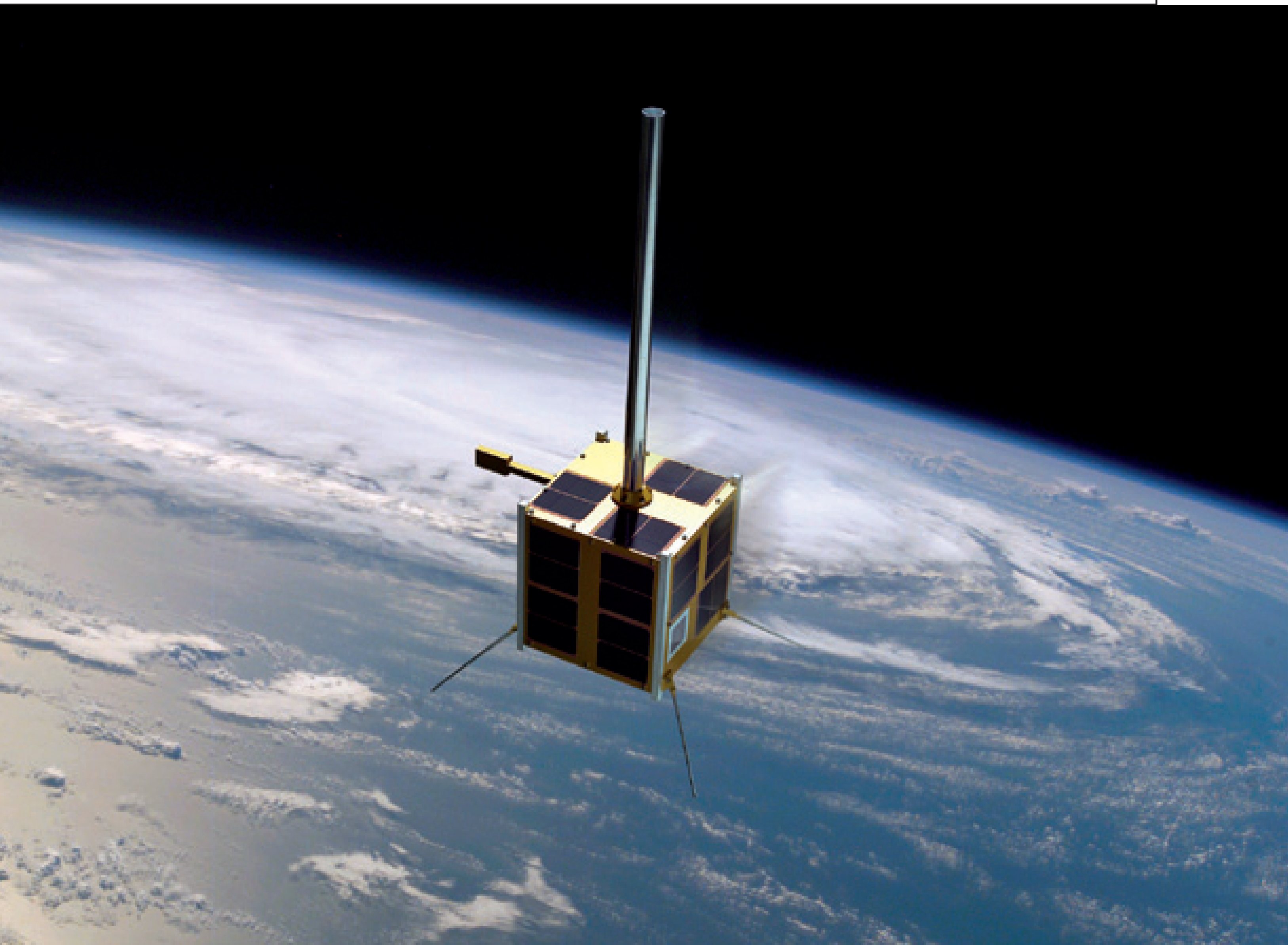
NORWEGIAN MINISTRY
OF TRADE AND INDUSTRY

Meld. St. 32 (2012–2013) Report to the Storting (White Paper)

# Between heaven and earth: Norwegian space policy for business and public benefit



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# Contents

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*Recommendation from the Ministry of Trade and Industry on 26 April 2013, and approved the same day in the Council of State. (Stoltenberg II Government)*

## Introduction

The previous time the Government asked the Storting to review an overall strategy for Norway in space was in St.meld. nr. 13 (1986–87): *Om norsk romvirksomhet* (On Norwegian space activity). In the 26 years that have passed since that white paper, our society's relationship to space has changed greatly. Satellite-based services have become an important part of Norwegian daily life, from ordering a taxi to operating advanced offshore petroleum facilities. In 2012, the consulting firm PricewaterhouseCoopers (PwC) evaluated key aspects of Norwegian space activity. The firm concluded that some aspects have worked as intended, but that improvement is needed in others. The Government therefore believes the time has come once more to anchor the broad guidelines of Norwegian space policy in the Storting.

Practical benefits have always been the chief aim of Norwegian space policy. Space activity has not been an end in itself, but a means to serve Norwegian interests. For this reason, most of Norway's public-sector undertakings have been intended to create value in high-technology industries and to meet specific national needs in communication, navigation and earth observation. Often, the technology has been high-flying; but the goals have always been down-to-earth.

Our participation in the European Space Agency (ESA) has put us in a position to develop independent national technological capabilities while contributing to advances that have benefitted Norwegian and other European users alike. Norway has supplemented its ESA involvement with nationally focused development support, bilateral agreements and an ever-stronger partnership in recent years with the European Union. The international collaboration, like the domestic initiatives, has contributed to the development of important infrastructure and services.

The Government intends to maintain Norway's down-to-earth orientation in space activities. The trends – with space infrastructure growing as a factor in everyday life and Norway relying on space to address key national interests such as the High North, the environment and climate policy – suggest that space policy in the years to come should focus even more directly on the practical needs of public administrators, businesses and private citizens. Today, a well-functioning society depends on technology that exploits space. Government policy must therefore seek to ensure that space activity can continue to be an instrument of Norwegian interests.

Norwegian space activities have always been – and will remain – dependent on international collaboration. To achieve results, we must be good at playing the cards we are dealt as technology, markets and international partnerships evolve. Today we can see that the game is changing, and that it may be necessary to adjust elements of Norwegian policy to better secure our interests.

There are three primary factors that could make policy adjustments necessary. The first is technological change. Technological advances in recent years have dramatically expanded the range of applications for space-based technology. The second factor that will help shape Norwegian space policy in the years ahead is a change in Norway's own needs. Space-based technologies provide cost-effective options for addressing Norwegian policy challenges that have assumed central importance in the past few decades, such as management of the High North and climate and environmental issues. The third factor that will affect our scope of opportunity in the years ahead is change within the international organisations that have long represented the framework for Norwegian investment in space activity. Without international collaboration, a robust and efficient Norwegian space sector would be unthinkable. The best way to approach such collaboration in the future will depend on developments within the international forums to which we have access.

Those involved in Norway's space effort can point to many success stories in the years since the previous white paper on space activity was submitted. Examples include the growth of competitive high-technology companies, the development of Norwegian AIS satellite technology, the broad phase-in of satellite-based services across Norway's public sector and the development of Norwegian infrastructure. It would be an exaggeration, however, to say that Norway is a major space nation. Our strengths lie in certain industrial niches and in the application of space-based services. Compared with leaders in space like the United States and France, we will always be small. A small country must prioritise its resources, and there would be little point in attempting to create a major national space industry or to resolve to send Norwegian astronauts into space. Yet there is no alternative to increased space activity if we are to maintain our role as a leading nation in ocean shipping, High North stewardship, technology and the environment. Norwegian space activities contribute greatly to economic growth, sustainability and the ability of Norwegians to live safe and comfortable lives. In the years ahead, the Government will continue to work hard to maximise the benefits that Norway receives from its participation in space. This white paper forms the basis of the country's continued involvement in space.

### Structure of this White Paper

Chapter 1 lays out the Government's goal for Norwegian space activity. Chapter 2 provides a historical overview, and identifies the global actors and driving forces behind modern space activity. Chapter 3 describes the emergence of Norwegian space activity, with emphasis on the country's needs in space-based services, scientific research and high-technology businesses development. This chapter also reviews the most important findings from the 2012 evaluation of Norwegian space activities by PwC. Chapter 4 shows how space activities may help Norway to solve current and future challenges in key policy areas. Particular emphasis is placed on the importance of space to issues affecting the High North, climate policy, the environment, security-related matters, transport and research. Chapters 5 and 6 cover issues related to collaboration with ESA and the EU. In Chapter 5, the focus is Norwegian participation in ESA. ESA's organisation, programmes and industrial policy are discussed, along with Norway's membership over time. Chapter 6 discusses the EU's role as a European space actor. After an account of the rise of the EU in space, focus shifts to the satellite navigation programmes EGNOS and Galileo, and to the earth observation programme Copernicus. The chapter concludes by describing Norway's participation in these two programmes along with the significance and consequences of the EU's expanded role. Chapter 7 provides an overview of Norway's ground-based space infrastructure, including facilities located in Svalbard, on Jan Mayen Island and in the Antarctic. Chapter 8 is devoted to state administrative responsibilities and ownership roles in organisations such as the Norwegian Space Centre, the Andøya Rocket Range, Norwegian Space Centre Properties and Kongsberg Satellite Services AS. Chapter 9 explains the Government's active space policy measures. The white paper concludes, in Chapter 10, with administrative and financial implications.

# 1 The Government's goals for Norwegian space activity

The Government will work to ensure that space activity remains a means to advance Norwegian interests. Four goals have been set: profitable companies, growth and employment, meeting important needs of society and user groups, greater return on international space collaboration, and high-quality national administration of Norwegian space activity.

## 1.1 Profitable companies, growth and employment

Today, space-based applications are important to all sectors of the economy. The domain of space technology extends well beyond companies that produce satellite and rocket components. We observe it spilling into other technology areas, through the development of products and services that rely on satellite-based services, and we observe it facilitating economic activity more generally. To assess the full impact of space activities on value creation, our perspective must encompass more than traditional space technology industry. The Government will work to ensure that public investment in space activities strengthens wealth creation and business development.

When Norway joined ESA in 1987, there were no satellite navigation services for civilian users. Most earth observation was the product of military intelligence satellites. The satellite communications market was still in its infancy. Today, satellite-based services reach into every corner of society, from Google Earth and automobile navigation systems to landslide monitoring and advanced control systems for offshore petroleum operations. The proliferation of satellites in combination with increased data processing capacity, the global spread of the Internet and the rise of mobile communications infrastructure make satellite services increasingly relevant to all aspects our lives. A large and growing industry has consequently evolved to offer services and equipment made possible by satellite communications, navigation and earth observation. Such downstream services and equipment in turn contribute importantly to value creation throughout the value chain, facilitating business activity in sectors ranging from natural resources to transportation. The Government intends to facilitate the competitive strength and export potential of Norway's downstream industry. In addition, it may be useful to formalise collaboration between actors in certain technological niches, such as satellite navigation, satellite communications or earth observation. The Government will therefore assess, in common with other business areas, whether an Arena project is needed for space-related research and business development, and in the longer term whether a Norwegian Centres of Expertise programme is needed.

Norway's commitment to space has helped promote business growth and development in large part through technology development, market access and system insight. The Government will work to ensure that these three mechanisms continue to contribute to development in Norwegian industry. Norwegian companies that have participated in ESA development programmes have seen their technological capabilities improve. Norwegian ESA membership has also made it possible for companies to conduct valuable trials of newly designed technical components. The national development support funding programme for space innovation, *Nasjonale følgemidler,* has been used actively to strengthen the positive effects of ESA membership on Norwegian industry. Nevertheless, much of the value of our ESA participation has come in the form of spillover to other technology areas, such as defence, aviation, offshore petroleum and ship transport. The Government will seek to ensure that private sector participation in ESA programmes continues to generate spillover effects in other technology areas.

Norwegian participation in the EU's Galileo, EGNOS and Copernicus space programmes allows Norwegian businesses to compete for contracts on an equal footing with companies based in EU countries. Similarly, Norwegian participation in ESA has expanded market access for Norwegian companies with space-related products and services. The Government will work to ensure that Norwegian businesses take advantage of opportunities provided under ESA's principle of guaranteed industrial return, and that Norwegian businesses are sufficiently competitive to obtain contracts in EU space programmes.

Early insight into satellite-based infrastructure systems is a key to success when developing associated products and services. Such insight has been an important objective of Norway's public commitment to space, and normally it can be obtained only by taking active part in the development of the systems in question. Norwegian authorities and businesses have gained valuable system insight from Norway's participation in EU and ESA programmes. This has strengthened the competitiveness of Norwegian products and services designed to exploit satellite-based navigation and earth observation systems. Through active participation in European space programmes, the Government will work to ensure that Norway obtains insight into systems under development as early as possible in the process. ESA activities are primarily focused on the upstream industry, in particular the development of satellite and launch technologies. But companies whose main focus is downstream report that they, too, see value in ESA participation, because of the technological insight they stand to gain. The Government will work to ensure that Norwegian firms in the downstream sector see greater benefit from participation in ESA programmes.

The 2012 PwC report supports the contention that important aspects of Norway's public-funding model for the space sector are working as intended. Space activities have positive ripple effects in the Norwegian economy, and the country's various support instruments are synergistically linked. Commercial activities account for a larger portion of the space industry in Norway than they do in many other countries, and Norwegian industry has achieved substantial market share in segments of the space-based services sector, particularly those related to satellite communications and earth observation. On the other hand, the PwC report points out growth challenges within the sector. To fully exploit the potential for value creation, it may be necessary to modify the policy instruments whose purpose is to ensure that benefits return to the Norwegian economy. In the Government's view, it is important that space-sector investments made to satisfy national needs also contribute to value creation in Norwegian industry. Apart from our participation in EU and ESA development programmes, the primary tool for promoting value creation so far has been the national development support programme for innovation, *Nasjonale følgemidler*. The growing importance of space activities outside the traditional space technology sector increases the urgency of assessing whether existing industrial policy instruments can be adjusted to better reach enterprises that stand to benefit from space activities despite having no direct link to the production and operation of space infrastructure.

The range of potential policy actions is large. An example would be to ensure that Norwegian companies that exploit earth observation data are able to gain access to the data they require. The PwC report points out that public agencies are major customers of earth observation data services. This customer role may trigger further technology development and ensure continued demand for services. A commercialisation strategy together with a strong domestic market may boost value creation. Norwegian participation in multinational satellite projects, coordination of national public-sector data procurement and an open data policy for state-owned raw data are possible means to achieve this. The Government will seek to ensure that businesses and other users of earth observation data have access to the data they require. The Government will also evaluate the measures mentioned above.

Another important policy tool for wealth creation will be active participation in European infrastructure programs like Galileo and Copernicus. Already this has provided early insight into system capabilities and limitations, helping to position Norwegian companies in the market for products and services that exploit such systems. Public procurement in the space sector should include an assessment of how intended purchases can help generate growth and development in Norwegian industry. It may also be necessary to adjust public development support so that it reaches companies further out in the value chain than the companies that produce satellites, launch vehicles and ground infrastructure. It will be important to inform all relevant actors of the opportunities inherent in Norwegian space activity. The Government will use policy mechanisms strategically to promote service development and commercial success in market segments with significant growth potential and comparative advantages.

## 1.2 Meeting important needs of society and user groups

Space-based applications affect most aspects of daily life these days. The use of space technology has become a precondition for the safe and efficient functioning of our society, including the pursuit of key policy objectives regarding the High North, climate and the environment. The Government will work to ensure that space activities help meet important needs of our society and of various user groups, and to do so cost-efficiently.

Space-based infrastructure is growing more strategically significant by dint of its increasing importance to critical services and the exercise of governmental authority. A certain degree of national control and independent capability is required to secure our interests, even in the case of commercially obtainable services. Norway has special needs in the High North and it cannot be assumed that actors outside of Norway will have the ability or interest to develop good solutions. The ability to influence the development of essential infrastructure will have consequences for public safety and crisis management. It is therefore important that Norwegian research and technology communities possess the insight and expertise required to identify workable solutions; such expertise is also necessary to be a competent counterpart in procurement transactions and international partnerships and, when appropriate, to develop and implement national systems. The Government will help to provide framework conditions in which Norwegian actors can develop and implement space-based systems geared to Norwegian user needs, whether through national initiatives or international collaboration. In so doing, the Government wishes to encourage a continued flow of expertise from Norway's research and educational institutions to Norwegian space programmes and enterprises. A deep understanding of space is an important part of this expertise. The Government intends to continue the Research Council of Norway's space research programme.

Satellite monitoring is already a very important tool for understanding the complex interplay of factors that affects our climate, for assessing the extent of pollution transported over long distances and for monitoring other damage to the natural environment. The importance of such monitoring will in all likelihood increase further as new, more sophisticated environmental monitoring satellites enter operation, as exemplified by ESA's Sentinel programme. Environmental monitoring, especially of northern regions and for climate study, must provide stable and continuous data access and adequate areal coverage. Satellite monitoring itself cannot solve our climate and environmental challenges, but it has become a useful tool in preparing decision makers to make informed decisions. For Norway, one key priority is to ensure data access for Norwegian experts and environmental authorities. Another is to contribute in a spirit of solidarity to systems that will inform the global debate on climate and the environment. The Government will work to realise the potential of satellite observations to advance climate and environmental policy.

Good satellite systems to cover Norwegian needs in the High North are one of the key objectives of Norwegian space activity. In a few years, thanks to Galileo and Copernicus, good systems will be in place for navigation and earth observation in the High North. The biggest remaining challenge is the need for communication systems – in particular, broadband services for ships. Existing satellite communication systems provide little or no coverage north of 75 degrees latitude. Communications satellites moving in polar orbit can solve this challenge. Several countries with interests in the High North have begun studying polar-satellite communications options, but so far, no immediately realisable plans exist. As recently as a few years ago, the problems associated with navigation and communications in the central Arctic Ocean were of purely theoretical interest. Few if any ship owners wanted to sail into the massive ice flows north of 80 degrees. Today, Norway's fishing fleet operates regularly at 82 degrees north, and the offshore petroleum industry, too, is moving steadily into the Arctic. Within a few years, we may witness a significant increase in ship traffic in the Northeast Passage. The steady rise of human activity in the area intensifies the need for good systems to aid navigation, communications, weather forecasting, sea rescue and monitoring. Experience shows that space-based systems can solve such challenges cost-effectively. Norway is determined to be a responsible steward of the far north. A major challenge in the years ahead will be to see that Norwegian authorities and users have access to the space-based infrastructure required for safe, sustainable, efficient High North operations. The Government will actively consider how best to address Norway's need for satellite communications in the High North, and will facilitate the implementation of good, robust satellite navigation coverage.

Transport is one of the sectors that have undergone the greatest change in recent years as a result of the increasing use of satellite-based infrastructure. It is also the sector whose use of satellite systems is most obvious on a daily basis. Satellite-based infrastructure in the transport sector includes technology for navigation, communications and earth observation. Satellite-based services are important aids to maritime, aviation and land transport. The Government will work to ensure that satellite-based services can be used as important elements in transport policy.

Because of technological advances in recent years, Norwegian authorities face fewer limitations on their ability to act on their own. This applies in particular to the emergence of relatively inexpensive small satellites. The launch of AISSat-1 in 2010 showed that the Norwegian authorities, with modest effort, are able to finance and operate highly effective space infrastructure at the national level. The operation of small national satellites will never replace multilateral collaboration on large, complex systems such as Galileo and Copernicus, but it can be a useful supplement. More information is required on the potential for domestic space infrastructure to support Norwegian users in government and business. The Government will actively use supplementary national initiatives as a means of addressing Norwegian user needs.

As with all systems that society makes itself dependent on, the increased reliance on satellite-based systems represents a potential vulnerability. As satellite systems gain importance to critical applications in aviation, civil preparedness and activities related to national defence, they may of course become targets for hostile attack. Natural phenomena, such as space weather, can also damage satellite infrastructure, as can space debris. Addressing vulnerabilities has become an important task for the authorities. The EU and the United States are leaders in the effort to establish international guidelines aimed at reducing the increasing amount of space debris in key satellite orbits. The Government will continue its efforts to address vulnerabilities associated with the use of satellite systems, and it will contribute to the task of establishing international guidelines to reduce space debris.

## 1.3 Greater return on international space collaboration

International collaboration has always been – and will remain – the backbone of Norwegian involvement in space. ESA membership has served Norway well as we developed our own competitive group of space-related businesses, expanded our space technology expertise and internationalised our research programmes. In the years to come, the Government will extend Norway's participation in ESA as a key way of promoting Norwegian interests in space. At ESA's ministerial-level council meeting in November 2012, Norway declared a commitment of 144.4 million euros to optional ESA programmes.

In addition to participating in ESA, however, it increasingly will be necessary to collaborate with the EU. Galileo and Copernicus will play roles in solving some of the key challenges that Norway faces. Norway should take an active approach to EU space policy in order to gain influence over infrastructure projects of significance to this country as well as to protect the interests of Norwegian industry, researchers and user groups while positioning Norway for a future in which the EU increasingly determines the broad outlines of European space policy. The Government will pursue proactive policies to secure Norwegian interests in EU space programmes, and it will work to ensure that Copernicus and Galileo perform well in Norwegian areas of interests.

Today, significant changes are coming into view that will require Norwegian policy adjustments if we are to ensure that our needs are effectively addressed in the future. For years, ESA has been the mainstay of Norwegian space activity. ESA participation will remain indispensable, but as time passes, that participation will no longer be sufficient to protect Norwegian interests. EU space programmes have emerged as necessary supplements to those of ESA.

ESA has its role to play as an arena for collaboration in research and development. The EU has the financial and political weight to build and operate large, costly infrastructure systems. Galileo and Copernicus will help Norway address key issues related to the High North, the climate and the environment. Active Norwegian participation in these programmes has already helped ensure that they address Norway's special needs; it has also given Norwegian participants early insight into opportunities linked to the programmes.

The EU's rise as a key player in European (and Norwegian) space activity presents Norwegian authorities with a new set of challenges regarding international collaboration in space. Until recently, most relevant matters were settled in ESA – an organisation focused on research, development and technology, in which Norway enjoys full membership. Norwegian interests have been addressed through Norwegian participation in ESA governing bodies. Increasingly, key matters are now resolved at the EU. As a result, Norwegian space policies are becoming increasingly similar to the country's general European policy. Norwegian interests must increasingly be championed in forums where we are not a member, or where our right to participate is limited. That makes it more urgent to strengthen the diplomatic dimension of Norwegian space activity. We must be good at promoting our interests in forums other than ESA, and particularly within the EU system. The Government will therefore seek to make sure Norwegian authorities are capable of successfully pursuing Norwegian interests in international space forums.

Norway's longstanding collaboration with Canada on radar satellites has demonstrated that Norway can achieve substantial benefits from bilateral cooperation in specific topic areas. The Government will maintain a pragmatic approach to the use of such agreements and will use them actively when appropriate to advance Norwegian interests. The Government will continue Norway's commitment to international collaboration in space-related research.

## 1.4 High-quality national administration of space activity

If space activities are to serve Norwegian interests, expertise is required in crucial segments of the Norwegian bureaucracy as well as in technology centres and user groups. Whether services and infrastructure are to be developed nationally, internationally or through commercial procurement, Norwegian authorities must be able to identify national needs, to judge the quality of technical proposals and to ensure their effective implementation. The demand for expertise is heightened by the fact that the technologies in question are often highly advanced, with user benefits that cut across traditional sector lines in public administration. The importance that Norway places on international cooperation and international projects heightens the demand for expertise further. To ensure that effective solutions can be properly developed and implemented, and that Norway's interests are protected in the international partnerships that may be required, we must draw together the expertise available in administration, technology and international relations. The Government intends to strengthen interaction and coordination among the relevant ministries.

The Norwegian Space Centre (NSC) is responsible for administering public appropriations on space activity, advancing Norwegian interests in international space programmes and advising Norwegian authorities and businesses on space matters. The NSC's advisory function will gain importance in the years ahead. Our society's growing dependence on space-based infrastructure systems increases demand for structured analysis of user needs and proposed technical concepts – analysis that is necessary to ensure that public investment in the sector is carried out in the most efficient manner. Public- and private-sector user groups will also be requiring more counsel, because they will want to make sure that the systems receiving investment are utilised optimally. The Government wants the NSC to remain the state body in charge of strategy, coordination and implementation, making efficient use of space for the benefit of Norwegian society. The Government will therefore strengthen the NSC's analytical and advisory capacities.

Norway's geographical advantages for space-oriented ground infrastructure on the mainland and elsewhere has enabled the country, since the 1960s, to scale up activities that have achieved world class standing in certain space-sector niches. Balloon releases and sounding rocket launches from Andøya are among them. Others include the ground stations in Svalbard, on Jan Mayen Island and in Antarctica for communicating with satellites in polar orbit. The Government will seek to ensure that operators of space-related ground infrastructure can continue to take advantage of Norway's favourable geographical location.

Since 2004, when the Norwegian Space Centre was converted from a foundation to an administrative agency, the state has had a 90 per cent ownership stake in the Andøya Rocket Range AS (Kongsberg Gruppen owns the remaining 10 per cent) and 100 per cent ownership of Norwegian Space Centre Properties, which in turn owns half of Kongsberg Satellite Services AS (Kongsberg Gruppen owns the remaining half). The Norwegian Space Centre manages the state's ownership interests on behalf of the Ministry of Trade and Industry. These companies have been important tools in developing key aspects of Norway's space effort. The investments have created a commercial basis for strong industrial growth in the companies, which increasingly derive their revenue from international markets.

The companies' growth and their increasing earnings from market activities make it necessary to examine the structure and degree of state ownership. Clearer distinctions may be needed between the administrative, political and commercial aspects of the state's involvement in space activities. The Government will seek to determine, by evaluation, the most appropriate organisational structure for public-sector space programmes, and will take the necessary steps to realise that structure.

# 2 On space activity

Space activity is an umbrella term for all activities associated with the development, construction and use of infrastructure in space. For many of us, the term brings to mind the space race, astronauts and rockets. It is probably less typical to associate space activities with weather forecasting, offshore petroleum operations, live broadcasts of World Cup football matches or ordering a taxi. The fact is that space-based activities enter our lives most directly through ordinary services like those. Over the last 25 years, services that rely on space infrastructure have become so seamlessly integrated into our lives that we reflect barely at all on the fact that they are made possible by space activity.

We can illustrate this with a thought experiment: What would happen if all satellite-based services suddenly disappeared? It's certainly the case that much of what we take for granted in everyday life would come to a stop. The quality of weather forecasts, especially long-term forecasts, would decline sharply. Many of us would lose our TV signals altogether, and others would have to make do with fewer channels. Modern shipping operations would be set back many years, to when cost efficiency, safety and crew welfare were of lower standard. The ability to summon emergency help and the effectiveness of search-and-rescue missions would be dramatically reduced. Official oversight of ship traffic, fisheries and sources of pollution off the coast would become more difficult and expensive to exercise. Researchers, meanwhile, would have a harder time understanding the factors that govern climate and other aspects of our environment. Without satellite navigation signals, private individuals, public emergency services and taxi companies would lose the use of electronic maps for navigation and fleet management. Land surveyors and construction planners would have to fall back on time-consuming manual processes, while airport directors would see punctuality and capacity decline.

The last time the Storting was presented with a comprehensive look at the role of space activity in Norway was in St.meld. nr. 13 (1986–87): *Om norsk romvirksomhet* (On Norwegian space activity). Already then, space activities were described as affecting many aspects of society. It is no exaggeration to say that the importance of such activities has increased tremendously in the more than 26 years that have elapsed since publication of that report. The proliferation and refinement of satellites – in combination with increased data processing capacity, the global spread of Internet services and the emergence of mobile communications equipment on earth – have given satellite-based services an ever-greater impact in daily life. In policy fields like climate research, the environment and the High North, which have risen to the top of the political agenda in recent years, satellite usage has become a prerequisite for efficient information gathering and public administration. The importance to security policy, the traditional pinnacle of applied space technology, remains at least as great as it was during the Cold War.

Space activity has quite simply become essential to modern society. It is inconceivable that we could live as we do today without the help of satellites in orbit. Space activity is not some peripheral, albeit fascinating, branch of basic science research. It is a basic part of our everyday lives, and a necessary element in government strategy to ensure competitiveness, security and sustainable development.

## 2.1 From space race to critical infrastructure: 50 years of the Space Age

The launch of the Soviet test satellite Sputnik 1 in October 1957 is generally regarded as the open-

**Box 2.1 Key terms**

*Space activity:* All activities related to the exploration and exploitation of space.

*Space-based infrastructure:* Technology on the ground or in space required for the pursuit of space activities; examples include satellites, launchers and ground stations.

*Space-based services:* Services based on the use of satellites.

ing of the Space Age. Since then, humanity has been capable of placing objects in orbit around the earth – an ability that is the basis for all the practical applications of space-based systems we see today. However, a good many years would pass before space activities with any practical significance to civilian society began to appear. In the early years, advances were motivated by and large by military and geopolitical considerations, as part of the Cold War arms race.

The first decade of the Space Age was marked by a rivalry between the United States and the Soviet Union, with each superpower seeking to be the first to boast new achievements in space. Soviet citizen Yuri Gagarin's orbit of the earth in 1961 and the first steps on the moon, by the American Neil Armstrong in 1969, were spectacular milestones in the struggle for hegemony in space. Driving the space race was each country's desire to demonstrate its technical skill, in part to impress its opponent and in part to impress its own population. Inherent in the rivalry was an understanding that rocket technology from the two competing space programmes also had an alternative use: to propel missiles with nuclear warheads between continents in the event of a global armed conflict between the superpowers.

By the early 1960s, space technology was being adopted, if gradually, for practical purposes on the ground. Yet military needs still took priority. In 1964 the United States inaugurated its TRANSIT military satellite navigation system, a forerunner of the GPS global navigation satellite system. Satellite communications were employed for both military and civilian purposes throughout the 1960s, first in the United States and later in many other countries. Earth observation satellites became a valuable tool for the intelligence services on both sides of the Iron Curtain. Such satellites provided a good overview of installations on the ground and made it possible to observe the territory of other states without committing airspace violations. Eventually, this military function and an increase in civilian applications caused other countries to desire space programmes of their own, allowing them to develop their own capabilities in a field increasingly seen as strategically important. In the late 1960s, China began making substantial investments to develop its space skills. In Europe, France took the lead in developing space technology and became a driving force in the establishment of European space cooperation.

Space activity continued as an arena for superpower competition through the 1970s and 1980s. Its significance to civilian life gradually became more apparent, however, especially in areas like meteorology and communications. The growing importance of satellite-based services for civilian purposes led to expanded international cooperation in developing and employing satellite systems. For small states, this was an opportunity to gain access to infrastructure they would not have been able to develop on a national level. For large states with substantial capabilities, i nternational cooperation made it possible to split the bill with others, without losing user privileges. Key milestones included the creation of INMARSAT, the international organisation for maritime satellites, in 1979, and EUMETSAT, the European organisation for meteorological satellites, in 1986. The international organisation for telecommunications satellites, INTELSAT, had been established way back in 1964 but expanded its membership and activities on a large scale throughout the 1970s and 1980s. The most comprehensive international collaboration on space activity to date came into being in 1976, with the founding of ESA.

In the 1990s, civilian use of space-based services began to increase sharply. The change can be attributed to several factors. Two of them are related to the end of the Cold War. First was the relaxation of international tensions as the superpowers stood down from their long rivalry. It was now tenable to loosen controls on technologies and systems that previously had been reserved for military use. That was the case with high-resolution satellite imagery, which had once been considered so strategically important that information about the best resolution achieved was kept secret. In the 1990s and 2000s, improved access to good satellite images opened the way for a growing business exploiting such images – the most prominent example being Google Earth. Secondly, the end of the Cold War brought with it a reduction in military budgets. The cuts were a blow to many strategic technology companies, which responded by turning to new civilian markets. Another important factor that helped boost civilian use of space technology was the information technology revolution in the 1990s and 2000s, which led to a rapid increase in data-processing capacity, Internet connections and mobile telecommunications equipment. The new information technologies made it possible to deploy satellite-based navigation, communications and earth observation systems in a far more comprehensive way than would have been technically feasible before.

Developments since the 1990s have been characterised by the accelerating integration of space-based technologies into everyday life. To put it another way, space activity has been «normalised». It is no longer a spectacular sector cut off from the rest of the economy, but is instead a source of critical infrastructure services along the lines of electricity generation and water supply. This change in character has had several different effects. The emphasis on socially beneficial space activities has become more explicit. To a greater extent than before, public expenditures on space activities are expected to return measureable benefits to the public. Satellites have become highly important tools to military and civilian authorities alike. Commercial interests that rely on the use of satellite-based services have grown quite large over time. The role of private actors in space-based infrastructure like satellites and launchers has begun to grow, though most global investments in this part of the space sector are still publicly funded. Cost-cutting demands, particularly among traditionally dominant players like the United States, have led to increased emphasis on international cooperation and innovative financing methods. Nonetheless, the approach to space remains intensely strategic, if in a somewhat different way than during the Cold War. Control over space-based infrastructure has become more important to security and national independence.

## 2.2 Global space activity in 2013 – actors and driving forces

Space activity today is far more complex than ever before. The number of fields affected by space-based infrastructure has increased. Likewise, the

**Box 2.2 Apollo**

The US Apollo programme of the 1960s was essentially a political project. The goal was to restore the United States as the world's leading technological and economic superpower. The means: a moon landing.

The moon programme was treated as a societal call to action. The price tag was USD 25.4 billion, equal to about USD 160 billion today. Some 20,000 industrial companies, 200 universities and colleges and nearly 400,000 people took part in the project.

On the technology side, the programme led to major advances. The most important was the transformation of computers from colossal machines, each the size of a house, into smaller and lighter machines with greater computing capacity, memory and reliability.

The other major legacy of the Apollo era was the concept of programme management. While the required technological leaps were formidable, a far greater challenge lay in programme management of the planning, manufacturing, testing, training and logistics involved. A fundamentally new concept for programme management was developed. It was subsequently used in the management of everything from urban planning to industrial processes, leading to improved profitability, safety and quality standards in other fields.

With less fanfare, a number of unexpected by-products of the Apollo mission – from improved medical monitoring equipment to new, fireproof textiles – slipped into services and products that we now take for granted. An important «spin-off» has been the very image we all have of the earth. A photograph of our planet titled «The Blue Marble», taken from the moon against an infinite black background, has been of great importance to environmental awareness.

Figure 2.1 The Blue Marble

Photo: NASA

number of actors actively involved in space on a global basis has increased. States are still the primary actors. States, or international organisations with states as members, are the main force behind large public infrastructure systems, and they are the primary funders of research and development. The number of states actively involved in space has grown in the past 25 years, while the balance of the various state actors has shifted to some degree. The other main actor is industry. Much of the traditional space industry has undergone major structural change since the end of the Cold War. Meanwhile, a large commercial sector has arisen to exploit satellite data and services. Space-related activity has increasingly become a tool to satisfy needs in other sectors in society. As a result, the main public drivers of space-sector developments are mainly to be found in economic policy, security policy and environmental and climate policy.

The dominant state actor is still the United States, although new entrants in recent years have increasingly challenged US dominance. The United States has leading capabilities in all areas of the space sector, and it aims to maintain its role as the dominant space nation. At the same time, the country's public investments in space have not been exempted from overall budget-cutting demands. The Obama administration's space policy has been characterised by attempts at reform, including the adoption of new space strategies for both the civilian and military sectors. The purpose is to reconcile a desire to maintain US hegemony in space with the need for economic tightening. Practically speaking, this has had three main effects. The first is that NASA and NOAA, the primary US space organisations, now face a requirement to return demonstrable benefits to society. A stronger emphasis is being given to applied technology in navigation, communication and earth observation, as well as to space technology that will provide spillover effects to the rest of the economy. Second is a continuous effort to establish public-private cooperation in the space sector, both as a means of cost control and a way to ensure that public investment filters into the private sector. Since the discontinuation of the Space Shuttle programme in 2011, the intention has been that private contractors will fulfil the demand for transportation services to the International Space Station. Steps have also been taken to strengthen international competitiveness within the US space industry by softening strict US export controls (ITAR). Third is a greater emphasis on international collaboration. The United States has initiated long-lasting collaboration with Europe on the shared use of weather satellites, and has been a major force in the global initiative *Group on Earth Observation* (GEO), which seeks to ensure open and free access to environmental monitoring data from satellites.

Russia's position as a world leader in space was weakened by the collapse of the Soviet Union. The harsh economic situation of the 1990s put the Russian space programmes in a powerful budget squeeze, and Russian authorities lost direct control over important industries and infrastructure in places like Kazakhstan and Ukraine. Russian economic growth in recent years has once again made it possible to make space a priority. The Putin administration is working hard to restore Russia as a leading space nation, through such projects as the modernisation of the GLONASS satellite navigation system, which deteriorated in the years after the Soviet Union's fall. New ground infrastructure is being established on Russian soil to replace the infrastructure in other former Soviet republics. The space sector is considered

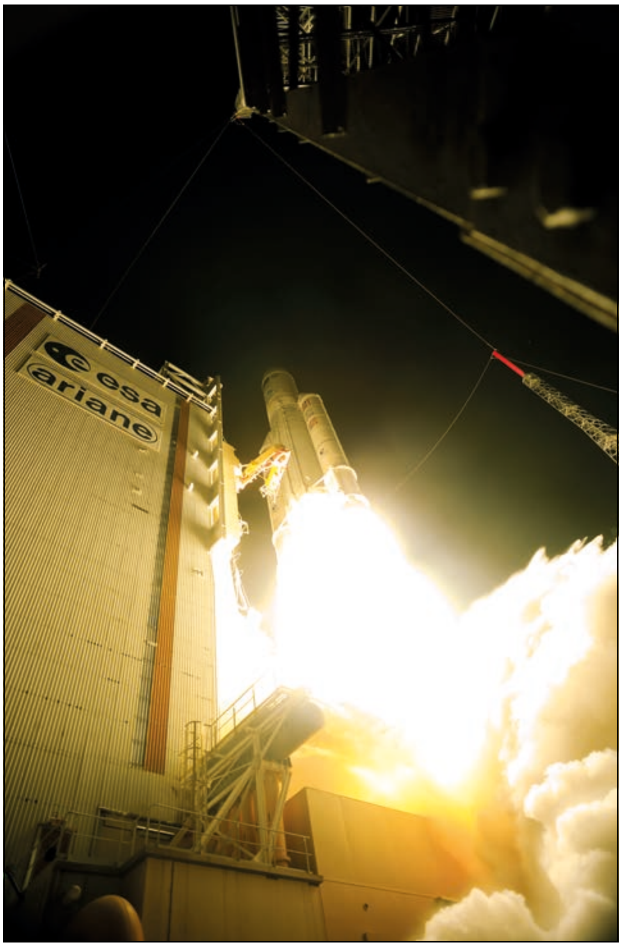


Figure 2.2 Ariane 5 at Kourou

Photo: ESA/S. Corvaja, 2012

strategically important to Russia's technological, economic and geopolitical goals. Russia has partially opened the door for international collaboration in space activities, primarily as a source of technology transfer. Cooperation between ESA and Russia on the use of Russian Soyuz rockets at the European launch base in Kourou, French Guiana, has so far proved highly successful.

China has for years invested heavily in its own space capabilities, and has ambitions to become the leading space nation in the 21st century. It sees the space sector as a catalyst for economic development and growth, with strategic importance for the country's goal of becoming a geopolitical leader. Space also plays a significant role in the building of national self-esteem and demonstrating Chinese expertise to the rest of the world. A major priority is the Beidou satellite navigation system, which is to be a global system corresponding to GPS, Galileo and GLONASS. The system is already operational in China and is scheduled for completion in 2020. Beidou is designed to ensure control over strategic military infrastructure as well as to boost Chinese industrial knowhow. Also in progress is the development of an earth observation system (something similar to Europe's Copernicus programme), launch vehicles and a Chinese space station. Chinese authorities aspire to execute a manned Chinese moon landing by 2030.

Indian efforts in space technology are primarily intended to meet specific national user needs related to economic development, resource management and military purposes. The country currently has its own satellite systems providing communication, television, meteorology and resource-mapping services, and it is in the process of developing its own regional satellite navigation system. Because of incomplete property records and poor infrastructure on the ground, India has benefitted greatly from the use of earth observation satellites for environmental and resource mapping. The wide availability of skilled engineers at low cost makes India highly competitive in some segments of the space sector. India in recent years has established itself as a competitive commercial provider of satellite launch services. Norway's AISSat-1 satellite was launched from India in 2010.

Elsewhere in the world, more and more nations have ambitions of building their own capabilities in space. Iran and North Korea are already able to loft satellites using their own launch vehicles. Japan, South Korea, Brazil, Argentina, Israel, Canada and Taiwan all have significant national space programmes. France and Germany, for their part, have mounted large national efforts that supplement their participation in ESA and EU programmes. For the vast majority of countries, however, international cooperation is the only way to play an active role in space. The largest and most comprehensive collaborations are in Europe, through ESA and increasingly the EU as well. Latin American and African nations are attempting to gain access to space infrastructure through bilateral agreements with the United States, China, ESA and others. The International Space Station (ISS) has been completed jointly by the United States, Russia, Japan, Canada and ESA.

The United Nations has long played a role in regulating the use of space and developing relevant international legislation. In addition, the organisation has itself become a major user of satellites. The UN's legislative work on space issues takes place within the framework of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), which was created in 1958. The committee currently serves primarily as a forum for information exchange and international debate on issues related to regulation of space activities. In the 1960s and 1970s, UNCOPUOS played a central role in the preparation of five international treaties governing the use of space. Norway is not a member of UNCOPUOS but has endorsed four of the international space treaties. In addition to UNCOPUOS, space-related issues today are discussed in arenas such as the Conference on Disarmament, the UN General Assembly, UNESCO, the International Telecommunication Union (ITU) and the World Meteorological Organisation.

Apart from its involvement in international space law and regulation, the UN is a major user of space-based systems to reach international goals related to climate change, crisis management and humanitarian aid. The value of satellite services is particularly high to developing countries, due to their relatively poor ground infrastructure. Satellite observation has also become an important way of viewing military conflicts and natural disasters from above, allowing more precise deployments of humanitarian assistance. Sustainable development efforts, meanwhile, have gained from satellite monitoring of phenomena such as deforestation, desertification and environmental factors that affect the spread of disease-carrying insects. The UN agency UNOSAT works to acquire satellite data and make it available for use in disaster management as well as environmental and development policy-making.

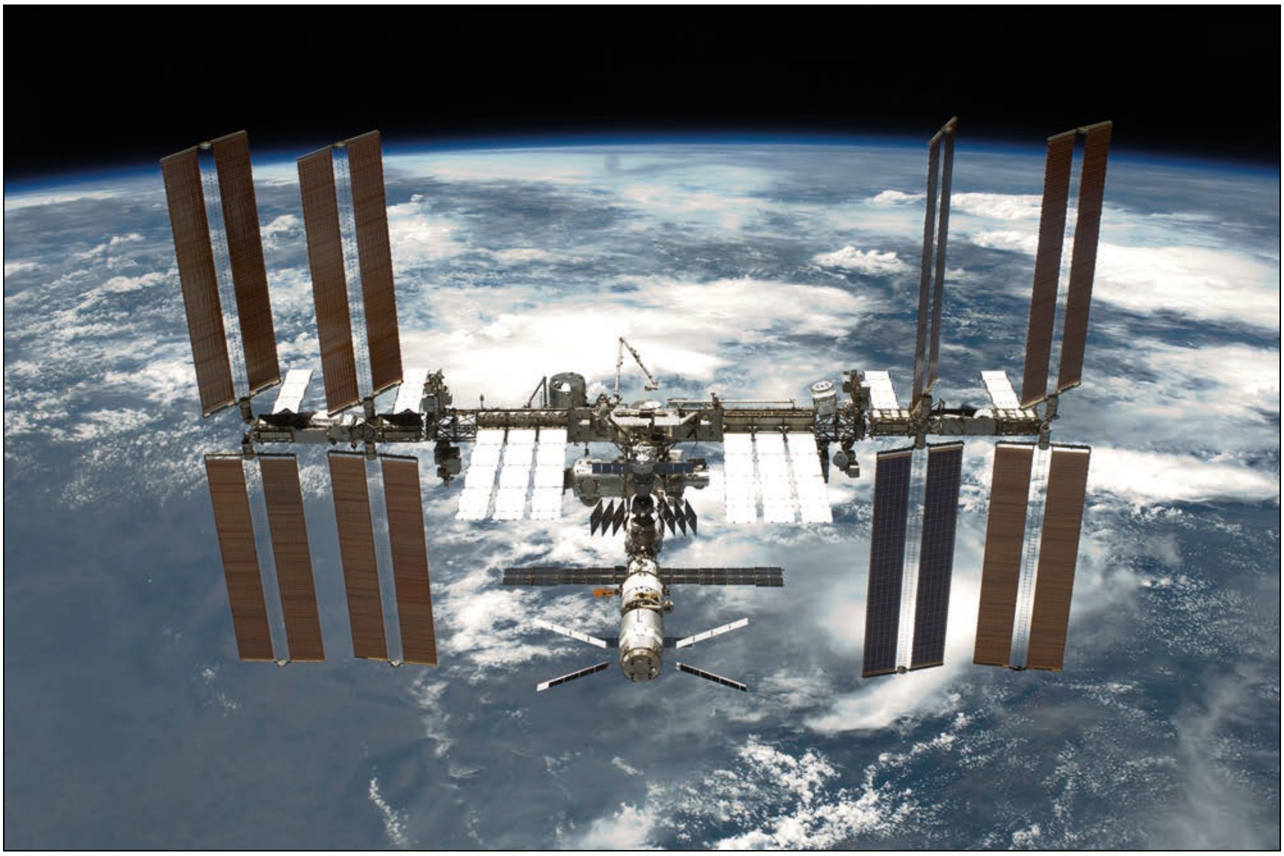

Figure 2.3 International Space Station

Photo: NASA

The other main group of global space players, apart from the states, is the business community. Space-related businesses are generally divided into two categories: upstream and downstream.

*Upstream industry* manufactures satellites and launch vehicles. Most companies in this part of the space industry are set up as a strategic matter, with financial returns normally limited in scale. Major technological challenges, low production volume and extremely stringent quality assurance needs combine to drive up costs relative to earnings potential. For reasons of strategy, technology and investment, upstream space actors are often closely tied to the aerospace and defence sectors. Such ties make it possible to benefit indirectly from space-related technological advances, through spillover into related sectors; technological spillover is in fact one reason companies engage in the upstream space industry. Public procurement and development support budgets are the main source of upstream funding. This reliance on the public sector is partly due to the substantial risks and small margins involved, and partly to the fact that many satellite types, including those for navigation and earth observation, can best be understood as public assets, with limited prospects for receiving income from users. Publicly funded satellites are important not least for the opportunity they represent to provide «flight heritage» for new technologies. Because of the risk that equipment sent aloft may perform unsatisfactorily, few commercial satellite owners are willing to deploy technology that has not already proved itself in space. Even for communications satellites, where there is more of a commercial market, public development programmes play a key role in the testing of new systems. Major players in the global upstream industry include Lockheed Martin, Boeing, OHB, Astrium and Thales. Since the end of the Cold War, transnational mergers and acquisitions have played a major role in the industry's evolution, particularly in Europe.

*Downstream industry* provides equipment and services that require satellite data and signals. Examples of such products include satellite navigation receivers, satellite-based telecommunications services and information services based on satellite images. The structure of the downstream industry is completely different from that of the upstream industry, with many start-up companies and small and medium-sized businesses in addition to larger players. Development costs relative to earnings potential are similar to those found in «normal» high-tech businesses – and far from the peculiar conditions prevailing in the upstream industry. Downstream activities have benefitted greatly from developments in modern information technology, with expanding opportunities for data processing applications, Internet-based communications and mobile telecommunications equipment. Although downstream and upstream activities are completely different, the two segments of the space sector are closely linked. One key factor for downstream success is a clear understanding of how satellite systems work, so as to foresee technical, end-user and commercial opportunities. Often, the only way for a company to gain such insight is to take part in major satellite infrastructure projects. Downstream players, therefore, are not just passive users of technology developed upstream; they are active participants in the development of new satellite infrastructure. A key reason for the establishment of Galileo and Copernicus, the EU's major space programmes, was a desire to position Europe's downstream industry in the competitive international market for satellite-based products and services.

To understand what is driving the changes we see in global space activity, it's helpful to examine

**Box 2.3 Dynamic positioning**

Figure 2.4 Dynamic positioning

Photo: Kongsberg Maritime

Dynamic positioning is a technology employed to keep vessels and floating offshore installations in fixed position above the seabed without the use of anchors, and to manoeuvre them with precision during transport. To determine correct positioning, the technology relies on navigational satellites. Industries that require dynamically positioned vessels include offshore petroleum, ocean shipping and cruise travel. Diving boats, shuttle tankers, supply vessels, cable-laying ships, pipe-laying ships, rock dumpers, crane vessels, drilling rigs and drillships all make extensive use of the technology. Norway is a leader in dynamic positioning.

what motivates countries and organisations to invest in it. Apart from the objectives of pure basic research, which remain important for Norway and many other countries, the rationales may be grouped roughly in three dimensions: economic value creation, independent strategic capability and sustainability.

Value creation has been a factor in space activity from the very beginning, in the 1950s and 1960s. The Apollo programme ushered into existence a space sector of comprehensive scale, which in turn lifted the technological level of the entire US economy – a boost with long-lasting effects. In the maritime and media industries, to take two examples, satellite communications have contributed to value creation since the 1970s. In the past two decades, though, the effect of space activities has changed. Instead of being important to only a few distinct sectors, what goes on in space now has implications for all parts of the economy, an influence so extensive that it is difficult to imagine how today's globalised economy could function without it. Value creation occurs well outside the traditional production of satellites, launch vehicles and ground infrastructure. It occurs on an even larger scale through the sale of satellite-related products and services, through spillover into other technologies and through the stimulation of economic activity in such fields as transport and natural resources. Space activities add a great deal of value to businesses involved in oil and gas exploration, transport, agriculture and road and rail tunnelling. As the economic impact of space activities has widened, value creation has become a stronger and more explicit rationale for public investment in the sector everywhere in the world.

Independent strategic capability was the original rationale for space operations. From the 1950s onwards, it was the primary reason for the big space programmes of countries like the United States, the Soviet Union and France. During the Cold War, space programmes were tools for developing missile technology, gathering intelligence and demonstrating technological strength to rival powers. Although the geopolitical situation has changed a lot since then, the strategic importance of space has not diminished; more likely, it has grown. Space-based infrastructure today affects vital civilian and military activities. Critical aspects of civil preparedness such as emergency communications, sea-rescue capability and disaster management depend on satellites for communication, navigation and surveillance. The same can be said for modern network-based military operations. Countries and organisations as diverse as the EU, the United States, Russia and China feel compelled for strategic reasons to invest heavily in the development and control of their own space infrastructure. Such control is deemed important to shoring up their security and independence.

Sustainability is a more recent consideration, but in recent years it has become an increasingly important rationale for public investment in space activities. That's because observation satellites have proved very effective in measuring phenomena that affect our climate, such as greenhouse gas emissions, deforestation, forest degradation, ocean currents, melting ice, wind systems and cloud cover. By monitoring the flow of industrial pollution or spilled oil, for example, these satellites help us to understand and mitigate its effects. Satellite-based communications and navigation are essential to the prevention of accidents and spills associated with shipping and offshore oil and gas activities. In arid regions, precision farming techniques based on data from navigation satellites help reduce water consumption. The use of satellite data in development policy is widespread and growing, as seen in UN-directed projects. Several major international initiatives, such as the EU's Copernicus earth observation programme, are primarily motivated by the need for information to support sustainable development policies.

The influence of space operations on modern society is intricate, with ramifications in fields that are not always obvious. Comprehensive policies are therefore warranted. To get the most out of our space activities, we must coordinate policies and skill sets that are not always perceived as clearly linked. These include technology, value creation, security, communications, transport, international relations and the environment.

# 3 Development of space activities in Norway

Norwegian space policy has always been pragmatically oriented. Public investment in space-related activities has never been an end in itself, but a tool for meeting important national priorities in other policy fields. The requirement of tangible social benefit, which today has become a part of space policy everywhere in the world, has always been a prerequisite for space activities in Norway.

Most Norwegian space activities have been motivated by geographic factors. Norway is an elongated country, reaching far to the north, with a sea area more than six times larger than its land area. We have a scattered population, rugged topography, long distances to cover and harsh climatic conditions. In addition, Norway's economy includes heavy elements of natural-resource extraction and maritime transport. The applied use of navigation, communication and earth observation satellites has been emphasised in addressing needs related to ship traffic, fisheries, agriculture, offshore petroleum and the public supervision of maritime activities. Another important objective for space investment has been to stimulate growth and innovation in Norway's high-tech economy.

As a small country, we have had limited ability to invest in space activities on our own. International cooperation has always been the mainstay of Norwegian efforts in space, first through ESA and later, to an increasing degree, in agreements with the EU. The cost of shared satellite systems is usually divided in accordance with the size of each participating country's economy. A country's cost share does not necessarily reflect the extent of its use of a particular system. A small country, therefore, gets off with a relatively low portion of costs, while gaining access to the infrastructure on par with countries that pay a great deal. Norway may be seen as potentially receiving an extra large return on its investments in space infrastructure. Norwegian infrastructure positioned in Svalbard, on Jan Mayen Island and in Antarctica has made N orway an attractive space partner. To take advantage of the international collaboration, supplementary national measures have been instituted, the foremost example being the national development support programme *Nasjonale følgemidler*.

More detail on Norway's international collaboration, national policy support instruments and national infrastructure will be presented in Chapter 5, 6, 7 and 8. In this chapter, we examine the political priorities that have fuelled Norway's rise in space. These priorities can be grouped roughly into three categories: Norway's need for space-based services, the development of its high-tech economy and the strengthening of its research capabilities.

## 3.1 Norway's space-based service needs

The desire to meet national user needs, both public and private, has been an important motivation behind Norwegian space efforts for as long as they have existed. Since the 1960s, Norwegian authorities have been willing to invest strategically to obtain space-based infrastructure, with the goal of meeting national user needs cost-effectively. Most Norwegian efforts have stemmed from challenges relating to the country's business interests and geography. Maritime communications and ocean monitoring fit that description, as do other challenges more specific to the High North.

The first major challenge that prompted Norway to check out satellite-based technology was communications – specifically, the need to communicate with Norwegian ships, the Svalbard archipelago and oil platforms in the North Sea. Prior to satellites, high-frequency radio (HF) was the best technology for that purpose, but its utility was limited by variable signal coverage and capacity constraints. In the late 1960s, Norwegian authorities began studying various ways to establish national satellite communications capacity. This result, in 1976, was that Norway became the first country in western Europe to have a national satellite system, in the form of the NORSAT A satellite system. It was based on the rental of satellite channel capacity through the International Tele-


Figure 3.1 Norway's maritime boundaries

Source: Norwegian Mapping Authority

communications Satellite Organisation (INTELSAT), and accommodated communications with Svalbard and with offshore oil platforms. Ship communications remained an unsolved problem. In the 1970s, Norwegian authorities assumed an active role in the International Maritime Organisation (IMO) and in the collaborative European project MAROTS, whose aim was to create a global

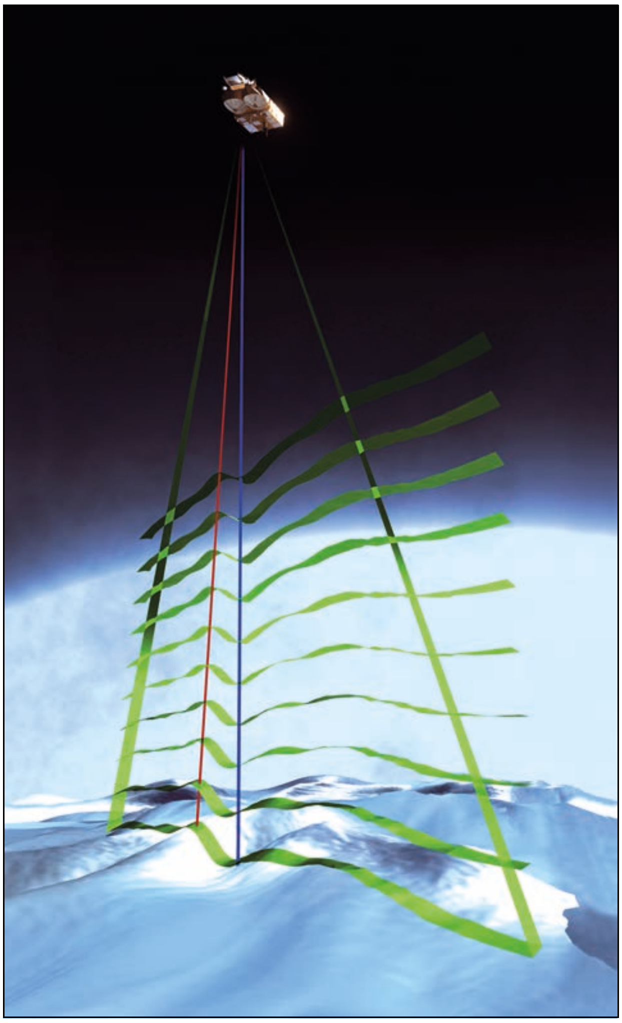

Figure 3.2 ESA satellite CryoSat measures the topography of the Arctic ice

Illustration: ESA

**Box 3.1 Radar satellites and Radarsat**

Radar satellites transmit microwaves and measure what is reflected back from the ground or sea. These signals pass right through cloud cover, and measurements can be made day or night. Radar satellites are thus an important tool for monitoring sea ice, oil spills, ship traffic and landslide danger. Due to their high power consumption, the satellites cannot operate continuously. Norwegian participation in international radar satellite projects helps ensure that high-priority areas for Norway are scanned. ESA's planned radar satellites Sentinel-1A (2013) and Sentinel-1B (2015) will permit additional surveillance of Norwegian maritime areas.

Norway's 2002 Radarsat agreement with Canada gives Norway the right to order about 2,000 images per year from Canada's Radarsat-2 satellite. The agreement follows up on a previous partnership between the two countries dating back to Radarsat-1, which was launched in 1995, and also gives Norway access to radar images over Norwegian areas that other countries or organisations order. The PwC evaluation of 2012 (see 3.3) attests to the agreement's benefits and cost-effectiveness for Norway. The current Radarsat agreement secures data access through 2014.

The need for additional Norwegian access to other kinds of radar satellite is under study. One alternative is for Norwegian agencies, acting independently, to buy high-resolution data as required in the «spot market». Experience from the Radarsat agreement suggests that collective access through the Norwegian Space Centre may hold advantages.

maritime satellite communications system. This effort led to the 1979 establishment of the International Maritime Satellite Organisation (INMARSAT), which operated a satellite system of the same name. Norway's active involvement gave it influence over INMARSAT's system design, performance specifications and coverage areas, and led indirectly to the emergence of a competitive satellite communications industry in Norway in the 1970s and 1980s. Given strong industry and user interests, satellite communications have remained an important priority for Norwegian industry and the Norwegian authorities, as demonstrated by heavy Norwegian participation in ESA development programmes in this area.

Maritime monitoring has for many years been another important priority for Norwegian space activity. Norway's management responsibilities extend across vast ocean areas that are difficult to monitor satisfactorily by way of aircraft, ships or land-based installations. Early on, it became clear that observation satellites would be a cost-effective aid in enforcing Norwegian sovereignty at sea. The need to monitor maritime areas has been a major factor in many of the key decisions and policy measures that have helped shape the Norwegian approach to space. The chance to gain expertise and exert influence over the development of earth observation technology was a significant incentive for Norway to join ESA in 1987.

Norway began to employ observation satellites for operational monitoring of Norwegian waters in the mid-1990s. The need for improved

**Box 3.2 AISSat-1**

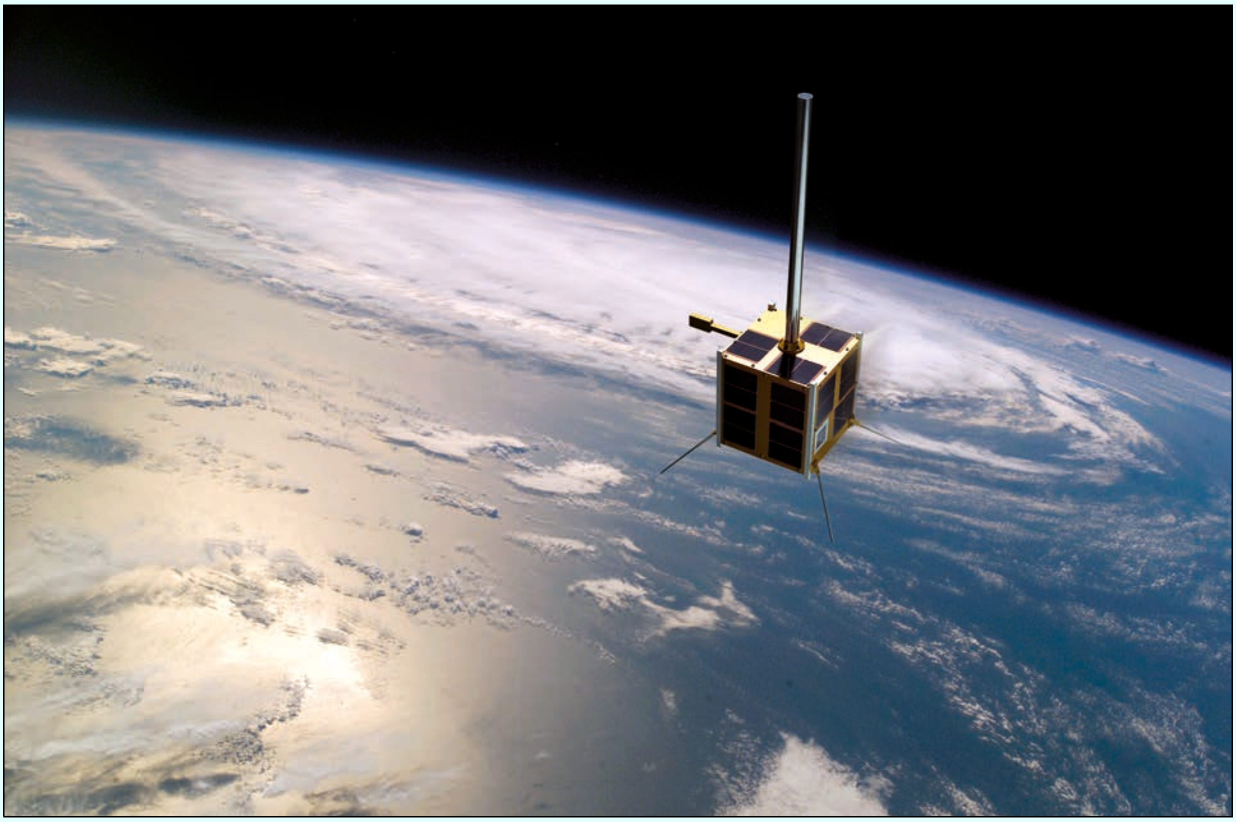

Figure 3.3 AISSat-1

Photo: Norwegian Space Centre/Norwegian Defence Research Establishment/Seatex

The small maritime observation satellite AISSat-1 is the first satellite owned and operated by the Norwegian state. The Norwegian Coastal Administration uses data from the satellite to track civilian ship traffic in waters off Norway and Svalbard left uncovered by the country's land-based Automatic Identification System (AIS) stations.

All large vessels are required to have an AIS transmitter on board that broadcasts information about their identity, destination and cargo. Along the Norwegian coast there is a chain of AIS stations, but they cannot track ships travelling beyond 40–60 nautical miles from shore. AIS ship signals now travel via Norway's AISSat-1 satellite to the Vessel Traffic Service monitoring centre at Vardø, in northern Norway, and to the country's rescue coordination centres. AIS information obtained by satellite makes it easier and faster for the vessel-traffic and rescue centres to monitor maritime activity, locate ships in need of assistance and identify vessels in the vicinity that may be able to help. Satellite-based AIS services also make it easier to identify vessels responsible for oil spills in Norwegian waters.

AISSat-1 is a nano-satellite measuring 20 cm x 20 cm x 20 cm. It moves in a polar orbit about 600 km above the earth's surface, bearing a long-range identification and tracking system. It passes over the waters off Norway and receives AIS data from ship traffic every 90 minutes. The lifespan of such satellites is estimated at two or three years. The satellite was launched from India in 2010 and represents a joint effort of the Norwegian Coastal Administration, the Norwegian Space Centre, the Norwegian Defence Research Establishment and Kongsberg Seatex. Its successor, AISSat-2, is to be launched in 2013.

coverage area led to long-term bilateral collaboration with Canada on the use of Canadian radar satellites.

Developments since then have shown earth observation satellites to be increasingly indispensible as tools for monitoring Norwegian maritime areas. Satellites provide an overview of large areas, enabling officials to direct more costly monitoring resources, such as aircraft and ships, to areas where closer scrutiny is required. Norway has regularly mounted new initiatives to maintain and enhance the national capacity for ocean monitoring, especially related to vessel traffic and oil spills. The Norwegian vessel-monitoring satellite AISSat-1 was lofted into orbit in 2010. Primarily monitoring areas where Norway has stewardship responsibility, it has also become an important resource in international collaboration, including the fight against piracy off the Horn of Africa. A major goal of Norwegian participation in the EU's Copernicus earth observation programme has been the need to secure future ocean-monitoring capacity over Norwegian areas.

Norway's investment in satellite navigation is another example of how national user needs have driven the development of Norwegian space activity. A major goal has been to address needs associated with maritime activity and the offshore oil and gas industry, but challenges in aviation and land-based operations have also been motivating factors. Norway's decision to join the EU satellite navigation programmes Galileo and EGNOS in 2009 may be the clearest example of national navigation needs helping to shape Norwegian space policy. The desire to satisfy such user needs, especially relating to maritime navigation in the High North, was a key motivation.

However, Norwegian involvement in satellite navigation extends quite a bit further back in time. A cornerstone of Norwegian expertise in this area was laid in the early 1990s. A NATO exchange agreement made it possible for researchers from the Norwegian Defence Research Establishment (known best by its Norwegian acronym, FFI) to work in the GPS Joint Program Office, which was responsible for developing the American GPS satellite navigation system. The technology skills and system insight these researchers brought home with them allowed Norwegian engineering experts to address special navigational challenges. In Norway's offshore oil and gas industry, the expertise was used to develop GPS-based technology for precision navigating, positioning and localisation during operations like seismic surveying and test drilling. Lower costs, greater accuracy and simplified procedures were the result.

Avinor, which operates Norway's airports, was quick to develop GPS-based airport flight approach procedures. This early adoption of GPS technology stemmed from a recognition that Norwegian navigation procedures needed improving, especially after tragic aircraft accidents at Torghatten (1988) and Namsos (1993). Avinor is now in the process of introducing the world's first satellite-based airport approach system (SCAT-1), which is to ensure safer approaches to Norway's regional airports. The system is based in part on the Norwegian-developed technology.

With regard to land-based tasks, the Norwegian Mapping Authority has long been engaged in developing satellite-based services for geographical surveys. These efforts have led to simplification and cost savings in mapping and surveying for construction, property delineation and other tasks that require accuracy down to the decimetre, centimetre and millimetre. In order to provide such precision, the mapping authority operates a network of reference stations across the country.

Straightforward satellite communications, ocean monitoring and satellite navigation are not the only space policy areas where user interests have helped determine the way forward. The objective of improving search-and-rescue operations at sea gave rise to one of the first international projects that Norway joined: the satellite-based emergency warning system COSPAS-SAR-

### Box 3.3 COSPAS-SARSAT

COSPAS-SARSAT is a collaborative international search-and-rescue system. Using satellites in polar orbit, it relays distress beacon signals to ground stations. The system is thus able to pinpoint the site of emergencies transpiring in the northern seas.

### Box 3.4 EUMETSAT

EUMETSAT is the European Organisation for the Exploitation of Meteorological Satellites. The organisation's main goal is to provide information applicable to weather forecasting and climate research. ESA and EUMETSAT have established a partnership in which ESA develops new-generation satellites and EUMETSAT prepares the way for their operational use. Norway is a member of EUMETSAT, and Norwegian agencies and research institutions are among the end-users of the information provided. Norwegian companies have supplied technology for many of the satellites in EUMETSAT's fleet.

SAT (see Box 3.3). Weather forecasting is another field in which national user needs have been crucial to the shaping of Norwegian space policy. Since 1986, Norway has been a member of EUMETSAT, the joint European programme for weather and climate satellites, and the country has long participated in a wide variety of ESA weather satellite programmes.

## 3.2 Development of high-tech Norwegian industry

Business development considerations have long played a major role in Norwegian space activity. Business development has occurred partly as a by-product of measures implemented chiefly to find solutions to Norwegian user needs, but also a result of conscious efforts by the Norwegian authorities to use space activities to help develop the country's industrial sector. Since 1970, Norway has created a niche-oriented, but competitive, array of space-oriented businesses. In some fields, the country is a global leader. Sales of Norwegian-produced goods and services related to space totalled about NOK 6 billion in 2011, with an export share of almost 70 per cent.

The most prominent policy instruments in the development of space-related industry in Norway have been the country's participation in ESA, its participation in the EU's Galileo and Copernicus space programmes, and the national technology support programme (*Nasjonale følgemidler*). A detailed account of how these contributing activities are organised will follow in Chapters 5, 6, 7 and 8. The theme of this chapter is how business development objectives have helped shape Norwegian space policy. There are three main mechanisms through which Norwegian investment in space has helped to promote growth and development in Norwegian industry. These can be designated as technological advancement, market access, and system insight. For 30 years, the desire to exploit those mechanisms to promote business development has been behind many of the key strategic actions of the Norwegian space effort.

The goal of technological advancement in Norwegian industry was a key motivation for Norway's accession to ESA in 1987. ESA is an industry-oriented organisation in which technological development is carried out in close collaboration with industry. Most development tasks are contracted out to suppliers based within the member states. A high degree of industry involvement is also traditional in development projects executed internally by ESA. Member states are thus quite able to use their membership to boost their own industries. Norway's ESA priorities have been guided in part by its ambition to develop technology relevant to Norwegian user needs and in part by its growth and development goals for Norwegian industry. Norwegian ESA participation has been especially strong in technology areas where we have large business interests, such as satellite communications. Norway has deliberately used its *Nasjonale følgemidler* support programme to enhance the positive effects of ESA membership on Norway's business community.

ESA's value as a tool for Norwegian technological advance has been largely twofold. First, participation has helped raise the technological level of Norwegian companies that provide goods and services to ESA development programmes. This has been possible through direct ESA funding of development projects, and through the transfer of technology to Norwegian companies from their ESA programme partners. Second, the provision of supplies to ESA test satellites has made i t possible to test out new technological components. Flight heritage, documenting that a company's technology has already served aboard a satellite, is normally a prerequisite for the company becoming a candidate to provide operational satellite components in the institutional or commercial markets. However, much of the benefit that Norwegian companies gain from ESA participation is a matter of technological spillover – the repurposing of space-related technologies for use in other sectors. There are few companies in Norway that operate exclusively in the space sector. International competition in the sector is formidable, and the markets to which Norway has access (primarily ESA, the EU and the commercial satellite segment) are relatively limited. Many companies, though, combine their space-related activities with other high-tech business pursuits. Most of these companies use their participation in ESA programmes as a means to develop technology that can also be applied elsewhere in their operations. The spillover effect from space activity is most notable in the realm of advanced technologies suitable for extreme conditions. Likely beneficiaries include the defence, aerospace, offshore petroleum and maritime industries.

Market access has been a considerable motivational factor for Norwegian participation in the EU space programmes Galileo, EGNOS and Copernicus. EU space programme supply con-

**Box 3.5 Technology spillover**

Products and product improvements that build on technology or expertise from ESA contracts and from Norway's own national development support *(Nasjonale følgemidler)* contracts:

- Receiver for AIS vessel detection (Kongsberg Seatex)
- Gas detector for measuring explosive gas at oil installations (SINTEF GasSecure)
- Calibration-free pressure sensor for extreme environments (Presens)
- Technology for radiation detection (Ideas)
- Technology for efficient transfer of images and video (Ansur)
- Software for large, complex development projects (Jotne)
- Data processing for ground stations (Kongsberg Spacetec)
- Methodology for software validation (DNV)
- Synergy effects between space and defence sectors (Kongsberg Gruppen and Nammo)

**Box 3.6 Norwegian satellite communications industry**

Norwegian companies involved in satellite communications had sales of NOK 4.2 billion in 2011, accounting for two thirds of space-related revenue in Norway. By far the largest portion consisted of communications services to the maritime sector, and to the broadcasting of television signals. Maritime communications service providers have proven to be very attractive as acquisition candidates, and most of them are now foreign owned.

tracts have been reserved for bidders from countries participating in the programmes. Through Norway's programme participation, Norwegian companies have been granted the same opportunity to compete for contracts as EU-based companies. Norwegian actors have proven themselves competitive, obtaining EU space-programme contracts valued at some 130 million euros through February 2013. In addition to direct sales income, those contracts represent high-profile reference projects for the companies concerned. Naturally, Norway's ESA participation has also opened up a market for Norwegian businesses. But the aggregate direct value of ESA supply contracts is relatively low in relation to ESA's value as a tool for technology development, partly because the volume of any single product purchased by ESA is normally rather limited.

System insight has been a motivating factor for Norway with particular regard to the EU space programmes, though ESA participation has led to a certain degree of system insight as well. Insight – as early as possible – into the technical, practical and commercial aspects of a satellite-based infrastructure system is a key to succeeding as a provider of products and services that exploit that system. Such insight can normally be achieved only through active participation in the development of the system. Norwegian authorities and business representatives have acquired a solid understanding of Galileo, EGNOS and Copernicus through participation in the governing bodies and working groups of these programmes. Gaining insight into those systems has been regarded as an important factor in Norway's competitive strength as a supplier of products and services that exploit satellite navigation and earth observation data. For that reason, it has been a major objective of Norwegian space policy. Norwegian companies have also gained insight into ESA space systems. ESA activities are relevant primarily to upstream companies. That agency's focus is on developing new technologies for satellites and launch vehicles; less attention is paid to building and operating infrastructure systems that may be favourable to value creation downstream. Nonetheless, Norwegian companies active mostly in the downstream sector report that they, too, benefit from participation in ESA programmes, by gaining insight into the technology that will underpin the next generation of operational satellite technology.

Norway's purposeful efforts to develop space-based industry by participating in EU space programmes and in ESA have been complemented by measures designed in the first instance to accommodate national user needs. That applies especially to business activities in the downstream sector, such as satellite communications and specialised satellite navigation services, where early involvement has paved the way for system insight, technology development and early testing of space-based services. Today, Norwegian suppliers are global leaders in services related to satellite communications and satellite navigation for the offshore sector. The Norwegian satellite communications industry grew in large part out of expertise built up in the 1970s in connection with efforts

**Box 3.7 Norwegian space players**

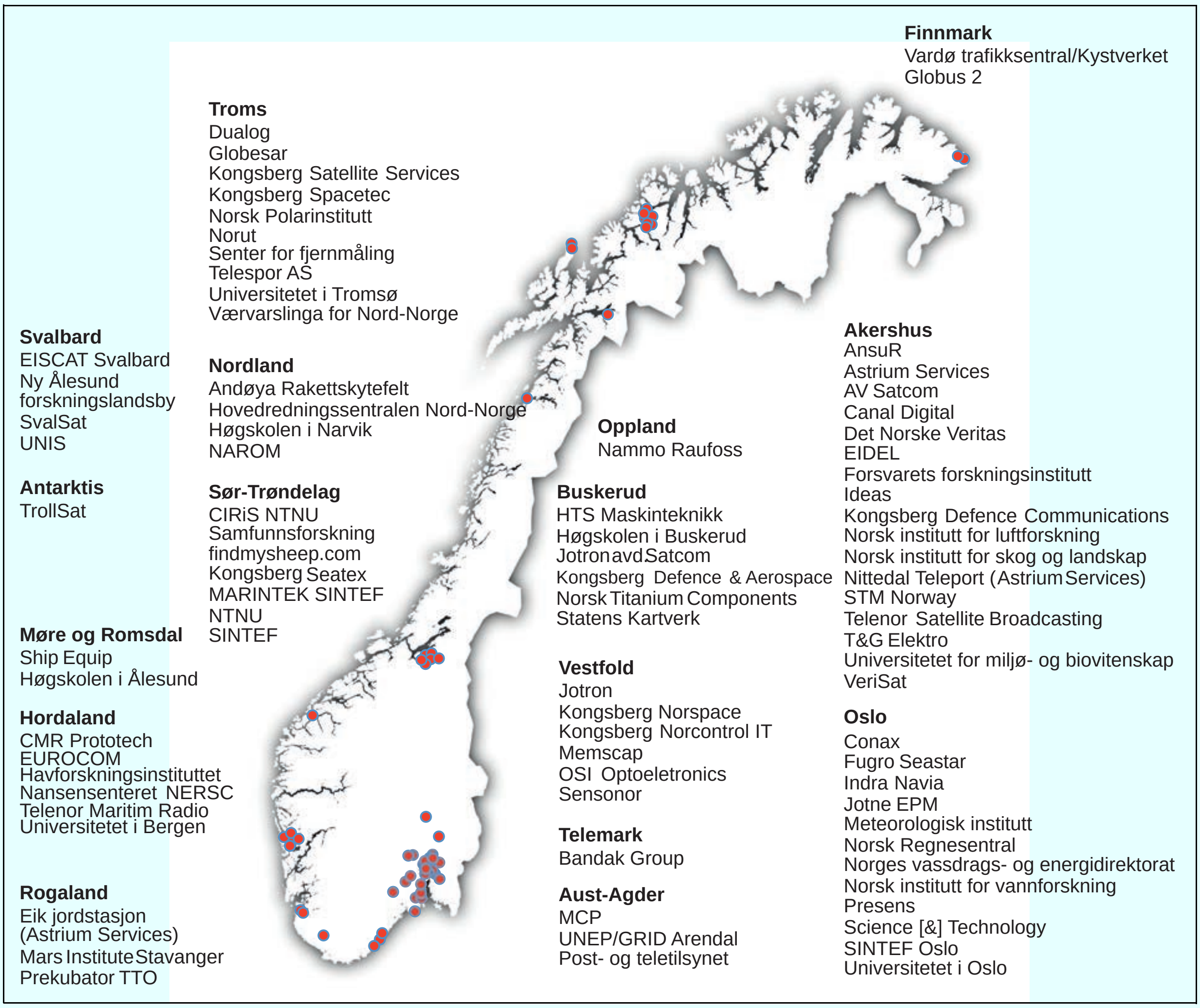


Figure 3.4 Geographical overview of Norwegian businesses engaged in space

Source: Norwegian Space Centre

Norwegian actors in space include a wide variety of companies, scientific research institutes, public agencies and educational institutions, of which a selection is presented here. They either supply products and services related to space-based activity or are active users of satellite data. They are spread throughout the country and their range of activities is quite large – from maritime satellite communications and rocket engine production to managing fish resources and tracking sheep.

to provide satellite communications for Norwegian ships. Development of high-precision navigation services for the Norwegian offshore petroleum industry gave rise to the emergence of competitive Norwegian technology companies – one example being Fugro Seastar, which today is the leading supplier of high-precision navigation services to the offshore industry. Telenor Satellite Broadcasting, which by revenue is clearly the largest Norwegian business player in the space sector, is a prime example of how investments motivated by national user needs have sparked commercial success. In the 1980s, Norway's challenging topography, large expanse and sparse settlement pattern made it difficult and expensive to develop a nationwide terrestrial network for television broadcasting. So Televerket, the state-owned forerunner of today's Telenor, pursued the development of satellite broadcasting – a business that has since become a major commercial success.

Since 1992, Televerket and then Telenor Satellite Broadcasting have acquired altogether six communications satellites. The company sells satellite capacity for broadcasting and for broadband service to shipping and offshore operations, and is currently the sixth largest satellite operator in Europe.

## 3.3 PwC's evaluation of some Norwegian space activities

Under assignment with the Ministry of Trade and Industry, the consulting firm Pricewaterhouse-Coopers (PwC) in 2012 conducted an evaluation of Norway's participation in the European Space Agency (ESA), the Radarsat agreement and Norway's own national funding support programme, *Nasjonale følgemidler*. The evaluation did not cover scientific activities or Norway's participation in Galileo and EGNOS. As a result, the evaluation does not provide a complete picture, but contributes helpfully to further space policy development. The review process was anchored in a reference group with input from relevant ministries, agencies and industrial players, and it was conducted in dialogue with the Norwegian Space Centre.

The report describes Norwegian space activities and the international framework in which they occur. It notes that important aspects of Norwegian space policy are working well, providing significant benefits to society; but the report also casts light on structural factors that may make policy adjustments necessary. It also makes several specific suggestions for the future design of Norway's policy apparatus. A complete and thorough review of PwC's comments and proposals is not possible in this white paper. We do present PwC's assessment of the strengths and weaknesses it found in various segments of the space sector, along with its strategic and operational recommendations. Those recommendations form some of the basis for the analyses presented in Chapter 1 of this white paper. Recommendations not included in Chapter 1 are not a part of the Government's policy.

The PwC evaluation focuses on Norway's participation in ESA as well as the country's national development support funding programme and the Radarsat agreement with Canada. The main conclusion is that Norway has benefitted greatly from all three. The report asserts that key aspects of the model for public support to the sector are working as designed, and that progress is being achieved towards the objectives of value creation, innovation, knowledge development, environmental protection and public security.

Norway's space industry is more commercial in nature than its counterparts in many other countries. It has large market share in segments of the space-based services sector, particularly those related to satellite communications and earth observation. Several companies in this sector have experienced rapid growth in recent years. Certain companies that produce space-related technological equipment have also seen growing revenues and market share, albeit to a lesser extent than companies in the service sector.

**Box 3.8 PwC's assessment of strengths in the Norwegian space activities it examined**

- Important aspects of the model for public support to the sector work as intended. These public policy instruments reinforce positive developments that contribute to the achievement of goals on wealth creation, innovation, knowledge development, environmental protection and public security.
- Norwegian industry has large market shares in segments of the space-based service sector, particularly in connection with satellite communications and earth observation. Certain companies that produce space-related technical equipment have also seen revenues and market share grow, albeit to a lesser extent than the service sector.
- Space activities create positive ripple effects across Norwegian industry. Positive synergies exist between the country's various support mechanisms. The proportion of national space industry that is devoted to commercial activity is greater in Norway than in many other countries.
- Norwegian space efforts have resulted in cost-effective systems that meet user needs in the public sector. The development of space-based systems for maritime surveillance, such as the AIS satellite, has been a particular success.
- The Norwegian Space Centre's expert advisory services and leadership are highly regarded by the authorities and by industry alike.

**Box 3.9 PwC's assessment of weaknesses and challenges in the Norwegian space activities it examined**

- Indicators are declining for Norwegian space-related industry as a whole. Total sales volume has not increased in recent years and the global market share for Norwegian companies is falling.
- Space-related companies are being bought up and incorporated into foreign-owned concerns. In some cases this has led to operations being moved out of Norway.
- Internationally, the sector is increasingly dominated by commercialisation and the emergence of new service segments. Norway's set of policy instruments is somewhat out of alignment with this development.
- Support mechanisms for industry are largely directed towards the production of space-related technology, while much of the international growth potential lies in service development.
- Structural changes in international space programmes, including the EU's enhanced role and increased activity by countries such as China, India and Brazil, pose a challenge to Norway's position.

The report also documents positive spinoff effects elsewhere in the economy, as well as positive synergism between the country's various support mechanisms. Participation in ESA strengthens Norwegian industry in general, with ripple effects in the form of increased sales for companies that have participated in ESA programmes. The report suggests there is positive interaction between support mechanisms – between, for example, the national development support funds for industrial development *(Nasjonale følgemidler)* and ESA programme participation.

Likewise, the national development support funds in combination with initiatives like Radarsat and the AIS satellite development programme have resulted in cost-effective systems that meet space-related needs in the public sector. The development of space-based systems for maritime monitoring, such as the AIS satellite, is cited as a particular success. The PwC report also points out promising projects associated with space-based systems for surveillance of land areas. Last but not least, the report says that the Norwegian Space Centre's expert advisory services and leadership are held in high regard by both the authorities and private industry. The NSC is also said to contribute to positive synergy among Norway's different support mechanisms.

On the other hand, the evaluation mentions a number of overall weaknesses, challenges and ongoing change processes that, according to

**Box 3.10 PwC's strategic recommendations**

1. *Support should be reoriented towards market segments with significant growth potential and comparative advantages.*
2. Earth observation data services have large public-sector customers that can trigger further technology development and demand for services. A commercialisation strategy for government procurement of earth observation data services should be considered. A strong domestic market could fuel growth in new value-added segments.
3. Support for space-related business development should increase in scope across the value chain and reach a larger number companies in order to ensure a level playing field among competing actors and solutions. Recruitment of new businesses in IT and telecommunications may help to increase the number of participants.
4. Further support to segments whose growth is stagnating should be carefully weighed to maker sure support corresponds to the potential for value creation and growth. Companies offering space-related ground equipment have anchor customers in the maritime sector but limited growth and market share. Certain upstream sub-segments have achieved strong results. However, there are strong obstacles to upstream industry growth, and no national anchor customers.
5. *Other tools to encourage service expansion must be developed, a process that may involve national or bilateral programmes.* In PwC's view, ESA programmes are less useful for service development. National programmes may have to be expanded to develop support mechanisms for the commercialisation of near-market-ready downstream technologies.

PwC, might make it necessary to adjust the public policy apparatus that supports Norwegian space activity. The report cites declining indicators for the industry as a whole in Norway. Overall, public expenditures on space-related activities are rising faster than commercial sales. Even though some companies and segments are growing, the space sector's share of Norwegian GDP is falling. Total sales volume has not grown in recent years, and the global market share of Norwegian companies is sinking. Ground equipment manufacturers in particular have lost a great deal of sales volume and market share.

Furthermore, few new companies have arisen in the past decade, and among the companies that have received support, there has been no growth in space-related employment. The report asserts that public funding has long been concentrated in a small number of actors – in particular, upstream companies that produce ground equipment and equipment for use in space. Meanwhile, the industry has experienced a prolonged period of consolidation, with space-related companies being bought up and incorporated into larger concerns. Some of these concerns have foreign owners, leading in some cases to the movement of operations out of Norway. Industry support programmes are largely geared towards the production of space-related technology, while much of the international growth potential lies in service development.

The report also cites challenges stemming from major structural changes in international space activities. Political processes in the EU and the United States will affect access to decision-making arenas in Europe and market access for Norwegian enterprises. The EU's strengthened role is highlighted as a possible challenge for Norway, especially in view of an accelerating EU-ESA convergence. Intensified activity in space by countries such as China, India and Brazil signals geopolitical changes underway. Internationally, the

**Box 3.11 PwC's operational recommendations**

1. The Ministry of Trade and Industry should develop a comprehensive policy on space-related activities that assigns relative weights to industrial development, public-sector programmes and scientific research.
2. Increased investment in national programmes should be conditioned on broader economic options analyses, along with normal assessments of life-cycle cost and market options.
3. Bilateral agreements and industrial return schemes should be subject to a greater degree of evaluation, pitting the benefits to particular companies against the state's costs. The processes should be open, with competition conforming to normal practice.
4. Clearer separation is needed between space programme development support and the acquisition of specific services from public bodies, such as Radarsat and AIS. Such separation will help to clarify objectives, priorities and costs. An expanding marketplace, meanwhile, is able to meet the state's operational requirements for data, and market options should be reviewed with regard to further investment in AIS. Procurements and support schemes should also be reviewed to make sure they accord with legal and regulatory codes.
5. The Ministry of Trade and Industry and the Norwegian Space Centre should revise their hierarchy of goals and priorities and link it more closely to governance dialogue and organisational strategy. The system of management by objectives and results should be simplified, clarified and made relevant to the Norwegian Space Centre's strategic plan.
6. Transparency with regard to support schemes and awards within the ESA framework can be improved. The information is not publicly available at present, which is a problem, given that so few companies are involved.
7. The Ministry of Trade and Industry should consider a reorganisation of corporate governance at KSAT to reduce the potential for conflict of interest.
8. The Ministry of Trade and Industry should consider strengthening capacity and support for changing ESA's budget process and IPSAS accounting principles.
9. If a further scale-up of national programmes is desired, the Norwegian Space Centre ought to be strengthened.
10. If the EU and ESA roles converge further, the Norwegian Space Centre ought to be strengthened.

market is increasingly characterised by commercialisation and the emergence of new service sectors. This poses challenges to the commercialisation strategies of Norwegian companies. According to PwC, the Norwegian public support apparatus for space activity is somewhat out of step with such developments.

According to PwC, there is also room for improvement with regard to public-sector governance issues. The Ministry of Trade and Industry and the Norwegian Space Centre could be clearer in their dialogue about goals and priorities. Clarifying and operationalising objectives, the report says, would be a step towards a more robust space strategy. In addition, strategies should be developed to improve the balance between national programme development and compliance with regulations, with the goal of avoiding risky practices related to procurement and competition. The report notes a potential conflict of interest in the state's partial ownership of Kongsberg Satellite Services (KSAT). Given the strength inherent in the company's solid growth, it is possible that close relationships with the Norwegian Space Centre and blurred roles could contribute to a potential conflict of interest and to the exclusion of market competitors.

On the basis of its analysis, PwC also recommends improvement measures, some of them strategic and some operational. A complete and thorough assessment of PwC's recommendations is not possible here. However, PwC's recommendations do form some of the basis for the analyses made in Chapter 1 of this white paper.

## 3.4 Research in Norwegian space activity

Space activities have always been closely linked with scientific research. The technologies that have underpinned practical applications and value creation in the private and public sectors often stem from basic research at research institutions. Society's increasing dependence on advanced electronic infrastructure has strengthened the need for knowledge about solar storms and other natural phenomena that can interfere with electronics on the ground, in aircraft and on satellites. Satellites have become an important tool for researching phenomena on the earth's surface and in the atmosphere, including ocean currents, weather systems and ice cover. Observation of distant stars and planets helps enhance our understanding of fundamental principles of physics.

Although national user needs and business development goals have been the main factors driving Norwegian public investment in space, scientific research has influenced Norwegian space activity as well. For many years, Norway has participated in international space-related research through ESA and EU framework programmes. In addition, bilateral and multilateral agreements have been signed with a number of countries, including Japan, Germany, France, Switzerland, the United States, Sweden and Canada. The Research Council of Norway's space research programme has contributed to national funding of space-related research for many years.

Norway has a long tradition of space-related research, particularly in fields relevant to the High North. Norwegian scientists have long played a pioneering role in aurora research; in 1899, they set up an observatory on Haldde mountain near Alta. Since 1962, Norwegian and foreign researchers have taken m easurements in the atmosphere and near space using sounding rockets launched from the Andøya Rocket Range (ARR). Over the years, Norwegian universities have developed advanced capabilities in fields such as solar research, cosmology and astrophysics. Largely due to its commercial interests and geographical location, Norway has long had leading research organisations active in such fields as ocean science, meteorology, polar research and climate and environmental research. Increasingly, such research relies on data from earth observation satellites. Norwegian universities, research institutes and public bodies are at the global forefront in exploiting earth observation data. Examples are the Norwegian Meteorological Institute, the Institute of Marine Research, the Norwegian Forest and Landscape Institute, the Geographical Survey of Norway, the Norwegian Institute for Air Research, the Norwegian Institute for Water Research, the Northern Research Institute (NORUT), the Norwegian Computing Centre and the Nansen Environmental and Remote Sensing Centre (NERSC).

Through ESA programmes, Norway participates in the development of satellites and space probes to observe the sun and outer space. Norwegian researchers utilise data obtained through ESA to investigate basic questions about the universe's origin, the possibility of life on other planets and the fundamental forces of the solar system. Norway also contributes to scientific research by way of a small financial stake in the International Space Station. This gives Norwegian researchers access to the space station's on-board

**Box 3.12 Space weather**

The sun is a variable star. Space weather occurs where solar radiation and the solar wind encounter the earth's magnetic field and atmosphere. The aurora borealis (northern lights) is a visible manifestation of this. Satellites and astronauts in orbit are more vulnerable to solar storms and space weather than people on the ground, but technical systems down below can be affected too. Space weather affects radio communications, navigational precision and radiation levels for aircraft personnel. The sun can also trigger geomagnetic storms, which can disturb power grids and increase corrosion in pipelines. Government, industry and tourism would all benefit from improved space weather forecasting. A European space weather service is under development, with participation by several Norwegian actors.

laboratories. Materials technology and biological processes are Norway's priorities in space-station research. Such knowledge is applicable to aquaculture, plant breeding and the development of new materials, among other things. The technology behind Norway's AIS satellite was tested aboard the space station. The control centre for ESA's space-station plant experiments is located in Trondheim. The Norwegian University of Science and Technology (NTNU) has been a pioneering environment for research into plant behaviour in weightless conditions and under varying light and radiation conditions. The University of Oslo has world-class expertise in solar research, and it houses the European data centre for Japan's Hinode solar research satellite and for an upcoming NASA satellite called IRIS. Research conducted with data from such satellites helps us to understand the fundamental laws of physics as well as pressing matters like the sun's effect on climate change and the phenomenon of space weather, which can disturb critical electronic systems.

Several Norwegian educational institutions have developed centres of learning with a focus on space. Narvik University College and NTNU offer engineering programmes in space technology. The University of Stavanger has research and educational programmes related to the synergy between space activities and the oil and gas sector. Most Norwegian universities offer educational programmes involving space-related physics.

The Tromsø Centre for Remote Sensing at the University of Tromsø is a hub of important Norwegian research actors in the field of earth observation. Participants in the centre collaborate on research, technology development, services development and the establishment and operation of earth observation infrastructure.

In 2013, the Birkeland Centre for Space Science was established as a Centre of Excellence in research. Its mission is to increase knowledge of electrical current flows around the earth, particle showers from space, auroras, gamma-ray bursts and other links between the earth and space. The work will lay a foundation for improved space-weather forecasting and heightened security for satellite navigation and positioning systems, TV signals, payment systems and other satellite-based services. The centre is operated by the University of Bergen and will receive a total of some NOK 160 million from the Research Council of Norway over a 10-year period.

The Research Council funds space research primarily through its 2011–2018 *Romforskning* (space research) programme. It was set up to fund follow-up research exploiting Norwegian space activities within ESA, EISCAT (European Incoherent Scatter Scientific Association) and NOT (Nordic Optical Telescope) organisations. The programme follows on the heels of prior programmatic commitments to basic research in priority segments of Norwegian space research. It aims to improve fundamental knowledge of space by examining important physical processes and developing the necessary technological tools. The research programme also encompasses near space, where cosmic radiation, solar wind and other solar processes interact in the earth's upper atmosphere.

The Centre for Earth Evolution and Dynamics (CEED) at the University of Oslo conducts research into mechanisms at work near the earth's surface and their connection to processes deep within the earth. The centre is to be funded by the Research Council of Norway as a Centre of Excellence from 2013 through 2023.

# 4 How space activity benefits society and contributes to key policy areas

The number of sectors touched in some way by space activities has been increasing in the past few decades. Norwegian authorities use satellites to address key public responsibilities related to sustainability, security and national sovereignty. Satellite-based infrastructure has become a significant factor in value creation across much of the economy, not least by facilitating safe, efficient operations in fields like transportation and natural resource extraction.

Norwegian space policy has been based in large part on finding concrete solutions to society's needs. Because of the country's geography and business interests, it became apparent long ago that Norway, more than many other countries, faced national challenges best addressed through space-based technology. Norwegian authorities, researchers and technology companies have often been quick to identify the opportunities represented by new space-related technologies. Today's advanced satellite systems for ship communications, ocean monitoring and high-precision navigation demonstrate how early-phase Norwegian involvement in promising new technology projects can result in beneficial services and commercial success.

More and more tasks these days can be accomplished cost-effectively by using space-based infrastructure. Moreover, many of the challenges that space-based technology may be helpful in solving have grown in significance in recent years. While Chapter 3 dealt with the political priorities that have shaped Norway's current approach to space, this chapter will look ahead to the role space activities may play in solving the country's present and future challenges. In some detail, it examines five policy areas where the use of space-based systems may be particularly cost effective: the High North, climate and environment, security, transport and research.

## 4.1 The High North

For several decades, the High North has been a central focus of Norwegian space policy. The Government's space efforts are also discussed in Report No. 22 (2008–2009) to the Storting: *Svalbard* and Meld. St. 7 (2011–2012) *The High North: Visions and strategies*. Our needs in the High North have been a key reason for Norway's commitment to the advancement of ocean monitoring technology through ESA, Copernicus and our radar collaboration with Canada. One of the most important goals of Norwegian participation in the EU satellite navigation programmes EGNOS and Galileo has been to make sure the programmes are able to perform satisfactorily in the High North. The satellite ground operations at Jan Mayen Island and Svalbard are representative of Norway's continuing involvement in the Arctic, and they help secure the deployment of satellite systems that perform capably over Norway's ocean expanses.

There are few if any alternatives to satellite-based systems when addressing the communication, navigation, surveillance and preparedness needs of the High North. Distances are too vast and human activities too scattered for land-based infrastructure, aircraft and ships to be effective. Satellite-based infrastructure provides coverage across wider areas. Once such infrastructure is rolled out, the cost of adding users to a service is very low. Radar satellites and AIS satellites can perform their observations day and night regardless of visibility conditions – an obvious advantage in harsh environments far to the north. Still, the High North poses special space-based infrastructure challenges. For some kinds of infrastructure, being on top of the world is an advantage. Satellites in polar orbit provide particularly good coverage near the poles. That's why ocean monitoring of the High North is one of their strong suits. For other types of infrastructure, northern geography is a challenge. Satellites that move in geostationary orbit, as most communications satellites do,

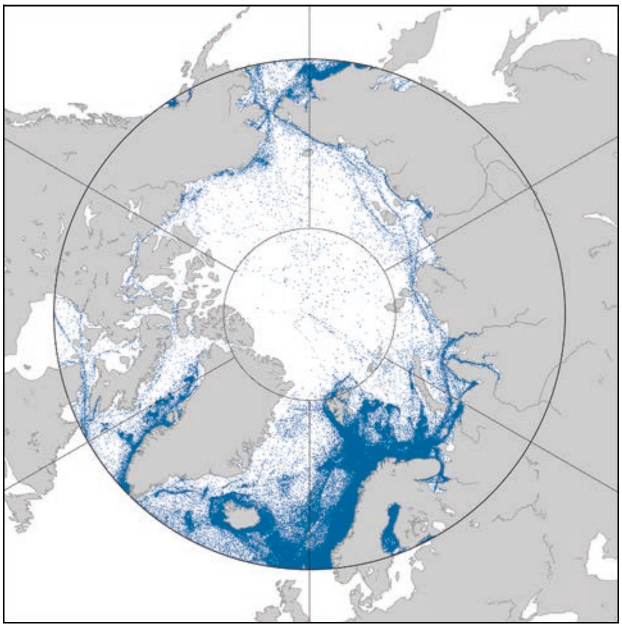

Figure 4.1 Ship traffic north of 60 degrees latitude (1 Oct. 2010 – 1 Oct. 2012)

Source: Norwegian Space Centre/Norwegian Coastal Administration

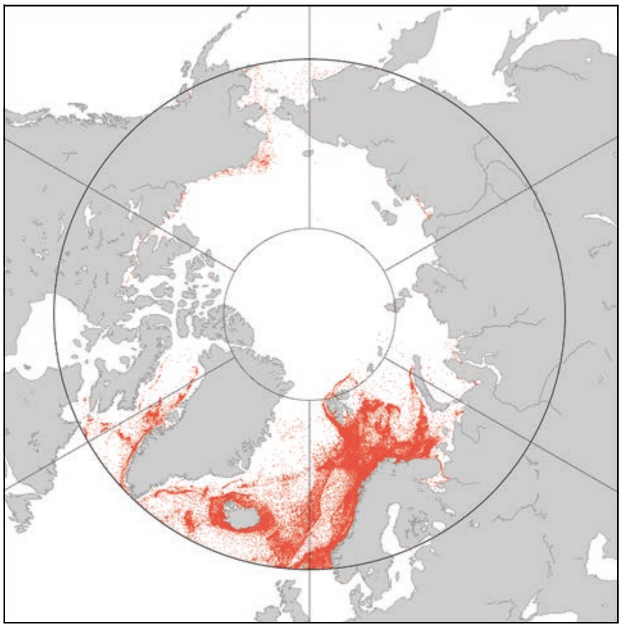

Figure 4.2 Fishing north of 60 degrees latitude (1 Oct. 2010 – 1 Oct. 2012)

Source: Norwegian Space Centre/Norwegian Coastal Administration

have limited coverage north of 75 degrees latitude. Communicating by satellite in the High North therefore poses special demands to the infrastructure employed.

Activity in the High North and the Arctic is on the rise. Norway's fishing fleet has been ranging farther and farther northward, and boats off Svalbard have crossed 80 degrees latitude on several occasions. Cruise tourism around Svalbard has grown in scope over the years. The offshore oil and gas industry is moving ever further into the Arctic, while the retraction of Arctic sea ice is increasing the feasibility of long-distance central Arctic Ocean shipping routes. Safe, efficient and sustainable shipping and natural resource extraction in the High North and Arctic will depend in large part on the use of satellite-based infrastructure. The great distances to be traversed and the lack of land-based infrastructure make satellite-based surveillance, navigation and communication essential to safe, efficient ship traffic and sea rescue operations. Advanced offshore petroleum exploration and drilling projects depend on navigation and broadband services available only by satellite. Norwegian authorities already have substantial experience using satellites to monitor oil spills and oversee fisheries. Now, High North shipping is on the rise, the operational radius of the fishing fleet is expanding, and oil and gas companies are entering sensitive environments as the authorities open new zones in and around the Arctic to petroleum activity. The need for improved monitoring is thus likely to intensify, underlining the importance of having high-quality communications and surveillance systems in place.

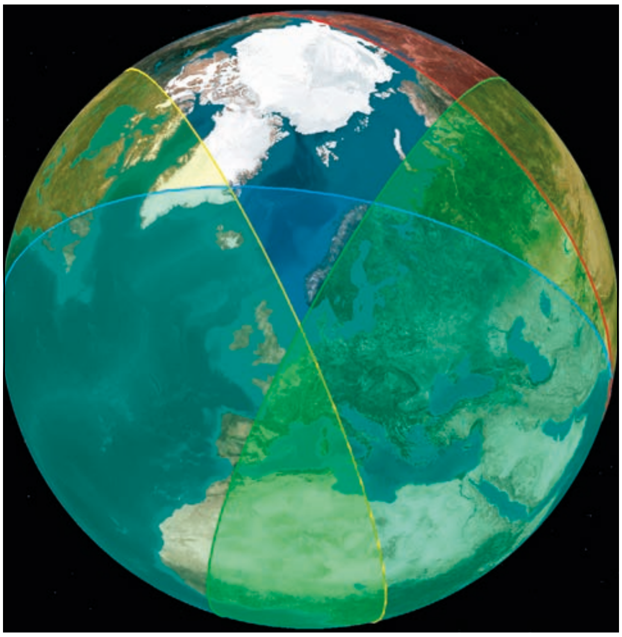

Figure 4.3 Fishing north of 60 degrees latitude (1 Oct. 2010 – 1 Oct. 2012)

Source: Norwegian Space Centre/Norwegian Coastal Administration

The EU satellite navigation programmes Galileo and EGNOS, in combination with the American GPS system and Russia's GLONASS, will provide robust satellite navigation coverage on land and at sea in the High North and Arctic. Norway's participation in Galileo's early phase has helped ensure that the system will perform better in the High North than had originally been planned. As to earth observation capacity in the region, the EU's Copernicus programme in combination with Norway's AIS and Canada's radar satellites should do an adequate job in the years ahead. Good communication systems for the High North, however, remain unprovided for; lacking in particular are broadband services for ships. Existing satellite communication systems offer little or no coverage north of 75 degrees latitude. Communication satellites orbiting over the poles can solve this challenge. Several states with High North interests have started to study options for polar satellite communications, but for now, no plans are ready to implement. In Norway, the Norwegian Space Centre and Telenor have begun the Arctic Satellite Communications project (Norwegian acronym: ASK). The project will examine potential commercial demand and Norwegian governmen-

**Box 4.1 Satellites**

Satellites are the foundation of all applied services that take advantage of space. More than 6,500 satellites have been launched since 1957. About 2,500 satellites currently orbit the earth, and between 800 and 1,000 of them are in active use. There are three main types of satellites, categorised by function. *Communication satellites* relay signals for TV, telephone and broadband service. *Navigation satellites* determine position, speed and precise time. *Earth observation satellites* register data on sea, land and air conditions. The satellites make use of different types of orbits:

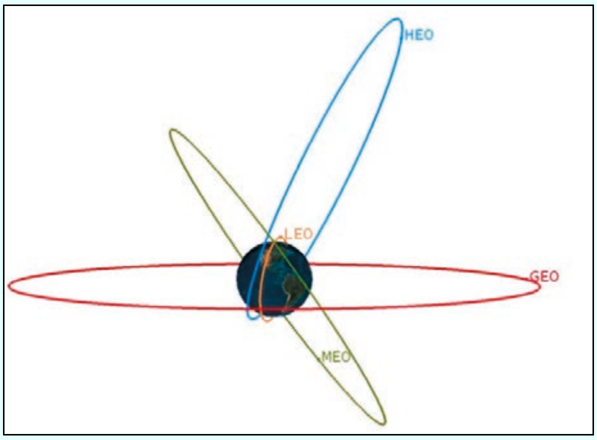


Figure 4.4 Illustration of different satellite orbits

Source: Norwegian Space Centre

Satellites in *geostationary earth orbit* (GEO) move at the same velocity as the earth's rotation, some 36,000 km over the equator. Their coverage area on earth ranges in latitude from 75 degrees south to 75 degrees north. The polar areas are left uncovered. From the earth's surface, such satellites appear to be stationary. They are used for TV broadcasting, telecommunications and earth observation.

Navigation satellites occupy *medium earth orbit* (MEO). These satellites move some 20,000 km above the earth's surface. Their orbit is inclined at an angle of about 60 degrees from the equator. Circling the earth takes 12 to 14 hours. A minimum fleet of 24 satellites is needed to ensure that four or more satellites have line-of-sight to a given surface location, so that geographical position can be calculated.

Satellites moving in *low earth orbit* (LEO) have almost circular paths at altitudes of 200 km to 1,500 km. Due to this low altitude, each satellite covers only a small area, whose boundaries shift continuously with the motion of the satellite. Each orbit takes 90 to 120 minutes, and the satellite stays within a user's line of sight for less than 20 minutes. Many satellites are required to achieve continuous coverage over a fixed area. LEO satellites are used for research, earth observation and communications.

A low-altitude satellite in *polar orbit* passes over or near the poles. Because of the earth's rotation, such a satellite can cover the entire surface of the earth in the course of relatively few orbits. At northern latitudes, each orbital passage can be observed.

Satellites in *highly elliptical orbit* (HEO) move around the earth at varying altitudes. These satellites are used for communications during the long orbital segment when they are furthest from earth. Those that spend most of their time over northern latitudes provide good coverage of the High North. Such orbits typically take 12, 16 or 24 hours.

tal needs as well as the relevant communications technologies, organisational structures, costs and funding needs. Such a development may generate activity in northern Norway while reinforcing the Government's High North strategy.

BarentsWatch is a web portal that collects information on coastal and marine areas from a variety of Norwegian governmental data sources, and makes it available. Though headed by the Norwegian Coastal Administration (NCA), BarentsWatch is beholden to no one agency. It is being developed in phases. The first version of the open information portal was launched in 2012. As services in the open system are gradually rolled out, a closed system for operational purposes is also to be developed. The closed system will combine information from various sources to improve the situational awareness of public maritime authorities. Over time, BarentsWatch is to become a comprehensive monitoring and information system for maritime and coastal areas.

The open portal, Barentswatch.no, will assemble facts and documentation that exist already, but it will also develop new web services that exploit combinations of data from numerous sources. The web portal will offer factual information of a historic nature – statistical data stored systematically over time – but also (near) real-time data reflecting current snapshots of certain activities, phenomena or geographic locations. Users will thus be able to follow developments over time as well as to observe what's happening at the moment.

The portal will assemble and present material relevant to five major subject areas:

- Maritime transport
- Marine resources
- Oil and gas
- Exercise of public authority/sovereignty
- Climate/environment

For target groups with interests in one or more of these areas, the portal will be a useful new tool. Information that previously was spread across many sites will be available in one place, and can be combined to achieve a new level of awareness.

## 4.2 Climate and environment

For years, climate and environmental issues have been rising on the political agenda, both in Norway and internationally. With greater political interest follows the need for increased knowledge to ensure that climate and environmental policy decisions can be made on the basis of sound information. Earth observation satellites have proved to be a particularly suitable tool for obtaining information crucial to our understanding of climate changes and other environmental issues.

The great advantage of using satellites to study environmental and climate-related issues is that they permit observation of large areas as well as repetitive scans of the same spots over time. The earth's climate is regulated by a variety of large, dynamic phenomena, including solar activity, greenhouse gas emissions, changes in snow and ice cover, atmospheric soot particles, ocean currents, wind systems and variations in cloud cover, to name but a few. Even a partial understanding of the causes and effects of climate changes requires a sense of the complex interplay among these and other phenomena over time. Comparable observations from around the globe, collected over a long period, are therefore necessary.

In the past 25 years, we have seen a rapid expansion of satellite observation capability. It is

### Box 4.2 The Government's Climate and Forest Initiative

During the climate negotiations in Bali in 2007, the Government decided to allocate up to NOK 3 billion annually for measures designed to reduce greenhouse gases in the atmosphere by preventing deforestation and forest degradation in developing countries. The Climate and Forest Initiative was established in 2008 and is administered today by the Ministry of Foreign Affairs and the Ministry of Environment. Verifying that recipient countries implement what they agree to do is a significant challenge. Satellites are a useful way to document deforestation and forest degradation. From 2009 to 2012, the Norwegian Space Centre led and coordinated Norway's involvement in the Group on Earth Observations' Forest Carbon Tracking Task (GEO FCT) and the Global Forest Observations Initiative (GFOI). GFOI is a platform to foster sustained access to satellite- and ground-based observations as well as to support the use of such observations in national forest information systems. The aim is to provide systematic access to satellite data for countries with tropical forests, enabling them to improve their surveillance and anti-deforestation programmes.

**Box 4.3 Oil spills, viewed from space**

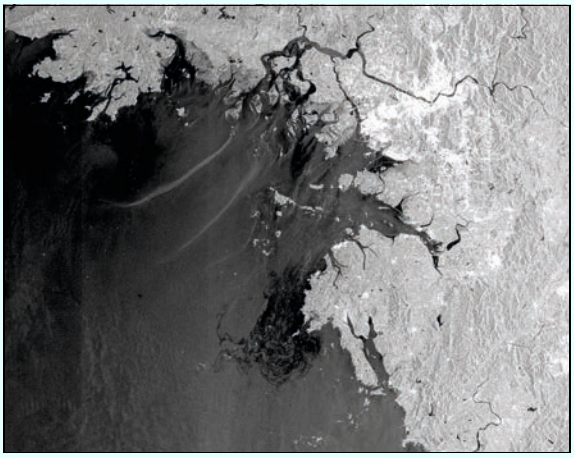

Figure 4.5 Satellite picture of oil spill off South Korea

Photo: ESA

Radar satellites can «see through» clouds and at night, and they cover large areas. Norway in the 1990s was the first country in the world to employ such satellites on a regular basis to monitor oil spills at sea. At KSAT, in Tromsø, satellite images from many parts of the world are analysed in a search for oil spills from ships or platforms. This form of observation has been developed jointly by Norway's authorities, research organisations and industrial companies.

now possible to observe most of the key factors influencing the climate. A number of indicators and illustrations presented by the U.N.'s Intergovernmental Panel on Climate Change (IPCC) are based on satellite data, much of it received in Svalbard. The overview provided by satellite observation is critical to monitoring environmental problems such as desertification, oil spills and the long-range transport of pollution. Where terrestrial infrastructure is poor, as in the polar regions and in developing countries, satellite observations are particularly important. They are also used to verify that individual countries fulfil their binding international agreements.

**Box 4.4 Satellite-based landslide mapping and monitoring**

New satellite sensors make it possible to detect movements of the earth's surface amounting to just millimetres per year. This has made it possible to develop effective techniques for mapping and monitoring of unstable geological formations, and potentially of road surfaces and railway tracks susceptible to ground movement. Satellite data will increase our knowledge of landslide dynamics and triggering mechanisms, so that advance notice of such events will become more common.

## 4.3 Civil protection, preparedness and crisis response

Satellite-based infrastructure is employed in a wide range of crucial tasks. Communications, navigation and surveillance via satellite have become very important to the performance of safety- and emergency-related public services ranging from sea rescues to oil-spill preparedness and crisis management. Satellite usage gives rise to new and cost-effective means of handling many of our society's vulnerabilities. At the same time, our satellite dependence carries with it a new type of risk. Saboteurs and cyber attackers, for example, or natural phenomena such as space weather, could cause significant harm by knocking out critical satellite infrastructure. Increasingly, Norway and major international space powers such as the EU and the United States acknowledge the importance of managing this risk.

The utility of satellite-based infrastructure in civil protection, emergency preparedness and crisis management stems from many of the same factors that make satellites useful in addressing needs related to the High North and climate and environmental policy. Satellite communications provide coverage in areas where no other communications systems reach. The value of satellite communications is also demonstrated when storms or other natural disasters damage terrestrial communications infrastructure. In the aftermath of the big Nordic storm «Dagmar», in December 2011, satellite communication systems were the only way to contact the outside world for many people in Norway's Sogn og Fjordane County. Earth observation satellites provide a quick view of disaster areas and make it easier to determine the appropriate response. Japanese authorities made e xtensive use of satellite observations to coordinate relief efforts after the Fukushima accident in March 2011. Radar satellites are becoming very important to the mapping and monitoring of unstable mountainsides in Norway.

As with all systems our society becomes dependent on, the increased reliance on satellite-based systems represents a potential vulnerability. As satellite systems become more and more important to aerospace, emergency preparedness and security-related activities, it is to be expected that those systems will become attractive targets for hostile attack. Satellite infrastructure can also be damaged by natural phenomena, including space weather, and by space debris. Measures to address such vulnerabilities have become an important governmental priority. The Norwegian Space Centre is in the process of preparing a vulnerability report on the civilian use of satellite navigation systems. The report was ordered by the Ministry of Fisheries and Coastal Affairs, which is responsible for coordinating Norway's civilian radio-navigation policy. The development of potential alternatives to the GPS satellite navigation system – Galileo, GLONASS and Beidou – will help reduce the vulnerability that comes with dependence on a single system. The «Public Regulated Service» component of the EU's Galileo programme is designed to provide national emergency service providers with access to encrypted satellite navigation services. These will be less vulnerable to attempts at sabotage or manipulation. With regard to space debris, the EU and the United States are pushing to establish international guidelines aimed at reducing the amount of space debris in key satellite orbits.

**Box 4.5 Space debris**

The number of objects in earth orbit has increased significantly over the past decade due to collisions and explosions. The orbits of nearly 20,000 objects are followed regularly by radar or telescope. Many additional orbiting objects are large enough to damage satellites, but too small to be tracked from the ground. The orbital speed is typically 7 km per second. With increasing frequency, operative satellites must be manoeuvred in their orbits to avoid collision with space debris. That requires fuel and reduces the lifespan of an orbiting satellite. The United States is the leading operator of space surveillance systems, and regularly transmits collision alerts to satellite owners in many other countries. A European capacity to contribute to space surveillance is under construction. The United Nations has also become involved in this field. Radar systems in northern Norway and Svalbard already contribute to efforts to obtain a clearer view of the traffic in space. It is hoped that larger satellites will be steered out of orbit when their operative periods end. Such end-of-life operations are not always successful. ESA's large environmental monitoring satellite ENVISAT suddenly stopped working in the spring of 2012, and will continue orbiting for more than 100 years if not removed by some other means.

## 4.4 Safe, efficient transport

Transport is one of the sectors that has changed the most in recent years as a result of the increased use of satellite-based infrastructure. It is also the sector whose use of satellite systems is most evident in daily life. Car navigation systems and handheld navigation devices are examples that come quickly to mind, but the transport sector relies on satellite-based infrastructure for communication and earth observation services in addition to navigation. According to the white paper Meld. St. 26 (2012–2013) *National Transport Plan* 2014–2023, the Government's overall objective for transport policy is to provide an efficient, accessible, safe and environmentally friendly transport system that meets the transport needs of society and promotes regional development. Satellite-based services are important to maritime, aviation and land-based transport activities, and are classified as intelligent transport systems and services (ITS).

### *Maritime transport*

In maritime transport, satellites are crucial to ship owners who require contact with their ships. Satellites also let crew members to talk to their families, watch television and access the Internet. Indeed, for ship crews far from land, satellite links are the only way to communicate with the outside world. To improve safety at sea, carriage requirements mandate the installation of satellite-based communications and navigation systems on larger vessels. Satellite data are also important for the

**Box 4.6 ITS (intelligent transport systems and services)**

The acronym ITS (intelligent transport systems and services) has evolved into a generic term for a wide range of technological approaches to improving transportation, in particular those focused on information and communications technology. Examples include systems for road-traffic information dissemination, satellite navigation, electronic ticketing and logistics. ITS can help increase capacity utilisation and efficiency across the entire transport sector: roads, rail, sea, and aviation.

Source: Ministry of Transport and Communications, *Strategy for intelligent transport systems*, 2010)

design of maritime navigational charts. Satellite data are also used to map the current status of ice cover, so that ship crews in northern waters can plot cost-effective routes. Norway, an active participant in the UN International Maritime Organisation (IMO), built a chain of AIS (Automatic Identification System) receivers along the Norwegian coast soon after the IMO enacted its resolution introducing AIS. Such coastal networks in concert with satellite-based AIS technology provide a clear overview of global traffic at sea. Data from the Norwegian AIS satellite and the Norwegian AIS receiver on the International Space Station have made v aluable contributions to the fight against piracy in the waters off Africa. Satellites also allow Norwegian authorities to substantially improve their supervision of vessel activity in the South Atlantic, including the waters around Bouvet Island and off Dronning Maud Land.

*Aviation*

Many Norwegian aircraft today use GPS for horizontal navigation during parts of their flights. GPS is the primary source of navigational data for the helicopter traffic that carries 600,000 passengers a year to and from North Sea installations. While flying in this airspace, helicopters broadcast their GPS-derived positions to ground stations. The use of this technology for monitoring and controlling air traffic halves the cost in comparison with construction of radar systems. The Norwegian air ambulance helicopter service uses GPS-based procedures on approach to bases and hospitals.

**Box 4.7 Volcanic eruption at Eyjafjallajökull**

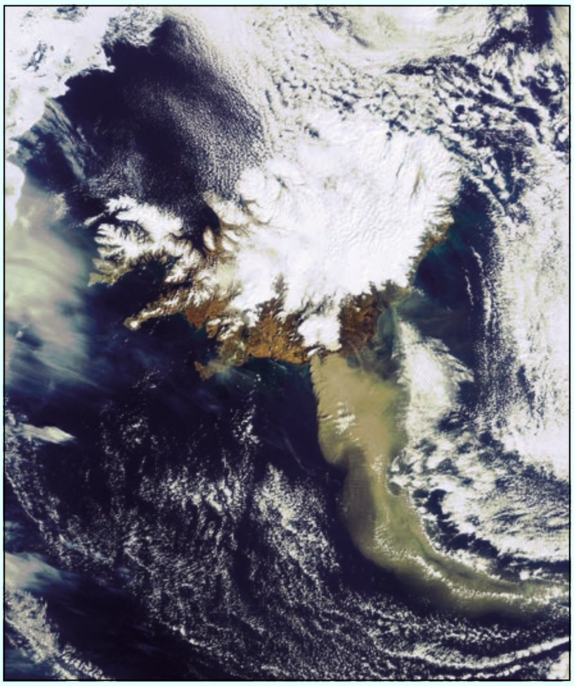

Figure 4.6 Eruption at Eyjafjallajökull

Photo: ESA

The April 2010 eruption of the Eyjafjallajökull volcano in Iceland had a major impact on air travel across Europe. In May 2011, however, during the eruption of Grimsvötn, Norwegian airspace could be held open. The country was thus spared major economic losses. Satellite imagery and weather models were key to the operational decision-making in 2011.

Satellite-based landing systems allow aircraft crews to land and take off in curving trajectories, to plan the most direct flight paths, to save energy, and to modify approach paths so as to minimise the noise burden for airport neighbours. Runway-length needs can also be reduced – a benefit for airports in northern Norway in particular. Of late, GPS has been used increasingly to provide vertical navigational assistance, especially during airport approach and departure and other situations where the system provides operational and environmental benefits. Satellite technology is an element of initiatives like Performance Based Navigation, which is being phased in here in Norway and elsewhere.

Satellite-based infrastructure assists aviation in many ways. When Iceland's Eyjafjallajökull volcano erupted in 2010, airborne volcanic ash created major problems for aircraft. Millions of passengers experienced delays, and even air ambulance services were grounded. The eruption inflicted major economic losses on airlines. But the following year, when Iceland's Grimsvötn volcano erupted, Norwegian authorities were able to hold large swaths of airspace open. By analysing detailed satellite observations and weather models, they were able to minimise travel delays and economic losses.

*Land transport*

Satellite-based infrastructure for navigation is very important to land transport. In 2010, 32 per cent of vehicles in the EU made use of satellite navigation. The Norwegian Public Roads Administration relies on satellite-based navigation and data services to perform road construction and maintenance. New forms of road pricing that rely on satellite navigation sensors are potentially more accurate than those that use existing ground-based tolling systems. Satellite navigation is also employed in fleet management and package tracking, enabling freight companies to plan their loading and unloading operations in advance and to alert customers when to expect delivery.

For rail systems, GPS data is more valuable than physical detection systems for calculating train speed and station arrival and departure times. Such positioning data is also used in combination with energy data to accurately invoice train operators for their energy consumption on routes crossing national boundaries. GPS devices fitted into locomotives are also used in maintenance planning; they let planners and workshop personnel know at all times where particular equipment is located and how far it has travelled since prior maintenance.

## 4.5 Research

In a relatively short period, researchers across nearly the whole spectrum of natural sciences have put satellite data to use in important ways. They use satellites to observe everything from wind systems and ice cover to air pollution and forest conditions. Among the great advantages of satellite-based technology are the ability to observe large areas in a cost effective manner and the ability to make many commensurate observations over time. Information obtained from satellites is particularly important to understanding large, dynamic phenomena such as weather systems, long-range migration of pollution and climate changes. Scientific research into the High North is a case in point. In a region characterised by vast distances, poor infrastructure and harsh climate, good alternatives to satellite-based observation are hard to find. Research results from the International Polar Year (2007–2008) show that satellite data are particularly valuable to research in the polar regions.

Norway participates in international space activities through ESA, Galileo and Copernicus, and through a number of bilateral agreements. Such cooperation puts Norwegian researchers in direct contact with their international colleagues and gives them dependable access to data and a say in scheduling future observations. The information obtained and lessons learned help Norway expand its scientific and technological knowledge base in areas of great strategic importance.

Data that can only be obtained from satellites play a major role in the study of processes in, on and around the earth. The oldest field of study is atmospheric dynamics, which is the basis for numerical weather models. Since the early years of the 20$^{th}$ century, when the physicist Vilhelm Bjerknes did pioneering work in meteorology, Norwegian scientists and organisations have been leaders in the development of weather models. More recently they have been in the forefront of climate modelling. Atmospheric models have been expanded to include a wide range of chemical components and reactions, and satellite instruments today measure a range of chemical components in the atmosphere. Observations and research conducted at Ny-Ålesund, in Svalbard, are among Norway's contributions to international conventions on monitoring global air pollution.

Ocean research is a field where satellite data is crucially important, due to the vast geographic extent of marine areas and the problems of physical access. Leading Norwegian academic and research groups participate in all the major European marine research programmes. Newer satellites, like ESA's GOCE research satellite, make it possible to include coastal areas in ocean modelling. That's a development of interest to Norway. Norway is also a leader in sea-ice research and oil-spill detection. The observation of algal blooms to help understand how they develop is also of great importance, not least for the aquaculture industry.

Research on land areas is multi-faceted, and Norway has made its mark on research into snow and ice and the use of satellite data for forest

**Box 4.8 What can satellites tell us about climate and the environment?**

- *At sea:* Satellite observation is especially useful over open water, where geometric resolution need not be particularly high. Satellites can measure sea level, sea ice, objects on the sea surface, wave height, currents, ocean temperature, ocean «colour» (associated with algal blooms, for example), particle content (suspended matter), distribution of spilled oil, etc. Wind speed and wind direction at sea level are measured for weather forecasting purposes.
- *Fresh water – rivers, lakes and groundwater:* Satellite observation technology is increasingly applicable to coastlines, fjords and freshwater bodies. The parameters that are measurable at sea are also measureable in freshwater bodies. Limitations apply, however, particularly for small water surfaces.
- *Land, land use and biodiversity on land:* Satellite observation applications ashore are wide ranging, from environmental surveillance of large areas to the details of properties or infrastructure. Satellites equipped with optical and infrared sensors can provide important data on vegetation, including climate-related changes, vegetation cover, land use, forest condition/forest damage/deforestation, pollen, and urban green areas. Radar observation can provide data on landslides, glacier movement, snow, ice and flooding.
- *Air pollution, both local and global:* Satellite observations are used increasingly in combination with in-situ measurements. Techniques to measure concentrations of $NO_2$ , $SO_2$, CO, $CH_2O$ and aerosols are well developed. Satellites still lack the accuracy and sensitivity of ground instruments, but their broad spatial coverage makes satellites useful. Satellites measure gas and particle concentrations, making it possible to estimate pollution emissions, monitor trends and issue alerts when appropriate. Detection of volcanic ash is an important application.
- *Climate and greenhouse gas emissions:* Not all gases are equally observable from space, because they have different absorption characteristics. Some greenhouse gases are observable by satellite, however, and products are available to measure $CO_2$, $CH_4$ and $H_2O$.
- *Ozone, UV and solar radiation:* Ways to quantify stratospheric ozone, ozone-depleting substances and related UV and solar radiation are well established. Satellite data are particularly useful in monitoring the size of the Antarctic ozone hole and studying the depletion of ozone in our own areas. Ozone data from satellites (TOMS/OMI) are used operationally in Norway to estimate and forecast UV radiation for the general public.
- *Polar regions:* Satellite observation is unsurpassed as a means to acquire data frequently and quickly on what's happening in the polar regions. In the years ahead, more than 150 instruments fitted onto various satellites will be able to observe Svalbard. Measuring sea ice is the most obvious application, since reliable measurement is practically impossible without satellite data. In addition to ice extent, thickness and volume, observable features include currents (ice transport) and changes in the sea ice's role as animal habitat and transport medium. ESA's CryoSat satellite provides sea-level data for the central Arctic Ocean. Looking down on polar land masses, satellites observe glacier coverage and changes in vegetation. The large flow of data will necessitate a substantial effort to calibrate and validate the various observed parameters, using ground-based measurements.
- *Cultural heritage:* Satellites are used to localise and monitor cultural heritage sites, as a supplement to field work.

research. At the Norwegian Forest and Landscape Institute, researchers have used earth observation of agricultural conditions to develop operative monitoring systems for forests and other outlying resources. Agriculture itself is largely dependent on observations made during the course of a short growing season. Because satellites now under planning will provide expanded observational coverage, researchers envisage potential new applications tied to resource mapping, forest degradation and other changes in vegetation. A long tradition of systematic, field-based sampling in agriculture provides a solid basis on which to develop earth observation services.

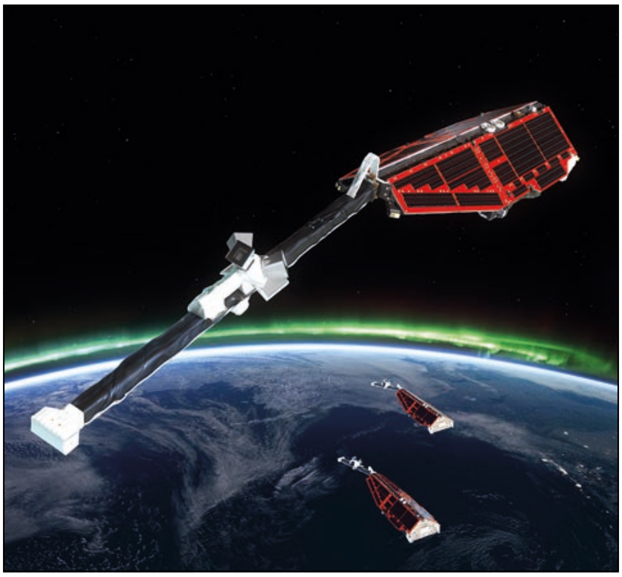

Figure 4.7 SWARM

Illustration: ESA/AOES Medialab

Satellites can tell us much about active processes inside the earth. In 2013, ESA will launch SWARM, a system of three satellites designed to observe the earth's electromagnetic fields. It is believed that such measurements from space will make it possible to answer questions about the earth's crust and interior. Research centres in Norway are strongly attuned to the earth's crustal magnetic fields. What they learn helps us to understand developments in Nordic geology as well as to chart natural resources.

In addition to being a major consumer of satellite data for research, Norway hosts a range of activities associated with the launch of research rockets from launch pads at Andøya and Svalbard. These rocket missions are a necessary complement to satellite and aircraft observations, and are important to understanding phenomena such as the aurora borealis, space weather and climate changes. Norway is one of the few places in the world where rocket-based research can be conducted at Arctic latitudes. International collaboration at Norwegian rocket ranges is extensive.

Norwegian research efforts have provided much of the basis for space-related business growth in Norway. But business development has been characterised by specialisation in clearly defined technical niches. A number of industrial players do operate within the same value chain, though on different levels. This has made collaboration and knowledge sharing possible. Formalised collaboration was attempted through the SIREN space cluster, an ARENA project in the 2006–2009 period. When the project was evaluated, a conclusion was that one and the same value chain lacked critical mass, despite the fact that several strong space-sector participants had been involved in SIREN. The space cluster contributed nonetheless to the founding of the Centre for Remote Sensing in Tromsø, in 2008.

In the field of satellite communications, back in the 1970s and 1980s, Oslo and Akershus counties saw the emergence of a network of companies, many of which had common goals in satellite operations and the development and manufacture of satellite communications equipment. Many of Norway's technology actors are participants in the Norwegian Centres of Expertise (NCE) programme, which offers collaboration and funding in the speciality disciplines the actors represent. Examples include NCE Instrumentation, NCE Systems Engineering and NCE Micro- and Nanotechnology. In addition, a number of companies and organisations established the Space & Energy Network in 2009 to promote cooperation between the energy and space sectors. The network focuses on open innovation, skills development, technology sharing and high-quality meeting arenas in which to highlight shared technology challenges like extreme operating conditions, remote control, automation, materials selection, project management and safety.

# 5 The European Space Agency

Membership in the European Space Agency (ESA) has been the mainstay of Norwegian space activity since the country became a member in 1987. Our participation in the organisation has contributed greatly to the growth of a competitive space industry, to the spread of technological expertise in government and business, and to the internationalisation and strengthening of Norwegian research. ESA has put us in a position to develop autonomous national capabilities even as we exploit the economies of scale that come with working in a large organisation. Like most ESA member states, Norway never would have had the financial or human resources on its own to develop large and advanced satellites, launch vehicles or space probes. By pooling their resources in ESA, member countries have been able to achieve results that most would have been unable to accomplish otherwise. ESA has not only put Europe on the space-technology map, but has made it possible for Norway and other member states to develop expertise sufficient to protect their interests in strategically important space technology and infrastructure.

ESA is an independent intergovernmental organisation with 20 member states, headquartered in Paris, with an annual budget of about 4 billion euros. The EU and ESA work closely together, and their memberships overlap. (Among ESA members, only Norway and Switzerland are not members of the EU.) ESA's role has primarily been in technology development. While ESA was responsible for the bulk of development work underpinning the Galileo and Copernicus programmes, it's the EU that sees to their operational funding. Under the 1975 ESA convention, ESA activities are to be restricted to peaceful purposes.

## 5.1 Context for Norway's ESA participation

ESA was founded in 1975 through the merger of the European Space Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO), both of which traced their origins to the early 1960s. While ESRO had had considerable success in developing scientific satellites, ELDO had never achieved its goal of developing a launcher that would give Europe independent access to space. The purpose of both ESRO and ELDO, and later of ESA, was to pursue European self-reliance in space technology. A great deal of space technology development was then taking place in Soviet and US military programmes closed to European countries. The 1975 merger was intended to improve the return on investment by member countries, in part through increased focus on industry and user-group interests. In the 1970s and 1980s, ESA developed the first European launchers in the Ariane series as well as a number of satellites and space probes, some for basic research and others for applied development projects in communications, earth observation and other fields.

Norway was never a member of ESRO or ELDO, and chose at first to remain outside ESA as well. Participation was not seen as relevant enough to Norwegian research or industry needs. What little there was of publicly funded space activity in Norway (primarily associated with the Norwegian Defence Research Establishment) was confined to domestic programmes or collaboration with US research institutions. Things began to change, however, in the late 1970s. The cause was complex, but three factors predominated.

First, Norway had developed a substantial community of experts in satellite communications. This expertise had sprung from the need for communications at sea by the Norwegian merchant shipping fleet. But as the 1970s unfolded, some Norwegian actors discovered that their expertise was in demand internationally. Norwegian participation in international development projects became increasingly important as a means of sharpening technological prowess and competitiveness.

The second factor that drew Norway towards ESA membership was the vast expanse of ocean that fell under Norwegian stewardship in the 1970s. It soon became clear that the proper exercise of administrative responsibility and sovereignty across such enormous and desolate areas would necessitate extensive satellite monitoring. ESA participation became a tool for developing the competence Norway would need to fulfil its stewardship obligations.

A third factor in the decision to move closer to ESA was a desire to strengthen Norway's industrial competitiveness by tying Norwegian companies more firmly to international networks. In the 1980s, technological innovation was increasingly recognised as a fundamental driver of economic growth. ESA participation was seen as a tool for technology transfer and a channel to new markets for high-tech Norwegian companies.

That was the background for Norway's agreement, in 1981, to become an associate member of ESA for a limited period. Norway became a full member on 1 Jan. 1987.

## 5.2 ESA's organisation

ESA's goals and governance structure are set out in the ESA Convention of 1975. The agency's highest governing body, the ESA Council, normally meets four times a year at the delegate level. Council delegates represent each of the member states and take positions on topical issues related to the management of ESA activities. As an associate member, Canada has the right to express its views. By act of the council, the European Commission and individual EU member states that are not ESA members may attend meetings and speak out on issues concerning matters of common interest to ESA and the EU.

Every three or four years, the ESA Council meets at the ministerial level. Ministerial-level council meetings are attended by ministers with responsibility for national space programmes. These council meetings determine long-term programming activity, membership contributions and overall strategic guidance. The last ministerial-level council meeting took place on 20–21 Nov. 2012, in Italy.

In addition to the ESA Council, ESA has four standing committees at the technical level, all of them with an advisory function. These are: the *Industrial Policy Committee* (IPC), which is responsible for ESA activities related to industrial development; the *Administrative and Finance Committee* (AFC), which follows through on ESA budgets; the *International Relations Committee* (IRC), which sees to relations with third countries and international organisations; and the *Science Programme Committee* (SPC), which has responsibility for ESA's scientific activities. In addition, programme boards have been established in each area of ESA activity, such as earth observation, navigation, communications and technological development.

Daily operations of ESA are supervised by an administration headed by a director general. The director general is appointed by the ESA Council for a term of four years, and can sit for more than one period. Frenchman Jean-Jacques Dordain has been the director general of ESA since 2003. Under the director general are about 2,000 employees divided between the agency headquarters in Paris and various technical centres in Germany, the Netherlands, Italy and Spain. Of all the


Figure 5.1 Ministerial-level ESA Council meeting in Naples, 20 Nov. 2012

Photo: ESA/S. Corvaja, 2012

European organisations active in space, ESA has the broadest base of technical expertise.

ESA is funded primarily through member-state contributions, of which there are two kinds. Contributions to mandatory activities go towards the funding of ESA administration, basic technology development and the science programme. In addition, countries can make financial commitments enabling them to participate in a variety of optional programmes. Those commitments are made at the time of ministerial-level council meetings. In addition to member-state contributions, ESA gets significant financial support from the EU and EUMETSAT.

## 5.3 ESA programmes and industrial policy

ESA's research-and-development activities are organised into programmes. These can be grouped into two categories: the mandatory programme and the optional programmes. The mandatory part is divided into the general budget programme (accounting for about a third of the budget) and the science programme. The science programme is focused on scientific research, such as exploration of distant planets, solar research and the search for dark matter. General budget programme activities are geared towards basic technology development.

The optional programmes are funded through financial commitments made voluntarily by member states on a programme-by-programme basis. Such commitments come in addition to the states' mandatory contributions. The motivation is usually to ensure participation in a certain programme by one's own national industries and research bodies. Optional programmes are mainly focused on the development of technology and applied services for communications, navigation and earth observation. It is the optional programmes that are of particular interest to Norway, as they cover technology areas where we have major industrial interests (like satellite communications and launch technology) or end-user interests (like earth observation).

ESA contributions are tied to the member countries' net national income (NNI). Mandatory subscriptions in particular are based directly on NNI share, with each country's percentage share of mandatory programme costs equalling its share of the combined NNI of ESA member states. For optional ESA programmes, contributions are essentially voluntary. Contributions representing less than a quarter of a country's NNI share level, however, give the country no voting rights in the programme in question.

ESA programmes are tightly linked to ESA industrial policy, which includes a principle of guaranteed industrial return. In principle, each member state's share of industrial contracts in a programme shall equal the percentage of programme costs that the country pays for, with a deduction for administrative costs. In practice, a country's return rate depends partly on its ability to deliver competitive products. For most member countries, the principle has worked well. The industrial policy ensures that member-state industries come into contact with ESA technology programmes while bolstering support within the member states for continued ESA participation.

Through ESA's industrial return policy, most member countries have found it possible to build a competitive space technology industry. The result is true competition between companies on price and quality. ESA policy is to actively promote industrial development in countries that struggle to achieve full return on their contributions.

## 5.4 Norwegian ESA participation over time

Norway's annual ESA participation, as measured in unadjusted kroner, has gone from just under NOK 100 million in 1987 to nearly NOK 500 million today. Figure 5.2 shows the change over time in mandatory contributions and annual payments to optional programmes.

The long-term increase in Norwegian contributions is attributable to two factors. The ESA budget increased by 5 per cent annually until 1994, and Norway's NNI share has almost doubled from 1987 to the present. Fluctuations from year to year are due to exchange-rate variations. The purchasing power of the mandatory contributions has been fairly stable over the past decade.

Norway's involvement in optional programmes was relatively stable from 1993 to 2005. At the ministerial-level meeting in 2005, great emphasis was placed on the importance of space investments to support the Government 's High North policy and Norwegian technology development. Norway contributed funds about equal to our NNI share of all the new optional programmes. The effect of this increase and an investment in new programmes at the ministerial-level council meeting in 2008 account for the sharp rise in contributions from 2006 onward that

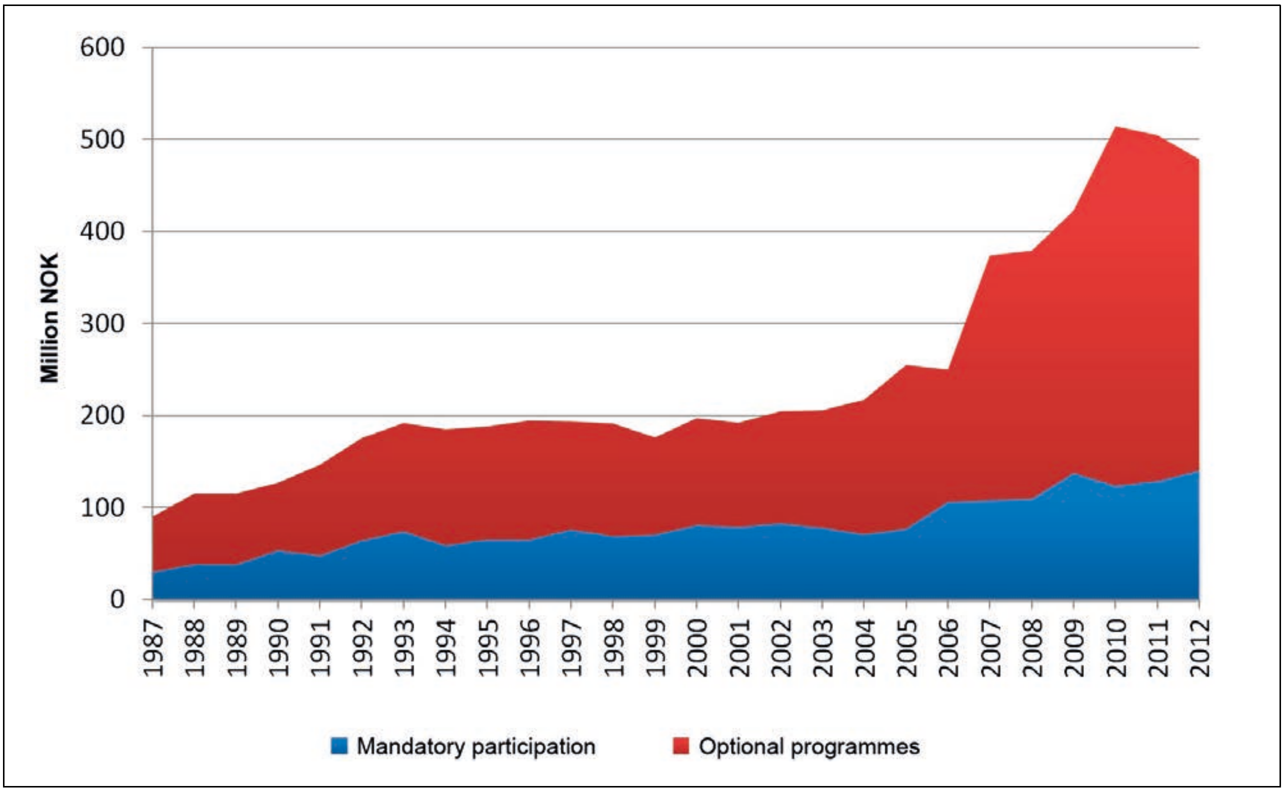


Figure 5.2 Norwegian participation in ESA programmes

Source: Norwegian Space Centre

can be seen in Figure 5.2. At the ministerial meeting in 2012, Norway declared the equivalent of a little below its NNI share in new optional ESA programmes (see Prop. 74 S (2012–2013)). The motivation for Norway's increased commitment is the opportunity it represents to develop technologies and markets, particularly those related to national utilisation of satellite data. In the case of earth observation, Norway pays about 2 per cent of the European total, and uses 15 to 20 per cent of the information, with a focus on information relevant to our expansive northern areas.

Until 2000, the level of industrial return to Norway was good for all ESA programmes. Since then, the return level for optional programmes has remained good, but it has been hard to achieve a satisfactory return level in the mandatory programme. The main reason for this is that Norwegian companies capable of contributing to satellite construction are relatively niche-oriented. In addition, wage growth in Norway has made it increasingly difficult to compete on price. ESA and Norway together have examined how these structural problems can be rectified. ESA has used internal funds, and Norway has used the technology programmes to strengthen the competitiveness of Norwegian actors. Norway's return has improved since 2010, and stands in 2012 at 95 per cent of the nominal value. In the straightforwardly technological programmes, Norway's nominal return is in line with what the programmes call for.

The utility of Norway's ESA membership was evaluated by PwC in 2012. The evaluation emphasises that revenues in the Norwegian space economy are unusually large for a small country, accounting for close to 2 per cent of the global space economy. The main conclusion was that Norwegian industry and end-users alike have benefitted greatly from the country's ESA participation, and that the industrial projects return clear socio-economic value.

# 6 The European Union

In a few short years the EU has become one of the most important European actors in space. When the Treaty of Lisbon entered into force in 2009, it gave the EU a space mandate for the first time. With the development of the Galileo satellite navigation programme and the Copernicus earth observation programme, the EU is about to become one of the world's major satellite infrastructure operators. The EU's growing involvement in space has captured the attention of European leaders. Once regarded as a relatively peripheral endeavour, done for its own sake, space activity has gained status over time as a means to achieve objectives in other policy fields – in particular, to promote growth and innovation. Space now has a place at the heart of European politics.

As the EU has gained influence in European space activities, ESA's role in some areas has changed. ESA's strength is that of a research and development organisation. The EU for its part has the political, financial and administrative muscle required to build and operate major infrastructure systems and hitch them to European policy objectives like economic growth, security, the environment and climate. In recent years we have seen a growing tendency towards a division of labour between the two organisations, with ESA developing basic infrastructure technology that the EU later funds and constructs for deployment. This was this model by which Galileo and Copernicus arose with considerable success. The future relationship between the two organisations has not been clarified. Some countries want to integrate ESA into the EU, as a EU agency, while others prefer to maintain the status quo. Regardless of the organisational structure that emerges, it is clear that many of the most important strategic decisions on European space activity in the future will take place in the EU by virtue of its size, its breadth of interest and its legitimacy in the eyes of member countries.

For Norway, the changing landscape affords both opportunities and challenges. On the one hand, the EU's enhanced role has given Europe the ability to execute large and complex infrastructure programmes, such as Galileo and Copernicus. Norway will benefit greatly from these systems. On the other hand, Norway's ability to promote its own interests may be challenged. The key decisions on European space activity are moving from ESA, where Norway is a full member, to the EU, where we are outsiders. This poses new challenges to Norwegian policy. Our space policy is becoming more like our other European policies, and we must find ways to make our voice heard on issues where EU space policy affects Norwegian interests.

## 6.1 The EU's role in European space activity – background and trends

The EU's role in European space programmes began to develop in the late 1980s, with the European Commission's initiative to open up the European satellite communications market. At the time, this market was hampered by a complex regulatory regime in which rules varied from country to country. The complexity stifled competition and was seen as an obstacle to the effective use of satellite communications technology in Europe. It is worth noting that this issue went right to the core of the internal market, namely the potential for cross-border business activity and effective competition. Right from the start, then, the EU's involvement in space touched on policy fields at the core of the EU project.

During the 1990s and 2000s, EU space activities became gradually stronger, primarily through close cooperation with ESA and through the EU's framework programmes for research and development. The EU's efforts were mainly aimed at developing space infrastructure and satellite-based services that would be helpful in achieving political goals in fields such as the environment, climate, transport and security. Since the late 1990s, the major pan-European infrastructure programmes Galileo and Copernicus have been the focal points of EU space activity and of EU-ESA cooperation.

As collaboration between the EU and ESA became more extensive, several initiatives were undertaken to formalise relations between the two organisations. The joint ESA-EU space strategy declaration of 2000 was intended to strengthen European space activity by establishing collaborative projects between ESA and the EU. In 2004, the two organisations signed a framework agreement. An important consequence of this agreement was that high-level EU officials began discussing space issues more frequently, including at regular ministerial-level meetings of a joint body known as the Space Council.

In the main, the early decades of the EU's participation in space was characterised by ad hoc initiatives and cooperation with ESA to solve concrete problems. The EU had no formal mandate to implement its own space policies. This situation changed significantly when the Treaty of Lisbon entered into force in December 2009. The treaty gives the EU an explicit mandate to formulate a European space policy to support scientific and technical development, competitive strength and EU activities in other policy fields. To implement the policy, the EU is to establish appropriate relations with ESA and if necessary to take other measures, like creating a European space programme. But the Treaty of Lisbon provides no legal basis for trying to harmonise member states' policies in the area; on the contrary, the text expressly exclude such initiatives.

As a step in carrying out the Treaty of Lisbon mandate, the EU issued a communication in 2011 titled «Towards a Space Strategy for the European Union that Benefits its Citizens». It contains three aims: public benefit, economic growth and a stronger EU role on the world stage. The aims of benefitting society and strengthening the European economy are familiar from previous EU initiatives in the area. Of more recent date is the explicit emphasis on the EU's global status. This must be seen in the context of the EU's heightened attention to security and foreign affairs (exemplified by the appointment of an independent high representative for security and foreign policy) and to the increasing emphasis on space infrastructure in these policy areas. Infrastructure in space is becoming a prerequisite for security on the ground. As a consequence, European capability has emerged as an important priority in it is own right, along with dialogue with major space actors like the United States, Russia and China.

The foremost characteristic of EU space strategy is its very strong orientation towards practical utility, with space activity defined as a means to achieve objectives in other policy areas. For many European countries, this implies a new way of looking at space. Traditionally, space activities have been regarded largely as basic research, albeit with significant side effects in the form of technological and industrial development. The basic premise of EU space strategy is that the space sector is to supply infrastructure, products and services critical to economic competitiveness, welfare and security in a modern industrial society. The clearest manifestations of such thinking are the space programmes Galileo and Copernicus.

**Box 6.1 Industrial policy in the EU**

From an industrial policy perspective, there are fundamental differences between ESA and the EU. ESA is a research and development organisation. The ESA convention calls for member countries to receive a timely share of projects and contracts in a proportion roughly equal to the payments they make to ESA – a policy of guaranteed industrial return.

The EU in principle has an industrial policy based on open competition among companies in the countries that participate in a given programme. This means countries have no «right» to get back contracts in proportion to the project costs they fund. EU industrial policy assumes that a country's industry must be competitive. For small businesses, it is important to be active in the sub-supplier networks of prime contractors.

Since price is an important factor in winning contracts, countries with high costs face major challenges in securing contracts in open EU competition.

## 6.2 EU space programmes – common infrastructure, common goals

Most of the EU's space-related activity takes place in the context of programmes whose aim is to develop and operate pan-European space-based infrastructure. By far the largest and most significant programmes to date are Galileo, the satellite navigation programme, and Copernicus, the earth observation programme. Through Galileo and Copernicus, Europe has in many ways stepped into a new era. In a few years, the EU will be managing space-based systems of a magnitude and complexity achievable by no one else but major powers like the United States, Russia and China.

Galileo's development is among the largest collaborative industrial projects ever mounted in Europe. The system ensures institutional demand for Europe's satellite navigation industry as well as European control and capacity in a service category of increasing strategic importance.

Copernicus will be an important tool for scientific research, public security and environmental and climate monitoring in Europe and around the world. Data obtained from the system's satellites will be an important component of public services and a commodity for businesses that process satellite data. In addition to Galileo and Copernicus, the EU has engaged in space-related activities through framework programmes for research and innovation. Some EU officials have an ambition to establish programmes on such topics as space research and space weather.

## 6.3 EU satellite navigation programmes: Galileo and EGNOS

The EU channels its satellite navigation investments into the EGNOS and Galileo programmes, whose missions are to develop, operate and expand systems of the same names. EGNOS (European Geostationary Navigation Overlay Service) has been in operation since 2009. It verifies and corrects GPS signals (and eventually will do so for Galileo signals) so the signals are more reliable and precise. Galileo is to be an independent global satellite navigation system comparable to the American GPS, Russian GLONASS and future Chinese Beidou systems. Unlike the others, Galileo will be a purely civilian system. EGNOS and Galileo are being built and operated as separate systems, but are funded from the same EU budget line. Each must be viewed in relation to the other.

In the mid-1990s, the EU and ESA began collaborating on satellite navigation, initially by developing EGNOS. At the same time, preparations began for a future independent satellite navigation system. Development of Galileo got under way in 2001. For the rest of the decade, attempts were made to fund the construction and operation of Galileo as a public-private partnership between the EU, ESA and private investors. It proved impossible, however, to get private investors to assume financial responsibility, mainly because of the modest direct revenue potential and the high political, technological and financial risks. In 2007, therefore, the EU decided to fully fund the system's development. The EU became the owner of the system with responsibility as well for its operation, maintenance and continued development. Construction was to be completed in 2013, but the project's complexity and the late introduction of additional safety requirements have delayed the programme and raised costs. Galileo is now scheduled to enter early operational status in 2015. By 2020 the system is to be complete, with 30 satellites in orbit and fully operational services. The development of next-generation Galileo satellites is already underway.

The EU regards Galileo and EGNOS as tools to help develop Europe's high-tech industrial capabilities and attain European self-reliance in a technology that is seen increasingly as a strategic priority. EGNOS consists physically of equipment installed on two satellites in equatorial orbit as well as a network of ground reference stations and four control centres. The signals from EGNOS can be received by most any GPS device, and are used to correct inaccuracies in the signals from these systems' satellites. EGNOS provides three services: an open service that provides more precise measurement data than GPS alone, a service oriented to the aviation market for use during airport approaches, and a data service that supplies raw data and corrections through the Internet.

When fully developed, Galileo will be a fully operational, global satellite navigation system consisting of 30 satellites and 20 or so ground stations. It will provide the following services:

- Galileo OS (Open Service), an open public service similar to today's GPS as experienced by its civilian users.
- Galileo PRS (Public Regulated Service), which will provide encrypted signals on dedicated frequencies. This makes the signal more resistant to disturbances and false signals, and makes it possible to regulate access. PRS will be offered to accredited users in the public sector.
- Galileo SAR (Search and Rescue), which will detect signals and positioning data from emergency beacons and relay them to the international search-and-rescue system COSPAS-SARSAT. In contrast to existing services, Galileo SAR will include a return channel, by which the party in distress will receive confirmation that its emergency signal has been received.
- Galileo CS (Commercial Service), which is still in the planning stages and is expected to provide high-precision services to professional users and signal-authentication for use in applications such as road pricing.

The construction and future development of Galileo and EGNOS provide assurance that Europe's

Figure 6.1 Galileo satellites

Illustration: OHB System AG

space industry will enjoy institutional demand for the satellite navigation technology. Such demand is a precondition for the very existence of the industry, given that foreign suppliers are barred from serving the (military) US, Russian and Chinese systems. In addition to the opportunity of supplying technology to satellites and ground infrastructure, Galileo and EGNOS give European companies and user groups early insight into, and influence over, programme specifications and technical systems. That insight is crucial for success in the growing market for products and services that exploit satellite navigation data, including intelligent traffic systems in the road sector, location-based smartphone applications and high-precision services for the maritime sector, the offshore oil and gas industry and agriculture.

By establishing Galileo and EGNOS, the EU achieves independent capability in a strategically important navigation technology. European demand for satellite navigation services so far has largely been satisfied by the US GPS system. While that system has met most European user needs, it is a military system outside European control. The Americans make no service guarantees and reserve the right to block signals if it would serve US needs. This has made it problematic to rely on GPS alone for critical services demanding high reliability, as in aviation. Moreover, dependency on another country's military system has been deemed undesirable with regard to European foreign and security policy autonomy.

Galileo will be compatible with GPS in such a way that satellite navigation device users will be able to receive signals from both systems. Users will in fact perceive the two systems as seamlessly integrated. With Galileo and GPS working together, the number of satellites available to users at any given time will be about twice what would have been the case if there were only one system. That means improved access to satellite navigation services in polar regions, in deep valleys and in the midst of buildings in urban areas. The existence of two independent but compatible systems also means greater robustness and reliability for the services provided. One side effect of the EU's investment in satellite navigation has been that it motivated the United States to improve its GPS system to meet the prospect of competition from Galileo. This was part of the reason US officials in 2002 chose to cease their intentional degradation of the civilian GPS service. The precision of the civilian GPS service improved overnight from 100 metres to 10 metres, a major benefit to users worldwide.

## 6.4 The EU earth observation programme: Copernicus

The EU invests in earth observation through the Copernicus programme, formerly known as Global Monitoring for Environment and Security (GMES). The primary purpose of this programme is to acquire information relevant to environmental and climate policy, ocean monitoring, research and security. Copernicus will collect data from earth observation satellites, airborne sensors and ground-based monitoring stations. It will also operate systems to process the data for different users. Copernicus represents a new phase in environmental monitoring by satellite. Until now, we have had to rely on individual research satellites with a limited service life. Copernicus by contrast will be an operative system providing continuous coverage, with replacement satellites going up as old ones are phased out. Such continuity is particularly important for the study of environmental and climate changes, work that requires repetitive observation over a long period of time. Thanks to Copernicus, Europe in 2015 will be operating the world's most advanced fleet of environmental satellites. Europe already has a well-developed system of weather satellites. In the long run the programme is meant to be Europe's contribution to the Global Earth Observation System of Systems (GEOSS). GEOSS will integrate data from different regional earth observation services to create a common platform, and will organise the information for different users. The goal is to develop a shared global infrastructure from which to obtain continuously updated information relevant to environmental management and disaster response.

Copernicus has its roots in international environmental and emissions agreements concluded in the 1980s and 1990s. With many countries committing themselves to emissions reductions and other environmental measures, there arose a need to document environmental conditions and monitor the extent to which countries lived up to their commitments. It soon became clear that the only effective way to do this would be to employ earth observation satellites. Against this background, the European Commission launched the idea of a pan-European initiative on earth observation in 1998, through a declaration called the Baveno Manifesto. A partnership was set up among the European Commission, ESA and the member states of the EU and ESA. In 2000, the partners began development work aimed at establishing an operational earth observation system for Europe. By 2010 they had progressed far enough to begin initial operations. The EU then adopted Copernicus as an EU programme, on par with Galileo and EGNOS. The initial operations phase, from 2011 to 2013, features the establishment of services based on data from existing national, commercial or ESA-owned satellites. The breadth of available data will be expanded considerably from 2013 onward, as the programme's own satellites begin to orbit. As planned, Copernicus is to achieve fully operational status in 2014.

Fully developed, Copernicus will consist of a large number of earth observation satellites in addition to land-based, ocean-based and airborne sensors. Some of the most advanced earth observation satellites, the Sentinels, are under construction and scheduled for launch in 2013. The programme will also use data from several existing satellites owned by ESA, the European weather satellite organisation EUMETSAT and the member states. Ground stations will also have to be set up to control Copernicus' own satellites and receive data. The data provided by all this infrastructure will permit the gradual development of a wide range of services for European and international users. Copernicus programme services will be categorised as follows:

– *Marine environments:* Monitoring in connection with maritime safety and transport, oil spills, water quality, polar environment, sea ice, oceanography and marine weather forecasting.
– *Land environments:* Monitoring in connection with freshwater access, flood risk, agriculture and food security, land use, changes in vegetation, forest conditions, soil quality, urban planning and conservation.
– *Atmospheric services:* Monitoring of air quality, long-range transboundary pollution, ozone, ultraviolet radiation and greenhouse gases.
– *Crisis situations:* Services to aid response to natural and man-made disasters such as floods, forest fires, earthquakes and refugee flows.
– *Security:* Support for border control, maritime surveillance and protections against terrorism and international crime.

It is the EU's stated goal that Sentinel satellite data and the core services, which are to be freely

Figure 6.2 The Sentinel satellites will be part of Copernicus

Illustration: ESA/P. Carril

and openly available, will give rise to significant commercial activity and innovation in downstream service markets. In other words Copernicus, while directly addressing significant challenges related to public administration, the environment, climate and security, is also supposed to stimulate commercial growth and innovation.

**Box 6.2 The Sentinel satellites**

At the core of Copernicus are the Sentinel environmental satellites, which will move in low earth orbit over the poles. Their continuity, predictability and sensory capabilities should satisfy important environmental monitoring needs, especially when it comes to data of global and international significance. The satellites are to be launched between 2013 and 2019. Six different categories of satellite are planned:

- *Sentinel 1:* Radar-imaging satellites capable of observing land and sea areas regardless of light conditions. These satellites will be particularly useful for ocean monitoring and landslide hazard detection.
- *Sentinel 2:* Satellites designed to provide images over land and coastal areas. These images will have particular value in the monitoring of forests, soil and freshwater bodies, and in support of emergency services.
- *Sentinel 3:* Satellites combining radar with optical sensors to be used for ocean monitoring and environmental monitoring over land.
- *Sentinel 4 and 5:* Satellites able to discern the chemical composition of the atmosphere.
- *Sentinel 6:* Satellites designed to take precise elevation measurements, to be used in determining changes in sea level.

## 6.5 Norwegian participation in Galileo, EGNOS and Copernicus

Norway's participation in Galileo, EGNOS and Copernicus has evolved gradually over the past two decades. In all three programmes, Norway was an early participant in developing technology and instruments, first through ESA and later through a cooperative arrangement with the EU under the European Economic Area agreement. Our participation has given us the opportunity to influence the programmes, so that they serve Norwegian interests to the degree possible. Norwegian companies and public authorities have gained early insight into the programmes, strengthening Norwegian players in the market for services and products that rely on satellite navigation and earth observation. Early insight has also made it possible for Norwegian public officials to identify ways the programmes could help improve public services. To date, Norwegian space-related industrial concerns have won contracts in the programmes totalling about 130 million euros.

*Galileo and EGNOS*

Norway has been involved in constructing the Galileo and EGNOS satellite navigation systems since work on the programmes began in the 1990s, first through ESA and later in cooperation with the EU. Norway has contributed 13 million euros to the programmes through ESA and 72 million euros through the EU. Through its participation, Norway is helping to construct pan-European infrastructure that will be of great benefit to Norway. Active Norwegian participation in the satellite navigation programmes makes it easier for Norwegian authorities, industries and enterprises to influence matters affecting coverage area, access and use of services. Norway's participation also helps the country's industries, companies and organisations gain access to the technology and expertise they need to exploit the opportunities that Galileo provides. This is fertile ground for developing competitive services and technologies with commercial promise that can be of particular support to users in Norwegian industry and public administration. An important aspect of participation in the Galileo and EGNOS programmes is the opportunity it represents to make sure those systems perform capably in Norwegian areas, particularly in the far north. Norway has worked actively – and successfully – in the Galileo and EGNOS governing bodies to improve system performance in the High North.

The Norwegian Storting approved Norway's participation in Galileo and EGNOS in 2009. The two European legislative acts that regulate the satellite navigation programmes were incorporated into the EEA agreement by decision of the EEA Joint Committee on 8 July 2009. The acts incorporated were:

- *Regulation (EC) No. 683/2008 of the Parliament and the Council of 9 July 2008 on the further implementation of the European satellite navigation programmes (EGNOS and Galileo)*
- *Council Regulation (EC) No. 1321/2004 of 12 July 2004 on the establishment of structures for the management of the European satellite radionavigation programmes*

Respectively, the acts deal with the construction of Galileo and the programme's funding through 2013 (No. 683/2008) and with the establishment of the GNSS Supervisory Authority, or GSA (No. 1321/2004). The act concerning the GSA was later replaced by a new one, which was itself incorporated into the EEA agreement by decision of the EEA Joint Committee on 15 June 2012:

- *Regulation (EC) No. 912/2010 of the European Parliament and of the Council of 22 September 2010 setting up the European GNSS Agency, repealing Council regulation (EC) No. 1321/2004 and amending Regulation (EC) No. 683/2008*

Apart from the acts incorporated into the EEA agreement, a bilateral agreement has been signed with regard to aspects of Galileo and EGNOS that do not naturally belong in the EEA agreement, including security, ground facilities, protection of frequencies and export control. Exchange of classified information related to the programmes takes place in the context of Norway's security agreement with the EU. Norway has committed itself financially to participate in Galileo and EGNOS until the end of 2013. Further Norwegian participation in the programmes, beyond 2013, would require a decision by the Storting.

Norway's participation in Galileo and EGNOS permits the country to sit in the programmes' governing bodies. As with other EU programmes, Norway lacks voting power, but our right to speak out and participate in other ways gives us considerable influence in the specialised bodies that govern Galileo and EGNOS.

Taking part in Galileo and EGNOS has resulted in contracts for Norwegian industry and the creation of satellite navigation infrastructure on Norwegian territory. Since 2003, Norwegian companies have won Galileo- and EGNOS-related contracts valued at some 79 million euros. Three Galileo sensor stations have been established on Norwegian territory – at Svalbard, Jan Mayen Island and the Troll research station in Antarctica. There is also an uplink station on Svalbard for navigational data, and a receiving station is being planned for the search-and-rescue service that underpins COSPAS-SARSAT. Additionally, EGNOS reference stations have been established at Svalbard, Jan Mayen Island, Kirkenes, Tromsø and Trondheim to ensure good coverage across Norwegian areas. The stations are run by Kongsberg Satellite Services and the Norwegian Mapping Authority. Galileo ground stations and EGNOS reference stations are part of the ground segment that monitors overall system performance and generates navigational data. The performance of EGNOS is steadily improving in northern latitudes. It is hoped that EGNOS will become a useful tool for pilots approaching airports in all of mainland Norway.

*Copernicus*

Norway helped develop the technology that underpinned the establishment of Copernicus, first through ESA and the EU's Seventh Framework Programme for Research (FP7), and since 2012 through the EEA agreement. The total Norwegian financial contribution to Copernicus through 2013 amounts to approximately NOK 227 million. In part because of Norway's early involvement in Copernicus, Norwegian authorities, industries and businesses today are able to influence the programme. It is important for Norway to ensure that Copernicus performs well over areas of Norwegian interest. Good performance, from Norway's perspective, refers to good geographic coverage of areas administered by Norway as well as the fine-tuning of satellites to generate the earth-observation data that is most relevant to this country. Norway is one of the nations assumed to benefit most from the data and services Copernicus will offer. Not only do satellites in polar orbit provide coverage that's twice as good in our areas than further south, but we have vast expanses of sea and land to cover. The programme is expected to be an important data


Figure 6.3 EGNOS will contribute to safer airport flight approaches

Photo: Markus Mainka/123RF

source for many Norwegian users, including national initiatives such as BarentsWatch. Participation will also result in a level playing field for Norwegian companies competing to supply the programme. Norwegian players are expected to be able to provide things like ground station services and the development of services using earth observation data. Norwegian participation is also considered a contribution, in solidarity with other nations, to the development of global earth observation capacity.

Norway formally became a participant in GMES (as it was then called) in 2012. The EU's regulation of GMES was incorporated into the EEA agreement by decision of the EEA Joint Committee on 13 July 2012, and was approved by the Norwegian Government in the Council of State on 12 October 2012. The regulation incorporated was:

– *Regulation (EC) No. 911/2010 of the European Parliament and of the Council of 22 September 2010 on the European Earth monitoring programme (GMES) and its initial operations (2011 to 2013)*

This regulation is to pave the way for a full-scale operational programme starting in 2014. Norway's approval of the regulation gives us the right, but not the obligation, to participate in Copernicus after 2014. Norwegian participation in Copernicus beyond 2013 would require action by the Storting.

Participation in Copernicus has resulted in contracts to Norwegian industry and opportunities to influence the services to be provided. So far, participation in the programme has returned contracts worth 51.5 million euros. In the initial phase of operations, Kongsberg Satellite Services has been awarded a framework contract valued at NOK 200 million to provide ground station services in Svalbard for five years. Kongsberg Spacetec, based in Tromsø, has supplied advanced signal processing equipment to ground stations serving the Sentinel satellites. Other Norwegian companies, too, have contributed to several of the satellites. Within the EU's FP7 programme, meanwhile, a number of Norwegian research institutions have had a hand in specifying services related to marine environments and atmospheric services. The Norwegian Meteorological Institute has been a central Norwegian participant on the service side with regard to both sea and atmosphere, ensuring that important public administration interests are safeguarded.

## 6.6 What does the EU's expanded role mean for Norway?

The EU's activity in space has major consequences for ESA and for the countries of Europe. In the course of a few years, ESA has gone from being the undisputed forum for pan-European space activity to being challenged by an EU with rising ambitions. The EU has made it possible to execute large infrastructure programmes that ESA would never have been able to manage alone; yet the EU also represents a challenge to ESA's role as an independent organisation. In countries with membership in both the EU and ESA, governmental focus on space has broadened as space-related issues rise to higher levels of political discussion in a greater number of policy areas. This gives space activities greater political weight, but it complicates national and European decision-making processes. Norway, one of only two ESA members not in the EU (Switzerland is the other), is in a unique position. On the one hand, the EU's strengthened role has led to the development of infrastructure from which Norway will benefit greatly. Galileo and Copernicus will help to solve major Norwegian challenges, many of them related to the High North and to Norwegian climate and environmental policy. On the other hand, influence is shifting from an organisation in which Norway is a full member to an organisation that obliges us to try to be heard while standing outside. As the EU expands its role, Norway's space policy naturally takes on aspects of the country's overall European policy.

The relationship between the EU and ESA to date has been characterised by a divvying of tasks, with ESA conducting research and development and the EU funding and carrying out the construction and operation of satellite-based systems. This arrangement has benefitted both parties and expanded Europe's capacity to develop space infrastructure serving public interests across national boundaries. It is unclear how the relationship between the two organisations will develop in the years to come. The European Commission has expressed increasing resistance to the idea of ESA issuing guidelines that may have bearing on the EU's own political priorities. On several occasions, leading EU countries have called for stronger integration between the two organisations – for example, by incorporating ESA into the EU as an agency comparable to the European Defence Agency. Other important EU members have aligned against such a proposal. Whichever structure emerges, many of the most important strategic decisions about European space activity in the years ahead will be taken in the EU, by virtue of the organisation's size, its breadth of interests and its legitimacy in the eyes of member countries.

In the years ahead, Norway's effect on the developing relationship between the EU and ESA will be limited. However, there is much we can do to safeguard Norwegian interests, regardless of how European space activities are organised. First, we can contribute constructively to ESA's further development, so the agency can continue, to the extent possible, to be a strong and independent a partner for the EU. If despite that effort ESA seems likely to face assimilation into the EU system, it can be surmised that Norway would seek to negotiate an agreement on participation. A strong Norwegian role in ESA in the meantime will strengthen our ability to negotiate an advantageous agreement. Second, it will be important to position Norway in near relation to EU space programmes and to take a proactive approach to developments in EU space policy. In our dealings with Galileo and Copernicus, we have seen that active participation in EU space programmes affords plenty of scope to advance Norwegian interests. Norway has earned a reputation as a competent and constructive partner, and the European Commission has repeatedly emphasised that the EU desires Norwegian participation in such programmes. Even without voting rights, our participation in the governing bodies and working groups of Galileo and Copernicus has proved to be a powerful means of addressing special Norwegian interests, and of obtaining early insight into programme capabilities and specifications. We have also seen that we can be excluded, without much ado, from important decision-making processes when we are not sufficiently committed to active participation. In 2011, when Copernicus became an EU programme after having been under ESA control, Norway lost the right, previously granted through ESA membership, to take part in meetings of the programme's governing bodies. Only in 2012, when Norway signed a special agreement with the EU to participate in Copernicus, did we regain our right to join the meetings.

# 7 Norway's space-related ground infrastructure

Many earth observation satellites move in polar orbit, circling the earth 14 times per day. Our northern location allows us to receive the data from most of these satellites. Norway's position – along with our tradition of successfully building and operating infrastructure in the Arctic and Antarctic – has given rise to a cluster of competitive companies offering ground-based services to research institutes and satellite operators. Space-oriented infrastructure has been established in Svalbard, on Jan Mayen Island, in mainland Norway and in Queen Maud Land in Antarctica. Some of the infrastructure is uplink and downlink equipment that represents a market in itself. Other infrastructure is part of the value chain in Norwegian services. Space-related infra-

**Box 7.1 SvalSat**

SvalSat is the largest ground station on earth for control of polar-orbiting satellites and data reception from them. Many of the satellites provide meteorological data essential to accurate weather forecasting. The European weather satellite organisation EUMETSAT and the US National Oceanic and Atmospheric Administration (NOAA) are heavy users of SvalSat's downlink services.

Figure 7.1 SvalSat

Photo: KSAT

structure attracts other activities and enterprises to the polar regions while simultaneously contributing importantly to Norwegian interests in these areas. The placement of this ground infrastructure also represents a significant component of Norway's international space collaboration.

*Svalbard*

Svalbard is the only easily accessible place in the world for communicating with polar-orbiting satellites on every one of their daily orbits. The hub of space activities in Svalbard is the Svalbard Satellite Station (SvalSat), owned and operated by KSAT. SvalSat is the world's largest ground station for communication with satellites in polar orbit. Japanese research and earth observation satellites are among those whose data are downlinked here. Of the many antennas at SvalSat, some are owned by KSAT and others by major customers such as NASA, the European Union (Galileo and EGNOS) and EUMETSAT. SvalSat is the main ground station for the US weather satellite Suomi NPP, which was launched in the autumn of 2011. SvalSat will also be crucial to the Landsat 8 environmental monitoring satellite and the IRIS solar research satellite, both owned by the United States and launched in 2013.

National and international organisations alike take part in space-related research in Svalbard. Notable Norwegian infrastructure includes the Norwegian Mapping Authority's geodetic observatory at Ny-Ålesund, the Kjell Henriksen Observatory outside Longyearbyen (for observation of the aurora borealis and space weather phenomena) and the Norwegian portion of the international EISCAT Svalbard Radar. The German and French space agencies, DLR and CNES, have positioned some infrastructure in Svalbard for improved tracking of their satellites' orbits.

Collaboration with the US organisations NASA and NOAA prompted the installation of fibre-optic cable to Svalbard in 2004. The subsea fibre-optic connection between Svalbard and mainland Norway is owned by Norwegian Space Centre Properties. The cable must be regarded as a critical part

**Box 7.2 Jan Mayen Island**

Stations on Norwegian territory, including the EGNOS monitoring station on Jan Mayen Island, are required for high-quality system performance across Norway's expansive areas.

Figure 7.2 EGNOS-stasjonen på Jan Mayen

Photo: Kjell Arne Aarmo

of Norway's space infrastructure; it also provides important services to the population of Svalbard. In 2010, the Government commissioned Uninett to install a fibre-optic cable between Ny-Ålesund and Longyearbyen. This cable is scheduled to be ready in 2013–2014. The increase in space-based activity in Svalbard is drawing increased attention from scientific communities elsewhere in Norway and around the world. That affects other activities in Svalbard, including businesses in other sectors. As stated in Report No. 22 (2008–2009) to the Storting: Svalbard, the Government aims to invest in space activities as part of Svalbard's future livelihood.

The Svalbard Treaty of 9 February 1920 establishes certain regulations in Svalbard that may have implications for space-related infrastructure. Pursuant to Norway's Telecommunications Act and § 3 and § 4 of its Svalbard Act, the Norwegian regulation on establishing, operating and using satellite earth stations contains special provisions for Svalbard. To ensure that earth-station operations are consistent with the Svalbard Treaty's prohibition against using the archipelago for «warlike purposes», Article 3 of the regulation establishes rules for the authorisation and use of earth stations in Svalbard.

In addition, a separate permit application must be made to the Norwegian Post and Telecommunications Authority for each satellite that is to make use of ground station services in Svalbard. The Governor of Svalbard is responsible for the oversight of ground station activities, and conducts regular inspections.

**Box 7.3 Troll**

The Norwegian Galileo sensor stations at Troll, Jan Mayen Island and Svalbard are important elements of the ground segment that calculates precise orbits for Galileo satellites and synchronises their clocks.

Figure 7.3 Troll, in Queen Maud Land

Photo: Kjell Arne Aarmo

*Jan Mayen Island*

Jan Mayen Island is the site of an EGNOS reference station. Recently, a Galileo sensor station was established there as well. This equipment is owned by the EU and is essential to the navigational performance of the two systems. The main technical purpose of the Galileo sensor station is to help make corrections to the orbits or timing of individual Galileo satellites, while the EGNOS station helps expand the EGNOS coverage area beyond mainland Norway.

There are also some Norwegian space-weather instruments on Jan Mayen Island, and the use of the island for this purpose is likely to increase. Jan Mayen Island has no fibre-optic cable connection, so communication to and from the island is entirely satellite-dependent.

*Antarctica*

The Troll research station in Queen Maud Land is operated by the Norwegian Polar Institute, and is staffed the year around. Troll is also the site of a satellite station – TrollSat – that is part of the global network of ground stations operated by KSAT. TrollSat has a variety of customers, and is especially important for establishing quick contact with new satellites in the critical phase after launch. Because of TrollSat's large bandwidth needs, its communications infrastructure is sufficient to serve the other activities at the research station. The launch of Telenor's Thor 7 satellite in 2014 will significantly improve communications options to and from TrollSat. This will permit growth in the number of missions and thus strengthen TrollSat's long-term role.

The Antarctic Treaty of 1 December 1959 establishes certain activity restrictions on the continent that may have implications for space activities. The treaty mentions specifically that Antarctica is to be used only for peaceful purposes, and is to be a demilitarized area. As a consequence of the treaty's environmental protocol, which came into force in 1998, Norway is under strict obligation to take measures to protect the environment in the course of its activities in the Antarctic. All states operating in Antarctica are subject to the right of other states to inspect their installations and bases.

Figure 7.4 Nittedal Teleport earth station

Photo: Telenor Satellite Broadcasting (TSBc)

*Mainland Norway*

On the mainland there are a number of different types of ground infrastructure related to controlling and receiving signals from satellites, sensors and smaller stations as well as basic research infrastructure related to space.

The Tromsø Satellite Station is owned and operated by KSAT. Its antenna array serves satellite owners from many countries and organisations on a commercial basis. (KSAT is discussed more fully in Chapter 8.) Nittedal Teleport is Telenor's main control station for communication satellites in the Thor family and for communication channels that Telenor controls on other satellites. The Eik earth station in Rogaland is operated by Astrium Services, of France, and relays broadband traffic to and from maritime parties. The Norwegian Meteorological Institute in Oslo has some antennas of its own for direct access to data from European and US weather satellites.

The Andøya Rocket Range (ARR) is a centre for the launch of research rockets and the release of scientific balloons. The rocket range is situated by the ocean, and rockets can be made to splash down in remote, unoccupied waters. In the mountains above the rocket range is ALOMAR, which conducts research on atmospheric conditions and assists with the launch of sounding rockets. (ARR is more fully discussed in Chapter 8.) Notable infrastructure elsewhere on the Norwegian mainland includes reference stations in Kirkenes, Tromsø and Trondheim to serve the EU's EGNOS system. The Norwegian Coastal Administration has 12 stations along the Norwegian coast for differential GPS enhancement.

The Tromsø Geophysical Observatory (TGO) operates a magnetometer network consisting of 14 instruments positioned around Norway, including Svalbard. Magnetometers monitor geomagnetism by measuring the strength and direction of the earth's magnetic field around the instruments. The measurement data have many different applications, from earthquake research to aurora forecasting and navigation for subsea oil drilling.

# 8 Space activity in Norwegian public administration

In Norway as in the rest of the world, public-sector needs and public-sector undertakings have dominated space activity, and continue to do so. Many space-technology advances have been triggered by the service requirements of public authorities. In Norway, public-sector demand has centred on the need for effective services for the oil and gas industry, the shipping industry and the population of Svalbard. As space-based services have developed, government agencies have been able to employ them to address immediate needs, or to modernise their methods and services.

Public authorities play a key role in facilitating the development of national infrastructure. The space sector is no exception. Getting satellite systems to address Norwegian areas of interest has become as important to government as to industry. And space activities require large investments. Public authorities therefore play a pivotal role in bringing forth the robust space-based infrastructure that key industries require. Government can help facilitate the development of systems whose performance and coverage properties meet public and private user needs.

In 1987, Norway felt motivated to join ESA in order to fulfil the country's goal of strengthening its technology, industrial capability and user services. Norwegian officials understood, however, that the benefits of membership could only be harvested if strategic actions were taken at the national level. That is why the Government of that time established the Norwegian Space Centre.

Over the past 25 years, Norwegian space activities have come far. Along the way, changes have been made to keep in step with national and international developments. At times, rapid processes have had to be initiated to seize opportunities as they arose.

The Norwegian state currently has administrative responsibility or ownership stakes in a number of space organisations and enterprises. The foremost of these are the Norwegian Space Centre, an agency, and the following companies: the Andøya Rocket Range AS, Norwegian Space Centre Properties AS and Kongsberg Satellite Services. The state also has ownership interests in companies whose space activities account for a minor part of their total business. That is the case with Kongsberg Gruppen, Telenor and Nammo. The Ministry of Trade and Industry has overall responsibility for Norwegian space policy, but the implications of space infrastructure are so broad as to involve other ministries and subordinate agencies as well. The Government therefore established an interdepartmental coordinating committee in connection with Norway's agreement to join the Galileo programme.

## 8.1 Norwegian Space Centre

The Norwegian Space Centre (NSC) was set up as a public foundation in 1987. At first the foundation's main duties lay in administering Norway's ESA membership and operating the Andøya Rocket Range, but gradually its responsibilities were expanded. In 1995, Norwegian Space Centre Properties was spun off from the foundation as a company wholly owned by the space centre. Norwegian Space Centre Properties was created to own and operate infrastructure in Tromsø and eventually in Svalbard. The company operated ground stations in Tromsø and Svalbard until 2001, when Kongsberg Satellite Services (KSAT) took them over. Ownership in KSAT was divided between Norwegian Space Centre Properties (50 per cent) and Kongsberg Defence & Aerospace AS (50 per cent). In 2005, when the Norwegian Space Centre was converted from a foundation into a government agency, the foundation's ownership stakes in the Andøya Rocket Range (ARR) and Norwegian Space Centre Properties were transferred to the state.

Today the Norwegian Space Centre (NSC) is an agency with a certain degree of autonomy within the Ministry of Trade and Industry. Under the current arrangement, the Storting each year authorises the NSC to manage the state's ownership interests on behalf of the Ministry of Trade and Industry. That includes the authority to buy or sell shares in the companies, and to allocate

**Box 8.1 National development support funding**

Norway's national development support funding programme (*Nasjonale følgemidler*) is designed in part to strengthen Norwegian actors so they will be better positioned to provide products and services to national and international space programmes; the programme is also intended to address specific national needs that international forums may fail to prioritise when the interests of other participants diverge from ours. The EEA has approved a set of rules to manage the allocation of such development support funds. In recent years, some 30 actors benefitted from the funding programme. In 2013, the funds amounted NOK 35.4 million.

dividends or sales income to space-related purposes.

The Norwegian Space Centre is designed to be the state's agency for strategy, coordination and implementation, making efficient use of space for the benefit of Norwegian society. The NSC promotes and pursues Norwegian interests in ESA, in the EU satellite navigation programmes EGNOS and Galileo, in the initial operations phase of the EU earth observation programme Copernicus, and in several bilateral agreements. In addition, the NSC administers Norwegian national development support funding, assists Norwegian industrial actors and prepares a national long-term plan for space activity.

The Norwegian Space Centre has 30 permanent employees and eight temporary ones, and it administers the state's ownership of the Andøya Rocket Range and Norwegian Space Centre Properties. The Ministry of Trade and Industry appoints the agency's board of five members and two alternates. Board representatives are appointed on the basis of their qualifications, and have traditionally come from government agencies, industry, institutes and R & D organisations. NSC budgets are separate line items in the national budget. The budgeting system permits the agency to receive other income than what is provided through the national budget.

## 8.2 State companies active in space

The Andøya Rocket Range, Norwegian Space Centre Properties and KSAT are the space-oriented Norwegian companies in which the state has both ownership and administrative responsi-

Figure 8.1 Andøya

Photo: ESA/J. Makinen

**Box 8.2 NAROM and «Spaceship Aurora»**

NAROM (the National Centre for Space-Related Education) is a national centre and teaching laboratory for all educational levels, established in 2000. NAROM is uniquely situated – in co-location with the Andøya Rocket Range – and makes active use of Norwegian Space Centre resources. Operations are funded through basic annual appropriations from the Ministry of Education and Research, as well as through the sale of services to educational institutions and others. The national objective for space-related education is to develop instructional programmes, courses and other training activities on selected topics. Service offerings range from elementary level to university level, and include online learning resources, educational activities, seminars and conferences on space technology, space physics, the atmosphere and the environment. These are developed and carried out in close cooperation with other educational institutions; NAROM does not award degrees. NAROM contributes to space-industry recruitment efforts, and seeks to encourage children and young people to pursue their interest in science and technology.

The Andøya Rocket Range is also in the process of establishing an activity centre called Spaceship Aurora (*Romskipet Aurora* in Norwegian). This centre will be tied to ongoing space activities, and will provide an exciting science-based experience to visitors from Norway and abroad. The centre will consist of buildings totalling some 1,000 m², including a visitor centre, café, exhibition space, auditoriums and offices. Interactive activities will be offered. Target groups include tourists and other visitors as well as schools and other educational institutions. For several years, one of the ARR's missions has been to boost public interest in science, technology and space exploration, and each year it has assembled pupils, students and teachers from around the world for exciting activities at Andøya. Spaceship Aurora will be a valuable addition.

bility. Public involvement and investment have helped turn the companies into substantial space-sector players. The space-related infrastructure they control makes Norway an attractive partner for international collaboration.

### 8.2.1 Andøya Rocket Range AS (ARR)

The ARR is a centre that provides research support to scientists studying atmospheric phenomena, primarily through the launch of rockets and research balloons. The centre is organised as a limited company owned by the Ministry of Trade and Industry (90 per cent) and Kongsberg Defence & Aerospace (10 per cent).

As a coastal island far from major settlements, Andøya's location is a competitive advantage exploited not only for research rocket launching, but increasingly for other activities that require lots of space, such as the testing of missiles and unmanned aerial vehicles (UAVs).

With 65 employees, the ARR is one of the leading high-technology centres in northern Norway. It started in 1962 as an operational arm of the Norwegian Defence Research Establishment, and became a limited company in 1997. In addition to the launch facility at Andøya, ARR's assets include the Svalbard Rocket Range (SvalRak) at Ny-Ålesund and two wholly owned subsidiaries: the Andøya Test Centre (ATC) and the Norwegian Centre for Space-Related Education (NAROM). The ARR also runs the Arctic Lidar Observatory for Middle Atmospheric Research (ALOMAR).

The ATC offers testing of rocket technology for the defence industry and civilian space activities, and it buys most of its services from the ARR. The Norwegian Armed Forces use the ATC to test anti-ship missiles and has made investments to optimise conditions there. NAROM (see Box 8.2) educates teachers, university-level students and school pupils. Half of its budget is funded by a Ministry of Education and Research grant. The Andøya-based ALOMAR examines our atmosphere using a laser technology called lidar («light radar») and a variety of other measuring instruments. The ability to combine measurements taken at ALOMAR with those obtained by sounding rockets is a competitive advantage for ARR. The SvalRak rocket range in Ny-Ålesund is used to launch sounding rockets. SvalRak is not permanently staffed, but is staffed by ARR personnel as needed.

ARR operations are supported in part by a multinational agreement, the Esrange Andøya Special Project (EASP), with participation by Sweden, Norway, Germany, France and Switzerland.

In 2012, revenues from this agreement accounted for approximately 45 per cent of sales. The share coming from international government sources has declined steadily the past 10 years.

The EASP agreement is a cooperative arrangement for use of the rocket ranges at Kiruna, Sweden, and Andøya. Norway joined the pact in its current form in 1990, but had been active since 1973 through an association accord with Sweden. The current agreement is automatically extended for five years at a time if none of the parties wish to change it. The present agreement covers the period from 2011 to 2015. It ensures the continuance of basic infrastructure and permits access to the facilities by user countries at somewhat reduced rates.

Germany is the country that makes the most use of the ARR through the EASP agreement. A large multi-year German-Norwegian rocket campaign called ECOMA, designed to measure meteoric dust in the atmosphere, was recently completed. Specific German research plans suggest a continued use of sounding rockets at Andøya. Other countries, too, have ties to the ARR. The United States has been and remains Norway's most important partner in space. This collaboration is based on a 2006 bilateral agreement that began as an agreement on shared activity involving sounding rockets at Andøya. A number of countries, including some that are not EASP participants, maintain scientific equipment at or near the ARR.

In 2012, Norway's funding contribution to the ARR under the EASP agreement came to about 2.3 million euros, while the combined contribution of the other countries was about 1.3 million euros. In addition come direct mission revenues from users of the rocket range (universities and research institutes). Rocket missions are sporadic by nature, with their duration depending on both the atmospheric conditions and the technical challenges that arise. The EASP agreement gives the ARR a smoother revenue stream and a longer planning horizon than dependence on mission revenues alone would have provided.

Other sources of operational support include customer payments and subsidies from the national budget for education activities. The ARR has received a total of NOK 17.6 million in funding from the Ministry of Trade and Industry to upgrade its infrastructure. This support is provided by way of earmarked funds from the ministry within the national development support programme administered by the Norwegian Space Centre.

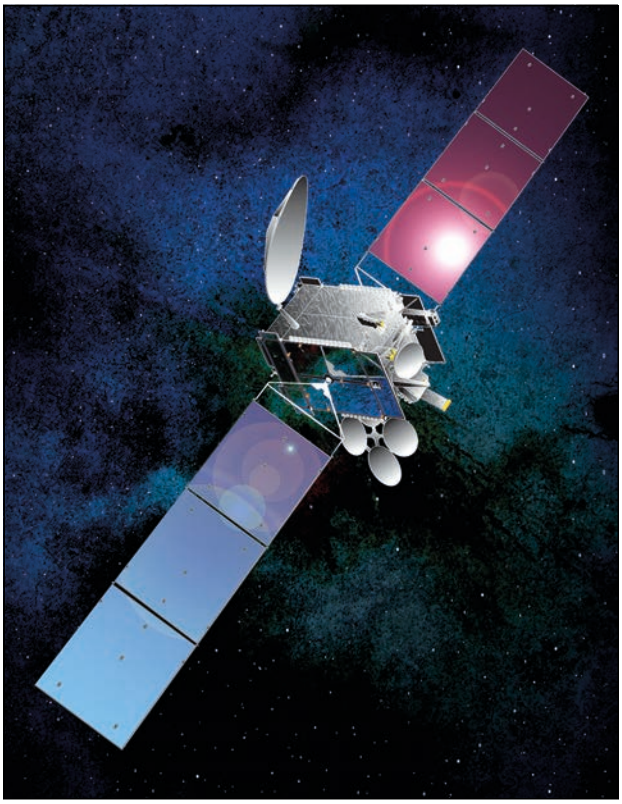

Figure 8.2 Thor 7

Illustration: Telenor Satellite Broadcasting (TSBc)

More than 70 people work at Andenes (the main settlement on the island of Andøya) for the ARR, ATC and NAROM. The focus on high technology and international relations makes this an attractive, income-generating element of the regional economy, drawing a great many visiting scientists, teachers and students.

### 8.2.2 Norwegian Space Centre Properties AS

The purpose of Norwegian Space Centre Properties is to help develop space-related infrastructure. Its activities are viewed in the context of the Norwegian Space Centre (NSC) itself. The state, represented by the Ministry of Trade and Industry, owns 100 per cent of the share capital of Norwegian Space Centre Properties. The NSC, a government agency, administers the state's ownership interests, as approved in the Government resolution of 12 December 2003. On behalf of the state, the NSC appoints the board members of Norwegian Space Centre Properties. The company receives no state subsidies.

Norwegian Space Centre Properties' focus on infrastructure development has been important to the High North. The company owns 50 per cent of KSAT, which operates satellite stations in Svalbard, Tromsø and Antarctica. The company also owns the fibre-optic cable linking Harstad on the Norwegian mainland to Longyearbyen, Svalbard. The fibre-optic cable was laid to serve the Svalbard Satellite Station and permit its further development.

The installation of a fibre-optic connection between Svalbard and the mainland in 2002 illustrated how ownership in Norwegian Space Centre Properties could be used strategically to achieve greater benefits than would otherwise be possible. The most significant part of the funding for the cable was obtained with help from loans originating in a long-term contract between the NSC on the one hand and NASA and NOAA of the United States on the other. Through agreements with Telenor and Uninett, Norwegian Space Centre Properties has ensured that the fibre-optic cable capacity also benefits other parts of the Svalbard community. The cable connection was established to serve KSAT's satellite station, but it has also contributed to a major improvement in communications options for Longyearbyen.

Norwegian Space Centre Properties has also leased capacity from Telenor for broadband communications to Antarctica via the Thor 7 satellite. The capacity is subleased to KSAT, the main user, but the entire Troll research station will enjoy the benefits when the connection is opened 2014.

### 8.2.3 Kongsberg Satellite Services (KSAT)

Kongsberg Defence & Aerospace owns the remaining 50 per cent in KSAT, which was founded in 2001. Prior to that, several foreign companies were involved in operating the satellite stations in Tromsø and Svalbard. The results were poor in several ways, and financial performance at times was highly negative. Through acquisitions and mergers, the Norwegian Space Centre helped sort out the ownership situation, concluding with the current two-way shared ownership of the ground station operations.

Norwegian Space Centre Properties' ownership stake in KSAT helps secure state control of strategic infrastructure. Much of the company's business is tied to the infrastructure in Svalbard and Antarctica. Even so, KSAT is a commercial company that has developed very positively, with 2012 sales in excess of NOK 400 million. KSAT today runs the largest ground stations in the world for satellites in polar orbit, and posts solid

Figure 8.3 KSAT receives satellite data in Tromsø

Photo: KSAT

earnings from the services it provides to public and private international clients.

KSAT currently has ground stations in Svalbard (SvalSat), Tromsø and Grimstad and at Norway's Troll base (TrollSat) in Antarctica, but also in Dubai, South Africa, Singapore and Mauritius. In addition, KSAT has signed agreements with suppliers for access to data from stations in South America, North America and Australia. The company is in a phase of significant expansion.

In recent years KSAT has also turned decisively towards the provision of satellite-based earth observation services. KSAT is a global leader in oil-spill monitoring. The company also provides services related to ship tracking, ice and snow mapping and navigation in icy waters. In 2009, 22 per cent of revenues stemmed from earth observation services.

### 8.2.4 Opportunities and challenges in state administration and ownership

By helping facilitate the construction of national space infrastructure, or by supporting the emergence of new technologies and services that meet both public and private user needs, the state can play a key role in developing Norway's space sector. The challenges – and opportunities – consist in organising the state's administrative and ownership roles so as to help achieve the objectives of Norwegian space policy in the best possible manner, in accordance with applicable laws and regulations.

The Andøya Rocket Range, Norwegian Space Centre Properties and KSAT are companies in which the Norwegian state has administrative and ownership roles. Their operations have grown as a consequence of substantial public investment and effort over several decades, reflecting Norway's top priorities in space. The companies were established as important sectoral policy tools, and have contributed to Norway's position as an attractive partner for national and international space-related organisations.

The establishment of the ARR and Norwegian Space Centre Properties as corporations has helped clarify management and responsibility issues, and paved the way for efficient operations and service sales in the marketplace. KSAT has built a solid commercial foundation for its activities while operating strategically important infrastructure in Svalbard and Queen Maud Land in Antarctica. The combination of public ownership, strategic interests and commercial considerations makes it necessary to clarify the state's different roles.

Today, the ARR, Norwegian Space Centre Properties and KSAT all manage valuable assets – and they do so commercially. Nonetheless there are differences in the operations, objectives and growth potential of the three companies:

- The ARR's main activities are tied to the infrastructure used in space-related research and education. Although operating results have been satisfactory in recent years, subsidies from the national budget have been necessary to fund substantial investments and modernisation.
- Norwegian Space Centre Properties is a significant owner and developer of strategic Norwegian space infrastructure, and stands out more clearly as a sectoral policy instrument. Its 2010 agreement with Telenor to lease Thor 7 satellite capacity for broadband communication with the Troll station in Antarctica came roughly to NOK 100 million. When, in addition, one considers the company's ownership stake in KSAT, its fibre-optic cable to Svalbard and its other High North infrastructure, Norwegian Space Centre Properties gives the impression of a robust, dynamic company. The company receives no state subsidies.
- KSAT has undergone strong commercial development since its inception. The company has solid earnings from the sale of services, and 30 per cent of profits are paid as dividends to the two owners, Norwegian Space Centre Properties and Kongsberg Gruppen. The majority of KSAT activities are nonetheless related to the operation of the vital infrastructure in Svalbard and Antarctica.

The current structures through which the state exercises administrative responsibility and ownership at the Andøya Rocket Range, Norwegian Space Centre Properties and KSAT have led to concerns over the state's different roles as owner and grant administrator in the space field. Such concerns become more urgent as the companies' market strength increases. The scope and organisation of state ownership must accommodate both industrial growth on a commercial basis and the continued pursuit of policy goals.

The Government will therefore undertake a detailed assessment of the state's interests in the ownership of ARR, Norwegian Space Centre Properties and KSAT, and of the significance these companies have today as sectoral policy tools. At the same time, it is important to recognise that these companies manage valuable assets. KSAT is distinguished by its strong commercial base, which may have significance for company's ownership structure. The Government will also explore the degree to which state ownership affects the ability of the companies to fulfil their international partnership roles, and it will examine what correlations exist between the companies' business activities and the contractual obligations of Norwegian authorities and the Norwegian Space Centre.

Consideration will also be given to the best way of organising state ownership in the companies to ensure proper corporate governance with regard to objectivity and the problematic issue of public subsidies, and to ensure that the companies effectively fulfil their sectoral policy roles. That would also be in line with recommendations made in the PwC report. The Office of the Auditor General of Norway has raised questions about the administration of the Andøya Rocket Range and Norwegian Space Centre Properties by the Ministry of Trade and Industry and the Norwegian Space Centre, most recently in Document 1 (2012–2013). As a specially empowered agency within the Ministry of Trade and Industry, the NSC is to be the state's organ for the strategy, coordination and practise of space activity. Under current arrangements, the NSC is authorised each year by the Storting to manage the state's ownership interests. This authorisation includes, as previously mentioned, the power to buy or sell shares in the companies and to expend dividend or sales income for space-related purposes. The Ministry of Trade and Industry and the NSC maintain close dialogue on management issues, and managers of the NSC also hold positions in the Andøya Rocket Range, Norwegian Space Centre Properties and their subsidiaries. These organisational relationships will be subject to renewed evaluation.

## 8.3 Ministries and agencies

Space activities affect many ministries and agencies, each of which is responsible for user perspectives in a particular sector or operational sphere. Many Norwegian agencies and centres of expertise cooperate with the NSC on development projects to identify potential benefits from space-based services, including the particular ways that such services might help each agency or centre to perform its duties more efficiently.

*The Ministry of Trade and Industry* is Norway's national space ministry. It participates in ESA's ministerial-level council and in the ESA/EU Space Council. The NSC coordinates national space programmes on behalf of the ministry. Appropriations to ESA and the NSC come entirely from the budget of the Ministry of Trade and Industry, which is also responsible for the lion's share of public funding for space infrastructure. The ministry is also in charge of Norway's participation in the Galileo and Copernicus programmes, with the NSC serving as secretariat.

Since Norway became a member of ESA in 1987, the Ministry of Trade and Industry has been the Norwegian state's main agent in space activities, both nationally and internationally. From the start, its tasks focused largely on developing industrial capability and skills. Eventually, as actual services came into being, greater focus was given to developing solutions for public-sector use. As new applications are demonstrated, it has been left to the individual ministries and agencies to determine whether and how to leverage the applications to improve their own operations.

*The Ministry of Education and Research* contributes to space research through the Research Council of Norway. When Norway joined ESA in 1987, the Research Council's predecessor was assigned the responsibility of funding basic research that ESA made p ossible, including instrument building and participation by Norwegian research groups.

The Research Council also coordinates Norwegian participation in EISCAT and the Nordic Optical Telescope. The Ministry of Education and Research pays Norway's dues in EUMETSAT, where the Meteorological Institute represents Norway with support from the Norwegian Space Centre. The ministry demonstrates its commitment to space-related learning through its supervision of universities, colleges and research institutions. The ministry funds aspects of the Norwegian Centre for Space-Related Education (NAROM). Basic funding for universities and colleges comprises its most significant contribution to space-related research and teaching.

*The Ministry of Fisheries and Coastal Affairs* is responsible for the coordination of civilian radio navigation policy, a field that includes satellite-based navigation. The Norwegian Coastal Administration monitors ship traffic and oil spills by satellite. It is the main user of the Norwegian satellite that monitors ship traffic at sea. It is also responsible for the BarentsWatch project. The Directorate of Fisheries and the Institute of Marine Research use satellite-derived information for research, monitoring, resource management and planning.

*The Ministry of Defence* contributes to space research and earth observation through the Norwegian Defence Research Establishment (Norwegian acronym: FFI). The Norwegian Armed Forces, including the Coast Guard, use information gathered from earth observation, communications and navigation satellites. Their satellite data requirements are expected to become so extensive in the years ahead that they plan to acquire their own satellite capacity. The Norwegian National Security Authority contributes to security programmes associated with the Galileo project and illuminates the importance of space infrastructure as an aspect of our nation's public security. Through the Globus 2 radar at Vardø, the Armed Forces help in the monitoring of space debris. The Ministry of Defence administers an agreement with the United States on access to the GPS system's military element.

*The Ministry of Justice and Public Security* has both direct and indirect use for satellite services because of its responsibility for civil protection and crisis management. Norway's rescue coordination centres use space services in connection with rescue operations, and the ministry participates in the international COSPAS-SARSAT search-and-rescue collaboration. During rescue actions in Svalbard, the authorities increasingly employ all three forms of satellite assistance: communications, navigation and earth observation. Satellite-based infrastructure is also used by the Norwegian Directorate for Civil Protection and the Norwegian National Security Authority. The police are a pertinent consumer of new space services like Galileo's Public Regulated Service.

*The Ministry of Agriculture and Food* is responsible for agricultural businesses, which use satellite-based navigation and positioning services for a variety of purposes. In the forestry industry, satellite-based positioning services are used throughout the value chain. Livestock and reindeer, meanwhile, can graze more safely in uncultivated areas if fitted with radio beacons traceable by navigation satellite. Such monitoring has positive animal-welfare consequences by permitting closer supervision and more efficient round-ups at season's end. Positioning services are also used when carrying out agricultural mapping and monitoring programmes. Agriculture-related earth observation research has led to operative mapping systems for forests and other wilderness resources.

*The Ministry of the Environment* represents Norway in some of the governing bodies of the EU's Copernicus earth observation programme. The Norwegian Environment Agency, the Directorate for Cultural Heritage, the Norwegian Polar Institute and the Norwegian Mapping Authority all use satellite-based earth observation and/or navigation services. Through the independent Norwegian Institute for Air Research, greenhouse gases in the atmosphere are quantified. Environmental officials use space-derived information in their reporting to international environmental monitoring programmes. The ministry supports the use of satellite data for monitoring tropical forests.

*The Ministry of Transport and Communications* is responsible for traffic flow and safety issues throughout the transport sector. The sector's use of satellite-based navigation services is growing. Major public users are Avinor, the Civil Aviation Authority, the Directorate of Public Roads and the Norwegian National Rail Administration. Through the Post and Telecommunications Authority, the ministry is responsible for radio frequency management, including the frequencies used by satellites, and for issuing permits to build and operate earth stations. The Governor of Svalbard enforces the specific provisions of Article 3 in Norway's earth station regulation.

*The Ministry of Foreign Affairs* contribute to research activity through project funding to the Research Council of Norway. It is the ministry's responsibility to make sure that Norway's obligations under international law are addressed as space activities are pursued. The Ministry of Foreign Affairs is party to a number of international initiatives involving space; these focus on topics such as crisis preparedness, maritime search-and-rescue and forest protection.

Table 8.1 Ministries and agencies, and the satellite services they use

| Ministry | Agency | Relevant services, areas of responsibility |
|---|---|---|
| Ministry of Trade and Industry | Norwegian Space Centre | ESA, EU space projects, earth observation, satellite communications, satellite navigations, industry |
| | Geological Survey of Norway | Mapping, landslide monitoring |
| | Innovation Norway/Industrial Development Corp. of Norway (SIVA) | Technology transfer, general business support and regional development |
| | Norwegian Maritime Authority | Sea safety – navigation. communications, monitoring |
| | Norwegian Metrology Service | Calibration, precise time measurement |
| Ministry of Finance | Norwegian Customs and Excise | Transactions, monitoring, road pricing |
| Ministry of Fisheries and Coastal Affairs | Directorate of Fisheries/Institute of Marine Research | Ocean research, monitoring, resource mapping |
| | Norwegian Coastal Administration | Navigation, safety, oil-spill monitoring, DGPS |
| Ministry of Government Administration, Reform and Church Affairs | Agency for Public Management and eGovernment | Digital services |
| Ministry of Defence | Norwegian Coast Guard | Fisheries supervision, environmental protection, search-and-rescue and customs control |
| | Norwegian Defence Logistics Organisation | Procurement, operations |
| | Norwegian Defence Research Establishment | Technology, methodology development |
| | National Security Authority | Preventive security, preparedness |
| | Norwegian Armed Forces | Military operations |
| Ministry of Health and Care Services | Norwegian Directorate of Health | Welfare services technology |
| Ministry of Justice and Public Security | Police | Communications, navigation |
| | Governor of Svalbard | Supervision of Svalbard earth stations |
| | Joint Rescue Coordination Centres | Search-and-rescue, COSPAS-SARSAT |
| | Norwegian Directorate for Civil Protection | Public security, emergency preparedness, hazardous materials |
| Ministry of Local Government and Regional Development | Counties and municipalities | Land-use planning, emergency preparedness |

Table 8.1 Ministries and agencies, and the satellite services they use

| Ministry | Agency | Relevant services, areas of responsibility |
|---|---|---|
| Ministry of Education and Research | Research Council of Norway | Space-related research |
| | Universities and colleges | Space-related research, instruction |
| | National Centre for Space-Related Education (NAROM) | Education, training |
| | Norwegian Meteorological Institute | Weather forecasting, EUMETSAT contact |
| Ministry of Agriculture and Food | Norwegian Forest and Landscape Institute | Monitoring, mapping, tracking, resource mapping |
| Ministry of the Environment | Norwegian Mapping Authority | Mapping, Norway Digital, geodesy, SATREF |
| | Norwegian Environment Agency | Climate, environment, pollution, resource management |
| | Norwegian Polar Institute | Environmental research, monitoring, climate, mapping |
| | Directorate for Cultural Heritage | Monitoring of historical sites |
| Ministry of Petroleum and Energy | Norwegian Petroleum Directorate | Monitoring, resource mapping |
| | Norwegian Water Resources and Energy Directorate | Hydrology, floods and landslides, mapping services, electric power supply |
| Ministry of Transport and Communications | National Rail Administration | Infrastructure construction and operation, maintenance, traffic control |
| | Accident Investigation Board Norway | Transport accidents |
| | Civil Aviation Authority | Air safety |
| | Norwegian Public Roads Administration | Traffic safety, navigation, infrastructure |
| | Norwegian Post and Telecommunications Authority | Frequency management |
| | Avinor | Aircraft safety, airport operations, SCAT-1 |
| Ministry of Foreign Affairs | Foreign service missions, NORAD | Crisis management, communications, earth observation, navigation, tropical forestry project |

## 8.4 Inter-ministerial coordinating committee for space activities

Norway's inter-ministerial coordinating committee for Galileo (Norwegian acronym: IKU) was created to coordinate matters relating to Norway's Galileo participation. The committee's statutory authority resides in Proposition No. 54 to the Storting (2008–2009).

But as the number of other Norwegian space issues proliferated – including matters related to the AIS satellites, the Andøya Rocket Range, BarentsWatch, Copernicus, Radarsat, research projects and the EU's space strategy – it was felt that the committee should handle them as well. All these issues have interested parties in several ministries. Coordination among ministries helps maximise the benefit from the Norwegian state's investments in space.

In 2011, therefore, the committee became the inter-ministerial coordinating committee for space activities (in Norwegian: *Det interdepartementale koordineringsutvalget for romvirksomhet*). The committee's job is to coordinate the handling of space-related issues by relevant ministries and to be an arena for information exchange. The committee meets two to three times per year, adjusting the tempo as required by events. It is headed by the Ministry of Trade and Industry, with the Norwegian Space Centre acting as secretariat. Other participants are the Ministry of Foreign Affairs, the Ministry of Defence, the Ministry of the Environment, the Ministry of Fisheries and Coastal Affairs, the Ministry of Justice and Public Security, the Ministry of Education and Research, the Ministry of Agriculture and Food, the Ministry of Petroleum and Energy and the National Security Authority.

# 9 The Government's commitment to space

The Government is committed to space activity, and will work to ensure that it continues to serve as a tool for Norwegian interests. Four strategic goals have been set: profitable companies, growth and employment; meeting important needs of society and user groups; greater return on international space collaboration; and high-quality national administration of Norwegian space activity.

To accomplish the four goals, the Government has prepared a number of priorities. What follows are the top priorities associated with each goal.

## 9.1 Profitable companies, growth and employment

The Government's industrial policy is intended to help create an environment in which companies succeed and have the ability to grow. The authorities seek to provide the most stable and predictable framework conditions possible; it is the companies themselves that must seize opportunities. The Norwegian space sector is no exception to this general perspective.

**Box 9.1 Measures**

*The Government will:*

- Work to ensure that public investment in space activity strengthens value creation and business development
- Work to enhance market access, technological development and system insight as means to stimulate Norwegian business growth and development
- Help ensure that Norway benefits as much as possible from its European space collaboration
- Foster conditions under which Norwegian industrial participation in ESA programmes contributes to greater strength in other technology areas
- Work to ensure that Norwegian industry takes advantage of the opportunities inherent in ESA's principle of guaranteed industrial return, and that Norwegian industry is sufficiently competitive to obtain contracts in EU space programmes
- Help to ensure that Norwegian downstream companies gain more benefit from participation in ESA programmes
- Help to ensure that downstream companies enhance their competitive strength and export potential
- Help to ensure that space-related investments addressing national needs also help to trigger value creation in Norwegian industry, provided the approach is consistent with choosing the most cost-effective solutions
- Use policy and funding instruments strategically to promote service development and commercial success in business segments with significant growth potential and comparative advantages
- Help to ensure that Norwegian businesses and other users of earth observation data have the access to data they need, by:
  - helping to develop a commercialisation strategy for satellite data
  - considering Norwegian participation in international satellite collaboration to secure access to useful data
  - studying the need for coordinated national procurement of satellite data
  - assessing the costs and benefits of an open data policy for raw data owned by the state
- Help to ensure that relevant industrial actors are informed about opportunities in the Norwegian space sector
- Consider, in kind with other industries, the potential for an Arena project in space-related research and business development, and in due course a Norwegian Centres of Expertise programme.

Through the basic mechanisms of technology development, market access and system insight, Norwegian investments in space activities have helped to promote domestic economic growth and development. International collaboration in concert with complementary national framework conditions has enabled those three mechanisms to boost profitability, growth and employment in Norwegian companies.

The Government therefore intends to carry out the following measures (see Box 9.1).

## 9.2 Meeting important needs of society and user groups

These days, space-based applications reach into many areas of everyday Norwegian life. Space operations have become essential to operating our society safety and efficiently and to pursuing key policy objectives in the High North and in climate and environmental policy.

Increasingly, space-based infrastructure has strategic value by virtue of its importance to the exercise of governmental authority and the provision of critical services. Protecting Norway's interests requires a certain degree of national control and independent capability, even when services can be purchased commercially. Norway has special needs in the High North, and there is no guarantee that actors outside of Norway will have the ability or interest to develop systems that successfully address them. Having influence over the development of essential infrastructure will be of significance to public security and crisis management. Norway's public officials and research and technology communities must therefore possess enough insight and competence to identify promising solutions, to be competent parties in procurement transactions and international collaboration, and to develop and implement national solutions where appropriate.

The Government therefore intends to carry out the following measures (see Box 9.2).

## 9.3 Greater return on international space collaboration

International collaboration has always been – and always will be – the backbone of Norwegian space efforts. ESA membership has served Norway well in several ways. It has helped the country to develop a competitive space industry, to accumulate expertise within the Norwegian state and business community, and to internationalise and strengthen Norwegian research programmes.

In the future, we must also be good at promoting our interests in forums other than ESA. Increasingly, important issues are settled at the EU. As a result, Norwegian space policy has taken on aspects of the country's European policy. Nor-

### Box 9.2 Measures

*The Government will:*

- Work to ensure that space activities are able to help meet important social and user needs in a cost-effective manner
- Actively employ supplementary national programmes to address Norwegian user needs
- Help to provide an operating framework in which Norwegian technology companies and other centres of expertise can develop and implement space-based systems that meet Norwegian user needs
- Work to ensure that Norwegian space research and expertise maintain a high international level
- Help to ensure that Norwegian space activities get the most out of the expertise available in Norwegian research and educational institutions
- Extend the space research programme at the Research Council of Norway
- Work to achieve good, robust satellite navigation coverage in the High North and the Arctic
- Review how best to address Norwegian requirements for satellite communications in the High North
- Work to exploit the potential of satellite observation to contribute to climate and environmental policies
- Continue efforts to deal with vulnerabilities associated with the use of satellite systems
- Actively participate in efforts to establish international guidelines for the reduction of space debris
- Work to make satellite-based services available as a key element of transport policy.

**Box 9.3 Measures**

*The Government will:*

- Continue Norwegian ESA participation as a key tool for promoting Norwegian space interests. In 2012, a commitment of 144.4 million euros has been declared towards Norway's continued participation in optional ESA programmes
- Work to secure Norwegian interests in EU space programmes
- Work to ensure that Copernicus and Galileo perform capably in Norwegian areas of interest
- Ensure that Norwegian authorities have sufficient ability to pursue Norwegian interests in international space forums
- Use bilateral agreements where appropriate to safeguard and pursue Norwegian interests
- Continue Norway's commitment to international collaboration in space-related research

wegian interests increasingly have to be promoted from the outside, in forums where we are not a member, or where our right to participate is limited. Galileo and Copernicus will help resolve very important challenges faced by Norway. An active Norwegian approach to EU policy-making in space is therefore essential for a variety of reasons, including: to secure influence over infrastructure important to Norway; to safeguard the interests of Norwegian industry, researchers and user groups; and to position Norway for a future in which the EU increasingly sets the political agenda for European space activity.

The Government therefore intends to carry out the following measures (see Box 9.3).

## 9.4 High-quality national administration of space activity

In order for space activity to best serve Norwegian interests, expertise is required both within the Norwegian state and in Norwegian technology circles and user groups. Norwegian authorities must be able to identify needs, assess system proposals and ensure effective implementation regardless of whether the services or infrastructure in question are to be developed nationally, developed in collaboration with other nations or purchased from commercial providers. To ensure that good solutions are developed and implemented in a sound manner, and to safeguard Norwegian interests in international collaborations, we must draw together the public-sector expertise available in administration, technology and international relations.

**Box 9.4 Measures**

*The Government will:*

- Strengthen collaboration and coordination between relevant ministries
- Use the Norwegian Space Centre as the state's organ for strategy, coordination and practise to ensure that space is exploited efficiently for the benefit of Norwegian society
- Strengthen the Norwegian Space Centre's capacity for analysis and consultation
- Facilitate the use of space-related ground infrastructure on the Norwegian mainland as appropriate
- Continue to exploit Svalbard's geographical advantages with regard to space activity in accordance with existing laws and regulations
- Facilitate the further utilisation of Jan Mayen Island for space-related activity
- Facilitate continued Norwegian space activity in Antarctica in accordance with the Antarctic Treaty
- Ensure effective organisation of space activities in the Norwegian public sector, with measures that include:
  - undertaking a detailed assessment of the state's interests in the ownership of ARR, Norwegian Space Centre Properties and KSAT, and of the significance those companies have as sectoral policy instruments
  - working to achieve as much transparency as possible regarding subsidy programmes and awards in the Norwegian space sector
  - assessing how governance dialogue with the Norwegian Space Centre can be improved

Since the 1960s, the geographical advantages of Norwegian-hosted ground infrastructure have been exploited to develop space activities now regarded as world class in certain sector niches. Among these are the balloon releases and sounding-rocket launches at Andøya and the downlink services for polar-orbit satellites at Svalbard, Jan Mayen Island and Antarctica. As the future unfolds, Norway's geographical location will remain an advantage for space-related ground infrastructure.

The state currently has administrative and ownership responsibility for several actors in the Norwegian space sector. The Andøya Rocket Range AS, Norwegian Space Centre Properties AS and Kongsberg Satellite Services AS have been valuable tools in developing key aspects of Norway's space effort. This effort has resulted in a foundation for commercial growth in the companies, which increasingly derive their revenues from the international market. Due to the combination of public ownership, strategic interests and commercial factors, a clarification of the state's different roles is called for.

The Government therefore intends to carry out the following measures (see Box 9.4).

# 10 Financial and administrative implications

With this white paper, the Government seeks to anchor within the Storting the Government's broad policy outlines for Norwegian space programmes. Its content is based on approved budgets and plans, and entails no additional financial commitment. For administrative purposes, notice is given that the Government will seek to determine, by evaluation, the most appropriate organisational structure for public-sector space programmes, and will take the necessary steps to realise that structure.

Norwegian Ministry of Trade and Industry

r e c o m m e n d s :

That the recommendation from the Ministry of Trade and Industry dated 26 April 2013 regarding «Between heaven and earth: Norwegian space activities for business and public benefit», be submitted to the Storting.

**Appendix 1**

# Abbreviations

| | |
|---|---|
| AFC | ESA Administrative and Finance Committee |
| AIS | Automatic Identification System |
| ALOMAR | Arctic Lidar Observatory for Middle Atmospheric Research |
| ARR | Andøya Rocket Range |
| ATC | Andøya Test Center AS |
| CERN | European Organisation for Nuclear Research |
| Copernicus | EU earth observation programme, previously (until 2012) called GMES |
| COSPAS-SARSAT | International search-and-rescue satellite system |
| EASP | Esrange Andøya Special Project |
| EDA | European Defence Agency |
| EGNOS | European Geostationary Navigation Overlay Service |
| EISCAT | European Incoherent Scatter Scientific Association |
| ELDO | European Launcher Development Organisation |
| ENVISAT | Environmental satellite |
| ESA | European Space Agency |
| ESRO | European Space Research Organisation (forerunner of ESA) |
| EUMETSAT | European Organisation for the Exploitation of Meteorological Satellites |
| FFI *(Forsvarets Forskningsinstitutt)* | Norwegian Defence Research Establishment |
| GEO | Group on Earth Observations |
| GEO FCT | Group on Earth Observations Forest Carbon Tracking |
| GEOSS | Global Earth Observation System of Systems |
| GFOI | Global Forest Initiative |
| GLONASS | Global Navigation Satellite System |
| GMES | Global Monitoring for Environment and Security |
| GNSS | Global Navigation Satellite System |
| GOCE | Gravity Field and Steady-State Ocean Circulation Explorer |
| GPS | Global Positioning System |
| GSA | European GNSS Agency |
| GSTP | ESA General Support and Technical Programme |
| IMO | International Maritime Organisation |
| INMARSAT | International Maritime Satellite Organisation |
| INTELSAT | International Telecommunications Satellite Organisation |
| IPC | ESA Industrial Policy Committee |
| IPCC | Intergovernmental Panel on Climate Change |
| IRC | ESA International Relations Committee |
| ISS | International Space Station |
| ITAR | International Traffic in Arms Regulations |
| ITS | Intelligent transport systems and services |
| ITU | International Telecommunication Union |

| | |
|---|---|
| KSAT | Kongsberg Satellite Services |
| NAROM *(Nasjonalt senter for romrelatert undervisning)* | Norwegian Centre for Space-Related Education |
| NASA | National Aeronautics and Space Administration |
| NNI | Net national income |
| NOAA | National Oceanic and Atmospheric Administration |
| NSC | Norwegian Space Centre |
| NSCP | Norwegian Space Centre Properties |
| PRS | Public Regulated Service, Galileo |
| PwC | PricewaterhouseCoopers |
| R & D | Research and development |
| SAR | Search and rescue |
| SCAT-1 | Special Category 1 |
| SPC | ESA Science Programme Committee |
| SvalSat | Svalbard Satellite Station |
| TRANSIT | US satellite navigation system in 1960s |
| TSS | Tromsø Satellite Station |
| UNCOPUOS | United Nations Committee on the Peaceful Uses of Outer Space |
| UNDP | United Nations Development Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organisation |
| UNITAR | United Nations Institute for Training and Research |
| UNOSAT | UNITAR's Operational Satellite Applications Programme |

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