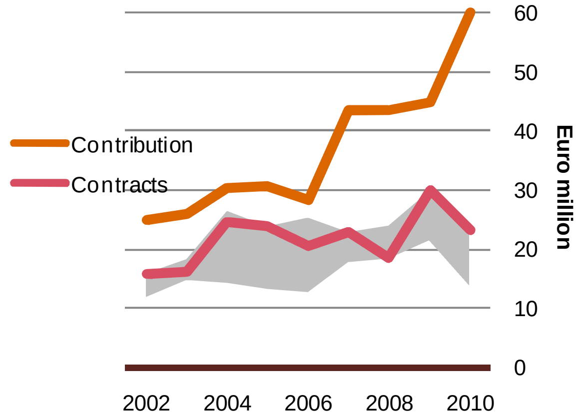
No clear trend, but Optional increased significantly in 2010

Figure 19: Mandatory and Optional program shares for Norway 2002-2010



Not all funds are returned as contracts and gap is increasing

Figure 20: ESA contribution and contract ratio



 Details and source information are available on pages 112 to 134 in the main report.

Distribution of funds is highly concentrated: Four firms receives 50 percent; 63 organizations share the rest.

As many as 67 organizations have been involved in either the ESA or national space funds programs over the last decade.

Distribution is highly concentrated:

- four firms receiving 50 percent overall; for ESA mandatory programs 80 percent is captured by three firms;
- a further 11 organizations receiving the next 30 percent; and
- 52 organizations share the remaining 20 percent and many of these amounts are very small lower than 0,1 percent of total.

The ESA system seem in practice favor larger organizations due to relatively high transactions costs and risks. Smaller firms have mostly accessed the technology development programs.

Regarding distribution of public funds:

Satellite component and launch manufacturers receive most and more than a third of total. The share has declines some but the amounts have remained about the same. Number of organizations involved have increased over the decade.

Ground equipment captures about twenty percent.

Other services receive 20 percent but the funding is concentrated to only one or two firms.

Telecom satellite services have received only minor amounts distributed across one or two firms over the decade.

Institutional R&D captures about 24 percent of totals. Their share has more than doubled over the decade.

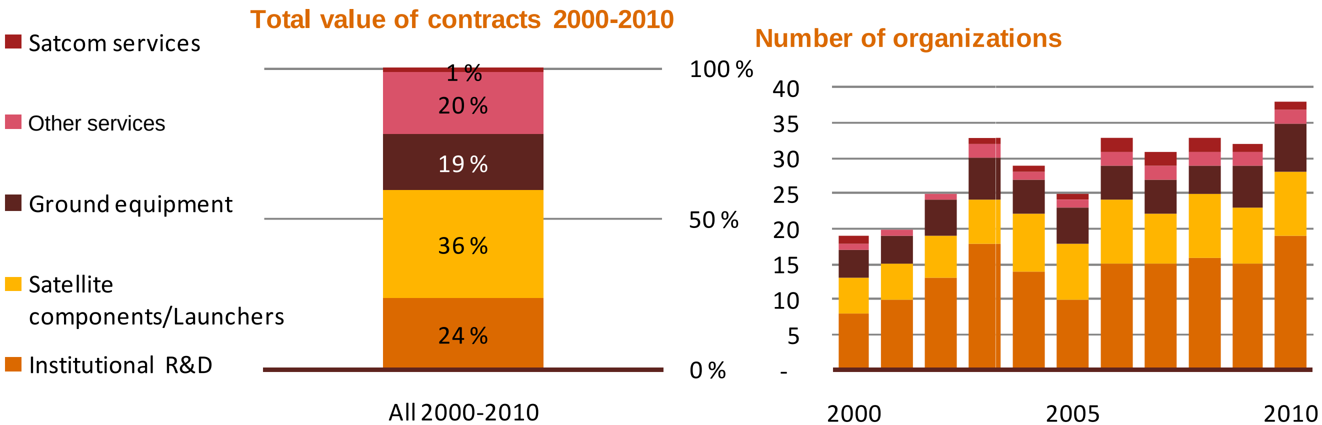
Those firm that receive support have a declining share of total space sales in Norway. During this time we have seen an increase in the ESA contracts for that same group. We should keep in mind that all this takes place in a context where there has been a real decline in commercial space sales over the last decade.

Firms that engage with ESA typically target different markets segments than those that operate outside of the institutional markets.

All upstream firms engage with ESA, i.e.. manufacturing of launchers and satellite components; while there is much less institutional activity from firms that operate in the downstream segments i.e.. satellite communications service segments. This also reflects the demand structure in the institutional markets which is predominantly about science and manufacturing.

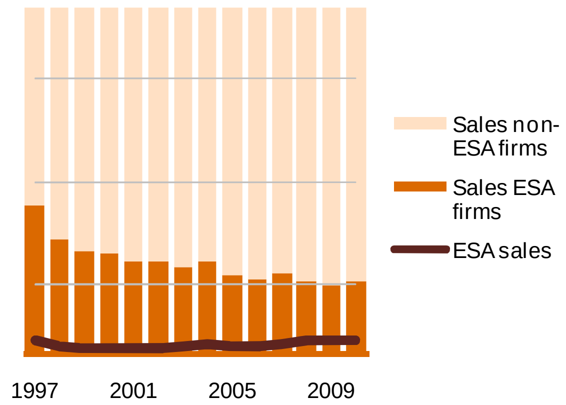
Most support for space manufacturing, and more R&D organizations participating

Figure 21: Distribution of funds among value chain actors



Sales of those who do not receive support grows faster than those that receive public support

Figure 21b: Sales by actor



Details and source information are available on pages 112 to 134 in the main report.

Declining turnover of the supported industry, no job creation, but conciderable spinoff sales are reported

Most firms that operate in the ESA market have other business outside of the space markets. There are only a few producers that are entirely space focused. The share of space related sales have generally fallen over the last decade for these enterprises. This can indicate a shift in focus and lack of alignment in corporate strategy with space markets, or it can indicate faster growth in other segments.

Space revenues have declined overall in particular during the last five years for ESA firms. This is much due to a few companies.
Its encouraging that there is robust growth, both in nominal and real terms, for the surviving firms. This growth has been consistent since 1985 at an annualized growth rate of about 16 percent.

Employment for space work has not picked up even for the surviving firms. There is a decline since the late 1990's having nearly lost half of the employees that were involved at the peak. The surviving firms show a flat trend over the last 15 years. Profits have increased in absolute terms though margins have stayed at about the same levels indicating cost increases.

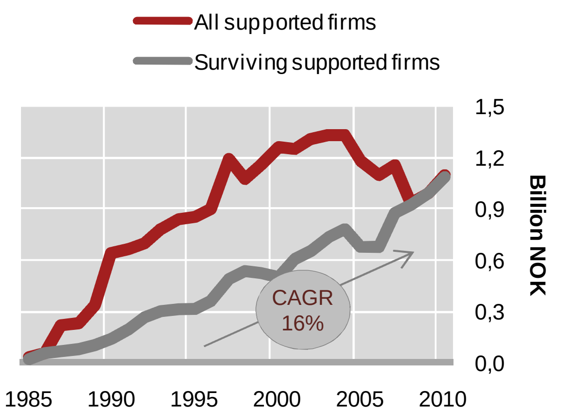
ESA contracts have increased over the last decade nearly doubling. This growth rate is well above the inflation and thus indicating growth in real terms. It is also faster than the growth of ESA budgets overall indicating that Norwegian firms have taken a larger share of the ESA market. As share of space sales for these firms we see that ESA contracts peaked significantly in the mid-nineties. Now 20 percent.

An important rationale for public support to private firms through ESA is the access it provides to cutting edge technology development programs. Firms emphasize the highly qualified interactions at all stages in the process including with the Norwegian space centre. Firms also emphasize the interaction between the national support schemes for industrial development that allows early stage work before ESA.

An important metric to gauge the success of this is the multiplier between support and sales generated from this. Firms have reported data since the early 1990's. Considerable impacts are observed. The multiplier is at **4,3** currently adjusted for inflation. Median firm impact is 3,5. Thus one ESA contract results in additional sales of about four times the amount indicating an impact.

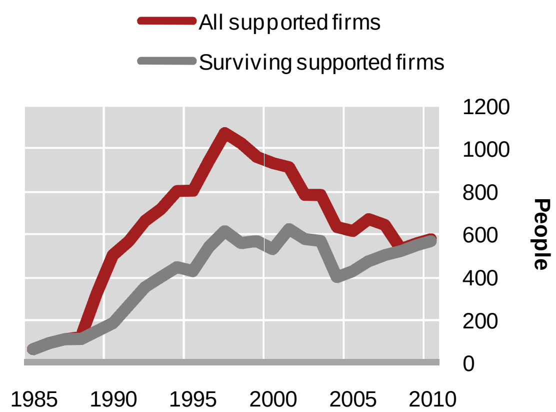
Decline for all ESA involved firms, though growth for surviving firms

Figure 22: Sales for ESA involved firms



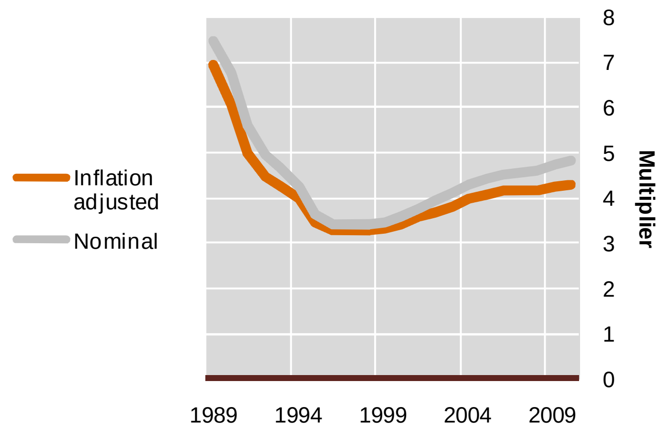
Lost jobs, and no growth for surviving firms

Figure 23: Employment for space related work among ESA firms



Considerable multiplier on sales

Figure 24: Multiplier of ESA support on sales



Details and source information are available on pages 157 to 171 in the main report.

Positive impacts on Norwegian economy mostly by firms spinoff sales

The multiplier shows divergence across different value chain segments. There are differences in levels and shifts over time.

Services how the highest levels (6,8) and an increasing trend. Ground equipment is lower and has been sliding for decades. Satellite component and manufacturing show multiplier of about 3,4 and slowly increasing.

R&D multiplier is sliding. These are R&D institutes who are engaged with much applied research funded through public or private sources. Their additional income may stem from other public financed programs, i.e.. FP7, or industrial sources. Scientific institutions and public agencies with ESA contracts do not have ripple effects of this nature and are not included.

A measure of the returns for the Norwegian economy is to measure the relationship between financial inputs and outputs. This is a measure taking into account all Norwegian funding for ESA and corresponding national industrial funds. We also take into account overheads in ESA, distribution of contracts by value chain and variations in multipliers, including contracts for scientific and public agencies, tax cost and import content.

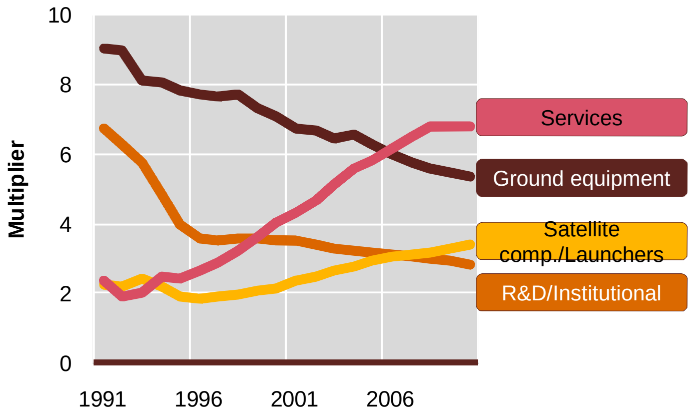
The net gains for economic activity in Norway is about 16 percent. There may be additional economy wide technological gains not accounted for. A budget allocation of 100 will result in an increased activity level in the economy of 100+16. We should also note that Norway has other objectives with ESA participation including access and contribution to a common European infrastructure. Those benefits will be additional.

To understand the wealth creation dynamics, the currently active successful firms have been studied in more detail.

This analysis looks at the costs associated with a firm contract and compares these to the benefits it creates. We focus on a more recent time period from 2004 to 2013 (projected sales). A subset of 25 currently active firms have been studied.
Costs include ESA contract and NRC support value, ESA admin and foregone returns. Costs are assigned proportionally by contract value. This differs from the approach to the left where all costs including those not attributable to firms were included. Impacts are seen from salaries and profits. Wage related effects is by far the largest contributor to benefits comprising 76 percent.

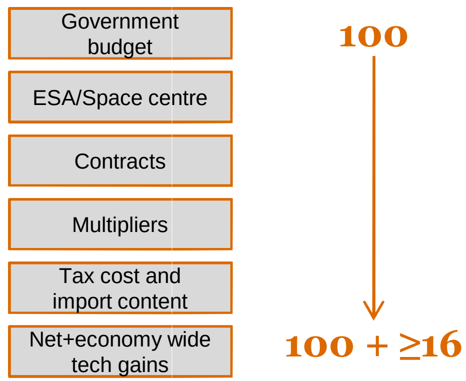
Sales multiplier differs across segments

Figure 25: Sales multiplier by value chain segment



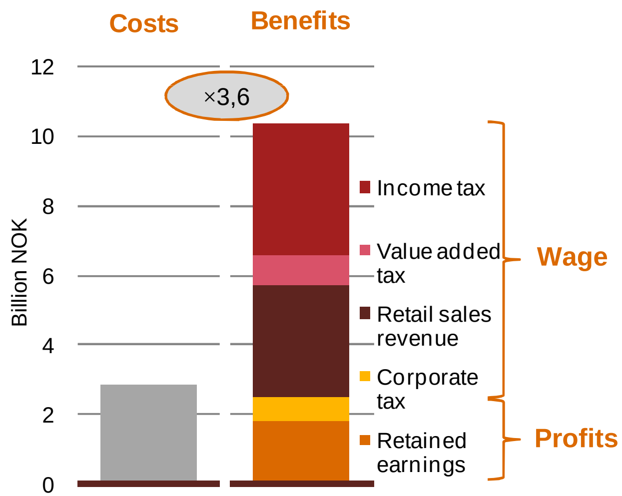
Full money cycle analysis show about sixteen percent gain in activity

Figure 26: Flow of funds and impacts of ESA multiplier



Value creation impacts from firms with ESA contracts at 3,6 ratio

Figure 27: NPV costs and benefits 2004-2013



Details and source information are available on pages 170 to 173, and 182 to 197 in the main report.

Public service programs has enhanced maritime surveillance capabilities

Data from satellites potentially offers cost efficiencies and quality improvements for important public sector functions. Satellite borne sensors can collect data for large areas, repetitively and within short time intervals. A strategy was developed during early 2000's setting out the objectives priority activities. Objectives have later been refined and has in practice focused on two priorities:

- Developing infrastructure to secure access to data;
- Focus on Ocean and Polar regions as these potentially offered the greatest cost efficiency potentials for Norway.

Different instruments exists. First, there are special development funds to develop applications for agencies. Second, there are specialized programs such as access to radar satellite data and AIS (ship tracking) data. Third, there are benefits from ESA in terms of access to developments and satellite information.

There are three agencies who operate highly professional and institutionalized systems on this basis. Those are the defense, coastal authority and the geological survey. A fourth, the meteorological institute is a heavy user but operates mostly on the basis of EUMETSAT specialized data outside of the purview of this analysis. About ten to fifteen further agencies and R&D institutes have various smaller projects most under implementation.

The flagship program is highly focused on providing maritime operational services. This is about surveillance and monitoring of ocean and arctic regions, ship traffic, fisheries monitoring, ice coverage and oil spill detection. These services are operating 24/7 integrating the satellite data with other sensors. Land based programs are increasingly important and the geological survey scans the country to detect surface instabilities and monitors certain high risk areas for catastrophic events.

Radar data are purchased to enhance maritime and terrestrial monitoring ability. These are much used for defense and security purposes, and well integrated into operations. There is also a highly relevant AIS satellite program to enhance maritime surveillance and satellite successfully launched by government. In total, advanced, integrated and user responsive monitoring system, but considerations to cost and governance issues can be addressed.

Busy above Norwegian waters as ESA satellite Envisat captures data enroute north

Figure 28: Snapshot of satellites above Norwegian territories a day in February 2012

Details and source information are available on pages 135 to 154 in the main report.

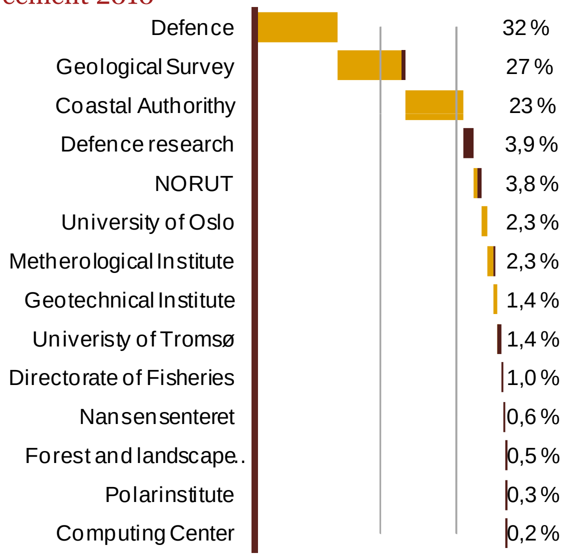
Net economic benefits of public service programs, but needs focus on cost reduction and benefits realization

Use of satellite earth observation data is increasing. Agencies may also be using communications satellites which is more mainstreamed and not included here. Data are mostly used for monitoring and surveillance, but also for a range of other applications such as mapping and detecting cultural heritage sites. About 22 agencies have some use with four big users dominating.

About half of the satellites used are commercial and provides high resolution optical images or radar. Public satellites offer free information and government accesses both European and U.S satellites.

Three professional heavy users of radar data

Figure 29: Users of radar data under the agreement 2010



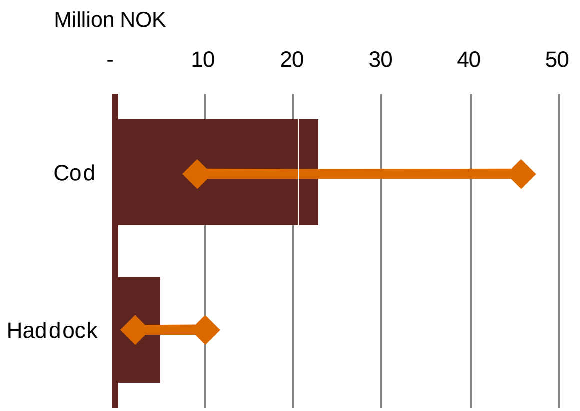
There are no direct benefits stemming from satellites. The satellites provide information – and the benefits depend upon how the information is acted upon.

Determining the value of information is complex. A range of outcomes are likely even in the case of fairly closed system contexts like the dedicated Norwegian used satellite systems (i.e. Radarsat and AIS).

The value will depend upon perceived risks, effectiveness of response options and the incremental information content value. Economic sciences generally find a value of 1 percent of total output stemming from availability of perfect information.

Value of satellite information for illegal fishing between 11-56 million

Figure 30: Value of satellite information for detecting illegal fishing (example)

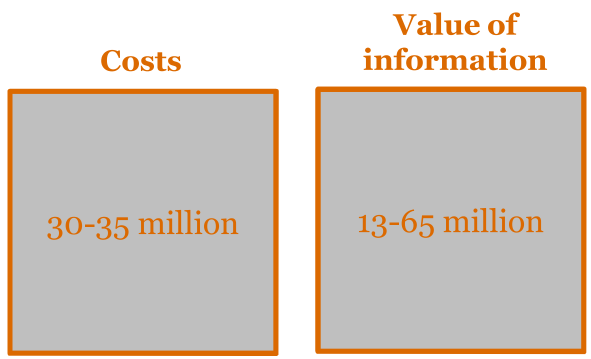


There can be variations. In particular in cases where there are deterrence effects such as monitoring of fisheries and oil spills.

Value of information for oil spills has been found to be between 1-10 percent across Europe (PwC 2008: Booz Co 2011). Value for fisheries monitoring have been found to be in the same range. Value for geohazards is less because the response options are more limited.

The value of satellite information in Norway has been quantified across the main usages: Oil spill detection; fisheries monitoring and geohazards.

We apply conservative estimates for value and generous estimates of cost. The range of benefits is valued at between 13-65 million annually. Costs are about 25 million annually. By far the highest impact is found from fisheries monitoring. There are also important impacts from oil spill detection and geohazards monitoring. Much resources for the latter is devoted to monitoring of high risk areas. The cost and loss of life of a major landslide in these areas is extraordinarily high. The probabilities are unknown and the cost efficiency of monitoring cannot be meaningfully ascertained.



Details and source information are available on pages 172 to181 in the main report.

The programs have delivered specific results over time, but declining contribution to wealth creation and uncertainty about sustainability

Overall objective

Space activities in Norway shall provide substantial and persistent contributions to wealth creation, innovation, knowledge development, and environmental- and public safety.

The overall goal encompasses different elements. The concepts are not mutually exclusive and overlap. i.e.. knowledge development and innovation. The Ministry has also defined more specific objectives and a discussion of progress on detailed objectives are found in the main report and the annex.

Specific results, but unclear impact on sustainable growth and wealth creation

Overall turnover of the space industries in Norway have declined by between 15-25 percent since 2003 depending upon how inflation is adjusted for. Contributions to wealth creation overall in Norway had declined by 33 percent since 2003 as defined by GDP with or without petroleum included. Employees involved in space activities have declined by nearly 50 percent since late 1990's though this measures only captures about 80 percent of companies.

Support for space related activities has provided results, but these are probably declining. There has been strong sales growth for those firms that receive most of the support albeit insufficient to offset the larger decline. There is growth in some segments of the value chain and some firms have seen phenomenal success. These do not necessarily coincide with those that receive support. Ripple effects on sales of the public support are reported and the socio-economic benefits are net positive.

The profile of the support portfolio is increasingly decoupled from market developments, business structures and growth potential over time. As such we question the sustainability of the support over time. It may also mean that the results are better for the evaluation period as a whole rather than the last few years in isolation.

Substantial and persistent contributions to environmental- and public safety are seen.

The national programs targeting ocean and polar monitoring capabilities have contributed towards environmental- and public safety. The systems provide information important for environmental safety. The space activities have also contributed much to the processing and institutionalizing of the information. Thereby increasing the probability of positive impacts on environmental and public safety.

Activities through ESA are less directly relevant for the enhanced public sector capabilities. ESA satellites or systems are today largely irrelevant for these capacities. There are however other linkages. The knowledge and insights, early development of algorithms, and development of the ground station have much been through ESA activities. For the future, the EU GMES holds much potential also for Norway. Dedicated access to other sources for a.o radar data is likely to be required also in the future.

Environmental- and public safety are also concepts which may have different meanings depending upon circumstances. They are not defined by the Ministry.

Policy and objectives might benefit from adjustment to ensure benefits

Further we discuss the relevance of the policies vis-à-vis the objectives. This is assessing to what extent the activities are suited to purpose. We will review the following evaluation questions related to relevance:

1. Are the instruments adequate from an overall perspective for achieving the space programs goals?

2. Has the space programs achieved an appropriate balance between the various instruments?

3. Is there overlap or conflicts of objectives between ESA participation and national support funds? Are synergies exploited?

4. How has the Space programs managed to adapt its instruments and advice to the larger context in which space activities interacts with other social, market, economic, political and environmental processes?

Additional issues are discussed in the detailed analysis.

1. Are the instruments adequate from an overall perspective for achieving the space programs goals?

There are differences across segments and we will review those in turn.

Three observations to note:

1. Limited growth potential in upstream production

There is a mismatch between support for upstream production companies and the potential for growth and wealth creation in this segment. This includes manufacturers of launchers, satellite components and ground equipment.

The support is insufficient in size and scope if the goal would be to build a large and sustainable space industry. That would require a considerable increase in Norway's participation in ESA, which is hardly justifiable in terms of Norway's overall policy for industry.

The difficulties of attaining competitiveness in ESA and global commercial markets of the upstream segments are an indication of this. A sufficiently strong domestic demand does not exist to create anchor demand for upstream actors. Market leaders are from larger countries and have sizeable domestic upstream markets available to them.

These difficulties will only increase driven by five trends indicated in the analysis:

- as value chains of global conglomerates converge across segments and between system integrators and component producers;
- as emerging markets gain competitiveness and global market shares;
- as U.S firms are driven onto global markets;
- as European countries launch semi-commercial national programs; and
- as access to semi-protected ESA markets become more difficult due to convergence of EU and ESA.

2. Growth and comparative advantages in the service sectors

Opposite these constraints in the upstream segment stands exceptionally strong domestic demand from other economic sectors notably from maritime and offshore industries.
These are growth drivers for space ground equipment manufacturers, and providers of communications and earth observation services. In these segments Norwegian firms are global market leaders and have considerable market shares in broadly defined market segments.

The tools seem adequate for satellite communications services. Relatively small investments here have had big impacts. This segment has also seen new entrants with rapid growth. There is no need to match the funding to the scale of the industrial turnover in the absence of market failures. Rebalancing could be considered to support development of near-market-ready technologies. ESA is ineffective to support this segment.

Tools are also adequate for the ground equipment industry. Although the space related turnover has dropped, there is little evidence of constraints in other segments of electronics and communications equipment markets. Those who produce space ground equipment have also grown more strongly in other segments. The declining turnover is related to collapse of one company. The inability of other firms to maintain or gain global market shares seem related to firm level decisions of focusing on other market opportunities.

Tools are adequate to support earth observation services firms but may be constrained in the near future. In fact, this is driven by strong demand from government for monitoring and surveillance capabilities. Needs , as in territorial, are at about the same levels as that of Europe combined and this creates anchor demand for certain services. Norwegian firms also have strong competitive positions in these segments. The national development programs are especially well suited. There is however a risk that the use of the support funds has been selectively targeted at a few actors. A consequence is a narrow base to recruit new service providers from.

Risks here relate to future developments of EU GMES programs. Norway needs access to these processes to maintain adequate instruments to support firms in this segment.

*3. T*ools to support environmental and public safety objectives are adequate or almost so.

There is a reasonable balance at the moment. Government demand is increasing.
For the ocean/polar region services this is about having more refined capabilities. The combination of national development programs and dedicated investments in a.o radar and AIS are adequate for ocean monitoring currently. Emerging difficulties here are about having flexible access to other sources of high resolution data to meet more sophisticated demand.

Future access to continuous radar imagery need to be secured given that the current main source is expiring in some years. There are several capabilities available that will meet current requirements but costs are likely to increase.

Terrestrial demand is currently adequately met. The model of combining development programs with access to radar satellite data is currently sufficient. Challenges are emerging. There are capacity constraints and scheduling conflicts for radar data. Access to optical imagery is not secured on a cost-efficient and continuous basis. Tools are adequate at the moment, but may be limited in the future as user sophistication grows.

In the near future there also needs to be access to EU GMES institutions.

Next we turn to the question of balance.

2. Has the space programs achieved an appropriate balance between the instruments?

Four observations to note:

1. The balance of ESA vs. National program allocations is appropriate but can be adjusted longer term.

The dynamic between the industry development program and the ESA programs seem to work well.

There is an observed difference in scale of national programs vis-a-vis ESA contributions compared to other larger space manufacturing nations.

Matching the funding levels of these countries is unattainable. Policy attempts to compensate for this are futile and will fail. Further selectivity and specialization may be considered.

The recent scale-up of ESA financing is questionable to the extent that it is not absorbed by industry contracts. The ration between contributions and contracts is increasing. The industrial return coefficient is below target and has to be met by separate transfer schemes from ESA.

National program funds on the other hand may be insufficient to meet public sector demand in the future. A necessary scale-up of commercialization strategies in the services segment for which ESA is less relevant may also be considered. Future growth may need to be directed towards this.

2. *I*ntra-ESA program allocations should be reoriented towards those segments with best potential for growth and wealth creation

There is a risk that current allocations are driven by other than cost-efficiency considerations including path dependency. Its fragmented, driven by expectations about where industries can deliver. Today's and specialization should be revised. The support is not oriented towards those segments with the highest growth or wealth creation potential.

The current allocation distribution implies most financing for launchers and satellite component manufacturers. This is questionable on cost-efficiency grounds as there is less growth potential and lower ripple effects than other segments. Some rebalancing may be warranted.

At a certain level, optimizing this allocation will be constrained by the fact that ESA predominantly offers opportunities for upstream and hardware producers.

Strategies for increasing participation of downstream actors, within or outside of ESA may need to be considered. This is where ripple effects are higher and growth potential larger.

The fragmented nature of ESA program allocations implies much discretion for the space centre in determining allocations. The implicit prioritization of certain industrial segments that the allocations imply, are not articulated, explicit or transparent.

3. Allocation of intra-national program funds should be reoriented and increase in scope.

Consider increasing service development funds. This is where the highest returns and growth potentials are seen.

A risk is that current involvement of commercial earth observation firms is too narrow and selective. Increases here need to be met by strategies to increase broader involvement of commercial service firms. Meeting longer term public sector demand also speaks for increasing this share.

Another risk is that cost-efficiencies achieved by monitoring of ocean areas by satellite does not currently have its equivalent on the terrestrial side. This may change in the future. But care is warranted in assessing alternatives.

4. Allocations between scientific activities and industrial support needs to clarified in a transparent policy.

, there is an unresolved balancing issue with regards to the funding of scientific space activities. These contributions have over the last decade not only pertained to the ESA mandatory scientific program, but also to other programs like the International Space Station and more importantly the Earth Observation Program. This reflects the scientific nature of many of the ESA Optional programs.

Finding an appropriate ESA investment level that is targeted at scientific communities need to take into consideration the scientific capabilities and priorities. This is what is being done in practice today. Balancing the scientific funding level with other investments however is ultimately a policy choice. It is not transparent today. Resolution could be sought within an overall policy framework for space policy including science.

3. Is there overlap or conflicts of objectives between ESA participation and national programs? Are synergies exploited? Are there other conflicts of objectives?

Three observations:

1. the synergies of industrial national support funds and ESA participation are strong. There is clear alignment of the priorities of the national program and the ESA activities. Overlaps or conflicts are not significant

2. the synergies between national service development programs and ESA are weaker. They exists, mostly through the ESA Earth Observation and met programs, but are not as strong as for the industrial side.

This is a reflection of the priorities of ESA. The scientific oriented earth observation programs are less suitable for meeting operational demand and requirements from the public sector in Norway. ESA satellites don't meet the requirements for continuity of access or don't have the appropriate capabilities.

In the future, this arena will shift towards the EU. It will be important to influence the EU processes to ensure alignment of objectives.

There is however no future scenario where the objectives of the national service programs and ESA are delinked. A model whereby EU systems are developed by ESA, such as for GMES, implies that there will be linkages also in the future. The same applies for EUMETSAT.

The implication is that it will be more important to secure alignment of objectives between EU priorities and Norwegian interests in arenas outside of ESA in addition to continue influencing development stages within ESA.

3. there are conflicts of objectives between meeting public sector demand and industrial development strategies. Meeting public sector demand in cost efficient ways is not aligned with schemes to support selective industries.

The support for industry is only aligned with public sector objectives as long as it leads to lower cost for government, or if the support has wealth creation and ripple effects that exceed the increased costs for governments. This also applies to bilateral support arrangements. This has to be assessed on a case-by-case basis through proper option evaluation methods.

There is a higher level conflict with structural policies for competition, public procurement and state-aid. Within ESA this is resolved as ESA is not regulated by EU or GATT principles. For national programs and subsidies this is a problem.

Public procurement and state-aid regulations are not well aligned with selective industrial development objectives. T

The practical implication is that national programs that try to merge these objectives, i.e. AIS satellite or Radarsat contract runs into legal compliance or cost-benefit difficulties.

There are only synergies in other areas where Norwegian industry is internationally competitive but national programs need to follow procedures whereby the competition is open. This is a problem today.

4. allocation decisions between science and industry do not reflect conflict of objectives. Uncertainties reflects that the balance has not been determined at a policy level. The balancing question cannot be resolved through cost efficiency considerations. The objectives and priorities are not defined by policy. That can be resolved through policy development.

5. allocation decisions between segments of industry may be seen as a conflict of objectives. It is not. Those can be determined by cost-efficiency considerations.

4- How has the Space programs managed to adapt its instruments and advice to the larger context in which space activities interacts with other social, market, economic, political and environmental processes?

There are several aspects of this. There are several indications of appropriate adaptations, and one area where it is more questionable. Four observations:

1. Well integrated with the strategic political focus on the arctic. The support for the ocean/polar and Barents sea activities are the leading examples of this. The leadership to bring Norway into the GMES programs is also a reflection of this. The importance given to Galileo and EGNOS coverage for the north is also an indication.

2. Adapted to the EU/ESA convergence. This is manifested in funding allocations for EU led work programs and in attention paid to EU policy issues.

3. Ability to find opportunities for small space nations. The programs have adopted to the trend were costs are falling and single mission microsatellites are attainable within a small resource envelope. This creates opportunities for small space programs for small nations. The AIS satellite is the practical manifestation of this so far.

4. Limited adaptation to structural market developments.

Space programs may have not been adapted well to a broader market trend with increased public-private partnerships and commercialization. Such concepts are driving developments within the earth observation segments, geotracking and military communications.

We see three implications:
(a)Increased opportunities for cost-efficient public sector programs in the future. Service offerings are likely to expand, in particular those relevant for public sector requirements. Prices will fall with increased competition including from low-cost countries. Flexibility in public sector instruments are likely to become more important. The ability to switch between providers of satellite data, and seek available low-cost options will be important.

(b) Risks that other countries, and ESA partners, will shift their priorities into public-private partnership programs rather than the joined up efforts in ESA.

(c) Opportunities for out-of-the box thinking in terms of matching commercial objectives with policy objectives. There will be more ideas like the AIS satellite in the future. A conceptual approach that brings in private risk capital and commercialization incentives may make programs financially feasible.

Governance issues and risks to be handled

In management of the space programs there are three issues to be noted:

1. Lack of proper prioritization and hierarchy of objectives

The Ministry sets out the overall objective, and determines five sub-objectives, and further 13 objectives at a level below that. There is a total of 19 formulations of objectives, 27 indicators (more as several are truncated) and about 20 activities or programs described in accordance with the system of accounts.

We would suggest revisiting this framework. It is:

- Over focused on performance indicators.
- Very many objectives with little prioritization between them
- The objectives are not clearly Unclear logical relationships.
- Poor relationships between the different objectives and the linkages with activities.
- Feedback and adjustment mechanisms are unclear

Two considerations in such a process:

First, establishing the hierarchy of objectives works best as a participatory process. Clarifying and operationalizing the objectives is a first step in implementing a robust strategy.

Second, consider establishing a logical alignment between the government framework and the long-term space center plan. Any inconsistency would introduce uncertainty about which frameworks prevails.

2. High risk practices for procurement and competition and risk of regulatory breach

Governance risks have been identified during the course of the study. This is not a focus area of the work but given the consequences for the space programs we note them here.

If not ameliorated, consequences include reputational damage and loss of credibility for the space programs, wasteful spending and reduced competitiveness of the industry.

There is a risk that basic regulations for public procurement and competition are not adhered to while implementing the largest national programs including AIS and Radarsat.

A rationale for pre-selection and exclusive support to single actors could possibly be justified, but the costs of such selection needs to be weighted against the benefits of alternative solutions.

The risks may stem from difficult tradeoffs between conflicting objectives especially for national programs.

A better balancing of public sector needs, industrial development and legal compliance needs to be found.

3. Potential conflict of interests with KSAT ownership structure

KSAT is recipient of the largest share of the ESA and NRS funds and part of all national government space activities. There are KSAT board guidelines for COI but they are insufficient to ameliorate the risks.

Close relations and extensive support for KSAT implies conflict of interest, fiduciary risks and blocking new entrant out of the market.

These risks are increasing as KSAT grows rapidly, also in the value added segment, and national support funds and projects involving KSAT expands. Perceptions of preferred provider status and proximity of relations acts as a disincentive for new entrants in a market dominated by government demand and space center managed programs.

The ownership should be managed within the regular structures of state owned enterprises to help avoid such conflicts.

Strategic needs

Against the background of the evaluations analysis and conclusions we would recommend the following steps:

1. **The support should be reoriented towards segments of industry that offer better growth potential and comparative advantages.** Maritime and offshore sectors are the dominant growth driver for the commercial activities of SatCom services and Earth observation services. The global position is very strong. Technologies are more developed but still in growth phase. Support for near-market ready technologies promise high rewards. There is little involvement of the support schemes for this segment and this could be reassessed.

2. **Services related to earth observation have anchor tenants and growth drivers in the Norwegian government which can release technology development and ensure demand for services**. Global market position is strong. Technologies and service concepts are in the growth phase. Support should aim to broaden participation to include other companies. A strategy for commercialization should be developed for government purchases of earth observation data services to exploit the government demand as growth driver in new value-added segments. This can benefit from involving a broader segment of businesses and a more competitive and open process than it is today.

3. **The support for space related business development should increase in scope across the value chain and in number of companies to ensure equal competitive conditions across actors and solutions**. Recruitment of new businesses from i.e.. R & D, IT and telecom services expand the base form the current low number of firms who have been repeat actors for decades.

4. **Further support for segments with stagnating growth should be reassessed to ensure that the support matches the growth potential.** Space related ground equipment has some maritime anchor tenants, but seems to have decoupled with respect to growth. Support must be very carefully considered as contributions to growth and wealth creation are doubtful. Parts of space manufacturing has a strong track record in global sub segment. There are however no domestic growth factors. Major obstacles are apparent in global markets. This segment receives most support today. Rebalancing should be considered taking into account whether potential growth and wealth creation impacts are better elsewhere.

5. ESA programs are mostly relevant for the upstream space manufacturers. **ESA programs are less useful for services and other tools may need to be developed and prioritized**. This could include expansion of national program expansion may be necessary to provide the near-market-ready support for downstream services.

Operational suggestions

1. The Ministry should develop a holistic policy for space activities including determining the relative importance of support industrial development, public sector programs and science.
2. Space related investments should be made subject to broader economic option analysis if national program investments are to be expanded. Life-cycle costs, market options, and tradeoffs between national content provision and additional cost for government need to be assessed according to normal standards.
3. If bilateral deals and industrial return schemes: consider transparency and competitive schemes for national content to reduce fiduciary risks and optimize outcome. Bilateral agreements and industrial returns do not come for free. Costs of these against alternatives need to made explicit or risk serving narrow interests.
4. There is increasingly a market capable of meeting Norwegian government operational requirements for a.o radar and AIS data. Competitive procurement schemes need to be considered. Consider advanced procurement strategies to ensure competitive offerings a.o competitive dialogue, framework agreements and multiple sources. There may be a need to separate the support schemes from acquisition of public services as tehse serve different needs and objectives. Clarify or develop policy principles for how to handle the balance of conflicting objectives for: procurement for public need, industrial development objectives, bilateral collaboration; and legal compliance and fiduciary risks. The Ministry should review ongoing and planned procurements or support schemes to ensure there is regulatory alignment and fiduciary risks are handled. Rapid external developments dictates rethinking before further AIS satellite investments. Market options and viability of government alternative should be reviewed with proper methods.
5. The Ministry and the Space Centre should reassess the governance framework and tie this more closely to the governance dialogue and strategy. The logical framework should be reviewed and further simplifications and alignment with the long-term strategic plan should be implemented.
6. Improve transparency of the grant schemes and ESA support. Information is not publically available today and this is problematic especially n light of how few companies that are involved and that receives substantial support.
7. Reduce conflict of interest potential with KSAT by reorganizing ownership management.
8. Consider reinforcing monitoring of ESA budget and account measures through the IPSAS accounting transition
9. If further scale-up of national programs, the space center may need to be reinforced.
10. If EU/ESA relationship converge further, the space center may need additional support.

Detailed analysis

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Introduction

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Section 1 Analysis of developments

The objective of this section is to establish a factual basis upon which we can have a reasoned discussion of relevance, effectiveness, strength and weaknesses of the national space programs.

Section 2 Policy effectiveness

The objective of this section is to determine real world impact, the degree of success of the space programs in reaching the objectives and governance risks.

Section 3 Suggestions for the future

The objective of this section is advice on future changes to the program priorities, approaches and governance.

Section 1 Analysis of developments

The objective of this section is to establish a factual basis upon which we can have a reasoned discussion of relevance, effectiveness, strength and weaknesses of the national space programs. Four important issues are covered:

1.1 Markets and industrial developments

The objective of this analysis is to review developments in industry and the markets it caters to.

We focus on two areas:

I. **Overview** of developments of space industries in Norway. We focus on important metrics that helps us understand how the industry performance and structure has evolved over time and vis-à-vis global developments; and,

II. **Space industry value chain** worldwide and in Norway. This is useful to understand how the industry is structured and how it has evolved. What are the industry chain economics; supply and demand? What are the markets segments, trends and resulting opportunities and risks.

This is a global industry and we analyze demand and supply worldwide, and identify Norwegian capabilities and trends in the market segments.

1.2 Institutional and policy developments

The objective of this analysis is to analyze developments in the external institutional and political arena which have implications for the relevance and effectiveness of the national space programs.

There are three perspectives on this:

I. **Global policy developments** are reviewed first. This is about the:

- **the U.S. 2010 policy.** We will review what the Americans have envisioned and discuss how industry and government in Norway may be impacted; and
- **European issues.** This is primarily about the reconfiguration of ESA and EU relationships with the implications this has for priorities and direction of policies.

II. **Emerging market developments** is about how developments in major emerging economies may impact space programs in Norway.

III. **Peer country review**

will focus on how these countries handle issues of interest for Norway. We focus on three countries : Canada, Sweden and Switzerland.

1.3 Implementation of programs

The objective of this analysis is to review how the programs have been implemented. What has been the activities? Where has the monies been spent? How is it governed?

We focus on three areas:

I. **ESA Activities**. How has Norway engaged with ESA? What has been the priorities? What are the developments over time? What segments of the value chain are engaged?

II. **National programs.** These have had complementary and supporting functions to the ESA engagements. We review the support for industry, and the programs to enhance public utilization of space capabilities. This includes a review of the Radarsat program.

III. **Governance**. We review the relationships between the Ministry and the Space Center and how the programs are managed. How is the strategy devised, planned and executed? How effectively is it monitored? What risks may exists?

Section 2 Policy effectiveness

2.1 Impacts

The objective of this analysis is to analyze what has happened as a results of the programs. What real difference has they made? We present important facts and analysis to help establish what the policies have accomplished.

We focus on three areas:

I. **Supported space industries**. We discuss impacts by segments and over time. How has their business evolved? How important are the public development funds and contracts? Are there ripple effects and tech transfer? What's the growth, the employment and the profits?

II. **Public sector impacts.** Many activities has targeted utilization of satellite capabilities in the public sector. We review what impacts are seen.

III. **Socio-economic assessment**. A deeper analysis of how the programs contribute to economic and social development. How does the costs transfer into broader societal gains? What would have happened in the absence of the space programs?

2.2 Meeting objectives

The objective of this section is to determine the degree of success of the space programs in reaching the policy objectives.

Two important issues are covered:

I. **Relevance.** This is assessing to what extent the activities are suited to purpose. Are the activities and outputs consistent with the overall goal? Are the activities and outputs consistent with intended impacts and effects?

II. **Effectiveness.** This is about assessing whether the objectives has been achieved and what are the major factors impacting achievement of objectives.

2.3 Governance and fiduciary risks

The objective of this section is to identify governance risks, mitigation strategies and critical enablers for program success.

This will focus on two areas:

I. The concepts for determining objectives, allocating activities and resources and measure and report on progress; and

II. Important governance and fiduciary risks to the space programs and which should be mitigated.

Section 3 Suggestions for the future

The objective of this section is advice on future changes to the program priorities, approaches and governance.

This has two important sections:

I. **Strategic considerations:** Identify areas of strategic misalignment of objectives and approaches and suggest ways to readjust; and

II. **Operational suggestions:** Identify areas where there is risk of deficiencies in realization of objectives, high cost inefficiencies or governance risks and suggests mitigation strategies to ameliorate the negative impacts.

Important legacies have shaped today's space policy in Norway

" The Norwegian Space Sector is predominantly "down to earth".

*Pål Sørensen, First Managing Director of the Norwegian Space Center.**

This phrase, as presented by the managing director in his final editorial of the annual review in 1997 encapsulates both the political orientation and the industry capabilities. In the metaphoric sense, this emphasizes the significance of utilitarian aspects of developing space capabilities in Norway. Policy priorities have been consistently pragmatic focusing on user needs and value creation

The phrase also indicates the capabilities and direction of industry and space researchers. The Norwegian Space Community has been dominated by ground equipment producers, earth observation applications, download stations and communications. This is very much the case today although increasingly there are businesses successfully aiming for space in the literal sense.

Legacies

Choices from decades ago shape the structure of Norway's space capabilities today and these also shape current policies and priorities.

The first important legacy is the decision to focus on business development, and in particular the concerted effort to develop maritime satellite communications. This turned out to be a highly significant for today's industry structure. Today there are world leading maritime satellite communications businesses in Norway and this is largely the result of visionary leaders and an effective industrial lobby at that time. In the late 1960's, focused efforts set the stage for defining telecommunications as the main priority for the Norwegian space effort. **

The telecom focus was originally oriented towards equipment producers but also through engagements in Inmarsat and other service offerings. There was an industrial electronics manufacturing base, and as importantly, there were commercial anchor tenants in the large merchant fleet controlled by Norwegian Ship-owners.

With some important changes in direction and make-up this still holds true today. Maritime satellite communications is by far the largest segment of the industry. The communications service segment has evolved to become the dominant feature of the industry encompassing some 60 percent of sales. The service segment is today mostly about providing internet broadband capabilities for ships and platforms. The communications ground equipment industries are still significant, but are struggling with increased commoditization and competition from low-cost producers. Their relative importance in the Norwegian economy has much declined.

The second important legacy stems from the realization that remote sensing and earth observation capabilities of satellites would be an effective solution to resolving strategic challenges for government related to the new-found wealth in the ocean territories of Norway. This argument found traction at the time and eventually carried over into ESA membership later. Early initiatives where launched i.e. to develop radar data processing capabilities, and also focused much on establishing telemetry stations – originally in Tromsø. These priorities have remained, and perhaps even increased in importance as the Arctic north is becoming an important strategic theatre for Norway.

Source: NSC Annual review 1997; ** Røberg 2005

Today's policies are mostly a continuation of the past

Norwegian space policies are still founded upon developing industrial and commercial capabilities, as well as ensuring that public sector utilitarian needs are met.

The stated objective of Norwegian support for space activities is:

"To provide substantial and sustainable contributions to wealth creation, innovation, knowledge development and environmental and public safety"

The policies are expressed in annual budget appropriation documents, and with regards to particular high profile issues, such as the decisions to participate in Galileo. More detailed documents governing the relationship with the National Space center sets out objectives and targets. The Space Center develops triennial plans which in effect is a more fully fledged strategy.

Government has a set of policy instruments to support these objectives:

- Most significant instrument is participation in the European Space Agency (ESA). Through this involvement, Norwegian businesses, scientists and civil servants participate in developments of programs which by themselves are to costly and complex for the Norwegian government or industry to undertake on their own.
- There are also other instruments; including use of national funds to complement ESA activities or to achieve other objectives.

Most of the instruments are managed by the Norwegian Space Center which operates under the auspices of the Ministry of Trade and Industry.

There are also other relevant government institutions and financing involved in space activities but for different purposes. This includes science; domestic university based activities and financing and contributions to EU Framework programs (FP7); or memberships in other space related international organizations such as the EU meteorological organization EUMETSAT.

Public funding for space activities in Norway, including science and public sector agency activities constitutes about a sixth of the total economic activity in the sector. ESA participation constitutes about half of the total government spending.

The space industry in Norway extends far beyond those activities which are supported directly through government instruments. In fact, about 95 percent of Norwegian enterprises sales are for commercial markets.

Future directions to take account of important developments

Things have changed. Determinants of much of today's capabilities are still based upon important legacies, but current external developments, both commercial and political, have altered the landscape. Future direction is less obvious.

First, the internal capabilities in Norway have expanded greatly over the last decades. Space based businesses have become commercial successes in more areas than before, including in classical space manufacturing disciplines such as launchers and satellite components. Even within once dominated public area of telemetry and downloading stations, we now find this as a commercial and global enterprise. Maritime satellite communications services are global leaders and this is evolving without any direct public financing. Technologies have become cheaper and Norway has launched its first satellite at a cost of "only" 30 mill NOK (USD 5,2 mill). This does open new possibilities.

Second, the domestic industry structure is changing and is now mostly directly foreign owned. Global industrial conglomerates control the largest share of Norwegian space industries. Maritime communications services firms has proven to be very attractive acquisition targets. The once successful ground equipment industry has seen much decline, which is only partially compensated for by a small growing space manufacturing and launcher industry. The other services (other than satellite communications services) segment is the fastest growing and second only to satcom in size. The industry turnover in Norway overall has seen a decline over the last 5-10 years.

Third, the global space industry is emerging as a more commercial structure. Telecommunications services operate fully commercial, but commercialization is increasing also in other areas such as imagery, radar and geotracking. This is still a world heavily dominated by Governments and public expenditure, but the relationships are evolving. Important national programs are being organized as public private ventures whereby government and business share both upside and risks. Remote sensing data, imagery and radar, are now available as commercial products from several producers. The satellites are still heavily supported by Governments although private financing is involved.

Fourth, the military frequently utilizes satellites with dual civilian and military capabilities. The Norwegian Military will develop a communications satellite with Hisdesat, a Spanish based manufacturer, and lease capacity to commercial customers. Another case in point is that GeoEye-1, one of the better image satellites currently in flight was financed in part by the Geospatial Intelligence Agency in the U.S and delivers images to the intelligence services, to other private and public customers worldwide, and to Google for its Google Earth application.

Fifth, the world of policy and institutions are also changing. U.S. space policies have changed much. There is a determined focus on commercialization and public expenditures are reduced. Relationships between ESA and the EU are still being worked out and the outcome has the potential to weakens Norway's position and industry's access to European institutional markets. There may be increasing opportunities for bilateral relationships with other countries, but government may also find itself involved in various public-private ventures, national and international. The current agreement with Canadian firm MacDonald, Dettwiler and Associates Ltd. (MDA) on use of Radarsat-2 data is an example.

Emerging market nations have entered space and their priorities and industrial capabilities are considerable and rapidly expanding. China now rivals Russia for most satellite launches and has already passed the U.S. India rivals U.S. satellite image firms and disrupts the markets by offering images at less than a third of the price.

These issues will impact outcomes in Norway for years ahead.

Objective, scope, and methodologies of the review

The objective

The objective is to evaluate the participation in ESA, the Radarsat agreement and the national support funds. The evaluation should also provide a basis for assessing the socio-economic benefits of the programs.

The review is commissioned by the Ministry of Trade and Industry and delivered in March 2012.

The ministry highlights three themes of particular importance:

-Whether the programs contribute to the accomplishments of the space policy objectives;

-Assess the socioeconomic benefits of participation in the programs, and

-Identify areas of improvement.

The request from the Ministry outlines a number of areas and detailed questions, all relevant to evaluate the past performance of the space programs, as well as to point the way ahead. Some questions in each area are about the relevance of the objectives such as scaling of programs and priorities, others are about effectiveness in reaching the objectives, while others again are about the cost-efficiency. It may require different methodologies to answer them all and hence it is useful to distinguish them.

The scope

There is a range of policy instruments to support space activities in Norway. We will review the first three on this list. A listing of programs would include:

1. Participation in the ESA. ESA mandatory and the Optional program, participation in which should reflect the Norwegian priorities.
2. The funds managed by the National Space Center for dedicated programs for industrial development and public service development including special initiatives such as AIS and Radarsat to enhance public sector capabilities.
3. Purchasing of radar satellite data through a separate agreement with Canadian firm MDA.
4. Participation in EU activities, whereby the space component is developed under ESA, such as Galileo and GMES.
5. Participate in other EU activities; FP7
6. National research programs through the Research Council support.
7. Science activities at universities and colleges.
8. Special programs i.e. (EASP) for national infrastructures, particularly the rocket range at Andøya.
9. Military activities including development of the new communications satellite.
10. Participation in dedicated organizations such as EUMETSAT and COSPAS-SARSAT.
11. Meteorological activities I Norway and by EUMETSAT.
12. Range of other public expenditures such as basic financing for science, higher education: and agency funding and activities such as the coastal authority.

Interactions between these instruments are important and we will explore those when relevant to inform the analysis.

Science is an integral part of the space activities. There are many space science activities in Norway and meaningful analysis of this needs to be holistically. That is beyond this work.

The focus the last ten years and if data is available, even longer back. There are long lead times in development of space activities and the fruition of policies may not be seen for decades. The Ministry mandate focuses on the years 2004-2010.

There is an emerging global consensus of how to define the space industries. Our approach to analyze the value chain and its definition is aligned with a.o approaches by the OECD and other market analysis and adapted to what's relevant for Norway.

The focus is on providing a robust basis for analyzing questions of to what extent to the instruments are appropriate for the purpose, their adequacy, consistency and balance. These are important issues for the Ministry and especially in a context with rapidly evolving external and internal issues.

Determining a way forward, including possible adjustments to the balance of instruments, will be deliberated upon among the actors. This work provides useful analytical background for such discussions.

Methodology and data

The evaluation combines indepth interviews with conciderable quantitative analysis of the support schemes and the sector in general. This includes:

Administrative and business data: Conciderable quantitative data have been used. The data are collected by the MoTI, NSC and ESA for different purposes but has some overlaps. As in all administrative datasets there are certain inconsistencies, broken time series and varying sample sizes. We have integrated this as best as possible and supplemented with information from corporate reports, financial statements and press and investor information. In total this is robust though there are minor unresolved inconsistencies. The evaluation also uses company specific information drawn from publically available sources. We have had access to non-public sensitive information of single companies and this has been important to calculate certain aggregate numbers.

Document analysis: Nearly 1500 pages of relevant documents hae been reviewed. Important documents includes annual reports and budget proposals, company annual reports, international studies, and a range of market analysis. This also includes information from press releases, investor relation reporting, financial analysts, as well as quarterly and annual reports.

Interviews. The analysis is further strengthened by interviews of actors across all segments of the value chain, private and public alike.

The **value chain for** space related activivities can be defined in several ways. We have based the analysis upon prevailing standards in market analysis and official publications. This is adapted to the Norwegian context where appropriate.

To utilize **international expertise** in the area and also to avoid any ties or conflict of interests with Norwegian space programs, the report has been develop din English. The report is translated into Norwegian and both versions made available.

Section 1

Analysis of developments

The objective of this section is to establish a factual basis upon which we can have a reasoned discussion of relevance, effectiveness, strength and weaknesses of the national space programs.
Four important issues are covered:

I. **Market and industry developments.** This focuses on external developments and the Norwegian capabilities in particular. We will review overall chain economics, supply and demand characteristics, and focus on those core segments that are most relevant for Norwegian industry and policy.

II. **Institutional and policy developments.** This focuses on the institutional landscape and how it is evolving. How does the new U.S. policies impact Norway? We will discuss the role of the European Space Agency, the emerging importance of the European Union and other institutional structures. Review the emerging markets, the priorities among nations and how are peer countries meeting the challenges?

III. **Implementation of the space programs**. This includes an analysis of how the monies has been spent and to what effect. We will review the priorities, the important instruments, initiatives and spending patterns. We focus on the three policy segments:

- ESA activities;
- National programs; and
- Governance: strategy and execution.

IV. **Impacts.** This focuses in-depth on the effects on the industry involved, on the public sector and on the broader socio-economic context.

Section 1.1

Markets and industrial developments

The objective of this analysis is to review developments in industry and the markets it caters to.

We focus on two areas:

I. An **overview** of developments of space industries in Norway. We focus on important metrics that helps us understand how the industry performance and structure has evolved over time and vis-à-vis global developments; and,

II. More detailed review of the **space industry value chain** worldwide and in Norway. This is useful to understand how the industry is structured and how it has evolved. What are the industry chain economics; supply and demand? What are the markets segments, trends and resulting opportunities and risks. What's the Norwegian value chain and how does it relate to the global markets? What's the key performance trends in major segments? What are the underlying drivers? What are the barriers to further growth for Norwegian companies?

This is a global industry and we analyze demand and supply worldwide, and identify Norwegian capabilities and trends in the market segments.

The overview

Activity has declined in real terms but may be reemerging

Activities increased strongly prior to 2003 and have since leveled off. In real terms there is a decline starting from 2003 though there may have been real growth in the last few years. The extent of the decline depends upon how price inflation is adjusted for but activity may have contracted as much as 25 percent between 2003 and 2007 if adjusted for producer price inflation (PPI). Total activity in this figure includes both institutional and commercial activities, but excludes consumer TV i.e. Canal Digital and Viasat.

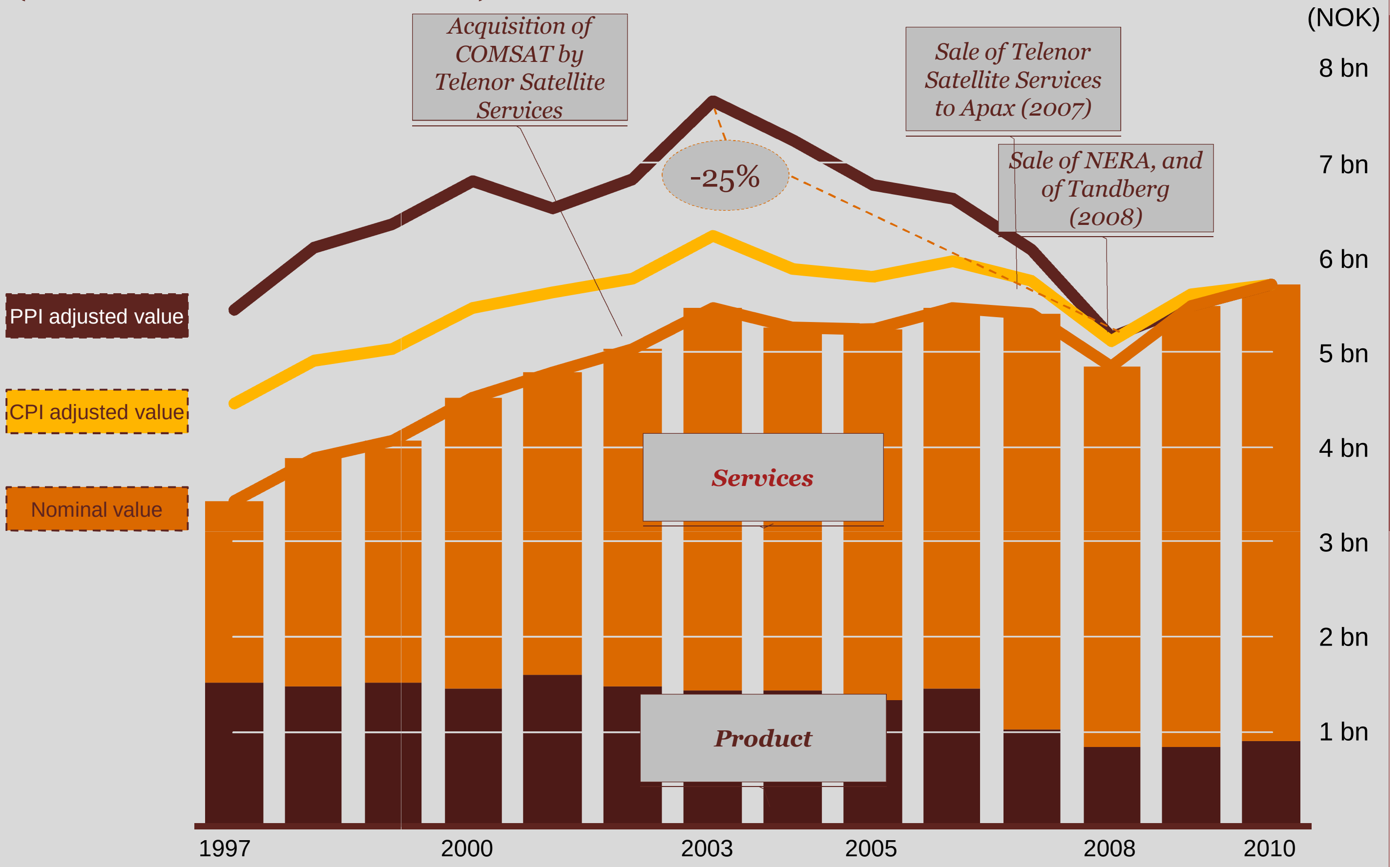
Services constitute the largest segment and has increased in significance over time. Product manufacturing is about 20 percent of total in 2010.

The declining product share is impacted by the closure of one company, but the overall decline started before this company was sold and eventually closed. The services segment may have been impacted by other industry M&A events and the most significant ones are indicated on the slide.

Understanding real growth in this sector is challenging. Money devalues over time and a such the value of a 1997 kroner cannot be compared against 2010 values. The space value chain however includes a variety of different segments where prices develop with some independence between the segments due to very different competitive characteristics. We will come back to this in later sections.

Turnover declined from 2003 but shown real growth in the last few years

Figure 1.1: Turnover of Norwegian space related business by product and service 1997-2010 (Current and constant 2010 NOK billion)



Source and notes: Space related turnover data for 50+ entities proprietary data from NRS;Deflated by Norwegian PPI (Producer Price Inflation - manufacturing base) and CPI (Consumer Price Inflation) Eurostat; Nominal values have normally been reported by NSR and as such this is shown separately.

Declining share of the economy

The pattern of decline is confirmed when comparing against other core economic parameters.

We find that the sector constitutes a little over 0,2 percent of GDP in 2010, a reduction of about 33 percent from 2003. Measured against the less oil dependent GDP Mainland numbers we find the same pattern of decline albeit with slightly higher numbers.

The export ratio in this sector is quite high, but we find a decline measured against other Norwegian exports.

Comparing space services exports against other service exports, we find a decline since 2003. Sales of space related services constitutes about 1,25 percent of total services exports.

Comparing the product exports against other manufacturing exports, we find an even more significant drop of about 43 percent since 2003. This share has declined since the late nineties and is now at about 0,3 percent of total exports.

We assume an equal export share for both products and services.

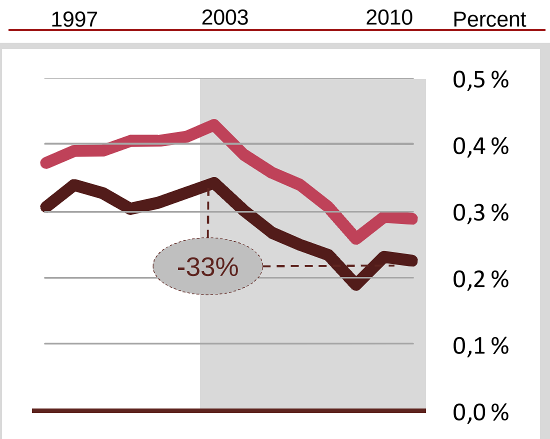
The significance of the industry is probably not best understood in terms of its size. i.e. the total 2010 turnover of 5,7 billion NOK is equivalent to one-eight of the operating budget of the City of Oslo.

Its significance relates more to the technological transfer potentials , and the capabilities provided which value cannot entirely be understood on a turnover basis alone. We will review these issues later.

The declining trend is nevertheless a worrisome finding in that it raises questions of the longer term viability of the industry in Norway. Especially given that the government spending for the sector has increased faster than the commercial turnover.

Declining share of GDP

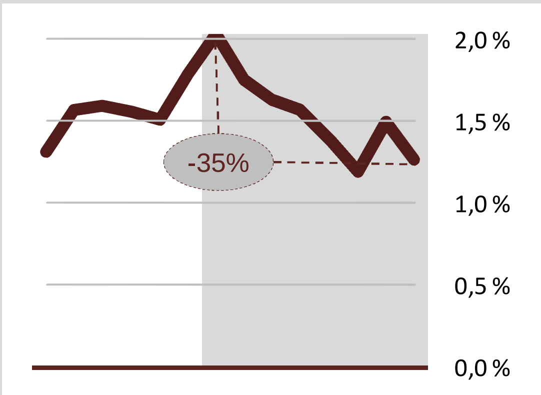
This is calculated with and without upstream oil activities. The measures are correlated. The total turnover, including public financing for space activities is declining against both measurements of GDP.



Declining share of services export

The services segment of the space economy in Norway has expanded, but shows a declining share of Services export.

This also peaked in 2003 and has fallen by 35 percent between 2003 and 2010.



Declining share of product exports

The product segment of the space economy shows and even more drastic decline measured against other exports of manufactured goods.

This also shows a longer term decline from the late 1990's.

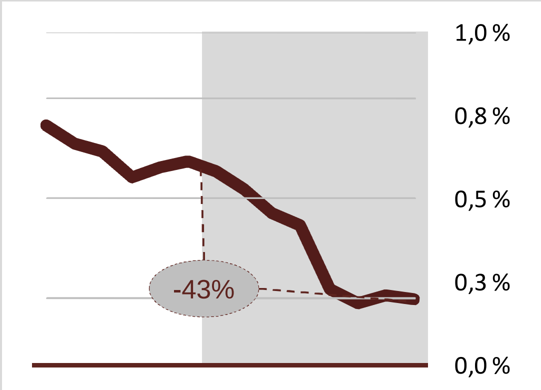


Figure 1.2: Total turnover (Commercial; Institutional) by GDP and exports

Source: Statistical Bureau Norway; NRS; PwC Analysis

Considerable global market share but loosing ground

Measuring the economic activity in Norwegian currencies has some caveats as much of the sales, and the cost base is denominated in US dollars i.e. costs for leasing transponder capacity for mobile satcom providers. Some of their cost base is nevertheless in Norwegian currency, salaries surely and possibly other costs as well. The ratios are not known. As such, it is possible that presenting turnover in Norwegian currency disguises whether there has been growth or market share developments in global markets.

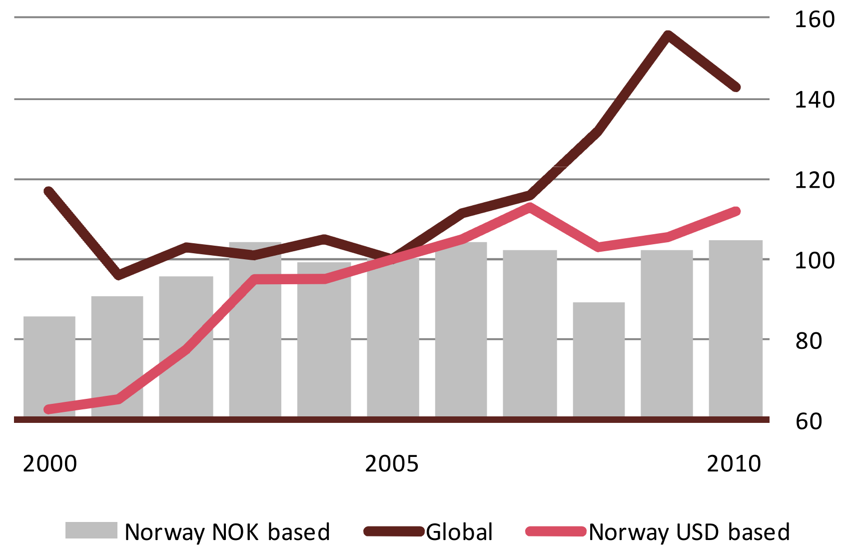
Rebasing all the commercial turnover to USD does indeed show a different picture. There has been growth from early 2000's, a drop during 2008 and an increase since.

Norwegian firms gained global market share during the first five years of the decade. This was particularly driven by gains in the mobile satcom markets. There is little market share in other segments. Since then the share has declined and currently stands at about 2 percent. The share measured in Norwegian currency is also shown.

The value of the activities are identical whether measured in Norwegian currency or U.S. dollars. What will make a difference in the longer run is whether the cost base develops differently for Norwegian firms than for its competitors. As at least a share of the costs are denominated in Norwegian currency, which has appreciated against the dollar, Norwegian firms may be faced with a disadvantage over time.

USD based turnover shows nominal growth, but slower than global growth from 2005

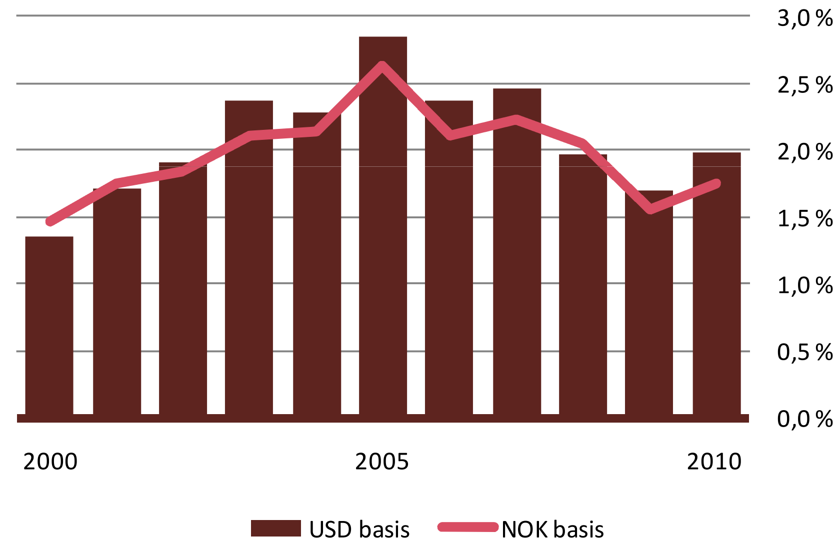
Figure 1.3: Indexed growth of commercial space markets excluding consumer TV and GPS equipment (USD/NOK nominal based, 2005=100)



Source: NRS data; SIA 2011; Space report 2011; PwC Analysis

Lost global market share since 2005 mostly in services and ground equipment

Figure 1.4: Market share of non-institutional space markets (excluding consumer) (USD and NOK nominal based)



Exports are falling, but industry remains highly commercial with 75 percent of sales to maritime and offshore industries

The export share has declined since 2004 from above 80 percent to about 68 percent currently. The decline may reflect a loss of competitiveness but could also indicate strong growth in domestic markets. Competitiveness has declined in the sense that exchange rates have appreciated and labor costs increased. The impact on each business will depend upon a.o how much of the cost base and revenues that are denominated in foreign currencies.

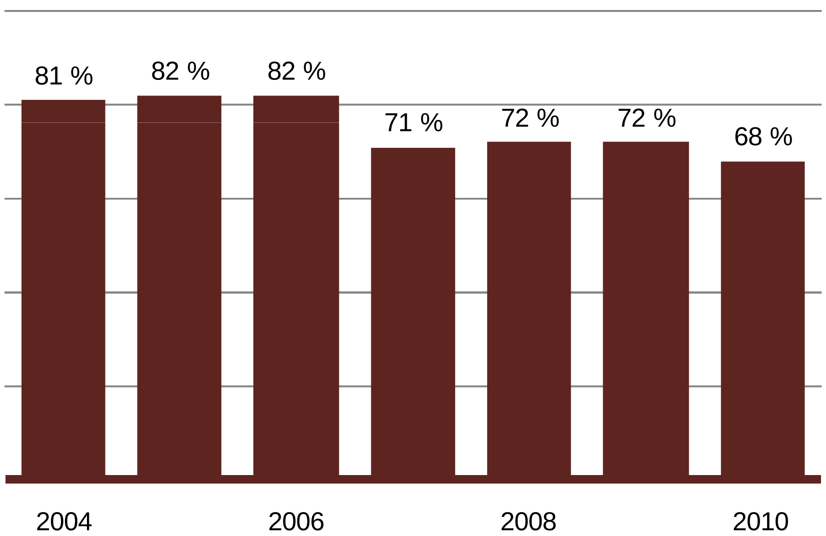
Home markets have also grown very strongly in this period, in particular maritime and petroleum related sectors where many space related businesses have strong anchor tenants.

The space economy in Norway is highly commercial and more so than its peers in many other countries. Most of the commercial sales are to maritime and offshore industries. This drives the ground equipment, satcom services and earth observation/navigation segments. About 60 percent of the commercial turnover stems from mobile maritime satellite services.

In the figure below ,sales to ESA, EU Galileo/GMES and Norwegian government space programs are is counted as institutional development contracts .

Declining export share since mid-2000's possibly driven by strong domestic offshore markets

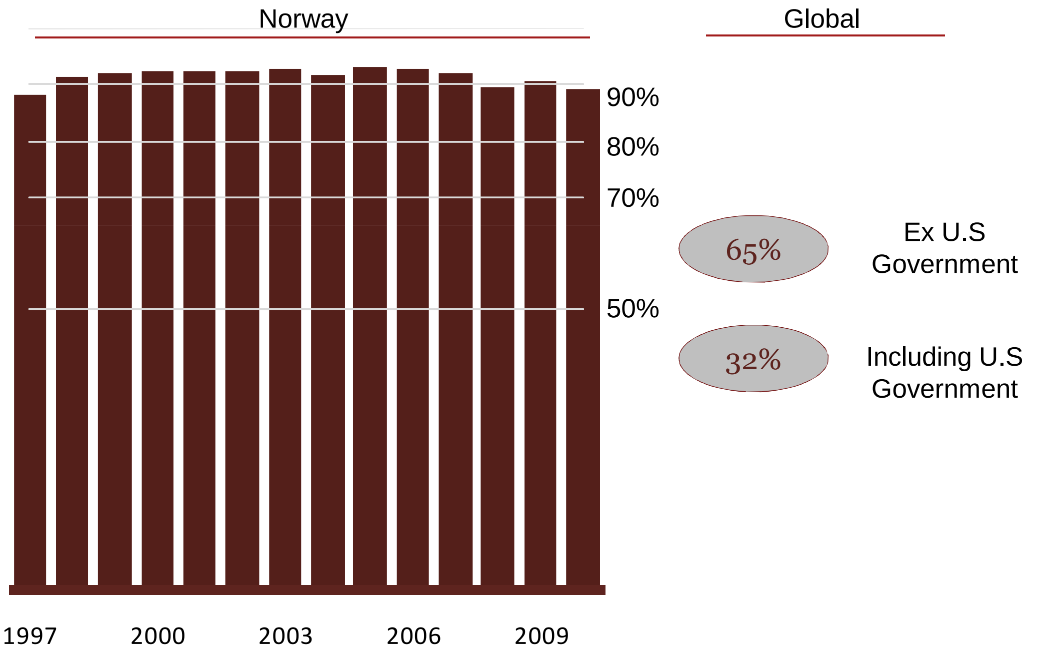
Figure 1.5: Share of exports by total turnover



Source: NRS data; PwC analysis

Much more commercial than its peers in other countries

Figure 1.6: Share of non-institutional revenues (Total of commercial and institutional excluding consumer TV segments)



Public expenditure increasing, commercial sales declining

Zooming in the developments of three categories of space related activity in Norway we note a few striking patterns:

-Commercial turnover is declining in real terms (inflation adjusted);

-Public agency expenditures are rising; and,

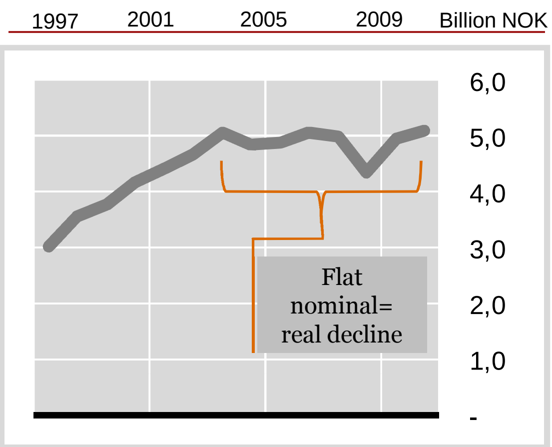
-ESA contracts are rising.

In the next section we will seek to understand what's driving these developments including a review of the value chain economics.

Declining commercial sales

These are sales in commercial markets by firms who have private capital at risk and not supported directly by institutional funds.

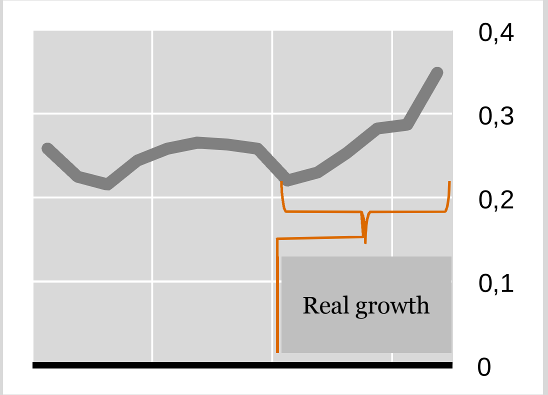
Commercial sales have been flat for nearly a decade, indicating a real decline.



Public expenditures rising

This includes science funding, various other agency funding and space agency financing. ESA funding not included.

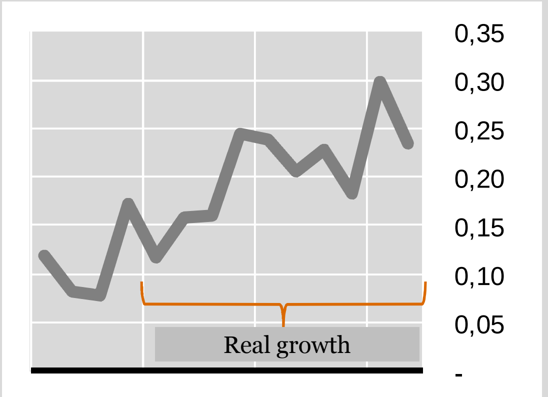
There has been an expansion of these of more than 50 percent since 2005.



ESA contracts rising

These are supported by public expenditures. These show a significant rise over the last decade more than doubling.

The public expenditures associated with this are contributions to ESA that are higher than the contracts received.



Source: Statistical Bureau Norway; NRS; PwC Analysis

Figure 1.7: Commercial turnover; government expenditure ex ESA; ESA contracts 1997-2010

Macroeconomic factors makes competition challenging for Norwegian space firms

It is possible that some of the difficulties observed may be related to macro structural factors particular for Norway such as labor cost increases and currency appreciation. Analyzing the competitiveness of export industries is quite complicated, but the key factors are about labor cost developments and currency appreciation. The underlying difficulty in Norway has to do with the impact of oil and gas exploration and the pressures this creates on labor costs.

Labor cost metrics specific for the space industries does not exist. A proxy indicator is the labor costs of industrial labor. This shows an increase over the last decade compared to trading partners. About two thirds of the difference is explained by wages differentials, the rest by currency appreciation. On average, a third of the developments of labor cost differential in industry can be explained by currency appreciation.

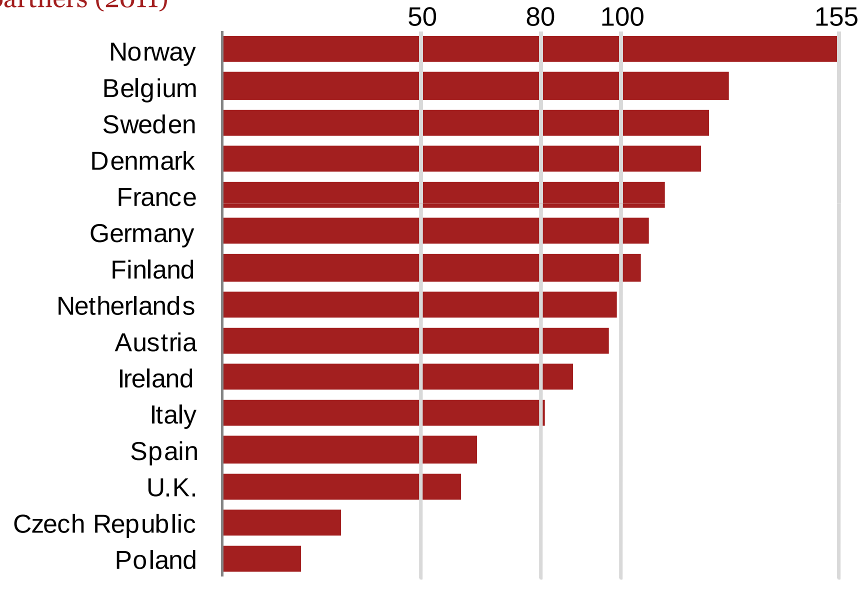
It is important to note that while the Norwegian kroner has appreciated against the dollar over the last decade, so has nearly every other currency in the world – in particular the Swiss Franc and Canadian dollars.

As such, competitors within the advanced economic zones are faced with similar issues. The impact will mostly be about an advantage for U.S. based exporters against everyone else.

Norwegian kroner has still appreciated a more than the Euro. Most of industrial trade in Norway is with Sweden and countries in the Euro zone. The particulars for space industries are not known.

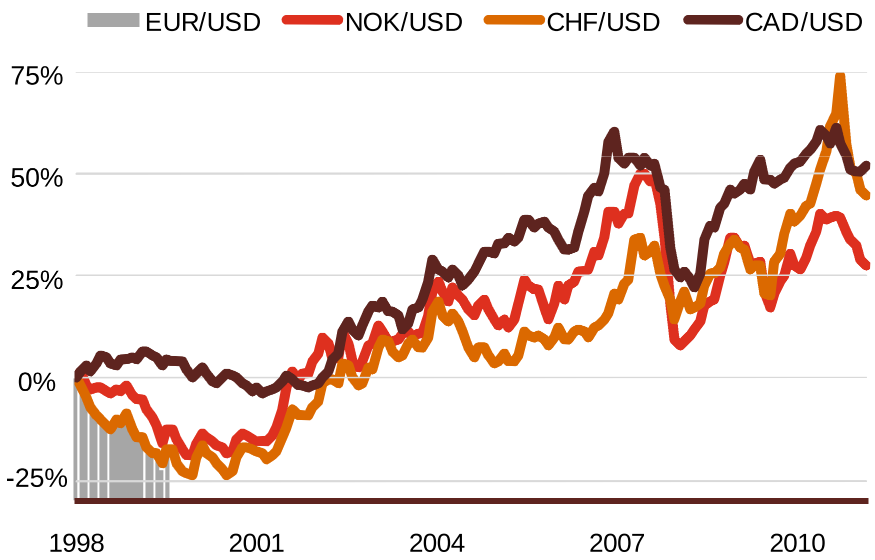
High cost production in Norway

Figure 1.8: Hourly industry wages indexed compared to EU trading partners (2011)



Currency appreciation against dollar cannot fully explain decline as competitors are faced with same issue

Figure 1.9: Exchange rates against USD 1999-Feb 2012 (Monthly percentage change)



Source: SSB, Eurostat, Beregningsutvalget 2012: FX rates midpoint of monthly bid-ask spreads O&A

The ability to compete with high costs differ across the value chain and is poorest for ground equipment producers

Differences in the ability to pass-on cost increases may vary across segments of the value chain. This ability impacts the viability to compete in a high cost country.

The phenomenon can only be observed by way of proxy indicators such as changes in producer prices. Data does not exist for space industries in particular, but there are reasonable proxies available. Indices at this level of specificity are not produced by Norwegian authorities nor Eurostat. The Bureau of Labor Statistics (BLS) in the U.S publishes disaggregated producer price indices for a range of relevant products and services. Given that space related products and services are traded globally we believe these U.S. Based indices are useful indicators of price developments.

An indicator of producer price increases for **satellite manufacturing and launcher** segments may be the *aerospace products and parts manufacturing indices*. This shows considerable price increase over the last decade, meaning that the prices the producer charges to customers further down the value chain have increased. This may indicate an ability to pass on labor cost and other cost increases. This segments may have seen less competitive pressures from low-cost producers. Space manufacturing has very high entry barriers which may further support this thesis.

Ground equipment production delivers network equipment, antennas and cables. Proxy indicators could include *communications equipment* and other electronics manufacturing. These all show deflation over the last decade indicating that there could be cost pressures from i.e.. low cost producers. This ability to pass-on cost increases may not exist.

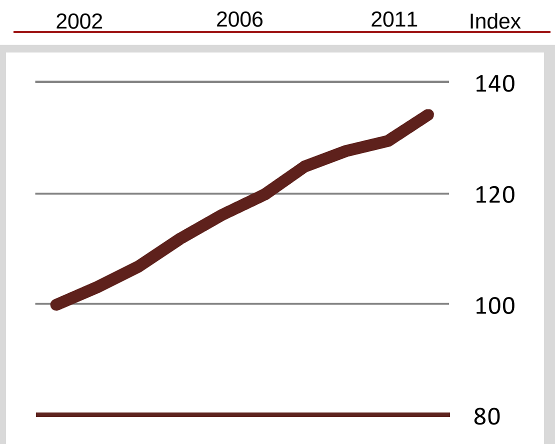
Satellite services is much harder to capture by way of proxy. Cable TV programming in the U.S is a substitute for satellite TV and shows an increase. Internet subscriptions prices in the U.S. have fallen, but the content and quality of deliveries may have increased. For the space segment, and particularly relevant for Norwegian enterprises, is that VSAT based broadband deliveries have a price point (measured as average revenue per customer) at about 50% above the Inmarsat fleet service. The value added of VSAT services is believed to be higher.

Figure 1.10: Producer Prices Indices for relevant market segments (US PPI BLS)

Inflation for Satellite and Launchers

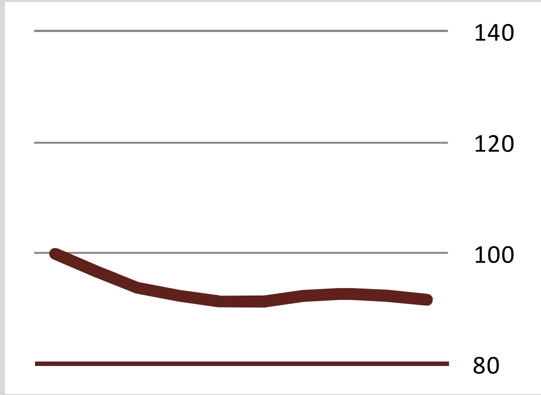
Markets for Aerospace product and parts manufacturing may be a proxy for price developments for space manufacturing.

This shows a considerable increase over the last decade, at par with average PPI in the U.S.



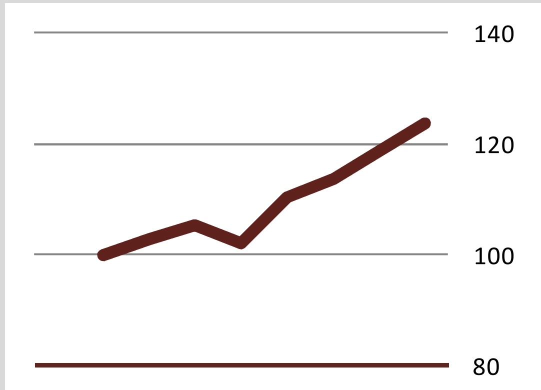
Inflation for Ground equipment

Ground equipment manufacturers are more exposed to cost pressures from low-cost producers as entry barriers are lower. Indices for communications equipment manufacturing show declining prices. Indices for other electronics manufacturing show even larger decreases.



Inflation for Satellite services

Satellite services are harder to measure by way of proxy. Cable and other subscription programming is a substitute for satellite TV and does show an increase over the decade. Anecdotal evidence of maritime broadband deliveries also show increases.



Source: BLS U.S.

Commercial activity concentrated in large enterprises, most of which are part of global conglomerates

Astrium Services, part of the larger EADS Astrium group is now the largest actor in Norway having acquired Vizada in 2011. Vizada provides satellite communications for maritime, aerospace and defense industries. It's a market leader in several segments; Second only to Stratos(US) as reseller of Inmarsat capacity, and leading the VSAT broadband market. Much of the maritime segment is managed from Norway where Vizada also runs Eik ground station. The acquisition is expected to increase the revenues of Astrium Services by 60%. Vizada has its origins in Telenor Satellite Services which was sold in 2007 and merged with France Telecom Mobile Satcom. Vizada has an estimated +4 bn NOK in revenues globally and according to the business registries (BBREG), about half of this is accounted for in Norway.

Telenor Satellite Broadcast is the only Norwegian entity which owns and operates a fleet of geostationary satellites and uses these for transmission of TV signals and broadband capacity. Its key customer is the Canal Digital (also Telenor) in the Nordic region, but is also believed to be selling to MTG and other groups in Eastern Europe and the Middle East. TSB runs Norway's largest ground station in Nittedal, the station alone employing some 70 people. The Telenor group has divested much of its satellite business over the last decade; including TSS (above) and a large share in Inmarsat. It has lately done some venture aquisititions of smaller satellite related business.

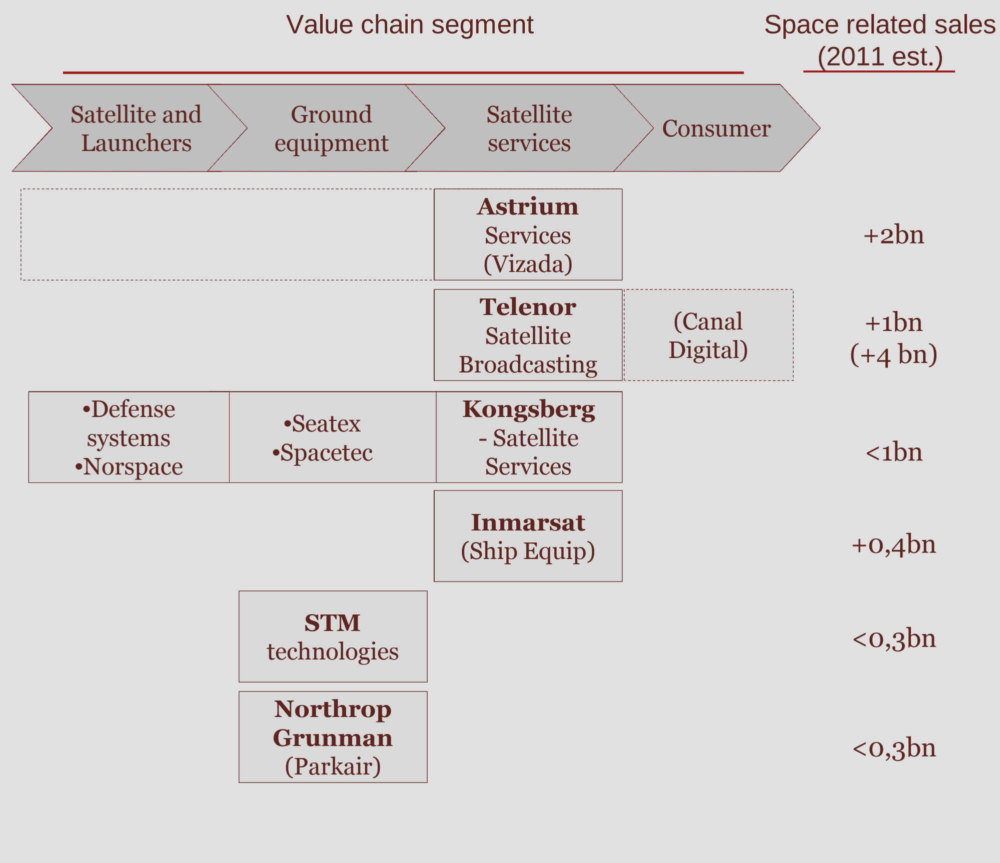
Kongsberg Group appears to be strengthening its space related businesses through recent acquisitions. It operates across the value chain, predominantly in manufacturing of launch, satellite components and ground equipment. Its units, such as Norspace, are market leaders globally for certain components. It also operates in the services segment through its part ownership of KSAT.

Inmarsat now operates in Norway through its acquisition of Ship Equip, an internet provider for the maritime industries (VSAT). Ship equip is reported to be the fastest growing internet provider for the maritime sector, and second only to Vizada as seller of VSAT internet solutions.

STM (US) picked up Nera Satellite broadband in 2007. Much of the R&D activity is maintained in Norway. STM enjoys an estimated six percent and growing share of the global VSAT equipment market.

US giant **Northrop Grunman** is also present in Norway through its ownership of Park Air systems.

Figure 1.11: Major industrial actors in Norwegian space industries



Source: Financial press, analyst reports; quarterly statements and press releases; PwC Analysis

Significant foreign M&A of high growth and profitable firms, and foreign ownership now control more than 60 of the commercial value chain (turnover based)

The ownership structure of the industry has changed significantly over the last five years. Norwegian enterprises have become favored acquisition targets. More than half of the commercial value chain (turnover based) is directly foreign owned.

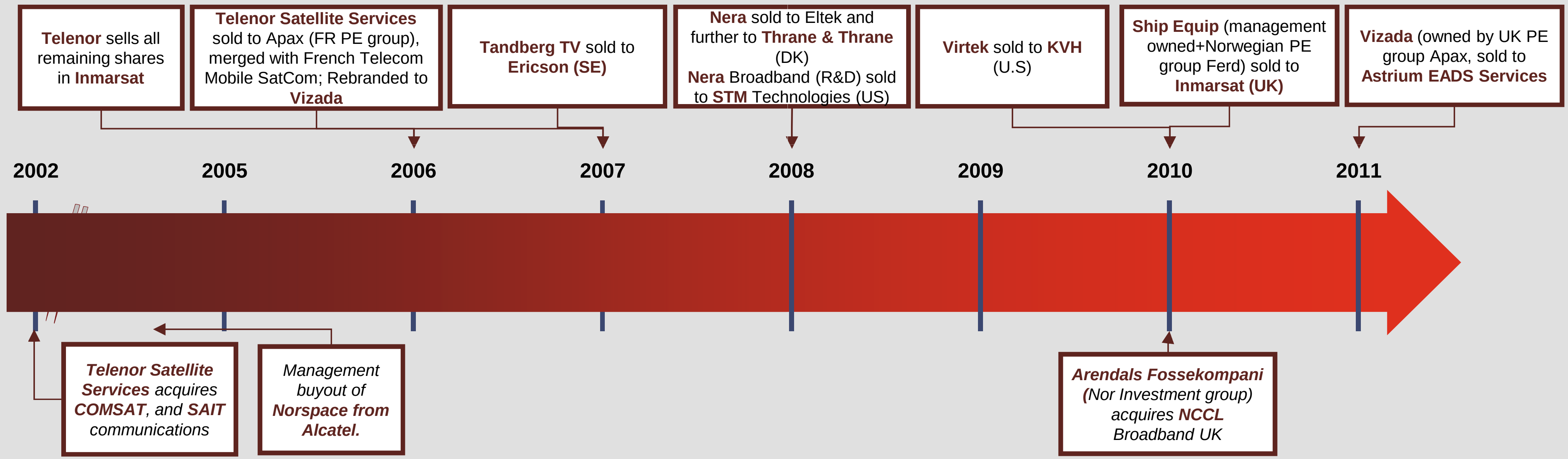
The impact of the takeovers in Norway is not fully understood. Important questions to understand better are: what would have happened if the ownership was not transferred; and how would jobs and profitability develop under foreign ownership?

There is a certain weariness in the community given the closures and job transfers resulting from the acquisitions of ground equipment producers Nera and Tandberg. Less is understood about how the service companies evolve under foreign ownership.

The acquisitions may be an indication of growth constraints in Norway. Fast moving companies need access to global distribution networks and capital to continue growth. There are few larger Norwegian based enterprises with whom there is sufficient strategic alignment to support expansion in the space segment.

There is no appropriate policy response option to this beyond the existing structural policies which help ensure that headquarters of the largest Norwegian actors i.e. Telenor and Kongsberg are maintained in Norway. And more relevant for space policy in particular - helping to ensure that there remains a healthy growth of smaller enterprises to fill any void which may appear.

Figure 1.12: Major foreign M&A events in the commercial Norwegian Space industries



Few new entrants to the space segment over the last decade

Most companies active the space segment in Norway are more than 10 years old. 80 percent dates back to 2001 and 60 percent to prior to 1995. Many of these firms have seen high sales growth, particularly in the period leading up to 2005, but overall there are few new entrants.

There have been some new entrants over the last decade. At least two of these have seen considerable commercial success, both in the mobile satellite communication segment.

There are many firms for which space related sales only constitute a share of totals and they may have entered the space markets late in their history. As such, date of incorporation may underestimate the degree of new entrants. Also, product and service offerings have expanded within some of the firms and to understand the success of those we need to review the sales statistics (above).

Entry into the space segment can be reviewed in detail for a subset of companies that are active with ESA. They represent three quarters of the companies but only 20 percent of turnover.

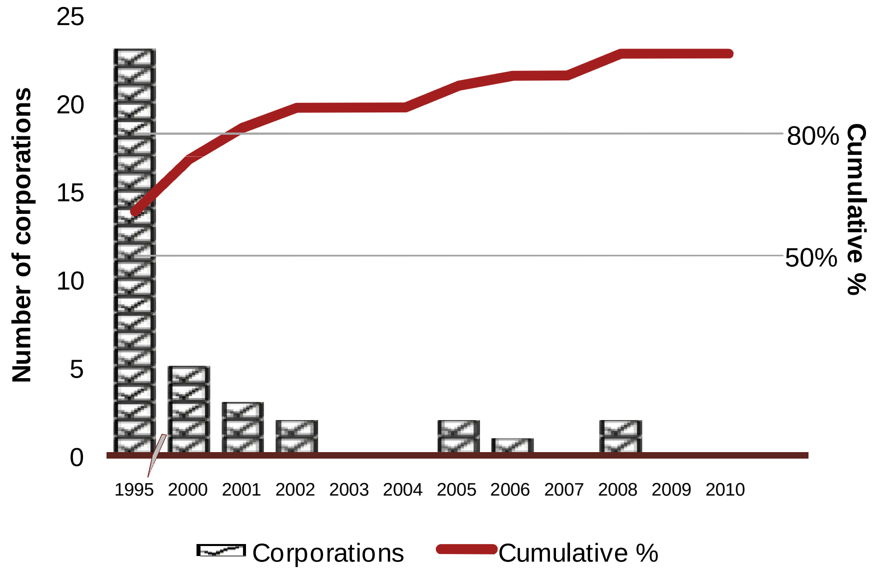
For ESA firms we find a similar pattern whereby 80 percent of the firms entered the space markets more than ten years ago. There have been a few new entrants over the last five years.

Another perspective emerges when reviewing the years in which any firm have recorded space related sales. In the period between 1992 and 2006 there is little, if any net increase in number of firms that record space related sales in any year. Activity has increased in the last few years.

Fully owned subsidiaries are recorded as separate corporate entities in this exercise. The numbers also include industrial oriented R&D institutes.

80 percent of active corporations established before 2001

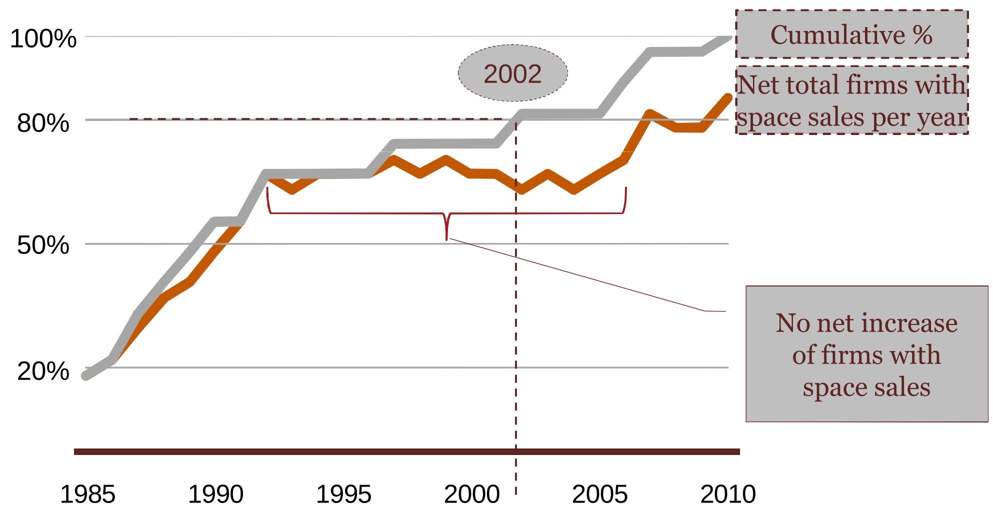
Figure 1.13: Year of incorporation for active companies in space industries (38 total)



Source: NSR data; BRREG; PwC Analysis

...and those that are active with ESA are about as old

Figure 1.14: Year of first space related turnover for ESA active corporations (Subset of 27)



Little specialization in space technology patents

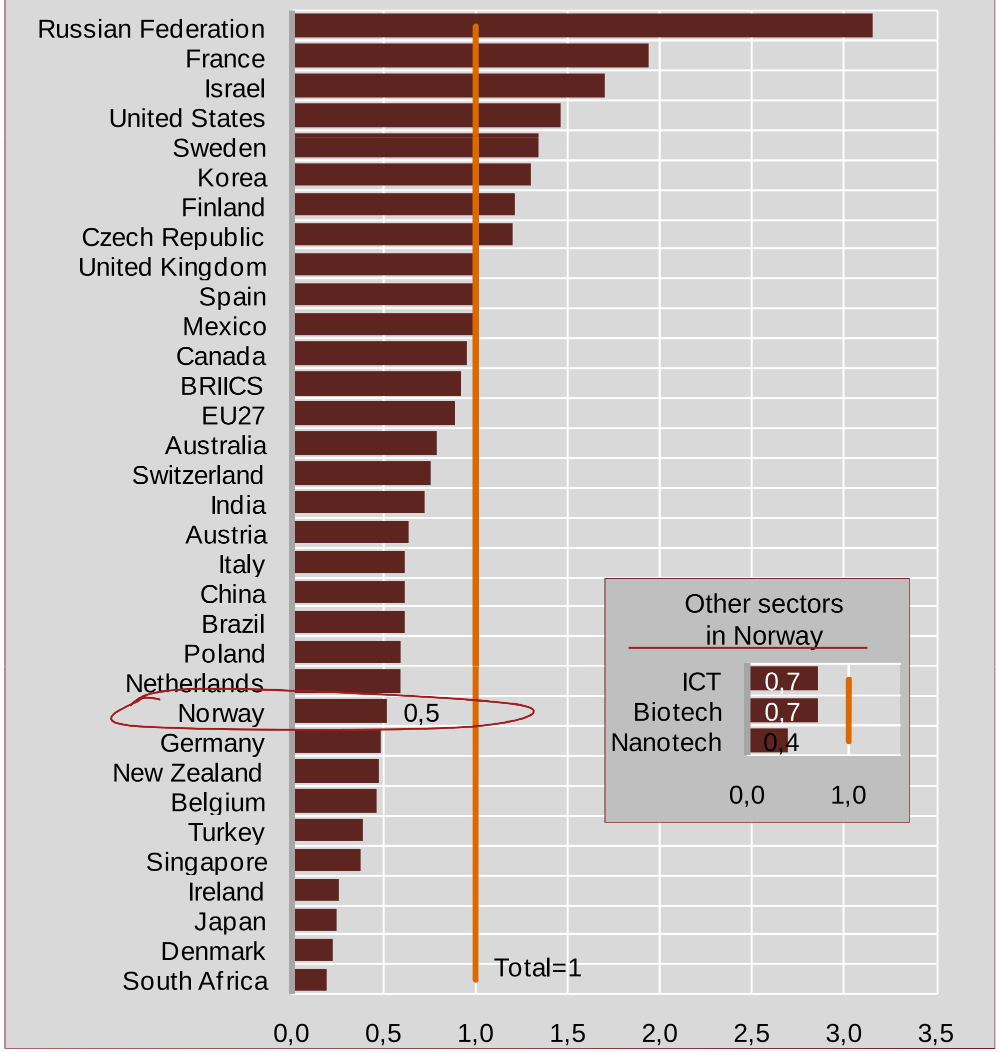
Some countries show a high degree of space related technology specialization. This includes Nordic neighbors such as Sweden and Finland. Traditional space powers also rank high: i.e. Russia, France, the U.S.. There are also a number of emerging markets countries high on this list such as Mexico, India, China and Brazil.

This index is defined as the country's share of patents in a particular field of technology, divided by the country's share in all patents. It is equal to 1 when the country share is equal to its share in all fields.

Norway is rated at 0,5 meaning that there is little specialization in this area compared to other sector in Norway. There are other emerging technology areas in which Norway has a score below 1, including ICT , bio- and nanotech though the ratios are higher for ICT and biotech than for space.

The low degree of specialization in Norway could be indication a problems. It may rise some concerns with regards to the ability of the sector to drive technological advancements throughout the economy.

Figure 1.15: Revealed technological advantage in space-related technologies; Patent applications filed under the Patent Co-operation Treaty by priority date and inventor's country



Source: OECD Space Economy at a Glance 2011; OECD Science, technology and Industry Scoreboard 2011; OECD patents database

The value chain

Overview of space industry value chain

When assessing how space activities contribute to wealth creation and other objectives it is useful to define the scope and range of space activities in the economy. We do this by mapping a value chain, that is understanding how actors and stages interact. There are three distinct elements of the space value chain:

First, there is **the institutional segment.** Governments globally spend resources to develop capabilities in space and many such systems are also operated by public sector staff. Historically, these developments have been much driven by military needs, i.e. communications and remote sensing needs. Scientific explorations of space also constitutes a core rationale and other public sector requirements such as environmental monitoring are important. These are often requirements for which there exist no private market or suppliers. New developments are necessary and these require significant investments and entails risks that few private enterprises are willing to embark upon alone.

Some of the systems developed by public sector organization have later been made available for commercial use. This includes the meteorological satellites, which are financed and managed by public sector agencies, but where the information collected is made available also to commercial meteorological organizations and thereby creating a commercial market. (EUMETSAT and NOAA) The availability of GPS signals to the public is another example of this concept.

Governments also use private enterprises as contractors for much of the development and operations. i.e. the ESA space systems are largely manufactured by European enterprises.

There is also an increased use of various public-private partnerships whereby private and public actors share risk and upside potential.

Value chain extends from scientific exploration to media and entertainment consumer products

Conceptual

Figure 1.16: Value chain concept for space industries

Institutional, Commercial and Consumer markets

There are also **commercial space segments**. We can divide this into its main value chain activities such as illustrated above. In principle, the institutional activities of governments can be grouped along the same dimensions but the commercial activities can be analyzed with more granularity mostly because of better availability of data and information. Many of the same private actors are also involved a contractors for developments of public systems and in some cases with mixed public and private financial involvement, it is not always possible to distinguish the institutional and commercial segments entirely.

Much of the commercial value chain is driven by the demand for communication services. This creates the demand for satellites, launchers and ground equipment. Most important is transmission of TV signals, but also for internet broadband and other communication services. Of increasing importance, albeit small yet, is also developments of remote sensing capabilities such as the images found on Google Earth. These service markets operate on pure commercial terms. There are international agreements governing use of frequencies and location of satellites but little other policy intervention. Much of the technological base has however been developed under institutional programs.

The satellite manufacturing and launcher segments are more captive. Most of the demand for their products stems from public sources. Nation states (and intergovernmental organizations such as ESA) typically prefer enterprises from their own countries. As such this market segment has more captive characteristics than the service segment. i.e. in the U.S government spending is estimated to constitute 85 percent of the demand for space manufacturing in the U.S. In Europe the ratio is closer to 50 percent. Yet, when a Satellite TV organization needs to increase their satellite capabilities, the manufacturing and business mechanisms around this are commercial.

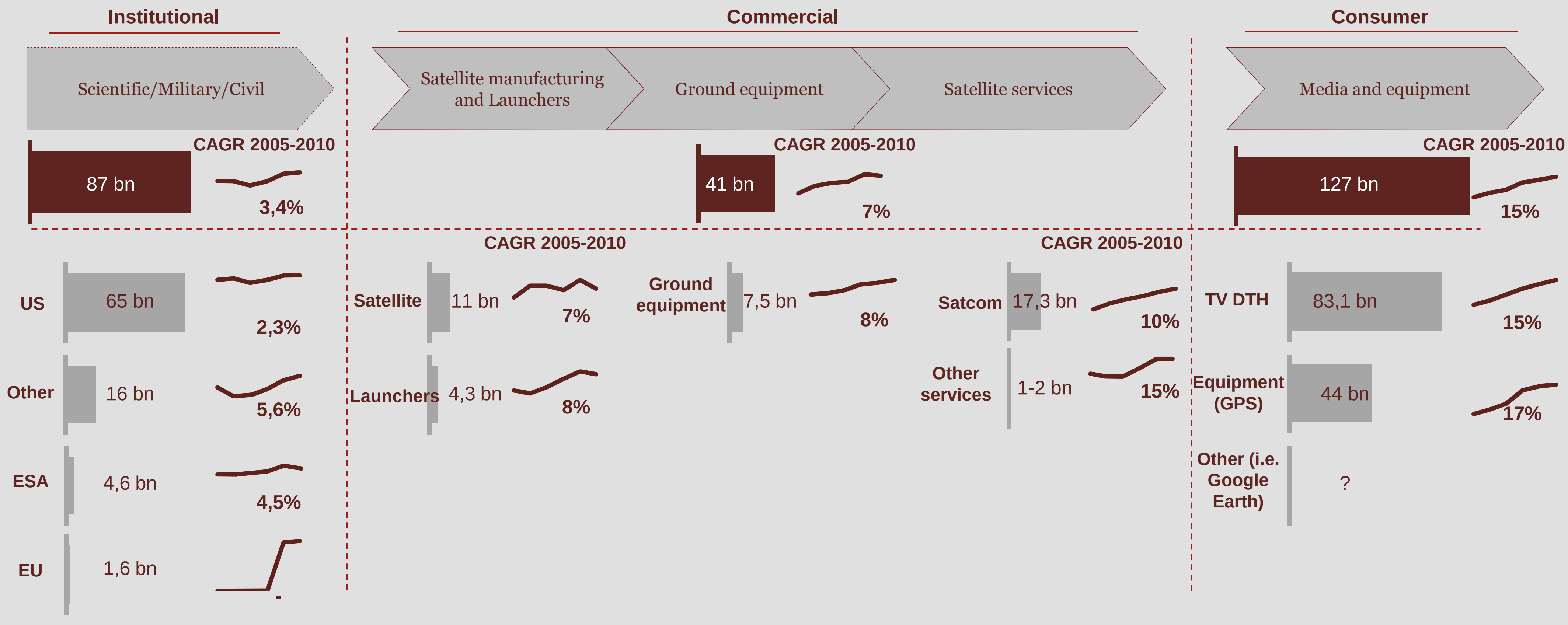
The tail end of the value chain is the **consumer distribution**. This includes service provision such as TV or broadband access, and also equipment manufacturing of i.e. GPS hand- or vehicle equipment, chipsets for smart phones or TV set top boxes. These segments are the largest ones in economic terms.

Fast growing commercial segments in the global value chain

The **institutional** segment of the value chain is particularly large and only second to the consumer segment. This is mostly explained by the large U.S government expenditures estimated at nearly 65 billion dollars in 2010. Other national programs of significance include countries such as France, Germany, Canada, Russia and China. Of particular importance for Norway is the ESA and EU spending at about 6,2 billion dollars. Institutional expenditures have shown nominal growth over the last five years.

The **commercial** value chain is in comparison smaller but is growing more quickly. Most significant segments are the satellite manufacturing and communication services. The **consumer** segments are largest and growing rapidly. This is much about TV distribution but also about consumer electronics such as GPS.

Figure 1.17: Global turnover by value chain segment for space industries (Current US$)



Unusual configuration of Norwegian value chain with small public expenditures and very large satellite communications services segment

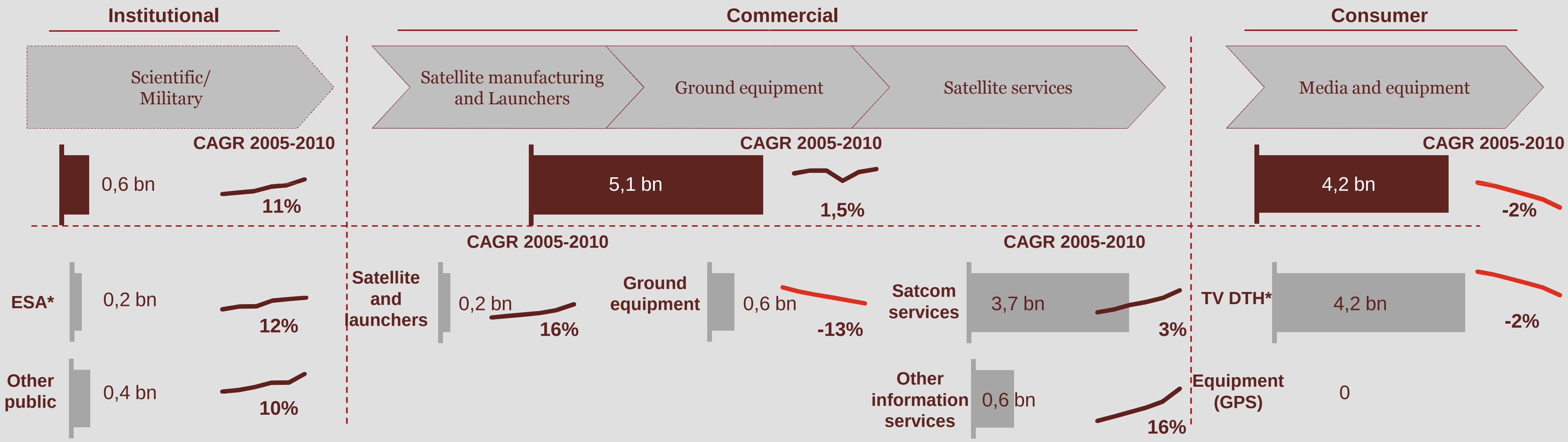
In Norway we find that the **institutional** side is much smaller than the commercial segments. This reflects partly low government spending in Norway, but also the success of the industry in global commercial markets. The institutional segment, i.e. government spending is growing more rapidly than turnover in the commercial segments and also more rapidly than government spending globally.

The **commercial** value chain is characterized by a very large communication services segment. There are companies with large global market shares included in this. There is also a rapidly evolving earth observation community, as well as an emerging space manufacturing industry. Ground equipment producers in Norway have had some difficulties over the last decade. Overall the commercial segment shows nominal growth but possibly a real decline over the last five years. The **consumer** segment is also significant, particularly for TV services. There are no consumer equipment manufacturers based in Norway.

There are about 40 enterprises active in this industry. Some are specialized in the space industries, while for others its only a share of their business. There are a further 20 public and scientific organizations which have been involved over the last decade.

Next we will turn to review developments in each segment. We discuss mainly the commercial value chain, and will come back to the institutional side in section 1b below. We will not focus on the consumer segments in this study.

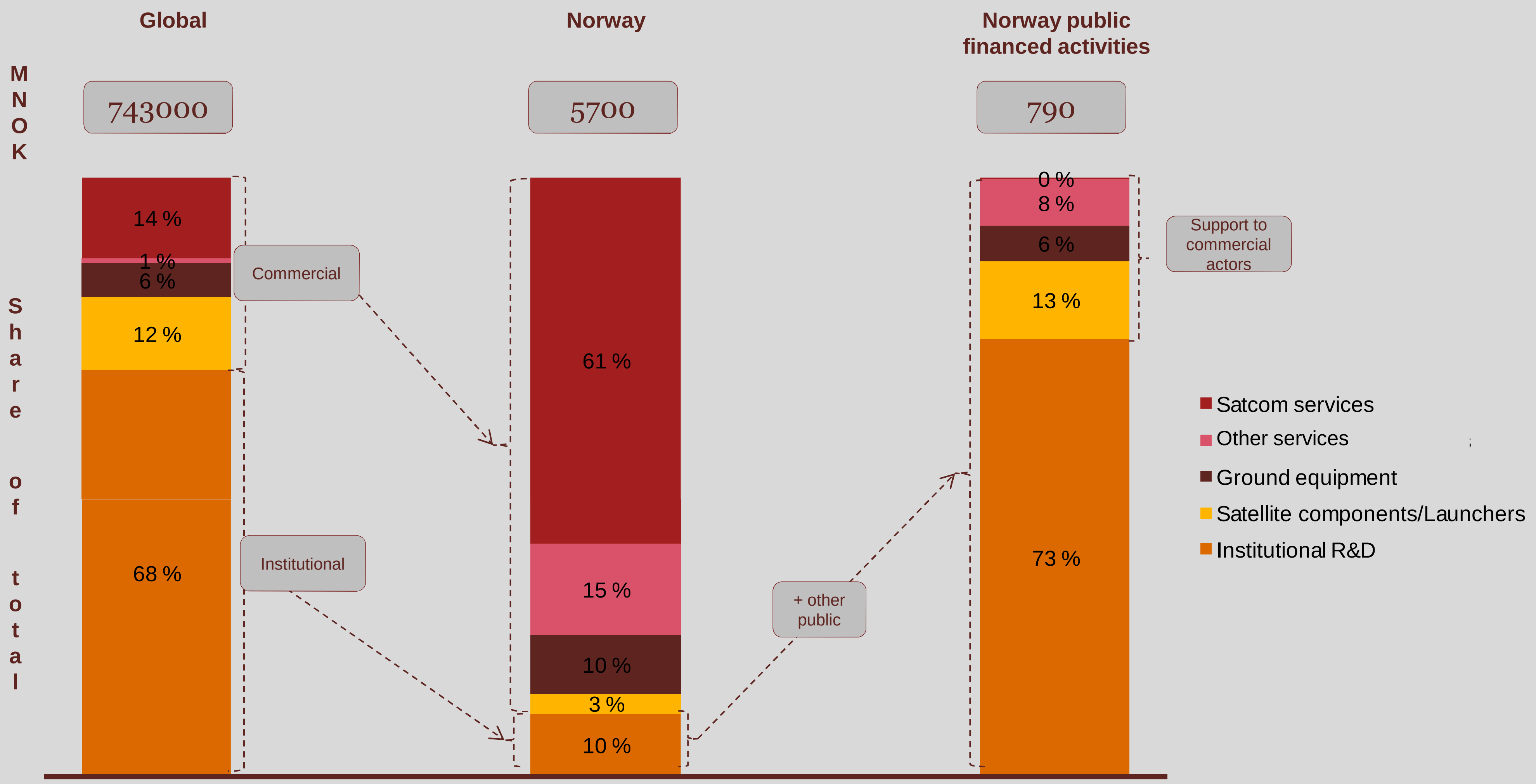
Figure 1.18: Norwegian turnover by value chain segment for space industries (2010 current NOK)



Source and notes: Commercial segments does not include ESA or government sales but there may be unidentified gaps or overlaps. NRS data, BRREG business registry; PwC market analysis

Norwegian space value chain is very different from global structures, and public support is directed towards the less commercial segments

Figure 1.19: Industry structure and support schemes by value chain (2010; and average 2008-2010 for public and supported firms data)



Source: SIA 2011; Space Report 2011;NRS Data on Norwegian space industry turnover; NRS Ripple survey and ESA/NRS details; NRS Longtermplan 2010-2013; PwC market analysis

Value chain segments

To understand whether the policies support the right actors with the appropriate tools we will analyze w the competitive positioning of Norwegian enterprises across the value chain.

All value chain segments with significant Norwegian activity will be reviewed. Consumer media and entertainment distribution is not discussed.

We focus on four segments:

I. **Satellite components and launchers.** This includes all Norwegian manufacturers who deliver components for launchers or satellites. Most of these are private enterprises but one is affiliated with a university and included here.

II. **Ground equipment.** This includes all producers of ground equipment. Product offerings vary but all are involved in professional markets only. None sell to consumer markets.

III. **Satellite communications services.** These firms are service providers only. They may own an infrastructure, i.e. satellites or ground stations, but they do not manufacture equipment. This is the largest segment in Norway.

IV. **Other services.** These are also pure service providers. The range in offerings quite wide, from offshore surveying, met services and ground station operators. These do not produce hardware, but may own infrastructure i.e. ships or grounds stations.

There are a number of research institutes active in the space community in Norway. We have not included those in the numbers above. From time-to-time we may not have been able to separate. They are not-for-profit institutions. Some have much government backing, while others sell mostly to industry. As a matter of definition we have grouped them all in one. This is more important for the analysis of how ESA and national funds have been distributed.

When presenting company specific information this is based upon publically available sources. This includes and is not limited to information from press releases, investor relation reporting, financial analysts, quarterly and annual reports, and official accounting information in the business registries. We have had access to non-public sensitive information of single companies and this has been important to calculate certain aggregate numbers.

Launch and satellite manufacturing receives most of the Norwegian support, and is a small growing segment with a fractional global market share

The launcher and satellite component segments combined have received 36 percent of total ESA contracts and NRS support funds since 2000. Its share of the Norwegian value chain is about 3 percent. The share of global value chain is 0,2 and 0,3 percent respectively for the segments. Ripple effects are about 3,8 and increasing.

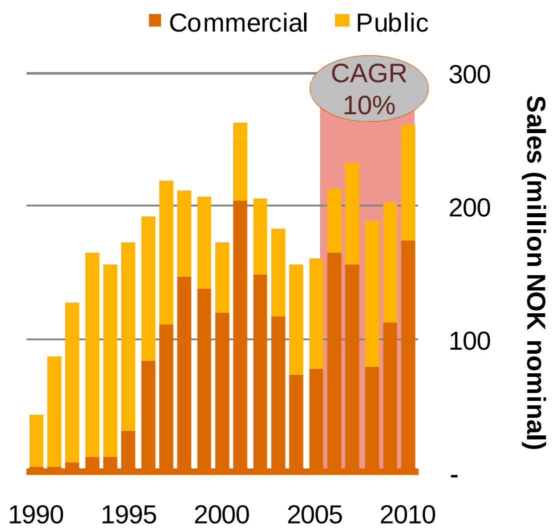
Next we turn to a discussion of launcher and satellite components segments. We cannot fully separate the two segments in the Norwegian data but will discuss capabilities, supply, demand and positioning separately.

First, the launcher market. This is exclusively about deliveries to Ariane-5. This is the ESA developed launcher operated by Arianespace. Its launch services are commercial.

Second, the satellite component market. This is more varied in terms of producers, products and clients.

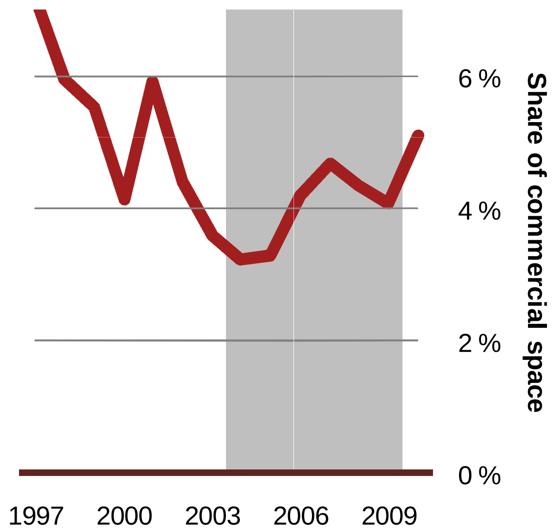
Growth between 2005 and 2010 but volatile

Figure 1.20: Sales launchers and satellite components (nominal NOK million)



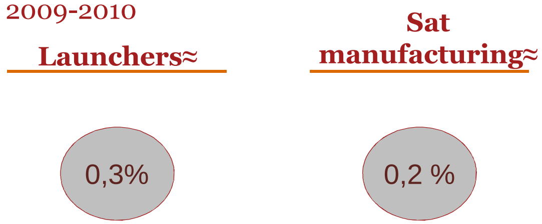
Share of commercial space sales in Norway declined, but gained since 2005

Figure 1.21: Share of total commercial space sales Norway 1997-2010



Fractional global commercial market share but increasing

Figure 1.22: Estimated global market share 2009-2010



Note: Commercial Norwegian sales measured against commercial global turnover for segment totals. Shares are higher within particular micro segments or product categories.

Norwegian firms only deliver components to other prime contractors or system integrators.

Source: NRS; BRREG; Space report 2011; SIA 2011; FAA 2011; PwC Analysis

Launcher market access only through Ariane-5

Capabilities

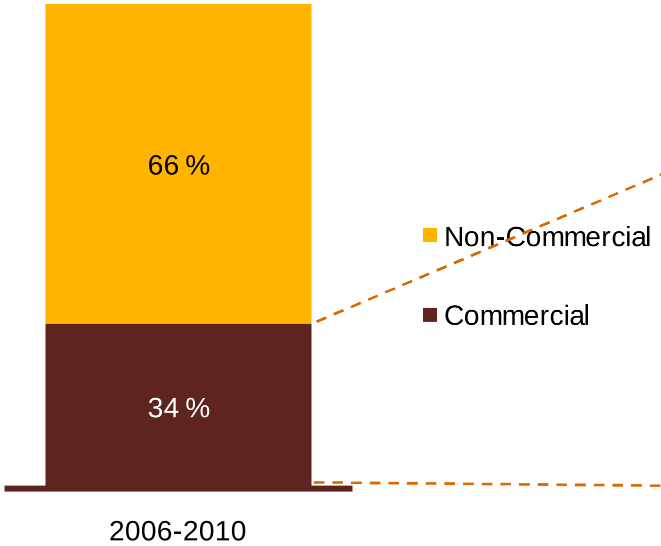
Three Norwegian corporations (and two-three subcontractors) delivers components to the Ariane-5 launcher operated by Arianespace. The Norwegian industrial capabilities have been developed largely through ESA programs and entry into the segment is one of the important successes of the space programs. Norwegian enterprises broke into this segment in the late 90's and have since had regular deliveries. There have been various upgrades and variations of the launch system in which they have participated.

The European launch vehicle developed through ESA is Ariane-5. This is an expendable launch vehicle mostly used for geostationary (GEO) orbits and operates mostly in the commercial market. It is one of the larger vehicles available on the market and is capable of lifting more than one payload (satellite). EADS Astrium is the prime contractor

Arianespace also operates two other launch vehicles put on the market last year; a vehicle for smaller launches (the Vega) and a Europeanized version of the Russian Soyuz rocket. There are no Norwegian contractors involved in the production of these.

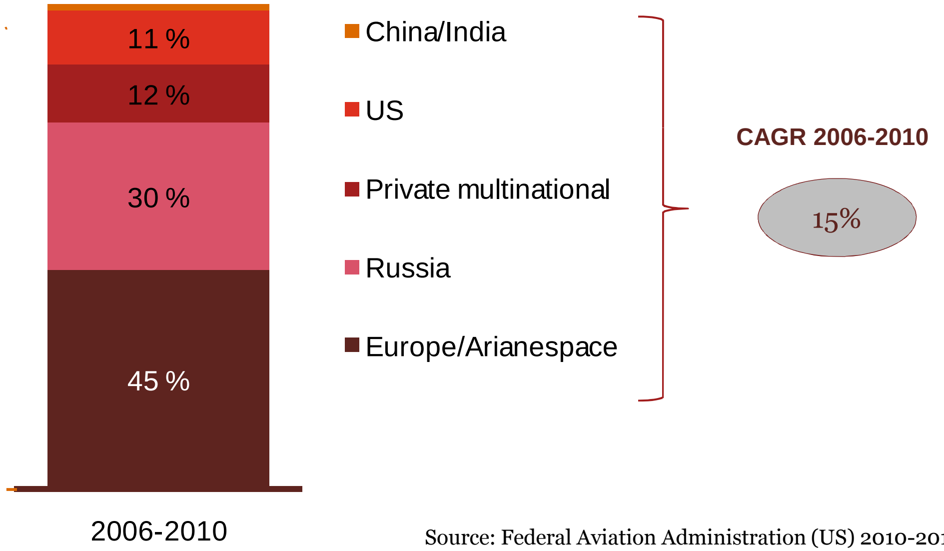
Two-thirds of payloads are non-commercial, but revenues from commercial payloads are higher at 55 percent

Figure 1.23: Share of launcher payload by commercial/non-commercial (2006-2010)



Arianespace captures most of the commercial launch revenues but competition is escalating

Figure 1.24: Share of commercial launch revenues by nation of prime contractor 2006-2010



Source: Federal Aviation Administration (US) 2010-2011

Growth in demand for launchers, but even more supply

Demand

The demand for launches of satellites is expected to show an increase over the next years. Market analysis range quite widely; between 50 (FAA) to 100 (Euroconsult) payloads annually of which about 40 percent can be expected to be for medium-to-heavy GEO satellites in which Ariane-5 is particularly competitive. This may translate into about 15-30 launches in the GEO segment annually over the next decade.

Developments in the markets for Broadcasting Services and Fixed Satellite Communications are the core drivers. Other technological and commercial developments such as an trend for increased use of shared payloads may act to reduce overall demand.

Supply

The supply of launch services is increasing and by some measures there is overcapacity. The important factors impacting future supply are:

First, the pure **commercial players** which offer very competitive pricing, streamlined commercial practices, schedule assurance and choice of launch locations. ***SeaLaunch*** is one such commercial operator remerged from bankruptcy. It operates out of San Diego and launches from the Pacific Ocean near the equator. This company originally had a Norwegian ownership share of 25 percent which provided the launch platform (modified offshore oil platform) and the mother ship. The company is now fully controlled (95 percent) by Russian investment group Energia Corporation. It also operates a sister entity – Land Launch. Its launch vehicles are Russian built.

Other commercial players include U.S. based **Space X** (Falcon 9 and its Heavy Vehicle version under design); Orbital's Thaurus I; ILS (U.S.) with its Proton M vehicle; and even Arianespace itself with the introduction of the Europeanized Soyuz -2 ST launch vehicle (Russian) now operated out of the spaceport in French Guiana alongside the Ariane-5 launch site. As the Soyuz has a degree of overlapping capabilities with the Ariane-5 it is possible that its introduction will cannibalize on the Ariane-5 demand.

Second, several **national operators** are capturing demand currently and more are expected to emerge in the future. This includes Japan (Jaxa H-IIA), Korean Space Launch Vehicle, and the Indian GSLV Mark III vehicle.

China Great Wall Industry Corporation (CGWIC) has an order book which includes a range of Asian and Latin-American satellites, and also satellites for Eutelsat (W3S) and satellites produced by European prime manufacturer Thales Alenia Space. **U.S. export control regulations (ITAR)** currently constraints the growth of the Chinese launch vehicle as satellites containing U.S technology cannot be transported to China for launch. Regulations may be relaxed in the future but this is uncertain.

Russian launchers leads the market for medium-size satellites which sometimes may be a substitute for Ariane-5. There have been difficulties with maintaining regularity and quality of Russian operations over the last years.

Third, declining U.S. space budgets is expected to prompt U.S producers to seek towards commercial markets. Commercialization incentives under the new U.S. Space Policy will further increase this pressure. This includes the capabilities which may emerge from the U.S. competition to develop a new launcher for human space flight.

Sources: FAA 2010, Futron 2011; Space report 2011; Press releases by Arianespace.

Rationale for future support for launchers should be revisited

Competitive positioning

The launcher market has certain captive characteristics which influences its development.

First, most governments prefer their national systems when launching non-commercial payloads.

Second, the development costs, and lead times, for developing new systems are substantial and mostly fronted by national governments (or through multilateral entities such as ESA).

Third, US export control regulations further limits the international trade.

President Obama cancelled mega size launcher Ares to save costs and encourage commercial developments

Figure 1.25: Ares at test site 2009 (PwC illustration photo)

Future developments of the market position of Norwegian enterprises and the policy response options will be impacted by:

(i) The competitive positioning of Arianespace; and,

(ii) The positioning of Norwegian suppliers within the future developments of Ariane vehicles. This is can be influenced by policy.

Arianespace is the market leader in terms of revenues. It has increased its share from about 35 percent during 2000-2005 to 45 percent over the last five years. Financial results have not been as impressive. It reports break-even financial results in 2011 but has struggled before that. It receives pricing support from its owners (European states and companies) at about ten percent of turnover.

In light of this, there is a risk that the growth in demand for the Ariane-5 launcher may level off and it is unlikely to see an increased market share over the next decade.

It is also likely that Arianespace will experience further **price pressures** and that these will transfer onto the sub-contractors including the Norwegian entities.

The policy issue will largely be about whether or not to maintain the position of Norwegian contractors through supporting further development projects under ESA, including the mid-life extension program of Ariane-5.

It seems logical that Norway should support those sectors that offer highest ripple effects and wealth creation potential. These do not necessarily coincide with maintaining capabilities. There are reasons to assess the balancing of today's funding.

Norwegian satellite manufacturing is mostly financed by public funds but commercial share has been increasing

While growth of the Norwegian penetration of the launch segment is constrained by the opportunities offered within ESA/Arianespace, the satellite manufacturing markets offer a larger upside. The satellite market is less captive than the launch segment and there are more opportunities for commercial deliveries.

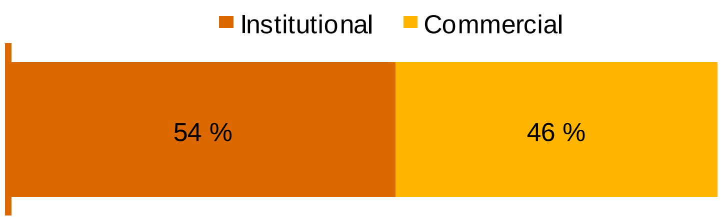
Capabilities

Norwegian producers delivers components that are used by prime manufacturers in the assembly of a satellite or sub-systems. About six Norwegian entities have delivered components or instruments which have been flown on satellites. There is also a group of other entities which have been part of various qualification processes but not had actual production. Both commercial manufacturers, and science organizations, including R&D groups closely attached to Universities are involved in this segment. There is also a range in the product offerings which exceeds the number of suppliers.

Norwegian deliveries are mostly confined within ESA programs. Kongsberg Norspace is the one exception that has been particularly successful in the commercial market. This is probably the global market leader within its focused segment.

The institutional market is most important for Norwegian manufacturers

Figure 1.26: Estimated ratio of institutional vs. commercial sales 2008-2010



Source: Estimated on basis of NRS overall turnover data, company specific information and information on institutional programs

Demand

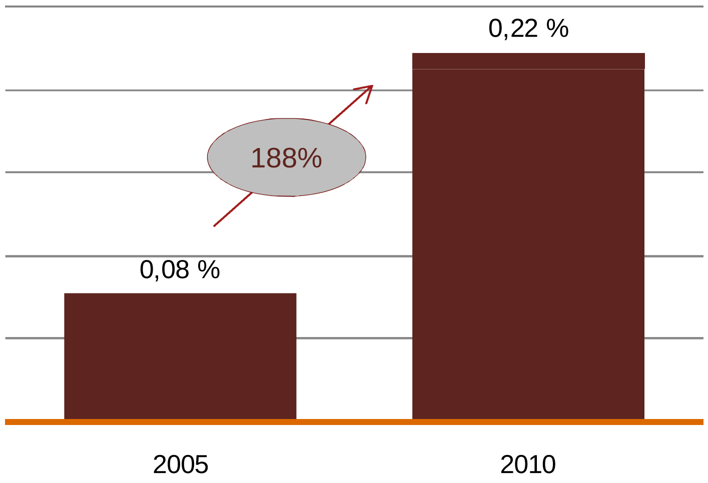
There is demand growth for satellite manufacturing. The range of estimates vary from a continuation of current volumes to about a 100 percent increase over the next decade. This is much driven by SatCom as we discussed on the previous pages under the launcher segment analysis.

Four issues should be noted:

- First, much of the demand increase stems from national programs from emerging space powers. These tend to favor their national producers and may not lead to much volume increase available for Norwegian suppliers.

A fraction of the global commercial satellite manufacturing volume, but growing rapidly

Figure 1.27: Estimated Norwegian enterprises share of global commercial satellite manufacturing revenues



High entry barriers for satellite components manufacturing but competition escalating

- Second, there is a trend whereby satellites are becoming smaller, have shorter development cycles and are less costly. More are single purpose satellites carrying few instruments. An increasing share of the overall are non-geostationary satellites , and some very small. This serves to lower the barriers to entry for producers and hence increases supply. Its impact on the overall market size is less clear as it also increases demand by making satellite technologies more affordable.
- Third, the volume available under ESA is particularly important for Norwegian producers. An expected increased ESA contribution from Norway in the future may further expand the ESA institutional market available for Norwegian enterprises. However, the accessible share of the institutional market is in practice capped by Norwegian contributions to ESA given the industrial return mechanisms.
- Fourth, there are no significant domestic institutional markets available for Norwegian suppliers as there is in some of the larger countries. Compared to smaller nations however, the structure is not much different.

Supply

An important characteristic of the supply side is the extreme **high barrier to entry**. This applies equally to the launch segment discussed above.

Satellite systems involve complex interactions of electrical, optical and mechanical systems which should be able to withstand high stress situations during launch. Quality requirements are intense and there is no tolerance for failure. Thus, much of the development, and qualification stage for emerging manufacturers takes place within the institutional context. The qualification processes are long and expensive. Qualifications and flight heritage gained through these processes are necessary requirements for entering commercial markets.

Repeat production potential, particularly for scientific instruments, is limited. These characteristics may discourage many participants. These same entry barriers also serve to protect incumbents.

Competition is increasing driven by three factors:

- First, producers from emerging markets have gained qualifications and flight heritage. These are likely to expand into global commercial markets as they have done for launchers. We will review the emerging market competition separately in section 1.2
- Second, U.S. manufacturers are strongly incentivized to expand into global commercial markets driven both by declining U.S. public budgets and by changes in the commercialization policies under the new U.S. space policy. This will also be discussed under section 1.2.
- Third, competition within ESA may intensify given recent fiscal difficulties for European countries. The overall size of the institutional market may not increase much in the future but supply side will remain constant. Related to this, an increased use of competitive procurement following the EU using ESA as the organization to procure satellites for GMES and Galileo, using the EU procurement rules. See section 1.2 for a review of ESA and EU developments.

Source: NRS reports: SIA 2011

With one exception, the position of Norwegian manufacturers in commercial markets is not strong and there is risk of mismatch between public funding and wealth creation

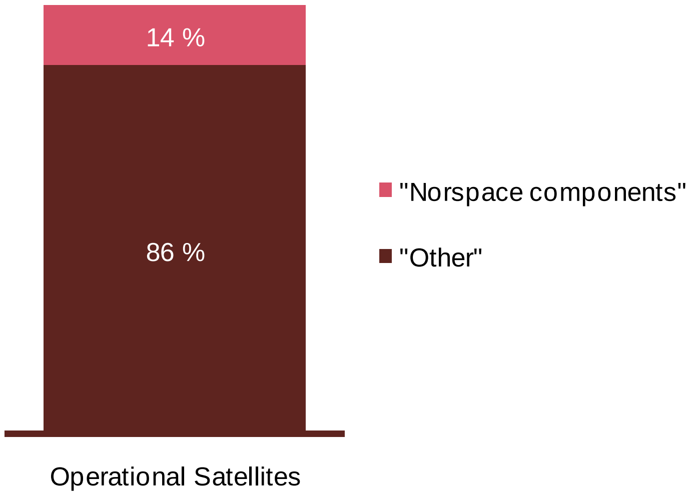
Competitive positioning

The positioning in satellite manufacturing markets can only be discussed broadly. Norwegian firms produce very specific components and there may be separate micro factors impacting those segments that diverge from the overall trend.

Notwithstanding the impressive technological achievements of Norwegian industry and R&D groups, the challenge remains to break into commercial markets. After supporting industry since late 1980's, one firm has a sustainable position in commercial markets.

One-of-seven satellites fly Norspace equipment

Figure 1.28: Share of operational satellites with Kongsberg Norspace equipment



Source: NRS reports: SIA 2011: Kongsberg Norspace reports having sold equipment for 140 operative satellites, 14 percent is our calculation based upon an estimated thousand operational satellites.

Certain other factors need to be considered:

First, most manufacturers globally are dependent upon public sector demand which is organized in captive markets. Few are sustainable on commercial demand alone. The total institutional share of demand among European space manufacturers is also in the same range as for Norway (about 50 percent).

Second, the impact of low-cost producers is probably not felt much yet. Pricing in the commercial markets seem not to have fallen though precise estimates are not available. An often used proxy is the producer price indices for aerospace manufacturing. Thus, manufacturers seem to be able to transfer some of their cost increases further down the value chain and we may not have seen similar cost pressures as for terrestrial electronics manufacturing. The high barriers to entry, combined with low volume repeat production may limit the attractiveness to low margin producers. This may work in favor of Norwegian producers in this segment.

Third, much of the emerging Asian capacity will be absorbed by growing national and military demand and may not impact the commercial segments for a while. (see discussion on Asian Space race in section 1.2)

Fourth, the ultimate rationale rests on the ability of the support to contribute to wealth creation. There is evidence of technology transfer and knowledge development. There is also evidence of ripple effects on other sales though it is lower in this segment than in other segments. This is reviewed in detail in section 1.4.

In conclusion, there is a risk of mismatch between the overall funding and support for launcher and satellite manufacturing segments (36 percent of total), the sustainability of the competitive positioning and the value creation.

As for launchers, It seems logical that Norway should support those sectors that offer highest ripple effects and wealth creation potential. These do not necessarily coincide with maintaining capabilities. There are reasons to assess the balancing of today's funding.

Norspace

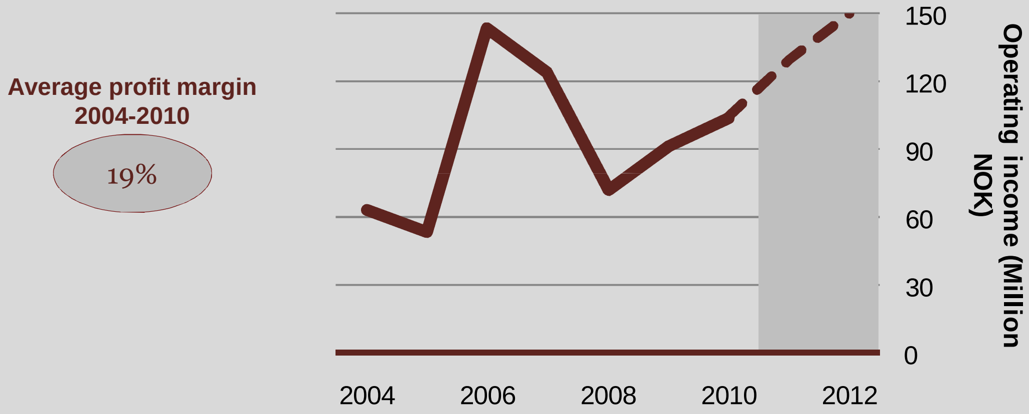
is by far Norway's most successful space manufacturer. The company delivers communication components to very many of the world's satellites. Its customers are global and predominantly commercial. Norspace has succeeded in developing repeat production and as such can produce at scale and with good profit. It operates entirely in the space segment and has no other production.

The company history dates back to mid-eighties where it started competing for ESA development and product delivery contracts. These were instrumental in establishing a track record for the company. It succeeded in penetrating the commercial market by the late nineties and its sales have since then been predominantly commercial. It has recently won large contracts to equip the fleet of Galileo satellites with its components.

Management bought the company from Alcatel Space in 2004 and continued operations. Ownership has varied over the decades. The company was acquired by the **Kongsberg Group** in late 2011.

Robust and profitable growth for Norway's most successful space manufacturer

Figure 1.29: Operating income and reported estimated sales (2004-2012)



Kongsberg Defense Systems

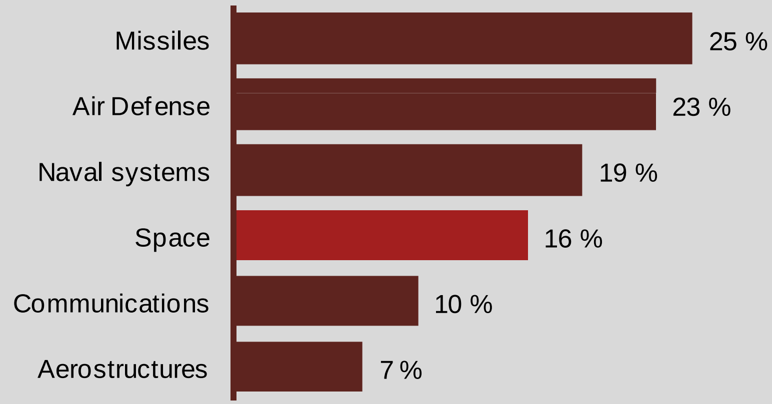
has the largest product offering of any Norwegian Space manufacturer. The space business is part of the larger defense systems group. Kongsberg deliveries started with booster attachments for Ariane-5 launchers. Development started in mid-eighties and serial production followed from the nineties. Kongsberg has successfully delivered these components for Ariane-5 launchers over the last few decades.

Its production of satellite components has mainly been for ESA scientific missions. Product offerings include deployment and pointing mechanisms, electro optical components, load carrying composite structures and various scientific instruments. There is a robust basis for evolving into more commercial and potentially larger markets.

KDS has a particular potential for technology transfer and spillovers between its business segments. There are indications of this happening.

Much potential for technology spillovers at Kongsberg

Figure 1.30: Share of turnover by business segments of Kongsberg Defense Systems 2011



Source: Company data from BRREG (Business registry), estimates for 2011-12 from press releases: KDS data from Capital Markets Day reports 2011

The once large ground equipment industry has seen much decline

The ground equipment segment has received 19 percent of total ESA contracts and NRS support funds since 2000. Its share of the Norwegian value chain is about 10 percent. The share of global value chain is about 1,3 percent. The ripple effect is about 4,7 and has been declining every year since the early 1990's.

Share of global market is assessed against the professional equipment segments only and not including much larger consumer electronics markets i.e.. GPS handsets and vehicle mounts, and TV set top boxes. These latter are about 90 percent of global volume.

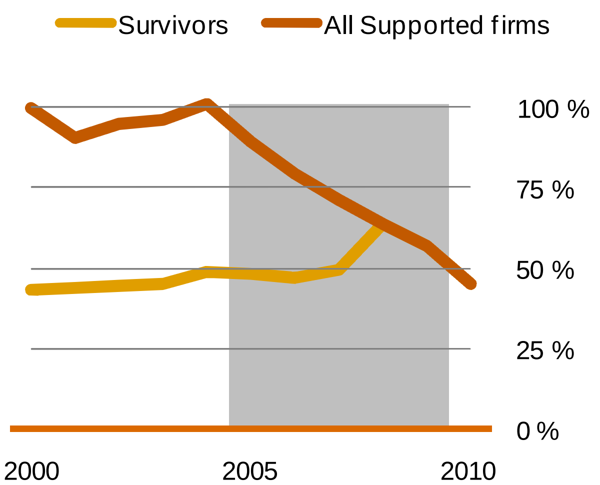
Capabilities

Current product offerings include ground station equipment, VSAT stabilized antennas to rescue beacons and AIS senders. There are about three firms who have most of the sales and a larger group of smaller players. The two largest companies are both broader electronics manufacturers who specialize in the maritime segments and have anchor tenants there. There is also a company providing ground station equipment for earth observation. Norwegian producers do not target the consumer markets. These three constitute nearly 95 percent of turnover.

There has not been new entrants to this market over the last decade though the product offerings have expanded. (One new firm is incorporated, but is organized as a subsidiary of another larger actor). Sales have declined by about 50 percent since 2005. There has been some growth in the remaining companies, but not enough to make up for the shortfall from the failed.

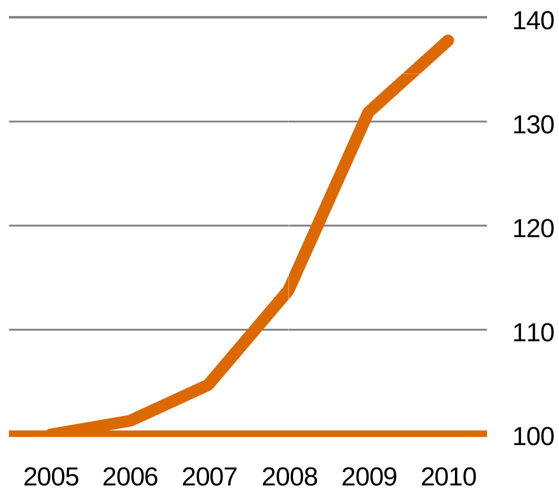
Sales decreased by more than 50 percent over the decade, flat for survivors

Figure 1.31: Indexed share of sales of space related ground equipment (estimated, 2000-2010 nominal prices)



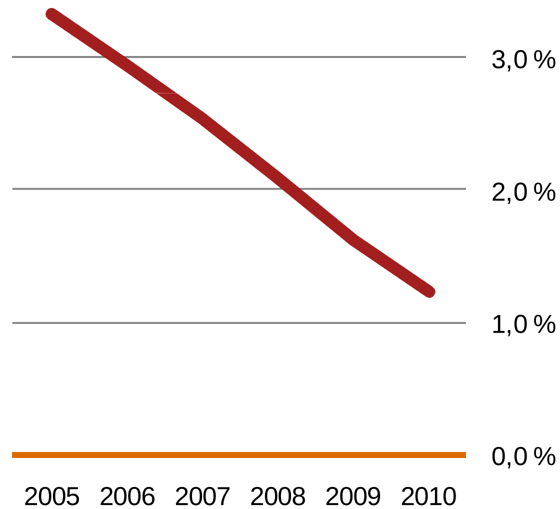
Strong growth of worldwide ground equipment markets

Figure 1.32: Global indexed growth of ground equipment, not including consumer equipment (NOK based nominal prices y-o-y changes, 2005=100)



Much loss of global market share

Figure 1.33 Estimated global market share



Source: SIA 2011; NRS; BRREG; PwC Analysis

The strength is sales to maritime industries

Capabilities (cont.)

The ground equipment development is much about the demise of Nera Satcom. This company was the global hardware market leader targeting mobile satellite communications. Their space related turnover declined for some time, and it was eventually bought by its key competitor Thrane & Thrane of Denmark in 2007. 15 months later the company shut down production in Norway. T&T cited cost reductions and overcapacity. T&T still operates sales activity in Norway but does not engage with the Norwegian space programs schemes anymore.

STM (U.S) picked Nera Broadband (much smaller) and has expanded its product range on the basis of this. Its market share in the VSAT network equipment market is about 6 percent (2009). The R&D activity has been maintained in Norway.

Demand

Globally, there has been real growth in the professional segments of ground equipment over the last decade. Growth is expected to continue driven by expanding communications and earth observation demand.

Norwegian suppliers cater very specific segments and about **80-90 percent of sales is for maritime markets**. The deep sea merchant fleet in Norway is very large (about the world fifth largest) and has have been anchor tenants for equipment producers in Norway. This is a common observation in Norway where growth drivers are very often derived demand from maritime and petroleum sectors that requires customized solutions and have high purchasing power.

The maritime sector in general has seen some hard times since the financial crisis in 2008 and this may explain some the observed lack of growth for the space related equipment producers. The global fleet has grown in the period, but many ship operators are faced with difficult markets.

Maritime sectors did however show historical growth in the period leading up to this and that growth is not reflected in the turnover of the space ground equipment manufacturers. Some segments of the maritime space electronics demand globally have seen growth much driven by new internet broadband technologies.

Supply

Within these segments, competition and supply stems from mostly U.S. and European based manufacturers. This is driven much by abilities to understand particular demands of the maritime customers and adapt technologies.

Structural factors such as low-cost production and is a risk longer term. Production is shifting to low-cost countries while R&D and engineering are maintained. Commoditization is a risk for a.o antenna and network equipment. Indeed, the current Norwegian producers also does their electronics production, i.e.. circuit boards, in low-cost countries.

Prices for communications and electronics equipment are dropping globally indicating cost pressures. PPI indices from the U.S. BLS shows less deflation for specialized equipment such as rescue beacons.

Nearly all sales to maritime customers

Figure 1.34: Containership (PwC illustration photo)

Electronics industry in Norway does well, not evident why space sales are falling

Competitive position

Given how few firms that are actually involved as space ground equipment producers in Norway, any findings are sensitive to company specific issues and may or may not represent a picture of structural realities.

The observed decline of space ground equipment is significant but it is also highly sensitive to the collapse of one company. It nevertheless remains a fact that the space related turnover of surviving ground equipment producers:

-Have not increased at a rate sufficient to cover the gap;

- Developed at a much slower rate than the overall growth of electronics manufacturing in Norway; and

-Lost considerable global market share overall though we don't know specifics for their micro segments.

As such we are left with wondering whether firms find the space segment particularly unattractive and deliver to other segments, or if they are actually faced with decreased competitiveness in the space segments. We have not been able to uncover whether there are any particular constraints to growth within the space segments.

There is a lack of linkages between service providers and ground equipment producers. The exceptional positions in the service segments by Vizada and Ship Equip (discussed in next section) are built on equipment technologies from U.S., Israel and Denmark. I.e.. Sea-Tel and Orbit enjoys market shares of about 70 and 17 percent in the VSAT antenna and network equipment market. Thrane & Thrane is also producing for this segment. There is a small Norwegian company targeting this segment and it has received much support in recent years.

Future and continued support for companies in this segment need to be based upon very careful assessments of the business plans and commercial viability of individual firms and product offerings. There are reports of high ripple effects, but the effects have been declining for decades.

Space specific or sectoral decline?

It is an important question whether the decline is due to company specific issues or whether it reflects structural issues which cannot be addressed by space policy tools alone.

The declining turnover seems likely to be space segment specific and not representative of the broader electronics industry.

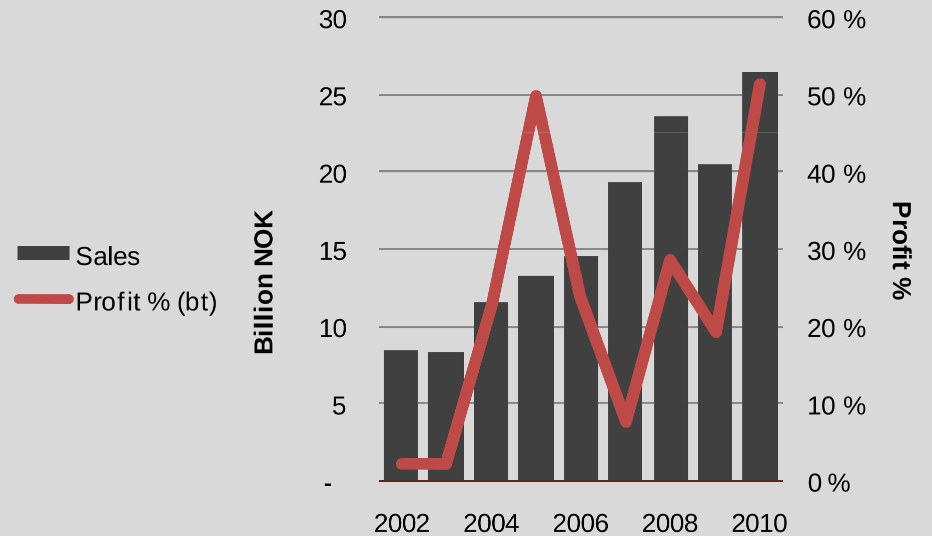
To that end we have investigated the economics of the broader electronics manufacturing industry in Norway over the last decade. The industry, encompasses about 300 firms. The space related ground equipment manufacturers are included in this sample. Space related electronics is about 2 percent of total and a sharply declining share.

The sector has seen strong growth leading up to 2008 and some volatility thereafter. Profits have dipped considerably in 2007 but have come back.

(*Manufacture of electronic components, loaded electronic boards, communication equipment, instruments and appliances for measuring, testing and navigation: NACE 26.11, 26.12, 26.30, 26.51)*

Increasing sales and healthy profits for electronics manufacturing in general in Norway

Figure 1.35 Sales and profits before tax for electronics industry in Norway



Source: Business Registry (BRREG); PwC analysis

SatCom services have lost some global market share but still accounts for two-thirds of commercial space sales in Norway

The satcom services segment has received 1 percent of total ESA contracts and NRS support funds since 2000. This is less than 0,2 percent of total public expenditure on space.

Its share of the Norwegian value chain is about 61 percent. The share of global value chain is about 3,5 percent.

High growth communications services firms have received some support but do not respond to the annual ripple effect surveys.

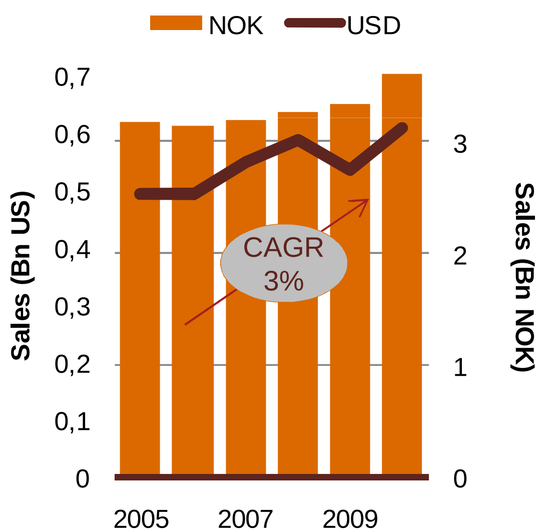
We will discuss mobile and fixed sub segments separately. Technologies are however converging so that fixed operators are also getting capabilities to service mobile customers.

First, the fixed segment. This has one Norwegian operator, Telenor Broadcast who operates a fleet of geostationary satellites.

Second, the maritime mobile segment. This is smaller globally, but has significant Norwegian capabilities. This has long been a stronghold of the Norwegian enterprises driven much by demand from the maritime segment.

Nominal sales growth especially '09-'10

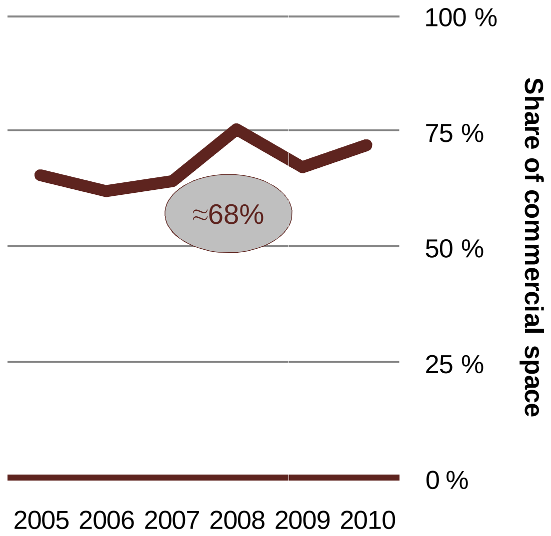
Figure 1.36: Sales commercial satcom services (nominal USD and NOK)



Source: SIA 2011; NRS; BRREG; PwC Analysis

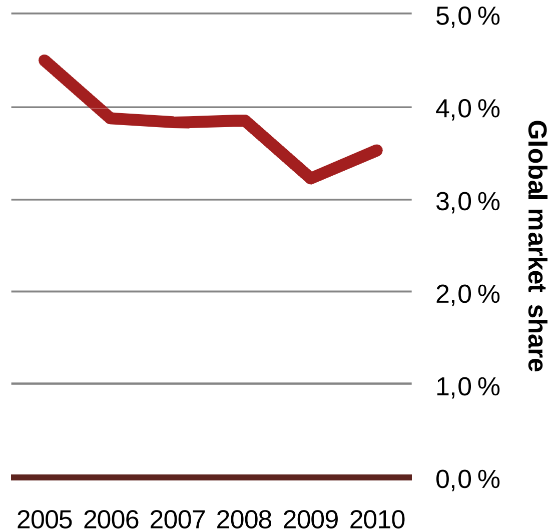
Slight increase and significant share of Norwegian commercial space sales

Figure 1.37: Share of total commercial space sales Norway



Slipping global market share

Figure 1.38: Estimated global market share



Fixed satellite operator Telenor goes strongly, but has divested most other engagements in space

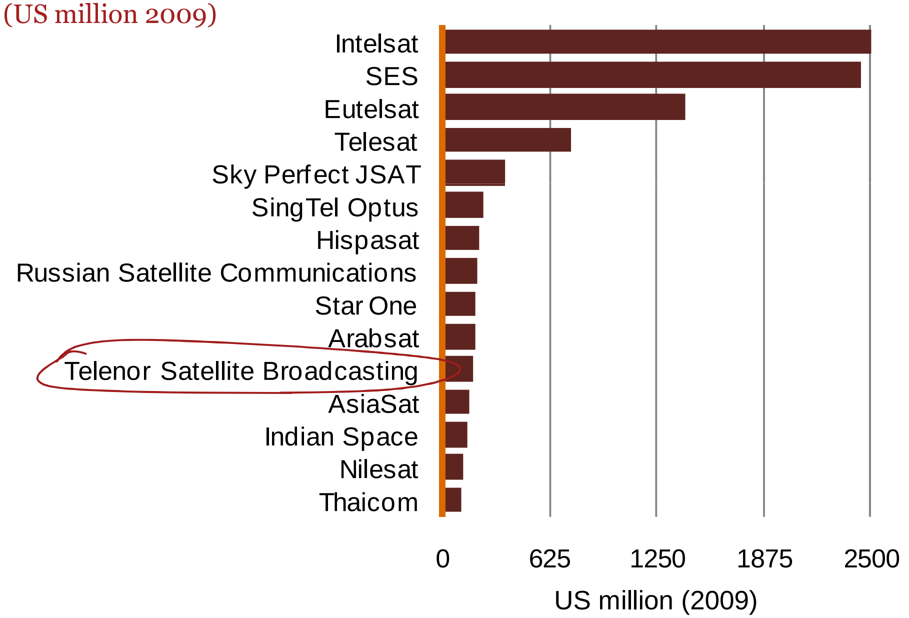
Capabilities, supply and demand fixed satcom

Telenor current satellite business is confined to broadcast. It distributes TV signals in the Nordic, Easter Europe and Middle Eastern regions and increasingly also service broadband. It's a profitable undertaking, recording EBITDA earnings percentage of close to 70 percent over the last few years. Its most important customer is Canal Digital.

It's the only Norwegian based operator that owns and operates satellites. It currently operates three and a fourth is under construction.

Telenor operates mainly in TV transmission but increasingly also in broadband market

Figure 1.39: Rank of top 15 Fixed Satellite Service operators by revenue (US million 2009)



The Telenor group was for long the pioneering, and dominant actor within Norwegian space industries. In line with corporate priorities it has chosen to divest much of its space related business over the last few years. This includes Telenor Satellite Services which has now become Astrium Services. Telenor also had a considerable ownership share of Inmarsat which is now fully sold.

Telenor Broadcast operates Nittedal ground station in southeastern Norway. This is the largest ground facility in Norway serving its fleet of satellites with TV signals and distribution to the terrestrial networks. It also operates teleport facilities in the U.K.

Demand is driven principally by TV transmission through fixed geostationary satellite networks. Global growth in this market averages 8 percent annually since 2005. The tail end of this market is the TV distribution to retail markets which has been growing at nearly 13 percent annually and is above 80 billion dollars in sales by 2010. Canal Digital operates across the Nordics and is controlled by Telenor. Viasat also operates in Norway.

Supply side is dominated by four large operators of geostationary satellites. These again drive about 40 percent of the demand for launches and satellite equipment discussed earlier. Six European based firms of about 50 worldwide.

Market analysts believe Telenor may be once again positioning itself for the mobile satellite markets. Their new Thor 7 satellite will have capabilities which will allow it to compete head-to-head with Inmarsat for provision of broadband to the maritime segments in Northern and Mediterranean seas.

Source: Space Report 2011; Company Investor information; Press reports

Global market leaders in maritime satcom and most is divested to foreign owners

Capabilities mobile satcom

The global maritime market is about 1,3 bn US in 2010 of which the VSAT segment may be about 800 million. Technologies are converging and services overlapping. The strength of the two largest Norwegian based enterprises are exceptional in the VSAT markets.

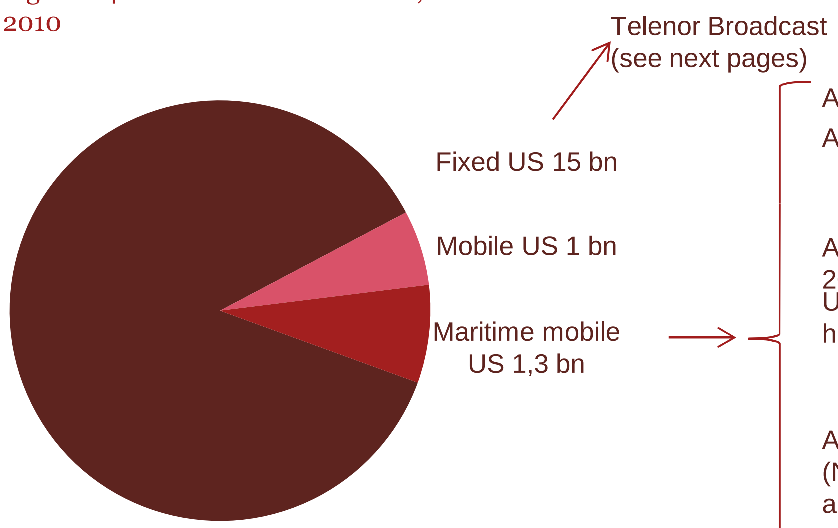
There are two significant Norwegian operators in this segment. These are service providers, do not own satellites or produce ground equipment. Eik ground station in Norway is operated by Vizada. Their equipment is mostly U.S, Israeli or Danish produced.

Two of these companies are now fully owned by global service providers; Astrium and Inmarsat. A third is acquired by Telenor. Vizada is the by far largest space operator in Norway and alone accounts for about 40 percent of the space related turnover. Vizada has business outside of VSAT markets.

Telenor's Maritime Communications Partner offers GSM roaming on ships and not broadband services as such.

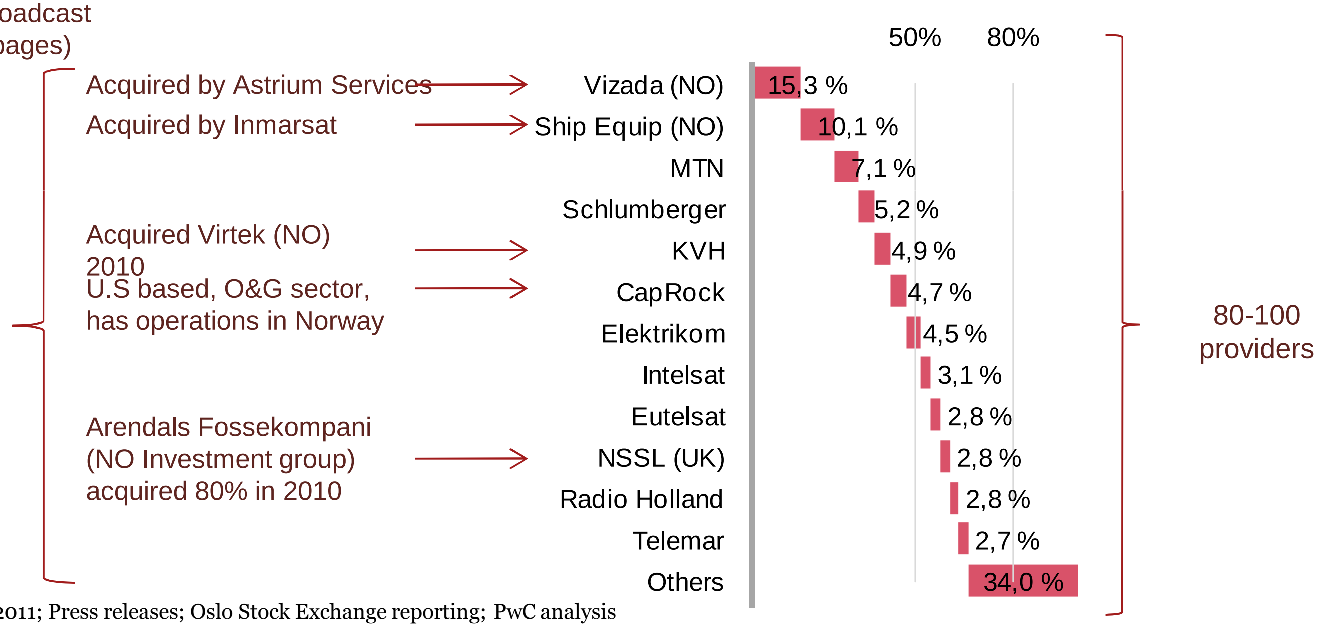
A 17 billion dollar pie of which Norwegian corporations have close to 3,5 percent

Figure 1.40: Global satcom services, fixed and mobile 2010



Global market leaders in the fast growing mobile maritime segment have been attractive acquisition targets

Figure 1.41: Oil & Gas and Maritime VSAT broadband service, share by vessel (2009 COMSYS)



Source: Inmarsat investor presentations; COMSYS 2010 market surveys; SIA 2011; Press releases; Oslo Stock Exchange reporting; PwC analysis

New entrants may challenge the positions in maritime mobile markets

Demand globally has been driven much by military needs, but of much importance for Norwegian based enterprises, a fast growing penetration rate for the global merchant shipping fleet. The maritime segment is mostly driven by crew welfare communications. Lately, demand is also driven by increased sophistication of ship operations. Some segments, i.e. seismic oil exploration ships transmit vast quantities of data. Ship Equip reports that each ship utilized about 650 mb of capacity each day, 80 percent of which is for crew personal use. Value additions include offerings such as internet cafes, Wifi, TV, telemedicine and mobile GSM roaming to home numbers.

There are about 100.000 ships in the global merchant fleet and the market is not yet saturated. The Oil & Gas segment is also important, but it is estimated that market penetration is already close to 100 percent.

The services sold by Vizada and Ship Equip differ from earlier generations of maritime broadband in that it has higher capacity and is fixed fee. The technologies involved are also different. Price points have been about 50 percent above the earlier market leading Inmarsat fleet service.

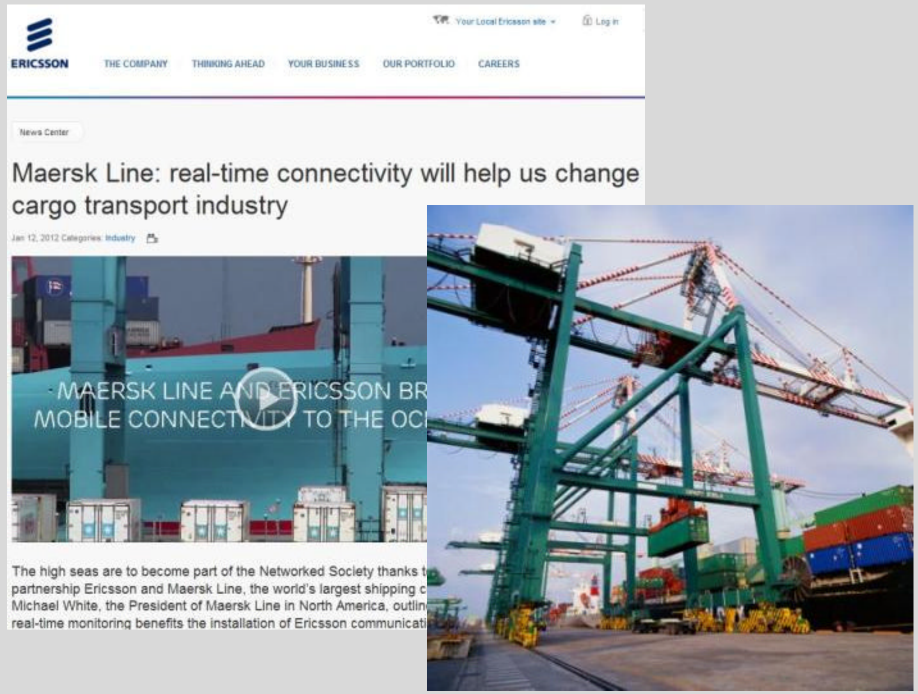
On the **supply** side there are both satellite owners and pure service providers. Inmarsat is the dominating satellite operator controlling about 55 percent of the market.

The business model of companies like Vizada and ShipEquip is about reselling a.o Inmarsat capacity and bundling this with various other value added services. Competition in the maritime service segment globally is intense with nearly 100 providers, most of whom have emerged over the last five years.

A new entrant is **Ericsson** (SE) who recently signed with Maersk (DK) to provide seven year end-to-end service for 400 container vessels. This is reported to be the largest maritime service contract ever. **Thrane & Thrane** (DK) will produce the hardware.

Largest ever maritime satcom contract between Maersk, Ericsson and Thrane & Thrane servicing 400 container vessels

Figure 1.42: Illustration Ericsson web and PwC illustration photo



Source: PwC analysis

Uncertain impact of foreign acquisitions on satcom service industry

Vizada's origins are from Telenor Satellite Services that pioneered VSAT technologies currently driving the market. TSS was sold to U.K based private equity group Apax in 2007 and merged with French Telecom Mobile Satcom. TSS had annual revenues of 2,4 bn NOK at time of sales and Apax paid five times as much for TSS as for FTMS.

At time of transaction with Astrium in 2010 it was reported that Vizada had quadrupled revenues and increased earnings sevenfold over the three years. Astrium paid 10 times EBIDTA earnings for Vizada.

Vizada revenues before the acquisition was 70 percent commercial, most from mobile satcom, and 30 percent from government customers mostly U.S. military. Much of the maritime mobile sales originates on the Norwegian side of the business but the particulars are not known. Vizada has been a reseller of Inmarsat and Iridium satellite capacity.

The core business of Astrium services before acquisition was providing bandwidth to NATO, British and German military. The acquisition will increase Astrium turnover by 60 percent.

The increases reported in the international press are not reflected in the revenues reported in Norwegian business registries by Vizada. It is possible that the growth is accounted for outside of Norway. We cannot determine precisely how the level of activity in Norway has developed.

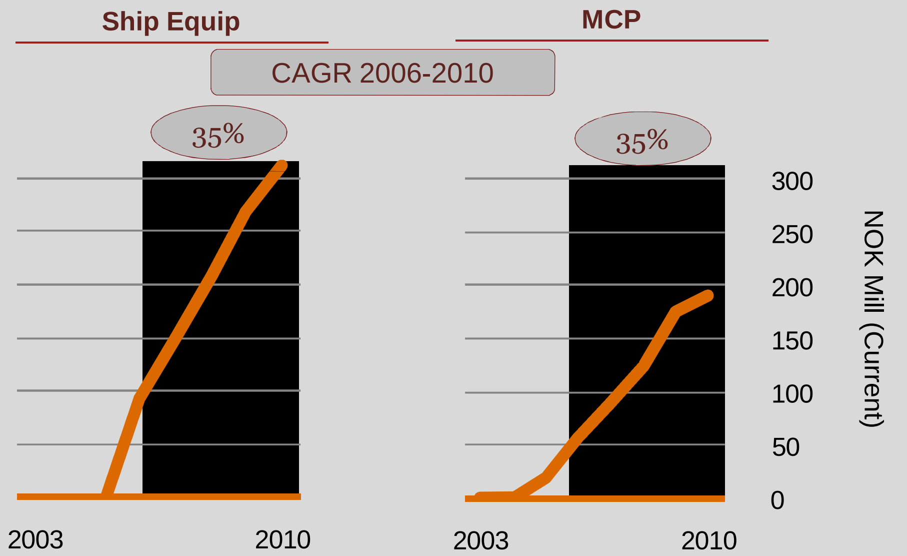
Ship Equip has captured an impressive market share of the maritime broadband segment. The company started operations in 2005 and reached above 300 million NOK (US50 million) in annual sales by 2010. It has some linkages with Norwegian producers, i.e.. a broadband distribution agreement with Telenor Satellite Broadcast for the Middle Eastern markets.

Ship Equip was mostly management owned and Ferd PE group had a 19 percent share at time of sales. **Inmarsat** acquired the full business in 2010. It is reported to be continuing its Norway based operations.

A third firm in this segment, **Maritime Communications Partner** (MCP) provides GSM roaming capabilities on ships. This has seen nearly as fast growth as Ship Equip and currently reports revenues at about 180 million NOK. MCP is now fully owned by **Telenor**.

Newcomers and fast movers in growing markets

Figure 1.43: Growth of Ship Equip and MCP sales 2003-2010



Source: PwC market analysis, Business Registry BRREG corporate data

Risks of dwindling satcom services activities in Norway and policy tools are not suited to redress the issue

Is there a problem? There could be two:

-Risk of dwindling sales overall, which may be related to the second;

-Impacts of foreign takeovers.

The question is whether or not wealth creation contribution from the maritime communications firms are dwindling and whether anything could be done to mitigate that risk?

The risk to wealth creation is that profits are not reinvested in Norway or that the activity level and wages, declines. We should keep in mind that financially speaking, the profits realized from sale of the company are in principle the present value of expected future earnings and technically there is no loss. There are gains to wealth creation if new owners reinvest earnings in the Norwegian enterprise.

Options to mitigate this risks to wealth creation are limited for the following reasons:

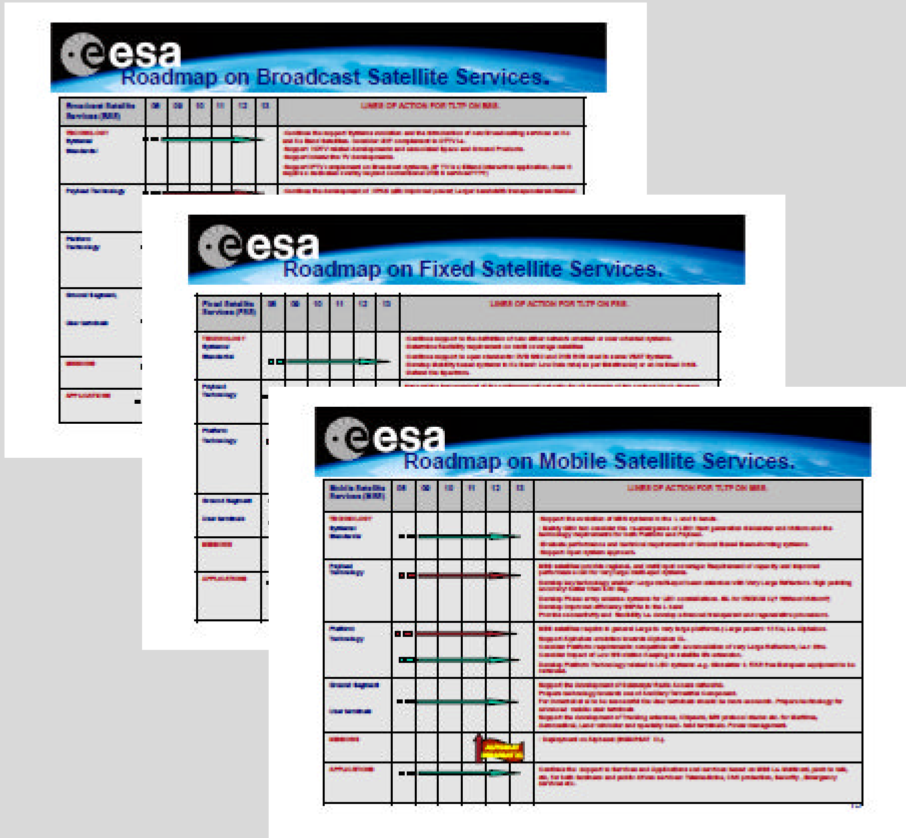
- These firm represent the service end of the value chain. The ESA telecom support schemes are more relevant for hardware technology development, satellite manufacturing or ground equipment.
- The nature of the business is less about technology development and more about bundling and managing a service offering. This may change in the future as competition intensifies.
- There is a policy risk of supporting the firms as Norway cannot be sure that the resources provided will contribute to wealth creation in Norway. There is bound to be some leakage, i.e.. all profits are likely not reinvested in the Norwegian business. The significance of this risk in comparison with all the other risks associated with supporting firms in the national space programs cannot be assessed. It may not be meaningfully more significant.

If there is an actual decline taking place, one could choose to see this as creative destruction, and recognize the limitations of policy.

There are linkages here to broader telecom and IT sectors. There are no meaningful clusters for these sectors in Norway although the potential has been recognized. Strategies could be discussed in that context.

ESA telecom programs are reinvigorated but mostly relevant for satellite manufacturing and ground hardware

Figure 1.44: Illustration of ESA telecommunication program priorities



Other satellite information services are emerging with strong Norwegian capabilities and market shares

Other satellite information services firms have received 20 percent of total ESA and NRS support funds since 2000. The ripple effect is about 6,8 and has been increasing for many years but stagnated since 2007. Public support is highly concentrated with only 1-2 firms annually receiving ESA or NRS funds. There are also several non-commercial R&D institutes that receives support for earth observation work. They are included in the estimate of overall turnover.

Capabilities. Four categories of capabilities in Norway:

I. **Offshore- onshore survey services**. Almost entirely linked to maritime and offshore industries. This is as much about *satellite navigation* as it is about earth observation. There is also a terrestrial focused geomatics firm included here. About 50-60 percent of turnover.

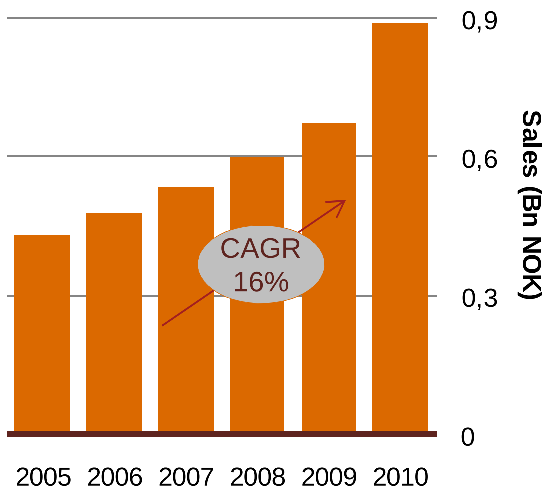
II. **Commercial meteorological services.** Highly competitive global met service provider based in Norway. Estimated share of turnover in this segment is 9 percent.

III. **Ground stations and related services:** These are the two Kongsberg companies KSAT and Spacetec. The latter is predominantly a manufacturer of ground station systems, but also develops software and applications. (In our statistics this is all counted as equipment and not accounted for here.) 30 percent of turnover.

IV. **Institutional R&D**. Several institutions with capabilities. Turnover here stems mostly from government funds, FP7 and ESA. Estimated share about5-10 percent.

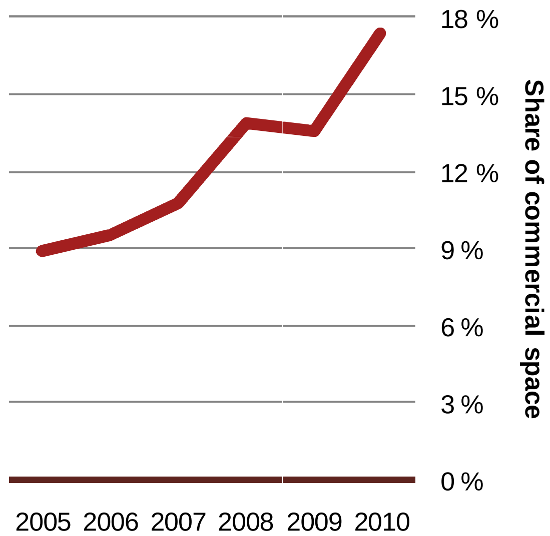
Rapid and real growth in sales

Figure 1.45: Sales other services (nominal NOK billion)



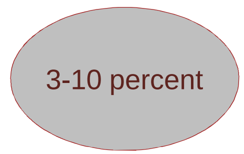
Increasing importance in Norwegian space economy second only to mobile satcom services

Figure 1.46: Share of total commercial space sales Norway



Important global market shares of other services market

Figure 1.47: Estimated global market shares



Source and notes: Robust estimates of total information services market volume does not exist. Better estimates exist of the EO and Met services markets and against those the Norwegian market share may be in the range of 3-10 percent. Robust estimates for sales volumes of services that utilizes satnav in basic or more advanced forms have not been found in forms comparable to the service offerings by Norwegian enterprises.

Sources: NRS data, turnover surveys; BRREG business registry; corporate websites and annual reports; Euroconsult 2011; Northern Sky Research 2011; PwC Analysis

Advanced commercial surveying and met services markets in Norway

Surveying off- and onshore increasingly using satellite information in addition to navigation

Figure 1.52: Illustration from Fugro corporate webpage

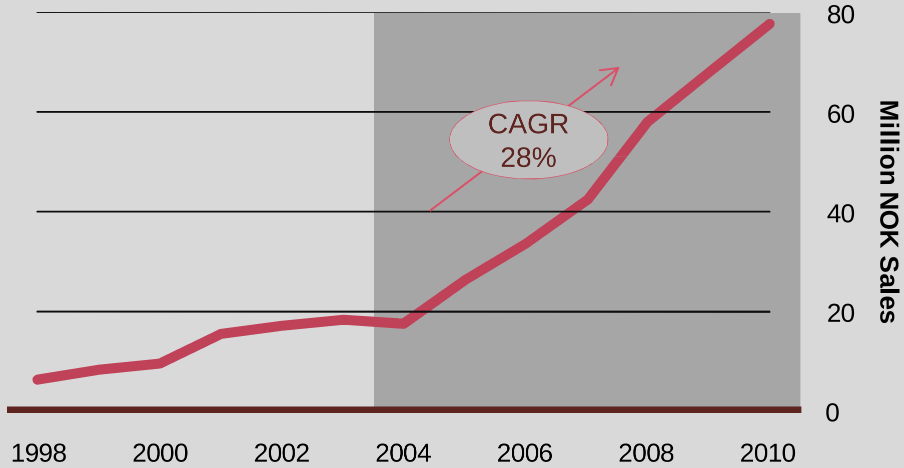
Surveying, and in particular offshore were early adopters of sophisticated use of positioning systems. These companies in Norway are driven by the oil- and gas exploration markets that are very strong. Norway is by some estimates the worlds largest market for offshore O&G. These firms also dominate the EO segment in Norway with an estimated 50-60 percent.

The same firms also use satellite **imagery and radar data** products to support exploration particularly in shallow waters. They also sell services for radar data monitoring to identify leakages (i.e. oil slicks), ice monitoring, oceanography and wave patterns etc.

Landside geomatics firms are to extent challenged by satellite imagery. Much of their capital is often invested in aero planes and instruments. This is evolving and their production processes change as the satellite products become better and lower cost.

Fast mover at the far end of the value chain

Figure 1.53: Revenues of StormGEO (NOK million nominal)



Note: StormGEO turnover has not been included in the annual statistics collected by the Space Center and as such there may be some inconsistencies wrt totals elsewhere in this report.

StormGEO's core business is **meteorological services**. Commercial weather forecasting has been made possible by decisions of U.S. and European agencies (EUMETSAT) to allow commercial operators access to the met satellite data. U.S. data are provided for free while European data are available for a fixed nominal fee (not cost basis). This has transformed the commercial met services market. The satellite infrastructure in Europe has been developed under ESA leadership and is operated by a dedicated organization EUMETSAT. Member states foots the bill of current and future met satellite developments except for the first satellite of each new generation which is financed by ESA.

StormGEO has evolved rapidly since 2004. It originated as a producer for a commercial TV station but has since then moved into specialized forecasts for industry, maritime and offshore sectors. It operates in six countries including Dubai and the U.S. StormGEO has also acquired a Swedish based weather routing service for deep sea commercial fleet markets.

The market size for commercial met services in Europe is about USD 200 million which would give StormGEO a **market share of close to 7 percent.** It records compound annual growth of about 24 percent since 2004. EBITDA earnings percentage of near 20 percent in 2010. The company is privately held: managements ownership and about 67 percent by Reitan private equity group.

Source: BRREG, StormGEO websites; PwC market analysis

Earth observation services supply side is commercializing while demand remains mostly government

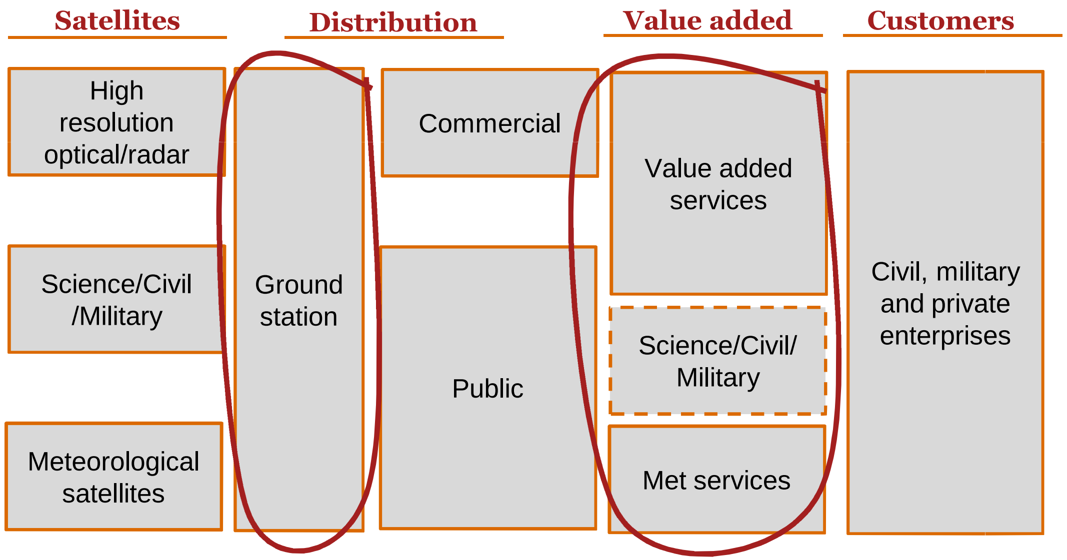
Supply side has become much commercial. This is a structural change over the last 5-10 years.

This is in particular about image and data acquisition from satellites. Pure private operators exist here, mostly in high resolution imagery (U.S). Various private-public partnerships (Europe) and commercial sales of government satellite data (Asia including Japan and Russia).

Ground stations services are increasingly commercial. ScanEx of Russia is fully private. Swedish Space Corporation is owned by Ministry of Finance but operates commercially. Kongsberg Satellite Services have much government ownership but operates commercially. Large operators also establish their own ground segments mixing own infrastructure with leased capacity (i.e. Digitalglobe and GeoEye).

Much Norwegian activity in selected parts of the value chain

Figure 1.48: Value chain Earth Observation



Value added services have also become commercial although governments develop much capacity in house including in Norway. This segment is also categorized by participation from R&D institutes.

Commercial meteorological service have evolved particularly in the U.S. but also in Europe. Services are commercial but their data are from public sources. Met satellite data from U.S. and European authorities are distributed through separate systems and accessible for licensed public and commercial users.

The supply side is integrating. Satellite operators and distributors move into the value added market. Ground station operators like KSAT also move into distribution (resale) and value added.

Demand side is mostly government. Estimates range from 60-85 percent. This is much driven by large scale purchasing from U.S. Intelligence services. U.S Intelligence also purchases radar data in large volumes from the three most important providers (non-American). About 30-40 percent of image sales are for enterprises.

Increasingly there are multiple use of the same systems, especially for commercial high resolution systems that are used by military, civil and private users alike. All the commercial systems have a high degree of government control and security restrictions.

Demand for value added services is also much from government. This is about developing applications and software to read and automate processing of image information, but also about data processing, data warehouses, geotagging of images, advising on image acquisitions etc.

Satellites for remote sensing, i.e. to monitor atmospheric conditions, oceanography, agriculture, climate change monitoring are not commercialized in downstream segments. Data are distributed through dedicated systems with general public or scientific access. We are not discussing those here.

No involvement in data acquisition and risks being locked out of the growing value added markets as value chains integrate

There are no Norwegian firms directly involved in data acquisition. The Norwegian government is a customer of several of these companies, mostly of radar data from MacDonald, Dettwiler and Associates Ltd. (MDA) but also of optical images from other providers.

In terms of **supply**, India operates the largest fleet of ten optical and radar satellites and markets these through Antrix. They have low-cost offerings of 1m resolution images and may threaten leading U.S. providers. Antrix accounts for about 20 percent of global sales. American firms dominate the high-end high resolution imagery markets. European and Canadian firms dominate the radar data business. Several more advanced systems are being launched over the next five-to-ten years both high resolution radar and optics.

The trend is a business model that integrates data acquisition and value added services. This is driven by the incentives to commercialize data sales and increase profits through value added offerings. This creates a risk for Norway in being locked-out of these markets.

Several space manufacturers have moved into value added service segments. i.e.. **Astrium** Geospatial Services selling products related to the EADS satellites a.o SPOT (image), TerraSar (radar) and forthcoming high resolution image system Pleiades . **MDA (Radarsat)** acquired Vexcel Canada in 2007, a subsidiary of a Microsoft company, specialized in radar data processing to add value added to its Radarsat offering. **Bhavan** of India (Antrix) is also strong in this segment. **ScanEx** of Russia, a ground station provider with strong market presence in that region also has service offerings related to radar and image data processing and value added.

New entrants from other segments entirely are also entering this space i.e. **Microsoft** has developed **Vexcel**, a company specialized in remote sensing data processing (though a Canadian subsidiary has been sold). **Google** has provided financing for the GeoEye-1 satellite and is developing offerings for its free Google Earth application as well as for its fee based enterprise service.

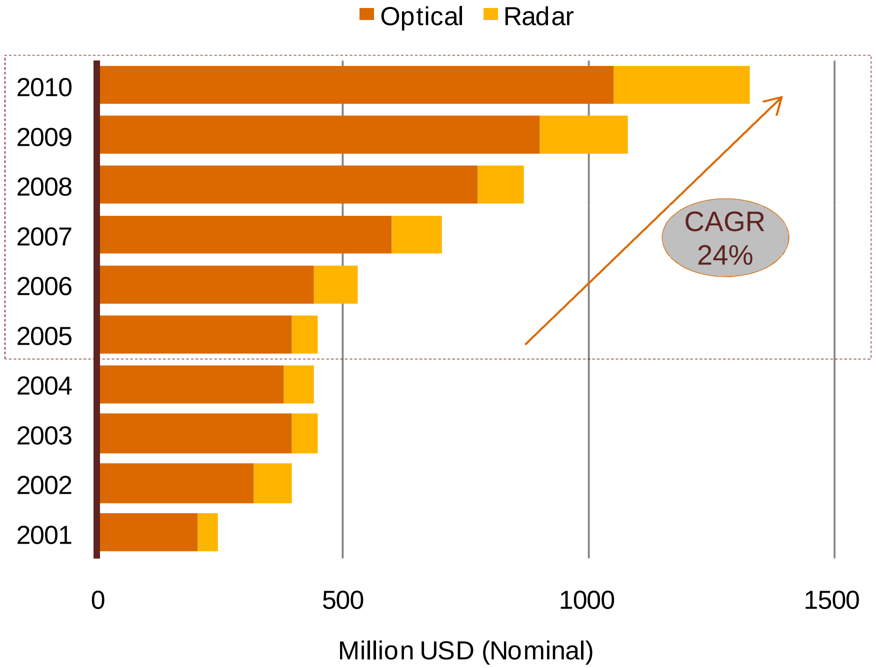
Source: Northern Sky Research Global Satellite-Based Earth Observation, 2nd Edition, November 2010, Euroconsult 2011; PwC market analysis; press reports; Yahoo Finance; Euroconsult; Futron

The **EU GMES satellites** will meet a different demand in that they will provide continuity of access to information especially suited for government civil purposes. Their capabilities will not directly compare against the high resolution commercial satellites. First generation commercial systems will be challenged.

There is however expected to be value added services potential on the basis of the data streams from the GMES satellites.

Data sales market growing rapidly after introduction of high resolution systems

Figure 1.49: Global commercial data sales for optical and radar (2010)



Sweet spot by KSAT in data distribution and a basis for expanding value added services

Kongsberg Satellite Services (KSAT) provides ground station services for earth observation satellites. Its customers are global: commercial and government. It operates facilities worldwide: Antarctica, Bangalore, Dubai, Singapore , and South Africa and in the in addition to its three stations in Norway (Grimstad, Tromsø and Svalbard).

Demand in this market is derived from the growth of remote sensing satellites and their usage. Demand also includes navigational , low orbit communications (i.e. Iridium) and geotracking systems. The most ambitious analysts indicate that the fleet of remote sensing satellites in polar orbits may increase by about 250 additions over the next decade. **Competition includes** other ground station operators: a.o Serco, DLR, SSC, ScanEx. There are both public and private providers.

Its key **competitive advantage** stems from the Svalbard facility and the subsea fiber connection to the mainland. Competitors do not have facilities located as far north as Svalbard and cannot offer the same view of all satellites or same length of download time. Earth observation satellites move fast and the download time window is short at other latitudes. Networked locations compete but Svalbard may achieve better cost-efficiency.

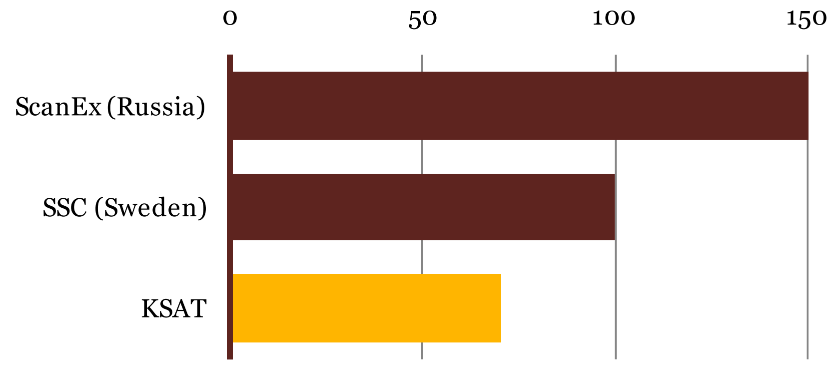
Longer term **technological disruption** may challenge the business model. One includes Data Relay Systems which will enable downlink for remote sensing satellites through geostationary satellites and teleports serving those. If successful, and at a competitive price point, these may be a game changer for the location based ground station business. Other technological challenges include crowding of frequencies near the poles as satellite traffic increases, or optical/laser linkages which enables faster downloads thereby making non-polar stations more useful.

KSAT has also offers **value added services** and reports that 23 percent of its revenues stems from this. That would make them among the largest actor for EO value added in Norway. Anchor demand is from the Norwegian government but there are also much other sales. Competitors also provides similar services. Competition also includes satellite operators firms which offer similar services with the images/radar data sales; and specialist firms.

A competitive advantage for KSAT VAS is its perceived independence from satellite operators. Customers might be willing to offer additional value for this and KSAT can develop offerings with broader capabilities than satellite operators. It also has anchor demand from government.

KSAT among the specialists in earth observation satellite ground station markets

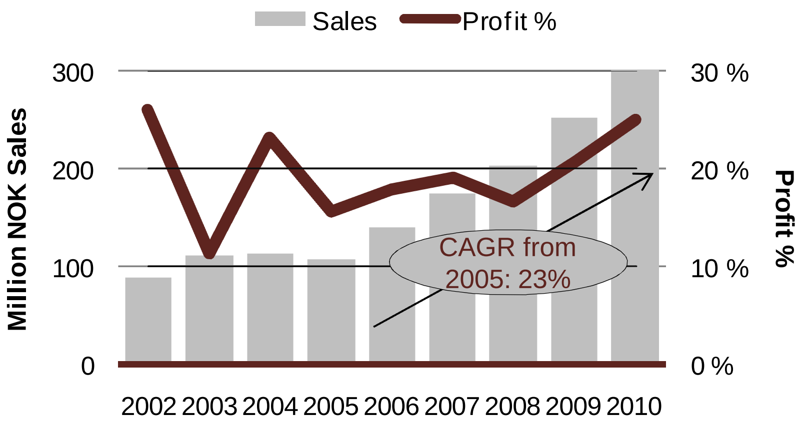
Figure 1.50: Reported tracked satellites for important earth observation ground station operators (2010/11)*



Source: Euroconsult: KSAT annual reports; BRREG (Business registry); Financial press; Corporate website and reporting; *ScanEx 150 satellites is more than estimated number of total EO satellites in operation. The number may include different types of satellites as well. PwC analysis

Sales tripled since 2005 and it is consistently profitable

Figure 1.51 Sales and profits of KSAT 2002-2010 (Nominal NOK, BRREG data)



Long standing earth observation R&D capacity in Norway but participates few FP7 projects

R&D institutes in Norway were early developers of algorithms to analyze radar (SAR) data from satellites. This is to recognize a.o oil spills, ice cover and ships from the radar data streams. National needs drove this research and applications are in operation in several agencies and R&D institutes. These have been enhanced since. The basic algorithms are now widespread and available globally and commercially.

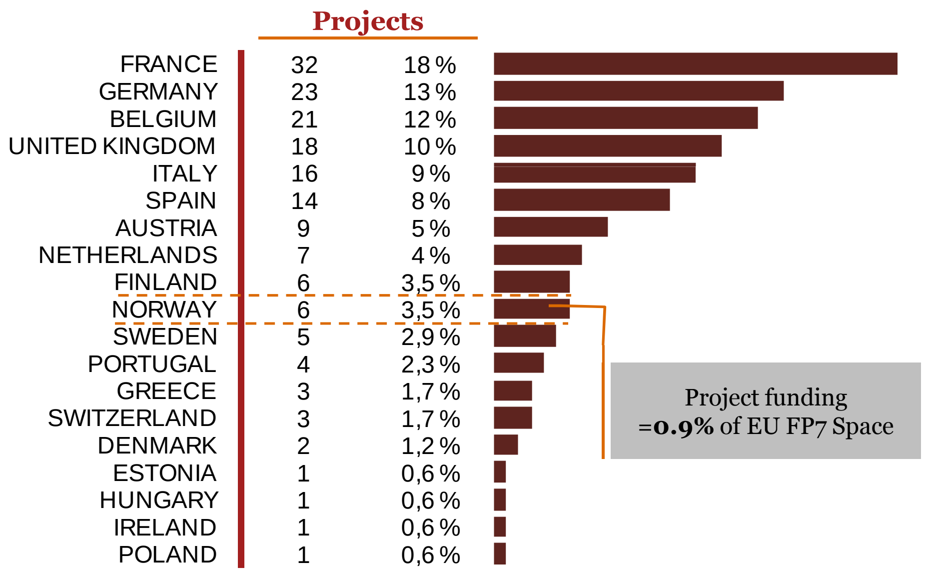
Most government financing for service and value added work has been directed at KSAT and these institutes. There are few examples of commercialization, i.e. SME spinoffs within these product and service offerings. This has been seen to a larger extent in other European countries. There is likely to have been knowledge and skills transfers to the offshore survey and met segments as they recruit from much the same base but we have not been able to document this.

An indication of the positioning vis-à-vis other countries can be derived from the **EU FP7 Space research** program. This is focused in particular on developing **earth observation services and applications** for the forth coming EU GMES series of Sentinel satellites. There are expectations that these will provide a basis upon which to expand value added business. EU has funded the programs with 1,43 billion Euro.

Norway has had some success in this program. It leads six projects, about 3,5 percent of total. The EU funding for these projects are about 0,9 percent of total indicating that they are smaller. Norway participates in further 22, or about 13 percent of total projects. The value of Norwegian content in those projects is more significant and estimated at about 16 million EUR and also entails that Norwegian research institutions would capture about 3,3 percent of the funding under the program.

Norway coordinates 6 projects, 3,5 percent of total but only 0.9 percent of FP7 Space value

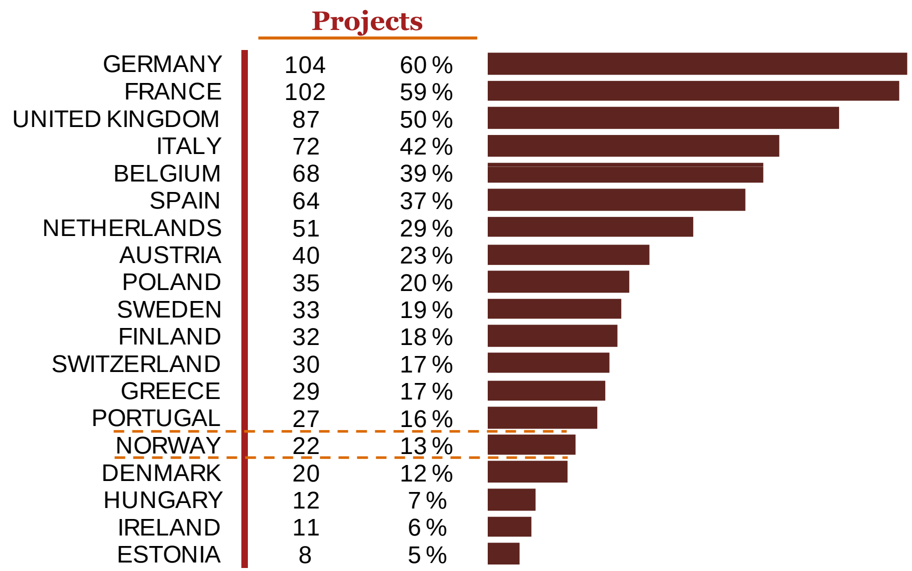
Figure 1.54: Prime contractors of FP7 Space projects by country



Source: EU Cordis data; PwC Analysis

Cooperates in more but less than other countries

Figure 1.55: Subcontractors of FP7 Space projects by country



Geotracking markets emerging with Norwegian capabilities

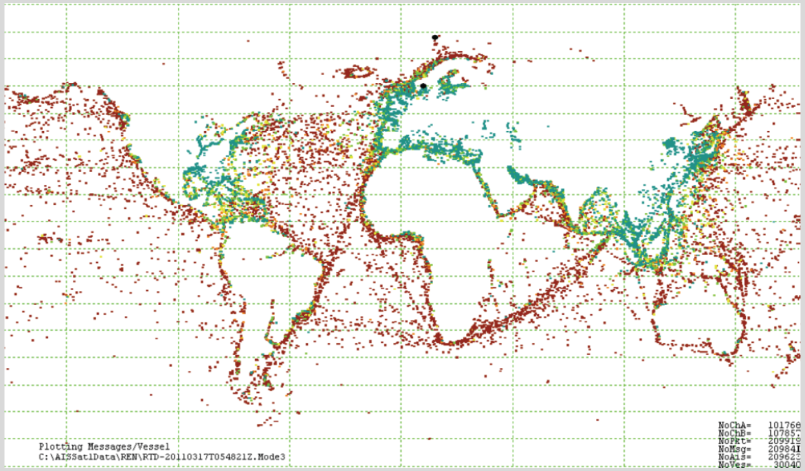
This is an emerging market segment and not classified separately in the value chain databases created. Development funds used over a four year period are about 30-40 mill NOK. This would equate to about 4-5 percent of annual ESA contracts.

Norwegian capabilities: The Norwegian government launched a dedicated AIS satellite in 2010. This project was initiated by the Space Center and managed by the Defense Research Establishment. Data from the Norwegian satellite are made available to Norwegian public entities.

The project was called a "demonstration" mostly for Government purposes but also for commercial value for the hardware manufacturer. It was not presented as a service concept of commercial value. Government has earlier reported plans to launch another two satellites and appropriations have been made for a second. Other service providers have emerged and we will briefly review this.

Global ship density mapped by the Norwegian AIS satellite

Figure 1.56: Illustration of ship density (courtesy NSC)



Source: Corporate websites: press releases, Financial press, ESA Artes 21 reports: Space Center annual reports; Orbcom 3rd quarter report 2011; Hisdesat press release February 16,2012;PwC Analysis

Demand: There is demand for geotracking services for terrestrial vehicle management and logistics operations, airtrafic and maritime segments. The maritime version of this is AIS**.** Ships above 300 tons are required by international regulations to carry AIS senders. Government demand is likely to come from coastal authorities and harbor management worldwide seeking to enhance maritime surveillance capabilities. Commercial demand stem from ship-owners and operators, logistical operations and financial services.

Market volumes are growing. Orbcom reports expectations of about 10-15 million US in AIS data sales and associated 90 percent EBITDA margin for 2012. Another leading operator ComDev/Hisdesat reports contracts with Canada, Australia, New Zealand, Japan and Singapore governments worth at least USD 10 million.

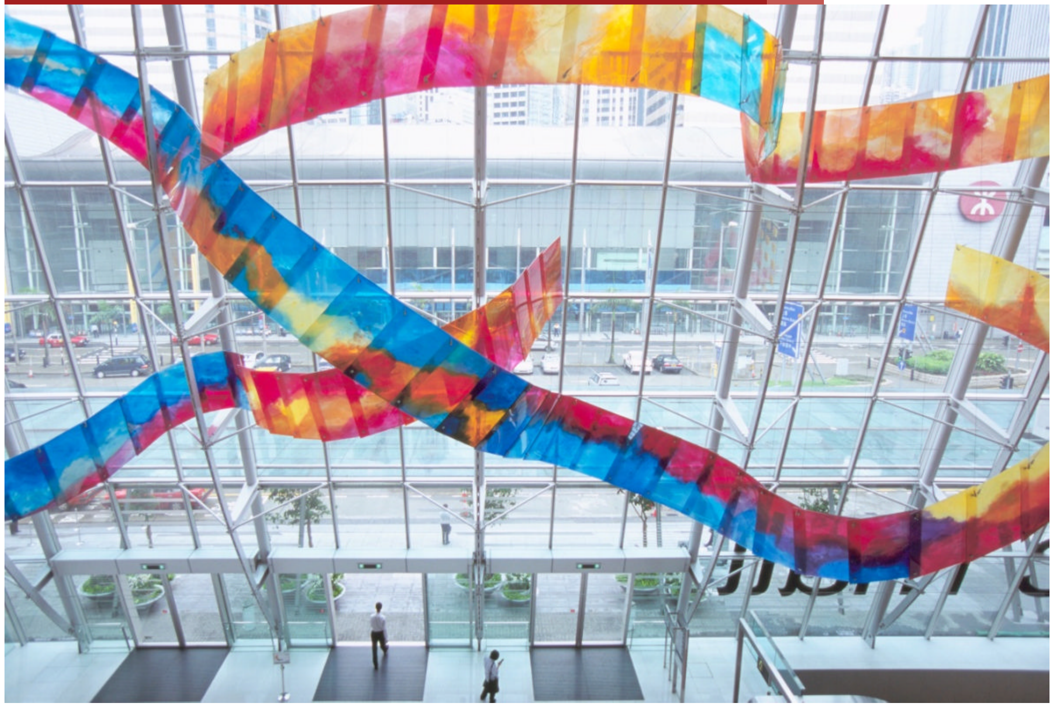
Supply: There is quite a development race ongoing and competition is escalating. Commercial operators have developed concepts, capabilities and are operational. The two most significant actors include Orbcom and ComDev. Of note is that the companies are quite small, i.e. annual revenues of Orbcom is about US 40-50 million. There is consolidation ongoing and Aprize capabilities were recently acquired by ComDev.

- U.S. based **Orbcom** is an early mover and operated AIS service from 2008. This was under development contract funded by U.S. Coast Guard from 2004. Data sales have been commercialized. Lloyds Registry and Fairplay has provided value added services integrating satellite and terrestrial (AISLive) data since 2008. The satellites failed during 2010-11. Orbcom is now equipping 18 satellites with AIS terminals and the first second-generation satellites are already in operation.
- **Exactearth** is a company formed by Canadian ComDev and now jointly owned by Hisdesat who owns 27 percent of the operation and is marketing services in Spanish speaking countries. Exactearth also has AIS satellites in orbit and plans to have 10 satellite constellation in service by 2014. Three are operational currently. **Hisdesat** also reports including AIS receivers on its new **Pas radar** satellites to be integrated with the ComDev AIS service. MDA reports plans of AIS receivers on the new RCM radar satellites.

Norwegian competitive positioning: As the government project only involves one satellite and was not intended as a commercial project a comparison may not be appropriate. The commercial position is nevertheless weak**.** The hardware producer may have gained relevant experience although its uncertain how this compares against those who deliver AIS receivers for the commercial operators.

Section 1.2

Institutional and policy developments



The objective of this analysis is to analyze developments in the external institutional and political arena which have implications for the relevance and effectiveness of the national space programs.

There are three perspectives on this:

Global policy developments are reviewed first. This is about the

the U.S. 2010 policy. This could be a game changer especially its approach to commercialization. We will review what the Americans have envisioned and discuss how industry and government in Norway may be impacted; and

European issues. This is primarily about the reconfiguration of ESA and EU relationships with the implications this has for priorities and direction of policies, as well as governance structures, and access and opportunities for Norwegian firms and other interests. This is an ongoing, and slow moving process, but certain emerging patterns can be ascertained. We will point to the key ramifications for Norwegian policy.

Emerging market developments

is about how developments in major emerging economies may impact space programs in Norway. This is about increasing competition and cost pressures from a sizeable and fast growing space industry in several emerging economies.

Peer country review

will focus on how these countries handle issues of interest for Norway. We focus on countries which may have overlapping priorities or shared issues with Norway. He analysis focuses on features or issues which may be interesting for Norwegian policy formulation. Three countries are discussed: Canada, Sweden and Switzerland.

Global policy drivers

U.S. space policy changes has implications

Leading

Being the giant and still spearheading most advances in science , civil, military and commercial application: important policy changes will have implications including for small and emerging space nations such as Norway.

While much of the national policy focus is understandably on ESA and the EU where the money goes, the implications of U.S. policies cannot be ignored.

U.S. public expenditures on space related capabilities are in the area of 64,6 billion US in 2010 (370 bn NOK). NASA's constitutes about 30 percent of these, some 43 bn is security spending by Department of Defense, National Reconnaissance Office and the National Geospatial Intelligence Agency, while various civil agencies, including NOAA and the Science Foundation spend about 2,25 bn US on space.

This is equivalent to about 75 percent of total global public expenditure, and about a third of the total value chain turnover including consumer TV distribution at the far end.

Spending has not increased over the last few years and there are concerns of a decline.

The full complexity of U.S. space programs and policies cannot of course be meaningfully reviewed within the context of this report, but we will focus on certain recent changes which should inform formulations of Norwegian policies.

The Obama 2010 policy

Most administrations in the U.S. have launched space policies outlining key priorities and principles. The Obama administration is no different and their policy is in many aspects a continuation, but also signifies some important changes.

We will turn to the changes in commercialization policies next.

A game changer especially for commercialization

Figure 1.57: Illustration of U.S. Space Policy release June 2010

Source: The White House; Space Foundation Report 2011; PwC analysis

Policies to drive U.S. commercialization leads to increased competition

The Americans have defined an expansive commercialization policy which ramifications will be felt also in Norway. This is a game changer.

The key is a definition of what commercial space activity implies and a set of principles determining the conduct. The definition implies risk sharing and goes beyond sub-contracting commercial vendors. A European term for this is Public-Private-Partnerships. The principles accompanying this are far reaching and have structural impacts. In addition comes possible reductions of public expenditure which may drive U.S. producers towards other markets.

U.S. business will continue to have defining anchor tenants in government but will also have stronger incentives to further commercialize products and services. A key example is the development process for human spaceflight whereby commercial actors compete. The capabilities developed during this process are likely to impact the launcher markets in the future. Similar impacts can be seen in the remote sensing segment i.e.. the developments of the optical satellites discussed earlier whereby private and government interests share risks and upsides We are also likely to see increased service developments related to these segments.

Impacts are twofold:

- **Increased competition** as U.S. producers are further incentivized to both develop new capabilities and to commercialize them including on global markets; and
- **Cost-effective solutions** as Norwegian governments may also be customers of these same offerings including in priority areas such as remote sensing and geotracking (AIS).

Related developments include possible revisions of the **export control regime**. This is originally motivated by security concerns but is increasingly seen as hampering commercial business developments. If changed, this will increase global competition.

The **free-and-open data access policy** for remote sensing satellites will continue and Norwegian authorities and businesses benefit from this. A challenge for U.S. authorities is to formulate such policies for remote sensing data gathered through privately owned systems where public and private interests collide.

The Definition

"The term "commercial," for the purposes of this policy, refers to space goods, services, or activities provided by private sector enterprises that bear a reasonable portion of the investment risk and responsibility for the activity, operate in accordance with typical market-based incentives for controlling cost and optimizing return on investment."

The Principles (edited)

- Purchase and use commercial space capabilities and services to the maximum practical extent when available in the marketplace;
- Actively explore the use of inventive, nontraditional arrangements for acquiring commercial space goods and services, including measures such as public-private partnerships, hosting government capabilities on commercial spacecraft, and purchasing scientific or operational data products from commercial satellite operators in support of government missions;
- Develop governmental space systems only when it is in the national interest and there is no suitable, cost-effective U.S.commercial or, as appropriate, foreign commercial service or system that is or will be available;
- Refrain from conducting United States Government space activities that preclude, discourage, or compete with U.S.commercial space activities, unless required by national security or public safety;
- Pursue potential opportunities for transferring routine, operational space functions to the commercial space sector where beneficial and cost-effective, except where the government has legal, security, or safety needs that would preclude commercialization;
- Cultivate increased technological innovation and entrepreneurship in the commercial space sector through the use of incentives such as prizes and competitions; and
- Ensure that United States Government space technology and infrastructure are made available for commercial use on a reimbursable, noninterference, and equitable basis to the maximum practical extent.

Source: U.S. Space Policy 2010 White House; PwC Analysis

EU solidifies its position as an important space policy actor in Europe

"The long-term and political perspective is to make ESA become an Agency of the EU by 2014"

*ESA Director General 2006**

It is still open how the relationship between two institutions will evolve. There is an increasing alignment between EU and ESA and this is the dominating institutional development over the last decade. The extent and depth of this development in the future will greatly impact the main institutional arena in which Norway plays out its space policies.

We will in the following brief point to the most significant developments and indicate scenarios for how this can impact Norwegian space programs.

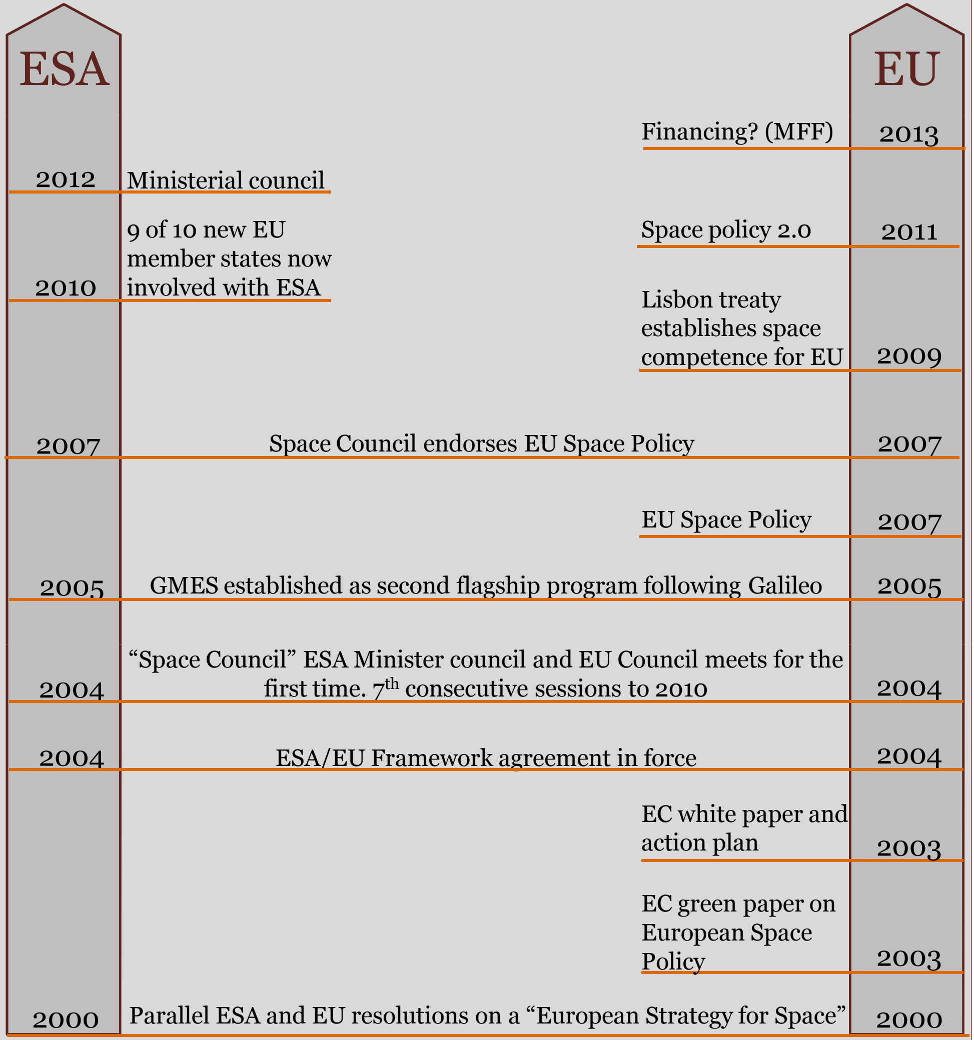
Two types of impacts particularly relevant. These are impacts on:

1. Governance: Influence on i.e.. articulation of policies, priorities and determination of programs and expenditure; and
2. Industrial policy, procurement and competition.

Next we will review the important drivers and impacts.

Ever closer integration of ESA and EU

Figure 1.58: Illustration major policy milestones 2000-2012



Source: PwC Analysis

Ambitious EU mandate that may be aligned with broader Norwegian policy priorities

In 2009 the Treaty Of Lisbon established competency for the European Union to draw up a European space Policy, to develop a European Space program, and to establish any appropriate relations with ESA. On this basis, the Commission issued a policy communication in 2011 setting out the direction: **" Toward a space strategy for the European Union that benefits its citizens."***

The policy is formulated on basis of four problem definitions:

1. **Security of critical European space infrastructure is not ensured.** There is not full and accurate information about satellites and debris orbiting earth and this constitutes a risk to space infrastructure;
2. **Europe lacks a long-term strategy and critical mass for space exploration.** The Commission argues "that space exploration gives nations involved in it a high political profile in the international arena. It is also a driver for technological innovation and is detrimental to Europe from an international standpoint, does not allow space exploration potential for innovation and competitiveness to materialize and could have negative effect on science and education";
3. **Space policies and investments are decided at national/ intergovernmental level.** The Commission argues that:
   a) Space initiatives only indirectly respond to broader European policy objectives;
   b) National space policies' target is national industry, which may be detrimental to the competitive development of the European space industry; and
   c) There is a risk of overlaps, fragmentation and discontinuity of the activities in the European space sector; and
4. **National investments for dedicated space programs cannot sufficiently address the needs of EU policies and interventions.** Due to the fragmentation of national decision making channels, space governance frameworks and lack of coordination of funding mechanisms, investment in essential space activities or space exploration cannot acquire the necessary critical mass.

Source: For this and following pages: COM (2011) 152; SEC (2011) 381

Lisbon treaty establishes competence for the EU on space policy matters

Figure 1.59: Article 189 of the Treaty of Lisbon

The Treaty on the Functioning of the European Union

Article 189

1.To promote scientific and technical progress, industrial competitiveness and the implementation of its policies, the Union shall draw up a European space policy. To this end, it may promote joint initiatives, support research and technological development and coordinate the efforts needed for the exploration and exploitation of space.

2.To contribute to attaining the objectives referred to in paragraph 1, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the necessary measures, which may take the form of a European space program, excluding any harmonization of the laws and regulations of the Member States.

3.The Union shall establish any appropriate relations with the European Space Agency. (*4. not shown)*

Ambitious EU action plan but with great financial challenges that are currently unresolved

Priority actions to redress the situation are identified as follows:

1. Satellite navigation: the Galileo and EGNOS programs. The systems that emerged from the Galileo and EGNOS programs represent the first major space facilities solely belonging to, and managed by, the EU;

2. GMES (Earth monitoring system). The Commission's aim is to implement the system "quickly and effectively" and is to become operational as of 2014. GMES is to provide current environmental and security-related data.;

3. Secure Space to Achieve Security and Defense Objectives. As an instrument it can serve the European Union's security and defense interests; as an asset it requires protection; and

4. Space Exploration. Priorities have been identified including: critical technologies, International Space Station (ISS)and access to space (Launchers).

Economic challenges

A core challenge is economic. Range for the policy is estimated between euro 130 million and 1,5 billion annually but it is stated that non-quantified costs could be "exponentially higher." Currently provisions for financing GMES are lagging and the EU indicates that ESA member states may need to finance this completely.

This relates to structural challenges of EU budgets and medium-term financing frameworks (MFF). The EU budgets overall are small compared to member states and are not rigged to take on large scale development or operational costs of a.o. space activities. I.e. Galileo and GMES costs have largely been funded by transfers from the agricultural programs.The scale of financing that is required for the more ambitious variants of the policy may go beyond what the EU budgets can absorb.

Closing this financing gap is an important and unresolved challenge.

EU ambitions already have practical implications

Figure 1.60: Illustration of EU space policy implications

20 percent of ESA 2011 budget from EU

Decades of guaranteed continuity of GMES earth observation satellite series

22 bn euro end-to-end costs of Galileo*

70 mill euro Norwegian contribution to development of Galileo

Source: * Financial Times Deutschland 2010, 20 yrs of operation

Future governance of European Space involves military ambitions, restructuring of ESA and Norway to take part in some programs

1. **Coordinate Member States:** The Commission wishes to better coordinate activities of member states, space infrastructure is to be explored jointly. Space program management remains fragmented and international investment segregated. The proliferation of protagonists – the Member States via the space agencies, the ESA, EUMETSAT and the EU – is not conducive to effective decision-making or implementation.

2. **Re-assess relations with the ESA.** Now, the EU's increasing involvement in space entails:

   a) Gradually adapting the ESA's operations so that maximum benefit can be derived from the two organizations.:
   b) As far as the Commission is concerned, the ESA should continue to develop into an organization with an **intergovernmental and an EU dimension** in which **military and civil** programs can coexist.
   c) The model should be flexible enough to adapt to the level of **funding** that the various protagonists set aside for the different programs in the future.
   d) A flexible membership structure should also be established in order to enable Switzerland and **Norway to take part in some programs** and to offer limited participation to some Member States.

3. **Third countries** cooperation:
   a) Certain space activities including the International Space Station, ISS) can only be conducted in cooperation with third countries.
   b) The Commission wishes to seek a "constructive" solution with **China** which claims the same frequencies as Galileo for its satellite navigation system COMPASS. This is a risk to the independence and fundamental rationale for the system.
   c) The Commission will discuss co-operations with **U.S. and Russia** in i.e. earth observation.
   d) The Commission seeks to utilize space capabilities as an instrument for development policy with a.o **Sub-SaharanAfrica**.

Future industrial policy will be more competitive but likely not fully aligned with EU procurement directives

1. The Commission declares it will draw up, in close cooperation with the ESA and the Member States, a **space industry policy** that reflects the specific needs of each sub-sector. The main objectives of such a policy would be the steady, balanced development of the industrial base as a whole, including SMEs, greater competitiveness on the world stage, non-dependence for strategic sub-sectors such as launching, which require special attention, and the development of the market for space products and services.

2. Special significance is given to **SatCom**: In order to maintain Europe's lead in satellite communication technologies, research must be carried out at European level, given the spin-offs it can create for other application sectors. The availability of the appropriate radio spectrum will be necessary to ensure that satellite communications and space infrastructure are operational and help achieve the European Digital Agenda and EU space policy objectives.

3. In order to improve competitiveness it is seen as necessary to make better use of the European regulatory framework:

   a) Regarding **trade** in particular;
   b) Of the financial instruments to support **research and innovation**;
   c) To define the most appropriate type of **procurement** procedures and the applicable award procedures when EU funding is concerned;
   d) The option of adopting specific provisions under particular legislative acts could be examined.

We wouldn't expect the full procurement volume to be subject to directives 17 and 18. Although the EC remains uncompromising on competition and procurement, in practice, the directives only govern an estimated 20-25 percent of total European public procurement.* Experiences of applying the directives and in particular the competitive dialogue procedures for Galileo development also showed that there may be a need for adaptations for this to work effectively for space procurement.

Source: PwC and London Economic: Public Procurement in Europe. DG MARKT 2011

ESA governance is independently challenged with rising membership causing inefficiencies and costs

ESA is constituted as an intergovernmental organization. There are currently 19 members including two non-EU members Norway and Switzerland. All EU 27 states are expected to be members over the coming years and the reminding are currently in various stages of accession.

ESA does what the member states decides it should do. **Rules of procedure** stipulates specific decision rules for different issues. Important decisions such as level of resources for programs are decided by unanimity. Thus full consensus is required, even by members that do not participate in a program.

This can be seen as serving the interests of smaller nations including Norway. It may also be seen as an important requirement for a smaller nation to join in the first place as it will have some assurance of influence. Norway as such exerts influence far beyond its 1-2 percent contribution. Repeat interaction possibly leads to reduces conflicts and a culture of compromises. This also reflects that ESA is mostly a consensus driven organization otherwise the unanimity procedures would be unmanageable.

The risk is, as the ESA DG points out*, that it leads to lack of flexibility, costs and delays. These risks will only increase as ESA expands and accepts new states with the same rights.

Industrial policy rules are faced with similar dilemmas. From an efficiency standpoint, there is a real risk that the rules which guarantee a contract return by country equivalent to its contribution are driving costs higher and causing delays. Most states, including Norway participates in all program families, often with very small contributions, and all of these have to be matched by contracts or reimbursements schemes. In the end it is not certain that this increases the overall competitiveness of European industry, but it will create opportunities for corporations which would otherwise not have been competitive.

The dilemma arises as these same rules also guarantee smaller nations a real voice and influence and a possibility to build-up industrial capabilities. Without these, ESA may soon loose its attractiveness for smaller nations.

A **longer term scenario** is that the system will be revised, compromises will be sought, and smaller nations including Norway may need to be more selective in its participation.

Source: Agenda 2011 ESA; ESA Agenda 2015; PwC Analysis

Challenging to apply the convention…and not easier with prospects of 29 members

Figure 1.61: Important decision rules in ESA

2012	Procedure and decisions	20++
19	**Unanimous:** -Level of Resources for programs -Changes of industrial policy	29
13	**Two-thirds:** -Adopt the general budget -Adopt each program -Technology export	19
10	**Majority of all member states:** -Accept Optional programs and prioritization	15
≤ 10	**Simple majority of represented states:** -Procurements -Other matters not specified	≤ 15

Norway's influence will be reduced and European markets more competitive and inaccessible for Norwegian firms

So, where does this leave Norway, small nation and non-EU member? It is difficult to predict whether Norway will be better off if the EU objectives are achieved. But there definitely a number of challenges:

Influence will decline as EU member states coordinate, possibly pool funds and a larger share of the funding and activity total originates in EU. How much, and with what significance is harder to ascertain.

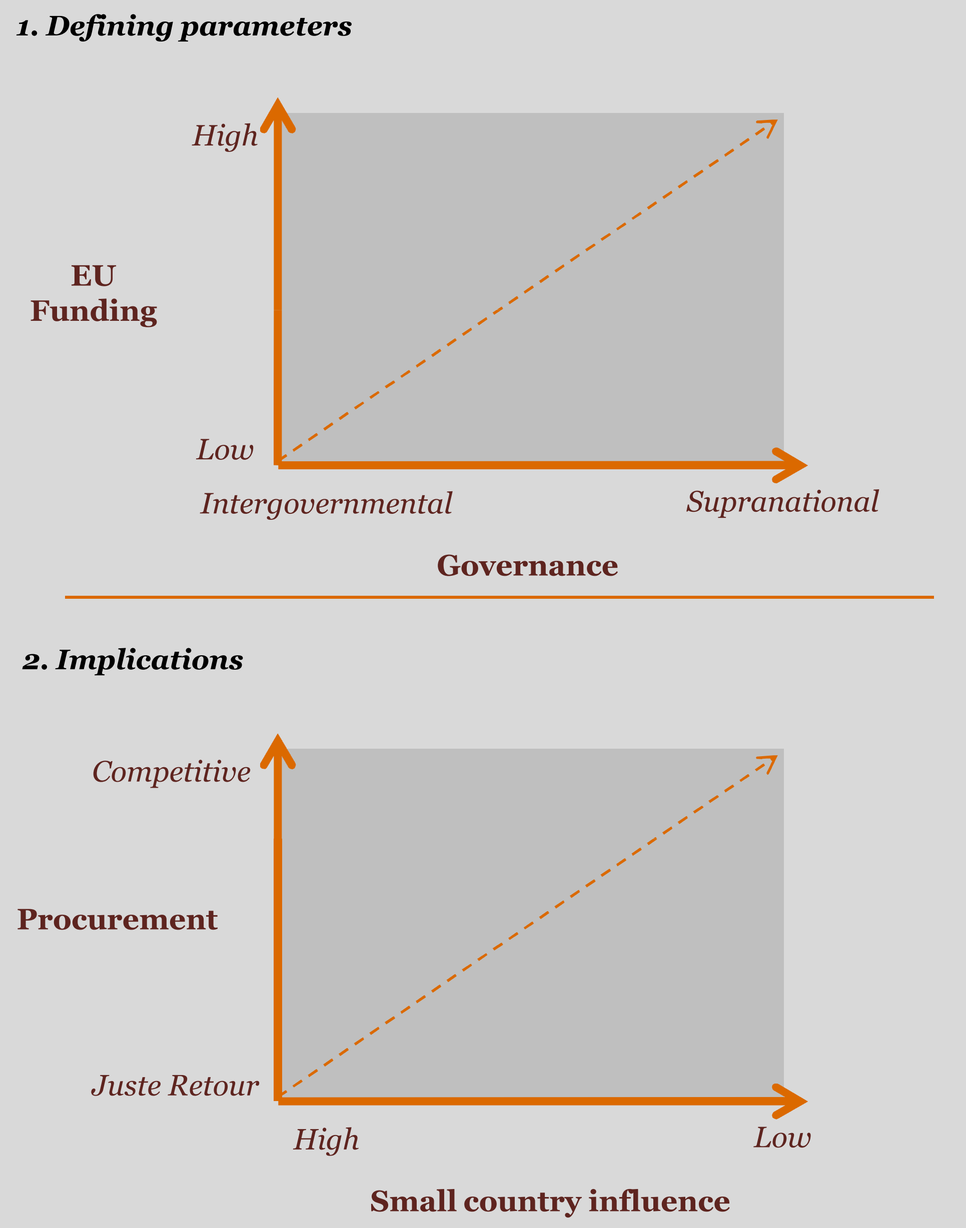
If small today, the ability to influence priorities, determine the agenda and strategies will undoubtedly decline in the future. Norway's current influence is disproportional to its resource contribution but there are only a few examples of where this has had a marginal impact.

Competitiveness will decline. Increased EU funding, and shifting member state money out-of-the *juste retour* system and applicable under EU procurement, will on balance damage Norwegian industries competitiveness. A few of the successful operations in Norway may actually gain as they are hugely competitive and are currently constrained by the juste-retour. Net, we would expect a decline.

The **risks cannot be ameliorated** entirely, but mitigation strategies could include significant scale-up of resource provision, ad-hoc program contributions ala Galileo; and more out-of-the-box: be prepared to seek supplementary venues for bilateral European or non-European cooperation.

Figure 1.62: Illustration policy scenarios

Conceptual



Increasingly national programs organized as partnerships with commercial orientation and private capital at risk

Boundaries between public and private roles are shifting. There are three models emerging:

- **U.S commercialization strategy:** Private investments and risks, government service contract backing**.** Especially seen in the earth observation markets for high resolution optical and radar satellites. Privately financed, i.e.. the GeoEye-1 satellite was co-financed by the U.S. National Geospatial Intelligence Agency and *Google*. Digitalglobe raised financing for its new satellite through a public offering of its shares in 2009.

  High private risks are involved as evidenced by the recent collapse in stock market prices of DigitalGlobe and GeoEye due to signals of cutbacks of government spending on imagery. U.S. intelligence services have also entered into five-year 85 million dollar contracts with non-American firms MDA, EADS and Infoterra for radar data. The competition to develop new launchers and service capabilities is the other important manifestation of the concept.

- **European PPP models:** U.K/Norway/France/Italy/Germany/Canada/Israel: Public private partnerships model whereby government investments are significant and private operators/owners are responsible for operations and commercialization. This has been seen in optical/radar satellite systems and also for military satellite systems. **TerraSAR-X** is a radar satellite developed by EADS Astrium and the German Space Agency. **Rapideye** is another private-public financed German project. The four satellite constellation **Cosmo-Skymed** is a military-civilian project which also offer one meter radar resolution images sold commercially through **e-Geos/Telespazio**.

  British military communications system Skynet-5 and **Norwegian-Spanish** military communications satellite HisNorSat are the other examples. Norway has an ownership stake while the British lease capacity from Paradigm and EADS. Both sell excess capacity.

- **Asian government commercialization:** India/Russia/South Korea: Full government financing but sales commercialized through a state owned company or by licensed agents. Earth observation image and radar satellites.

Governments use new approaches to lower cost of capital, align incentives and encourage commercialization

Figure 1.63: Important functions of public-private partnership models

Purposes	Important challenges
Lower cost of capital. This is about reducing risks for private participants thereby lowering the cost of capital.	**Balancing risks and incentives.** The most important difficulty is finding a balance of appropriate balance of private capital participation versus sharing of upsides. Current programs are likely to provide lessons in this regard but it may be too early to make any assessment.
Aligning incentives. Private capital risk and commercialization incentives aligns incentive for cost and quality between private and public actors.	
Lower life-cycle costs through revenue streams. Commercial sales creates revenue streams and thereby reducing life-cycle costs.	
Incentives for commercialization. Incentives to increase revenues, reduce risks and dependency on government sales.	

Emerging markets developments

Russia

Emerging market but an old space power. Estimated budget for Roscosmos in 2011 at 3,7 billion US* (2,8 billion EUR/21,5 billion NOK). Eight percent nominal growth from 2010 but high inflation may reduce the real gain. A reinvigorated the Russian space programs after decades of decline. The GLONASS (SatNav) is now operational with 31 satellites in orbit. Only country with ability for human space travel (after retirement of U.S. space shuttle) Structurally, Russian industry benefits from large and captive demand from defense-driven government applications. Industry suffers from a retiring workforce and loss of qualifications. Concerns are rising after a string of recent engine failures of the old Soyuz launcher.

Analysts believe opportunities may exist for European companies.

Russia has also started construction of a satellite ground station at Svalbard. Norwegian authorities dispute the construction on environmental grounds and have demanded it removed.

Russian arctic strategy reveals Svalbard ambition and results in construction of ground station

Figure 1.64: Illustration of Russian Svalbard strategy and construction site

China

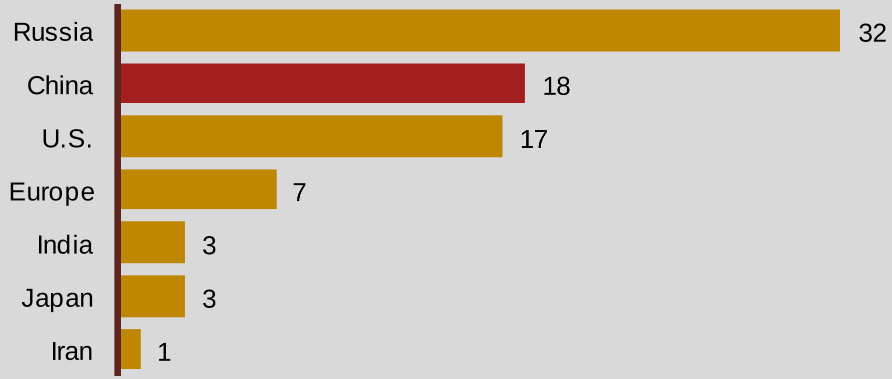
Estimates of annual spending range widely between 2,5-6,5 billion US. High end estimates include the science programs. An ambitious space program and a white paper released last year. Supporting much infrastructure development: i.e. four launch sites, Chinese space station under development, seven satellite constellation SatNav system (Beidou), data relay satellite, military communications and earth observation satellites, and satellite orbiting the moon.

Surpassed the U.S. in launches last year and now rivals Russia in launching medium-size commercial communications satellites.

About 40 large enterprises and an estimated 48.000 space workers. Annual revenues of aerospace manufacturers at about 22 bn USD in 2010 (NOK127bn/EUR17bn) up 60 percent since 2005, half of it by commercial companies. Only parts of these sales are for space and the exact amount cannot be ascertained.

Catching up to Russia in the medium size satellite launch segment?

Figure 1.65: Number of orbital satellite launches 2011



Source: *Globalsecurity.org 2011; Barents Observer 2012 ; New York Times Dec 2011, Federa l Aviation Administration 2011; Space Foundation 2011; OECD 2012

India

Budget for the space organization of about 1,5 bn US in 2011. More than 30 percent increase two years in a row. The space agency has 15.000 employees.

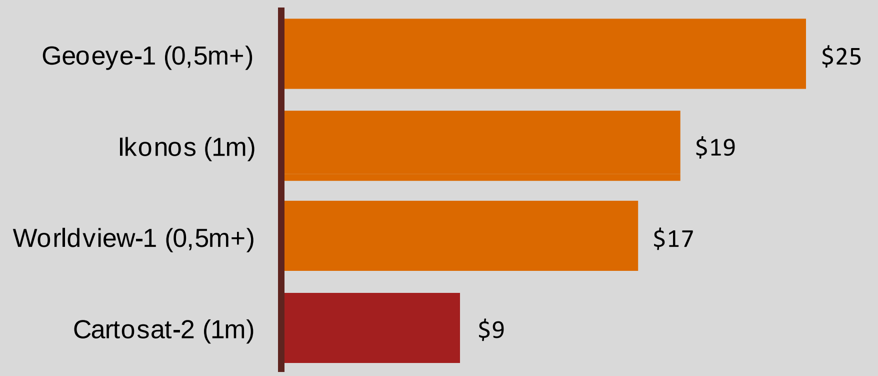
Large domestic communications system with eleven satellites providing TV signals for 90 percent of the population. Fleet of ten optical and radar earth observation satellites.

Has an estimated market share of 20 percent of the global optical image business. They will also expand into radar satellites in the near future. Value added services increasing and i.e. Antrix/Bhavan has launched a 3D mapping image service to rival Google. Some 500 active companies.

Tested ballistic missile defense system in 2011 indicating a focus on military programs in response to the so called "Asian Space Race". i.e. Japan launched two "spy-satellites" in 2011, and several more by the People's Liberation Army.

The low-cost image challenger

Figure 1.66: Indicative market prices high resolution, fresh images, per Sq km



Latin-America

The region does not see the same scale-up as in Asia, but there are a number of countries with space programs, satellite production and ambitions.

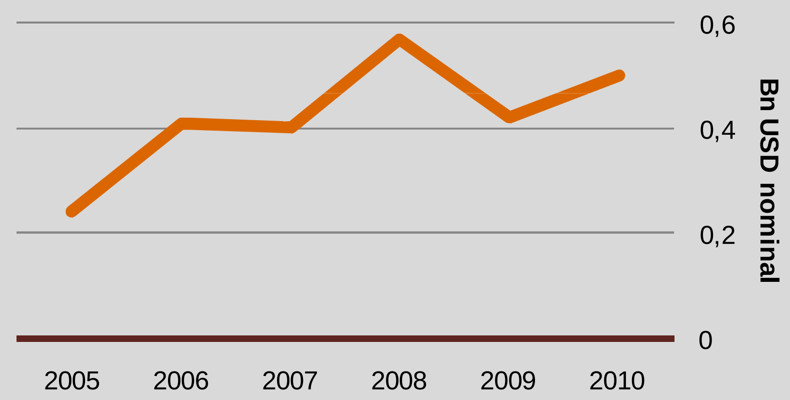
Brazil and Mexico are the largest. Mexico has developed a telecom company with three geostationary satellites in orbit. Other countries with active programs and accomplishments include: Argentina (built its own geostationary com satellite), Chile, Colombia, Peru. Several countries have had astronauts in orbit. Most are focused on remote sensing capabilities.

Brazil's policy in particular is characterized by extensive bilateral cooperation programs and utilitarian objectives. The flagship program is the Chinese-Brazilian **earth observation** systems (CBERS), three satellites currently in orbit used for a.o rainforest monitoring and natural resource management.

Brazil also develops a **launcher** (Cyclone-4) in cooperation with Ukraine. The industry is backed by the significant aerospace industry which is the worlds third largest.

Space manufacturing turnover in Brazil is small and not much ahead of Norway though it is growing faster

Figure 1.67: Revenues space manufacturing Brazil (USD Bn Nominal)



Source: Prices from Telespazio, Antrix. GRES, Astrium Geo Services; Brazil data from Associação das Indústrias Aeroespaciais do Brasil

A future of low-cost space, commoditization and service expansion will threaten Norwegian firms

A large number of emerging markets are developing space capabilities. Mostly on the Asian continent, but also in Latin-America. Other more mature markets with expanding capabilities include Israel , Japan and South-Korea.

Commercial capabilities
are still somewhat limited. Those relate primarily to operation of SatCom services for domestic or regional markets; The launcher industries of Russia and China have significant market shares and especially China has begun to make inroads into the more profitable segment of launching commercial communications satellites directly in competition with a.o Arianespace; Within the broader Earth observation segment, also in India especially the image segment is semi-commercialized and they have gained shares in the global image sales markets. The satellites are government backed here as everywhere else, but data sales are commercialized.

There are two trends characterizing these developments:

The Asian Space race
is a heated competition mainly between China, India and Japan but also impacting South-Korea, Malaysia, Indonesia, Thailand, Vietnam and Taiwan. There is very little cooperation between these nations and no pooling of resources or sharing of technologies in the manner seen in ESA. A regional organization do exist, but the countries mainly pursue national agendas and there are concerns of increased militarization and arms race. This resonates with a broader geopolitical backdrop.

Latin-American partnerships
characterizes the Latin -American developments. Although less evolved capabilities, the countries priorities are less driven by security issues. Remote sensing and communication needs drive the developments. Brazil in particular is active in developing collaboration with others and there are industrial contract sharing deals associated with this.
There are also increasing linkages between Asia/Russia and Latin-America.

Source: Moltz Nature journal 480 Dec 2011; PwC Analysis

Opportunity or threat?

Implications are twofold:

Growth opportunities
may exist. This could be linked to a few manufacturers who maintain global specialized competencies in some segments of i.e. satellite components and ground equipment. This is however also the area which is likely threatened longer term.

Communication services, optical image and radar data will become more affordable, systems will have better capabilities and **demand will grow** as a result of declining hardware prices globally. Derived demand, i.e.. for value added services will grow.

There are certain strengths among Norwegian providers in these segments which may expand on the back of this - particularly within communication and image/radar value added services. Demand for earth observation download services will grow and the locational advantages at Svalbard does provide a competitive edge.

Threats prevail
particularly for hardware manufacturers. The institutional markets in Europe will remain protected from these developments backed by political considerations. The global commercial segments may not.

As more producers in a range of countries gain capabilities, flight heritage and space qualifications, there will be more competition and lower prices in the global markets.

Those producers who are closely linked to anchor tenants in Norwegian or regional markets, i.e. offshore or maritime may maintain advantages. Others will have a harder time.

Peer country developments

Peer country review

The purpose of this segment is to highlight developments in three countries. The three countries are selected in collaboration with MoTI. They represent in different ways relevant cases for Norwegian policy.

Canada: Has a shared interest in the arctic region. As we shall see its policies and programs are also oriented towards this. Its public service development programs in particular are similar to those of Norway. Canada has a highly focused and selective space program. The industry structure in Canada is quite similar to that of Norway. It is larger in absolute terms but about the same in GDP terms. Industry has seen real growth mostly driven by services segments as in Norway. Canada has recently launched a far reaching policy review process. A rationale for the process is to address emerging challenges and competition.

Sweden: Has a tradition of large scientific programs including launches of own satellites. This seems to be changing. Government is scaling down the national satellite developments and focusing on ESA participation. There is much commitment to the Ariane-5 launcher programs due to strong deliveries by Volvo Aero and Ruag Saab. Its national programs are at about the same size as Norway but the approaches differ. They are more programmatic and closer tied to research. The Swedish space agency also manages the science funding for space. The industry turnover is smaller than in Norway constituting about 0,06 percent of GDP. There has been limited growth but possibly a decline if adjusted for inflation. There has been calls for a comprehensive space policy but no process launched so far.

Switzerland: Has traditionally channeled most of its space program support through ESA. Upon a strategic review, whereby it was found that the context is changing, Switzerland now has a stated policy that includes an expansion of the venues and instruments.

We will review the three countries in turn focusing on issues of interest for Norway and apparent differences in approaches.

Source: PwC analysis

Canadian industry has structural similarities with Norwegian industry

Context
Beyond the obvious differences in context there are also some relevant similarities.

- Canada has a particular interest in arctic territories. It has large territories for which satellite surveillance and communications are important. It also has strategic interests in arctic developments due to natural resources deposits and control of the North West passage.
- The industry is mostly service oriented and has a comparable structure to that of Norway.
- It is also seen as a specialist and component producer for U.S. based prime manufacturers.

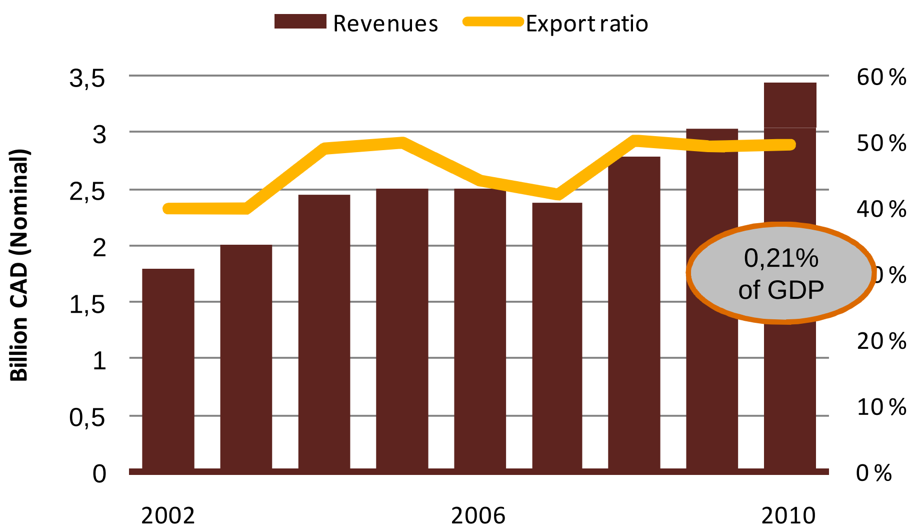
Canadian dollar has appreciates much against the USD and EUR. More than the NOK over the last decade.

Industry has shown real growth over the last five years. This is reported to be almost exclusively (97 percent) driven by growing telecommunications services. There is a domestic market constituting about 50 percent of revenue. Exports have been growing faster than domestic sales over the decade and stabilized at about 50 percent over the last few years.

Important industry events over the last years include the Cabinet blocking the sale of Vancouver-based MacDonald, Dettwiler and Associates (MDA) to U.S. firm Alliant. This type of government involvement in markets is unusual in Canada also in the space segment. Some analysts see this a break with history and a signal of more national ambitions on behalf of the current government. Of note is that MDA was owned by U.S. Orbital Science Corporation during 1995-2000. During which time it also acquired Canadian company Radarsat from Spar Aerospace. The Canadian government raised no concern at that time.

Real growth in revenues mostly from telecom, and overall size comparable to Norway's GDP ratio

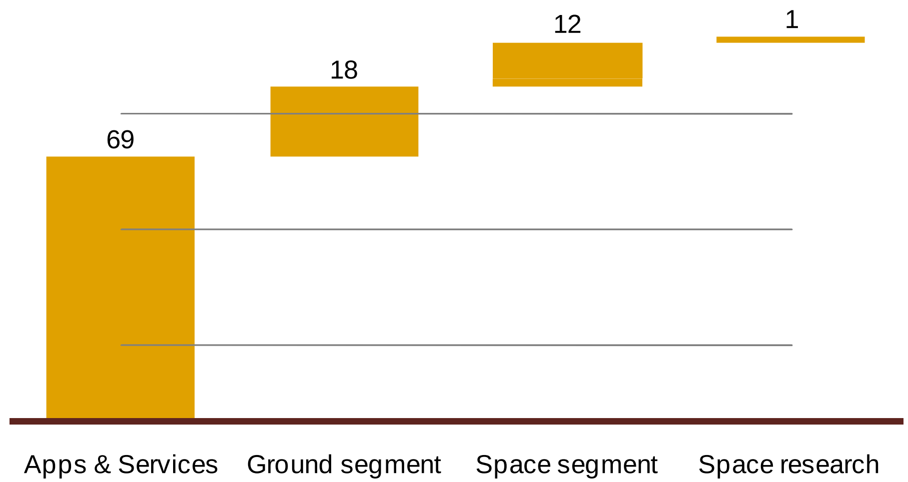
Figure 1.68: Revenues and export ratio Canadian space sector (2010)



Source:CSA industry statistics; MoTI Canada Departmental performance Report 2011; IMF Art IV 2012; PwC Analysis

Service oriented industry structure and fastest growth in the service segment

Figure 1.69: Space industry turnover Canada by segment (Percent, 2010)



Focused and selective Canadian space program

Space programs
Its space policy and programs are characterized by a highly selective and programmatic approach. Its focused on three areas: Earth observation, space exploration and Satcom. Each program is composed of a research component, mission developments and operations components. There is also a generic technology program in support of these three. An emerging, but currently much smaller program is for space awareness and learning.

Its budget for 2011 is at 322 million CAD, apprx 1,8 billion NOK. This is about 10 percent of industry revenue, also comparable to Norway.

Its participation in ESA is linked to these programs. Its ESA contribution is about a third of Norway's.

The space strategy was approved by government in 2005 after much deliberation and consultation across industry and with other interests.

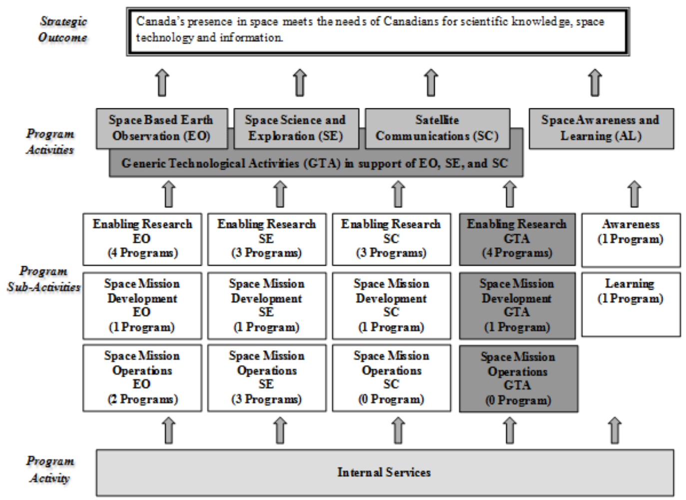
Its earth observation program has similarities and interfaces with Norway's. There is a mission development program focusing on Radarsat. Radarsat-2 is owned an operated by MDA but the Canadian government financed about 75 percent in return for data. Currently, most expenditure here is for development of the planned radar constellation mission (RCM). MDA is prime contractor for this. We will return and discuss this separately as there is much interest for Norway.

Its EO program is also highly focused on service and application development and has similar approaches tot hat of the service development program in Norway.

There is some uncertainty about the future financing at the moment, but reports indicate that the EO program is seeing an 30 percent increase driven by the RCM development.

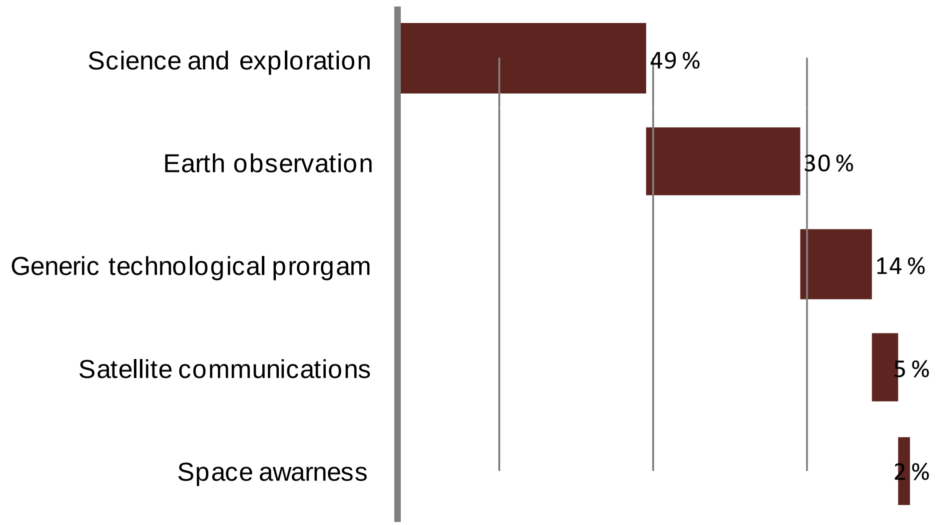
Highly programmatic approach and much selectivity

Figure 1.70: Illustration of Canada space program priorities (2011)



Most public support for exploration and earth observation

Figure 1.71: Public development programs Canada by segment (Percent, 2010)



Source:CSA industry statistics; MoTI Canada Departmental performance Report 2011; IMF Art IV 2012; PwC.

The Canadians find Radarsat a technical success, but concerns about competition, commercialization strategy and level of government risk

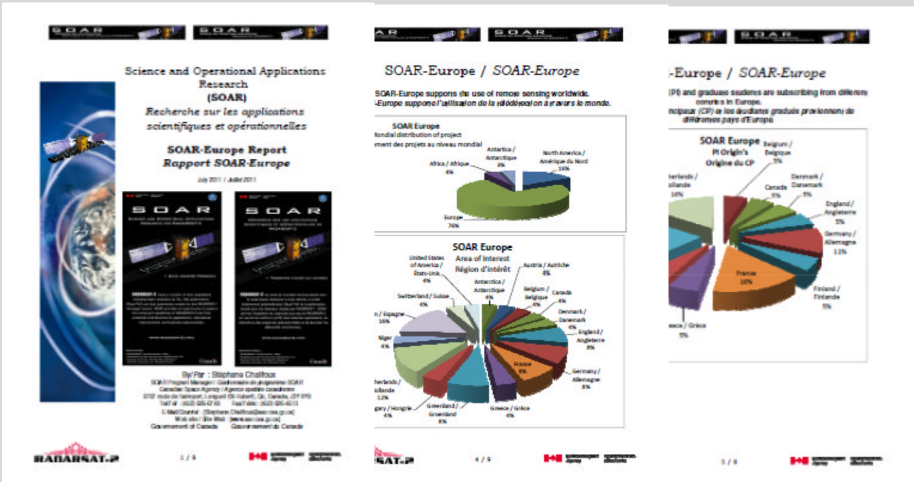
The Canadian government had originally proposed to develop the satellite as an ESA program but failed to get approval within ESA. Norway supported this as an ESA project at the time and continued discussions with Canada and eventually entered into an agreement with RSI/MDA.

The Canadian government decided to launch the program and entered into a partner ship with MDA for its development. The Canadian government financed about 450 million CAD of development cost with MDA providing about 150 million CAD. Government got access to all data and MDA would get the upside from commercial data sales. MDA owns and operates the satellite.

The Canadians also launched an associated research and development program open to international participants, to develop applications and support science.

Canadian research program with 192 projects launched but no Norwegian principal investigators

Figure 1.72: Illustration of SOAR program participants and focus



Source: * Evaluation of Major Crown project Government Consulting Service Canada 2009 **MDA 3rd quarter financial report 2011; Investor conference call reported in financial press; MDA press release Sept 23, 2011:

Canadian experience is reported to have been mixed.*

The success relates to technical performance. The technologies were seen as advanced and competitive against other recent developments.

Concerns have been raised about the delays which resulted in a competitive disadvantage as other competing commercial systems were launched first.

Concerns were also raised about the financial arrangements in which government assumed much of the risk and had little upside. MDA on the other hand assumed all commercial risk but had a lower investment at stake. The new radar sat project in Canada is planned with full government ownership.

An objective of the program was also to help develop the Earth Observation sector, much like the commercial satellite communications sector had been developed. The sector did not expand as foreseen and MDA reduced the market potential estimate by 80 percent. The program may still have been profitable for MDA and contributed to enhanced capacity. Current investor relations reporting from MDA reveals an expanding geospatial satellite business line, mostly driven by sales to U.S. Intelligence services. MDA recently won a contract of sales of Radarsat-2 data to U.S. intelligence. **

Utilization at government agencies was slow to pick up and an estimated 65 percent of allotted capacity was used in 2009. Readiness assessments had been developed and barriers to developments identified. Many were dealt with, mostly through information campaigns and development of applications. Costs of data processing was (is) covered centrally over the Canadian Space Agency budget.

The most important international element reported was the failure to secure a launch agreement with NASA. The satellite was launched at a commercial service. The Americans noted that the program was too commercial and a competitive threat to U.S. industry.

The agreement with **Norway** was the only bilateral agreement. Others have been organized as commercial contracts later. An early agreement with Orbimage about international data distribution was absolved as MDA acquired the company.

Ongoing policy reorientation to address emerging challenges

GoC has launched an extensive policy process recently. A high level commission has been appointed to review the aerospace and space strategies. Canada's aerospace sector is estimated to be the world's fifth largest. The review is to focus on the following:

• What are the comparative advantages and vulnerabilities of Canada's aerospace sector?
• What opportunities and challenges do changing conditions present?
• What can the Canadian aerospace sector do to take advantage of these opportunities and meet these challenges?
• What might Canada learn from strategies used by governments, companies, and researchers in other countries?
• What impacts are existing policies and programs having?
• What modified or alternative policies and programs might government consider?

A discussion paper has been issued. Of significance for the space sector it highlights the success of the telecoms sector, but points to challenges and competetitive threats in the other segments.

New radar satellite development scheduled for launch in 2016

Figure 1.73: Important issues with RCM development

The new radar satellite program (Radar Constellation Mission RCM) is organized as a government program entirely. GoC will own and operate the satellites. MDA won the tender as prime contractor.* There has been amendments to the contract since then. It is a designed as constellation of three satellites in polar orbit. There are discussions reported in the press about extending the program to global coverage. Canadians see German and Israeli developments as the important competitors.

Of interest for Norway is the decision to carry AIS receivers on board the satellite thereby reducing the correlation problem of having different AIS and radar satellites. An RFP for feasibility studies of AIS and radar integration was solicited in July 2011.** Spanish Hisdesat is expected to launch its radar satellites with AIS capabilities in 2012.

Also of interest is that the design concept plans development of a new ground segment structure in Canada, and use "foreign" facilities at Svalbard as backup.*** Government has developed an international engagement strategy to "Clarify fundamental questions concerning the extra capacity management, constraints, governance and priorities ". **** Government of Canada will own the new constellation in contrast with Radarsat-2 where MDA is the owner and operator.

Source: www.aerospacereview.ca; * MDA press release 14 nov, 2008* GoC RfP Solicitation Notice W7714-115156/A ;CSA Radarsat Constellation mission Components and Specifications (read February 2012);****Flett at Nasa presentation October 2010;PwC Analysis

Swedish space program with strong industrial focus and integrated scientific program

Contextual differences
There are differences in priorities and organization of the space programs in Sweden and Norway. Important contextual differences may explain this:

- The economic structure of Sweden is different with a broader industrial base and less driven by oil & maritime sectors as in Norway. A relevant implication is the capabilities within Aerospace (Volvo Aero and Ruag (SAAB))
- The arctic interest is also different with no territorial interests beyond Northern Sweden.
- There is also a different historical path with more emphasis on science and national (science) programs including development and launching of scientific satellites.

Differences in objectives and focus
The objective of the space programs are also set differently. There is not the all encompassing objective as is defined for Norway. Rather there is a set of defined activities defined for the space agency. The space agency is mandated to allocate government resources to *science*, *space technological development*, and *remote sensing activities*. Practical implications are:

- A dedicated science program (up until 2011 ESA science program was also budgeted for within the larger science program)
- Industrial program more explicitly focused on upstream segment (although there are a number of smaller downstream firms also being supported)
- Less extension into public service development programs as seen in Norway.

There is no space policy as such in Sweden although it has recently been called for by the space agency.

Organization
There is a space agency (Rymdstyrelsen) with 14 staff in 2010 compared to about 30 in the Norwegian counterpart. The agency is organized under the auspices of the Ministry of Education.

In terms of financing however, 75 percent stems from the Ministry of Trade and Industry. MoE finances the science programs, including contributions to ESA science programs. The latter is a function of ESA mandatory financial contribution.

Of relevance is also the Swedish Space Corporation (SSC). This is a fully owned state corporation. Ownership is managed under the Ministry of Finance as other state owned enterprises. It has a 10 percent profit target by government. It has currently four business lines. The two largest are : (i) Satellite management services is comparable to KSAT and constitutes about 30 percent of revenue.; and (ii) Science Services is about Esrange and comparable to Andøya Rocket Range. This constitutes about 15 percent of revenue. It also operates Aerospace services (testing at Esrange) and Aerospace systems (surveillance systems including for oil spill detection and fisheries management). It has large holding in various technology and services companies contributing about 35 percent of revenue.

SSC sold its space division in 2011 to German OHB. One of Europe's top three satellite manufacturers. The space division had mostly sales to ESA but was also the main instrument for the earlier national satellite development programs. The annual report states loss of competitiveness against integrated manufacturers in Europe. Press reports also claims this was related to policy choice of limited willingness to continue to support national satellite projects, and focusing most industrial resources on the Ariane-5 development where both Volvo Aero and Ruag Saab has much interest.

Source: SFS 2007:1115; Annual report and budget proposals 2010-2011 Rymdstyrelsen; Technopolic 2010; PwC Analysis

Swedish ESA participation focused on Ariane

ESA and national programs
ESA contributions constitute 75 percent of total in 2011. This is up from about 65 percent in earlier years. The space programs also include a dedicated science component which in Norway is budgeted for elsewhere. The science program is in total about 11 percent and this includes money for Esrange (EASP program as in Norway). The national program vs ESA ratio is closer to 17 percent similar to what has been seen in Norway in recent years. (adjusting for differences in accounting for the science programs)

Its **ESA** optional contributions are more concentrated than for Norway. 35 percent are for telecoms (about 25 percent in Norway 2010) and 30 percent for Ariane. The latter was decided at cabinet level reflecting a decision to support Volvo Aero and Ruag Saab. There is also an 18 percent share for earth observation at about similar levels as for Norway.

Its **national programs** have different focus and organization than in Norway. The approach is programmatic. Fewer participants, larger contracts. High degree of transparency in terms of areas of focus and awards. Sweden has also developed a industry-research program with a longer term R&D approach.

There is also a smaller earth observation program. This has not the same operational focus as the public service development program in Norway although there is some overlap.

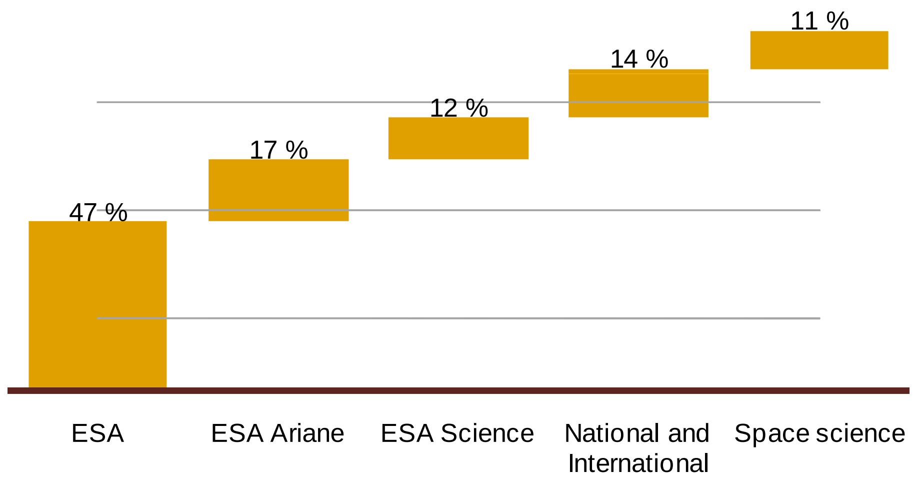
There is an important difference with regards to organization of scientific support. This is coordinated in full by the space agency and includes national programs (100 mill) and ESA scientific (110 mill). All amounts in SEK.

Industry has seen real decline from 2004 as in Norway. There is an increase in 2009. To the extent that the data are comparable, overall turnover is about a third of that in Norway.

Industry turnover represent 0,06 percent of GDP in 2009 compared to about 0,2+ percent in Norway and Canada.

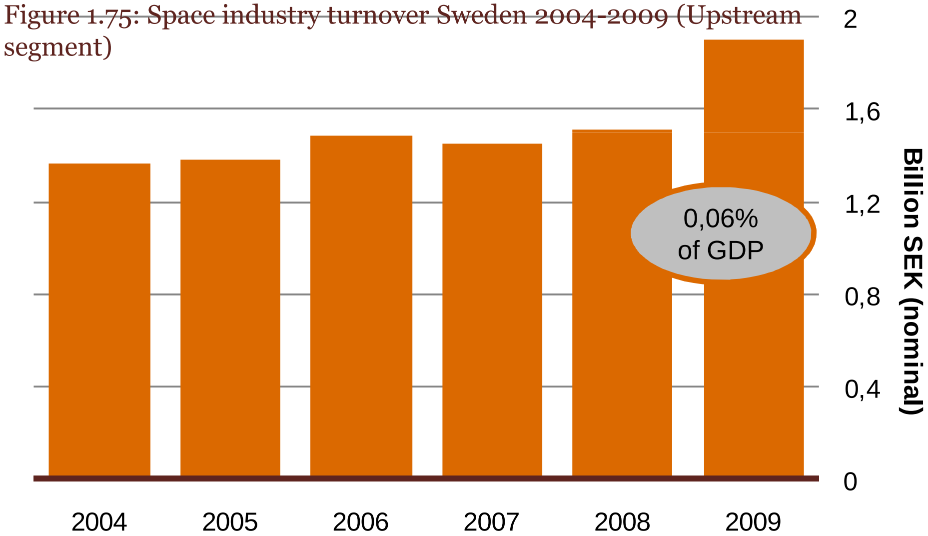
75 percent for ESA and dedicated science program

Figure 1.74: Distribution of expenditure Swedish Space Program (2011)



Turnover shows little growth, but jump in 2009

Figure 1.75: Space industry turnover Sweden 2004-2009 (Upstream segment)



Source: SFS 2007:1115; Annual report and budget proposals 2010-2011 Rymdstyrelsen; Technopolic 2010; PwC Analysis

Switzerland: High cost, high sophistication but no national program

Context
Switzerland is particularly relevant as is a non-EU state but is an ESA member state.

Swiss exporters are also faced with a difficult macro environment as the Swiss Franc is one of the world's most highly valued currencies and has appreciated much against both the Euro and the dollar. Much more than NOK.(see slide 52). On other parameters, Switzerland is quite different from Norway.

- Its industry is mostly about manufacturing of space related components. There are few service providers like seen in Canada and Norway. As much as 118 companies have been involved with ESA during 2000-2002. About threefold of in Norway.
- There is only a very limited national program. 97 percent of public resources are for ESA.

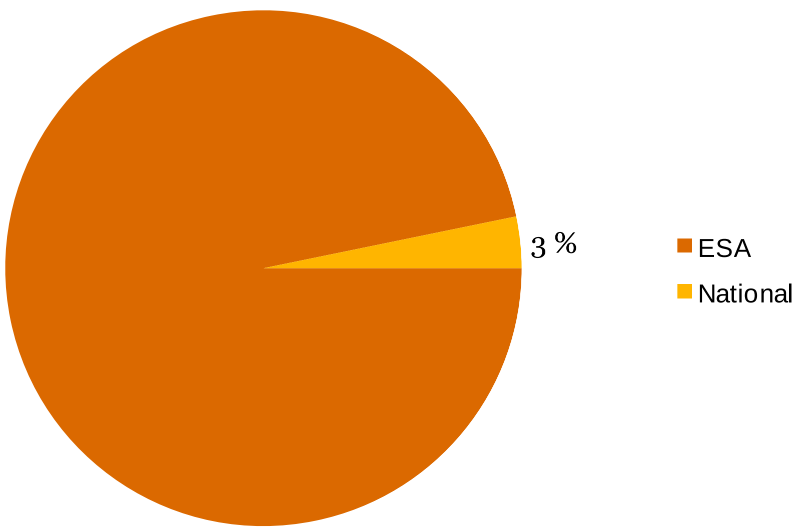
While industry is mostly manufacturing, it is noted that an SME segment of service and application based companies are seeing a considerable upswing. Statistics are not available.

Perceived challenges led to policy revision
Switzerland commenced upon a review of its space policies in 2006 in light of perceived challenges. The policy was delivered in fall of 2008. The policy was framed in the following context:

- The space sector is experiencing a transformation process
- Emerging countries entering the scene
- Declining U.S. budget and flat European budgets
- EU entering the scene with challenges for competition policy
- Increasing national programs
- Industry consolidation and emerging new smaller fast moving players

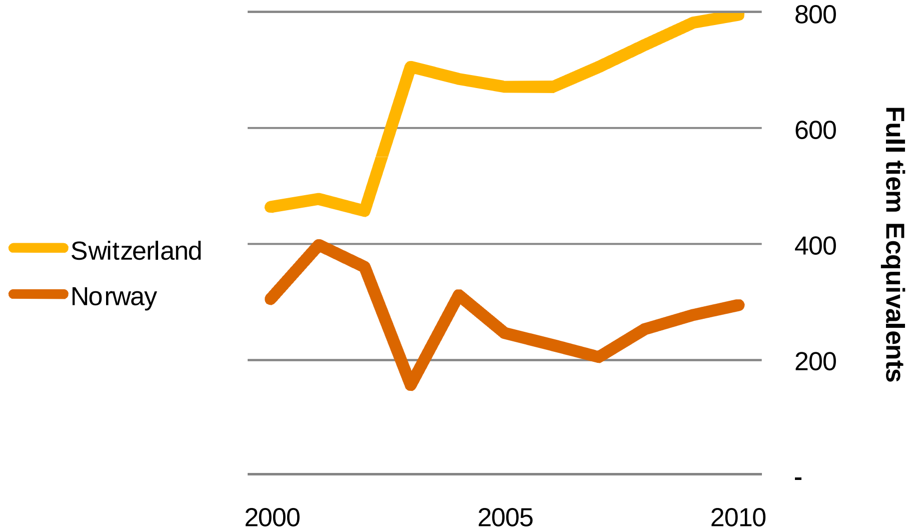
3 percent for national programs

Figure 1.76: Expenditures planned 2011 (2011)



Robust manufacturing sector showing growth in employment

Figure 1.77: Space manufacturing employment Norway and Switzerland



Source: Evaluation of Switzerland activities in space 2011; Eurospace manufacturing data 2011; Revision der schweizerischen Weltraumpolitik 2008; PwC Analysis

Switzerland: Policy revision to address EU and ESA challenges

Important elements of Swiss strategy

- The strategy needs to be changed systematically. Ensure Swiss access to and participation in EU components of the EU/ESA programs, and define an appropriate legal and financially secure framework or engagement with the EU.

- Given the declining relative importance of Switzerland within ESA and non-membership in the EU, alternative means are required. Activities can be bilateral as well as multilateral forms of cooperation.

Specific proposals include:

Consolidation of existing tools:
- Commitment to development of ESA
- Targeted participation in ESA using existing instruments
- Participate in relevant international organization (EUMETSAT, EUTELSAT, IMSO and ITSO)
- Foster international cooperation for peaceful purposes as part of UNCOPUOS.
- Support international organizations use of information gathered from space and in communications

New needs:
- Examine opening bilateral and multilateral cooperation within and outside of Europe
- Defend Swiss interest in terms of access and sub-participation in the preparatory and operational phases of EU programs
- Ensure systematic identification and coordination of user needs

Source: Revision der schweizerischen Weltraumpolitik 2008; PwC Analysis

Section 1.3

Implementation of the space programs in Norway

The **objective** of this analysis is to review how the programs have been implemented. What has been the activities? Where has the monies been spent and to what effect?

We focus on three areas:

I. **ESA Activities**. How has Norway engaged with ESA? What has been the priorities? What are the developments over time? What segments of the value chain are engaged? We also review relationships between ESA contracts and Space Center support funds.

II. **National programs.** These have had complementary and supporting functions to the ESA engagements. We review the support for industry, and the programs to enhance public utilization of space capabilities. This includes a review of the Radarsat program.

III. **Governance**. We review the relationships between the Ministry and the Space Center and how the programs are managed. How is the strategy devised, planned and executed? How effectively is it monitored? What risks may exists?

Real growth in public expenditure and most of it for Space Center managed programs

First, a birds eye perspective on total public sector spending on space related matters. Most of the financing is related to the activities managed by the space center which constitutes nearly 60 percent of total. We shall see later that this has increased over the last five years. We also find that other spending, in particular on R&D is quite significant and at 30 percent of total. There are several sources for this, including basic financing for Universities, Research Councils, and EU FP7 . Of other institutional financing it is mostly the Met institute and Mapping authority that matters.

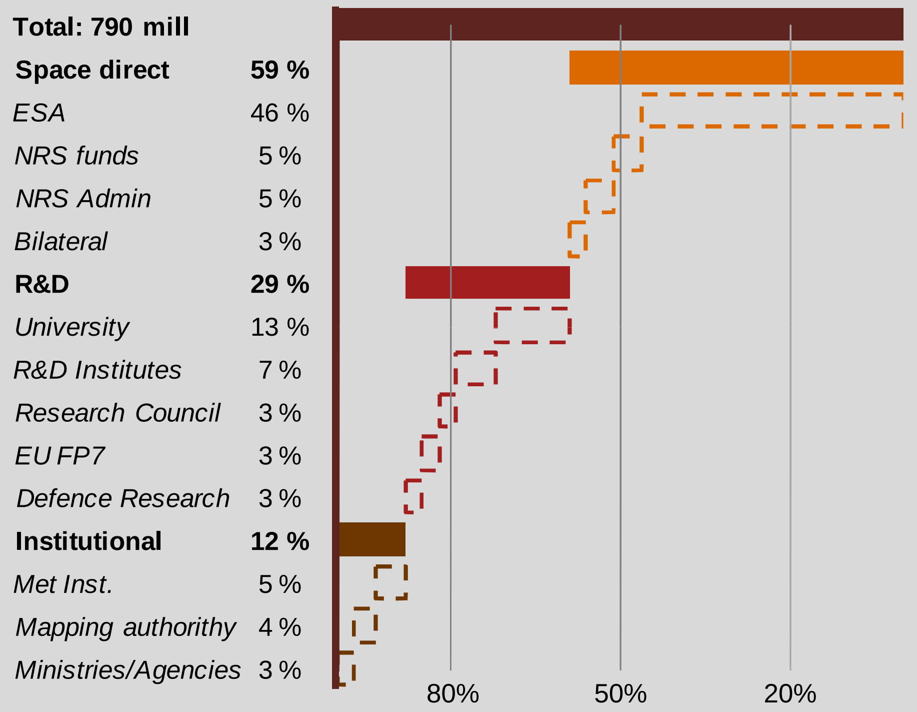
There has been real growth, above inflation, in public expenditure over the last five years. Much of this growth is seen within the Space Center managed programs.

Next we turn to the ESA activities.

Following this we will review the important national programs.

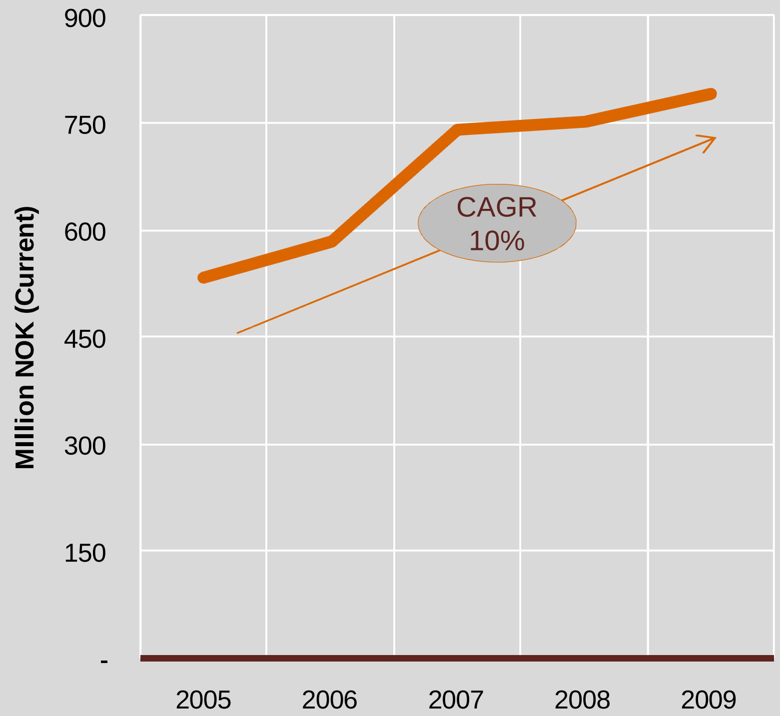
Sixty percent of public funds for Space Center Managed programs

Figure 1.80: Distribution of public expenditure 2009



Real top line growth in public budgets

Figure 1.81: Growth of public expenditure 2005-2009 (nominal)



Source: NRS LTP 2006-2010; Numbers for ESA differ from those used elsewhere in this analysis as these e numbers are appropriations and not the contract volume which firms receive. Excludes Defense sector.

Norway participates in other space related international fora and agencies

The focus of this study is on the ESA engagement, related activities and on public sector users needs. There are however a number of related international agencies and fora in which Norway participates. We present here a short overview of three important agencies. There are intersections between these and ESA, in particular for EUMETSAT.

EUMETSAT
European Organization for the Exploitation of Meteorological Satellites

The main purpose of EUMETSAT is to deliver weather and climate-related satellite data, images and products. This information is supplied to the National Meteorological agencies of the member states, as well as other users including commercial users world-wide. EUMETSAT is constituted as an international organization and was founded in 1986. Norway was a founding member.

Satellite earth observation has transformed meteorology. Satellites are now the most important information source upon which forecast models are built.

EUMETSAT has similar membership construction to ESA. Contributions are determined on a GDP basis.

There is a very close operational relationship with ESA. The principle is that development work, including delivery of the first satellite in a series, is done by ESA.

As such there is much involvement with ESA also for the met institute in Norway. The space center supports this. The met institute participates in various development programs of new satellites to influence developments and learn.

COSPAS-SARSAT
International search and rescue signal system.

The purpose of COSPAS-SARSAT is to enable a global distress alert and location data system help search and rescue authorities locate people in distress. Participant nations implement and develop a satellite system capable of detecting signals from radio beacons anywhere on the globe.
The organization does not operate the system itself but establishes standards for interoperability and processes. Member states contribute with satellite capabilities and transfer signals to relevant Search and Rescue services. The EU Galileo satellites are expected to carry search and rescue receivers.

Founded in 1979 originally by Canada, France, the U.S. and USSR – a novel cold war cooperation at the time. Norway is a contributing state and the practical implication is that it manages a ground segment at the search- and rescue facility in Bodø.

The system contributed to the rescue of 2300 persons in 2010 and a total of 33000 persons over the lifetime of the system.

There is a commercial link as rescue beacons that comply with standards are developed by commercial manufacturers. Total population of beacons is estimated to about 1 million. A manufacturer in Norway produces a share of this.

ITU
International Telecommunications Union

ITU is constituted as a specialized U.N. agency. Members are 193 countries and 700 private sector organizations (business and civil society).

Its relevance for space activities are about two fundamental issues:

- Coordination and allocation of radio frequencies. There are regulations and processes adopted for the purpose. Frequencies is a scares good and allocation needs to be managed.
- Coordinates orbital slots for satellites. A process is established with various filing requirements.

A satellite projects success is entirely contingent upon getting access to usable radio spectrum and an orbital slot. Slots for the geostationary orbits are highly contested. These are particularly valuable and a scarce good.

Source: Organizational websites; EUMETSAT 25 years anniversary study; COSPAS-SARSAT system data December 2011; PwC analysis

ESA activities

ESA participation remains the primary instrument

Norway joined ESA in 1987 having had an associated membership some years before that. Today it remains the primary instrument to support and develop Norwegian space capabilities

The core rationale for participation is related to access to pooled capabilities and development programs beyond what Norway could accomplish on its own. The ability to get access to "cost-efficient" systems that meets demand and requirements for public agencies is emphasized in addition to access to scientific programs and instruments for researchers. Another rationale is that Norwegian industry gets access to technology development programs and qualified ESA assistance, and opportunities to deliver into ESA development programs of satellites and other systems. Large segments of the space industry value chain is captive to government programs, and in absence of ESA access, Norwegian industry would not have access to important markets.

Important decision points arise every three-to-four years in relation with the ESA ministerial conferences at which longer term priorities and budgets are agreed. Annual budget proposals are submitted to Parliament accordingly.

Important ESA mechanisms for Norway include:

I. **Mandatory programs.** These are activities for which financing is a mandatory function of membership. The fee is determined on a GDP basis. Activities supported include general budget items and operations of ESA, as well as participation in the scientific program. This also entails access to various committees, scientific development programs, and access for industry to compete for deliveries under those programs.

II. **Optional programs.** These are ESA programs (other than the scientific) decided by the member states but financial contributions are Optional.

III. **Juste Retour**. An important mechanisms whereby the volume of industrial contracts is mandated as a function of a country's financial contribution. The target is a longer-term return ratio of 1 adjusted for various overheads. The target indicator is measured at the aggregate level, but based upon individual program contracts and contributions. The ratio excludes ESA overhead costs which are assumed identical for all countries. ESA is not a member of the EU or WTO and general principles for procurement and competition does not apply. The Juste Retour system has evolved over decades with several specificities.

Next we turn to a review of Norwegian activities. In section 1.4 we will return to assess the impacts.

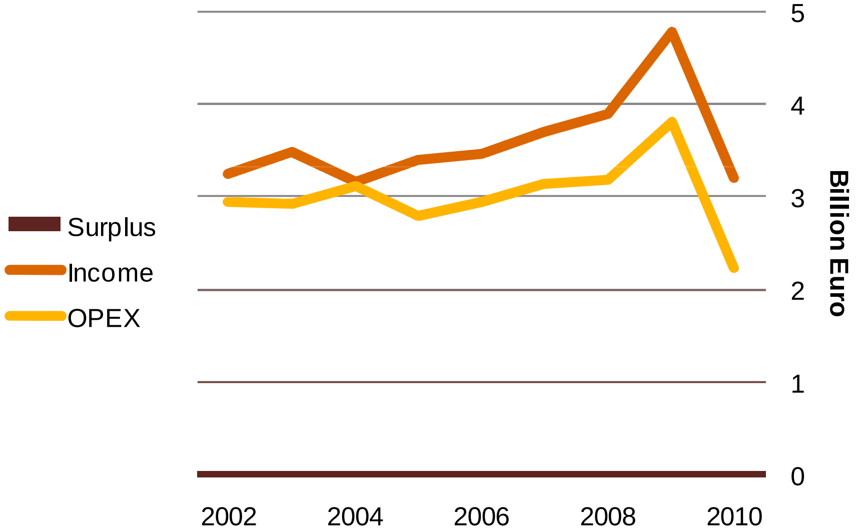
EU finances 20 percent of ESA budget

First some overall comments regarding ESA budgets.

- Expenditures have generally grown since 2002 albeit with a significant decline in 2010. Budgets for 2011 are higher but not as high as the 2009 record levels.
- Incomes are higher than expenditures as presented in the accounts. This results in a surplus that has accumulated over time and equates to one billion Euros in 2010. The “reality” and nature of the surplus is a matter of some discussion. ESA is in the midst of implementing IPSAS accounting procedures and it is possible that the new accounting systems may be better suited and offer better financial information and controls than the legacy systems.
- The European Union is now the largest single contributor to ESA at about 20 percent of the 2011 budget. The EU is not a member as such, although all member states except Norway and Switzerland are part of the union. EU financing is directed towards Optional programs and there are specific provisions in the ESA convention governing this relationship requiring i.e. consent of two-thirds of the member states.
- Further four countries contribute in total 80 percent of ESA’s budget. The remaining 15 countries contribute 20 percent. This includes Canada (non-member). There are also additional contributions, much smaller, from a group of Central and Eastern European states who are not fully members of ESA.
- Norway is expected to contribute 1,6 percent of total 2011 budget which puts it as number 11 in terms if rank of overall income by actor.

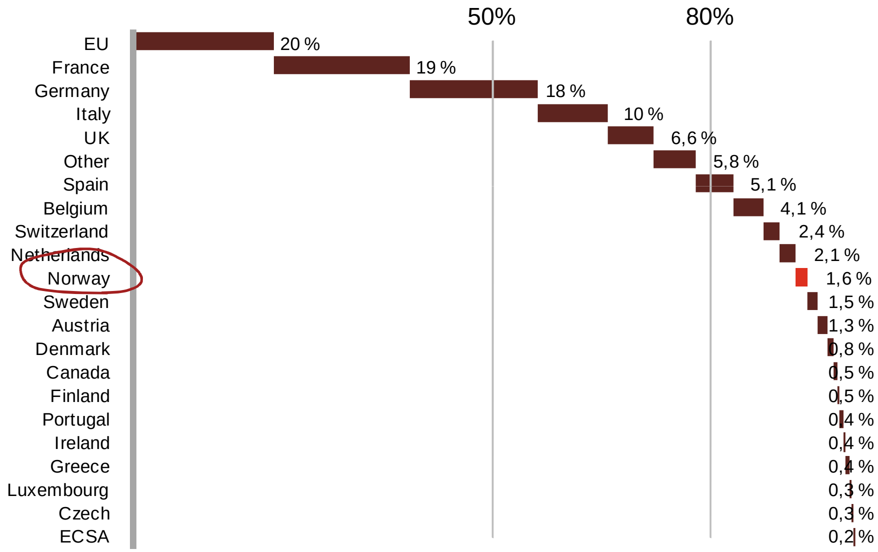
Rising ESA expenditure though some drop in 2010

Figure 1.82: ESA incomes, expenditure and surplus 2002-2010 (Actual, Euro billion nominal)



4 billion budget for 2011 of which EU is the biggest contributor

Figure 1.83: Share of ESA income by source (Budget 2011)



Source: ESA audited financial statements 2002-2010; ESA budget information 2011; PwC Analysis

Considerable increase in Norwegian contributions and gaining share in ESA

Contributions to ESA have increased at an annualized rate of 11 percent between 2002 and 2010. In nominal terms this implies more than a doubling. Financing is committed for multiyear funding periods and hence the noticeable jumps in 2007 and 2010. In addition comes contributions to special programs such as the Galileo with significant financing from 2010.

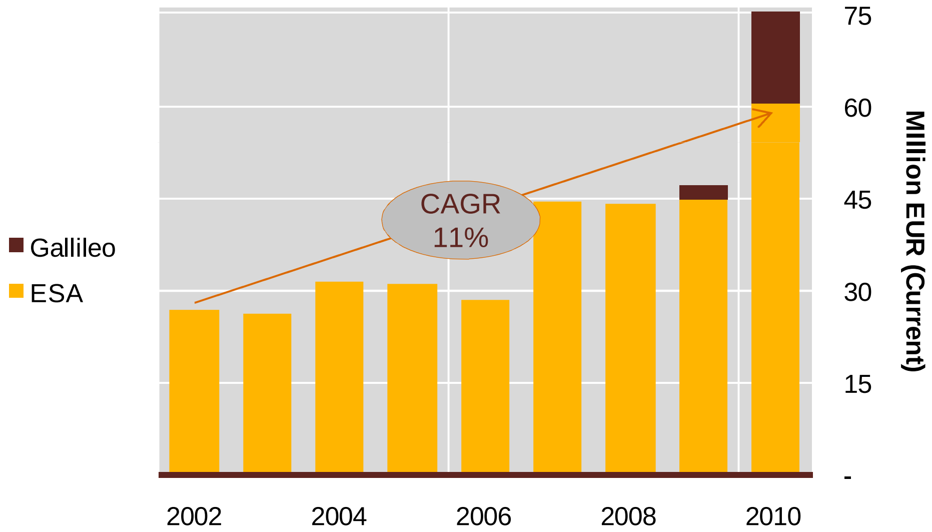
By 2009-2010 ESA financing constituted about half of the total Norwegian public expenditure for space activities. Other financing is increasing faster and the share of ESA contribution relative to other Norwegian space financing is declining.

Contributions have risen faster than for many other ESA states and the share of the total financing envelope for ESA is increasing. The contribution was equivalent to 2,8 percent of actual ESA spending in 2010, and about 1,8 percent of total income. The share has dropped a little in 2011 to an estimated 1,6 percent of total income, but this is still higher than long run averages.

The drivers for the increase are both about ESA mandatory financing rules and as a result of Norwegian policy. Contributions for the mandatory budget are rule bound and determined on a GNI basis. This has resulted in increases for a.o Norway over the last years. Other programs are optional and has no mandatory financing but Norway has chosen to increase the share of contribution to these.

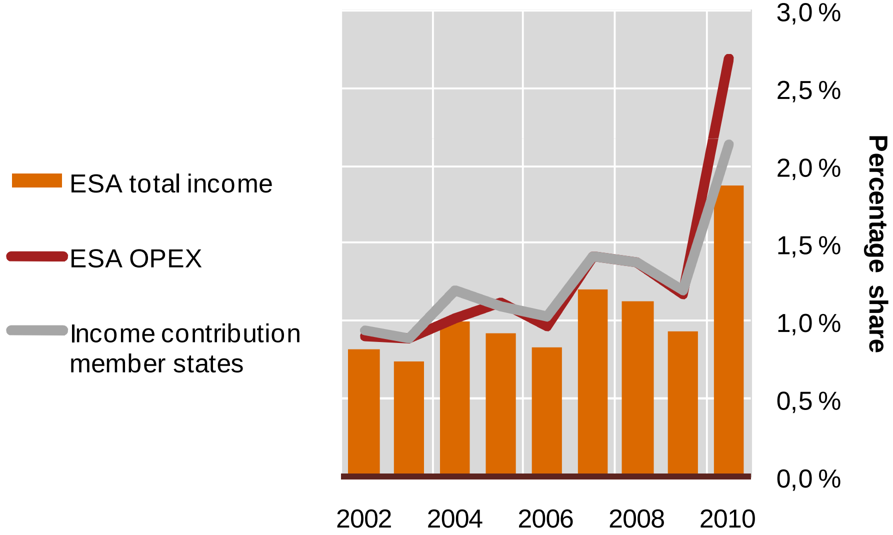
Rising ESA expenditures of 9,4 percent annually, even higher if including Galileo from 2009

Figure 1.84: ESA expenditures by Norway 2002-2010 (Euro million nominal)



Increasing share of ESA OPEX and ESA incomes, and major rise in 2010 (some decline in 2011 not shown)

Figure 1.85: Share of Norwegian contribution by ESA total income; ESA OPEX and other ESA member states contribution, excluding Galileo costs, current 2002-2010



Source: Norwegian government expenditure data; ESA audited financial statements 2002-2010; PwC Analysis

Most contributions for Optional programs, but less for these than ESA average

About two-thirds of contributions have been for Optional programs. There is possibly a trend change whereby the share is increasing and the levels of Optional financing in 2010 reached nearly three-quarters. This seems to be sustained also in 2011.

This is still lower than an estimated ESA overall ratio of about 80 percent for Optional program. (measured on the basis of actual program expenditures for the last decade).

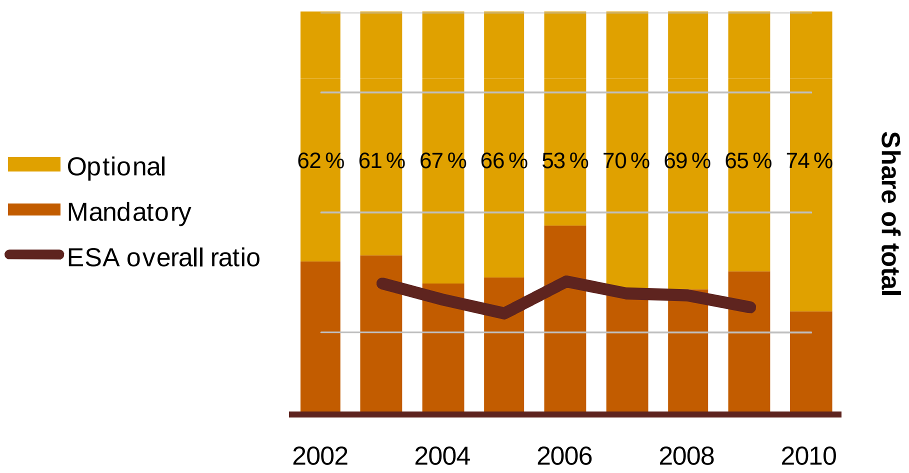
The Galileo and GMES programs currently under implementation are not part of the numbers below but could possibly be considered Optional programs although the mechanisms are slightly different given the involvement of the EU. The total financing package for these two programs is not yet in place owing to approval delays of the EU financing part.

Norway is below mid-point in terms of ratio between mandatory and Optional programs. Some nations, both small and large have considerably higher Optional program weighting. The larger space nations, i.e.. France, Germany and Italy all have much financing devoted to the Optional programs with France recording 89 percent over the last decade. The U.K has only selective involvements in the Optional programs.

Norway's share can be understood in the context of an increasing GDP driven share to the mandatory budget, but beyond this a lower degree of overall involvement than for many other countries.

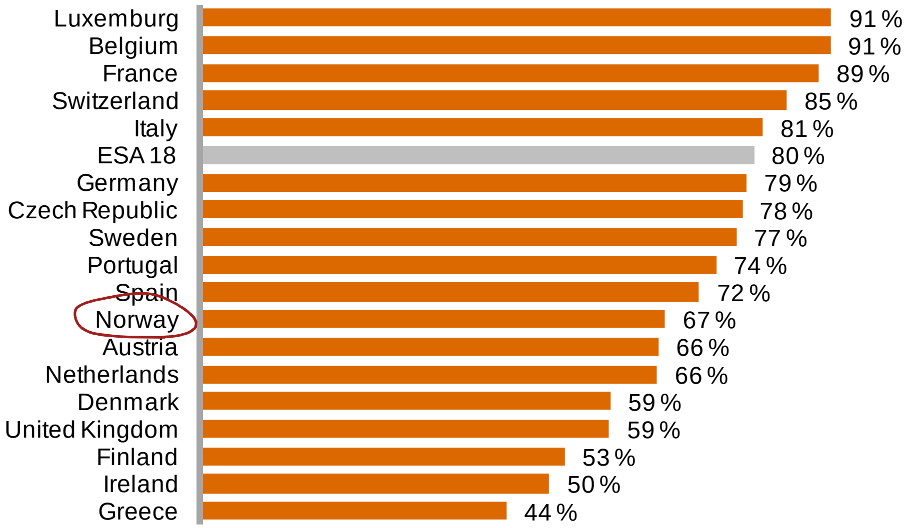
No clear trend in distribution between mandatory and optional, but optional increased significantly in 2010

Figure 1.86: Mandatory and optional program shares for Norway 2002-2010



A longer term estimate puts the Norwegian optional share at about 67 percent

Figure 1.87: Mandatory and optional program shares 2000-2011



Source: NRS proprietary data: PwC Analysis

Up-and-coming ESA player especially in optional programs

Over time we note a number of developments for Norway and other nations with regards to distribution between mandatory and optional programs. The dynamics can be understood by comparing growth rates of contributions with longer term levels.

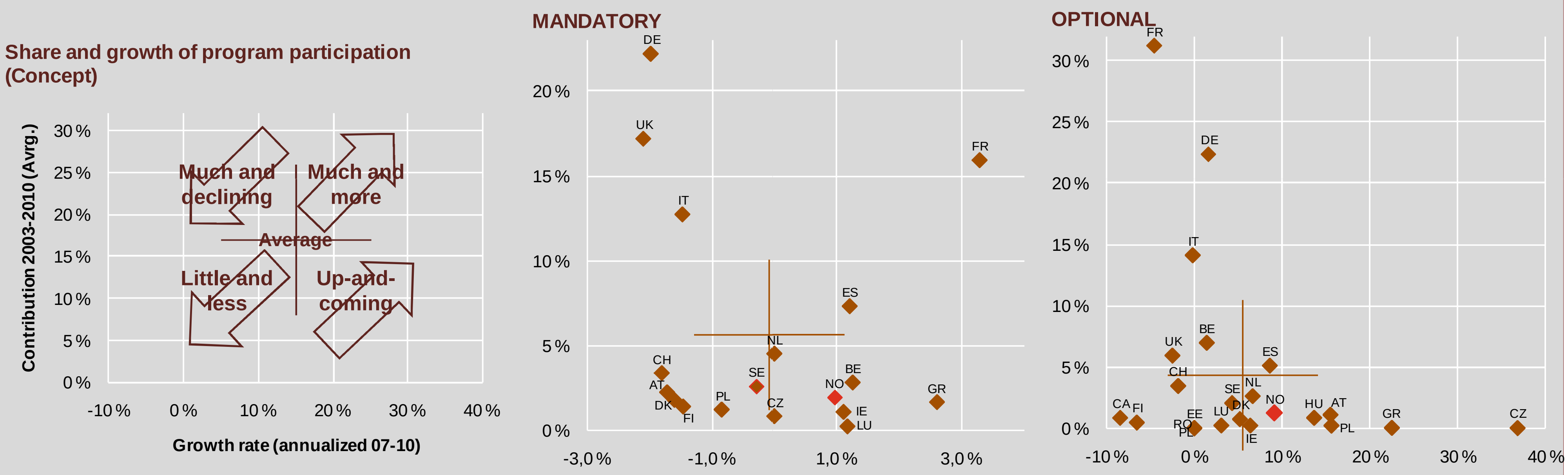
In the figure below, we have classified all countries by their share of contribution to the mandatory and optional programs respectively, and calculated the growth rates between 2007 and 2010.

The cross indicates the average of those countries, and positions above the line have higher than average contributions, and to the right of the line have higher than average growth rates.

Germany is the largest contributor to the mandatory programs though its share is declining. So is the UK and Italy. Mandatory contributions from France and Spain have been increasing. France in particular, with its large contributions lifts the average growth statistic. Among the smaller nations we also see some divergence. Austria, Finland and Switzerland have decreasing shares, and all below average to begin with. Sweden and the Netherlands are about at average growth rates. Norway is growing just a little slower than Belgium Ireland and Luxembourg.

Optional program contributions shows a similar pattern although France has been reducing its relative share. Some of the new member states record high growth rates but from very small levels. Norway records about the same growth rate as the Netherlands and Spain, and lower than Austria, Poland and Greece. Sweden has a decreasing share.

Figure 1.88: Share of contribution and growth rates in Mandatory and optional programs



Source: ESA financial statements 2003-2010; 2007-2010 growth rate is point-to-point CAGR based; PwC Analysis

Participates in most optional programs but recent shifts in priorities

Longer term, telecom has been the most favored optional program. This is actually constitutes of a number of smaller programs most of which are technology development programs whereby industry gets 50 percent financing and access to qualifies ESA assurance of their work. Earth observation sees almost as high share at about 16 percent of total financing. These priorities are inline with longer term Norwegian priorities. This program also attracts many institutional R&D organizations although we do not have data to match the programs and actors entirely. The general technology program also ranks high, while launchers, space station and navigation follows.

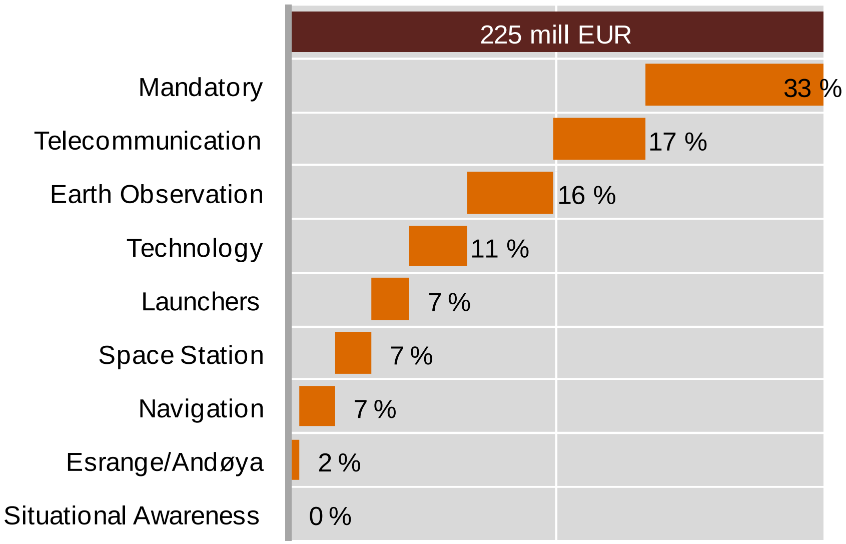
The linkages between the programs and what actors in Norway that participates are not always obvious. For launchers this is more straight forward, but the other programs sees participation from a range of actors.

Much has happened over time. A shift can be observed from 2007 whereby a significant share was allotted to the general technology program. This now encompasses about 25 percent of total. Earth observation has also increased significantly in the last few years.

Telecom has declined in significance as well as launchers. All of this takes place within a context or real growth so there is not an observed actual decline in allocations to the latter except possibly for launchers.

Most for telecom and earth observation programs

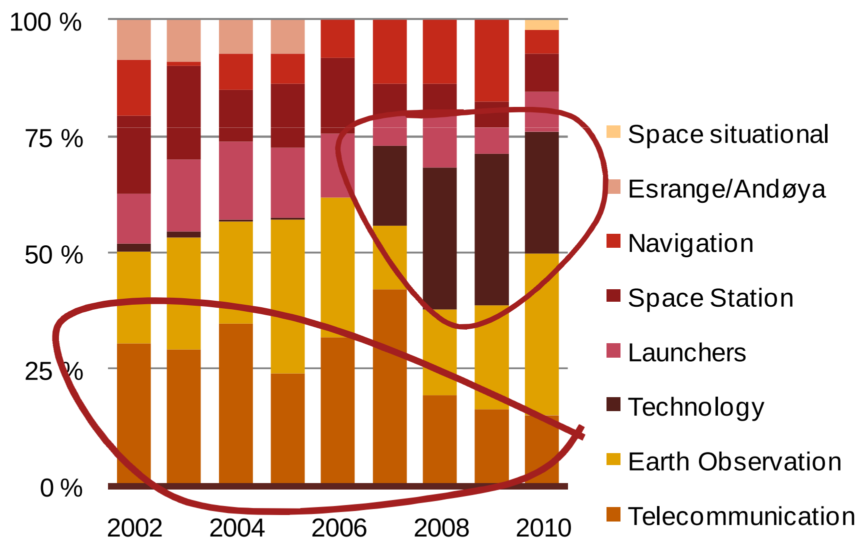
Figure 1.89: ESA contributions by program by Norway 2002-2010



Source: NRS proprietary data: PwC Analysis

Increase in technology program expenditure, falling telecom share

Figure 1.90: Share of contributions by optional program 2002-2010



Different than average ESA allocations to programs

The Norwegian expenditure pattern deviates from ESA averages. We zoom in on the last three years to capture recent developments.

Launchers captures about 17 percent of ESA expenditures but only 6 percent of Norway's. We also note that the participation in the Technology program, at about 21 percent of total, far exceeds the ESA average of the last three years. Earth observation remains important for both Norway and ESA while Space Situational Awareness sees a higher Norwegian share.

Another perspective emerges when viewing contribution as share of total to the same program. To analyze this we have data for all countries for all programs and those are accumulated for years 2000-2011. As such the technology program share is likely higher currently while Telecom may be lower.

Contributions are generally low for all program families but with a relative higher contribution to Technology, Telecom and Navigation compared to other countries.

Its not obvious whether there is any pattern or priority to the Norwegian expenditures when comparing against all countries for all program families. Overleaf is a presentation of this.

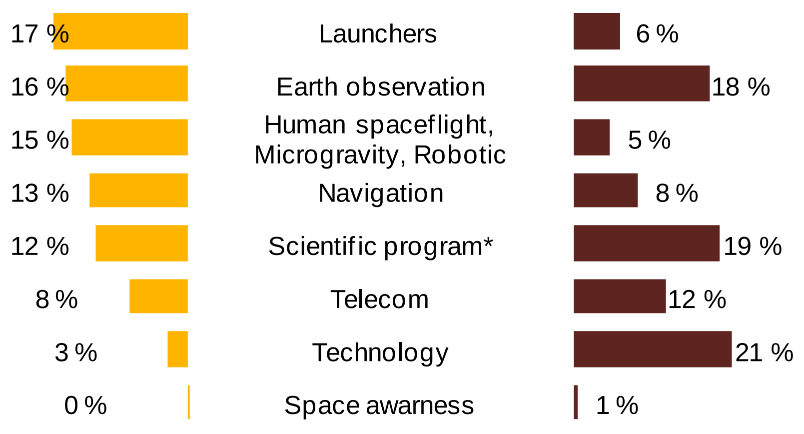
We note that France, Germany and Italy dominates the largest programs. The UK is quite selective but participates strongly in Telecoms, Earth observation and Navigation.

Of smaller nations of interest we note that Sweden appears quite selective with larger participation in some programs and insignificant contributions in others.

Norway ranks at about the same level for most programs and it is not obvious whether there is any prioritization. Norway's relative most significant participation is in the smallest (and newest) program Space Situational Awareness.

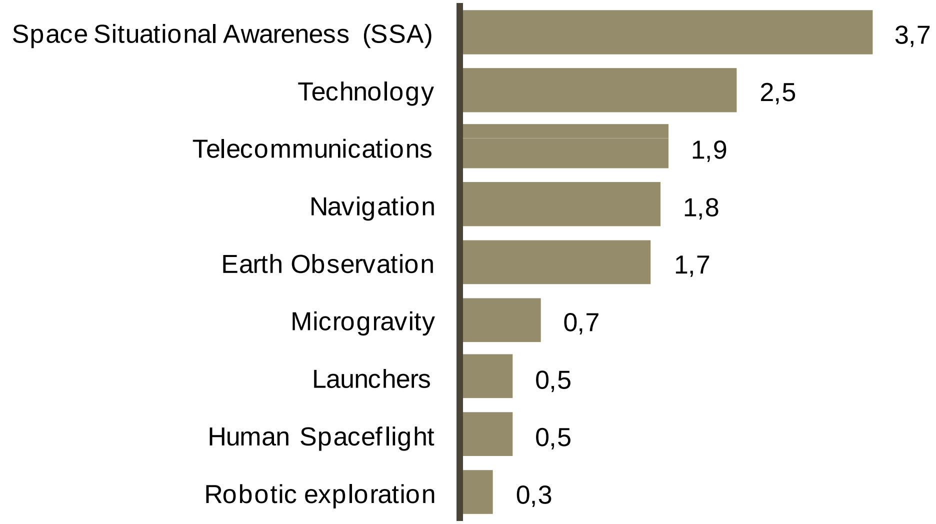
Last three years: Technology, Scientific and Earth Observation most important for Norwegian contribution

Figure 1.91: Average share of total ESA expenditures and Norway contributions 2008-2010 (ESA financial statements, Norway budgets)



Small overall shares for program families

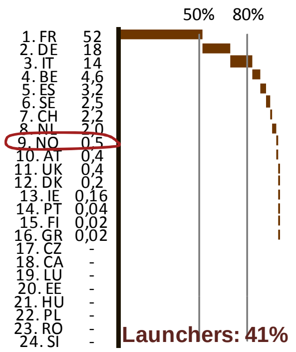
Figure 1.92: Share of contribution to program families 2000-2010



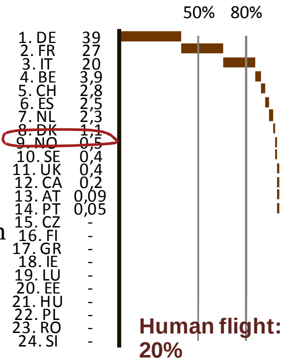
Source: * Mandatory; ESA audited financial statements, Juste Retour statistics ESA; Norwegian budget appropriations; PwC Analysis

Figure 1.93: Share of contribution to optional programs by country 2000-2011 (total share of ESA expenditures also shown)

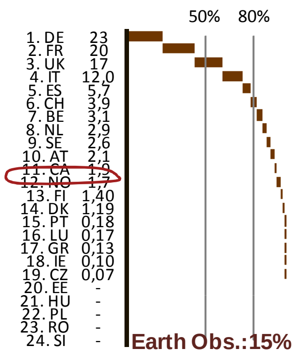
Its mostly French, the **launch** program, and with significant contributions from Germany and Italy. Norwegian contribution at 0,5 percent and rank number nine. Swedish contribution five times larger, Swiss four times larger.



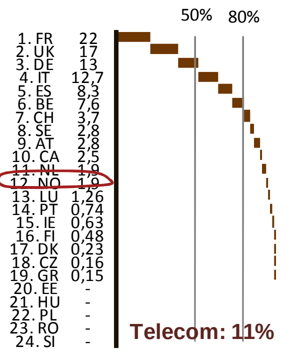
Human Spaceflight sees stronger German involvement but is also mostly for the three large nations that finances 80 percent. Norwegian contribution at 0,5 percent ranks nine, above Sweden and five times smaller than the Swiss.



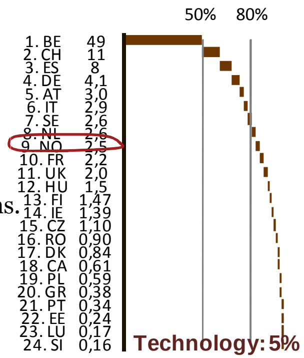
Earth observation is more popular among many. Six nations contribute 80 percent. Also one of the few UK priorities. Norwegian contribution at 1,7 percent and ranks number 12.



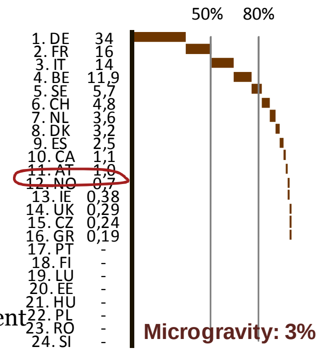
Telecom participation is more widely distributed. Important for many nations including UK. Norwegian contribution at 1,9 percent and ranks number 12. Half of the Swiss and 65 percent of Swedish contribution.



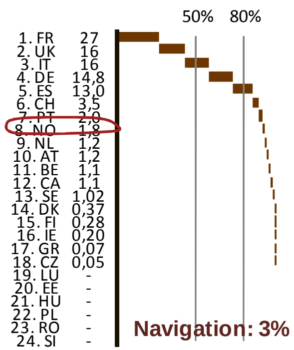
Technology program is a favorite among the small nations. Norway at 2,5 percent above France. Just below Sweden but Swiss contribution is five times larger and Belgian contribution twenty times larger.



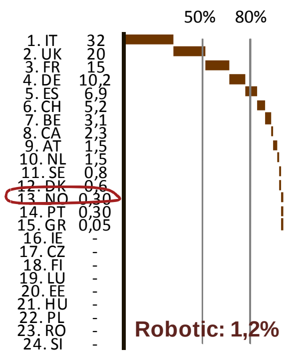
Microgravity sees the large nations upfront absent the UK. Swedish contribution at eight times the Norwegian. O.7 percent and ranks number 12.



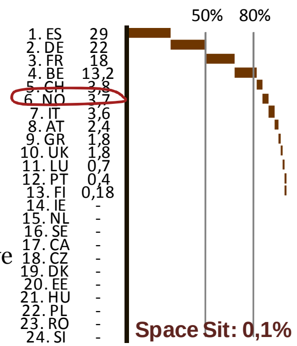
Navigation participation is dominated by the large four. Norwegian contribution at 1,8 percent and ranks number 8, much ahead of Sweden. Swiss contribution at twice the Norwegian level.



Robotic exploration is a small program but dominated by the large four. Norwegian contribution at miniscule 0,3 percent and ranks 13. Fifteen times higher contribution from Switzerland.



Space Situational Awareness appears as a relative Norwegian priority albeit small in total. 3,7 percent of total financing and ranks number 6



Allocation decision determined mostly on basis of industrial capability

The focus on program families disguises the fact that actual allocations are allotted to sub-programs about 60 each year. For some there is even more granularity, particular for the technology development programs where specific project proposals may be proposed by industry and presented to ESA by the space center.

Interviews suggest that the level of participation is mostly based upon expectations of industry and institutional R&D capacity to deliver within certain subcomponents of the programs. This is a puzzle that requires much and close interaction between the space agency and the actors.

Considerations of strategic importance of programs appears less prominent. Official documents do not divulge much about the background or objectives of the prioritizations with regards to details in such manner that it is possible to understand the determination of the size of allocations.

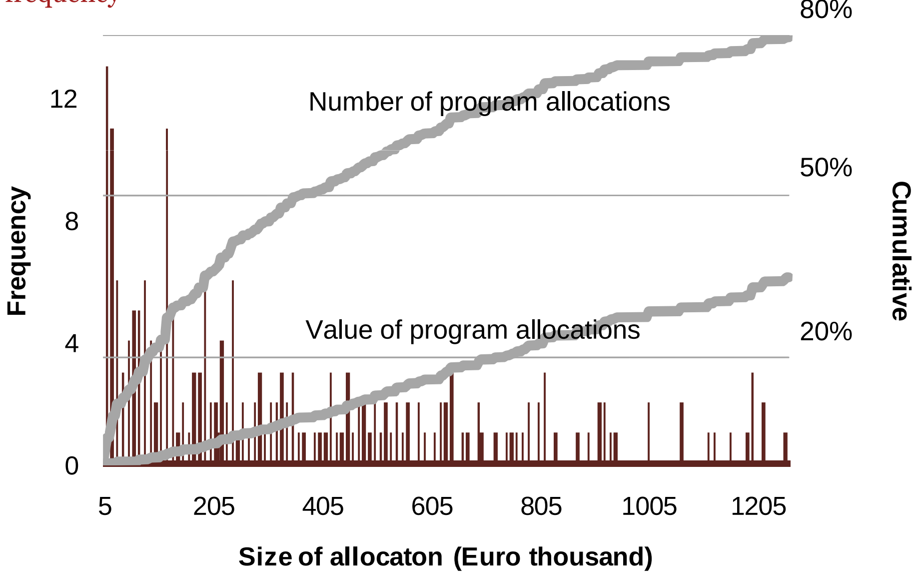
Frequency studies reveal that 80 percent of allocations are below 1,2 million Euros yet they constitute only 35 percent of value. Thus there are a few allocations, 20 percent, that comprises 65 percent of value.

We find little patterns when relating the size of each allocation to the share of contribution form all countries. The red cross signifies median values of both allocation values and contribution to the total ESA programs during 2000-2011. This is at subprogram level.

Telecom is all over the place but most individual contributions below the median allocation reflecting many small sub-programs. For some sub-programs the Norwegian contribution is significant, yet there are small monies involved (lower right quadrant). Launchers and space flight sees higher individual values yet the share of total ESA programs are below median. Technology sees higher values and higher relative importance compared to other countries. Earth observation has high allocation value but not significant shares of total program financing.

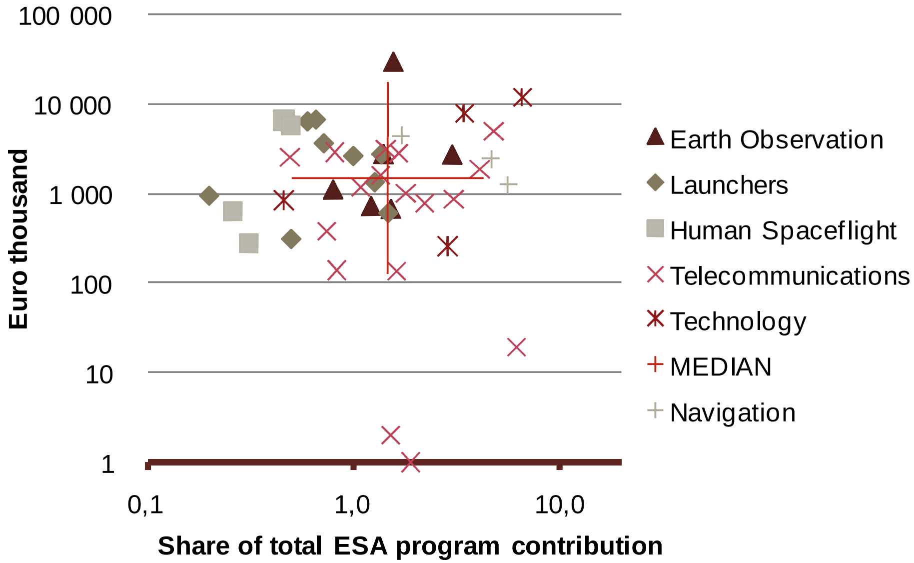
Large number of program allocations with very small values

Figure 1.94: Sub-program allocations for Norway 2002-2010 by value and frequency



No relationship between size of Norwegian contribution and its share of ESA total program cost

Figure 1.95: Allocation to optional programs (Vertical) and share of ESA total within that program (Horizontal) (2000-2011 total)



Source: NRS proprietary data: PwC Analysis

58 percent of contributions come back as contracts and the ratio is falling

Procurement under ESA is as known a tightly managed scheme whereby countries have expectations about returns of contracts for industry and other organizations. We will return to the industrial return scheme in a moment and first look at returns in a more pure financial sense.

Over the last nine years we observe that the total accumulated contributions to ESA are about twice the level of contracts returned. As such the actual return over nine years is about 58 percent.

In establishing contract values we have used four different sources that all differ to a degree but all estimate the contract levels with a reasonable range seen in the figure below. The estimates are on the basis of reporting from a subset of companies (ripple survey), detailed space center records, and ESA annual reports that details the total contract commitments and share for each country and a final series form the space centre. The contracts include development contracts under ESA , Galileo and GMES.

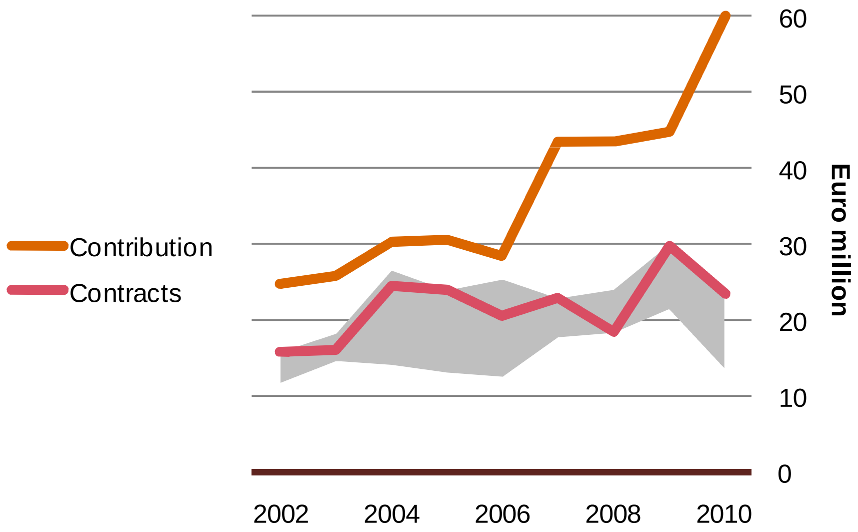
The return percentage seems to be declining. Contracts have not kept pace with the increase in Norwegian contribution to ESA and growth rates diverge.

There could be several reasons for this: One is of lag time in between contributions to budget, procurement and distribution of contracts. As such we would expect the ratio to even out in years ahead though the growth rates are diverging at an increasing rate. Another hypothesis is that of lack of absorptive capacity in industry or lack of competitiveness.

This ratio is lower than what appears when analyzing the industrial return statistics. Reasons are that this method will also take account of actual overheads and issues such as delays or the operating surplus ESA has observed in recent years.

Contract awards not keeping pace with increase in contribution

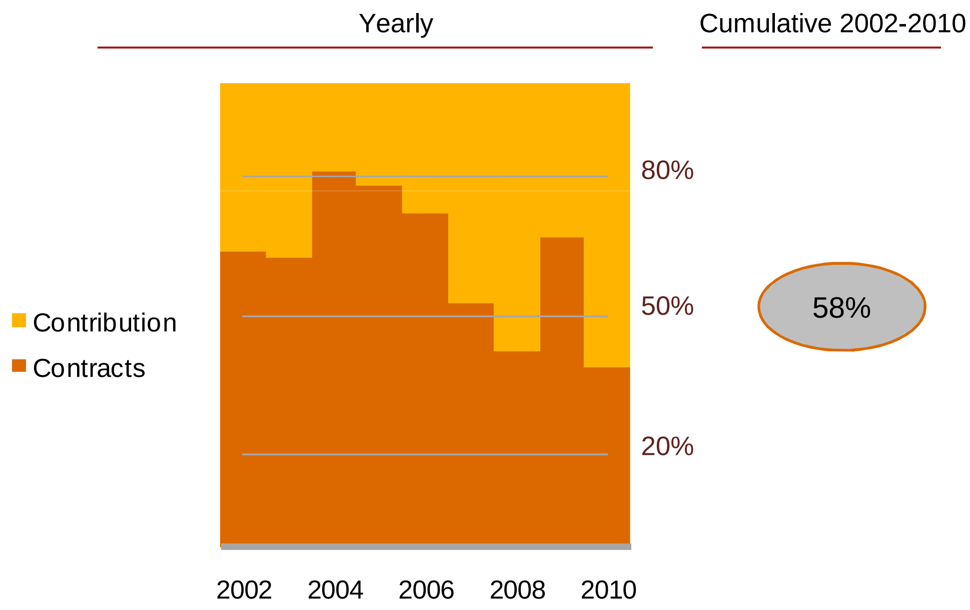
Figure 1.96: ESA contributions and contracts by Norway 2002-2010



Source: Note re contract values: We have had access to several different sources, none of which are consistent. The calculation here is on the basis of a high-case. Range is shown above. ESA annual reports 2003-2010; NRS ripple survey and proprietary data: PwC Analysis

Return ratio declines from about two-thirds to one-third

Figure 1.97: Ratio of contributions and contracts during 2002-2010



Juste retour on science programs remains under expectations

The industrial return scheme allocates contracts to companies based upon country contributions to each program. Each country can expect a return percentage close to 100% over a defined time interval (decade). Current statistics have been recalibrated from 2000 and are expected to run until 2014. These return percentages calibrates distribution of contracts among countries. They are useful for comparing returns between countries, but they do not constitute the full picture of financial flows as discussed on the previous page.

There is also an actual financial return coefficient that may be different form the official return coefficient. All contracts are not **weighted** equal in the system. This implies that when calculating the official return coefficient, some contracts are included at 100 percent of actual value while others are included with only a smaller percentage of the actual contract value. Most development contracts are weighted 1:1 but certain operational contracts, i.e. providing ground station services, are weighted at lower ratios. Thus, we find the unweighted overall financial return is close to 100% (excluding overheads) while the weighted return is about 90 percent per June-2011.

A recurring theme in Norwegian ESA involvement is poorer returns on the **mandatory science programs**. Also during this period the return is about 67 percent weighted and at ten points higher in unweighted terms.

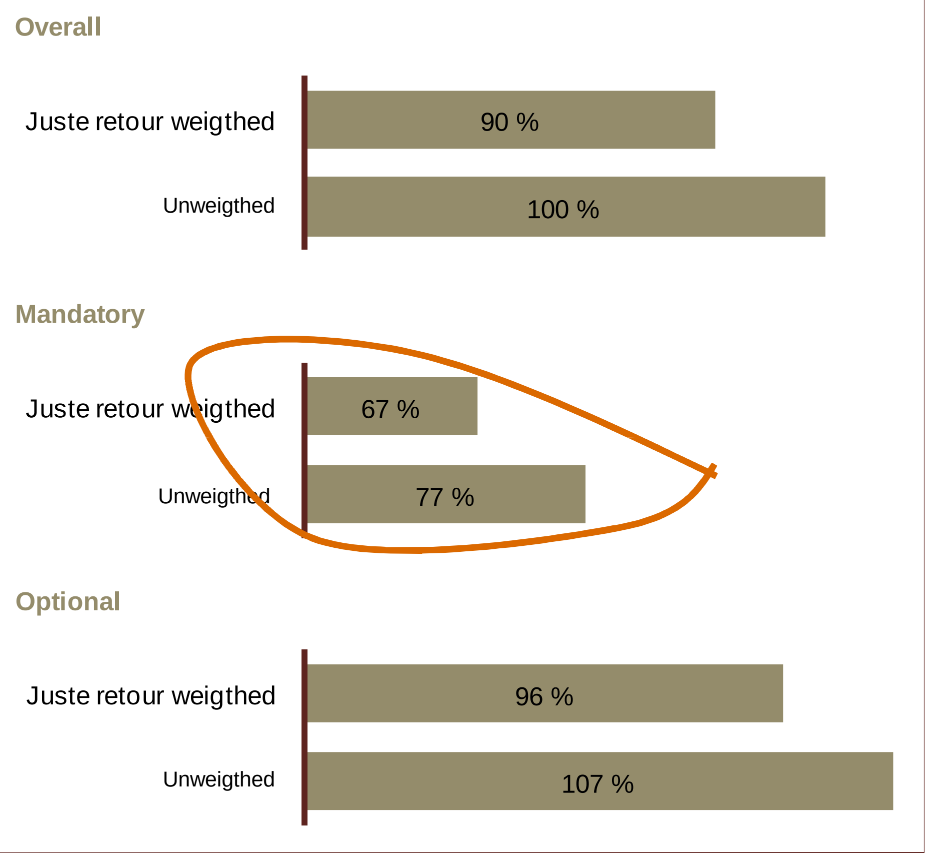
Reasons behind this are diverse. Science programs often develop very specialized satellites, equipment and instruments. Development costs are significant and commercial payoff less obvious. i.e. there is little reproduction potential. At the same time this is often where the cutting edge science and technology development meets and the potentials for technology transfers and new discoveries could be significant. The fact remains that fewer Norwegian actors deliver into this, and not well enough to compete with providers from other countries. 80 percent of contracts under the mandatory program is delivered by three firms only in Norway.

Industry reports mixed views on the causes of the low return. The science programs are useful entry points for new(er) manufacturers and allows them to develop a track record. At the same time the commercial viability of producing one-off instrumentation is limited and the risks involved are quite high. R&D institutions are also involved in these programs and may with different objectives and finds these more unequivocally relevant.

Next we turn to a more detailed view of returns on the optional programs.

Most of it comes back, but losses on the mandatory science programs

Figure 1.98: Industrial return by main program categories 2000-2011* (Euro nominal)



Source: NRS data; PwC Analysis:
*Includes certain programs that started in 1997: Ends June 2011

Playing the optional game well and getting strong returns

Many of the optional (sub) program offer **guaranteed returns of 100 percent**. These are technological development programs, general or attached to certain focus areas such as telecom or launchers. Specific project proposals are submitted and Norwegian financing allocated 1:1 less overheads.

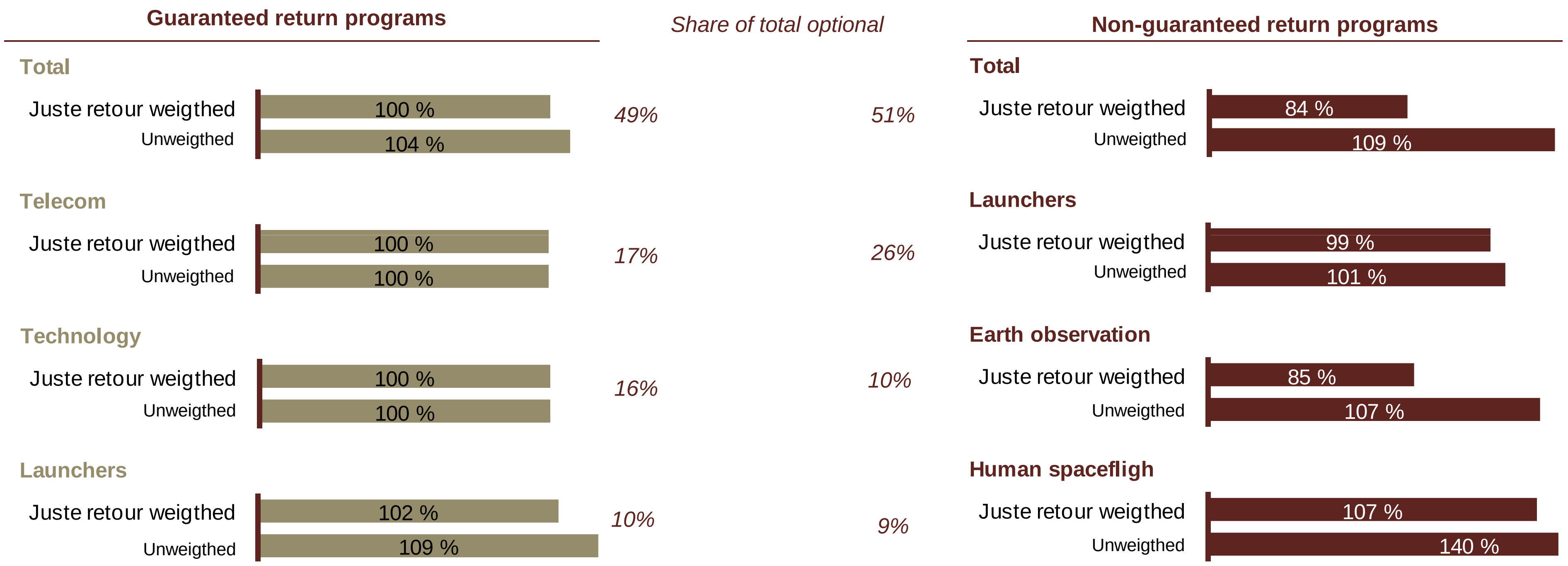
Some of the optional programs are **non-guaranteed**, and contractors compete along the same rules as for the mandatory program.

Norway's allocation is about 50:50 between the two. Return on the guaranteed programs are about 100 percent, in fact a little higher if not adjusted for the weights. Returns on non-guaranteed programs are lower but higher than for the mandatory program. Possibly reflecting that these are areas where Norwegian contractors have relatively better capabilities.

Industry reports much appreciation of the guaranteed programs for technological development. Its about more than the financing (50 percent financing requirement) and also about getting access to ESA expertise, quality assurance and a stamp-of-approval impact. Many of these grants are small and as such there are some concerns about the transaction costs and "bureaucracy".

Some have also voiced concerns about the integrity of intellectual property and prefers to enter the ESA development contracts when they have secured initial IP's through other means first. This is possible only a realistic option for the larger companies.

Figure 1.99: Industrial return by key optional program categories 2000-2011* (Euro nominal)



Source: NRS data; PwC Analysis: *Includes certain programs that started in 1997: Ends June 2011

Not much potential to increase ratio of Norwegian staffing

Staff are hired by ESA and are not supposed to represent country interest or influence on behalf of their member state. ESA recruitment policy gives primary consideration to qualifications, knowledge, skills and personal qualities. Policy also states to give due weight to nationality and gender to ensure fair representation. There is no explicit "quota" system though the constant ratios between nationalities may indicate this in practice.

The ratios between country staff have remained nearly constant for the larger countries over the 2003-2010 period for which we have data. The distribution key is not entirely correlated to neither GDP, population or contribution beyond a general relationship with size. There are some changes within the group of smaller countries (10th percentile). Norway's share has been marginally reduced from about 1,4 percent earlier. Sweden reduced from 2,7 percent to 2 percent, and Switzerland from 1,7 percent to 1,4 percent.

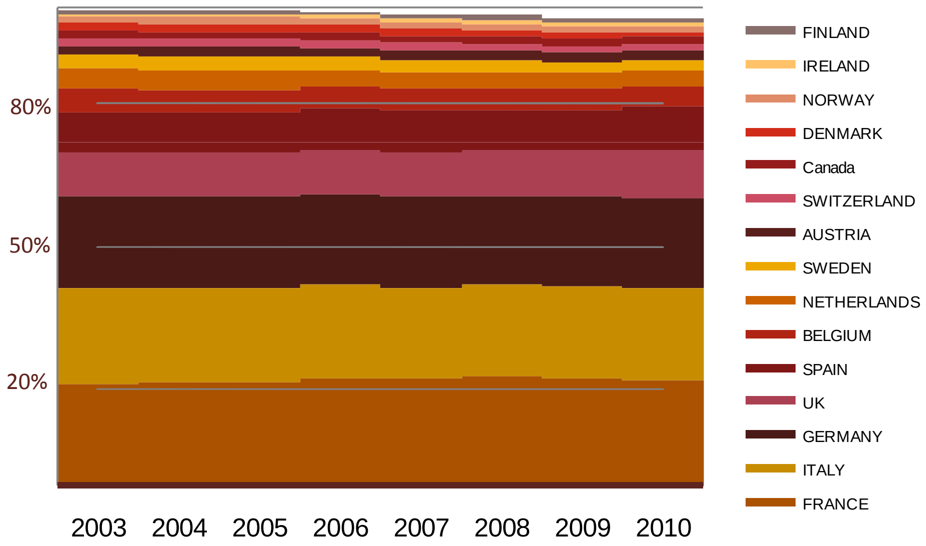
The larger countries, especially UK and Span and to a lesser extent France show some increase. Germany show a small reduction.

Staff from new member states have been hired and it seems like some of this need to bring new staff within country "quotas" has been accommodated by the smaller nations including Norway.

Norwegian staff is not necessarily an indicator of **influence** though informal networks and access to insiders generally tend to enhance influence in institutions. Given these trends, or lack thereof, there does not appear to be much potential to increase Norwegian staffing and related influence.

ESA is successful at maintaining ratios between country staff over time, but marginal changes are seen

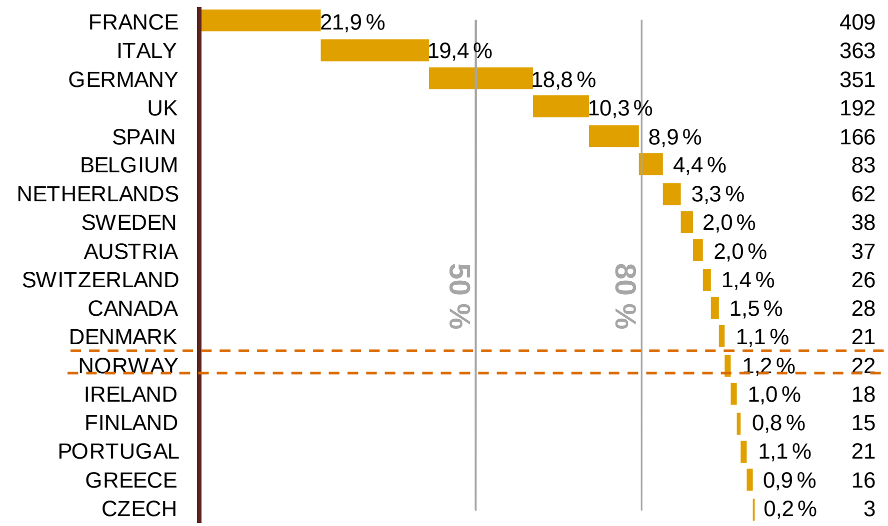
Figure 1.100: ESA staff by nationality A-level 2003-2010 (Not including new members states over the period)



Source: ESA Annual reports 2003-2010, PwC analysis

Staff numbers correlate much with size

Figure 1.101 Staff distribution by country 2010 (A-level)



There is influence through committee leadership

Leadership positions in committees and statutory bodies can be a different indication of influence. ESA has a number of standing committees. These include the program bodies for main optional programs, and "delegate bodies" for i.e. science, industrial policy, administrative and finance and so forth.

Below is a representation of this. Every year a country has had a position is counted as a person-year over the 2003-2010 period. Most positions are elected for more than a year.

Of note is that not all membership countries are represented. The bodies indicated in the charts have representation from 13 nations during the 2003-2010 period.

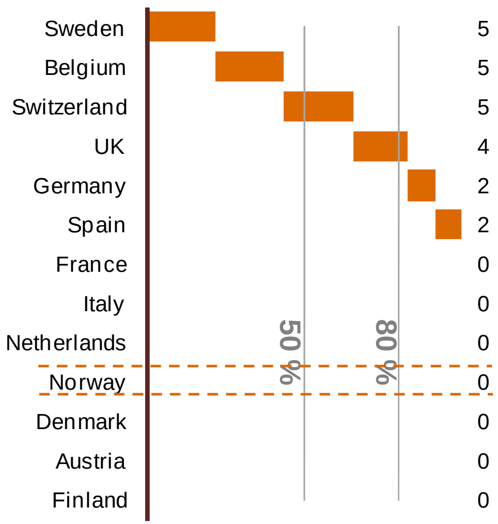
Chair of Counceil and vice chairs positions since 2003 is marked by leadership positions of Sweden, Belgium and Switzerland.

The larger number of program board and delegate bodies show leadership from the large nations France and Germany. Norway ranks equal to Switzerland, Spain, Netherlands and Finland perhaps indicating some over representation compared to size or contribution.

The audit committee is here represented by more than the leader. This shows leadership interest from Netherlands and the U.K. Norway ranks high in this regard albeit with few person years overall. Membership of the audit committee rotates more frequently. The lack of continuity is perhaps surprising given the transfer to IPSAS accounting and the challenges indicated in the latest audit reports.

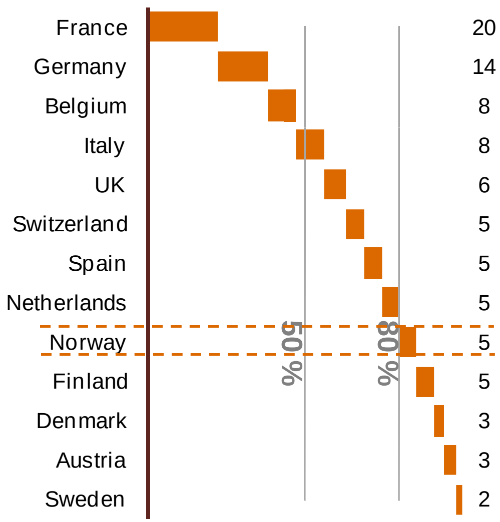
Swedish leadership positions

Figure 1.102: Counceil and vice-chairs (person years 2003-2010)



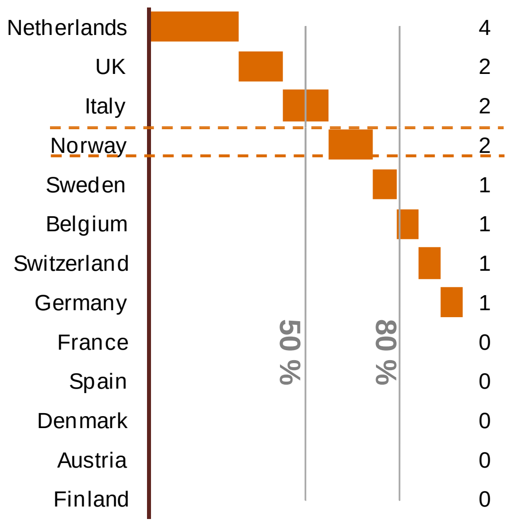
Norway has relatively more representation than many comparable countries

Figure 1.103: Program boards and delegate bodies (person years 2003-2010)



Audit a relative priority

Figure 1.104: Audit Committee (person years 2003-2010)



Source: ESA Annual reports 2003-2010, PwC analysis

Most ESA and NRS resources for satellite manufacturing and Institutional R&D

Next we review how the ESA and national funds have been distributed. We analyze this by value chain segment of the recipient organization. First we review the overall distribution patterns.

Satellite component and launch manufacturers receive most and more than a third of total. The share has declines some but the amounts have remained about the same. Number of organizations involved have increased over the decade.

Institutional R&D captures about 24 percent of totals. Their share has more than doubled over the decade. There are many, and an increasing number of entities involved totaling nearly 20 organizations in 2010.

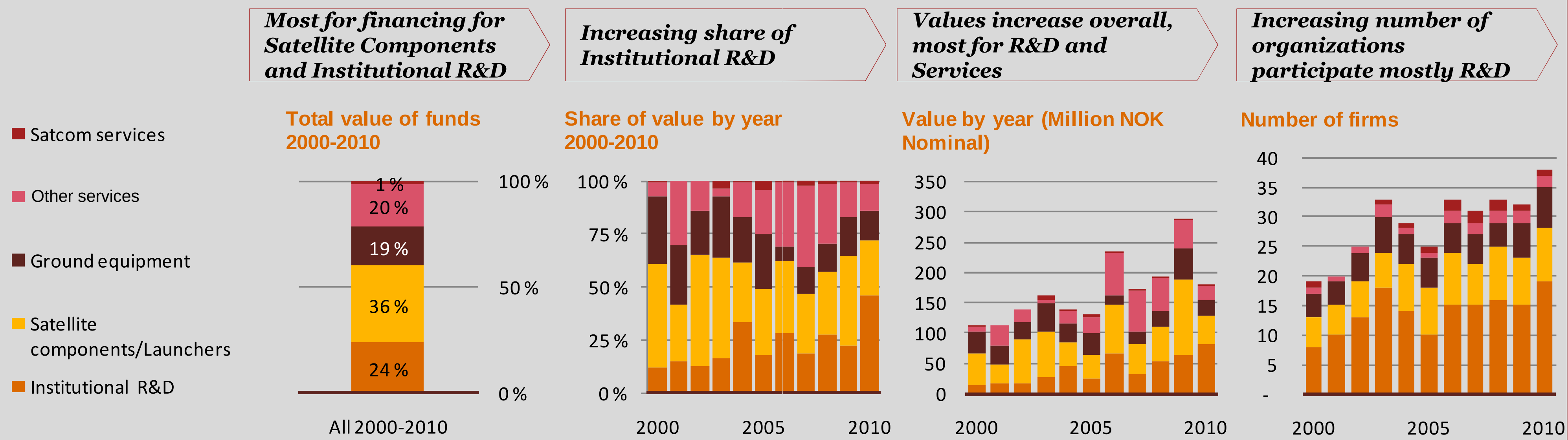
Ground equipment captures about twenty percent. Ground equipment monies have remained about constant but the share of total as decreased as everything else is growing.

Other services also captures about 20 percent. The share of have increased to near the same levels of components manufacturers. The funding is concentrated to only one or two firms.

Telecom satellite services have received only marginal amounts distributed across one or two firms over the decade.

Next we turn to a more detailed view of the distribution by instruments.

Figure 1.105: Distribution of all ESA and Space Agency funds by value chain segment (Nominal)



Source: NRS ESA data, PwC analysis

Figure 1.106: Distribution of mandatory, optional and Space Agency funds by value chain segment (Nominal)

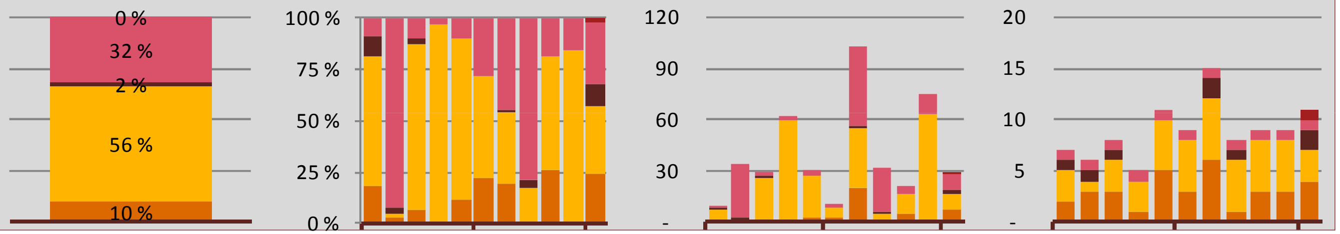
	Total financing 2000-2010	Share of value by year	Value by year (Million NOK nominal)	Number of firms

ESA mandatory programs

Satellite components manufacturers captures most of this related to the scientific program. Of the category "other services" which receives support this is mostly for downloading services by KSAT.

The values are highly volatile year-to-year and there are a limited number of organizations involved. No trends are apparent.

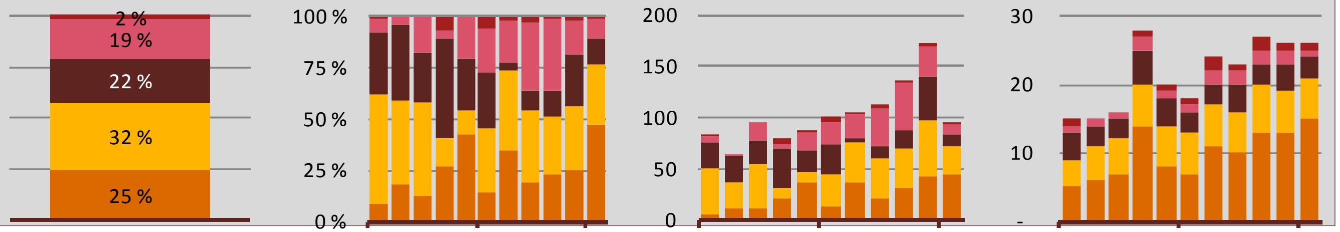
Most for Satellite Components and download services | *Varying shares interyear…* | *…and interyear volatility in contract volume* | *Few but increasing number or organizations*



ESA Optional programs

These funds are widely distributed across all but the telecom service segments. Shares are about equally distributed across the four main segments. Other services and Institutional R&D have increased mostly at the expense of ground equipment. Overall values are increasing and the number of organizations are about 25 annually. Most of the increase in participation are from institutional R&D. Commercial organizations have not grown much.

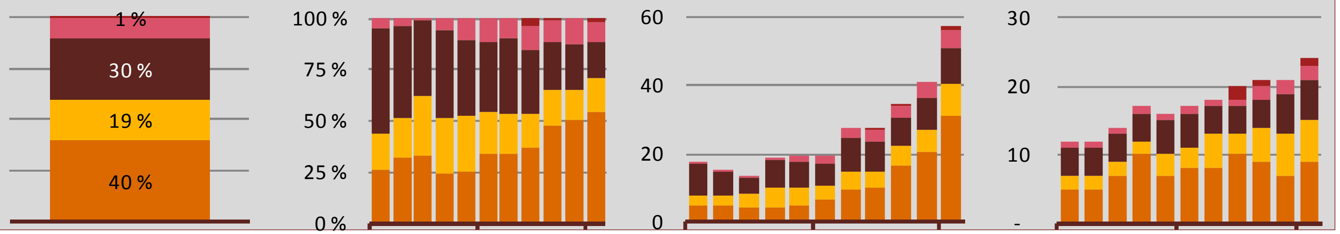
Widely distributed | *More for institutional R&D and EO services* | *Overall growth albeit drop in 2010* | *Most increase in R&D organizations*



National Space Center Support Funds

Funds are mostly allocated to institutional R&D and ground equipment. Priorities have shifted in recent years, i.e. R&D and EO services growing at the expense of satellite components and ground equipment.
The commercial share has been reduced to about 50 percent. Number of entities have grown gradually and comprises about twenty organizations over the last years. Growth in participation is fairly widely distributed across the segments.

More focused on R&D and ground equipment | *Clear shift in priorities over time* | *Steady overall growth across segments* | *Doubling of organizations over the decade*



Highly concentrated distribution with 4 firms receiving 50 percent of funds

As many as 67 organizations have been involved in either of the three programs over the last decade.

Distribution is however highly concentrated:

- four firms receiving 50 percent;
- a further 11 organizations receiving the next 30 percent; and
- 52 organizations share the remaining 20 percent and many of these amounts are very small lower than 0,1 percent of total.

The ESA system seem in practice favor larger organizations due to relatively high transactions costs and risks. Smaller firms have mostly accessed the technology development programs.

By international standards most Norwegian firms are small, but those who deliver most here belong to larger industrial groups or R&D entities.

Next we turn to a breakdown by instrument.

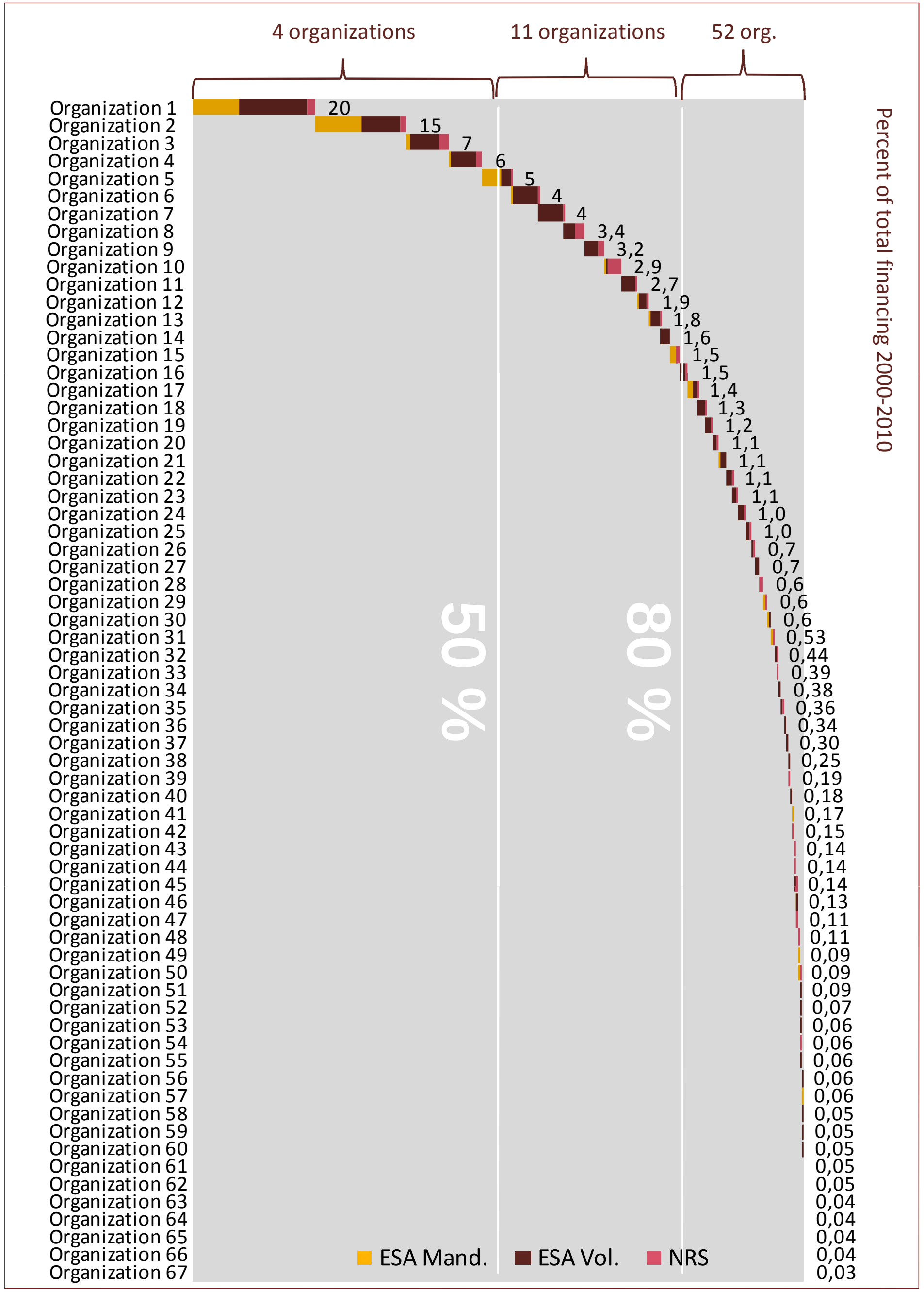


Figure 1.107: Distribution of all ESA Mandatory and Voluntary programs, and National Space Agency funds by value and recipient organization 2000-2010 (Nominal)

Source: NRS data; PwC Analysis

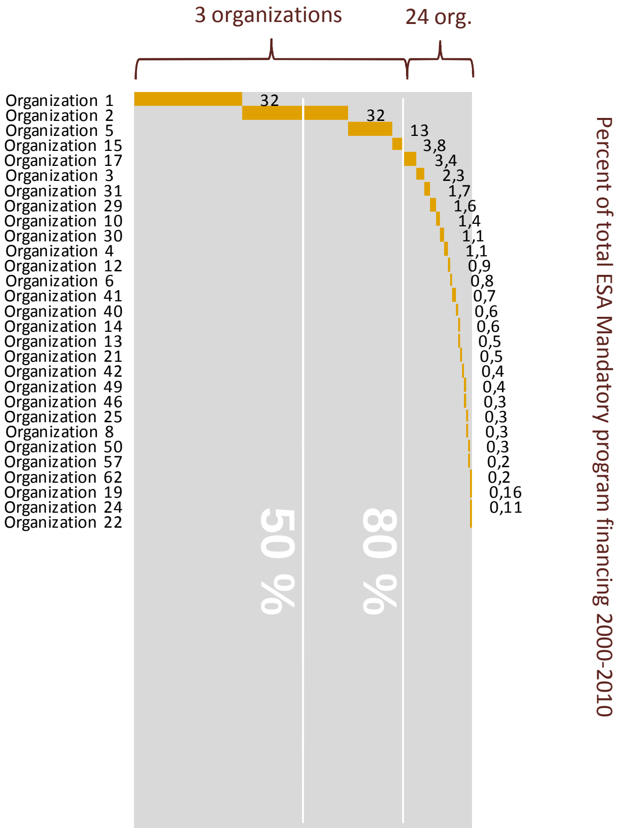
Figure 1.108: Distribution of all ESA Mandatory and Optional programs, and National Space Agency funds by value and recipient organization 2000-2010 (Nominal)

ESA Mand. ESA Vol. NRS

ESA Mandatory programs

These are extraordinarily concentrated with three organizations receiving 80 percent of funds. A further 24 organizations share the remaining 20 percent.

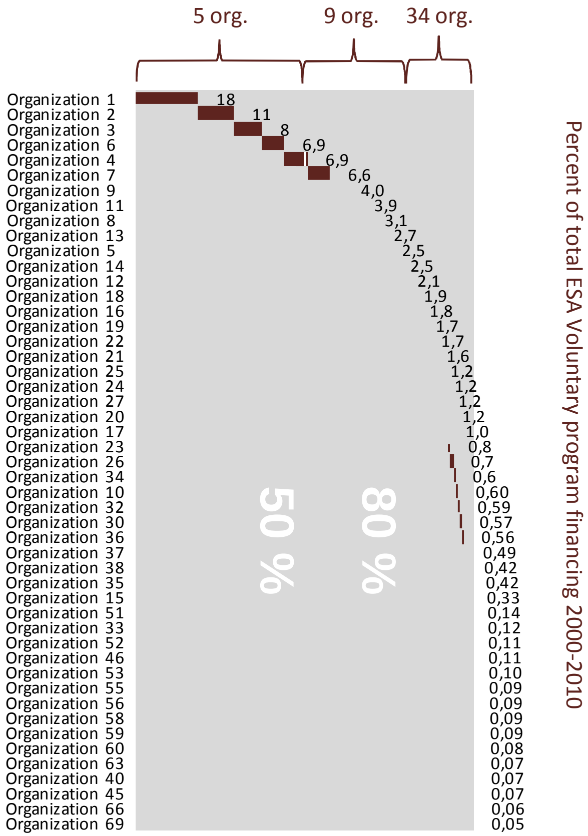
Overall there are 29 organizations with some involvement over the last decade.



ESA Optional programs

These engage more organizations, 49 in total over the decade. There is less concentration with 14 organizations receiving 80 percent of funds. These organizations are mostly found in the top ranges of the mandatory program as well.

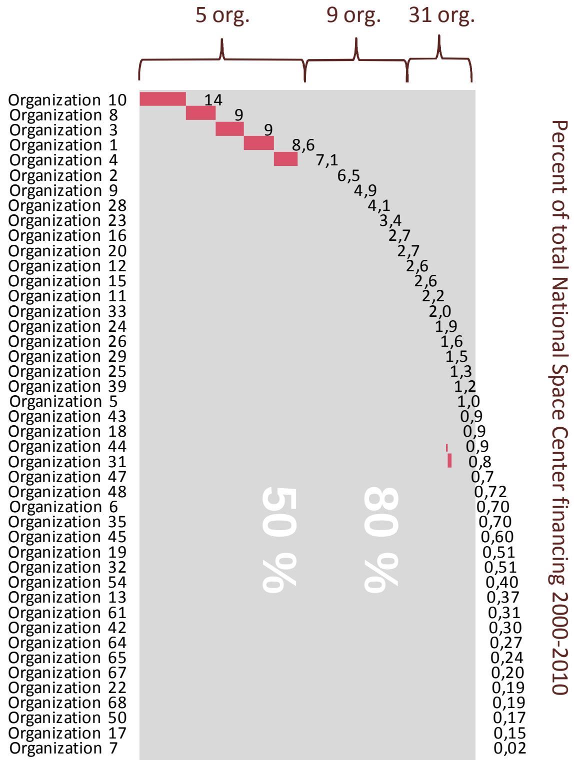
Most organizations receive only small engagements with 27 organizations having less than one percent share each over the decade. One percent equates to about 11 million NOK (1,5 million Euros).



National Space Center programs

Have a similar distribution pattern to the Optional programs although there are many more institutional R&D entities are active here. 14 organizations share 80 percent of which 5 receive about 50 percent.

31 organizations share the last 20 percent. The average contribution per entity over the decade for these is about 2 million NOK (250.000 Euros).



Source: NRS data; PwC Analysis

Participants emphasize quality experience and valuable engagements albeit cumbersome procedures and concerns about profitability

Participants across the value chain report generally positive experiences. Small or large firms in different segments report very similar issues.

Positive perceptions relate to:

- The technology development programs in particular (general and their sectoral counterparts).
  - These are seen as particularly helpful in exploring advanced technology development under qualified assistance. The assistance and involvement of ESA experts was generally perceived as high value.
  - Such programs may lead to getting technologies and products space qualified by ESA which is perceived necessary for entering the markets. There exist very few alternatives to this, or at least, no examples of Norwegian firms who have entered space markets without going through ESA. There are however, few firms who have had such deliveries at all, and especially for other markets than ESA, and little basis to conclude upon.
- Much feedback relates to the *importance* of ESA as an accessible marketplace, not to whether or not it was a positive or learning experience in itself. It is strongly perceived that working with ESA is a necessary requirement to gain broader market access especially for firms who manufacture products that are to enter space.
- Some state that their firms wouldn't have existed without the ESA program or products developed as a result. We will also come back to these impacts in section 1.4
- Emphasis is also put on the broader networks and contacts that can be gained.
- Most emphasize the professional expertise at all levels. This also includes advise and interactions with the space center in Norway. Few have had ESA engagements without deliberations with the space center first. Space center assistance was also valued at times when there were "difficulties" of procedural or other nature within ESA.
- Many also emphasize the usefulness of the industrial support funds with regards to qualifying for ESA funds. We will come back to this when we discuss impacts.

Source: NRS ESA data, PwC analysis

Concerns relate to:

- Concerns about **Norwegian priorities**. Both with regards to distribution of funds between large and small actors, and between segments. Some report that earlier policies of not supporting smaller firms had now changed. Some perceive the prioritization to be focused on "traditional" firms and less open to "newer". Some claim tat the "one-child" policy from the space center that entails not supporting competing firms but choosing one has reduced variety and discouraged firms.
- Some concerns relate to **protection of IPR** when engaging with ESA as there is a perception that knowledge and information is distributed more widely than envisaged. These concerns are mostly voiced by larger actors. It is also emphasized that national support funds are helpful in that regard as they can help secure IPR before engaging with ESA.
- Space center perceived as a **gatekeeper** for entry to ESA. Positive sides of this, as it relates to helpfulness and professional advise. Concerns relate to the prioritization issues above.
- Non-specific complaints about **bureaucracy** and difficult work practices at ESA. Small firms in particular reported this as creating difficulties.
- Many claimed the ESA projects themselves had **not been profitable** and possibly represented a loss. There were still perceived wider benefits reported i.e.. knowledge development and credibility that had positive impacts on the business overall. Only a few reports directly profitable projects with ESA.

National programs

Number of national programs to strengthen ESA competitiveness, enhance public sector use and capabilities

The space center also operates national programs. In total the programs are at about 20 percent of ESA contributions. The following programs are identified identified:

- **National support funds.** There are three objectives for these funds:
  1. Support Norwegian business and research establishments so that they reach a level of technological readiness to be competitive within ESA so that Norway can gain from the ESA investments;
  2. Contribute to develop space based services to meet national public needs in a cost effective manner, including participation in development projects from public agencies; and
  3. Support scientific projects which in different ways increases support for space based activities from the general population.
- **Radarsat**: Used for acquisition of data from commercial operator of radar satellites. Data are distributed across several agencies and research communities;
- **AIS satellite development funds:** This is to develop an AIS equipped satellite that was launched in 2010 and preparations for further satellites;
- **Infrastructure funds:** Used for providing financial support to the facilities of Kongsberg Satellite Services, Andøya Rocket Range and certain Galileo and EGNOSS reference stations to enhance navigational coverage in the north.
- **EASP/Andøya:** Support scheme to finance use of the rocket range for scientists. This is organized as multilateral agreement amongst various European countries with contributions from them as well.

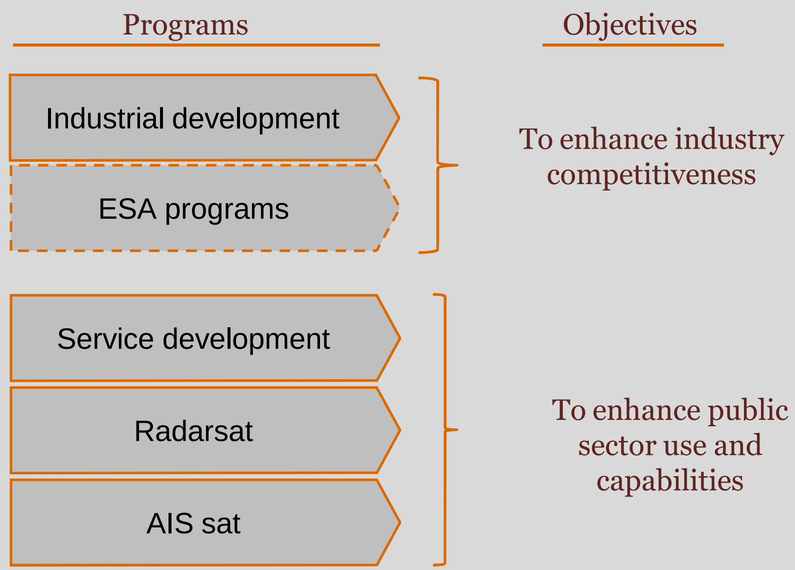
Particularly the service development, Radarsat and AIS work towards the shared objective of enhancing public sector capabilities. The learning and development funds have also to an extent been used for this purpose.

The government budget identifies most of these as “national support funds” under which some have earmarked allocations. i.e. the AIS satellite is singled out with earmarking and so are the infrastructure programs. Radarsat and EASP are budgeted for in different chapters “International Space Activities”. We are mandated to review the Radarsat agreement but not the EASP.

The following discussion will first present an overview, thereafter discuss the most significant programs.

Several of the national programs are mutually reinforcing

Figure 1.109: Illustration of important linkages between programs



Source: PwC Analysis

National program financing increasing faster than ESA contributions

Financing for national space programs have increased significantly and nearly tripled in monetary terms since 2005

These have increased more than the ESA contribution and more than doubled as share of these.

The financing is recorded under various budget lines, some as "international" i.e.. Radarsat, while others are mapped as National Support Funds (Post 72) or sub-categories thereof. The distribution can be seen to the right.

The data pre-2005 are incomplete and there are gaps in the reporting. Also after 2005 when comparing against official government accounts (Statsregnskapet post 72), there are a number of gaps between the details for the programs reported in annual reports by the space center and the official accounts of government that we cannot determine. The figures here should be read with some caution

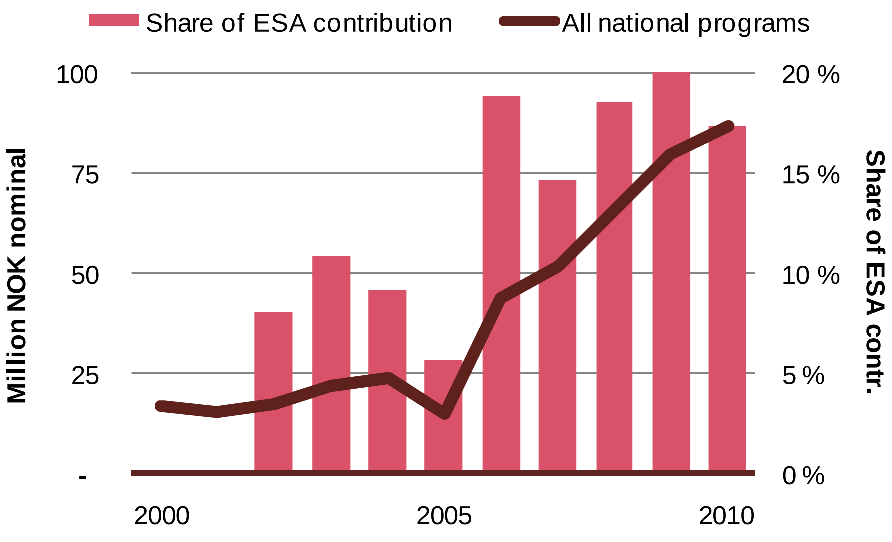
The increase has mostly been for special programs or initiatives. Prominent among these are the Radarsat agreement with MacDonald, Dettwiler and Associates Ltd. (MDA), The AIS Satellite program and infrastructure developments such as for maintenance at Andøya Rocket range, and support for the Kongsberg Satellite Services Station in Antarctica.

The more long running support schemes aimed at industry and earth observation service development have seen some increase in absolute terms. The numbers fluctuate quite much and it is hard to see a clear trend.

The industry and service development programs has decreased in significance compared to other special programs.

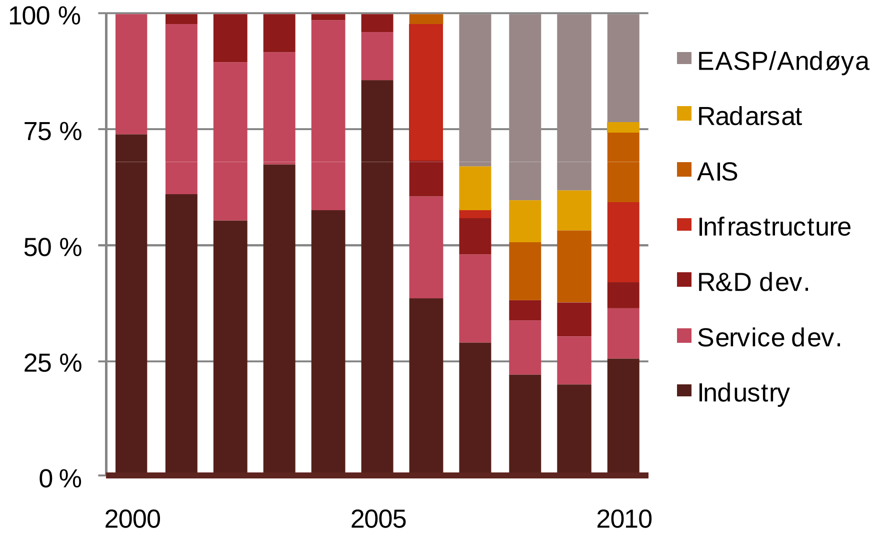
Considerable increase of financing for various national programs, also compared to ESA contributions

Figure 1.110: National programs including financing for radar data, Andøya, KSAT Troll station, AIS



Industrial development program less significant, more focus on other activities

Figure 1.111: Share of national program expenditures



Source: Governments budget documents 2000-2010; NRS annual reports 2000-2010;; PwC Analysis

National support funds dedicated to support technology- and service development, and popular science

First we turn to what is commonly referred to as the "national support funds" (Følgemidler)

This is the core of the national support fund usage. The programs have been long running, broadly corresponding to three objectives as stipulated in the official government budgets:

1. Support Norwegian business and research establishments so that they reach a level of technological readiness to be competitive within ESA so that Norway can gain from the ESA investments;
2. Contribute to develop space based services to meet national public needs in a cost effective manner, including participation in development projects from public agencies; and
3. Support scientific projects which in different ways increases support for space based activities from the general population.

In the following we will present the important facets of the programs.

We will discuss each of the three programs. The industrial program is more significant in terms of financing. It is however very closely linked to ESA and as such we have presented much detailed information and analysis under the "ESA activities" section above.

The schemes may involve state-aid. Hence they were notified by the European Surveillance Authority in February 2008. This implies restrictions of what activities can be supported and with what level of financing, i.e. scale from 25-100 percent depending upon type of activity. Most fall within the 50 percent support category. The state-aid rules are mostly relevant for the industrial scheme where most private sector activities fall. There are also private sector activities under the service development program but much smaller in level and frequency.

Industrial development program

Aimed at supporting technology development for Norwegian firms to engage with ESA.

Largest. Slight increase during 2004-2009, significant rise in 2010.

Service development

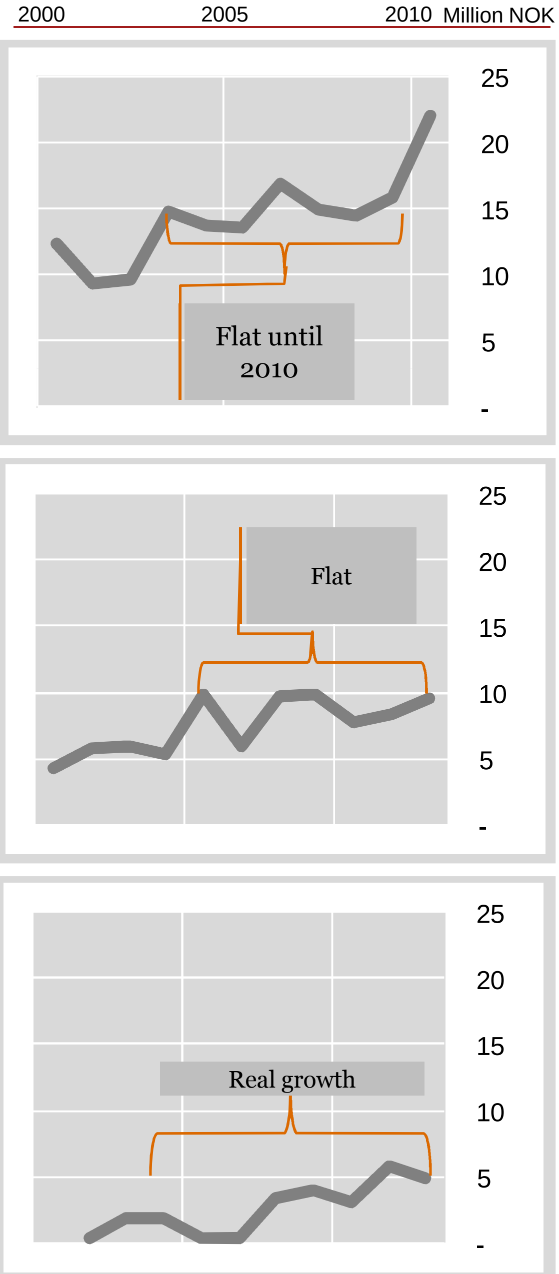
Aimed at supporting development of efficient services in public sector.

Half of industry funds. Increased during 2000-2005, mostly flat since.

Popular science

Aimed at supporting popular science to enhance public support for space activities.

A quarter of industry funds. Much growth from 2005 but from very low levels.



Source: NRS data

Figure 1.112: Expenditures on national programs (Industry, service and science) (Nominal)

Industrial fund scheme to support pre-ESA technological development is the largest

Concept

The purpose of the overall national support scheme is to help finance development projects for future deliveries to the space segment, user equipment or utilization of data from satellites. The industrial scheme is very closely linked to that of ESA is that Norwegian companies may need assistance from a dedicated program before engaging with ESA or space markets.

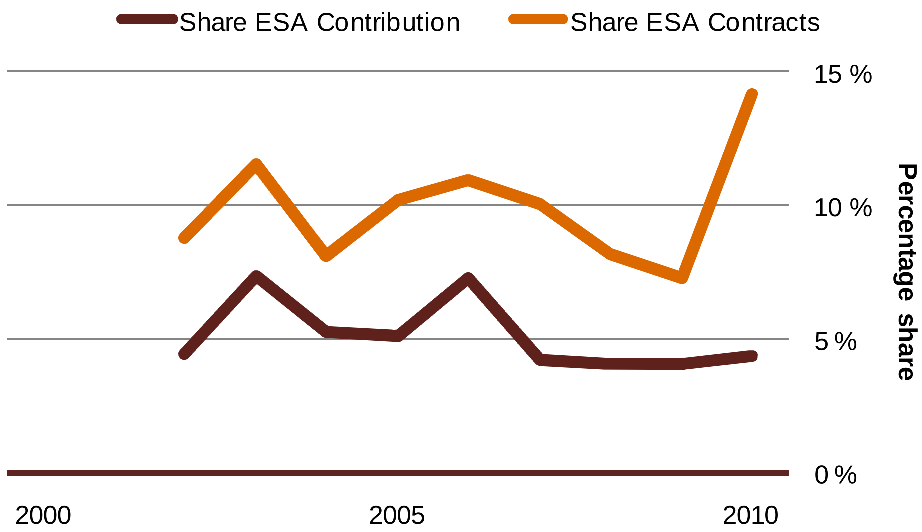
This is based upon two considerations:

-Industrial base for space manufacturing in Norway is and has historically been quite small and may develop if supported through a dedicated scheme; and

-The larger space nations have industrial scale national programs under which much technology development is supported. If Norwegian enterprises is to stand a chance in the competition, they need to be supported.

Possibly declining as share of ESA contribution

Figure 1.114: Industrial program as share of ESA Contribution and ESA contracts (2002-2010)



Source: NRS interviews and prop reporting; ESA contract is midpoint annual estimate from three sources, see page 125; PwC Analysis

Activities

The scheme focuses primarily on technologies as in hardware, Its addressing primarily **space manufacturers** and **ground equipment** producers as discussed earlier in this report. Certain services, i.e.. software and applications may have been supported.

A range of areas are indicated: Industrial positioning for manufacturing of satellites, deliveries to future navigational satellites; commercial communications satellites; earth observation satellites; ground stations/terminals or technology development for the international space station (ISS).

Its an application based scheme but the space agency has authority to initiate projects at its own will. Certain issues are given priority when deciding an allocation:

Companies must demonstrate:

•"Real" capacity to develop technologies for space activities ;and

•Technological spin-off potential within the space segment or in other markets;

•Organizations that are engaged with ESA technology development programs may seek support for complementary activities.

There has only been structured reporting of activities for the last two years (2009-2010). That followed a redesign of the fund governance after the EU/EEA state-aid notification in 2008. The reporting is also quite limited and gives little ability to analyze trends and developments.

As such, most of the analysis of national funds need to be done without linking use of funds directly to the programs (industrial, service). This is analyzed in the section above.

Users strongly emphasize linkages with ESA programs

Emphasizing the linkages with ESA programs is a recurring theme from participants. Space center support allows them to refine concepts and possibly secure IPR, before engaging with the larger ESA system. This applies even for the technology development programs of ESA that also has certain SME and early stage development objectives.

The support is used by small and large organizations with most funds going to the recurring actors i.e.. industrials who engage regularly with ESA.

Some participants argue their firms would not have existed without the initial support from the space center funds.

Participants also emphasize the helpfulness and expertise at the space center allowing them to refine strategies for engaging with ESA.

A deeper quantitative **analysis** is found in the chapter on ESA activities (above), and quantitative and qualitative analysis in the section on impacts below.

Next we turn to the service program.

Service development program to enhance public sector use and capabilities, smaller and possibly declining

Concept

Data from satellites potentially offers cost efficiencies and quality improvements for important public sector functions. Satellite borne sensors can collect data for large areas, repetitively and within short time intervals.

A strategy was developed during early 2000's setting out the objectives priority activities. Objectives have later been refined and has in practice focused on two priorities:

- Developing infrastructure to secure access to data;
- Focus on Ocean and Polar regions as these potentially offered the greatest cost efficiency potentials for Norway.

Activities

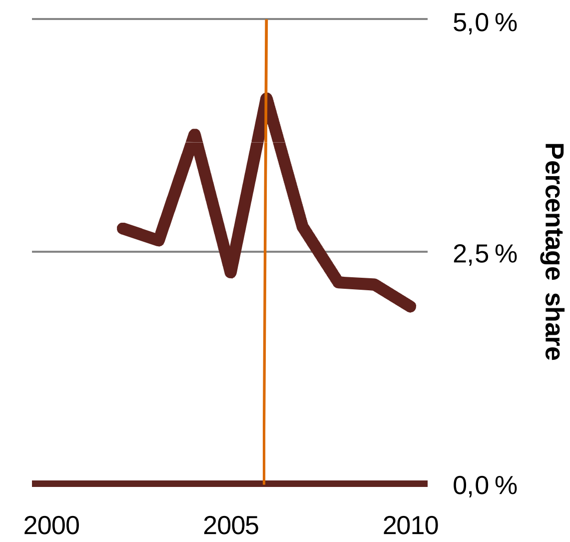
Two main instruments exists:

- First, there is a service development program. This is comparable in design to the industrial program and operates by the same procedural rules. Projects are required to have user involvement, expressed user demand, identified national needs or international reporting obligations. Complementarities with ESA- or EU projects are also important.
- Second, there is a set of specific activities to enhance data access. This is mostly about the radar data agreement, support for processing and to an extent the AIS satellite.

There are complementarities between these. The funding shown below only show the service development program and not expenditures on radar data and AIS.

Volatile but declined since 2006 as share of ESA contributions

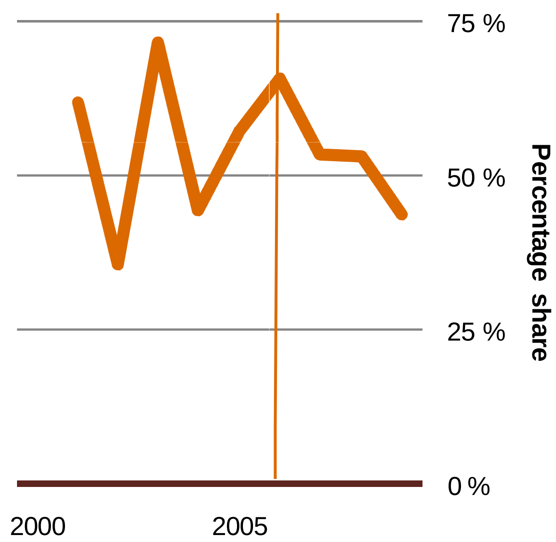
Figure 1.115: Service program as share of ESA contribution



Source: NRS data; PwC Analysis

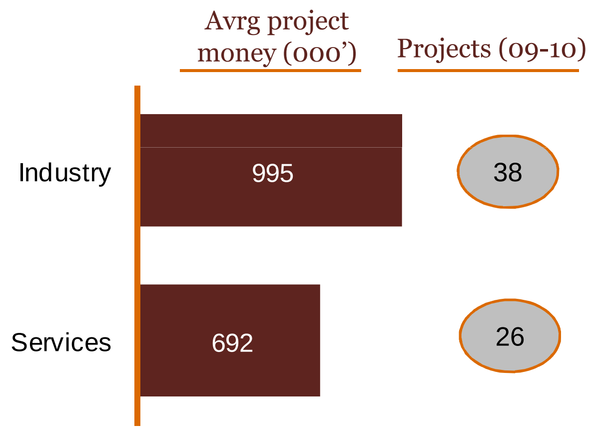
Volatile but declined since 2006 as share of industrial program

Figure 1.116: Service program as share of industrial program



Smaller and fewer projects than the industry program

Figure 1.117: Average project sizes for industrial and service programs (2009-2010)



Activities range between programmatic work, to advisory and coaching functions

The tools and purposes are broader compared to the industry programs and ESA activities. This is also much about NRS staff time and competencies.

First, the most instrumental activities have been about ensuring data access and applications development. This is about establishing a government wide agreement for access to Radarsat-2; and related work to develop applications and manage the process. These activities uses most NRS funds.

Much of this spending is on institutional R&D organizations. Commercial spending is highly selective and involves mostly KSAT. This is detailed in section 1.2 above.

Second, there is also, perhaps increasingly, involvement in other government wide processes. A flagship program is "Barentswatch". Currently led by the coastal authority but being institutionalized in a separate structure. There has been much input and assistance from the space center to this and other processes.

Third, a range of information activities over many years.

Next we turn to the data access and applications program in more detail.

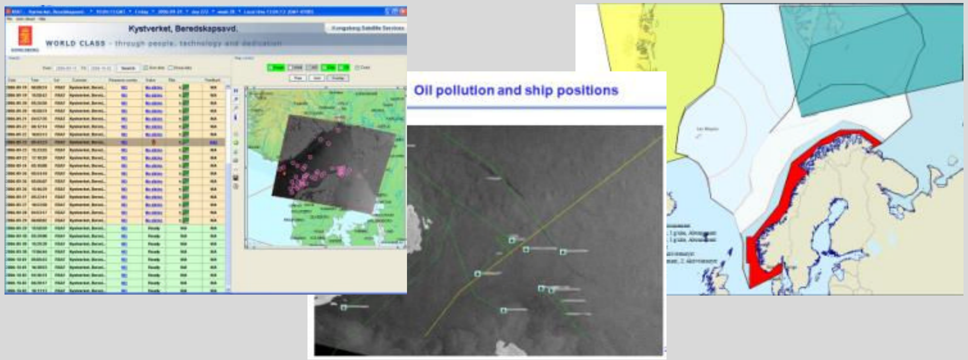
We will return in section 2.1 to an analysis of real world impacts.

Figure 1.118: Illustration of program focus

Data access and applications

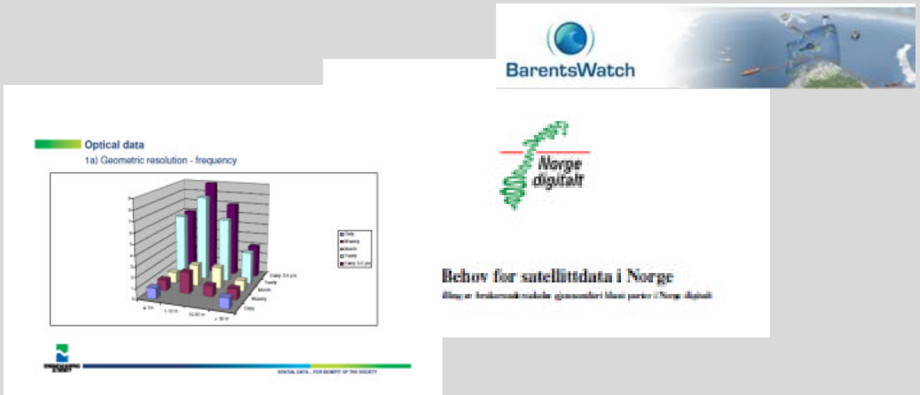
The most instrumental and costly activities. Includes:
- Acquisition of Radarsat-2 data;
- Processing support;
- Application development; and
- coordination of use.

Conceptualized and implemented through programs like SatOcean.



Support for government processes

Support for government wide processes. Main events over the last years includes processes:
- Barentswatch. Supported concept and strategy development.
- Digitalt Norge. Supported and advised process of mapping user requirements.

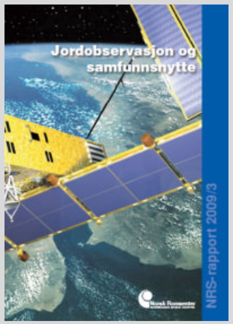


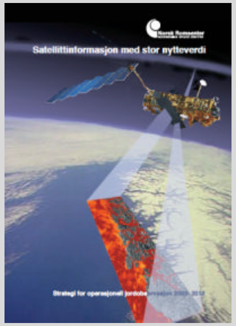
Information and advise

Range of activities to sensitize, inform and advise government users.

Advisory and coaching role is important and much appreciated at agencies.

Publications, presentations and discussions.





Source: PwC Analysis

Flagship program highly focused on providing maritime operational services

The rationale for the focused effort is related to the effectiveness and cost-efficiencies of satellite systems to monitor the large ocean territories. There are also valuable economic activities derived from resource use of these areas: Petroleum, Fisheries and maritime transport. The areas cannot be effectively monitored by other technologies. Northern location also has some advantages for effectiveness of satellite surveillance as earth observation satellites in polar orbits have a relative coverage of the Barents region of 4-5 times more than at the equator as orbits converge near the poles. The importance of having such capabilities is perceived to be increasing as the arctic north is becoming the key strategic theatre for Norway.

Priorities have been pragmatic. Users from operative agencies have been involved throughout and the purpose has been to solve operational issues and meet operational requirements.

Activities have been ongoing since mid-eighties supported by the space center. Development projects have involved users, scientists and industry. Activities were scaled up upon securing a radar data agreement from MDA/Canada in early 2000's. Project funding levels doubled during these years and a conceptual framework was refined: **SatOcean**.

This was conceptualized as a national program to utilize Earth observation data to support national maritime needs. It was an initiative from the space center. The objective was help resolve a long standing problem by establishing a coordinated effort for government institutions to utilize satellite data in a cost-effective way. It was presented as complementary to GMES service development in Europe.

Its focus activities have been:

- Securing radar (SAR) utilization. Long-term and routinely supply of relevant satellite data at competitive prices for operational use;
- Near Real Time processing and distribution of SAR and AIS data;
- National ground station support to secure national capabilities;
- Application development to serve operational requirements.

Busy above Norwegian waters as ESA satellite Envisat captures data enroute north

Figure 1.119: Snapshot of satellites above Norwegian territories a day in February 2012

User responsive marine service program highly operationally advanced

The program was organized with a board of important users and specific developments were defined by these.

Priority services were determined as: (i) Sovereignty and fishery control - ship detection and AIS; (ii) Environmental monitoring - oil spill (and AIS) and water masses; (iii) Polar and climate monitoring - sea-ice, ocean circulation; (iv) Fish farming - algae bloom monitoring; and (v) Operational oceanography - wind, waves and currents.

Functional priorities included data continuity, access to data (including formatting, near real time processing and service provision); cost effective and good enough as the standard.

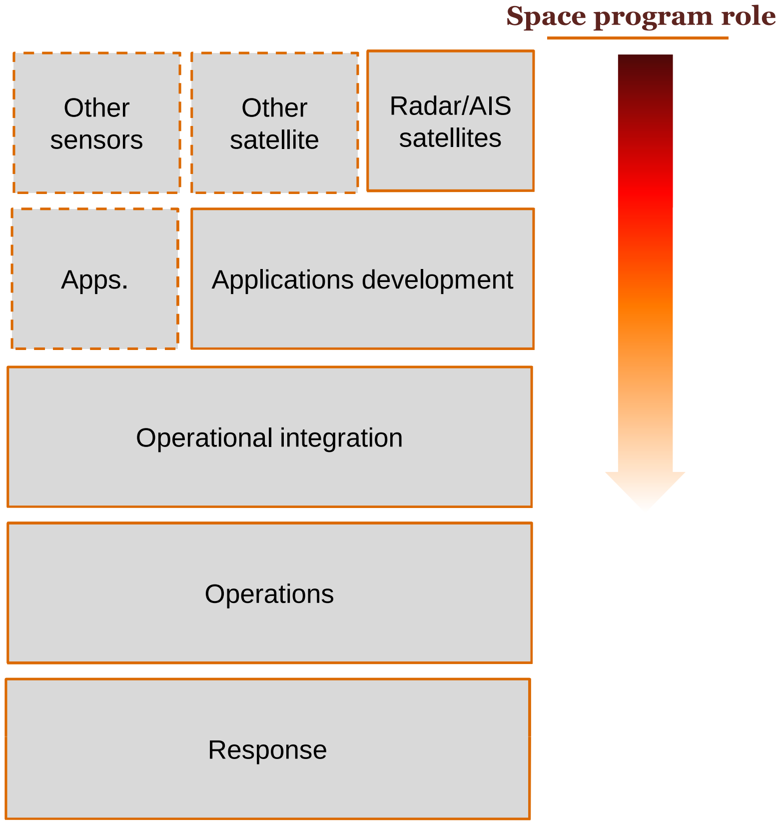
There as been an iterative process whereby demonstration projects have been developed, improved upon methods and processing chains, developed and improved services to institutions with monitoring responsibilities; and with adjustments and further development work. Multiuse concepts have been encouraged. This implies reusing data and coordinating acquisitions. An operational implication of this is that the Coastal Authority manages the data stream distribution to other agencies. There has been less reuse of scenes in practice and we will return to this when discussing the radar data agreement.

At the user end, radar information is integrated with other sensory information. This includes satellite radar images from other sources, i.e.. oil companies or EMSA; or AIS satellite information for ship identification or the fishing vessel system (VMS). There are 24/7 monitoring and surveillance centers operated using the sensory inputs from satellites as part of the broader set of surveillance and monitoring arrangements. Coastal Authorities and Coast Guard have various response protocols depending upon what is detected.

Programs in Norway are highly advanced compared to developments elsewhere. EMSA operates a similar concept for all of Europe modeled upon the Norwegian model. U.S. Coast Guard also explores similar programs. The EMSA system covers European areas including Norway, but capacity is insufficient for full coverage in Norway. There is an allocation protocol which allows Norway access to a share of radar scenes (300-400). This is often used for near real time high resolution requirements for which the Norwegian radar data agreement is insufficient. EMSA overall acquires no more than about 2000 scenes, same as Norway.

Space programs instrumental in early process chain and diminishes as satellite data are integrated into operational systems

Figure 1.120: Illustration of process chain



Two concluding remarks about the role of the space programs:

1. The importance is highest at early stages in the process chain, i.e. data acquisition and applications development. It diminishes as the sensory inputs are integrated into larger operational systems.
2. Longer term there is a probable scenario whereby data acquisition and international cooperation protocols are more mainstreamed and will be more effectively handled by operational agencies directly. We are not there yet. The space programs will have a useful and important role in developing the next generation of surveillance systems.

Land focused programs are emerging, focused on catastrophic geohazards

Radar interferometry is used to detect surface movements. Radarsat and other earth observation satellite data has been acquired for these purposes. The main areas for satellite monitoring on land are (i)glaciers and snow covers (e.g. Norwegian Water Resource and Energy Directorate, Meteorological Institute and The Polar Institute), (ii) forests (e.g. Norwegian Directorate for Nature Management and Norwegian Forest and Landscape Institute) and (iii) areas prone to rock and land slides (Geological Survey). The by far most frequent user of Radarsat data for mapping and monitoring of land is the Geological Survey (NGU).

The country is mapped in broad sweeps and high resolution imagery is used for identified high risk areas. The NGU's main objective with regards to the Radarsat data is to do a thorough geological mapping for the purpose of improving safety for people and infrastructure. With a satellite dataset they can identify risky areas, in which special precautions must be taken with regards to building new or maintaining old infrastructure in order to avoid potentially disastrous rock or mud slides. Certain areas must be monitored, some continuously.

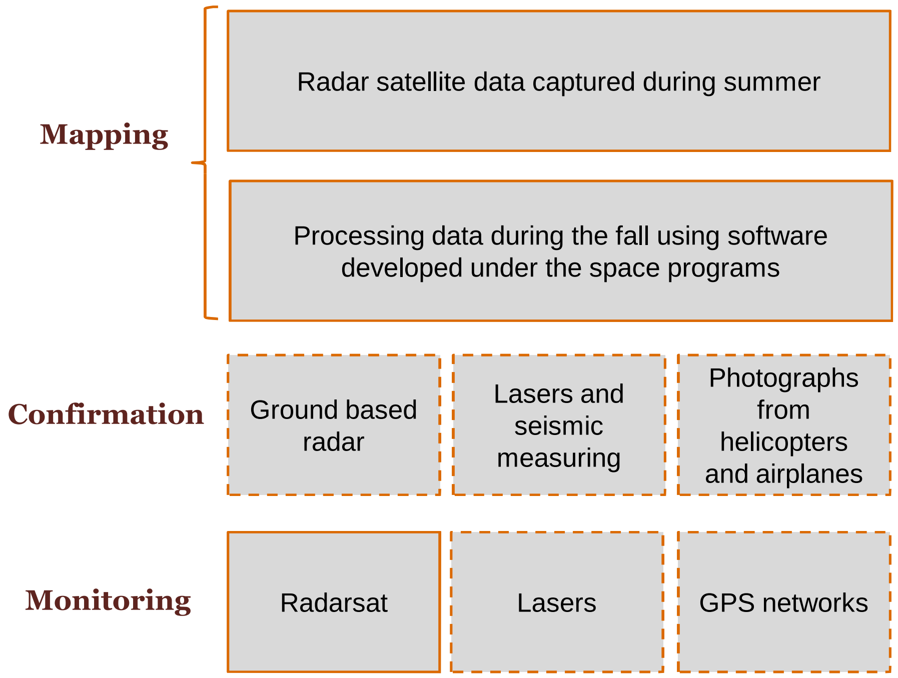
The use of satellite data in the monitoring process is not as institutionalized as it is in the mapping process. Once risky areas have been identified, a range of ground based instruments are put to use to monitor them, weather stations, lasers , seismic measuring and small networks of GPS sensors, in addition to some satellite monitoring.

This use of a wide range of ground based instruments for monitoring land areas is considered to have very high costs. There is a belief that a more steady stream of satellite data, accompanied by artificial reflectors on the ground would give considerably better data on movement within rock and land formations, at lower cost then today's mix of ground based instruments. The prospects of increasing the satellite share of rock slide monitoring is currently being assessed by the NGU in collaboration with the Space Centre.

There is ongoing development work to develop applications for monitoring of landslide and avalanches for the road and railway infrastructure.

The role of satellite data in the process of mapping, monitoring and preparing for rock and land slides

Figure 1.121: Illustration of process chain



Three concluding remarks about the role of satellite data in mapping and monitoring areas prone to rock and land slides:

1. The mapping by satellite to identify areas of risk is well established
2. To confirm the risk, airplanes and ground based instruments are used
3. For continuous monitoring there is potential for increased satellite usage. There are barriers of cost and technology currently. Over time this may reduce the number of instruments and total costs of monitoring.

Current Norwegian EU GMES priorities include financing and prioritization of interests, but over time coordinated government efforts are required to secure benefits

Recent priorities have focused on participation in the development stages of GMES. This includes financing over ESA Optional programs and contributions to FP7. Activities include research and application development. (see page 87 for an overview of FP7 participation).

Medium term priorities include securing Norwegian interests in prioritization of services and direction of program development. Government is currently negotiating participation in the Initial Operations phase, led by the EU, which will determine priorities and operational principles.

Issues include prioritization of use, scheduling of capabilities and priority areas. Although a significant scale-up of capabilities compared to earlier efforts, the GMES systems will meet conflicting demands from different users across Europe and issues of allocation and selectivity will be important. Norway has large areas for which monitoring capacities are useful but access to the monitoring infrastructure and capacity is not given at all times.

The risk is that without beneficial resolution over the short term, these issues will lead to higher costs and slower realization of benefits for Norway over the long run. Benefits may still accrue over time, but there are risks for higher costs and reduced uptake in public sector if services are less relevant for needs.

Longer term success will require continued leadership. The space center is well experienced and equipped to perform such a role, but issues of cross-budget financing and coordination is a risk and a constraint longer term.

Of great benefit for Norway is the government wide experience in developing and operating multiuser satellite information systems. Articulation of requirements and priorities are highly evolved and there is real life experience.

There is a risk that commercial growth in the downstream service segment will be low as little of the Norwegian efforts have focused on developing broader commercial actors. European programs are more advanced in this regard. This is balanced by strong involvement of KSAT, and a broader EO R&D segment in Norway which have capabilities. Broader commercial development may still remain a challenge.

The game changer for environmental monitoring: EU GMES Sentinels

Figure 1.122: Illustration of EU GMES concept

Satellite series

- Sentinels 1 Radar for land and ocean
- Sentinels 2 High res optical for land services
- Sentinels 3 optical, radar and altimetry for land and ocean
- Sentinels 4 and 5 Data for atmospheric monitoring
- Sentinel Jason CS to provide altimetry observations mainly for ocean

In-situ

The component is based on infrastructure owned and operated by several stakeholders and coordinated by the European Environment Agency (EEA). Instruments for observation include ground-based, airborne and ship- or buoy-based sensors and instruments.

Service segments

GMES service provision is organized in six segments:

•Atmosphere
•Climate Change
•Land Monitoring
•Emergency Management
•Marine
•Security

Program is funded by the EU.

ESA develops the instruments and satellites. In-situ component developed by EEA.

Service segment developed under EU and financed by FP7 Space.

EU funded Initial Operations agency to coordinate developments during 2011-2014

Source: PwC analysis

Radar data purchased to enhance maritime and terrestrial monitoring ability

Relevance of concept

Satellite radar data are acquired to enable effective surveillance of maritime areas by security agencies in Norway. Modern radar satellites can detect ships, oil spills and ice coverage. They are also used to monitor land areas and can be used to monitor landslides and snow cover. They are also workable at night and in overcast weather. Optical image satellites cannot provide the same functionalities. There are also scientific uses for radar data.

The scientific and institutional radar satellites a.o ESA ENVISAT and earlier ERS satellites also has radar capabilities but these do not have the same capabilities. Resolution is lower and revisit times less frequent in areas of interest for Norway. ENVISAT is also currently unstable ,drifting in its orbit, and not useful for operational purposes.

Radar capabilities are also available aero planes, including on the Norwegian military Orion surveillance planes. Aero planes are non-competitive for this purpose as they cannot cover the same large areas with the same time efficiency as sweeps by satellite borne radar.

Objectives

The ability to meet operational needs are emphasized in the annual government budgets. The agreement with RSI contains other provisions which we will detail on the following pages.

There are ongoing discussions of how to secure data for the future and we will return to this discussion towards the end of this segment.

Activities and organization

A contract was entered into by the space center with Radarsat International Inc (RSI) in 2002 whereby an agreement was made to purchase data worth USD 10 million during 2002-2009 from the satellite Radarsat-2. It also included provisions for delivery of data from Radarsat-1 in event of delays in launching Radarsat-2. The satellite was much delayed and became operational in August 2008. The agreement has been extended until 2014 reportedly without prejudice or costs for Norway.

RSI is as a subsidiary of MacDonald, Dettwiler and Associates Ltd. (MDA) a company with its main business in surveillance, intelligence and communication sectors.

The agreement allows about 2000 scenes with scheduled capacity, and access to further 8000 background scenes (non-priority requests). The agreement allows resolution of up to 3m for Government users only and in predefined areas. Certain security restrictions and privileges for the Canadian government apply.

Kongsberg Satellite Services, under commission, downloads the data at the Svalbard facility, processes and distributes these to Norwegian users. KSAT also has access to data for resale and pays government 1,2 million NOK annually for the privilege.

KSAT is further paid 5 million NOK annually by Defense and the Coastal Authority for processing services. The space center pays 2,5 million to cover costs for smaller users. The latter is recorded as an allocation under the national support funds.

The space center coordinates users and a process that allocates use of allotted scenes.

Source: Coastal Authority webpage; MoTI documents; PwC Analysis

Radar data are much used for defense and security purposes, and well integrated into operations

The data are much used. Utilization is at about 90 percent of the scheduled allocation. Security purposes dominate. Defense is the predominant user at nearly 36 percent if including the Defense Research. The Coastal Authority uses further 23 percent. The geological survey uses about 27 percent. Beyond these the remaining ten agencies use about 15 percent. Some for scientific purposes.

The geographical coverage has been mostly in northern ocean areas. Less use along the coast and at the mainland. Sweeps are scheduled for daily (or more often), weekly or other intervals depending upon user specification. There are also seasonal variations in use.

There are reports of scheduling conflicts mostly due to the increased use over land areas. Capacity of the system may be borderline full especially for near real time acquisitions.

The additional capacity of 8000 scenes is severely underutilized. Numbers indicate about 15-20 percent utilization but the figures are considered unreliable by the users. To the extent that the numbers are to be believed, they indicate that defense uses 70 percent of this – an additional 1000 scenes which is more than under the scheduled use.

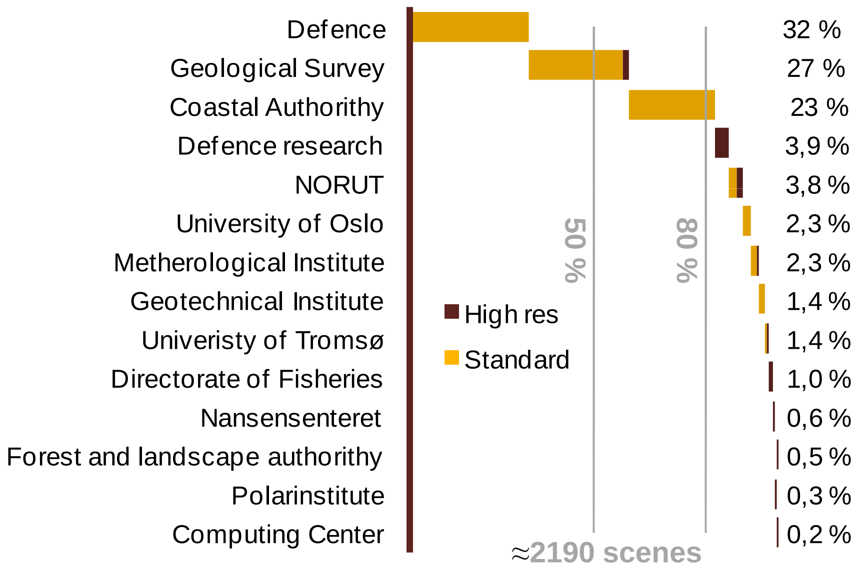
The overall pattern is similar to that of Canadian authorities. Security and natural resource services constitute 80 percent of usage. Canadians use about five times as much as Norwegians. The Canadian numbers are likely to have increased since 2009 reported below. The expected use was 15.000 scenes.

The impacts must be seen in relation with the other earth observation service development programs and the AIS capabilities.

See also the analysis of the Canadian context for Radarsat-2 in section 1.2.

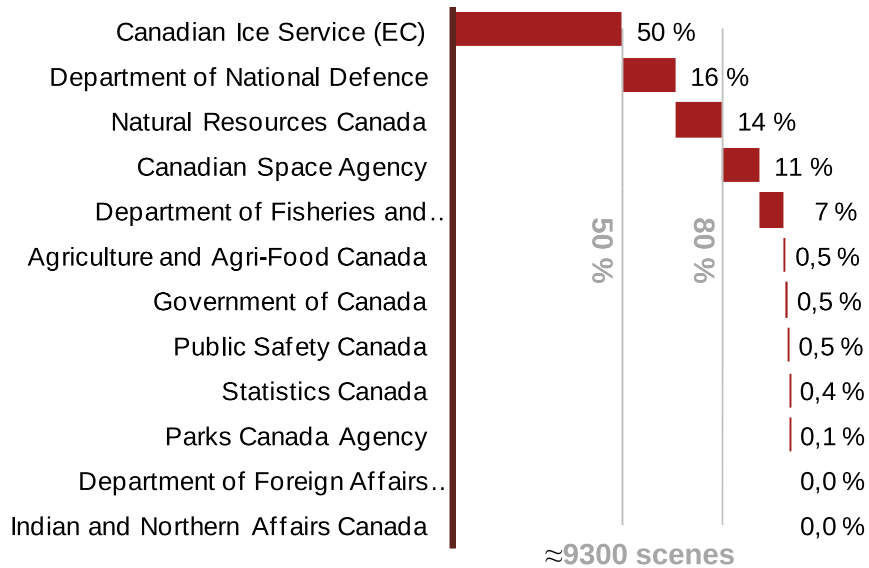
Defense, Geo and Coastal Authority uses more than 80 percent

Figure 1.123: Use of Radarsat-2 data in Norway by agency (2011)



Broadly similar pattern in Canada

Figure 1.124: Use of Radarsat-2 data in Canada by agency (2009)



Source: NRS data; KSAT user needs Radarsat 2011; Evaluation of Major Crown project Government Consulting Service Canada 2009; PwC Analysis

A cost-efficient agreement, but contract included several items unrelated to government needs that raises risks

Cost effective

Commercially, the agreement may have been beneficial for Norway. A fixed fee of USD 10 million was agreed for provision of data to be paid at annual installments upon delivery of data. The amount was not inflation adjusted. A nominal entry fee was agreed. Currency appreciation has since made the agreement more financially attractive for Norway.

Compared to current published Radarsat-2 prices, the price achieved implies a discount of about 50 percent if assuming a customary 30 percent volume discount. Radarsat-2 prices are today determined in a competitive market and are as such indicative of prices form other sources as well.

The financial risks for Norway was associated with risks of not being able to exit the agreement and seek alternative providers if delays.

We cannot determine whether the costs were competitive against other providers that launched at the same time as there were no competition or negotiations with these. The agreement was entered into five years before the satellite was launched. Other commercial alternatives were available at time of launch, but may not have been evident at time of negotiation in 2002.

Contract contained several provisions unrelated to government data needs

- An exclusive European distribution agreement was given to Kongsberg Satellite Services (then TSS);
- Kongsberg is also identified as the exclusive distributor and processor of data to the Norwegian government; and
- Ground station contracts to Kongsberg Spacetec;
- An MoU was also agreed indicating areas of civil and scientific cooperation but without binding financial commitments. There has been little if any follow-up of the MoU for bilateral cooperation.

There was no competitive or open process in choosing the Norwegian firms mentioned in the contract.

There are dilemmas and risks of combining industrial return schemes with those of acquiring the best option for government. These include:

- Questionable benefits for society and increased costs for government; and
- High fiduciary risks and regulatory issues due to selectivity, favoritism and non-competitive nature of process.

There are no straight forward ways to combine such objectives and we would advise to approach this differently in the future. Risks involved are high and may cause unnecessary damage to the space programs. Transparency and competitive procurements are the regulatory default process and we see no reason why this shouldn't be followed in the next acquisition.

Highly relevant AIS satellite program to enhance maritime surveillance successfully launched

Relevance of concept

Ships above 300 mt are required by international regulation to constantly transmit signals of its identity speed and course and other information. This is originally designed as a terrestrial system whereby other ships and coastal stations pick up the VHF signals. Terrestrial systems have limited range and satellite reading of the signals significantly increases the ability to monitor the traffic.

A core rational for the system was to develop a satellite system useful for monitoring purposes for coastal authorities, search and rescue, harbor management and defense. The space center proposal of 2006 calls it a "concept-demonstrator" to cover the Norwegian economic zone and waters further north and east.

It was stated that is the satellite was not to be designed to receive signals form the North Sea and channel areas with more dense traffic as this would require a "much more advanced satellite".

Objectives

Specific objectives for the AIS satellite(s) are not stated in the Parliamentary budgets beyond those generic for the space programs. It is said that the program is an important element of a comprehensive surveillance system for the northern ocean areas.

The specific proposals by the space center submitted to Government articulates a whole range of reasons for the program. Those relate to industrial and political considerations in addition to the core relevance of the program.

Activities

Proposals have been submitted by the space center during 2006-2013 for the existing and planned satellites. Appropriations have been made in annual government budgets since 2007 for the first and second satellites but not yet for a third.

The concept originated in a concept competition in the community whereby participants where invited to propose concepts for national programs. Proposals included other segments such as telecom.

The Defense Research Establishment led and coordinated the project.

The satellite was purchased from a Canadian manufacturer. The AIS receiver was produced by Kongsberg Seatex. The Kongsberg firm had an earlier development contract with the space center in which technologies were evolved. Seatex has also later produced an AIS receiver for testing purposes under ESA development contract. Kongsberg Satellite Services was selected as ground station provider. The satellite was successfully launched in 2010 from India. Expected design life is between one and three years.

Operations are now with the Coastal Authority and integrated into the monitoring system. Coastal authority manages access to applications for other users.

Source: Coastal Authority webpage; MoTI documents; PwC Analysis

AIS system has been enthusiastically received albeit some operational challenges

Results

The coastal authority claims this has been a "small revolution" in monitoring of ocean areas. Vessels can be tracked and their activities investigated. This is reported to have been helpful in determining responsibility for oil spills. The authority uses the data, and integrates it with the terrestrial system.

The satellite revisits north eastern waters every 90 minutes. Coverage in southern Norway is less frequent. Data are downloaded at the Kongsberg Svalbard facility and processed at the Defense Research Establishment before being transmitted to the Coastal Authority.

Data access is restricted to public authorities. The data policy is aligned with that of the terrestrial system. There are commercial applications of these data. Exceptions can be granted if for "useful" purposes.

There are possibilities for integrating AIS data with radar data from other satellites and combinations creates opportunities including for detecting sources of oil spills or ships that are not carrying AIS senders. The coastal and defense authorities have access to such capabilities.

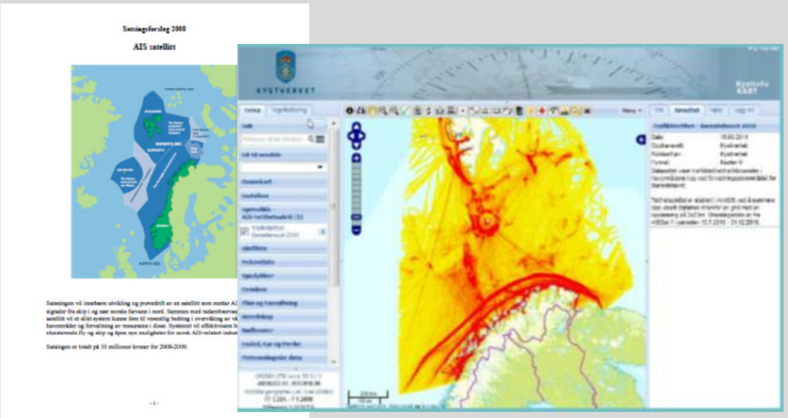
Operational difficulties reported include:

- Very many ships are "lost" in areas with dense traffic.* The satellite is unable to detect all messages from ships in high traffic areas. The ship based senders are designed to work with a terrestrial system which manages conflicting messages. This difficulty is identified in other AIS satellite systems globally and various actors claims to have resolved this in different ways. We don't know how the Norwegian system compares;
- Messages on ship type and hazardous goods are picked up 10 percent of the time.** The system picks up messages on identity, navigational status more consistently (AIS message type 1,2 and 3).;
- AIS applications software difficulties.*** It is reported to have high user thresholds and issues with robustness and historical data management and integration with other data sources i.e. ship registries.

We will review impacts taking into account the integration with Radarsat and other programs in section 2.1

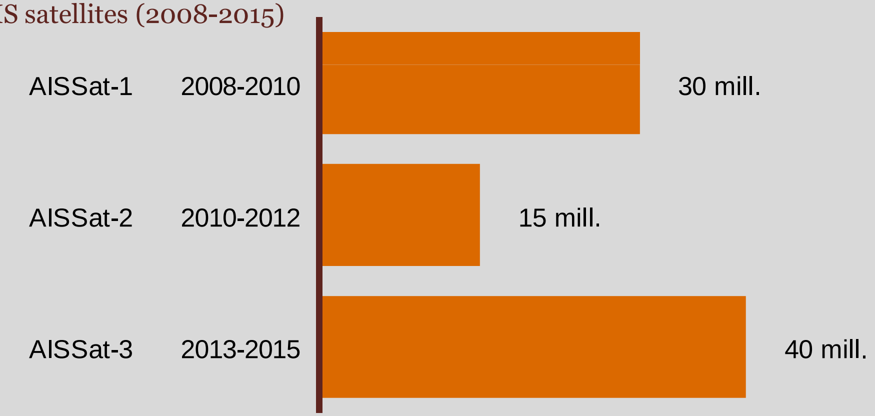
Detects signals from ship mounted senders and enhances coastal authorities monitoring ability

Figure 1.126: Illustration of application



Development costs increases for third generation with a more ambitious program

Figure 1.127: Accrued and planned earmarked development expenditures for AIS satellites (2008-2015)



Source: *AIS User forum, Coastal Authority presentation by senior engineer Aasheim "AIS fra satellitt" page 8; **page5; ***AIS user forum, CA presentation, Kamstrup "Statistikk behov" pages 4,8;CA website and press release re one year anniversary of satellite; PwC Analysis

Questionable life-cycle costs compared to alternatives and this should be properly assessed before further investments are made

There is no economic option evaluation comparing against alternatives including the market options. The proposals for AIS submitted to government over the years contain a number of arguments for developing the system but little specifics on development costs and only indications of life-cycle costs.

The first 2006 proposal had a high level discussion of other terrestrial concepts as alternatives. At that time there were no other satellite systems operational worldwide. The 2012 proposal mentions that they "see a development" whereby U.S. commercial operators would launch systems but assessed the benefits for Norway to be greater without being specific. The 2013 proposal (submitted in 2011) adds that "cost wise it seems to be an advantage compared to if the coastal authority purchases information from commercial actors. No details of costs either for the government project or the market solutions are presented.

Risks for the government option (one satellite) are not discussed but it points too risks for the private operators. "In addition we do not know how persistent the commercial actors will be."

More recently, market options have become an alternative. Both OrbComm and Exactearth have systems with polar orbiting satellites. Capabilities and offerings may vary between them and compared to the Norwegian satellite and it is beyond this study to review the options.

Also of note are the policy developments in Europe. The discussions in Europe are still ongoing and final decisions has not made. ESA claims it is testing the commercially available systems (OrbComm/Exactearth) against European Maritime Safety Association (EMSA) requirements and has does not intend to launch a public system. Member states may decide differently but no decision has been made yet.

Source: NRS budget proposals to MoTI 2008-2013; *SEC 10-K filing ORBC March 17, 2008;**10-K filing **10-K March, 2012;***10-K March 2011; Market interviews; PwC Analysis

Life-cycle costs may not be competitive taking into account cost and quality

Figure 1.128: Illustration of important cost elements

This is only to exemplify some cost elements indicating why this is a relevant problem. A full life cycle cost analysis is beyond this study.

Development costs for the Norwegian satellite are indicated as 30 million NOK (U.S. 5.2 million) for the first satellite. Other costs include earlier development work financed under the space center for Kongsberg Seatex. There is also defense sector funding, especially in earlier design stages and for bridging financing between disbursements from the space funds. Thos costs could be annualized over the expected lifespan of the satellite indicated at 1-3 years in the proposals.

Recurring costs are in the original 2006 proposal indicated at about 4 million NOK annually. It is not specified further. These may be costs related to the monitoring of the data stream.

Alternatives in the marketplace for AIS satellite data streams are priced between 0,3 and 1,2 million USD (1,8-7,2 million NOK) annually depending upon specifications of the service (i.e. regional/global). These are price estimates from the actors provided to PwC. All providers have arctic coverage though number of satellites and revisit times vary. 5+ satellites in polar orbit is available from one system. There are currently two providers actively distributing service and more actors with service offerings in preparation.

There are other **qualitative** elements that would enter into such an assessment. The market options offer better number of satellites, revisit times, quality of data from areas dense areas, and redundancy of the systems.

On the other hand, sovereign control of the infrastructure and the data stream would have value for the Norwegian government. This has to be assessed against increased cost, poorer quality and higher risks.

In total, advanced, integrated and user responsive ocean monitoring system, but considerations to institutionalize financing may be necessary

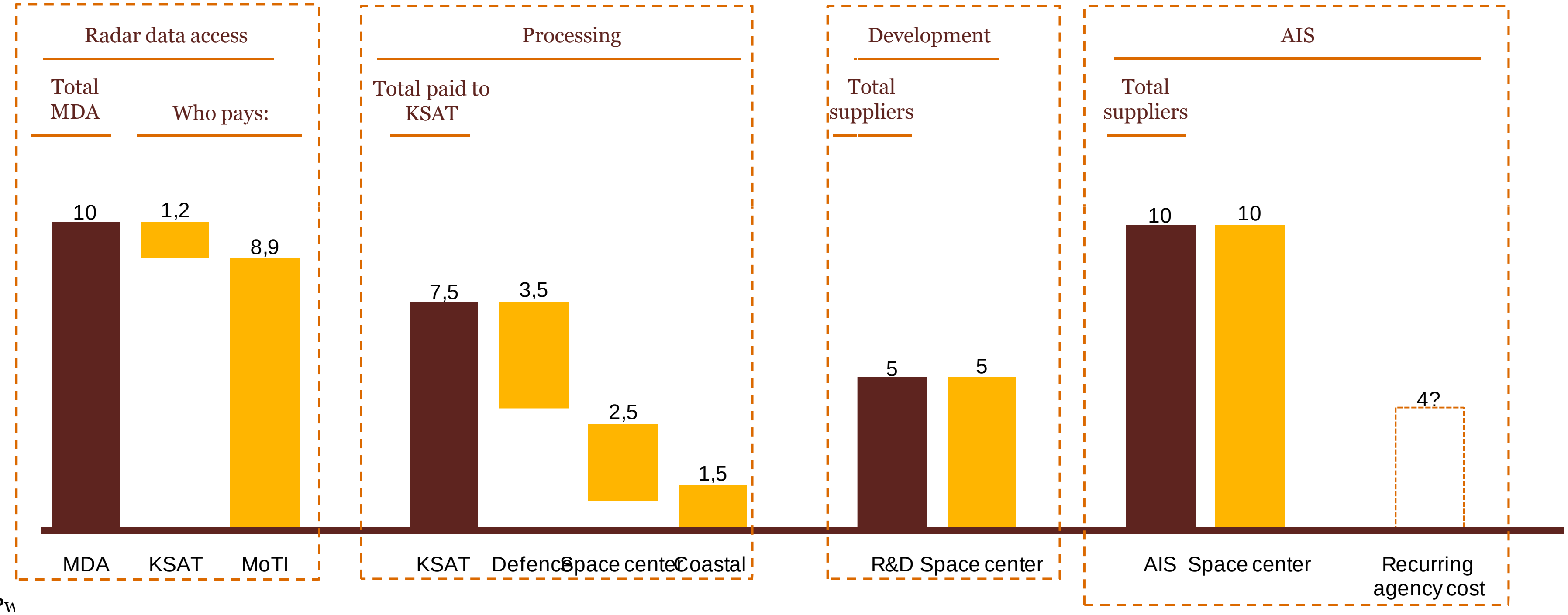
This is to indicate the total costs of running the monitoring and surveillance systems. These will be compared against the benefits later in this study. Costs are budgeted for under a number of different chapters in government budget. Most are under the space program chapter of the MoTI budget. Not all are explicit i.e. the annual allocation for KSAT processing costs (2,5 million) is budgeted as a National support grant.

Longer term: Funds that are essential for maintaining operational capabilities should be identified and made explicit in budget. This would help prepare for longer term scenarios whereby services are institutionalized and are no longer related to the objectives of the space programs. These are costs are for acquiring essential services cross government and should be identified as such.

1. Data access for radarsat-2 data. This includes funds for MDA and a payment from KSAT who has been given privileged access to data and reimburses government.
2. Processing costs to KSAT shared between users. Space agency funds used to pay KSAT to cover costs for smaller users.
3. Development funds under the national service program
4. AIS development costs annualized and recurring costs (estimate)
5. Other agency recurring costs for applications and monitoring.

Approximately 32,5 million NOK in total annual cost excluding other agency recurring costs and provisions for other sensory information

Figure 1.129: Approximate flow of funds for maintaining ocean surveillance capabilities



Largest national program is for military communications but with limited involvement from Norwegian space firms

We include a short overview of this program. It is a sizeable national program and important for the context of the analysis. This program is beyond the scope of the analysis, and the space programs under the purview of the Ministry of Trade and Industry.

A dedicated defense satellite will be developed to serve the communication needs of The Norwegian Defense Forces. Its constructed as a public-private partnership where the commercial operator assumes financial risk and is responsible for commercializing sales of excess capacity. Spanish firm Hisdesat owns 60 percent and the Norwegian defense logistical corporation 40 percent. Investments for Norway at about 1,3 billion NOK with the Spanish partner covering the rest. Launch is expected in 2014. The satellite will carry 40-50 transponders and excess capacity will be leased on the commercial market. The program also includes about 300 terminals for land, air and maritime forces in addition to ground equipment.

Three important issues to note:

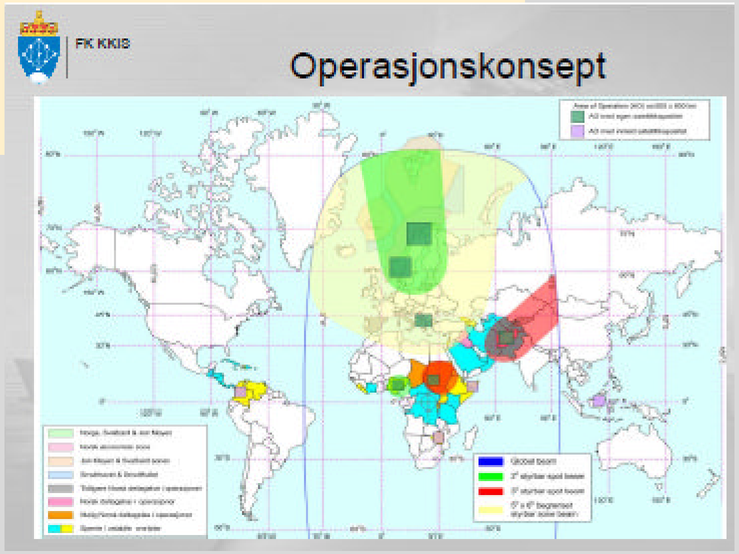
- First, the choice of concept is based upon formalized cost-benefit assessments whereby several models have been considered including short- and long term leases. The conclusion was that an owner/operator model with commercial sales of excess capacity would involve lowest risks, investment and life-cycle cost.
- Second, the public-private-partnership concept is comparable to that of the British Defense Ministry that is established with Skynet-5. Several providers were invited to bid and Spanish Hisdesat was found most attractive. This included provision of an orbital slot for the geostationary satellite. The procurement process and choice of partner caused some controversy in Norway in that Norwegian industry was largely excluded.
- Third, the arrangement is reported to include sales of military hardware and other offsets in a broader military agreement between the two countries in which the satellite is only a part. There is expected to be industrial contracts for Norwegian space industry and a procurement concept has been developed.

HisNorSat will serve most of the needs of a future networked defense system

Figure 1.130: Illustration of needs met by HisNorSat

Defense SatCom needs are expected to "explode" as networked concepts are deployed. The program is expected to meet most of these requirements with some exceptions:

- Arctic coverage is limited and there will be continued leased capacity for these purposes
- F35 needs will be handled by other system most likely the U.S. Mobile User Objective System under development by the Pentagon
- UHF capacity from the NATO systems (leased from a.o Astrium services)



Source: Press, Parliamentary papers, and publically available presentations of the program; PwC Analysis

Section 2

Policy effectiveness

There are three objectives of this section:

I. **Understand impacts. A**nalyze what has happened as a results of the programs. What real difference has they made? This focuses on three areas:

- Space industries.
- Public sector impacts.
- Socio-economic.

II. **Determine accomplishments vis-à-vis policy objectives.** This analysis will determine the degree of success of the space programs in reaching the stated policy objectives. Two issues of focus:

- Relevance. This is assessing to what extent the activities are suited to purpose.
- Effectiveness. This is about assessing whether the objectives has been achieved and what are the major factors impacting achievement of objectives.

III. **Identify governance risks, mitigation strategies and critical enablers**. This will focus on two areas:

- The framework for determining objectives, allocating activities and resources and measure and report on progress; and
- Governance and fiduciary risks.

Section 2.1

Impacts

The objective of this analysis is to analyze what has happened as a results of the programs. What real difference has they made?

We focus on three areas:

I. **Industry impacts**. We discuss impacts by segments and over time. How has their business evolved? How important are the public development funds and contracts? Are there ripple effects and tech transfer? What's the growth, the employment and the profits?

II. **Public sector impacts.** Many activities has targeted utilization of satellite capabilities in the public sector. We review what impacts are seen.

III. **Socio-economic assessment**. A deeper analysis of how the programs contribute to economic and social development. How does the costs transfer into broader societal gains? What would have happened in the absence of the space programs?

Industry impacts

Supported firms have declining share of total space sales in Norway

Firms that are supported by public funds and has contracts with ESA has seen a decline in overall space related turnover of the last 15 years. During that time we have seen an increase in the ESA contracts for that same group but the ESA share remains small.

Sales of space related firms that do not receive support has seen an increase over the period. We should keep in mind that all this takes place in a context where there has been a real decline in commercial space sales over the last decade.

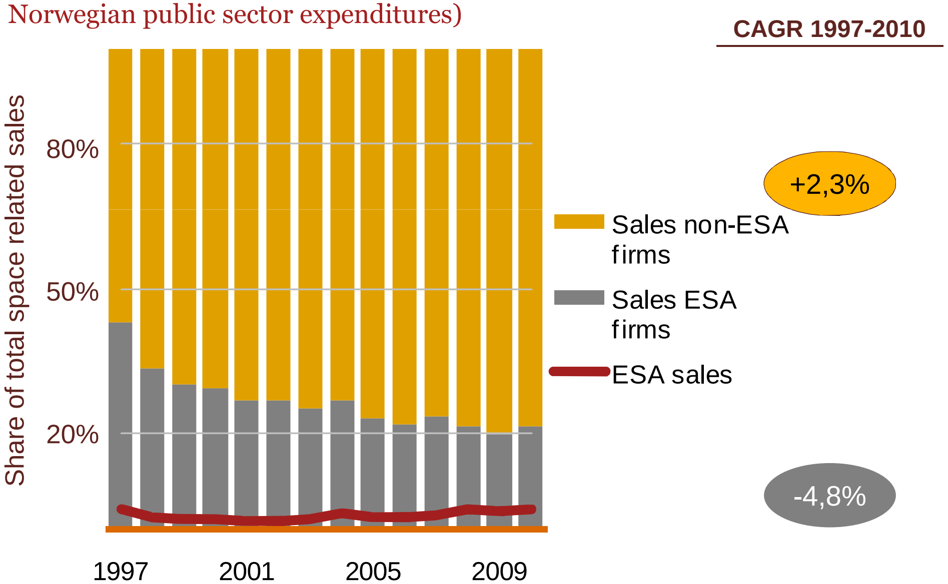
Firms that receive public support typically target different markets segments than those that operate outside of the institutional markets.

All upstream firms receive support and engage with ESA, i.e.. manufacturing of launchers and satellite components; while there is much less institutional activity from firms that operate in the downstream segments i.e.. satellite communications service segments.

This reflects the demand structure of ESA where most of the Noorwegian public support is are directed.

Supported firms have declining share of total space sales

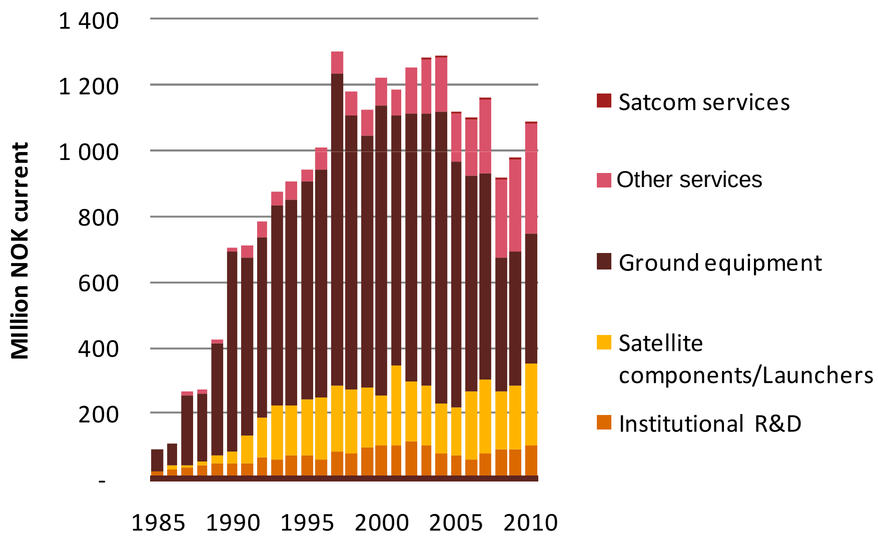
Figure 2.1: Share of total space related sales 1997-2010 (excluding Norwegian public sector expenditures)



Source: Basis is NRS 2011 ripples survey data; adjusted for sales of two large service companies with only nominal ESA engagement; also made adjustments to T&T historical data.

Ground equipment producers feature strongly among the supported industries, Satcom Service providers are absent

Figure 2.2: Space related sales by value chain segment for ESA firms in Norway (1985-2010)



Sales to other sectors is more important than space sector for supported firms

Most firms that operate in the institutional segments have other business outside of the space markets. There are only a few producers that are entirely space focused.

The share of space related sales have generally fallen over the last decade for these enterprises. This can indicate a shift in focus and lack of alignment in corporate strategy with space markets, or it can indicate faster growth in other segments.

It should be noted that much of the sales increase over the last five years is attributable to Kongsberg Defense Systems, a large business unit within the KG group that has seen much growth. However, the pattern still holds if adjusted for KDS sales indicating that this may be a broader based development.

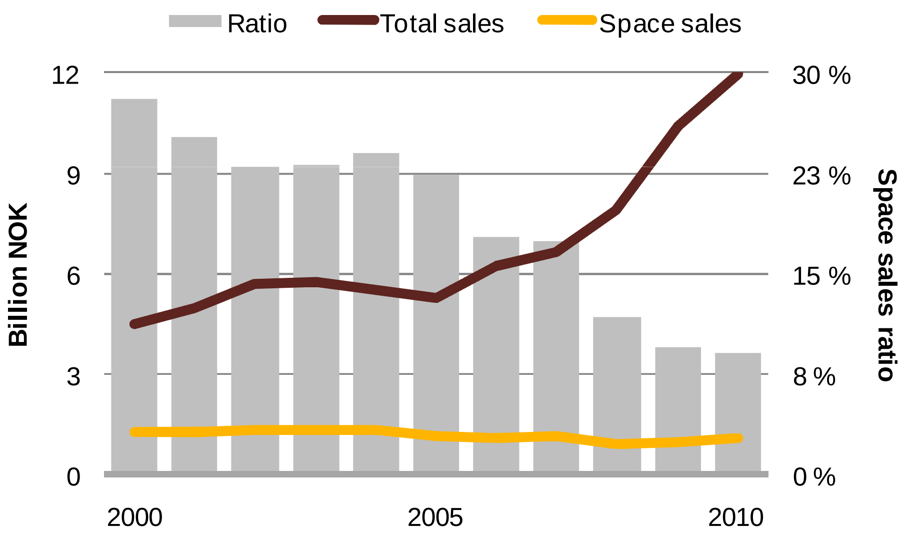
The specialized producers contribute more to overall space sales. There are 4-5 enterprises serving the institutional space markets that have very little sales outside of the space markets. These are also the same firms that contribute most to total space segment sales.

One company in the sample is off the chart, Nera Satcom which have contributed as much as 40 percent of total space related sales during 1985-2008 before production closed in Norway. This lifts the average line indicated in the chart below.

Due to the significance of Nera in the statistics we will present a few of the following metrics indicating how the “surviving” companies have performed.

Ratio of space related sales has declined

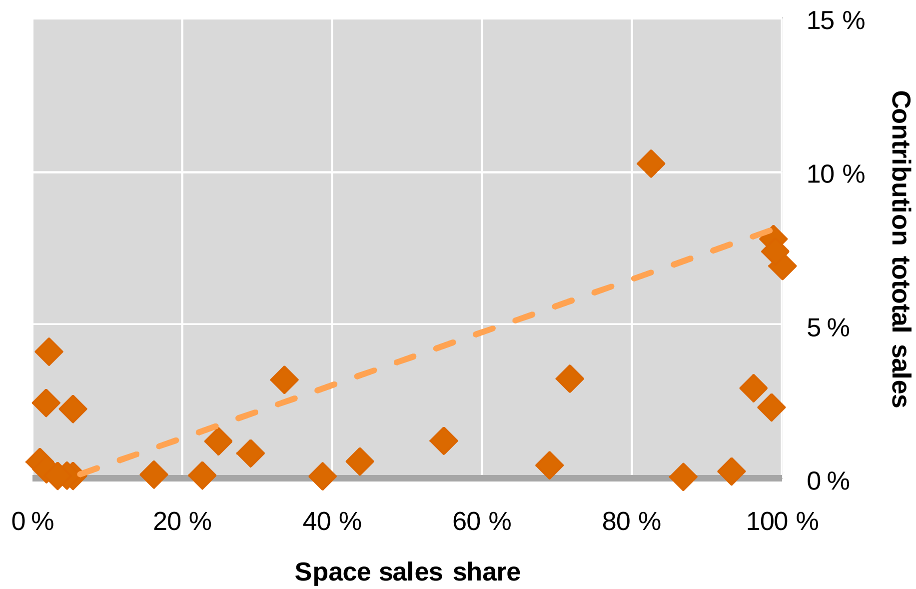
Figure 2.3: Ratio of space sales compared to other sales for industries that engage with ESA (2000-2010)



Source: Basis is NRS 2011 ripples survey data; adjusted for sales of two very large non-space service companies with only marginal space involvement over the last decade.

And specialist space firms contribute more to overall space sales

Figure 2.4: Share of space related sales and contribution to total space sales in Norway for ESA firms (1985-2010)



Declining sales for supported firms and not employing more people

Space revenues have declined overall in particular during the last five years for ESA firms. This is much due to the collapse of a few companies.

Its encouraging that there is robust growth, both in nominal and real terms, for the surviving firms. This growth has been consistent since 1985 at an annualized growth rate of about 16 percent.

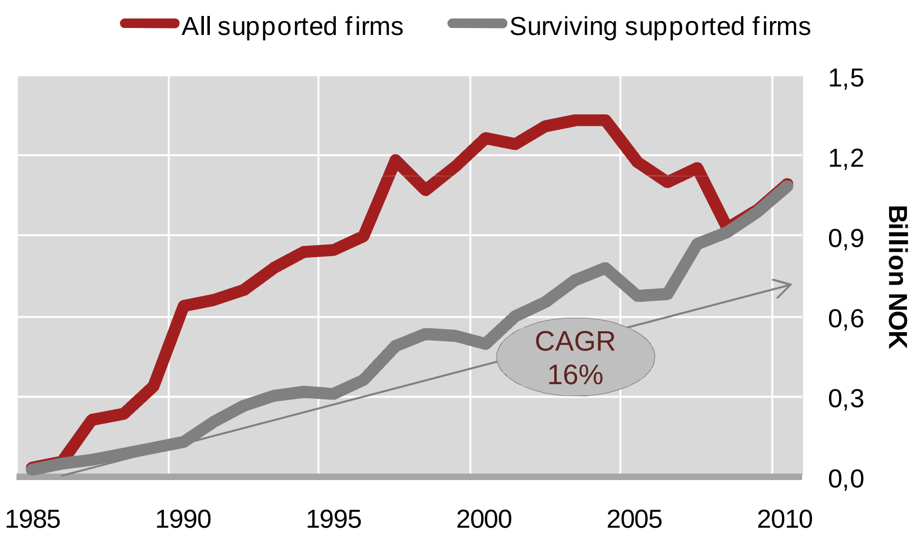
The overall success of the policy may still have to judged on the basis of the total, but it is promising for the future that these firms show such robust growth. It should be noted however that prior to 2003 there were few indications that there were underlying problems for the whole group which grew even faster at that time.

Given this increase it seems peculiar that employment has not picked up even for the surviving firms. Overall there is a decline since the late 1990's having nearly lost half of the employees that were involved at the peak.

The surviving firms show a flat trend over the last 15 years. On the positive side this could indicate considerable productivity increase as revenues have increased in real terms during the same period. The impact on wealth creation will be a function of how wage cost and profits have increased and are distributed. Wages have increased but we do not know if they have kept pace with the sales growth. Profits have increased in absolute terms though margins have stayed at about the same levels as we will see below.

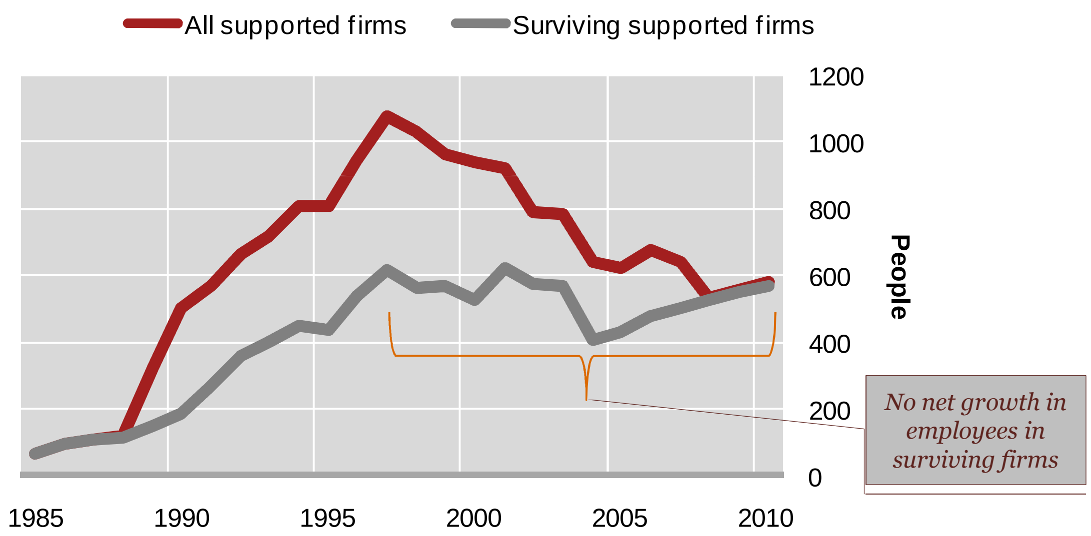
Robust growth for surviving firms

Figure 2.5: Space revenues for ESA firms (Billion NOK nominal)



Employment has not increased over the last decade even for survivors

Figure 2.6: Space related employment for ESA firms (1985-2010)



Source: Space Report 2011; Company Investor information; Press reports

ESA contracts are becoming less important for space sales for supported firms

ESA contracts have increased over the last decade nearly doubling. This growth rate is well above the inflation and thus indicating growth in real terms. It is also faster than the growth of ESA budgets overall indicating that Norwegian firms have taken a larger share of the ESA market.

Adjusted for inflation the contracts values have still not reached the peaks seen in the mid-nineties. This probably needs to be understood in the context of Ariane-5 developments. The launcher development had significant development contracts at that time. Ariane-5 production contracts are now technically recorded as commercial contracts. It also reflects however that some of the companies active with ESA at that time have since succeeded in commercial markets beyond launchers. The implication is that the real increase over the last decade is also due to increased competitiveness in more product categories.

As share of total space sales we see that ESA contracts peaked significantly in the mid-nineties. At that time the large ESA contracts were for firms involved in launchers and satellite components, mostly Nammo, Kongsberg KDS and Norspace. There has been some increase in the ESA share since 2002.

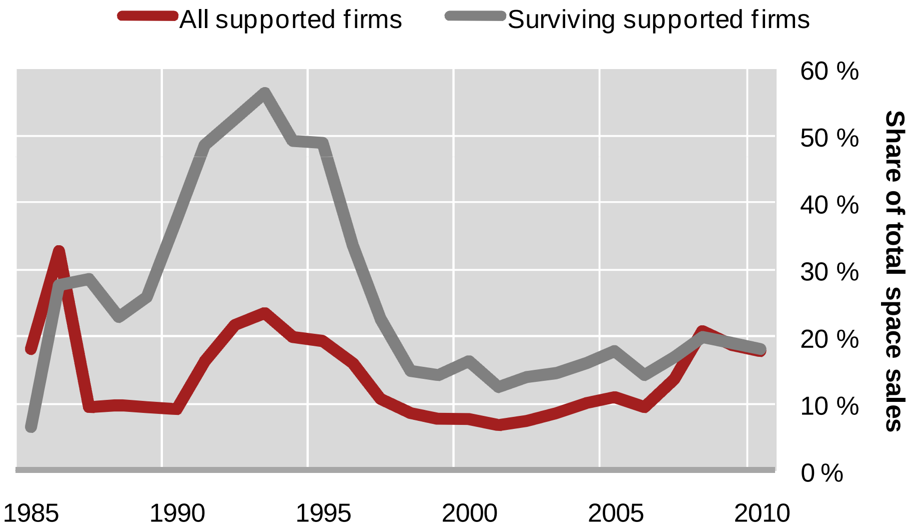
The reduced share may also indicate that firms that have engaged with ESA in the later periods have been less dependent upon the institutional markets. This applies mostly to the ground equipment producers and the service segment.

ESA contracts peaked in mid-nineties but have picked up again over the last decade

Figure 2.7: ESA contracts 1985-2010 (NOK nominal)

Importance of ESA contracts have increased over last ten years after significant importance in initial years

Figure 2.8: ESA contracts as share of total space revenue for ESA firms



Source: NRS data; PwC analysis

The public contributes half of ESA active space organizations development costs

Organizations that receive public support are heavily dependent upon public development financing. Public sources finance more than half of development expenditures.

We also note the increased significance of Space Center development funds which have been nearing 20 percent of totals in the last few years. These funds are mostly captured by commercial players.

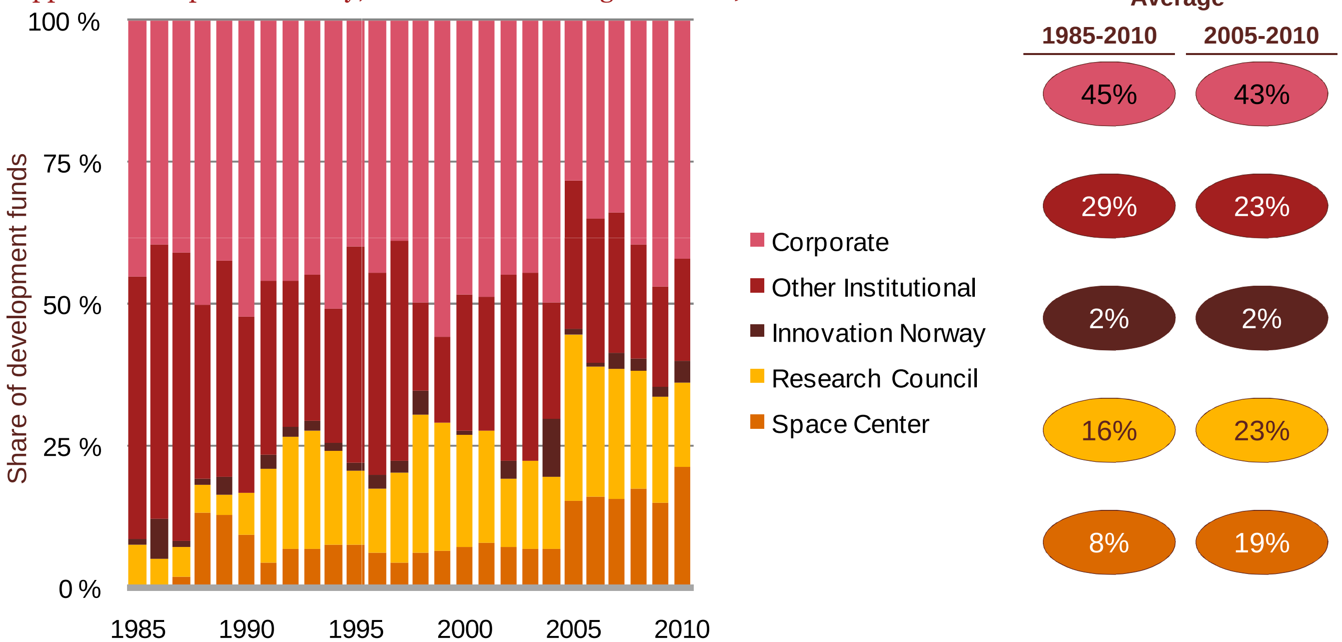
Somewhat surprisingly perhaps we find that resources from the Research Council are quite high and have also increased in the period. These amounts are above the levels of the space chapter of the Research Council budget indicating that firms tap into other programs as well. This funding is mostly captured by R&D institutes. These are institutes who perform development work for private and public clients. Basic science organizations are not included.

Pure commercial players have a higher corporate contribution above 50 percent in total.

Innovation Norway support is insignificant.

Organizations with ESA contracts are very dependent upon public development costs

Figure 2.9: Development funds for ESA active organizations (Includes R&D institutes with applied development activity, not basic science organizations)



Source: NRS ripple survey data; PwC analysis. Category "Other" is assumed to be mostly ESA development contracts or EU FP's. Details are not known.

Public development support is a significant, but declining as share of profits

Public support has however become a less significant share of overall space sales for firms that operate in the ESA market. We note the very high ratio during the eighties. This is at the time when targeted industrial support for space manufacturers started and it is evident that this stage of their development was heavily supported.

The share has been about 10 percent over the last decade with no clear trend evident. The declining share may also be seen as a success of the support provided in the initial stages: It may however also indicate that there has not been a renewed effort of the type that was seen 25 years ago.

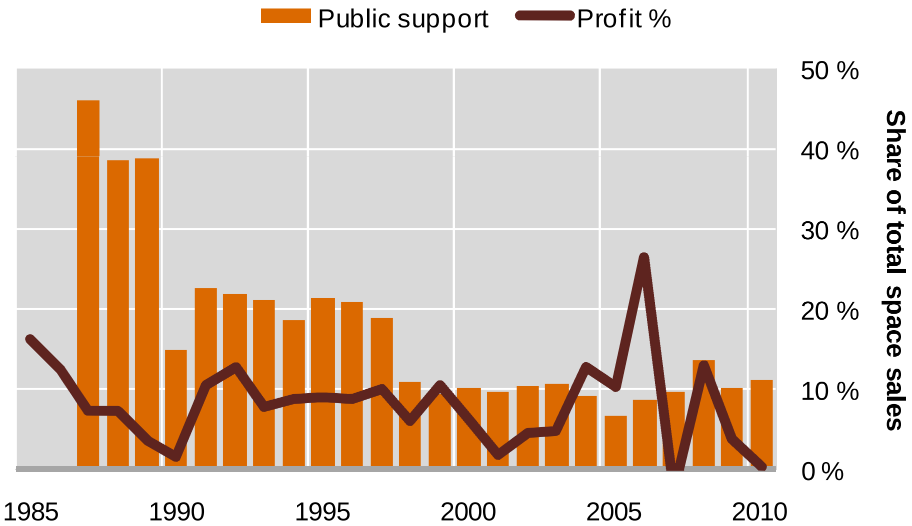
Profits have not been very high compared to what is seen in other segments of the value chain i.e. services. No pattern is clear except increased volatility in the last five years. Profit percentage is generally below 10%. R&D institutes are not included in this calculation.

In the early years of Norwegian space manufacturing development, the public development costs far exceeded profits. This was a heavily subsidized venture. The ration quickly fell however as core products were developed and sales growth started.

The ratio is currently in the area of 35 percent of profits indicating that the industry is still supported significantly compared to many other industries. The longer term trend is downward sloping.

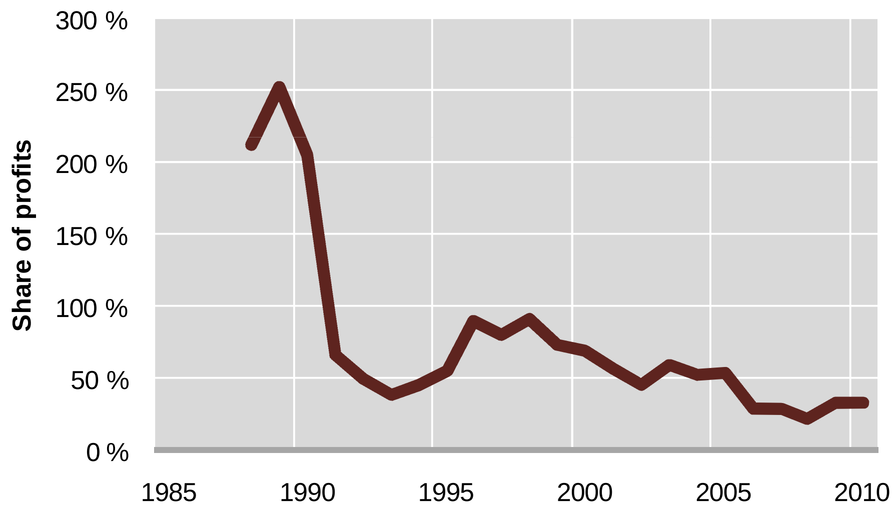
Public support declines as share of total space sales

Figure 2.10: Public support as share of total space sales for ESA firms; profits as share of space sales (profits for subset only, 3 yr moving average)



Public funds constitute 35 percent of profits

Figure 2.11: Public development support as share of profits for ESA firms



Source: NRS ripple survey. Profit numbers should be interpreted with some care. R&D institutes not included. We have made manual adjustments to the reported data to adjust for broken time series and eliminated extreme (negative) values based alignment with official business registry information. The impact of correction goes in the positive direction.

Some organizations work with ESA without NRS funds but these have a low share of total financing

There are intentional linkages between NRS funds and ESA contracts. One aim of the NRS funds is to help businesses qualify for ESA contracts. It should be noted however that much of the increase in NRS funding over the decade is linked to other purposes than industrial development and recipient entities may have less commercial inclination and ability to compete within ESA.

Business and R&D institutions regards the NRS funds highly and claims it helps them position for ESA contracts. Initial technology development can commence this may help business enter European institutional markets.

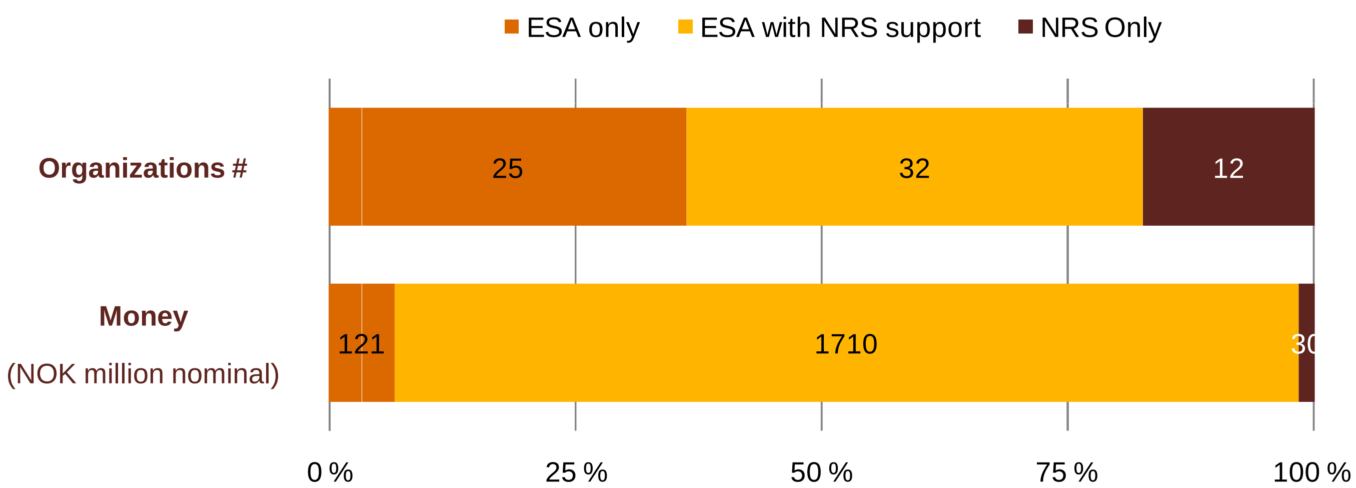
Quite a large number of organizations engage with ESA without having any involvement with the NRS funding schemes (36 percent of organizations). A small subset also engages exclusively with the national schemes.

Moneywise those who engage with both schemes receive the largest share. The shares for those who are not involved with NRS schemes is only about 7 percent although in terms of organizations their ratio is about 36 percent.

Next we turn to a review of how the distribution of ESA contracts and NRS funds appears for those organizations who receive both.

Many organizations carry on with ESA without NRS financing, but the big money is with those who use both

Figure 2.12: Number of organizations with ESA contracts and NRS support 2000-2010



Source: NRS ESA NRS data; PwC analysis.

Those who receive most ESA funds also receive much NRS funds

Among those who receive both NRS and ESA funds we can conceptualize the linkages by dividing the organizations into four equal quadrants along two dimensions:

- All organizations are classified with regards to whether they have received more or less than the median of NRS funds; and
- By the ratio of NRS funds to ESA contracts. Lower ratio means "better value for money" for NRS funds.

We should keep in mind that a subset receives ESA contracts without NRS funds whatsoever, and another subset receives only NRS funds. These are not included in the calculations. Concept and results are visualized below. Scales are logarithmic as the range is otherwise to large to scale properly.

Distinct patterns emerges.

-The laggards receive about 44 percent of NRS funds yet only 12 percent of ESA contract volume;

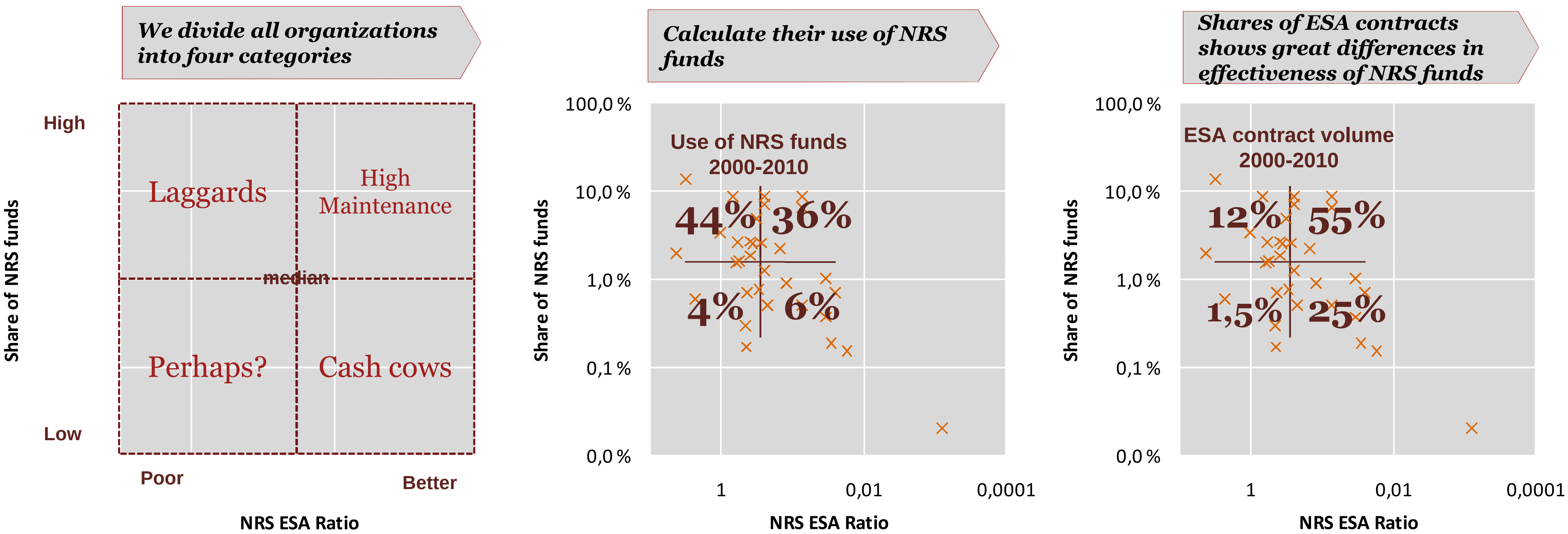
-High maintenance firms receive 36 percent of NRS contracts but nearly 55 percent of ESA contract volume;

- Cash cows sees only 6 percent of total NRS funds yet sees 25 percent of ESA contracts.

-- A group of smaller beneficiaries of NRS and ESA funds may or may not move to other categories in the future.

There are distinct differences across value chain segments and we will now turn to review these.

Figure 2.13: Distribution of NRS funds and ESA contracts 2000-2010



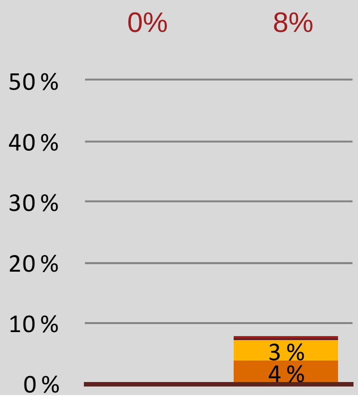
Source: NRS ESA data, PwC analysis

Share of: NRS financing: ESA contracts:

NRS financing: ESA contracts:

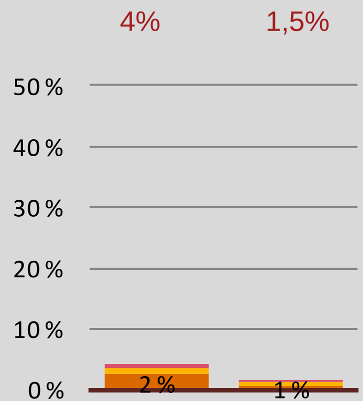
ESA only

Those that engage directly with ESA are some **institutional R&D** and **satellite components** manufacturers. Overall ESA contract volume is about 8 percent.



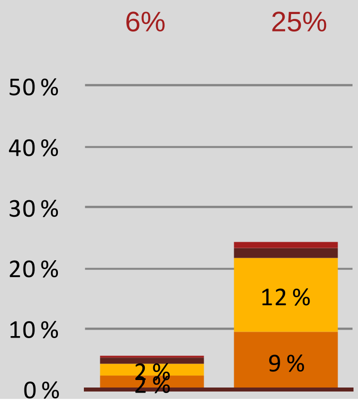
Perhaps?

Hard to say how this will develop. Small **Institutional R&D** who receives some NRS funds and a lower proportion of ESA funds.



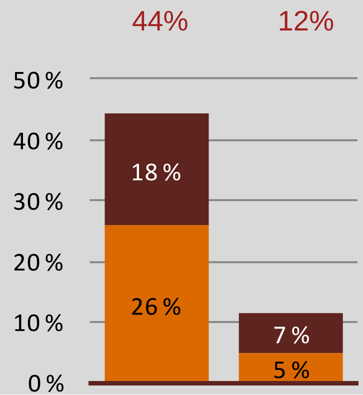
Cash Cows

These are also mostly satellite **components** and **institutional** R&D.



Laggards

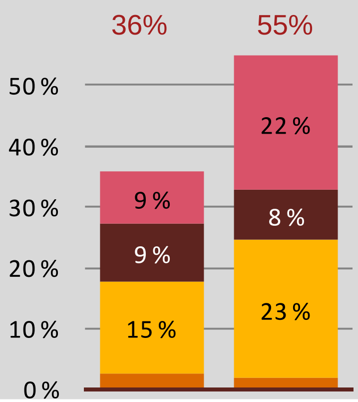
Large share of **institutional R&D**. These are other types of R&D organizations than those who have better NRS to ESA fund ratio. They are more public in their orientation and less industrial focused. The commercials here are **ground equipment** manufacturers which receives much NRS funds but less share of ESA contracts.



High maintenance

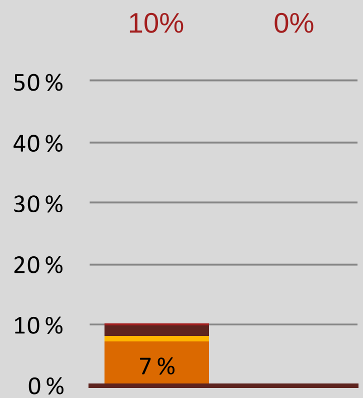
Mostly pure commercial players in this category.

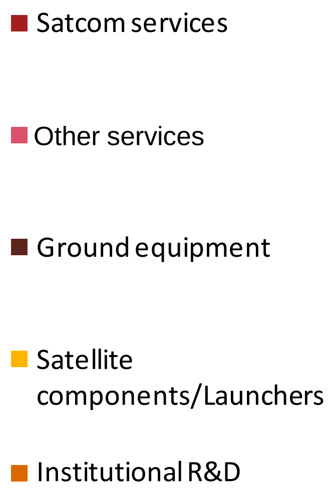
The **Earth observation** services feature heavily here. A large share for **satellite** components/launchers and some **ground equipment** producers.



NRS only

These are almost exclusively institutional R&D but one or two commercial firms in satellite component or ground equipment segment.





Understanding the ripple effect of ESA support

A key metric to gauge the success of the support schemes is the “ripple effect”. This attempts to measure additional sales generated by the ESA and NRS funds. Data has been collected since the beginning of the schemes, through a consistent methodology, and allowing for understanding the impact over time.

While some countries have adopted similar approaches we don’t find that the concepts are directly comparable. A recent OECD reports has a slide where it presents these findings and Norway is ranked very high on this only second to the U.S. The underlying methods differ however, quite much, and we cannot compare these prima face.

It is possible that the ripple effects reported in Norway are actually higher as Norwegian industry was mostly an “infant” space industry when this started. We would expect much impact in the early stages. That may not however entirely explain why the multiplier is currently nearly twice the levels observed in other countries and rising which doesn’t correspond with other findings on sales growth and market shares.

The equation aggregates sales from 1988 and support from 1985. A three year shift is introduced to take account for lag times. Companies are surveyed annually.

Methodologically some issues should be noted. An important difficulty is that we do not know how and if, firms have **discounted** the impact of ESA support over time. i.e.. is support from 1985 attributed 100 percent to sales in 2010 or not? And would it be reasonable to attribute the whole amount over such a long time period? Possibly not, but the key difficulty is that we don’t for sure whether firms implicitly report with a discount, or what an appropriate discount rate would be.

The numbers need to be **adjusted for inflation** Currently the schemes compares values of a 1985 kroner with a 2010 kroner and this is incorrect. Unadjusted this will overestimate the multiplier. We present adjusted values on the next page.

There are also possible self reporting biases but no alternative information exists and this is as good as it gets.

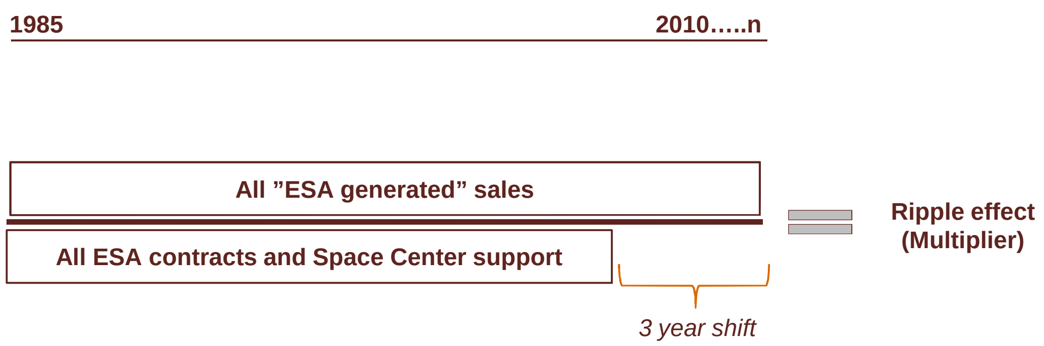
Regarding **interpretation** it is important to note that increases in sales are not identical with wealth creation. The latter, which is the objective of the policies, is a function of profits and labor costs.

A second point is that since the equation aggregates values over (increasingly) long time periods, it will become (increasingly) less sensitive to annual changes in outer years. Its “response time” will be slower. Its usefulness as an indication of impact of current policies, to pick up changes in recent years, will be increasingly limited. We recommend it should be supplemented with a shorter-time approach to allow for a better short-time feedback mechanism.

The indicator features centrally in policy discussions including in parliamentary papers. Some care is warranted in its presentation to ensure that it is made clear that it is only an indication of ripple effect for commercial firms that receive ESA contracts. It is not an indicator of the full money cycle of support to ESA or space programs in general. ESA has overheads, the industrial return is less than one, and other than commercial actors also receive ESA funds. This leads to a net impact of total space support that is lower than the multiplier alone indicates.

The ripple effect equation takes account of all sales and development support since 1985

Figure 2.14: Illustration of ripple effect equation



Considerable ripple effects are reported, on both space- and non-space related sales

Considerable impacts are observed. The multiplier is at **4,3** currently (2010) adjusted for inflation. There is a trend increase since the late 1990's, having declined in the first decade.

This could be an indication that space production does have tech transfer impacts or that ESA engagements successfully work to qualify firms for commercial space markets. The indicator is supplemented by a range of anecdotal examples that seem to support the concept. Few firms report little or no ripple effect and we will review the distribution on the next page.

The impact of inflation adjustment is not dramatic but lowers the estimated value from 4,8 to 4,3 (2010). It would be important to introduce inflation adjustment for future presentation as the impact of unadjusted values will increase over time. We have used PPI for manufacturing as this is representative for where most funding has been.*

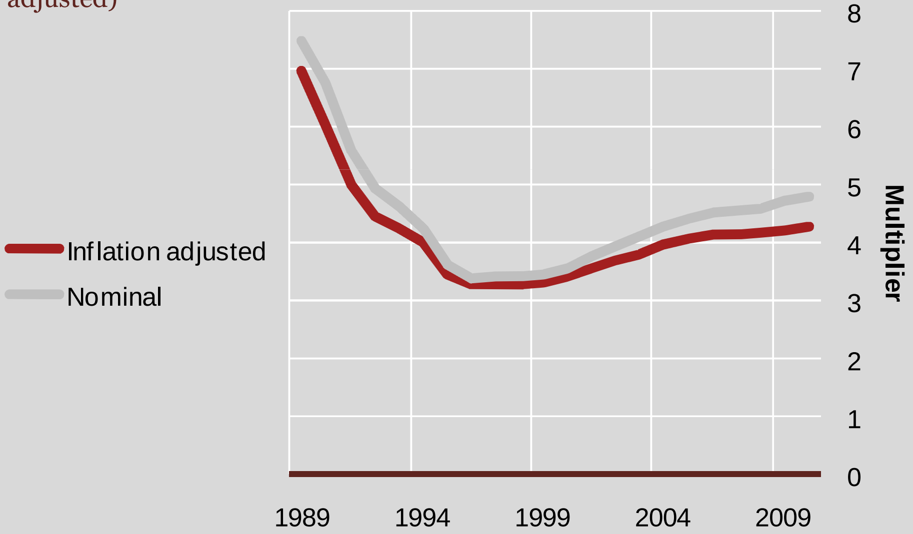
The impacts can also be measured with regards to space – non-space sales. It seems there is some more impact on space sales with a slight decline observed over the last decade. The impact is currently close to 50/50 meaning that ESA contracts are likely to bring about additional space sales of about 2,2 times the contract amount.

The numbers are remarkably consistent. We should keep in mind that the survey respondents have remained nearly the same throughout this period (about 27).

It does not seem that the ESA ripple effect can explain the relative increase in non-space sales growth as the multiplier for non-space sales have remained nearly constant. As we recall, the share of non-space sales have increased significantly more than space sales in the same period for the surveyed firms (see p 159). These could be sales unrelated to the ESA contracts.

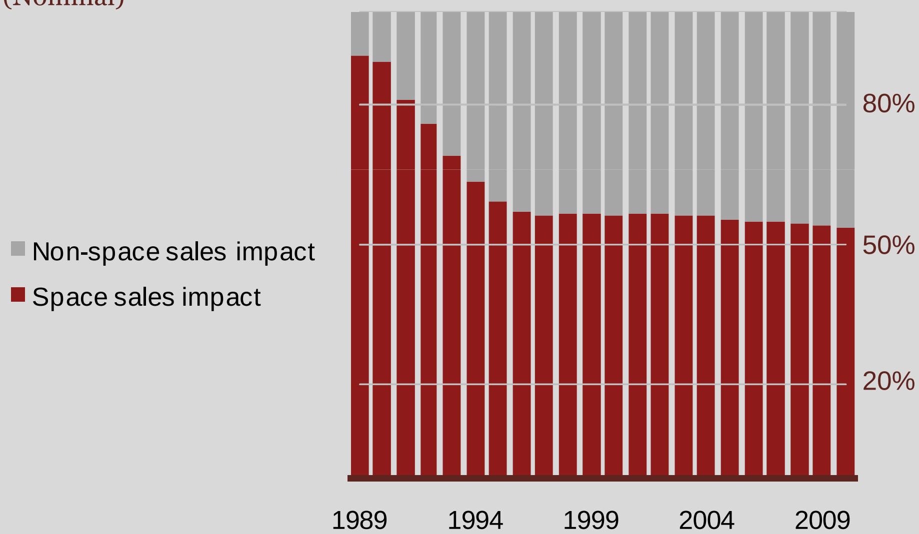
Considerable, and increasing multiplier impacts

Figure 2.15: Ripple effect multiplier 1989-2010 (Nominal and Constant PPI adjusted)



More impact on space sales multiplier

Figure 2.16: Multiplier for space- and non-space sales 1989-2010 (Nominal)



Source: NRS ripple survey; PwC analysis; PPI manufacturing adjusted (Eurostat). * PPI manufacturing index may overestimate inflation on ground equipment prices but would be representative for space manufacturing and possible also services.

Firm median ripple effect at 3,5 compared to 4,3 for the total

Some range is seen in the distribution of impacts. Most firms however fall within proximity of the average at 4,3. There are some firms that report little or no impact, and there are a few that report significant multipliers i.e. 20 and 40.

We should keep in mind that the methodology has a certain positive bias. Negative impacts are not possible. Firms that have lost money on ESA contracts, and not seen ripple effects, will have a negative impact but this will not be picked up here. There is no indication that negative impacts are significant though they may exist.

The frequency distribution of number of firms and total sales is quite close also indicating that the multiplier is quite consistent across the respondents. Seventy-five percent of firms, and similar on value basis, reports a multiplier less than 5 (nominal). The outlier firms with multipliers above 10 constitute about 10 percent of total value of sales generated.

Firm level analysis may be a better indication of the expected value when engaging to support a particular firm. This reveals some distance between mean and median numbers indicating the distribution is somewhat skewed as can be seen on the scatter plot.

The median value shows that half the companies have multipliers above/below this particular value in a given year. The mean number shows the arithmetic average of all multipliers in a given year.

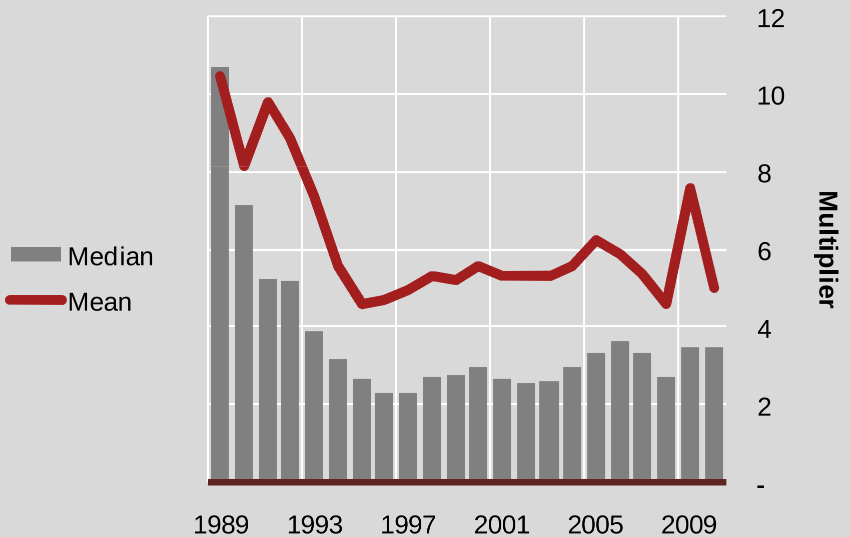
The mean value is quite sensitive to the two outliers. Beyond those two companies with extreme multipliers the mean and median values are quite close and at about 3,5 currently.

Most firms report within a similar range, but there are a few significant outliers

Figure 2.17: Ripple effect multiplier by firm and total ESA generated sales 1985-2010 (Nominal)

Firm level data shows more variation and lower median values

Figure 2.18: Firm level mean and median multipliers (constant 2010 PPI)



Source: NRS ripple survey; PwC analysis; PPI manufacturing adjusted (Eurostat). * PPI manufacturing index may overestimate inflation on ground equipment prices but would be representative for space manufacturing and possible also services.

Services multiplier rising fast and ground equipment sliding

The multiplier shows divergence across different value chain segments. There are differences in levels and shifts over time. The key shift is between Services and Ground Equipment whereby Services are rising fast and Ground Equipment is sliding.

Note that the services shown here include only Earth Observation Services. High growth communications services firms have received some support but do not respond to the annual ripple effect surveys.

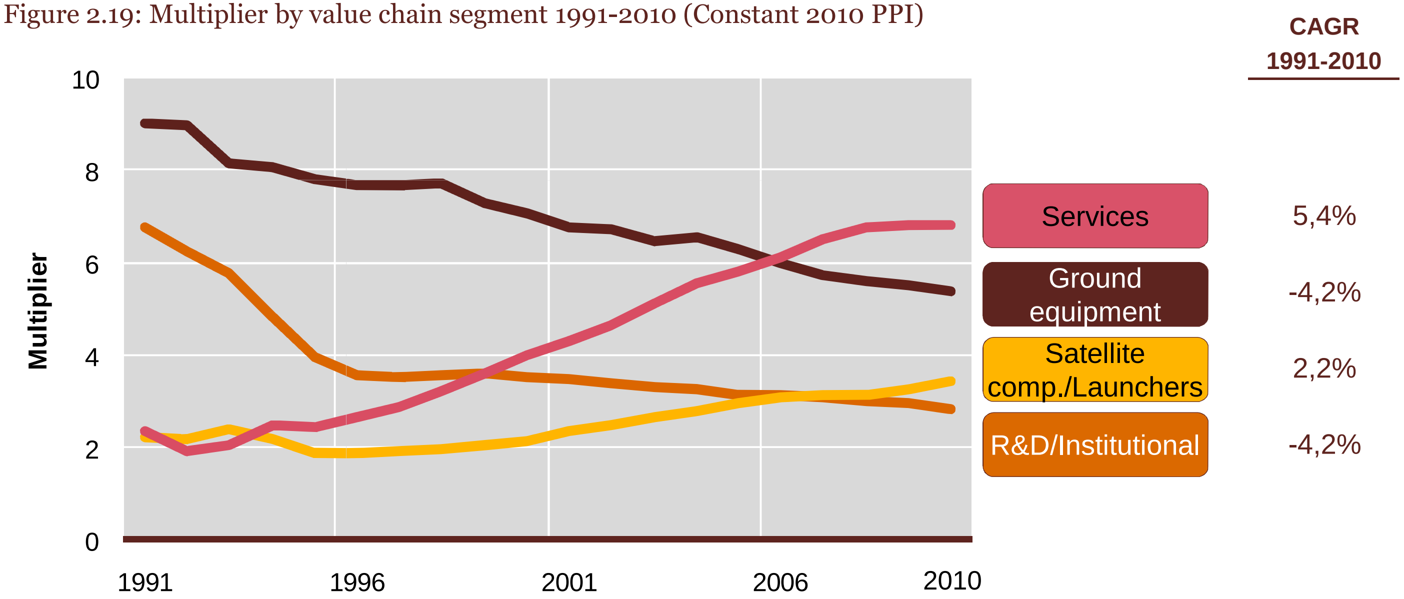
Satellite components and Launchers have seen a rise although at lower levels than the services segment.

R&D multiplier is also sliding. These are R&D institutes who are engaged with much applied research funded through public or private sources. Their additional income may stem from other public financed programs, i.e.. FP7, or industrial sources. These institutions capture about 28 percent of the ESA contracts for science/institutional R&D. The other 72 percent is captured by science or public agencies.

Scientific institutions and public agencies with ESA contracts do not have ripple effects of this nature i.e. increased sales. The benefits of their participation is related to other factors.

Much difference of multipliers among value chain segments

Figure 2.19: Multiplier by value chain segment 1991-2010 (Constant 2010 PPI)



Source: NRS ripple survey data; PwC analysis.

Net uplift of about 16 percent in increased economic activity in Norway for ESA expenditure

This implies gains of about 16 percent + economy wide technology benefits that are unknown. Following the flow of funds from government budget we can model a scenario based upon the average ratios of the last 10 years. That would imply the following scenario:

- Distribution between ESA and Industrial development fund of 5/95
- 58 percent of ESA contribution is returned as contracts (though lower share in recent years)
- Average distribution across value chain actors
- Contracts from ESA and multiplier effects by segment
- Import content of industry at average 40 percent**
- Increase of Norwegian economic activity is 34 (less cost of tax at 30)

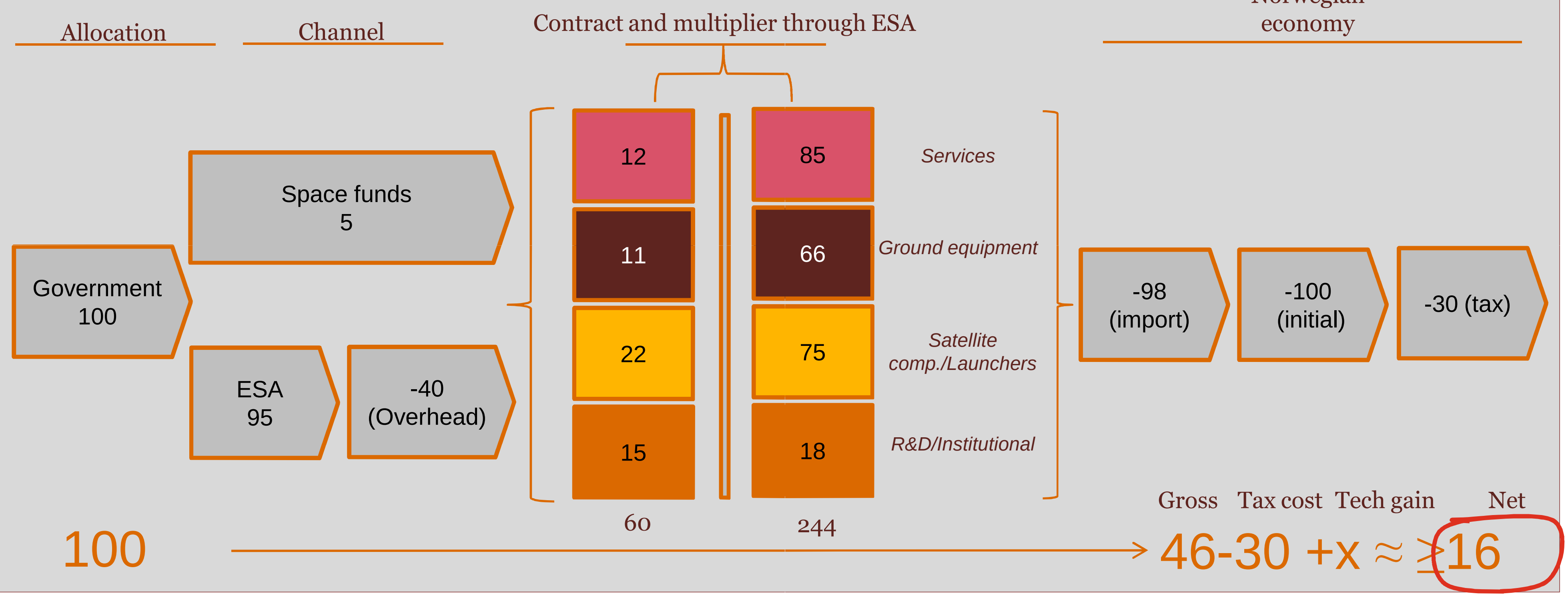
Standard cost of tax coefficient is 30% (Min Finance standard) which should be deducted from this. Economy wide technology benefits apply but are unknown.

The R&D multiplier takes account of the distribution between science/public/applied research and hence the net impact on additional sales is lower than for the applied institutes alone.

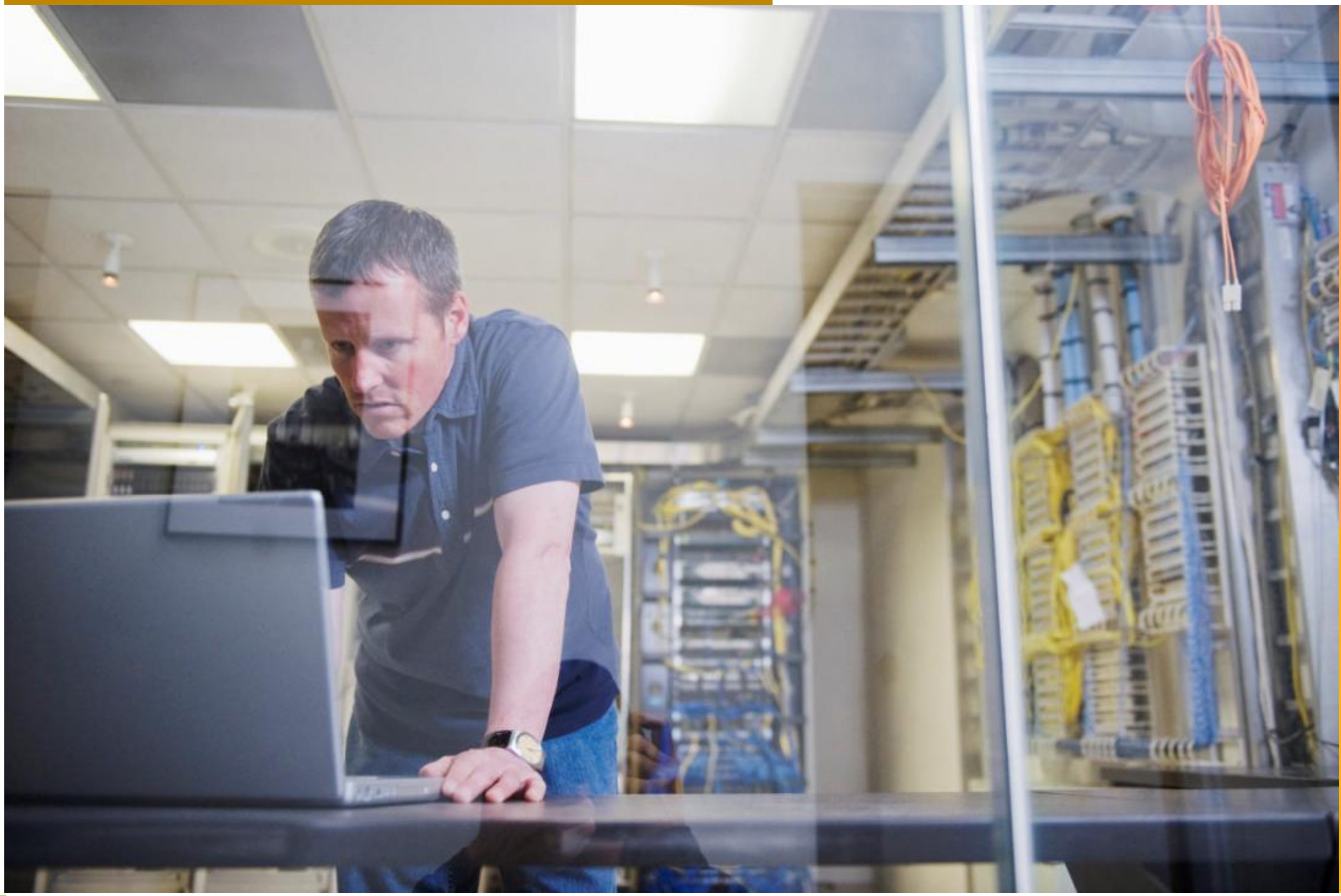
Socio-economic gains are analyzed in a separate section below.

A budget allocation of 100 provides an uplift of economic activity in Norway of 0,16 (+ economy wide technological gains)

Figure 2.20: Estimated impacts of flow of funds through ESA and back to Norway



Public service impacts



Understanding the usage

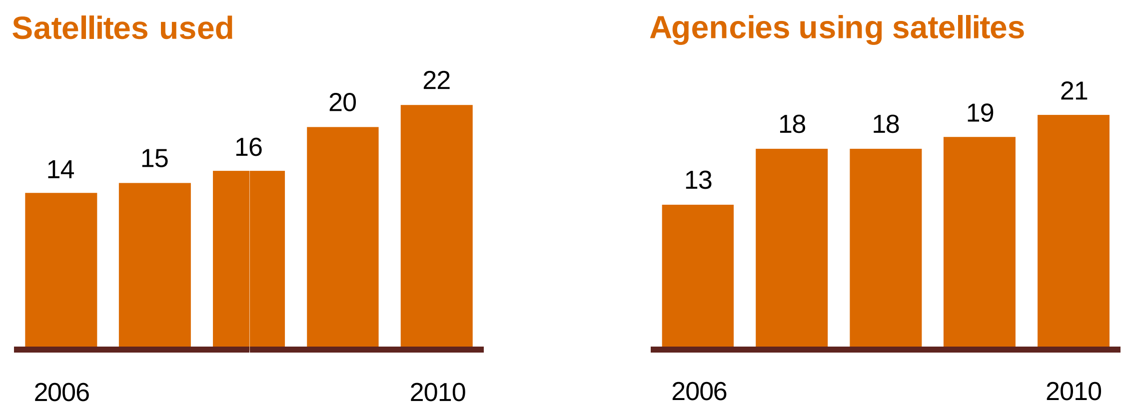
Before turning to assessments of impacts it is helpful to understand the patterns of use. This pertains to use of earth observation satellites. Agencies may also be using communications satellites and GPS systems which is not recorded.

Several patterns can be observed:

- Use is increasing. Information from satellites is used by more agencies and from an increasing number of satellites.
- There is much use of both public and commercial satellites. The four ESA earth observation (science) satellites are used by a number of agencies. About an equal number uses the American satellites. 6 of 14 public satellites being used are American, 8 are European.
- Commercial users are predominantly using the Radarsat-2 data for which Norway has a subscription. The number of agencies using Radarsat data increased to 14 in 2011. The high-resolution optical satellites are also popular.
- Public satellites are used more for research purposes. These have other sensors and enables different types of measurements. Private satellites are used much for surveillance but also for a variety of other purposes such as surveying cultural landscapes and forestry.

More agencies and more satellites are being used for earth observation

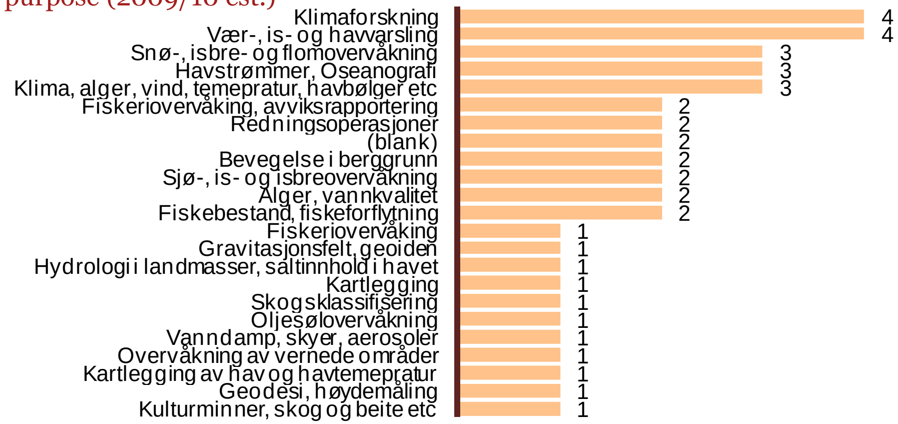
Figure 2.21: Use of satellites and agencies using them in Norway (2010)



For varied purposes and from a variety of commercial and publically available sources

Public satellites used much for research

Figure 2.22: Use of public satellites by public sector agencies in Norway. By purpose (2009/10 est.)

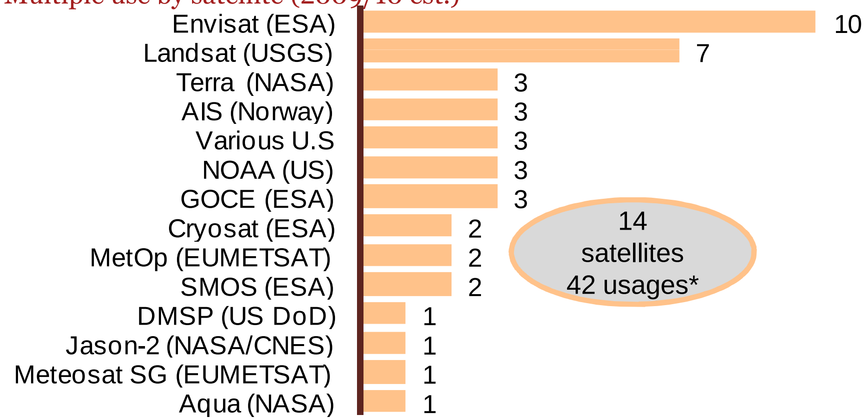


Commercial satellites for surveillance and monitoring

Figure 2.24: Use of commercial satellites by public sector agencies Norway. By purpose (2009/10 est.)

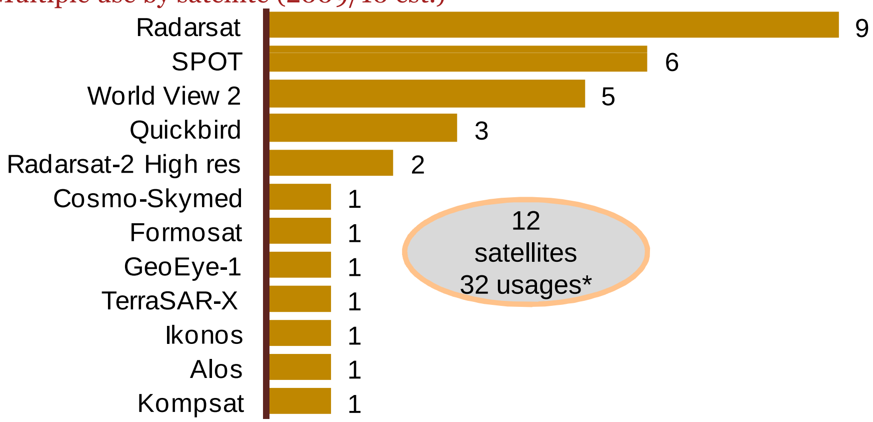
Mostly Envisat and the free low-resolution image American satellites

Figure 2.23: Use of public satellites by public sector agencies in Norway. Multiple use by satellite (2009/10 est.)



High-res radar and imagery purchased from a range of commercial sources

Figure 2.25: Use of commercial satellites among public sector agencies in Norway. Multiple use by satellite (2009/10 est.)



Source: *multiple use; NRS data; PwC Analysis

But there are only a few high volume users in the public sector

There are four agencies with persistent professional use integrated into operations. Those are: the defense institutions including the Coast Guard; Coastal Authority; Geological Survey and the Meteorological institute.

Defense, Coast Guard and Coastal Authority uses the information for continuous monitoring of events. Civilian purposes include oil spill detection, and monitoring of fisheries. These have advanced operational systems that integrates the satellite data with other sensors (seed page 144).

The geological survey uses data much for identifying risk areas for landslides. There is also experimental developments to use radar data to survey roads and railroads for landslides.

The Met institute mostly accesses the EUMETSAT and American met satellites. Weather forecasts uses sensory information form many sources, but satellite data has become very important. It also operates an ice monitoring service and occasionally accesses radar sat data for this purpose. It also operates its own ground station located in Oslo tracking both geostationary and polar orbiting satellites.

Beyond these four there are several others. Some are R&D institutes who access information for scientific or development work. Other agencies are mostly testing and experimenting.

Some are quite advanced: i.e. the Cultural Heritage agency developed software applications to identify cultural heritage sites using data from high resolution optical satellites. It is reported to successfully have discovered previously undiscovered sites.

The total usage volumes and precise costs cannot be ascertained. Detailed data are available only for Radarsat and that is presented above.

Next we turn to a discussion of impacts.

Four heaviest public sector agency users of satellite data in Norway

Figure 2.26: Illustration of important government users of satellite data

Defense, including Coast Guard	Surveillance and monitoring including of fisheries
Coastal Authority	Surveillance and monitoring activities for ship traffic, incidents, oil-spill detection, harbor management.
Geological Survey (NGU)	Risk and emergency applications. Surface monitoring of slope instabilities, surface movements in cities (bridges, tunnels, constructions); and water reservoir and dam monitoring.
Met institute	Specialized met data are acquired through EUMETSAT and US systems. Radar data for ice monitoring are also acquired through EUMETSAT.

Much lower volume and lower frequency users include: Nansen Centre for Remote Sensing; Water Resources and Energy directorate; Directorate for Cultural Heritage; Forestry and landscape Institute; Polar institute; Directorate of Fisheries; various scientific institutions.

Determining the value of satellite information

We include a discussion of how to understand the benefits and value of satellite information for public agencies in Norway. There is a more formal cost-benefit assessment in the next section focusing on the industry impacts on the economy. The purpose of this discussions is to provide insights by:

- **Understanding the value of information from satellites.** There are no direct benefits stemming from satellites. The satellites provide information – and the benefits depend upon how the information is acted upon.
- **Gain insight into how the benefits weigh against the costs.** The analysis does show considerable differences across activities and it may be useful to focus both on cost aspects, and on benefit enablers in the future.

There are limits to how useful formal economic modeling is for this purpose as the uncertainties and constraints of assumptions are very high.

The approach presented here is still a valuable concept and could serve as a framework for guiding decisions on future investments. Its being used by a.o the EU in determining GMES priorities.

Source for this section: An influential work on the value of information for policy is by Nordhaus. Nordhaus WD. The value of information. In: Krasnow, RP, editor, Policy aspects of climate forecasting. Proceedings, May 4. Washington, DC: Resources for the Future;1986: p.29–34.

Very many studies have built upon this since and expanded the insights into the subject. Particularly in the context of EU GMES preparations has there been relevant work focusing on understanding the benefits of satellite information. An important conceptual paper is the work by Macauley: M. K. Macauley, The Value of Information: A Background Paper on measuring the Contribution of Space-Derived Earth Science Data to National Resource Management, Resources of the Future, 2005.

The discussion in our study is based upon an elegant application of the subject by consulting firm Booz & co from November 2011 in an CBA assessment for the EU GMES commissioned by DG ENTR. We will also draw upon findings from an empirical focused PwC study from 2006 on cost-benefits of GMES. We seek to apply these concepts and gain insights into policy implications for Norway.

PwC analysis. The decision parameter model presented here is not discussed in the above mentioned literature but derived from related concepts.

Quantifying the value of information is helpful for comparisons against alternatives. Determining the value of information is complex.

A range of outcomes is likely even in the case of fairly closed system contexts like the dedicated Norwegian used satellite systems (i.e. Radarsat and AIS). Introducing additional systems that Norway has access to: i.e. ESA, NASA, EUMETSAT and Commercial satellites further expands the range of outcomes to the extent that an overall analysis does not become meaningful.

It is however helpful for structuring an analysis or decision regarding incremental investments in new systems or applications. We will turn to a review of Norwegian applications over the next pages.

The approach is based upon modern information economics. The key finding form this is that the value of information can be determine, and that it is remarkably consistent across sectors, and there is some understanding of what causes variation.

Across a range of sectors and multiple studies it is found that the value of better or perfect information is about 1 percent of total output.***

There are variations: For example studies on U.S. meteorological services find the value to range between 3-6 percent.* A PwC study on GMES satellite value of information for illegal fishing found the value to be as high as 10 percent. This was driven by deterrence effects and effective response mechanisms.**

An assumption of across-the-board 1 percent value of information has also been applied in recent cost-benefit assessments for the EU on GMES.***

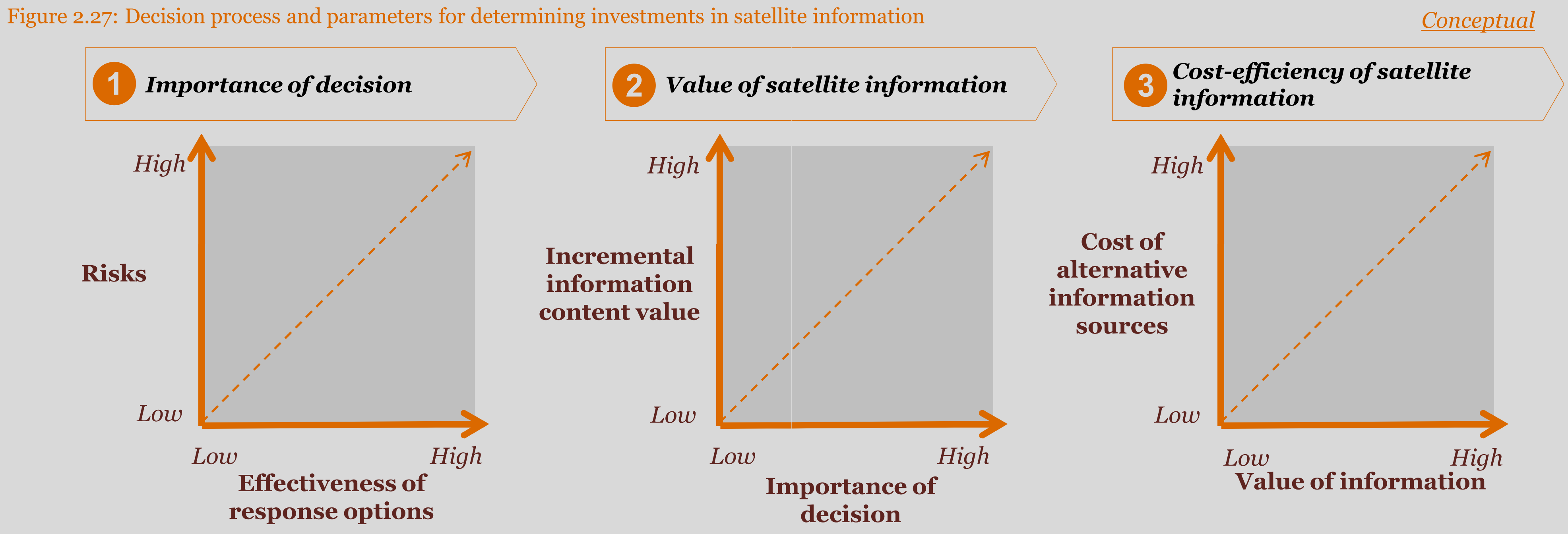
Source: *NOAA: "An Investigation of the Economic and Social Value of Selected NOAA Data and Product for Geostationary Operational Environmental Satellites (GOES)", February 2007. **PwC 2008;***Booz & Co 2011.

Three step decision process determining the value of information

The following concept is helpful to assess the value of satellite information for new applications. In many cases, the value is known. i.e. mapping. The value of information is known to the mapping authorities and it is only a question of assessing the cost efficiencies of satellite imagery versus aero imagery. For emerging applications however the value is not fully understood and there are difficulties in determining priorities and allocating expenditure.
A three-step process can be applied to assess the value of information and compare alternatives:

1. **Understanding the importance of a decision.** This is driven by two factors. (I) Risks, which is a factor of probability and consequence; and (ii) Response options. In some cases, the probabilities and consequences are known (i.e. oil spills) while in other cases the probabilities cannot be determined (landslides) If risks are perceived as high and response options exists, there will be a willingness to pay.
2. **Incremental information value from satellites.** This relates to subjective beliefs about probabilities of events. If subjective beliefs about probability are at extremes, there may be higher willingness to pay. If other, substitute information sources exists, there may be less subjective beliefs and incremental value of satellite information is lower.
   For example, there are few information sources available about activities in the arctic and Barents regions. Hence, we could expect Norwegian authorities to value information from satellites highly. Norwegian Barents policy would still exist without satellite information, but policy had to be based upon other sources of information. Other sources exists but they may be less accurate or timely. The City of Oslo has many sources of information, there is little uncertainty, and it does not perceive an incremental value added of monitoring traffic from satellites.
3. **Cost-efficiency assessment by traditional methods.**

Figure 2.27: Decision process and parameters for determining investments in satellite information



The value of satellite information for oil spill detection is between 1 and 5 million annually

Radar satellites are seen as highly effective in detecting oil spills. The algorithms for this have evolved over decades. i.e. there are examples of the alarms being triggered by whale carcasses seeping fish oil.* Ship identities can be determined in combination with AIS or the fishing vessel identification system. Experts claim that the deterrent effect is considerable. Over the last decade the regulatory framework has also been made more effective, thereby increasing the deterrence effect, and there are now significant fees for pollution.

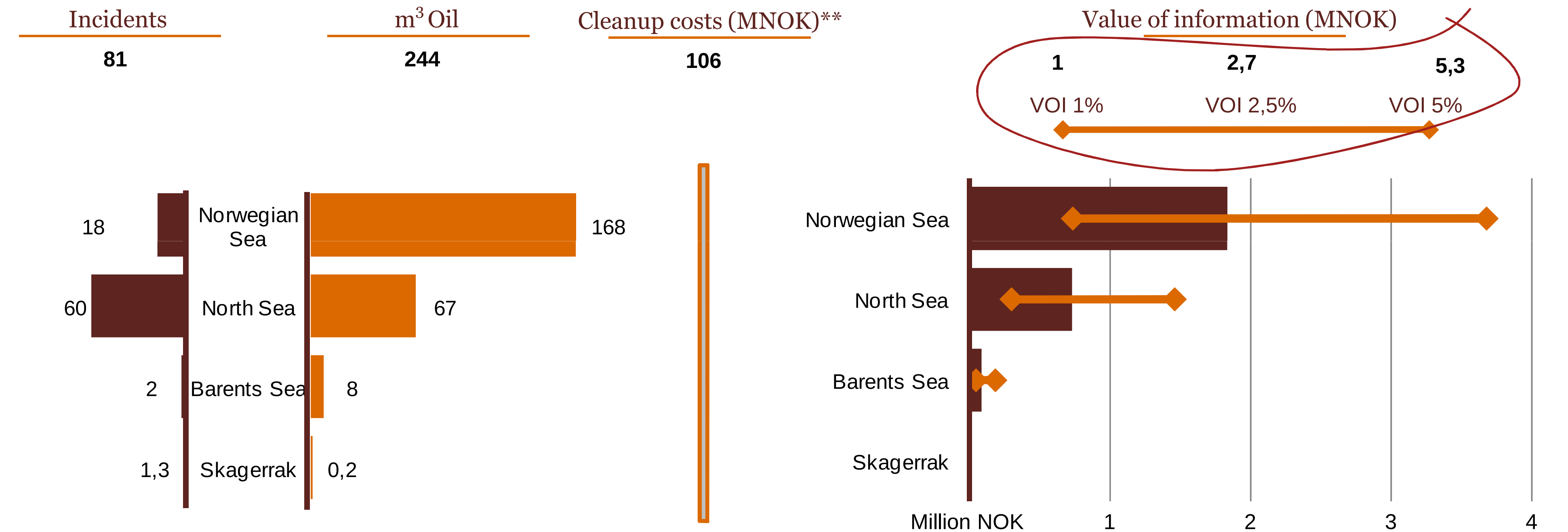
Value of information for oil spill detection has been found to be quite high across Europe. About 10 percent is estimated. We apply a more conservative range here as the non-satellite monitoring systems in the North Sea are quite extensive. Satellite systems only add an increment to those existing systems and they may actually be most effective outside of the North Sea, but there is also less risk of oil spills in those areas.

In determining the cost baseline we apply a time period before Radarsat-2 was employed to avoid any discount impact of the deterrent effect. There has been a shift in the pattern since then. A reduction has been seen in the Norwegian Sea and the North Sea (Oil Installations) is the most polluted area. There are hardly any oil spills detected in the Barents Sea, before or after Radarsat-2 deployment.

Cleanup costs are based upon international averages.** Costs are reported to reach 1 million NOK a ton if the oil reaches shore, and ten times lower if handled at source.*

Most incidents are reported by the actors themselves. About two a month are uniquely identified by satellites.* We apply no discount for this in the estimation assuming that this could be related to the deterrent effect.

Figure 2.28: Estimated range for value of information of detecting oil spills based upon pre Radarsat-2 incidents (average of 2004-06)



Source: *Coastal Authority interview; Coastal Authority data;**440000 NOK per ton equivalent to estimates in IMO: "Report on the Correspondence Group on Environmental Risk Evaluation Criteria, MEPC 60/17, 18th December 2009.; ***PwC 2008 CBA GMES; PwC analysis

The value of satellite information for detecting illegal fishing is between 11 and 56 million NOK annually

The satellite information is also used to monitor illegal fishing. Radar satellite data in combination with the fishing vessel information systems, and in some cases AIS, are reported to have been helpful. The fishing vessel system is based upon transmitting vessel data through communications satellites but is not reviewed in this report.

Illegal fishing has been a problem in the Barents region home of some of the worlds largest fish stocks. Overfishing is an issue.

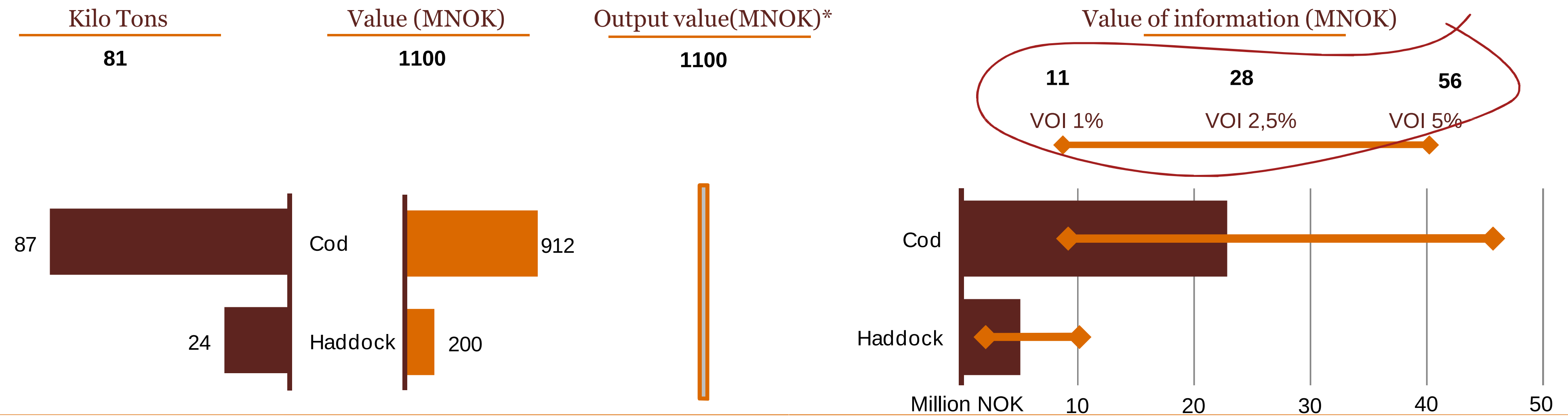
Value of information has been estimated to be about 10 percent in other recent work.* Lower estimates were applied in the 2011 GMES study. We apply a conservative estimate as we did for oil detection.

A difficulty in establishing the cost baseline is that is that illegal fishing in the region is currently reported to have been reduced to _zero_. This from a range of about of 80.000-110.000 tons of cod during 2002-2006. This has been a policy priority and a range of initiatives have been implemented. The satellite surveillance system is believed to be effective but operational details are classified.

To avoid discounting the deterrent effect we use baseline data from 2004-06 and 2005-07 for two species. There are data reliability issues and uncertainties. 2010 prices are applied.

The range is found to be between 11 and 56 million NOK annually. The high end estimate would double if an 10 percent VOI is applied.

Figure 2.29: Estimated range for value of information of illegal fishing upon pre Radarsat-2 incidents (average of 2004-06 COD; 05-07 Haddock)



Source: CG interviews, Norwegian Fisheries Directorate; SSB; PwC GMES 2008;PwC Analysis

Value of information for Geohazards range between 1 to 3,5 million NOK

Most activity in Norway has focused on mapping and determine areas with slope instabilities. (see page 145) Much resources are devoted to monitoring of certain high risk areas where catastrophic events may occur.

Applications for floods are mostly related to improved forecasting and meteorological services. This is the purview of ESA and EUMETSAT and not the Norwegian national programs. Satellite data may also be used during events to monitor water levels and guide disaster relief efforts. The value of information is however often found to be low as response options are limited and the incremental informational value form satellites compared to other sources may be limited.

Applications for roads and rails infrastructure relate to identifying slope instability as discussed above, but also for scanning and directing rescue/repair efforts.

The value of information coefficient is generally seen as lower in these areas. We operate with a range of 0,25 percent to 1 percent here consistent with recent studies.

Determining baseline costs is a difficulty. An indication can be derived from total insurance settlements. This also include storm and wind damage unrelated to floods and landslides. The nationals Perils database only include information of incidents with more than 50 million NOK in damage. Its also a discretionary database but has indications of source of the damage (flood, landslide, weather)

For floods, 2011 was an extraordinary year with nearly 1,5 billion in insurance settlements, while the average over the past ten years was about 54 million.

Major landslide events with damage are fewer. Two recorded over the last ten years. Damage to roads is not identified for any but snow avalanches. This has been estimated to cause about 1,5 million NOK in damages. Perhaps surprisingly low.

The overriding rationale for current satellite monitoring in Norway is driven by risks of catastrophic events in selected areas. The costs of a bad decision is extraordinarily high and the willingness to pay is correspondingly very high. The cost efficiencies of that monitoring cannot be meaningfully determined.

Satellite information have useful applications for Geohazards, but baseline costs are hard to determine

Figure 2.30: Illustration of value of information for selected GeoHazard events

	Damage Cost	VOI Annualized (0,25-1%)
Insurance settlements natural disasters (average 2005-2010)	340 MNOK annually	0,85-3,4 MNOK
Flood damage 2011	1500 MNOK	3,8-15 MNOK
Major flood events 2000-2010 (damage +50 mill)	3 events/ 547 mill	0,1-0,5 MNOK
Major landslide events 2000-2010 (damage +50 mill)	2 events/ 110 mill	0-0,1 MNOK
Snow avalanches on roads	1,5 MNOK annually	0-0,02 MNOK
Chance of catastrophic landslide events:	5 in 100 years	

Source: NGU; Financial Services Organization; Naturals Perils Pool databases ; PwC 2008 Cost benefit of GMES; Cicero; PwC analysis

Focus on prioritization and benefit enablers

This review has mostly focused on situations where the important parameter is to understand the incremental value offered by satellites. There will be other situations where the efficiency of use of satellites can be determined by more traditional techniques. i.e. shift from airborne to satellite based cartography. The economics of such choices can be determined with much less uncertainty than what is shown here

The focus on oceanic areas seems rational within the limits of this economic assessment. Land focused programs offer less obvious benefits and expansion here should be viewed with some care.

Some observations on costs and benefits:

Costs

The cost estimate presented is at the high end and includes the full capability of radarsat-2, AIS and national development programs. (see page 153)
Some attention could be paid to the expenditures.

In the near future the cost-structure is likely to be impacted by higher costs for radar data unless a new equally beneficial agreement is found. Current market prices exceeds Norway's costs with about 100 percent. Attention is currently paid to this issue but the expected outcome is probably increased costs.

Cost reductions through getting access and priorities assigned from EU GMES Sentinels will be important. They have capacities which overlaps with current use of Radardata. Full substitution is not expected and there will be a need for dedicated resources. GMES access and benefits will also be offset by costs of Norwegian contributions into the larger program.

Longer term, other government wide cost reduction measures such as collective purchasing arrangements, central databases etc should be considered as demand expands. This is possibly mostly relevant longer-term when costs for satellite information will be reduced. Other applications will emerge y then that currently are not economically viable.

Benefits

Agency and sector: Challenges to increase the value of satellite information is mostly about strengthening the response mechanisms. Space programs can mostly assist in improving capability to understand incremental value offered by satellites, and to access cost effective information.

Space programs: GMES readiness will be important to help realize benefits from the systems which EU will provide. GMES will offer possibilities to increase benefit realization in Norway without much incremental costs. Many applications can be expected to offer low value of information and will only be justifiable if the information is provided at low or no incremental cost.

A strategy for broader commercial involvement and value added creation could be considered to help offset costs and realize benefits. Much of the Norwegian application is advanced but has only involved some few selected providers. There are markets evolving in Europe and the U.S and these are largely supported by home country government demand.

Costs	Value of information
30-35 million	13-65 million

Socio-economic impacts

Assessing the socio-economic impacts of Norway's participation in ESA and the national support funds

Objective

The objective of this part of the study is to assess the socio-economic impacts (costs and benefits) of Norway's participation in ESA and the national support funds between 2004 and 2010 and to determine whether this space-related expenditure has led to a net cost or a net benefit to the Norwegian economy. More specifically:

1. **Participation in ESA.** ESA mandatory programs (General Budget - management and basic technology - and the Science budget, financed on GDP basis) and the voluntary program.

2. **National support funds.** The funds managed by the Norwegian Space Centre for a range purposes, including dedicated programs for industrial development, earth observation and learning.

Methodology

The methodology used is Cost-Benefit Analysis (CBA), based on Norwegian government and European Commission impact assessment guidelines, established economic principles and international best practice (e.g. UK government HM Treasury's *Green Book*).

Data sources include the NSC, the NSC's Ripple Effects survey, responses to a bespoke PwC/LE survey and other official Norwegian sources.

A detailed Excel-based economic model underlies the analysis.

A non-technical description of the analysis is presented on the subsequent slides. A more detailed technical description is provided in the Appendix.

This analysis is based on the 25 enterprises (1 of the 26 enterprises did not provide data) that are surveyed as part of the Ripple Effects analysis (more details provided later). A supplementary bespoke survey of these enterprises was carried out to obtain additional information to permit the Cost-Benefit Analysis.

Details on method

A comprehensive guide and methodology is provided in the annex.

Important factors in the analysis

What	•Expenditure: Funding of the European Space Agency (ESA), the Norwegian Space Centre (NSC) and its support scheme (NSCSS) •Research and development/innovation, ESA contracts, ESA programmes •Sales, jobs, revenues, profits, salaries, consumer expenditure
When	[redacted] Indirect effects are valued from 2007 to 2013, allowing a 3 year lag for analysis)
Who	•Norwegian Ministry of Trade and Industry, Norwegian Space Centre (NSC), ESA •Norwegian enterprises that win ESA contracts, receive NSC support, supply to Norwegian space sector enterprises under contract with ESA or use ESA outputs to improve their own products or services •Research institutes that use the results of space-related research •Norwegian students •Non-Norwegian entities (leakage from the Norwegian economy)
How	•Taxation: Corporation tax, income tax, value added tax •Post-tax worker expenditure: Retailer sales revenues •Post-tax profits: Retained earnings •Productivity enhancement and spillovers •Utility benefits to end-users •Attractiveness of careers in Science, Technology, Engineering and Mathematics (STEM) •Competitiveness of the Norwegian economy

Both direct and indirect costs and benefits are considered

First we consider the **direct effects** of this funding:

If an enterprise is successful with a bid for an **ESA contract**, it will lead to a direct increase in the **sales turnover** of the ESA contractor, yielding **profit** (or loss), and supporting related **employment**, compensated through **salaries**. The after-tax, or disposable, income of the workers will lead to an increase in **consumer expenditures** in the economy, with knock-on 'multiplier' effects.

There will also be a direct increase in the sales turnover, profit (loss), employment and salaries of **Norwegian suppliers** that supply inputs to the ESA contractor in fulfillment of the ESA contract.

The **socio-economic impacts of these direct effects** are:

- ***Job creation.*** Whilst increased man-years is estimated as an output in itself, the value of employment created is monetized through wages/salaries, which are decomposed into income tax and expenditure of disposable income (value added tax and retailer sales revenues), see below.
- ***Income tax*** is charged on the salaries of workers fulfilling ESA contracts, both in the ESA contractor and their suppliers.
- ***Value added tax*** is levied on the expenditure of workers' disposable (after-tax) income on goods and services.
- ***Retailer sales revenues*** are the post-VAT revenues related to the expenditure of workers' disposable income on goods and services.
- ***Corporation tax*** is charged on any profit that an ESA contractor and their suppliers earn on ESA contract revenue.
- ***Retained earnings*** are post-Corporation tax profits.
- There is also likely to be an impact on the effectiveness and efficiency of the ESA contractors and their suppliers, through a range of ***productivity, skills and efficiency gains***, which in turn leads to lower cost and increased **competitiveness of the Norwegian economy**.

There are also **indirect effects** of the funding:

The enhanced technical and innovative capabilities, expanded contacts and knowledge base and ESA flight heritage gained as a result of the national support funds and ESA contracts should allow enterprises to improve their competitive position, facilitating **increased sales**. Such sales may take two forms:

- There may be demand for the products and/or services provided to ESA under contract from other enterprises **within the space sector** or other space agencies; or
- New, or adapted, products and/or services based on the technology of those provided to ESA under contract, sold to enterprises **outside the space sector** (e.g. solar cells developed for satellite use, adapted for earth-based use).

Each type of indirect, or secondary, sales is likely to lead to a direct increase in the sales turnover, profit (loss), employment and salaries of **Norwegian suppliers.**

The **socio-economic impacts of the indirect effects** mirror those of the direct effects.

Unfortunately, **not all suppliers are Norwegian**, and therefore some of the benefits that could accrue to Norway are lost to other economies **(leakage)**.

Furthermore, **research facilities, universities and high technology enterprises** represent end-users that benefit from Norway's ESA participation through **usage of the ESA program outputs, earth observation data and any innovative space-inspired technologies.**

The fact that Norway plays an important role in space could also mean that starting a **career in Science, Technology, Engineering or Mathematics** becomes more appealing.

Difference between the Ripple Effects multiplier and the cost-benefit ratio

The Ripple Effects multiplier

The Norwegian Space Centre has run an annual data collection exercise with ESA contractors and support fund recipients since 1985, with a consistent methodology, called the 'Ripple Effects' survey.

The objective of the Ripple Effects analysis is to understand the impact of ESA support on total sales, separated into space- and non-space-related. The primary output of the analysis is the ***Ripple Effects Multiplier***, defined as aggregate sales from 1988 to 2010 divided by aggregate support from 1985 to 2007. Note that a three year shift is introduced to take account for lag times.

The Ripple Effects Multiplier is calculated as the ratio of the non-deflated and non-time adjusted sum of ESA generated sales (1988-2010) relative to the non-deflated and non-time adjusted sum of ESA contract value and support funds (1985-2007).

The Benefit:Cost Ratio

The *Benefit:Cost Ratio* is calculated as the ratio of:

the Present Value sum of costs (ESA contracts, support funds, ESA administration costs and foregone return from ESA) deflated to constant 2010 prices relative to

the Present Value sum of benefits (corporation tax, income tax, value added tax, retailer sales revenues, retained earnings and user utility resulting from ESA contracts, support funds and facilitated sales, supplier inputs and end-user usage of program outputs) deflated to constant 2010 prices.

The difference between the two

The *Ripple Effects Multiplier* focuses on the value of sales as benefits, rather than considering the wealth created (e.g. salaries, productivity improvements and profits) through socio-economic impacts. There is no consideration of additivity relative to the counterfactual. There is also no account of ESA administration costs and foregone return from ESA, which are legitimate costs.

The *Benefit:Cost Ratio* on the other hand, includes all costs (including ESA admin) and considers only additive benefits, measured (quantified and valued) as the wealth created by the ESA contracts, support funds and facilitated sales and supplier inputs, through corporation tax, income tax, value added tax, (post-tax) retailer sales revenues, (post-tax) retained earnings, additional jobs and user utility. The values are deflated to constant 2010 prices and the Present Value sum of Costs and Benefits is used to account for time preference.

Furthermore, the Benefit:Cost Ratio is calculated using data from a shorter and more recent time period, which reduces the temporal issues of the Ripple Effects multiplier.

However, the Benefit:Cost ratio does draw on the strengths of the Ripple Effects analysis because it is based on the rich data collected by the Ripple Effects survey.

Assessing the costs

Norway's space expenditure represents the cost side of the Cost-Benefit Analysis. Cost data are available from several sources, each with a different total value, so some judgment and refinement is necessary. In addition, the data used to estimate benefits is limited to the 25 enterprises (respondents in 2010) that provided permission to their Ripple Effect data, so it is important the cost estimates also only pertain to this same (albeit large) subset of enterprises. Thus, the value of costs employed in the CBA model utilizes several data sources in order to ensure that the costs side of the CBA accurately reflects space-related costs pertaining to the subset of enterprises that provided individual Ripple Effects information.

The value of costs included in the CBA is derived from the Norwegian Space Centre's budget, the Ripple Effects survey, and data provided by the Norwegian Space Centre in a way that ensures that the value reflects the magnitude of Ripple Effects data and a share of the budget that reflects the data from the Norwegian Space Centre:*

- Norway's total ESA budget is available from the **Norwegian Space Centre's annual reports**. The budget covers contribution to ESA's programs, which in turn covers the contracts that Norwegian firms win, and the administration costs of the ESA programs.
- Data on organization-level ESA contracts and support funds was also provided by the **Norwegian Space Centre**.
- The **individual Ripple Effects data** does not hold all the Norwegian enterprises or organizations that won ESA contracts or received funding from the Norwegian Space Centre's Support Scheme. As the individual Ripple Effects data forms the backbone of the Cost-Benefit Analysis, it is necessary to include only a share of the ESA budget in the analysis.
- The share of the ESA budget that is included as costs in the CBA comprises **ESA contracts to the individual Ripple Effects enterprises and the share of administration costs of Norway's ESA participation that is attributable to those firms.** Administration costs must be included because the enterprises that supplied individual Ripple Effects responses could not have got the contracts in the absence of administration costs.

* A technical description of the underlying calculations is available in Appendix 3.

In addition to ESA costs, the Norwegian Space Centre's Support Scheme enters the CBA on the costs side. The value of those costs is observable from the individual Ripple Effects survey responses. Administration costs of the Norwegian Space Centre's Support Scheme enter the Norwegian Space Centre's annual reports separately.

The proportion of Norwegian Space Centre administration costs that is included in the CBA is the same proportion as for ESA administration costs. In nominal terms the value of ESA contracts far exceeds the value of support scheme funds, and since the ESA contracts would not have been won if it had not been for the Norwegian Space Centre (and thus its administration costs), we find that the ESA contract proportion represents the fairest number.

Evolution of monetized Costs and Benefits

Costs

ESA contracts and ESA administration costs and foregone return are by far the most important cost drivers.

ESA administration costs and foregone returns fluctuate in value over time, but have seen an overall increase over the period. ESA has been running operating surpluses in recent years, which is likely part of the explanation for the increase in administration costs and foregone returns.

NSC support funds and administration costs have remained largely constant over the period, with evidence of small growth.

Benefits

In the first three years (2004, 05 and 06), benefits are limited to direct effects, due to the three year lag allowed for indirect effect manifestation.

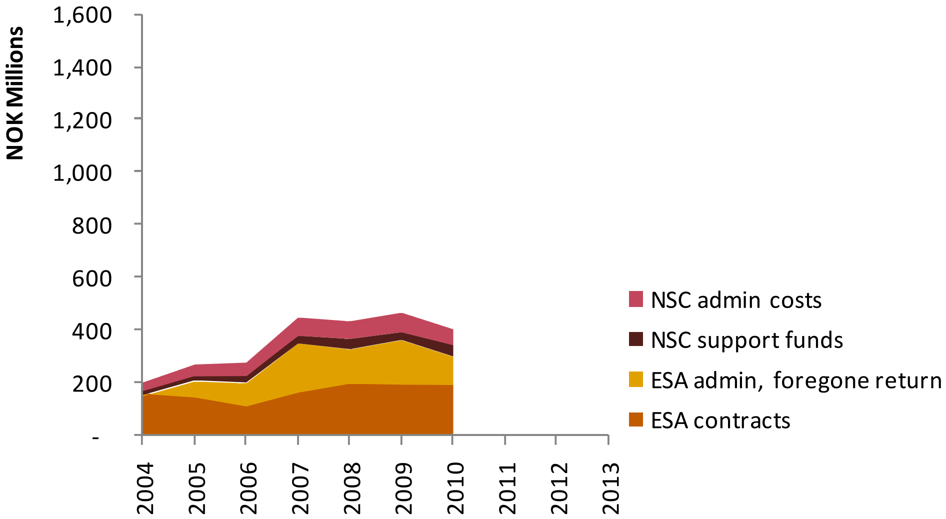
Annual benefits increase significantly from 2007 onwards when the indirect effects arising from ESA and/or NSC generated sales are first included. Benefit values fall slightly from 2011 on due to the removal of ESA contract value.

ESA contract value alone is not sufficient as an economic rationale for government investment, as can be seen from the first three years' benefits (< 1:1 ratio, due to imports which are a leakage from the Norwegian economy).

The average number of **man years** supported per year is 642 (6,419 man years in total between 2004 and 2013).

Costs dominated by ESA-related costs

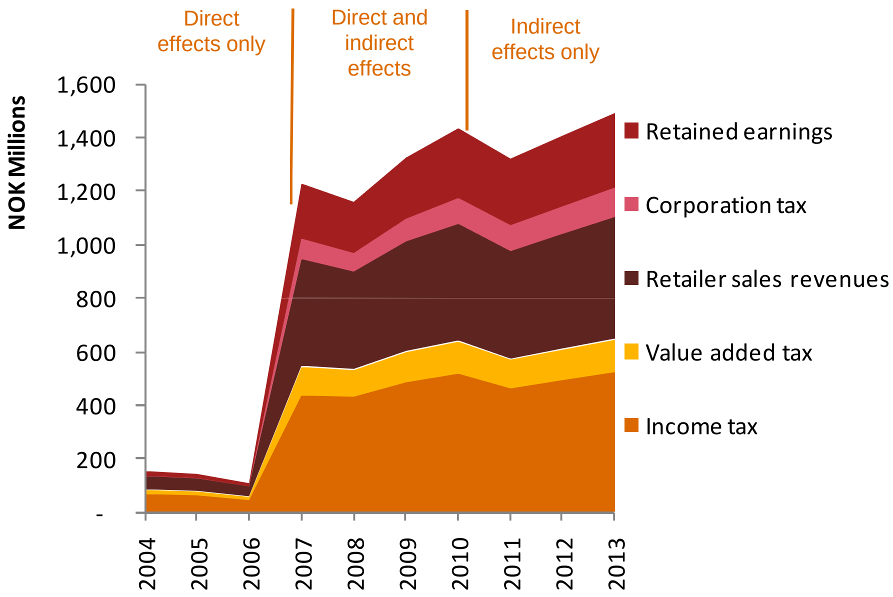
Figure 2.32: Annual Values (2004-2010) of Costs



See Appendix 3 for a detailed break-down of the calculations underlying the assignment of administration costs.

Socio-economic benefits dominated by indirect effects

Figure 2.33: Annual Values (2004-2013) of benefits



Direct effects are benefits accruing immediately (same year) as the ESA contract and NSC funding.
Indirect effects are benefits accruing over later years associated with the ESA contract and NSC funding (3 year lag assumed).

Total monetized Costs and Benefits

Costs

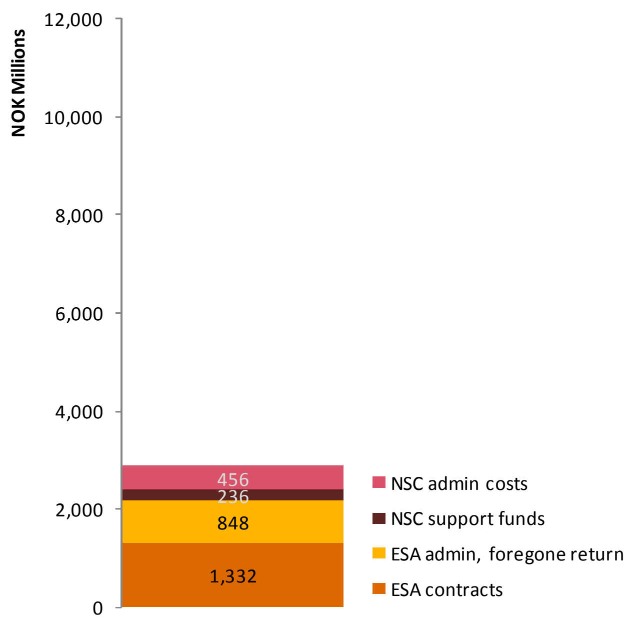
As monetized benefits cover the 25 organizations that provided individual responses to the Ripple Effects survey, we restrict costs to match.

- **ESA contracts and NSC support funds.** Only contracts and funds received by the 25 organizations are included.
- **ESA administration costs and foregone return.** Only ESA administration costs associated with the 25 organizations are included, assigned based on ESA contract value.
- **Norwegian Space Centre operating costs.** As the central distributor, NSC costs are assigned based on ESA contract value for the 25 organizations.

There are no non-monetized costs to report.

Costs dominated by ESA-related costs

Figure 2.34: Present Values (2004-2010) of Costs



Benefits

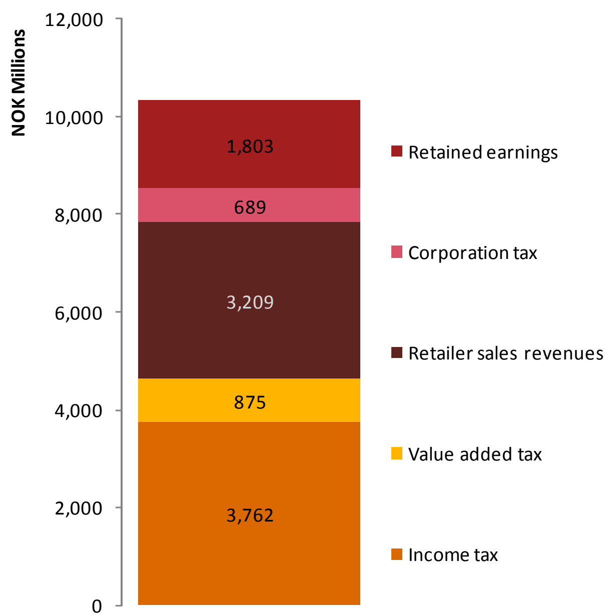
As previously explained, benefits comprise both direct and indirect effects.

- **Direct effects.** Benefits accruing immediately (same year) as the ESA contract and NSC funding is received, valued over the period 2004 to 2010.
- **Indirect effects.** Benefits accruing over later years associated with the ESA contract and NSC funding received from 2004-2010. We adopt the same 3-year lag for such secondary effects as that used in the Ripple Effects analysis, and valued over the period 2007 to 2013. The Ripple Effects survey includes budgeted values for 2011 and projections for 2012 and 2013.

The quantified benefits comprise wages/salaries (income tax, value added tax, retailer sales revenues) and profits (corporation tax, retained earnings). **Wage/salary-related effects are by far the larger contributor to Norway's benefits from investing in space programs.**

Primary socio-economic benefit is employment

Figure 2.35: Present Values (2004-2013) of benefits



Cost-Benefit Analysis results

Our objective was to assess the socio-economic impacts of Norway's participation in **ESA and the national support funds** between 2004 and 2010 and to determine whether this space-related expenditure has led to a net cost or a net benefit to the Norwegian economy.

Monetized costs and benefits

The Cost-Benefit Analysis results (based on 25 organizations that provided individual responses to the Ripple Effects survey) presented in the above table provide answers to these questions, summarized as follows:

- The **total cost of participation (2004-2010)** was **2.9 billion NOK**, an average annual participation cost of **386 million NOK**.
- The **total benefit of participation (2004-2013)** is expected to be **10.3 billion NOK**, an average annual participation benefit of **1.353 billion NOK**.
- We therefore determine that participation in **ESA and the national support funds** between 2004 and 2010 brought about **a Net Benefit** of **7.4 billion NOK.**
- The **Benefit:Cost Ratio** of **3.59 : 1**, shows that the **Present Value of benefits exceeded the Present Value of costs in this period by a factor of 3.59.**

N.B. It is important to note that **3.59 is the *average* impact of each NOK of funding from 2004-2010**, and that **it is <u>not</u> the *marginal* impact of an *additional* NOK of funding.**

Non-monetized costs and benefits

We have attempted to monetize all identified costs and so there are non - monetized costs to report. Non-monetized benefits are explored on the subsequent slides.

Figure 2.36: Summary of costs and benefits

Summary of Cost-Benefit Analysis results	MNOK
Final year of benefit accrual:	2013
Present Value analysis, Discount rate:	4%
PV(Total Cost)	2,871
Average Annual Cost	386
PV(Total Benefit)	10,295
Average Annual Benefit	1,353
Net Present Value (NPV) = [PV(Total Benefit) - PV(Total Cost)]	7,424
Average Annual Net Benefit (or Cost)	998
Benefit:Cost Ratio	3.59

Non-monetized benefits: Public agency effectiveness and efficiency – Data access and quality primary driver of user benefit

Survey responses

Several different groups of end-users were identified by the survey respondents, including: **supranational and Norwegian government organizations**, **research institutions**, **private companies**, and **consumers**.

Data **availability**, **accuracy**, **reliability**, and **efficiency** were the main types of user benefits identified by the respondents to the survey. Examples of the specific usage of ESA outputs include:

- **Satellites** give telecommunications enterprises the opportunity to offer new applications in broadband and mobile internet to rural areas. This benefits not only the telecommunications firms and the users, but, potentially, also Norwegian competitiveness, as information technology improves productivity.
- Though ESA satellites are one of a number of sources, **surveillance data** are used by meteorologists who gain access to more detailed data that help them provide more accurate weather forecasts which benefits, for example the country's fishing fleet, the agricultural sector, and the population as a whole. Surveillance data are also used by military and civilian Norwegian authorities involved with maritime surveillance. The data enables these authorities to monitor Norwegian water more closely and assert sovereignty if need be. Earth observation data is also used to monitor land use, forestry, the size and water content of ice, etc.
- The importance of **European access to space** was mentioned by one survey respondent. The fact that Europe, through ESA, has sufficient capacity to build and run space ports and satellite launch facilities means that Europe is no longer dependent on foreign goodwill to make space related projects happen.

Sources: ESA Annual Report, 2010; Convention for the establishment of a European Space Agency & ESA council Rules of Procedure, 2003

Discussion

To assess the impact of Norway's participation in ESA in terms of user benefits, careful consideration of the **counterfactual and additivity** is essential.

In the first instance, if Norway's contribution meant the initialization of an ESA program, then the **additive user benefits could be substantial.**

- Norway's contribution to ESA amounts to roughly 2% of ESA's budget, and Norway is credited for funding a number of individual projects under different ESA programs (e.g. in Earth Observation). On this evidence, it is plausible that Norway's contribution to ESA has indeed caused initialization of projects. This, in turn, implies that Norwegian users of outputs from those ESA programs benefit.

In the second instance, if the outputs of the ESA programs would have been available to Norwegian entities in the counterfactual case if Norway had not contributed to ESA, then the **additive user benefits would be small.**

- ESA's Convention states that data and outputs of ESA programs shall be made widely available. However, some of the ESA data would not have been available, so some industrial benefits would have been missed. Membership of ESA allows Norway to influence decisions made in regard to the ESA projects, so the outputs may be better suited for Norwegian users, but the degree of additional user benefits is likely small. On balance, there would still have been many benefits available without ESA membership.

In the third instance, if there exist alternative external sources for similar products or services, then the **additive user benefits would be negligible.**

- If ESA program outputs were available from a different supplier, then the user benefits associated with ESA membership are limited. If similar outputs were available at a price, then the total cost of obtaining the outputs would have to be weighed against the price of ESA participation to ascertain whether users benefit from ESA membership.

In summary, it seems that additive user benefits from Norway's ESA membership are limited because most program outputs would have been available if Norway was not a member.

Consequently, consistent with the **principle of proportionality**, these benefits are not monetized.

Non-monetized benefits: Competitiveness of the Norwegian economy

Competitiveness of the Norwegian economy

In order to assess the impact of space expenditure on the competitiveness of the Norwegian economy, it is important to consider the different **channels through which Norwegian enterprises compete with foreign enterprises**.

- **Quality of the service.** Quality is partly reflected in the product development capabilities of an enterprise, as greater product development capabilities improves the quality of the match between the supplied and the demanded good or service. The PwC/LE bespoke survey asked respondents how ESA contracts had impacted their product development capabilities, with responses suggesting that **ESA contracts impact product development capabilities of enterprises substantially.** Synergies with other markets, lower R&D cost and innovation were cited in responses and of the total of 12 responding enterprises, 6 report effects between 20% and 35%, whereas 3 report effects between 3% and 10% and 2 respondents report 100%-300%.
- **Price of the good or service.** Productivity is a ratio of production output to inputs, and improvements in productivity imply cost reductions. **Most firms report zero productivity effects**, but for a few, methodologies and engineering efficiency have improved by between 0.5% to 25%.
- **Reputation and experience.** If the proposing enterprise is inexperienced or unknown, it might be more difficult to win the contract. **Network, and reputation and flight heritage** are by far the most prevailing channels through which ESA contracts impact sales with more than half the respondents quoting either or both effects. Among the enterprises that quantify the effects, the range between 5% and 30% dominates.

The PwC/LE bespoke survey asked respondents for their views on the effect of own ESA contracts on **suppliers**, beyond the immediate sales effect. The effects on suppliers was not reported to be of great magnitude although it was pointed out that additional suppliers were used and so more enterprises were able to enter the space sector. In fact, one respondent stated that the very existence of some of their suppliers hinges on ESA contracts because working for ESA contracted enterprises makes the suppliers capable to fulfill other contracts, and, to a certain degree, keeps the suppliers in business. The quality of supplier inputs was also reported to have improved.

Roughly half of the respondents thought that **competitors** were better off as a result of the ESA contracts. Effects such as knowledge sharing within the ESA environment and the incentive for competitors to keep up with the contracting enterprise were quoted. However, many respondents did not see any effects.

Attractiveness of careers within Science, Technology, Engineering and Mathematics subjects

Another, and perhaps more long-term, way involvement in space programs benefits Norway is through the attractiveness of a career in science, technology, engineering and mathematics (STEM). If young people decide to educate themselves within STEM subjects, the returns to society are significant and substantial. A recent study by London Economics (2010) shows that the net present value of **lifetime benefits** to the **UK** finances arising from individuals with a **STEM undergraduate degree** amount to **£64,471-£171,784** compared to an individual whose highest level of attained education is the GCE A-levels.

These effects arise in spite of more time passing before individuals start earning, and although there is a direct cost associated with education. Tax payments and National Insurance contribution paid after graduation exceeds that of an individual with A-levels substantially.

As a full ESA member, Norwegians are entitled to a number of jobs at ESA. As a result of Norway not filling all of its allocated jobs, ESA made appearances at three Norwegian universities in January and February 2012. This initiative along with the general media exposure of the Norwegian Space Centre, space sector firms, ESA symposiums in Norway, and the AnSat student satellite program in which 83 students had participated by the end of 2010 all show the opportunities that lie within different areas of space related employment.

See London Economics, "Estimating the returns to the Chemical Sciences", Final report for the Royal Society of Chemistry, Table 2 for a detailed break-down of the exchequer benefits relating to degrees.

National Insurance is a British unemployment insurance scheme which is operated by the State. Notice that the analysis is undertaken for the UK whose income tax levels and benefits levels are considerably different from Norway. These numbers provide a feel for the difference in value to the public finances, but cannot be expected to apply literally.

http://romsenter.no/ESA+p%C3%A5+studentjakt+i+Norge.d25-TwlzOYb.ips, accessed 09/02/2012

Section 2.2

Meeting the objectives

The objective of this section is to determine the degree of success of the space programs in reaching the objectives.

Two important issues are covered:

I. **Effectiveness.** This is about assessing whether the objectives has been achieved.
II. **Relevance.** This is assessing to what extent the activities are suited to purpose.

Each section will start with a definition of criteria

The programs have delivered specific results over time, but declining contribution to wealth creation and uncertainty about sustainability

Overall objective

Space activities in Norway shall provide substantial and persistent contributions to wealth creation, innovation, knowledge development, and environmental- and public safety.

The overall goal encompasses different elements. The concepts are not mutually exclusive and overlap. i.e.. knowledge development and innovation. The Ministry has also defined more specific objectives and a discussion of progress on detailed objectives are found in the main report and the annex.

Specific results, but unclear impact on sustainable growth and wealth creation

Overall turnover of the space industries in Norway have declined by between 15-25 percent since 2003 depending upon how inflation is adjusted for. Contributions to wealth creation overall in Norway had declined by 33 percent since 2003 as defined by GDP with or without petroleum included. Employees involved in space activities have declined by nearly 50 percent since late 1990's though this measures only captures about 80 percent of companies.

Support for space related activities has provided results, but these are probably declining. There has been strong sales growth for those firms that receive most of the support albeit insufficient to offset the larger decline. There is growth in some segments of the value chain and some firms have seen phenomenal success. These do not necessarily coincide with those that receive support. Ripple effects on sales of the public support are reported and the socio-economic benefits are net positive.

The profile of the support portfolio is increasingly decoupled from market developments, business structures and growth potential over time. As such we question the sustainability of the support over time. It may also mean that the results are better for the evaluation period as a whole rather than the last few years in isolation.

Substantial and persistent contributions to environmental- and public safety are seen.

The national programs targeting ocean and polar monitoring capabilities have contributed towards environmental- and public safety. The systems provide information important for environmental safety. The space activities have also contributed much to the processing and institutionalizing of the information. Thereby increasing the probability of positive impacts on environmental and public safety.

Activities through ESA are less directly relevant for the enhanced public sector capabilities. ESA satellites or systems are today largely irrelevant for these capacities. There are however other linkages. The knowledge and insights, early development of algorithms, and development of the ground station have much been through ESA activities. For the future, the EU GMES holds much potential also for Norway. Dedicated access to other sources for a.o radar data is likely to be required also in the future.

Environmental- and public safety are also concepts which may have different meanings depending upon circumstances. They are not defined by the Ministry.

Objective 1: The objective is formulated as "Ensuring that space activities have significant industrial ripple effects".

Output measures relate to a range of different concepts and there are seven quantitative indicators defined.

Progress against the objective is mixed. We will review the important issues.

Related to the four government output measures we find that:

International positions show overall decline with some bright spots. Overall global market share for Norwegian space firms have declined from about 2,8 percent to 2 percent during 2005-2010. Export shares have fallen. From about 82 percent of sales in 2005 to 68 percent in 2010. Exports of both services and products have declined relative to other Norwegian exports of services and products respectively. Several individual firms have strong positions in particular micro segments. This applies across all segments of the value chain.

There is not full industrial return on the ESA programs. Overall rate is at 90 percent in June 2011. A special initiative has been launched by ESA to direct more contracts toward Norway. The ratio is lowest in the mandatory programs at 68 percent. It is highest in the technology development programs with guaranteed returns of 100 percent. In other optional programs it is about 84 percent. The ratio of contributions to guaranteed and non-guaranteed return is about 50/50.

Norwegian firms have in practice similar access to Galileo development contracts as European firms.
There were initial restrictions, but special provisions and agreements were entered into between Norway and relevant European Authorities that ameliorated the restrictions effective from 2009/2010.

There are industrial ripple effects but turnover is decreasing. Industrial ripple effects are seen at about 4.3 in aggregate and at about 3.5 median value per firm. The indicator accumulates "ESA generated sales" sales during 1985-2010 by ESA and space center support.

Turnover has been decreasing since 2003. Inflation adjusted the decline is about 15-25 percent.

Objective 2: The objective is formulated as "High utilization of Norway's geographical advantage". There is only one output measure: "Norway holding a leading role in the Arctic space related infrastructure".

Indicators relate to KSAT and Andøya Rocket range.

KSAT business is going strong. We have estimated ScanEx of Russia and SSC of Sweden to track more satellites (150/100) but the comparability and definitions are unclear from all parties.

Andøya rocket business has seen some decline though student rockets are increasing. The decline is reported as being caused by shrinking science budgets. Numbers for their key competitor, Esrange in Kiruna, show about similar developments.

Andøya and Esrange are supported through a special program to incentivize use, a bilateral agreement between six countries. (EASP) Financing has averaged 24 million NOK annually since 2007 and an additional allocation of 15 million was provided to support infrastructure in 2010. EASP is outside of the purview of this study.

Objective 3: The objective is worded as "Developing cost-effective systems meeting national and international demand. Output measures relate to two different concepts:

First, **the performance of satellite navigational systems covering the arctic regions**. Egnos (airtrafic) performance was reported as "not full coverage in accordance with operative demands." in 2010. From 2011 this is replaced by a Galileo/GNSS measure.

The logic being that ESA membership would influence the performance of these systems in arctic regions. Norway has had influence, in particular on Galileo design.

Second, this objective of **developing cost-effective systems meeting national demand** has driven much of the efforts behind the SatOcean programs. These efforts can only be seen as successful and are discussed extensively in the report.

Objective 4: The objective is worded as Strengthening Norwegian research communities through international cooperation.

Output measures relate to two different concepts: Norwegian research communities having central roles in space related research projects ; and Norwegian scientists having access to the best satellite measurements in their field of research.

Scientists with access to satellite data has increased much over the last five years. Whether this represent improved access or more scientists exploring these fields is not explicit but possibly mostly the first. Number of researchers involved in space related research projects is reported to be increasing. Whether and how this can be measured has been a recurring theme in the dialogue between the space centre and the MoTI.

The logic here is that ESA membership creates access for Norwegian scientists. ESA creates opportunities particularly within the scientific programs. There is a coordination mechanisms with the research council for this. Government instruments to support space sciences are also about more instruments than ESA and includes the research council, EU FP's basic funding for universities a.o.

The impact and effectiveness of the science support must be analyzed holistically to be meaningful. We do not explore this in more depth here.

Objective 5: The objective is worded as Increasing knowledge in science and technology through information from the space industry.

There are three output measures: Increasing the outward information flow; Increasing media attention and Increasing activity towards students.

The activity level is very high. Four lectures weekly, twice weekly radio appearances, weekly events with 30 participants on average. This has increased much over the last five years. Website is elaborate and has frequent visitors. There are also student offers for support in writing master thesis and other research. TV appearances is the only indicator that show a decline.

The broader concept here relates to education, recruitment and work force capabilities over the long run fro which the space program tools are limited.

A detailed presentation of all indicators is found in the annex.

Policy and objectives might benefit from adjustment to ensure benefits

Further we discuss the relevance of the policies vis-à-vis the objectives. This is assessing to what extent the activities are suited to purpose. We will review the following evaluation questions related to relevance:

1. Are the instruments adequate from an overall perspective for achieving the space programs goals?
2. Has the space programs achieved an appropriate balance between the various instruments?
3. Is there overlap or conflicts of objectives between ESA participation and national support funds? Are synergies exploited?
4. How has the Space programs managed to adapt its instruments and advice to the larger context in which space activities interacts with other social, market, economic, political and environmental processes?

Additional issues are discussed in the detailed analysis.

1. Are the instruments adequate from an overall perspective for achieving the space programs goals?

There are differences across segments and we will review those in turn.

Three observations to note:

1. Limited growth potential in upstream production

There is a mismatch between support for upstream production companies and the potential for growth and wealth creation in this segment. This includes manufacturers of launchers, satellite components and ground equipment.

The support is insufficient in size and scope if the goal would be to build a large and sustainable space industry. That would require a considerable increase in Norway's participation in ESA, which is hardly justifiable in terms of Norway's overall policy for industry.

The difficulties of attaining competitiveness in ESA and global commercial markets of the upstream segments are an indication of this. A sufficiently strong domestic demand does not exist to create anchor demand for upstream actors. Market leaders are from larger countries and have sizeable domestic upstream markets available to them.

These difficulties will only increase driven by five trends indicated in the analysis:

- as value chains of global conglomerates converge across segments and between system integrators and component producers;
- as emerging markets gain competitiveness and global market shares;
- as U.S firms are driven onto global markets;
- as European countries launch semi-commercial national programs; and
- as access to semi-protected ESA markets become more difficult due to convergence of EU and ESA.

2. Growth and comparative advantages in the service sectors

Opposite these constraints in the upstream segment stands exceptionally strong domestic demand from other economic sectors notably from maritime and offshore industries.
These are growth drivers for space ground equipment manufacturers, and providers of communications and earth observation services. In these segments Norwegian firms are global market leaders and have considerable market shares in broadly defined market segments.

The tools seem adequate for satellite communications services. Relatively small investments here have had big impacts. This segment has also seen new entrants with rapid growth. There is no need to match the funding to the scale of the industrial turnover in the absence of market failures. Rebalancing could be considered to support development of near-market-ready technologies. ESA is ineffective to support this segment.

Tools are also adequate for the ground equipment industry. Although the space related turnover has dropped, there is little evidence of constraints in other segments of electronics and communications equipment markets. Those who produce space ground equipment have also grown more strongly in other segments. The declining turnover is related to collapse of one company. The inability of other firms to maintain or gain global market shares seem related to firm level decisions of focusing on other market opportunities.

Tools are adequate to support earth observation services firms but may be constrained in the near future. In fact, this is driven by strong demand from government for monitoring and surveillance capabilities. Needs , as in territorial, are at about the same levels as that of Europe combined and this creates anchor demand for certain services. Norwegian firms also have strong competitive positions in these segments. The national development programs are especially well suited. There is however a risk that the use of the support funds has been selectively targeted at a few actors. A consequence is a narrow base to recruit new service providers from.

Risks here relate to future developments of EU GMES programs. Norway needs access to these processes to maintain adequate instruments to support firms in this segment.

*3. T*ools to support environmental and public safety objectives are adequate or almost so.

There is a reasonable balance at the moment. Government demand is increasing.
For the ocean/polar region services this is about having more refined capabilities. The combination of national development programs and dedicated investments in a.o radar and AIS are adequate for ocean monitoring currently. Emerging difficulties here are about having flexible access to other sources of high resolution data to meet more sophisticated demand.

Future access to continuous radar imagery need to be secured given that the current main source is expiring in some years. There are several capabilities available that will meet current requirements but costs are likely to increase.

Terrestrial demand is currently adequately met. The model of combining development programs with access to radar satellite data is currently sufficient. Challenges are emerging. There are capacity constraints and scheduling conflicts for radar data. Access to optical imagery is not secured on a cost-efficient and continuous basis. Tools are adequate at the moment, but may be limited in the future as user sophistication grows.

In the near future there also needs to be access to EU GMES institutions.

Next we turn to the question of balance.

2. Has the space programs achieved an appropriate balance between the instruments?

Four observations to note:

1. The balance of ESA vs. National program allocations is appropriate but can be adjusted longer term.

The dynamic between the industry development program and the ESA programs seem to work well.

There is an observed difference in scale of national programs vis-a-vis ESA contributions compared to other larger space manufacturing nations.

Matching the funding levels of these countries is unattainable. Policy attempts to compensate for this are futile and will fail. Further selectivity and specialization may be considered.

The recent scale-up of ESA financing is questionable to the extent that it is not absorbed by industry contracts. The ration between contributions and contracts is increasing. The industrial return coefficient is below target and has to be met by separate transfer schemes from ESA.

National program funds on the other hand may be insufficient to meet public sector demand in the future. A necessary scale-up of commercialization strategies in the services segment for which ESA is less relevant may also be considered. Future growth may need to be directed towards this.

2. *I*ntra-ESA program allocations should be reoriented towards those segments with best potential for growth and wealth creation

There is a risk that current allocations are driven by other than cost-efficiency considerations including path dependency. Its fragmented, driven by expectations about where industries can deliver. Today's and specialization should be revised. The support is not oriented towards those segments with the highest growth or wealth creation potential.

The current allocation distribution implies most financing for launchers and satellite component manufacturers. This is questionable on cost-efficiency grounds as there is less growth potential and lower ripple effects than other segments. Some rebalancing may be warranted.

At a certain level, optimizing this allocation will be constrained by the fact that ESA predominantly offers opportunities for upstream and hardware producers.

Strategies for increasing participation of downstream actors, within or outside of ESA may need to be considered. This is where ripple effects are higher and growth potential larger.

The fragmented nature of ESA program allocations implies much discretion for the space centre in determining allocations. The implicit prioritization of certain industrial segments that the allocations imply, are not articulated, explicit or transparent.

3. Allocation of intra-national program funds should be reoriented and increase in scope.

Consider increasing service development funds. This is where the highest returns and growth potentials are seen.

A risk is that current involvement of commercial earth observation firms is too narrow and selective. Increases here need to be met by strategies to increase broader involvement of commercial service firms. Meeting longer term public sector demand also speaks for increasing this share.

Another risk is that cost-efficiencies achieved by monitoring of ocean areas by satellite does not currently have its equivalent on the terrestrial side. This may change in the future. But care is warranted in assessing alternatives.

4. Allocations between scientific activities and industrial support needs to clarified in a transparent policy.

, there is an unresolved balancing issue with regards to the funding of scientific space activities. These contributions have over the last decade not only pertained to the ESA mandatory scientific program, but also to other programs like the International Space Station and more importantly the Earth Observation Program. This reflects the scientific nature of many of the ESA Optional programs.

Finding an appropriate ESA investment level that is targeted at scientific communities need to take into consideration the scientific capabilities and priorities. This is what is being done in practice today. Balancing the scientific funding level with other investments however is ultimately a policy choice. It is not transparent today. Resolution could be sought within an overall policy framework for space policy including science.

3. Is there overlap or conflicts of objectives between ESA participation and national programs? Are synergies exploited? Are there other conflicts of objectives?

Three observations:

1. the synergies of industrial national support funds and ESA participation are strong. There is clear alignment of the priorities of the national program and the ESA activities. Overlaps or conflicts are not significant

2. the synergies between national service development programs and ESA are weaker. They exists, mostly through the ESA Earth Observation and met programs, but are not as strong as for the industrial side.

This is a reflection of the priorities of ESA. The scientific oriented earth observation programs are less suitable for meeting operational demand and requirements from the public sector in Norway. ESA satellites don't meet the requirements for continuity of access or don't have the appropriate capabilities.

In the future, this arena will shift towards the EU. It will be important to influence the EU processes to ensure alignment of objectives.

There is however no future scenario where the objectives of the national service programs and ESA are delinked. A model whereby EU systems are developed by ESA, such as for GMES, implies that there will be linkages also in the future. The same applies for EUMETSAT.

The implication is that it will be more important to secure alignment of objectives between EU priorities and Norwegian interests in arenas outside of ESA in addition to continue influencing development stages within ESA.

3. there are conflicts of objectives between meeting public sector demand and industrial development strategies. Meeting public sector demand in cost efficient ways is not aligned with schemes to support selective industries.

The support for industry is only aligned with public sector objectives as long as it leads to lower cost for government, or if the support has wealth creation and ripple effects that exceed the increased costs for governments. This also applies to bilateral support arrangements. This has to be assessed on a case-by-case basis through proper option evaluation methods.

There is a higher level conflict with structural policies for competition, public procurement and state-aid. Within ESA this is resolved as ESA is not regulated by EU or GATT principles. For national programs and subsidies this is a problem.

Public procurement and state-aid regulations are not well aligned with selective industrial development objectives. T

The practical implication is that national programs that try to merge these objectives, i.e. AIS satellite or Radarsat contract runs into legal compliance or cost-benefit difficulties.

There are only synergies in other areas where Norwegian industry is internationally competitive but national programs need to follow procedures whereby the competition is open. This is a problem today.

4. allocation decisions between science and industry do not reflect conflict of objectives. Uncertainties reflects that the balance has not been determined at a policy level. The balancing question cannot be resolved through cost efficiency considerations. The objectives and priorities are not defined by policy. That can be resolved through policy development.

5. allocation decisions between segments of industry may be seen as a conflict of objectives. It is not. Those can be determined by cost-efficiency considerations.

4- How has the Space programs managed to adapt its instruments and advice to the larger context in which space activities interacts with other social, market, economic, political and environmental processes?

There are several aspects of this. There are several indications of appropriate adaptations, and one area where it is more questionable. Four observations:

1. Well integrated with the strategic political focus on the arctic. The support for the ocean/polar and Barents sea activities are the leading examples of this. The leadership to bring Norway into the GMES programs is also a reflection of this. The importance given to Galileo and EGNOS coverage for the north is also an indication.

2. Adapted to the EU/ESA convergence. This is manifested in funding allocations for EU led work programs and in attention paid to EU policy issues.

3. Ability to find opportunities for small space nations. The programs have adopted to the trend were costs are falling and single mission microsatellites are attainable within a small resource envelope. This creates opportunities for small space programs for small nations. The AIS satellite is the practical manifestation of this so far.

4. Limited adaptation to structural market developments.

Space programs may have not been adapted well to a broader market trend with increased public-private partnerships and commercialization. Such concepts are driving developments within the earth observation segments, geotracking and military communications.

We see three implications:
(a)Increased opportunities for cost-efficient public sector programs in the future. Service offerings are likely to expand, in particular those relevant for public sector requirements. Prices will fall with increased competition including from low-cost countries. Flexibility in public sector instruments are likely to become more important. The ability to switch between providers of satellite data, and seek available low-cost options will be important.

(b) Risks that other countries, and ESA partners, will shift their priorities into public-private partnership programs rather than the joined up efforts in ESA.

(c) Opportunities for out-of-the box thinking in terms of matching commercial objectives with policy objectives. There will be more ideas like the AIS satellite in the future. A conceptual approach that brings in private risk capital and commercialization incentives may make programs financially feasible.

5. How much influence does Norway have in ESA?

There are three dimensions to this : (i)Formal structures, (ii)organizational capabilities such as committee representation and staffing, and (iii) perceptions of actual influence being used.

Three observations:

First, the formal decision making structures does by default create a strong basis for influence. This is unrelated to the size of the country or the size of the financial contribution. Rules for unanimity and two-thirds majority gives potential to negotiate and influence.

There are reports that Norway acts in the "general" interest most of the time. We don't see this as an indication of lack of influence but as a choice in how to manage the culture of consensus.

There is a risk that influence will decline over time as the involvement EU and coordination among EU member states may increase. This is however only a problem as long as there is misalignment of objectives or priorities between ESA and Norway. Currently, the objectives seem aligned.

Second, organizational issues such as committee membership and staffing. Norway has stronger membership in the boards and committees than its size would suggest. It has had leadership positions in important program boards and committees. In fact the number of leadership positions over the last decade is at par with Switzerland, Span and Netherlands. This suggests influence.

Number of Norwegian staff is relatively less than the level of financial contribution. The ratios between country staff is in practice quite stable. There may not be much potential to expand this. Growth of new member states further limits the potential. There are some indications that Norwegian staff levels have not decreased as much relatively speaking, as i.e. Sweden.

Staff are hired by ESA and are in principle not to exert national influence. It is however beneficial to Norway to have access to networks and insiders and this may be facilitated by Norwegian staff as it is for all other countries.

Third, much more subjective indications indicate reasonable influence. An earlier research report by the space center suggested that influence was as much as "any other country". Such perceptions are highly subjective and this cannot be verified.

Certain events suggests influence in matters of great importance for Norway. In particular the redesign of the Galileo orbital constellation is reported to have been influenced by Norway. The original design had less coverage of the arctic. Activities included financing analytical work to document effects of alternatives. It is argued that the revised constellation is better for all stakeholders regardless of Norwegian interests. As such there was alignment of interests. Other countries also had interests in providing improved coverage of the arctic.

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6. Is the Ministry's governance and involvement at the appropriate level?

Five observations:

There may be a rationale for more involvement in the following areas:

(a)Policy guidance on how to balance implementation of national programs with industrial objectives. There are conflicting objectives here. Implementation of national programs has run into conflicts with principles of procurement, competition, favoritism and state aid. A better strategy for handling this needs to be implemented.

(b)Policy guidance on how to balance science versus industrial financing could be required. Its currently not possible to understand the distribution of funds between the two based upon a.o documents presented to Parliament. Yet, the distribution has changed much over the last few years mostly at the discretion of the space agency. Principles and policies for how much is allocated towards research institutions, industry or public sector agencies is not transparent today.

(c) In a scenario where national programs are to be scaled up or continue at recent levels, there will be a case for stronger involvement. In particular with assessing larger investment proposals and programs. There may be a need for capabilities to "second-guess" or independently assess the quality of the proposals and analysis provided.

(d) There will be a need for stronger government-wide coordination and leadership in the future. Current involvement is appropriate. Future issues includes resolving cross-budget financing of enhanced public sector space capabilities. There are also issues with data management and processing capabilities where cross- government coordination might be needed in the future.

(e) Governance framework (objectives result indicators) seem overly detailed and possibly ineffective. Consider revisiting this.

(f) The larger role of the EU (currently focused on GALILEO and GMES) extends the traditional scope of space policy.

7. Does the space centre have the appropriate level of administrative resources to implement the programs?

This is contingent upon external and internal developments in the future. It may impact both the level of financing and the skills mix.

<u>Currently</u> it seems reasonably balanced.

<u>A future with even stronger EU involvement</u> in policy and prioritization will require a change. This could also entail increased need for policy analysts and related competencies.

<u>A future with stronger and larger national programs</u> will also require increased resource base. This would include skills for program management, oversight and economic planning option-analysis.

There are some concerns with regards to <u>governance and procurement</u> in the larger national programs. We would not suggest that the space center invests in procurement capacity to manage large scale technical acquisitions. Such capacities may be better to acquire from time to time from the operational units who benefit from the acquisitions i.e. Defense or Coastal Authority. These have professional procurement units to handle technical acquisitions.

Section 2.3

Governance and risks

The objective of this section is to identify governance risks, mitigation strategies and critical enablers for program success.

This will focus on two areas:

I. The concepts for determining objectives, allocating activities and resources and measure and report on progress; and

II. Governance risk areas that should mitigated.

Governance framework

The mandate also asks us to review the framework of objectives, results and monitoring. This is the framework in which government expresses its objectives and priorities. The space center as the implementing agency is held accountable against results. It is also the framework that guides recurring dialogue between the Ministry and the space center.

Government sets out the overall objective, and determines five sub-objectives, and further 13 objectives at a level below that. Accompanying the objectives is a description of budget appropriations corresponding to the accounts of the government budget. There is a total of 19 formulations of objectives, 27 indicators (more as several are truncated) and about 20 activities or programs described in accordance with the system of accounts. The objectives have remained largely unchanged since 2004 although some of the indicators have been revised from time to time. Annual reports are produced every year with detailed narratives describing progress and activities against the objectives.

In addition there exists a “Long-term plan for space activities sin Norway” developed by the space agency. This is a triennial plan setting out an overall objective (identical to government’s) and five sub-objectives with a corresponding action plan for each objective. Those five objectives broadly correspond to the same concepts as in the government framework but the wording , nuances and possibly meaning are different. The space center is mandated by the directives governing the institution to produce such a plan.

Next we turn to observations and suggestions for the system.

Governance framework with 19 objectives and 27 indicators

Figure 3.1: Governance framework and results indicator

Den årlige rapporteringen fra Romsenteret, samt den tilhørende styringsdialogen mellom Romsenteret og departementet, skal ta utgangspunkt i disse indikatorene.

Delmål	Resultatmål	Indikatorer
1) Sikre at romvirksomheten gir betydelige industrielle ringvirkninger	1a) Norske rombedrifter skal oppnå sterke internasjonale posisjoner	-Eksportandel av norsk romindustri
	1b) Full industriretur på programmer i ESA	-Akkumulert returkoeffisient
		-Akkumulert verdi av ESA kontrakter
	1c) Norsk romindustri skal ha like vilkår som europeisk romindustri i konkurransen om kontrakter til utbyggingen av Galileo	-Galileokontrakter til norsk romindustri
	1d) Romvirksomheten skal ha ringvirkninger utover den direkte returen	-Ringvirkningsfaktor
		-Verdien av norskproduserte romrelaterte varer og tjenester
2) Sikre at Norges geografiske fortrinn i romvirksomhet blir utnyttet	2a) Norge skal ha en ledende rolle innen romrelatert infrastruktur i polarområdene	-Antall antenner på SvalSat/KSAT (inkl Troll) og deres utnyttelsesgrad (antall pass). Dette omfatter bare de antennene over 2,5 meter i diameter som er i aktivt bruk
		-Galileo/EGNOS bakkestasjoner på norsk territorium
		-Norsk deltakelse i europeiske GNSS-prosjekter (Global Navigation Satellite System) som er relevante for nordområdene
		-Antall satellitter som utnytter SvalSat/KSAT. Denne indikatoren bør ledsages av en vurdering av markedsandelen innenfor polarbanemarkedet
		-Antall oppskytninger og Andøyas gjennomsnittlige markedsandel innen oppskytning/eksperimenter i nord over de tre siste år
		-Antall forskerdøgn på Andøya
3) Bidra til å utvikle kostnadseffektive systemer som dekker nasjonale og internasjonale behov.	3a) Tilfredsstillende GNSS-ytelse i nordområdene	-EGNOS ytelse i nordområdene (Kartverket/ESSP målinger)
		-Galileo ytelse i nordområdene
		-Utviklingen i bruk av GNSS i profesjonelle og samfunnskritiske anvendelser
	3b) Relevante norske brukere har tilgang til aktuelle Galileo-tjenester	-Formell norsk status i forhold til tjenestetilgang
	3c) Norge skal være ledende innen utnyttelse av satellittinformasjon	-Antall jordobservasjonssatellitter som benyttes av norske myndigheter Inkluderer bare jevnlig bruk
		-Antall etater som benytter satellittinformasjon. Forutsetter mer enn bare sporadisk bruk
4) Gjennom internasjonalt samarbeid bidra til å styrke norske forskningsmiljøer	4a) Norske forskningsmiljøer skal ha sentrale roller i forskningsprosjekter som utnytter rommet	-Antall prosjekter med norske deltakere/ prosjektleder. Skal gi en indikasjon på størrelsen på det norske engasjementet i vitenskapelige romprosjekter
	4b) Norske forskere skal ha tilgang til de beste satellittmålingene på sitt felt	-Antall norske forskere som benytter seg av datatilgang eller deltakelse i prosjekter. Antyder betydningen av at det legges til rette for bruk av satellittmålinger
5) Gjennom informasjonsarbeid om romvirksomhet bidra til å øke kunnskapen om teknologi- og realfag.	5a) Økt utadrettet virksomhet	-Antall arrangementer og antall deltakere på arrangementene
		-Antall foredrag holdt eksternt
		-Antall besøk på Romsenterets nettsider
	5b) Økt oppmerksomhet i media	-Antall oppslag i aviser, fagblader og på nett
		-Antall medvirkninger i radio/TV
	5c) Økt studentrettet aktivitet	-Antall søkere på studietilbud formidlet gjennom Norsk Romsenter

Framework should be revisited

Issues

1. **Over focused on performance indicators.** Many of the objectives are basically a long list of performance indicators. This is related to the next:

2. **Unclear or lack of prioritization.** Are “media appearances” as important as “ Achieving international competitiveness for space industries”? These are both sub-objectives at the same hierarchical level.

3. **Unclear logical relationships**. Example: “Norway shall have a leading role within space related infrastructure in polar regions” is an indicator subordinated to “Ensure that the geographical advantages are utilized”. It seems logical that the latter is an activity which may contribute to the first.

4. **Better linkages with activities**. The description of activities does suggest what their general purpose is. This can still be made clearer and would help clarify priorities.

5. **Feedback and adjustment mechanisms are unclear.** The narratives in the annual reports are narrative and activity based. There are no tabulations of indicators or time series. There are various observations and important issues are pointed to. This could be more structured and simplified. Emphasis should be on items useful for control and learning by the Ministry, which will enable them to further develop and improve the space programs.

Suggestions

We would suggest revisiting this framework. Two considerations in such a process:

First, it works best as a process. Clarifying and operationalizing the objectives is a first step in implementing a strategy. It involves prioritizations and requires involvement at the appropriate level.

Second, consider establishing a logical alignment between the government framework and the long-term space center plan. Any inconsistency would introduce uncertainty about which frameworks prevails.

Governance risk areas should be addressed

Governance risks have been identified during the course of the study. This is not a focus area of the work but given the consequences for the space programs we note them here.

If not ameliorated, consequences include reputational damage and loss of credibility for the space programs, wasteful spending and reduced competitiveness of the industry.

The risks may stem from difficult tradeoffs between conflicting objectives especially for national programs.

A better balancing of public sector needs, industrial development and legal compliance needs to be found.

The specific risks identified are:

I. Procurement and fiduciary risks with AIS satellite.

Non-competitive procurement of AIS satellite, all components, including AIS receiver by Norwegian producer and service provider for downloading. and national content. Markets exists for all products and services. NO public tendering was done. We recommend reviewing the ongoing process with AISSat-2.

We also recommend developing strategies to better balance development of national programs and regulatory compliance. The approaches we have seen entails to much fiduciary risk.

II. Radar data acquisition. This is similar but considering the agreement is ten years old the focus should be on the strategy for the next acquisition. The previous agreement was also non-competitive. It also entailed several provisions unrelated to government need. i.e. national content provisions. There was no competitive process for provision of the national content. This also entails regulatory and fiduciary risks. Careful considerations should be given to the balancing of industrial return with the cost increases it entails for government.

III. Conflict of interest with Kongsberg Satellite Services. Close relations and extensive support for Kongsberg Satellite Services implies conflict of interest, fiduciary risks and blocking new entrant out of the market. KSAT is recipient of the largest share of the ESA and NRS funds and part of all national government space activities and has favorable access to a.o radar data and AIS signals. There are NSC guidelines for COI but they are insufficient to ameliorate the risks. These risks are increasing as KSAT grows rapidly, also in the value added segment, and national support funds and projects involving KSAT expands.

Perceptions of preferred provider status and proximity of relations acts as a disincentive for new entrants in a market dominated by government demand and space center managed programs.

Mitigation strategies include: Transfer ownership management to the governments professional ownership department; and/or other solutions include further divesting the ownership. There may be industrial reasons for the latter but is beyond this report to expand on that subject. We see no negative impacts of mitigating these risks.

The objective of this section is advice on future changes to the program priorities, approaches and governance.

This has two important sections:

I. **Strategic considerations:** Identify areas of strategic misalignment of objectives and approaches and suggest ways to readjust; and

II. **Operational suggestions:** Identify areas where there is risk of deficiencies in realization of objectives, high cost inefficiencies or governance risks and suggests mitigation strategies to ameliorate the negative impacts.

Section 3

Suggestions

Strategic needs

Against the background of the evaluations analysis and conclusions we would recommend the following steps:

1. **The support should be reoriented towards segments of industry that offer better growth potential and comparative advantages.** Maritime and offshore sectors are the dominant growth driver for the commercial activities of SatCom services and Earth observation services. The global position is very strong. Technologies are more developed but still in growth phase. Support for near-market ready technologies promise high rewards. There is little involvement of the support schemes for this segment and this could be reassessed.
2. **Services related to earth observation have anchor tenants and growth drivers in the Norwegian government which can release technology development and ensure demand for services**. Global market position is strong. Technologies and service concepts are in the growth phase. Support should aim to broaden participation to include other companies. A strategy for commercialization should be developed for government purchases of earth observation data services to exploit the government demand as growth driver in new value-added segments. This can benefit from involving a broader segment of businesses and a more competitive and open process than it is today.
3. **The support for space related business development should increase in scope across the value chain and in number of companies to ensure equal competitive conditions across actors and solutions**. Recruitment of new businesses from i.e.. R & D, IT and telecom services expand the base form the current low number of firms who have been repeat actors for decades.
4. **Further support for segments with stagnating growth should be reassessed to ensure that the support matches the growth potential.** Space related ground equipment has some maritime anchor tenants, but seems to have decoupled with respect to growth. Support must be very carefully considered as contributions to growth and wealth creation are doubtful. Parts of space manufacturing has a strong track record in global sub segment. There are however no domestic growth factors. Major obstacles are apparent in global markets. This segment receives most support today. Rebalancing should be considered taking into account whether potential growth and wealth creation impacts are better elsewhere.
5. ESA programs are mostly relevant for the upstream space manufacturers. **ESA programs are less useful for services and other tools may need to be developed and prioritized**. This could include expansion of national program expansion may be necessary to provide the near-market-ready support for downstream services.

Operational suggestions

1. The Ministry should develop a holistic policy for space activities including determining the relative importance of support industrial development, public sector programs and science.
2. Space related investments should be made subject to broader economic option analysis if national program investments are to be expanded. Life-cycle costs, market options, and tradeoffs between national content provision and additional cost for government need to be assessed according to normal standards.
3. If bilateral deals and industrial return schemes: consider transparency and competitive schemes for national content to reduce fiduciary risks and optimize outcome. Bilateral agreements and industrial returns do not come for free. Costs of these against alternatives need to made explicit or risk serving narrow interests.
4. There is increasingly a market capable of meeting Norwegian government operational requirements for a.o radar and AIS data. Competitive procurement schemes need to be considered. Consider advanced procurement strategies to ensure competitive offerings a.o competitive dialogue, framework agreements and multiple sources. There may be a need to separate the support schemes from acquisition of public services as tehse serve different needs and objectives. Clarify or develop policy principles for how to handle the balance of conflicting objectives for: procurement for public need, industrial development objectives, bilateral collaboration; and legal compliance and fiduciary risks. The Ministry should review ongoing and planned procurements or support schemes to ensure there is regulatory alignment and fiduciary risks are handled. Rapid external developments dictates rethinking before further AIS satellite investments. Market options and viability of government alternative should be reviewed with proper methods.
5. The Ministry and the Space Centre should reassess the governance framework and tie this more closely to the governance dialogue and strategy. The logical framework should be reviewed and further simplifications and alignment with the long-term strategic plan should be implemented.
6. Improve transparency of the grant schemes and ESA support. Information is not publically available today and this is problematic especially n light of how few companies that are involved and that receives substantial support.
7. Reduce conflict of interest potential with KSAT by reorganizing ownership management.
8. Consider reinforcing monitoring of ESA budget and account measures through the IPSAS accounting transition
9. If further scale-up of national programs, the space center may need to be reinforced.
10. If EU/ESA relationship converge further, the space center may need additional support.

Appendix

I. **Appendix 1.** Detailed methodological notes on the socio-economic analysis

II. **Appendix 2**. Detailed review of governance indicators

Appendix 1

Detailed methodological notes on the socio-economic analysis

Introducing Cost-Benefit Analysis

In everyday life, it is often useful to establish whether an activity is 'worthwhile' or not. To do so, we compare the value of the costs with that of the benefits realized from the activity. If the benefits outweigh the costs, the activity is considered worthwhile, or cost-effective. This is the crux of Cost-Benefit Analysis.

Cost-Benefit Analysis (CBA) is an economic analysis that quantifies **in monetary terms and compares as many of the costs and benefits of a policy as is feasible**, including items for which the market does not provide a satisfactory measure of economic value, in order to determine whether the policy has given rise to a Net Benefit (i.e.. is cost-effective and is justified by economic rationale, subject to consideration of non-monetized costs and benefits) or a Net Cost.

Deflation, discounting and Present Values

Whether one considers prices of groceries, fuel, or wages (the price of labor) they increase over time. In economics, the concept is known as inflation, and the difference in price from one year to the next is known as the *inflation rate*. In order to be able to compare like for like, values are deflated. In the present setting, the ***production price index*** for manufacturing is used to make the values comparable.

Deflating values, however, is not sufficient, as people generally prefer to receive goods and services sooner rather than later, and so they value costs incurred and benefits reaped in the current year higher than those in future years. The difference in value from one year to the next is known as the *discount rate*.

As costs and benefits of policies arise in different time periods, it is necessary to *discount* future values to a common base year, known as ***Present Values (PV)***, in order to permit direct comparison. The difference between the Present Value of the stream of benefits and the Present Value of the stream of costs is called the ***Net Present Value (NPV)***. A positive NPV, signaling a Net Benefit, is the primary criterion for deciding whether government action has been justified. Similarly, the ***Benefit:Cost Ratio*** is simply the Present Value of Benefits divided by the Present Value of Costs.

The **principle of proportionality** implies that the effort applied to the estimation of cost and benefits, should be proportionate to the scale of the costs and benefits, outcomes at stake, sensitivity of the policy and the time available.

Non-monetized costs and benefits

A CBA can only incorporate monetizable costs and benefits. This means that the resulting *Benefit:Cost Ratio* cannot be considered as exclusive and final evidence, but must be seen in the context of non-quantifiable costs and benefits. Non-quantifiable costs and benefits are discussed qualitatively on separate slides.

Additionality and the counterfactual

The impact of a policy on socio-economic factors depends on the degree of additionality – the degree to which the policy has created activity that would not have otherwise occurred absent the policy (the counterfactual). All costs and benefits included are defined and measured as deviations from the counterfactual – the ESA contracts, other space sector sales, sales outside of the space sector and related benefits that would not have been available if Norway had not participated in ESA, or provided support funds.

In terms of the users of ESA program outputs, despite the fact that some data would not have been available (and therefore some benefits missed), end-users could have had access to much of the data or outputs they currently use from different sources.

The impact is the highest in a case where ESA effectively employ idle workers in Norway, and the skills, innovation and production processes learned by those workers through ESA's programs allow them to sell goods and services to other clients. If ESA effectively crowd out other potential clients, then the impact will be less pronounced.

Norwegian and international best practice

Our analysis is based on Norwegian government and European Commission impact assessment guidelines and international best practice (e.g. UK government HM Treasury's *Green Book*).

Underlying CBA model

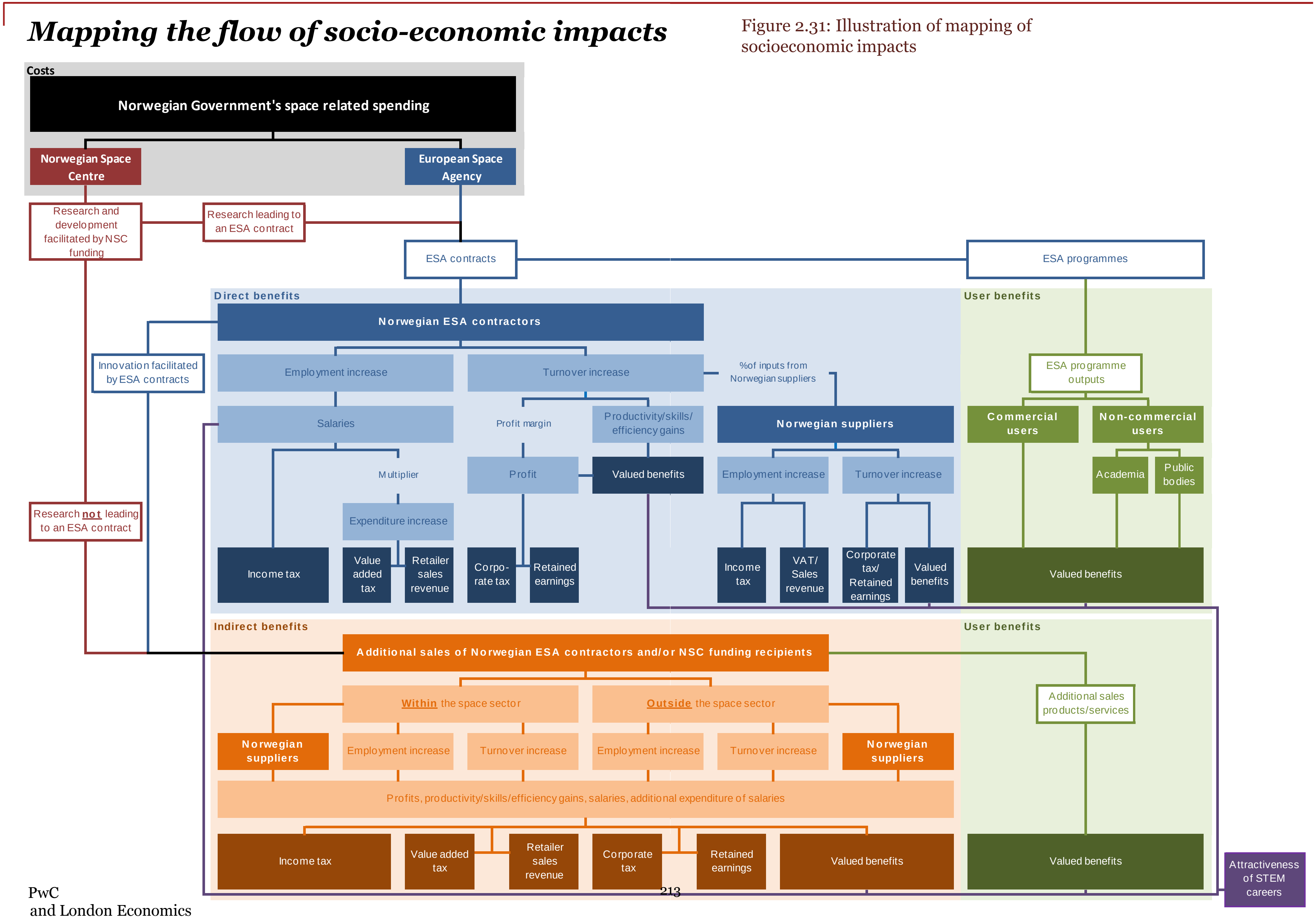
A detailed Excel-based economic model underlies the analysis (delivered separately).

Other notes

More detailed technical description is provided.

Sources: Utredningsinstruksen (issued by Fornyings-, Administrasjons- og Kirkedepartementet), The Green Book (issued by HM Treasury), and Impact Assessment Guidelines (SEC(2009) 92).

Figure 2.31: Illustration of mapping of socioeconomic impacts



Existing evaluations are limited in their coverage of economic and social impacts

Very often, assessments of the economic benefits flowing from public spending on space activities limit themselves to estimating the gross impact on companies benefiting from space related contracts and the multiplier effect of this impact on the rest of the economy. Only in some cases is the net (wealth creation) effect or the wider impact on innovation and technological change at the companies, their suppliers and, potentially, in the rest of the economy considered.

Examples of such approaches include:

- The **Norwegian Space Centre** which estimates that for each NOK of government funding of space activities (ESA or the national support scheme), Norwegian companies have attained in 2009 an additional turnover of 4.7 NOK (i.e.. the spin-off factor is 4.7 unadjusted for inflation).
- The **European Space Agency** estimates that the direct revenues generated by the space industry (manufacturing and satellite services) represent only 17% of the total financial impact of space on the economy. Indirect revenues generated by suppliers to the space industry accounted for 47% of the total financial impact of the space industry and induced revenues (via the multiplier effect) accounted for 36% of the total financial impact of space on the economy.
- The study by **Amesse et al. (2002)** of the economic effects and spin-offs of Canadian space spending adopted the methodology developed by the **Bureau d'Economie Théorique et Appliquée (BETA)** of the University Louis Pasteur of Strasbourg. This methodology focuses on the indirect, dynamic effects of R&D projects such as space programs and distinguishes between:
  - Indirect technological effects arising from:
    - the sale of the same product to other customers (i.e.. the extent to which the turnover of companies increases as a result of additional sales to third parties of the product/service sold to the space program
    - Improvements in the current product line based on the space technology developed for the space client
    - Sales of new products based on the space technology
  - Indirect marketing effects which arise from the enhanced reputation of the company selling to the space client and improved image following successful completion of the project for the space client, and potentially the network boosted by new firms that were part of the project
  - Indirect process and organizational effects, i.e.. the learning of new processes, methods, management techniques during the course of the project for the space client and the application of these skills outside the project
  - Critical mass effect

  Using this BETA approach, the study found that the overall ratio of effects for one CDN$ 1 in payment was 4.2 in 1993.
- The **BETA team** has undertaken numerous evaluations of ESA programs using the approach outlined above and in a summary of the their studies (see **Bach et al., 2002**) undertaken for the eighties, they report an overall ratio of effects to ESA contracts of slightly more than 3.2.
- A set older **US studies**, focusing on the impact on the US economy of spending by NASA aimed to assess the impact of NASA's spending on private productivity using a production function approach.
- Furthermore, **various studies** focusing on specific space programs/applications used a cost-benefit analysis framework to assess the net impact of particular activities.

Unfortunately, the studies listed above do not fully take account of all the economic and social impacts of space-related activities.

On one hand, the BETA-type studies focus primarily on the direct and indirect effects on the particular firm arising from the demand of a space agency for particular goods and services. On the other hand, cost-benefit-analyses focus on the net (benefits less costs) effect of the full range of impacts of specific activities/programs funded by a space agency.

Utilizing the Ripple Effects survey data

The Norwegian Space Centre has run an annual data collection exercise with ESA contractors and support fund recipients since 1985, with a consistent methodology, called the 'Ripple Effects' survey.

The objective of the Ripple Effects analysis is to understand the impact of ESA support on total sales, separated into space- and non-space-related. The primary output of the analysis is the ***Ripple Effects Multiplier***, defined as aggregate sales from 1988 to 2010 divided by aggregate support from 1985 to 2007. Note that a three year shift is introduced to take account for lag times.

It is important to realize that increases in sales are not equal to **wealth creation**. Wealth creation is the objective of Norway's space policy, and is a function of profits and labor expenditure.

As the Ripple Effects Multiplier is generated using data spanning several decades, there are issues relating to timing:

- **Values are not adjusted for inflation.** Inflation erodes value over time. Thus, NOK100 is worth less in real terms (buying power) in 2010 than in 2004, and significantly less than NOK100 in 1985 – more NOK is required to purchase the same basket of goods today than in earlier years. As the Ripple Effects Multiplier simply sums the stream of support and lagged sales over a 23 year period, it incorrectly places equal weight on each NOK1 of support in 1985 as each NOK1 of sales in 2010, producing a potentially misleading estimate. In addition, the 3 year gives rise to a systematic (but minor) overstatement of the multiplier.
- **Unclear temporal link between ESA contracts and ESA-generated sales.** Some enterprises may still be reporting ESA-generated sales associated with early ESA contracts, others may not. Enterprises may also discount the degree of ESA-facilitation of their sales. It is unknown.
- **Effect smoothed over time.** By aggregating sales and support over 23 years, fluctuations due to events specific to one year, or a trend over time, may be dampened by the sheer volume of previous sales and support.

Spin-off company to handle commercialization

One survey respondent has created a *spin-off company* to commercialize the knowledge gained from the ESA contract, which is not included in the Ripple Effects survey, which only covers recipients of ESA or support funding.

The spin-off company is currently in its infancy, but has a promising future with substantial funding from industry heavyweights starting to materialize. If this spin-off approach is adopted by more enterprises, then the Ripple Effects Multiplier will underestimate the effect.

Ripple Effects data

Despite the noted shortcomings of the Ripple Effects Multiplier, the Ripple Effect survey data remain the most comprehensive data source to achieve our objective, so it forms the primary data source used in our assessment.

The Norwegian Space Centre has supplied the Ripple Effects aggregate survey data for the purpose of this study. The Norwegian Space Centre also provided a list of contacts in the organizations that respond to the Ripple Effects survey.

Individual enterprise-level Ripple Effects survey data

Because the Norwegian space sector firms differ greatly in terms of size, degree of space sector specialization, and position in the value chain, the individual responses from the Ripple Effects survey are necessary to perform a meaningful impact assessment. 25 of a total of 26 enterprises agreed to provide their specific responses from the Ripple Effects survey. Across the period 2004-2010, these 25 enterprises account for approximately 95% of the total value of ESA contracts and the following shares of key information:

- Individual enterprise level
  - 25 out of 26 enterprises
  - 95% of total ESA contract value 2004-2010
  - 100% of total NSCSS funds
  - 50% of total turnover
  - 33% of total employment
  - 100% of space sector profits
  - 99% of ESA generated sales within the space sector
  - 80% of ESA generated sales outside the space sector
  - 99% of non-ESA generated sales within the space sector

Filling the information gaps: PwC/LE bespoke survey and workshops

PwC/LE bespoke survey

In order to inform the impact assessment beyond the information that was available in the Ripple Effects survey, PwC and London Economics used an online questionnaire to survey the Norwegian enterprises that participated in the Ripple Effects survey.

The questions relate to the financials of each enterprise, and comprise pre-tax profit margin, labor cost share, and Norwegian supplier input share. These topics were delineated into specific parameters for ESA contracts, ESA generated sales to space sector enterprises and outside, and other space related sales. In addition, questions on indirect effects, such as productivity and marketing gains, from the contract were included.

A total of 26 enterprises were invited to take part in the analysis, and after an initial response period reminders were sent to non-responding enterprises, and follow-up phone calls made to fill in missing responses. 22 of the 26 enterprises responded to the survey. These 22 enterprises account for 85% of enterprises and 90% of total ESA contract value.

17 of the respondents completed the survey. The response rate varies between the individual questions. More than two-thirds of the respondents have provided answers to the questions about ESA contracts, and more than half of respondents answered the questions about additional benefits from ESA contracts. ESA generated sales within space and outside space were commented on by roughly two-thirds and a half of respondents, respectively. Non-ESA generated sales in space covered by one-third of respondents and impacts on suppliers touch on by only a few of respondents.

In considering these response numbers, however, it is important to note that not all questions apply to all enterprises (e.g. if an enterprise did not experience ESA generated sales, questions relating to such sales are void for that respondent), so a complete set of responses is not necessarily 25.

PwC/LE workshops

PwC and London Economics hosted a workshop with stakeholders from Norwegian enterprises and research bodies involved with space. The information obtained there was used to get a feel for the industry as a whole, and to inform qualitative discussions about Norway's benefits from space activity.

PwC/LE survey particulars

- 22 respondents of 26 enterprises.
- 90% of total contract value accounted for.
  - By type of sale: ESA contract, ESA-generated space sales, ESA generated non-space sales, NSC generated sales:
    - Degree of facilitation by ESA/NSC
    - Profit margin
    - Share of sales value spent on labor
    - Share of sales value spent on Norwegian supplier inputs.
  - In addition, for ESA contracts, effects beyond direct increase in sales:
    - Impact on product development capabilities
    - Impact on productivity (output per labor hour)
    - Impact on sales (e.g. through marketing effects).
  - Qualitative questions about:
    - Users of services
    - User benefits
    - Impact on suppliers
    - Impact on competitors.

The full survey, including response rates is available in the Appendices.

Technical description of CBA methodology, input values and sources (i)

The Cost-Benefit Analysis modeling logic

There are two high-level types of benefits. ***Direct benefits*** and ***Indirect benefits***. The direct benefits follow as an immediate effect of ESA contracts (e.g. sales, employment), whilst any secondary effects are termed indirect benefits.

Two types of enterprises are the basis for calculating the direct benefits. They are **(i) Norwegian ESA contractors** and **(ii) Norwegian suppliers to (i)**.

Norwegian ESA contractors are the enterprises that win contracts with ESA. The benefits driven by Norwegian ESA contractors are further separated into *static* benefits (once-off) and *dynamic* benefits (ongoing).

Direct static benefits through ESA contractors can be thought of as benefits that happen at the same time as the ESA contract is active. The benefits accruing to the Norwegian state are driven by **wages and profit**, measured by **tax revenue, retailer sales revenues, retained earnings, and employment**. Three types of tax are relevant: **Income tax**, **value added tax**, and **corporation tax**.

Multiplying the ESA contract value (Ripple Effects Survey responses) by the share of ESA contract value spent on labor inputs (PwC/LE bespoke survey) yields the total salary bill relating to ESA contracts of ESA contractors. With the total salary bill related to ESA contracts in place, the **income tax** generated by ESA contracts can be estimated by multiplying the salary bill by the income tax rate (www.skatteetaten.no).

The employees of ESA contracts are remunerated for their ESA work. Under the assumption that they spend their disposable (i.e.. post-tax) income, they will be paying **value added tax** on their purchases. However, the spending of the employees of the Norwegian ESA contractors helps generating jobs and additional tax revenue in the economy (**multiplier effect**). The multiplier is assumed at 1.3 (Kommunal- og Regionaldepartementet) and multiplied by the disposable income of employees of Norwegian ESA contractors and the value added tax rate (www.skatteetaten.no) yields the tax revenues from **value added tax**. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

... continued on the next slide (Assumptions, parameter values and sources relating to the above analysis are presented on the right hand side of this slide)

Relevant input and assumptions values and sources

Direct static benefits through **Norwegian ESA contractors:**

•ESA contract value is taken from the individual Ripple Effects Survey responses.

•Salary share of ESA contract value taken from PwC/LE bespoke survey.

- 16 respondents provided an estimate in 2005 and 17 respondents provided a number in 2010. The number used in the model is the average of responses weighted by the value of ESA contracts won by the responding enterprises.
- If the numbers differ, it is assumed that years before 2005 apply the 2005 value, years after 2010 apply the 2010 value, and years between 2005 and 2010 apply a linear evolution of the parameter value. The weighted average of 2005 values is 63.0% and the weighted average of 2010 values is 48.7%, so the 2007 value is 57.3%.

•Income tax rate was found on the website of the Norwegian Tax Authorities (www.skatteetaten.no). The latest income tax rate is assumed to persist in the future. The income tax rate for 2007 was not available on the website, so it is assumed that the 2007 income tax rate is the simple average of the 2006 and 2008 income tax rates.

•The multiplier is based on the finding in Kommunal- og Regionaldepartementet "Effekter og effektivitet", 2004, that public consumption affects BNP at a factor of 1.3. Public consumption is almost exclusively made up of salary expenses, so the effect arises from additional salaries paid. Thus the multiplier is likely to be close to 1.3.

•Value added tax rate was found on the website of the Norwegian Tax Authorities (www.skatteetaten.no). In Norway, value added tax is different among food, transportation, and general consumption. Using the average consumption pattern of Norwegian consumers found on Statistics Norway's website (www.ssb.no) consumption weighted average value added tax rate was computed.

Technical description of CBA methodology, input values and sources (ii)

The Cost-Benefit Analysis modeling logic *(continued)*

The calculation of **employment** increase (job creation) is based on the total salary bill. The number of employee years assigned to ESA contracts is defined as the total salary bill divided by the average salary in the space sector (Statistics Norway).

Corporation tax is calculated as the ESA contract value (Ripple Effects Survey) multiplied by the pre-tax profit margin on ESA contracts (PwC/LE bespoke survey) and the corporation tax rate (www.skatteetaten.no). **Retained earnings** are measured by subtracting corporation tax from the measured profits.

Direct dynamic benefits through ESA contractors are benefits beyond the immediate and static benefits.

The productivity gains associated with ESA contracts is available from the PwC/LE bespoke survey. It is assumed that 60% of the productivity improvement is legible as profit increases. Total space-related profits is available from the Ripple Effects Survey. Multiplying total space-related profits by productivity improvement, 60% and the corporation tax rate yields the **corporation tax** revenues arising from productivity improvements. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

Relevant input and assumptions values and sources

•Statistics Norway do not provide the average salary for space, so the simple average salary in industry and communications were chosen to reflect that the space sector is loaded towards high-skilled employment (communications) but contains manufacturing and engineers as well (industry).

•ESA contract value is read from the individual Ripple Effects Survey responses.

•Pre-tax profit margin on ESA contracts taken from PwC/LE bespoke survey.

- 15 respondents provided an estimate in 2005 (10.2%) and 17 respondents provided a number in 2010 (4.5%). The number used in the model is the average of responses weighted by the value of ESA contracts won by the responding enterprises. See “labor cost share” on the previous slide for the treatment on years different from 2005 and 2010.

•Corporation tax rate was found on the website of the Norwegian Tax Authorities (www.skatteetaten.no). The 2010 corporation tax rate is assumed to persist.

Direct dynamic benefits through **Norwegian ESA contractors:**

•Total space-related profits is read from the individual Ripple Effects Survey responses.

•Productivity improvement from ESA contracts taken from PwC/LE bespoke survey.

- 10 respondents provided a number (11.2%). The number used in the model is the average of responses weighted by total space-related profit of the responding enterprises.

•The share of productivity feeding into profits is assumed to be less than 100% as fixed cost may impact the calculation. 60% was chosen by London Economics.

Technical description of CBA methodology, input values and sources (iii)

The Cost-Benefit Analysis modeling logic *(continued)*

The PwC/LE bespoke survey also asked about the share of overall sales (Ripple Effects Survey) that could be attributed to ESA contracts. Multiplying the two terms by the average of ESA generated space-related pre-tax profit margin and NSC generated, not ESA-facilitated space-related sales (PwC/LE bespoke survey), and corporation tax rate yields the **corporation tax revenues** arising from additional sales driven by ESA contracts. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

Relevant input and assumptions values and sources

•Total sales is read from the individual Ripple Effects Survey responses.

•Overall sales increase driven by ESA contract is available from the PwC/LE bespoke survey:

- 11 respondents provided a number (11.2%). The number used in the model is the average of responses weighted by total space-related profit of the responding enterprises.

•Pre-tax profit margin on ESA generated space-related sales is taken from PwC/LE bespoke survey.

- 13 respondents provided an estimate in 2005 (12.5%) and 17 respondents provided a number in 2010 (14.2%). The number used in the model is the average of responses weighted by the value of ESA- facilitated space-related sales of the responding enterprises.

•Pre-tax profit margin on NSC-generated sales not facilitated by ESA is taken from PwC/LE bespoke survey.

- 10 respondents provided an estimate in 2005 (14.5%) and 11 respondents provided a number in 2010 (16.3%). The number used in the model is the average of responses weighted by the value of NSC-generated sales not facilitated by ESA of the responding enterprises.

Technical description of CBA methodology, input values and sources (iv)

The Cost-Benefit Analysis modeling logic *(continued)*

Knowing the share of overall sales that is attributable to ESA contracts and the share of sales value spent on salaries provides the opportunity to calculate the **income tax revenue** accruing as a consequence of ESA work. The PwC/LE bespoke survey asks about the salary share of ESA-generate sales in space and the salary share of NSC-generated sales not facilitated by ESA. The average is used to compute the salary share of total sales. Multiplying total sales by the degree of additional sales beyond the ESA contract and the average salary share and the income tax rate provides the **income tax revenue**.

The total salary bill from additional sales divided by the average salary in the space sector provides an estimate of the **number of workers employed** as a result of the additional sales.

Subtracting income tax revenue from the total salary bill yields the disposable income of worker employed as a result of additional sales arising from ESA contracts. The disposable income is multiplied by the multiplier defined above, and the weighted average value added tax rate to yield **value added tax revenues** arising through additional sales driven by ESA. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Relevant input and assumptions values and sources

•Total sales is read from the individual Ripple Effects Survey responses.

•Overall sales increase driven by ESA contract is available from the PwC/LE bespoke survey:

- 10 respondents provided a number (11.2%). The number used in the model is the average of responses weighted by total space-related profit of the responding enterprises.

•Salary share of ESA generated space-related sales is taken from PwC/LE bespoke survey.

- 13 respondents provided an estimate in 2005 (39.6%) and 17 respondents provided a number in 2010 (38.8%). The number used in the model is the average of responses weighted by the value of ESA- facilitated space-related sales of the responding enterprises.

•Salary share of NSC-generated sales not facilitated by ESA is taken from PwC/LE bespoke survey.

- 10 respondents provided an estimate in 2005 (50.5%) and 9 respondents provided a number in 2010 (35.4%). The number used in the model is the average of responses weighted by the value of NSC-generated sales not facilitated by ESA of the responding enterprises.

•Statistics Norway do not provide the average salary for space, so the simple average salary in industry and communications were chosen to reflect that the space sector is loaded towards high-skilled employment (communications) but contains manufacturing and engineers as well (industry).

•Income tax rate, average salary in space, dynamic multiplier, and value added tax rate all defined above.

Technical description of CBA methodology, input values and sources (v)

The Cost-Benefit Analysis modeling logic *(continued)*

Direct static benefits through **suppliers** to ESA contractors are measured using the share of ESA contract value that is spent on inputs from Norwegian suppliers (PwC/LE bespoke survey). Multiplying the value of ESA contracts by the share of ESA contract value spent on inputs from Norwegian suppliers yields the total turnover of Norwegian ESA suppliers driven by ESA contracts. Assuming that salary share and pre-tax profit margin of Norwegian suppliers to ESA contractors mirror the averages of space-related sales for ESA generated sales for ESA contractors (PwC/LE bespoke survey) provides the bases for calculating **corporation tax revenue** and **income tax revenue** taken through Norwegian suppliers to ESA contractors.

Corporation tax revenue is calculated as ESA contract value multiplied by Norwegian supplier share (PwC/LE bespoke survey), average pre-tax profit margin on space-related sales (PwC/LE bespoke survey), and corporation tax rate. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

A share of the ESA contract value that goes to suppliers trickles further down the system to the suppliers of the suppliers to ESA contractors. Assuming that the ratio of leakage to supplier share among suppliers is the same as the ratio among ESA contractors provides a way of calculating the value of what trickles through. The share is defined as

$\text{Suppliershare}_{\text{suppliers}} = \text{Suppliershare}_{\text{contractors}} * (1\text{-salaryshare}_{\text{suppliers}} - \text{profitmargin}_{\text{suppliers}})/(1\text{-salaryshare}_{\text{contractors}} - \text{profitmargin}_{\text{contractors}})$

Multiplying the supplier share for suppliers by the value that goes to suppliers yields the value that goes to the suppliers of suppliers. This value is counted as **retained earnings.**

Income tax revenue is calculated as ESA contract value multiplied by Norwegian supplier share (PwC/LE bespoke survey), average salary share of space related sales (PwC/LE bespoke survey), and income tax rate.

Workers employed by suppliers to ESA contractors caused by the ESA contracts is calculated as the total salary bill divided by the average salary of space-related employees.

Relevant input and assumptions values and sources

Direct static benefits through **suppliers** to ESA contractors

•ESA contract value is read from the individual Ripple Effects Survey responses.

•Norwegian supplier share of ESA contract value is taken from PwC/LE bespoke survey.

- 15 respondents provided an estimate in 2005 (12.1%) and 17 respondents provided a number in 2010 (21.9%). The number used in the model is the average of responses weighted by the value of ESA contracts of the responding enterprises.

•Average pre-tax profit margin from space-related sales is defined above.

•Average salary share on space-related sales is defined above.

•Pre-tax profit margin and salary shares for contractors are defined above.

•Corporation tax rate and income tax rate are defined above.

•Average salary in space sector is defined above.

Technical description of CBA methodology, input values and sources (vi)

The Cost-Benefit Analysis modeling logic *(continued)*

Value added tax revenue is calculated as the total salary bill driven by ESA contracts for suppliers to ESA contractors multiplied by the dynamic multiplier and the value added tax rate. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Direct dynamic benefits through suppliers to ESA contractors are driven by increases in productivity.

The productivity gains accruing to suppliers as a result of ESA contracts is available from the PwC/LE bespoke survey. It is assumed that 60% of the productivity improvement is legible as profit increases. The profits calculated above form the base of the calculation. Multiplying profits by productivity improvement, 60% and the corporation tax rate yields the **corporation tax revenues** arising from productivity improvements. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

Relevant input and assumptions values and sources

The dynamic multiplier and value added tax rate are defined above.

Direct dynamic benefits through **suppliers** to ESA contractors

•Supplier productivity gains driven by ESA contract is available from the PwC/LE bespoke survey:

- Few respondents were able to quantify additional benefits to suppliers. Those that did quantify, and had supplies in the relevant years, estimated 10%, which is the number used in the model.

Technical description of CBA methodology, input values and sources (vii)

The Cost-Benefit Analysis modeling logic *(continued)*

Indirect static benefits through **ESA contractors** due to ESA-generated sales within the space sector are based on ESA-generated sales within the space sector (Ripple Effects Survey). Multiplying by the share of ESA-generated sales within the space sector that is attributable to ESA (PwC/LE bespoke survey) and pre-tax profit margin (PwC/LE bespoke survey) yields the profits earned by ESA generated sales for ESA contractors. Further multiplying by the corporation tax rate yields the total **corporation tax revenues**. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

Multiplying the value of ESA-generated sales within the space sector by the salary share of ESA-generated sales within the space sector (PwC/LE bespoke survey) yields the total salary bill attributable to ESA-generated sales within the space sector. Further multiplying by the income tax rate yields the total **income tax revenue** arising from ESA-generated sales within the space sector.

Subtracting the total income tax revenue from the total salary bill attributable to ESA-generated sales within the space sector yields disposable income. Multiplying by the dynamic multiplier and the value added tax rate gives the total **value added tax revenues** caused by ESA-generated sales within the space sector. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Dividing the total salary bill by the average salary in the space sector gives the number of **workers employed** due to ESA-generated sales within the space sector.

Relevant input and assumptions values and sources

Indirect static benefits through **ESA contractors** due to ESA-generated sales within the space sector.

•The value of ESA-generated sales within the space sector is read from the individual Ripple Effects Survey responses.

•The share of ESA-generated sales within the space sector attributable to ESA is taken from the PwC/LE bespoke survey.

- 13 respondents provided an estimate in 2005 (92.7%) and 17 respondents provided a number in 2010 (90.7%). The number used in the model is the average of responses weighted by the value of ESA- facilitated space-related sales of the responding enterprises.

•Pre-tax profit margin on ESA generated sales within the space sector is taken from PwC/LE bespoke survey.

- 12 respondents provided an estimate in 2005 (12.7%) and 17 respondents provided a number in 2010 (14.2%). The number used in the model is the average of responses weighted by the value of ESA- facilitated space-related sales of the responding enterprises.

•The corporation tax rate is defined above.

•Salary share of ESA generated sales within the space sector is taken from PwC/LE bespoke survey.

- 13 respondents provided an estimate in 2005 (39.6%) and 17 respondents provided a number in 2010 (38.8%). The number used in the model is the average of responses weighted by the value of ESA- facilitated space-related sales of the responding enterprises.

•The income tax rate is defined above.

•The dynamic multiplier and weighted average value added tax rate is defined above.

•The average salary in the space sector is defined above.

Technical description of CBA methodology, input values and sources (viii)

The Cost-Benefit Analysis modeling logic *(continued)*

Indirect static benefits through **suppliers** to ESA contractors due to ESA-generated sales within the space sector are based on ESA-generated sales within the space sector (Ripple Effects Survey), the share of ESA-generated sales that is attributable to ESA (PwC/LE bespoke survey), and the share thereof spent on inputs from Norwegian supplier (PwC/LE bespoke survey). The product of those factors forms the basis for the calculations.

Multiplying the basis by the average pre-tax profit margin within space and the corporation tax rate yields the total **corporation tax receipts** from suppliers. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

A share of the ESA-generated sales that goes to suppliers trickles further down the system to the suppliers of the suppliers to ESA contractors who experience additional sales. Assuming that the ratio of leakage to supplier share among suppliers is the same as the ratio among ESA contractors provides a way of calculating the value of what trickles through. The share is defined as

$\text{Suppliershare}_{\text{suppliers}} = \text{Suppliershare}_{\text{contractors}} * (1\text{-salaryshare}_{\text{suppliers}} - \text{profitmargin}_{\text{suppliers}})/(1\text{-salaryshare}_{\text{contractors}} - \text{profitmargin}_{\text{contractors}})$

Multiplying the supplier share for suppliers by the value that goes to suppliers yields the value that goes to the suppliers of suppliers. This value is counted as **retained earnings.**

The basis multiplied by the average salary share within the space sector yields the total salary bill, and the income tax rate provides the total **income tax receipts** from suppliers.

Subtracting the total income tax receipts from the total salary bill yields disposable income, and multiplying that number by the dynamic multiplier and the value added tax rate provides the total **value added tax receipts**. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Dividing the salary bill by the average salary in the space sector provides the number of **workers employed** by suppliers fulfill ESA-generated sales within the space sector.

Relevant input and assumptions values and sources

Indirect static benefits through **suppliers** to ESA contractors.

•The share of ESA-generated sales within the space sector that is attributable to ESA is defined above.

•Norwegian supplier share of the value of ESA-generated sales within the space sector is taken from PwC/LE bespoke survey.

- 13 respondents provided an estimate in 2005 (18.4%) and 17 respondents provided a number in 2010 (17.7%). The number used in the model is the average of responses weighted by the value of ESA-generated sales outside the space sector of the responding enterprises.

•The average pre-tax profit margin and the corporation tax rate are defined above.

•The average salary share and the income tax rate are defined above.

•Pre-tax profit margin and salary shares for contractors are defined above.

•The dynamic multiplier and the weighted average value added tax rate are defined above.

•The average salary is defined above.

Technical description of CBA methodology, input values and sources (ix)

The Cost-Benefit Analysis modeling logic *(continued)*

Indirect static benefits through **ESA contractors** due to ESA-generated sales outside the space sector are based on ESA-generated sales outside the space sector (Ripple Effects Survey) and the share of ESA-generated sales outside the space sector that is attributable to ESA (PwC/LE bespoke survey). Multiplying by the pre-tax profit margin (PwC/LE bespoke survey) yields the profits earned by ESA generated sales for ESA contractors. Further multiplying by the corporation tax rate yields the total **corporation tax revenues**. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

Multiplying the value of ESA-generated sales outside the space sector by the salary share of ESA-generated sales outside the space sector (PwC/LE bespoke survey) yields the total salary bill attributable to ESA-generated sales within the space sector. Further multiplying by the income tax rate yields the total **income tax revenue** arising from ESA-generated sales within the space sector.

Subtracting the total income tax revenue from the total salary bill attributable to ESA-generated sales outside the space sector yields disposable income. Multiplying by the dynamic multiplier and the value added tax rate gives the total **value added tax revenues** caused by ESA-generated sales within the space sector. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Dividing the total salary bill by the average salary in the space sector gives the number of **workers employed** due to ESA-generated sales outside the space sector.

Relevant input and assumptions values and sources

Indirect static benefits through **ESA contractors** due to ESA-generated sales outside the space sector.

•The value of ESA-generated sales outside the space sector is read from the individual Ripple Effects Survey responses.

•The share of ESA-generated sales outside the space sector attributable to ESA is taken from the PwC/LE bespoke survey.

- 8 respondents provided an estimate in 2005 (18.7%) and 9 respondents provided a number in 2010 (21.0%). The number used in the model is the average of responses weighted by the value of ESA- facilitated non space-related sales of the responding enterprises.

•Pre-tax profit margin on ESA generated space-related sales outside the space sector is taken from PwC/LE bespoke survey.

- 7 respondents provided an estimate in 2005 (6.0%) and 10 respondents provided a number in 2010 (9.5%). The number used in the model is the average of responses weighted by the value of ESA- facilitated non space-related sales of the responding enterprises.

•The corporation tax rate is defined above.

•Salary share of ESA generated non space-related sales is taken from PwC/LE bespoke survey.

- 8 respondents provided an estimate in 2005 (45.5%) and 10 respondents provided a number in 2010 (53.0%). The number used in the model is the average of responses weighted by the value of ESA- facilitated non space-related sales of the responding enterprises.

•The income tax rate is defined above.

•The dynamic multiplier and weighted average value added tax rate is defined above.

•The average salary in the space sector is defined above.

Technical description of CBA methodology, input values and sources (x)

The Cost-Benefit Analysis modeling logic *(continued)*

Indirect static benefits through **suppliers** to ESA contractors due to ESA-generated sales outside the space sector are based on ESA-generated sales outside the space sector (Ripple Effects Survey) and the share thereof spent on inputs from Norwegian supplier (PwC/LE bespoke survey). The product of those factors forms the basis for the calculations.

Multiplying the basis by the average pre-tax profit margin outside space and the corporation tax rate yields the total **corporation tax receipts** from suppliers. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

A share of the ESA-generated sales that goes to suppliers trickles further down the system to the suppliers of the suppliers to ESA contractors who experience additional sales. Assuming that the ratio of leakage to supplier share among suppliers is the same as the ratio among ESA contractors provides a way of calculating the value of what trickles through. The share is defined as

$\text{Suppliershare}_{\text{suppliers}} = \text{Suppliershare}_{\text{contractors}} * (1\text{-salaryshare}_{\text{suppliers}} - \text{profitmargin}_{\text{suppliers}})/(1\text{-salaryshare}_{\text{contractors}} - \text{profitmargin}_{\text{contractors}})$

Multiplying the supplier share for suppliers by the value that goes to suppliers yields the value that goes to the suppliers of suppliers. This value is counted as **retained earnings.**

The basis multiplied by the average salary share outside the space sector yields the total salary bill, and the income tax rate provides the total **income tax receipts** from suppliers.

Subtracting the total income tax receipts from the total salary bill yields disposable income, and multiplying that number by the dynamic multiplier and the value added tax rate provides the total **value added tax receipts**. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Dividing the salary bill by the average salary in the space sector provides the number of **workers employed** by suppliers fulfill ESA-generated sales within the space sector.

Relevant input and assumptions values and sources

Indirect static benefits through **suppliers** to ESA contractors.

•The share of ESA-generated sales outside the space sector that is attributable to ESA is defined above.

•Norwegian supplier share of the value of ESA-generated sales outside the space sector is taken from PwC/LE bespoke survey.

- 7 respondents provided an estimate in 2005 (16.0%) and 9 respondents provided a number in 2010 (11.5%). The number used in the model is the average of responses weighted by the value of ESA-generated sales outside the space sector of the responding enterprises.

•The average pre-tax profit margin and the corporation tax rate are defined above.

•The average salary share and the income tax rate are defined above.

•Pre-tax profit margin and salary shares for contractors are defined above.

•The dynamic multiplier and the weighted average value added tax rate are defined above.

•The average salary is defined above.

Technical description of CBA methodology, input values and sources (xi)

The Cost-Benefit Analysis modeling logic *(continued)*

Indirect static benefits through **ESA contractors** due to NSC-generated sales within the space sector not facilitated by ESA are based on other sales within the space sector (Ripple Effects Survey). Multiplying by the share of other sales attributable to NSC and not ESA (PwC/LE bespoke survey) and pre-tax profit margin (PwC/LE bespoke survey) yields the profits earned by NSC-generated sales. Further multiplying by the corporation tax rate yields the total **corporation tax revenues**. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

Multiplying the value of NSC-generated sales within the space sector by the salary share of NSC-generated sales within the space sector (PwC/LE bespoke survey) yields the total salary bill attributable to NSC-generated sales within the space sector. Further multiplying by the income tax rate yields the total **income tax revenue** arising from NSC-generated sales within the space sector.

Subtracting the total income tax revenue from the total salary bill attributable to NSC-generated sales within the space sector yields disposable income. Multiplying by the dynamic multiplier and the value added tax rate gives the total **value added tax revenues** caused by NSC-generated sales within the space sector. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Dividing the total salary bill by the average salary in the space sector gives the number of **workers employed** due to NSC-generated sales within the space sector.

Relevant input and assumptions values and sources

Indirect static benefits due to NSC-generated sales within the space sector.

•The value of other sales within the space sector is read from the individual Ripple Effects Survey responses.

•The share of NSC-generated sales within the space sector not attributable to ESA is taken from the PwC/LE bespoke survey.

- 10 respondents provided an estimate in 2005 (36.9%) and 11 respondents provided a number in 2010 (60.5%). The number used in the model is the average of responses weighted by the value of other space-related sales of the responding enterprises.

•Pre-tax profit margin on NSC-generated sales within the space sector is taken from PwC/LE bespoke survey.

- 6 respondents provided an estimate in 2005 (14.5%) and 8 respondents provided a number in 2010 (16.3%). The number used in the model is the average of responses weighted by the value of other space-related sales of the responding enterprises.

•The corporation tax rate is defined above.

•Salary share of NSC-generated sales within the space sector is taken from PwC/LE bespoke survey.

- 7 respondents provided an estimate in 2005 (50.5%) and 9 respondents provided a number in 2010 (35.4%). The number used in the model is the average of responses weighted by the value of other space-related sales of the responding enterprises.

•The income tax rate is defined above.

•The dynamic multiplier and weighted average value added tax rate is defined above.

•The average salary in the space sector is defined above.

Technical description of CBA methodology, input values and sources (xii)

The Cost-Benefit Analysis modeling logic *(continued)*

Indirect static benefits through **suppliers** due to NSC-generated sales within the space sector are based on ESA-generated sales within the space sector (Ripple Effects Survey), the share of other sales that is attributable to NSC (PwC/LE bespoke survey), and the share thereof spent on inputs from Norwegian supplier (PwC/LE bespoke survey). The product of those factors forms the basis for the calculations.

Multiplying the basis by the average pre-tax profit margin within space and the corporation tax rate yields the total **corporation tax receipts** from suppliers. **Retained earnings** are measured by subtracting corporation tax from the measured profits.

A share of the NSC-generated sales that goes to suppliers trickles further down the system to the suppliers of the suppliers to ESA contractors who experience additional sales. Assuming that the ratio of leakage to supplier share among suppliers is the same as the ratio among ESA contractors provides a way of calculating the value of what trickles through. The share is defined as

$Suppliershare_{suppliers} = Suppliershare_{contractors} * (1\text{-}salaryshare_{suppliers} - profitmargin_{suppliers})/(1\text{-}salaryshare_{contractors} - profitmargin_{contractors})$

Multiplying the supplier share for suppliers by the value that goes to suppliers yields the value that goes to the suppliers of suppliers. This value is counted as **retained earnings.**

The basis multiplied by the average salary share within the space sector yields the total salary bill, and the income tax rate provides the total **income tax receipts** from suppliers.

Subtracting the total income tax receipts from the total salary bill yields disposable income, and multiplying that number by the dynamic multiplier and the value added tax rate provides the total **value added tax receipts**. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Dividing the salary bill by the average salary in the space sector provides the number of **workers employed** by suppliers fulfill NSC-generated sales within the space sector.

Relevant input and assumptions values and sources

Indirect static benefits through **suppliers** to NSC-generated sellers.

•The share of other sales within the space sector that is attributable to NSC is defined above.

•Norwegian supplier share of the value of NSC-generated sales within the space sector is taken from PwC/LE bespoke survey.

- 6 respondents provided an estimate in 2005 (12.1%) and 8 respondents provided a number in 2010 (17.2%). The number used in the model is the average of responses weighted by the value of other sales of the responding enterprises.

•The average pre-tax profit margin and the corporation tax rate are defined above.

•The average salary share and the income tax rate are defined above.

•Pre-tax profit margin and salary shares for contractors are defined above.

•The dynamic multiplier and the weighted average value added tax rate are defined above.

•The average salary is defined above.

Technical description of CBA methodology, input values and sources (xiii)

The Cost-Benefit Analysis modeling logic *(continued)*

Static benefits arising from **recouped expenses** on the running the Norwegian Space Centre.

One entry of the running cost of the Norwegian Space Centre is likely to be partly recouped. Salaries and social expenses (NSC Annual Reports) are liable for **income tax**.

Multiplying salaries and social expenses by the income tax rate yields the total **income tax receipts** attributable to Norwegian Space Centre employees.

Subtracting income tax receipts from the total salary bill of the Norwegian Space Centre yields the disposable income of Norwegian Space Centre employees. Multiplying the disposable income by the dynamic multiplier and the weighted average value added tax rate provides the **value added tax receipts** from Norwegian Space Centre employees. The multiplied disposable income less value added tax provides a measure of **retailer sales revenues**.

Temporal assumption

In order to make fair comparisons between present, future and past costs and benefits, a discount factor (Finansdepartementet) is used.

Relevant input and assumptions values and sources

Static benefits arising from **recouped expenses** on the running the Norwegian Space Centre.

•Salaries and social expenses is read from the annual reports of the Norwegian Space Centre for the period 2004-2010.

•The income tax rate is defined above.

•The dynamic multiplier and weighted average value added tax rate are defined above.

Temporal assumption

•The discount rate used is the one recommended in Finansdepartementet, R-109/2005, 2005.

PwC and London Economics bespoke survey (i)

PwC/LE bespoke survey questions and number of responses:

Q1: Please provide the name of your enterprise: 22 responses.

Q2: If your enterprise received NSC support funds between 2004 and 2010, would you say these funds were a *critical enabler** to winning the types of contracts listed below?

a. An ESA contract: 19 responses. (16 Yes)

b. A non-ESA space-related contract: 16 responses. (11 Yes)

c. A non-space-related contract: 14 responses. (4 Yes)

Q3: In respect of your enterprise's ESA contracts in 2005 and 2010, please indicate the following items as a percentage (%) of total contract value:

a. Labor costs %: 2005: 16 responses, 2010: 17 responses.

b. Inputs from Norwegian suppliers %: 2005: 15 responses, 2010: 17 responses.

c. Pre-tax profit margin %: 2005: 15 responses, 2010: 17 responses.

Q4: Would you say that ESA contracts and/or NSC support funds have an impact on you enterprise *in addition* to the direct increase in sales turnover and employment? 21 responses. (16 Yes)

Q5: Please indicate the nature and approximate *effect size*** of such additional impacts.

a. Your product development capabilities: Type of effect: 12 responses, Effect size: 12 responses.

b. Productivity (i.e.. process efficiency): Type of effect: 9 responses, Effect size: 10 responses

c. Sales (i.e.. network, reputation, flight heritage): Type of effect: 11 responses, Effect size: 10 responses.

d. Other (please specify): Type of effect: 7 responses, Effect size: 2 responses.

Q6: In respect of the ultimate end-users of the ESA program to which your ESA contract(s) contributed (e.g. government agencies, commercial enterprises, consumers), please indicate:

a. What are the main end-users of the ESA program?: 18 responses

b. What benefits would such end-users derive from the ESA program?: 18 responses

Q7: In respect of '*Space*-related sales *facilitated* by an ESA contract and any related NSC funding' in 2005 and 2010, please indicate the following items as a *percentage* (%) of the total value of such sales.

a. Degree of facilitation by ESA contract/NSC funding %: 2005: 13 responses, 2010: 17 responses.

b. Labor cost %: 2005: 13 responses, 2010: 17 responses.

c. Inputs from Norwegian suppliers %: 2005: 13 responses, 2010: 17 responses.

d. Pre-tax profit margin %: 2005: 12 responses, 2010: 17 responses.

Q8: End-users of '*Space*-related sales *facilitated* by an ESA contract and any related NSC funding'

a. What are the main groups of end-users? 13 responses

b. What benefits would such end-users derive?: 14 responses

*: it would not have been possible for your enterprise to win the contract without the NSC support funds.

**: In addition to the numerical effect size, please choose and specify (in the answer box) your measure (for example: % reduction in R&D cost; % reduction in unit production costs; % increase in turnover; etc.).

PwC and London Economics bespoke survey (ii)

Q9: In respect of '*Non-space*-related sales *facilitated* by an ESA contract and any related NSC funding' in 2005 and 2010, please indicate the following items as a *percentage* (%) of the total value of such sales.

a. Degree of facilitation by ESA contract/NSC funding %: 2005: 8 responses, 2010: 11 responses.

b. Labor cost %: 2005: 8 responses, 2010: 10 responses.

c. Inputs from Norwegian suppliers %: 2005: 7 responses, 2010: 9 responses.

d. Pre-tax profit margin %: 2005: 7 responses, 2010: 10 responses.

Q10: End-users of '*Non-space*-related sales *facilitated* by an ESA contract and any related NSC funding'

a. What are the main groups of end-users? 10 responses

b. What benefits would such end-users derive?: 10 responses

Q11: In respect of '*Other-space*-related sales, *NOT* facilitated by an ESA contract and any related NSC funding' in 2005 and 2010, please indicate the following items as a *percentage* (%) of the total value of such sales.

a. Degree of facilitation by NSC funding (please consider only NSC funding that did not lead to an ESA contract*) %: 2005: 10 responses, 2010: 11 responses.

b. Labor cost %: 2005: 7 responses, 2010: 9 responses.

c. Inputs from Norwegian suppliers %: 2005: 6 responses, 2010: 8 responses.

d. Pre-tax profit margin %: 2005: 6 responses, 2010: 8 responses.

Q12: End-users of '*Other-space*-related sales, *NOT* facilitated by an ESA contract and any related NSC funding'

a. What are the main groups of end-users? 8 responses

b. What benefits would such end-users derive?: 8 responses

Q13: Would you say that your enterprise's ESA contracts and/or NSC support funds have any impact on your *suppliers*, in addition to the direct sales and employment effects? 15 responses. (6 Yes)

Q14: Please indicate the nature and approximate *effect size*** of such *supplier* impacts.

a. Suppliers' product development capabilities: Type of effect: 5 responses, Effect size: 4 responses.

b. Suppliers' productivity (i.e.. process efficiency): Type of effect: 3 responses, Effect size: 4 responses

c. Suppliers' sales (i.e.. network, reputation, flight heritage): Type of effect: 6 responses, Effect size: 5 responses.

d. Other (please specify): Type of effect: 2 responses, Effect size: 3 responses.

Q15: Would you say that your enterprise's ESA contracts and/or NSC support funds have any impact on your *competitors*. If yes, please explain. 9 responses.

Q16: Are there any other comments that you wish to make to the project team? 13 responses

*: NSC support funds that *did* lead to an ESA contract has already been considered in earlier questions. The responses given here will be matched to the '*Other* space-related sales' data from the Ripple Effects survey.

**: In addition to the numerical effect size, please choose and specify (in the answer box) your measure (for example: % reduction in R&D cost; % reduction in unit production costs; % increase in turnover; etc.).

Derivation of cost inputs (Norwegian ESA expenditure)

Potential costs data are available from a number of sources, but the values are quite different. The following approach rests on several data sources in order to ensure that the costs side of the CBA accurately reflects space-related costs pertaining to the subset of enterprises that provided individual Ripple Effects (RE).

Norway's total ESA budget (budget) is available from the Norwegian Space Centre's annual reports. The budget covers contribution to ESA's programs, which in turn covers the contracts (contracts) that Norwegian firms win, and the administration costs (admin) of the ESA programs.

The individual Ripple Effects data does not hold all the Norwegian enterprises or organizations that won ESA contracts or received funding from the Norwegian Space Centre's Support Scheme. As the individual Ripple Effects data forms the backbone of the Cost-Benefit Analysis, it is necessary to include only a share of the budget in the analysis.

The share of the budget that is included in the CBA comprises ESA contracts to the individual Ripple Effects enterprises, and the share of admin costs of Norway's ESA participation that is attributable to those firms. Admin costs must be included because the enterprises that supplied individual Ripple Effects responses could not have got the contracts in the absence of admin costs.

The contract value used in the CBA is directly loaded from the individual Ripple Effects survey. The value of admin costs pertaining to the individual Ripple Effects survey enterprises is calculated using the following formula:

(Budget – Contract value (RE) – Contract value (Non-RE))* (Contract value (RE)/Contract value (Non-RE))

Contract value (non-RE) is calculated based on the Norwegian Space Centre's data for ESA contract value. The numbers from this source do not match with the numbers from the Ripple Effects survey, but we assume that the shares are accurate. Thus, the ratio of total contract value (non-RE) from the Norwegian Space Centre source over total contract value (RE), multiplied by contract value(RE) yields a number that is comparable in size to the number from the Ripple Effects survey, and a ratio comparable to the numbers from the Norwegian Space Centre data.

Appendix 2

Detailed review of governance indicators

Objective 1a

Objective 1
The objective is formulated as "Ensuring that space activities have significant industrial ripple effects". Output measures relate to a range of different concepts and there are seven quantitative indicators defined.

Progress against the objective is mixed. We will review the issues in turn:

1a): International positions show overall decline with some bright spots.

Overall global market share for Norwegian space firms have declined from about 2,8 percent to 2 percent during 2005-2010. There are declining market shares in large segments of the industry including ground equipment and satellite communications services. Ground equipment producers may have dropped from above 3 to about 1 percent over the last five years. SatCom services also show a decline from about 4,5 to 3,8 percent. Satellite manufacturing and launchers show small market shares of about 0,2-3 percent. These are increasing. Most growth is seen in earth observation services and there are considerable market shares in this segment. About 10-20 percent in aggregate depending upon how the market is defined.

Export shares have fallen. From about 82 percent of sales in 2005 to 68 percent in 2010. Exports of both services and products have declined relative to other Norwegian exports of services and products respectively. Product export has declined since 1997. Reductions since 2003 are 33 and 43 percent respectively.

Several individual firms have strong positions in particular micro segments. This applies across all segments of the value chain.

Figure 2.40: MoTI framework for objective 1

Outcome	Output	Indicator
1) Significant industrial ripple effects	1a) Norwegian space enterprises achieving strong international positions	Export share of Norwegian space industry
	1b) Full industrial return on ESA programs	Accumulated return coefficient (from 2000)
		Accumulated value of ESA contracts (from 2000)
	1 c) Norwegian enterprises competing on same terms as European firms for Galileo contracts [New 2011]	Galileo contracts to Norwegian enterprises [New 2011]
	1d) Industrial ripple effects in addition to return on ESA programs	Ripple factor
		Value of Norwegian produced goods and services in space industry

Source: See section 1.1. and 1.2 for a definition of the value chain, market segments and more detailed analysis of development, positioning and growth constraints.

Objective 1b-c

1 b) There is not full industrial return on the ESA programs

Overall rate is at 90 percent in June 2011. A special initiative has been launched by ESA to direct more contracts toward Norway. The ratio is lowest in the mandatory programs at 68 percent. It is highest in the technology development programs with guaranteed returns of 100 percent. In other Optional programs it is about 84 percent. The ratio of contributions to guaranteed and non-guaranteed return is about 50/50.

Without taking into account the juste retour weights, the overall return exceeds 100 percent. Many Norwegian contracts are for service delivery and these have lower weights.

Contract volumes have increased. They have not fully met the target.

Actual financial return ratio is about 58 percent. This is the ratio between actual contributions from Norway and value of all contracts received. This ratio has been decreasing from about two-thirds earlier in the decade. This is impacted by a rise in Norwegian contributions to ESA which have not been fully matched by rising contract volumes.

1 c) Norwegian firms have in practice similar access to Galileo development contracts as European

ESA is an implementing agency of the EU in this regard. The procurement is competitive and do not follow the ESA industrial return scheme. The markets are open to companies with headquarters located outside the borders of the Union, without prejudice. However, in the original provisions for Galileo procurement, for security reasons only EU firms may participate in public procurement of the deployment phase. The holder of a contract may, however, **outsource** production of non-security sensitive products and services to a.o countries of the **European Economic Area (Norway)** or other third countries.*

Special provisions and agreements were entered into between Norway and relevant European Authorities that ameliorated the restrictions effective from 2009/2010.

A Norwegian firm won a subcontract of about 170 million NOK in 2010. Total Norwegian appropriations for Galileo development phase are at about 550 million NOK and spread over 2008-2013.

Objective 1d

1 d) There are industrial ripple effects but turnover is decreasing.

Industrial ripple effects are seen at about 4.3 in aggregate and at about 3.5 median value per firm. The indicator accumulates “ESA generated sales” sales during 1985-2010 by ESA and space center support.

There are differences among segments whereby earth observation services are highest at about 7 and with highest growth rate. Support to Institutional R&D have lowest ripple effects. Ground equipment show declining ripple effects over two decades but remain second highest. Satellite component and launcher producers show slowly increasing ripple effects at about 3.7. Satcom services ripple effects cannot be measured as the firms who have received support do not respond to the survey. Those firms have shown rapid growth but the impact of ESA support cannot be ascertained here.

Ripple effects impact space sales and non-space sales about equally. Total non-space sales for the supported firms have however been increasing even faster indicating that those sales are driven by other factors than impact from the ESA support.

There is also an indicator for total turnover for the industry. This has been decreasing since 2003. Inflation adjusted the decline is about 15-25 percent. See discussion of the overall objective 2 pages above and analysis of ripple effects on pages 167.

Note: Our numbers differ from earlier space center reports as we have adjusted the 1985-2010 values for inflation. See page 167 for a discussion of ripple effect methodology.

Objective 2

Objective 2

The objective is formulated as "High utilization of Norway's geographical advantage". There is only one output measure: "Norway holding a leading role in the Arctic space related infrastructure".

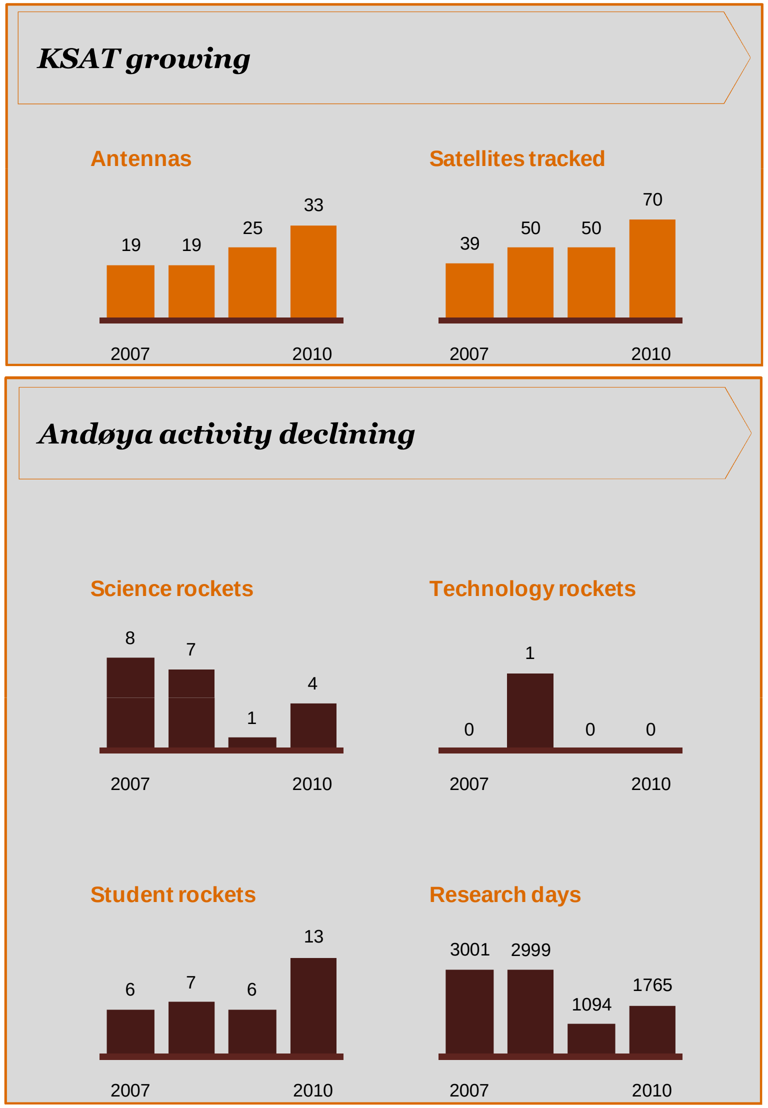
There are four indicators relating to business performance targets for Kongsberg Satellite Services and Andøya Rocket range. It also asks to include an assessment of market shares. The latter is not reported in a structured format. This is only part of the monitoring framework that has business performance targets for specific commercial businesses aligned with government targets.

Two additional targets were added in 2011 and not shown here. They pertain to the navigational matters: Number of Galileo and EGNOS ground stations and participation in Global Navigation Satellite System(GNSS) research.

KSAT business is going strong. The company operates commercially but has strong government backing. There has been some capital support for its Antarctica site. Its market share is hard to determine. We have estimated ScanEx of Russia and SSC of Sweden to track more satellites (150/100) but the exact definitions of the performance indicators is not available from all parties and comparability cannot be fully assessed. Total market value globally may be estimated but is beyond this study to investigate. The complicating factor is that many ground stations are operated as fully funded government agencies. Others are built by satellite operators. There are however not many independent ground station operators serving polar satellites exclusively. The market for geostationary ground stations/teleports is much larger and possible to define, but less relevant as benchmark though there may be some substitution. See our analysis of KSAT on page 83.

Andøya rocket business has seen some decline though student rockets are increasing. The decline is reported as being caused by shrinking science budgets. Numbers for their key competitor, Esrange in Kiruna, show about similar numbers. Andøya is supported through a special program to incentivize use, a bilateral agreement between six countries including Esrange. (EASP) Financing has averaged 24 million NOK annually since 2007 and an additional allocation of 15 million was provided to support infrastructure in 2010. EASP is outside of the purview of this study.

Figure 2.40: MoTI framework for objective 2



Source: See section 1.1. and 1.2 for a definition of the value chain, market segments and more detailed analysis of development, positioning and growth constraints.

Objective 3

Objective 3

The objective is worded as developing cost-effective systems meeting national and international demand. Output measures relate to two different concepts:

First, the performance of satellite navigational systems covering the arctic regions. Those presented here relate to EGNOS (Airtrafic) and have recently been replaced by Galileo. Egnos (airtrafic) performance was reported as “not full coverage in accordance with operative demands.” in 2010. From 2011 this is replaced by a Galileo/GNSS measure.

The logic being that ESA membership would influence the performance of these systems in arctic regions. We have earlier discussed the influence. Norway held the chairmanship of the navigational committee in ESA for some years during mid-2000’s when Galileo was being designed. There are indications of Norwegian influence, in particular on Galileo design as pointed to earlier.

Second, this objective of developing cost-effective systems meeting national demand has driven much of the efforts behind the SatOcean program discussed in section 2.2. These efforts can only be seen as successful and are discussed extensively above. The indicators presented here may not fully capture the impacts of these programs.

We note that the number of satellites being used, and the number of agencies using them are increasing. Most of this use is quite sporadic. Agencies are testing, experimenting and much is ad-hoc. It still seem accurate that usage overall is increasing. There are about four agencies in Norway that can be seen as high level users where satellite information is an integral part of their operations. The numbers do not capture use of mainstreamed satellite services, i.e. telephone or satellite TV. Government use is discussed above in section 1.3 and impacts in 2.1.

Four heavy users of satellite data in general and many more emerging

Figure 2.41: Government satellite usage (2006-2010)

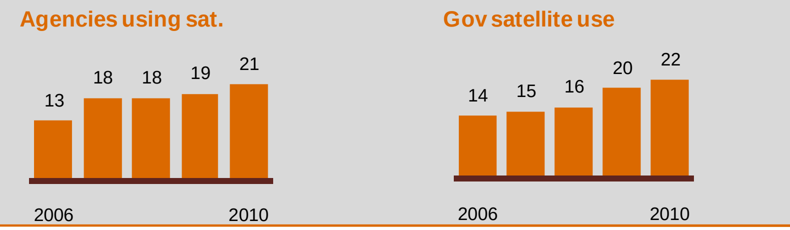


Figure 2.40: MoTI definition of objective 3

Outcome	Output	Indicator
3) Developing cost-effective systems meeting national and international demand	3a) Adequate Arctic EGNOS performance [replaced 2011]	EGNOS performance in Kirkenes/Tromsø [2010 replaced 2011]
	3c) Norway being a leading nation in satellite information usage	No. of satellites used regularly by Norwegian government agencies
		No. of Norwegian government agencies using satellite information regularly

Source: See section 1.3. and 2.1 for a more extensive analysis of government use and impacts.

Objective 4

Objective 4

The objective is worded as **Strengthening Norwegian research communities through international cooperation**. Output measures relate to two different concepts: Norwegian research communities having central roles in space related research projects ; and Norwegian scientists having access to the best satellite measurements in their field of research.

Scientists with access to satellite data has increased much over the last five years. Whether this represent improved access or more scientists exploring these fields is not explicit but possibly mostly the first. Number of researchers involved in space related research projects is reported to be increasing. Whether and how this can be measured has been a recurring theme in the dialogue between the space centre and the MoTI.

The logic here is that ESA membership creates access for Norwegian scientists. ESA creates opportunities particularly within the scientific programs. There is a coordination mechanisms with the research council for this. Government instruments to support space sciences are also about more instruments than ESA and includes the research council, EU FP's basic funding for universities a.o.

A large scientific ESA engagement by Norway relates to experiments on the International Space Station (ISS). An extensive multi-disciplinary program managed by NTNU. This includes a control center, one of ten globally. About 7 percent of the Norway's ESA Optional contracts over the last decade has been devoted to this.

The impact and effectiveness of the science support must be analyzed holistically to be meaningful. We do not explore this in more depth here. Issues of coordination have been discussed in section above under relevance (page 199).

Four heavy users of satellite data in general and radar data in particular

Figure 2.42: Scientific satellite usage

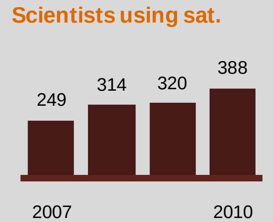


Figure 2.43: MoTI definition of objective 4

Outcome	Output	Indicator
4) Strengthening Norwegian research communities through international cooperation	4a) Norwegian research communities having central roles in space related research projects	No. of projects with Norwegian participants/ leaders
	4b) Norwegian scientists having access to the best satellite measurements in their field of research	No. of scientists actively using data from satellites, space stations etc.

Objective 5

Objective 5

The objective is worded as **Increasing knowledge in science and technology through information from the space industry.** There are three output measures: Increasing the outward information flow; Increasing media attention and Increasing activity towards students.

The activity level is very high. Four lectures weekly, twice weekly radio appearances, weekly events with 30 participants on average. This has increased much over the last five years. Website is elaborate and has frequent visitors. There are also student offers for support in writing master thesis and other research. TV appearances is the only indicator that show a decline.

The broader concept here relates to education, recruitment and work force capabilities over the long run. The

Figure 2.43: Outreach activities