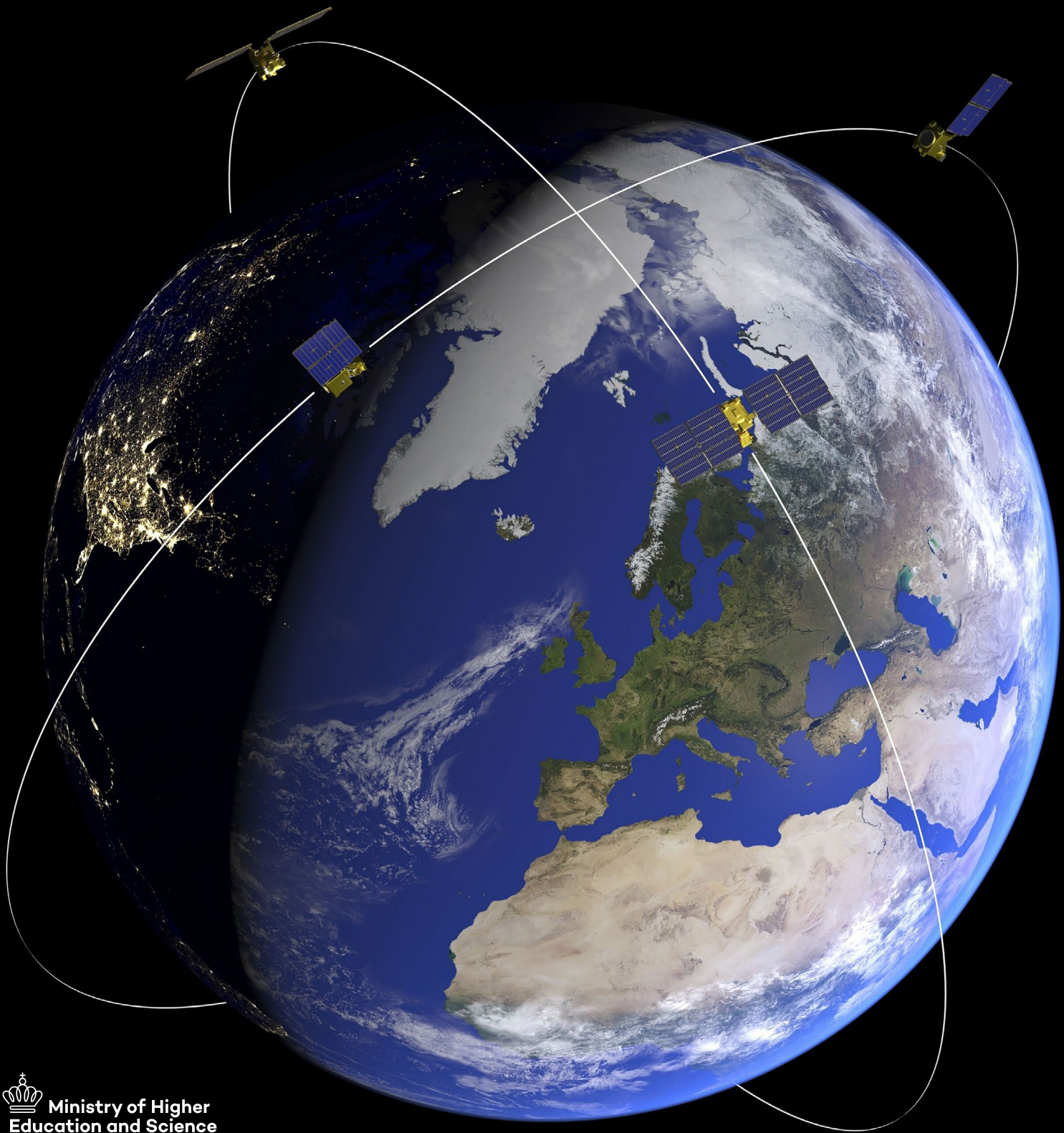
Strategy for space research and innovation

National priorities for Danish space research, innovation and technology development 2025-2035

November 2024



Ministry of Higher Education and Science
Denmark

Cover photo: ESA illustration of Arctic Weather Satellite.

AWS is a satellite smaller than the conventional weather satellites. It covers the Arctic region several times a day. The Danish Meteorological Institute (DMI) participates together with the other Nordic meteorological institutes in the analysis of data from AWS, while DTU Space and Danish companies contribute with technology and know-how to the mission.

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Preface

As long as humanity has existed, we have turned our eyes to the stars. Up there, dreams and ambitions have no boundaries. For a long time, space has been associated with something unachievable, but no more.

Ever since the now world-known race to the moon, outer space has only come closer. And now we are at a stage of history where it is essential that as a nation, Denmark contributes to exploring its possibilities and influencing the technology development.

Because space contains enormous potential. Space technology can make life on earth better, greener and safer and contains new intriguing possibilities for Danish companies.

We live in times in which the world is developing at a fast pace. The volatile geopolitical landscape brings with it insecurity and conflict. More than ever before we depend on our critical infrastructure and strategic autonomy - we simply must be able to stand on our own feet to a greater extent.

Denmark and the EU has to remain a strong player in the space sector to avoid risking breaches of our security vis-a-vis those who do not necessarily want what is best for us.

We are also in the middle of a global climate crisis. Extreme weather phenomena devastate coasts, forests and land areas, making large areas infertile and uninhabitable. If we want to reach our goals as regards the green transition, we must use more satellite data and weather monitoring for efficiently and sustainably transforming our agricultural, building and transportation sectors. In this area, we cannot compromise, on the contrary.

But research, innovation and technology development within the space sector should also be seen as a possibility. The Danish growth layer of companies within the space sector must take part in solving the problems, because there is a substantial growth potential within the space industry over the coming years.

Strategy for space research and innovation

If we are going to play a larger role in space, it is required that we build a strong Danish ecosystem for space research and technology development.

Even if Denmark is a small country, we are far from insignificant in the space sector. We have a very well-developed research environment within space research and some of the world's best researchers. We are going to take advantage of that fact.

We are going to invest heavily in research, innovation and technology development in the space sector, and we do that best having an effective strategy for the Danish research and innovation efforts. The strategy must enclose and aim our total efforts for the Danish operators to ensure the best use of our investments and resources.

But despite of Denmark's good position, we are largely dependent on the international cooperation. The European Space Agency (ESA) is one of the most important platforms for Danish researchers and companies to enter into international collaboration.

ESA plays a decisive role to the European collaboration in the space sector and to EU's ability to act independently within the sector. If we are facing the next chapter of the space race, Denmark should not be alone, because then we risk lagging behind.

Many of us thought that the space race ended when reaching the moon. But when the flag was planted on the surface, it was probably in reality the beginning of the next chapter. A new chapter of the space history that we, as a nation and an international operator, cannot run the risk of being outside.

This strategy for the Danish research efforts in the space sector must be a launching pad that can lead us safely into space and into the future.

Christina Egelund
Minister of Higher Education and Science Denmark

Introduction

In 2016, Denmark launched its first national space strategy and updated it in 2021 with new objectives and efforts. At that time, the framework was set up to show how space-based technology and infrastructure contributes to achieving climate goals, an efficient digital public sector, green value creation and increased security and preparedness in society.

A new strategy with an independent focus on research, innovation and technology development increases the ambitions and provides a distinct direction with strategic milestones and initiatives for developing the Danish space sector. The strategy will form the basis for an increased growth layer of innovative companies and contribute to transforming space research to strengthen Danish defence, security and preparedness as well as new solutions to society's climate, nature and biodiversity crisis. Therefore, the strategy must be seen in the context of other governmental priorities.

A critical infrastructure of material importance to Denmark's security and green ambitions

Space infrastructure (space technology, space data and space services) forms part of modern navigation and communication services on land, at sea and in the air. For example in connection with military and civilian preparedness, weather services and in the form of satellite data for sustainable and efficient optimisation of i.a. agriculture, building, and transportation; also, satellite data assists in predicting changes to nature and the environment.
At the same time, the technological development poses an increasing threat in that space technology has dual use potential and can be used for both civilian and military purposes. The double nature of space technology means that the technology forms both a potential security risk, while at the same time being a precondition for maintaining national security - including in Denmark's sphere of interest in i.a. the Baltic Sea and the Arctic regions. Space has become increasingly important in terms of security policy. Russia's invasion of Ukraine has illustrated the development. There are increasing indications that outer space may be the subject of a state race on great power influence and technological dominance, which has enhanced attention to the security-political aspects of space with a number of international organisations, including the EU, NATO and the UN.

Therefore, the EU also launched a space strategy for security and defence in 2023 as part of EU's efforts to make space systems and services more resilient and make the EU ready to respond to hostile activities or threats. Also, since 2019 NATO has declared space an operational domain, and leading space powers within and outside the EU consider space in the same manner, which is i.a. reflected in institutional initiatives e.g. the establishment of military units, such as the establishment of the American Space Force in 2019.

A number of countries and the EU thus increase their strategic focus and investments in space for the purpose of achieving technological sovereignty, furthering innovation and growth and strengthening autonomy and security in space and on earth.

A new and more commercial operating landscape

Once, to a high degree, it was states and national/regional space organisations as the European Space Agency, ESA, and the American space agency, NASA, which solely fuelled the development of space technologies and the use of space. Today, the development of space is increasingly driven by a new and more commercial operating landscape, which is made possible by the fact that it has become easier and cheaper to do space-research and to use space. For example, private companies transport both provisions and astronauts to the International Space Station (ISS), whereas commercial partners work on developing new international space stations for research, technology development and commercial activities.

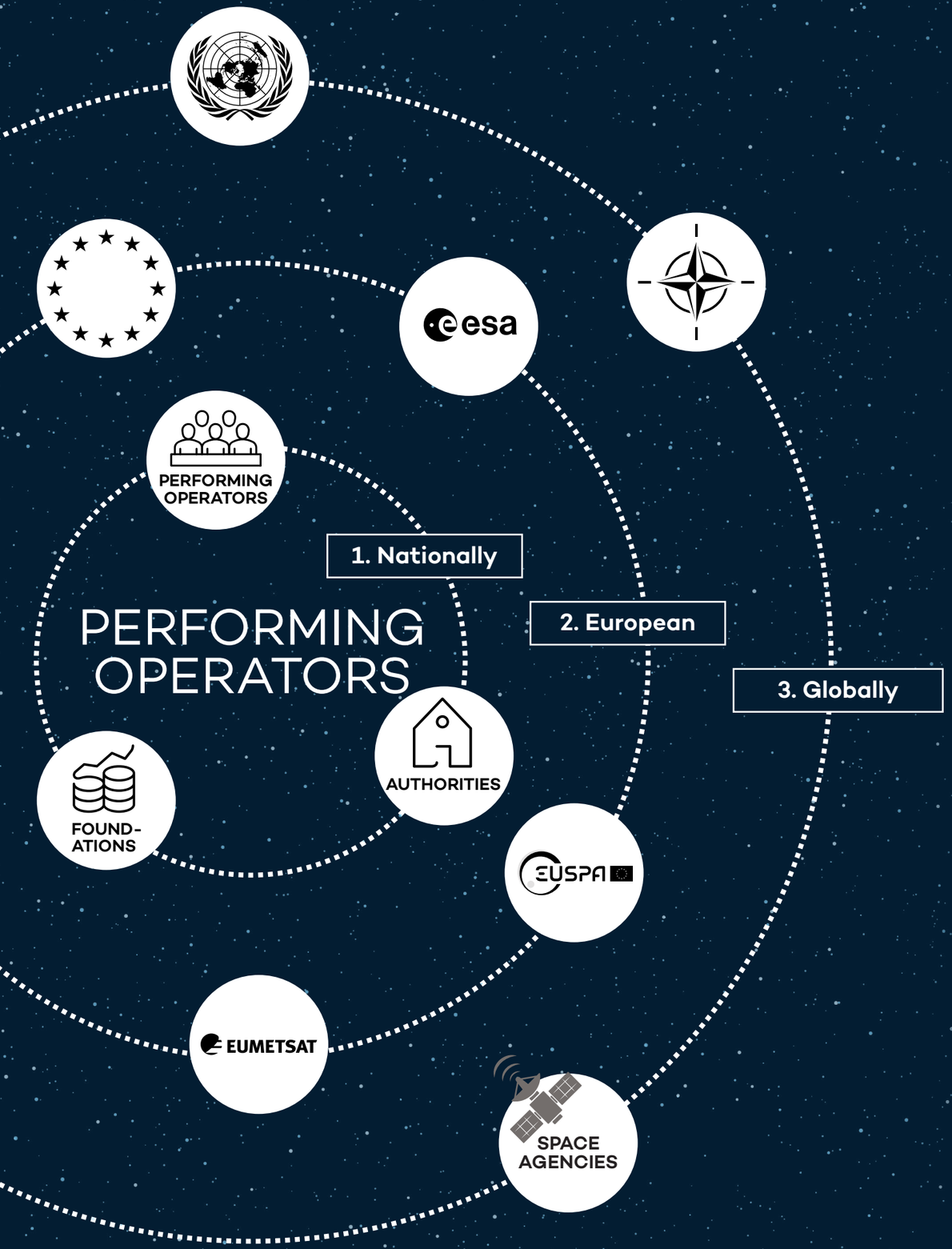
The growth is primarily driven by the emergence of Low Earth Orbit (LEO) Economy, which are constellations of satellites in the lower orbits around earth, making it possible to develop new services within communication, navigation and earth observation. At the same time, both growth and potential for increased use are expected to increase in line with satellite services being coupled with artificial intelligence and more powerful super and quantum computers for analysis and processing of large quantities of satellite data.

While costs for sending launch vehicles into space decrease rapidly, a broad range of entirely new uses is made possible. This applies to e.g. laboratories and production facilities in space which may exploit weightless conditions to research, develop and produce new innovative products, such as pharmaceutical products and advanced microchips. At the same time, development in global space industry is driven by finding sustainable solutions, such as being able to reuse launching capacities and enhance useful life of existing satellites.

The Danish space sector

Despite its small size, the Danish space sector has developed strong research environments and highly specialised and innovative companies within specific areas. This makes the Danish education and research institutions and companies significant operators within i.a. satellite technology (design, development and production of small satellites), rocket technology, earth-based control and test systems, sensors and instruments (i.a. antenna and signal technology, advanced stellar camera technologies, power supply technologies, etc.) and use of data for developing digital green solutions.

The most recent count from 2023 shows that there are about 240 Danish companies (including startups) which to a large or small extent are engaged in space-related financial activities. Measured in terms of revenue and employment the latest analysis in 2022 shows that the entire revenue was at DKK 5.8 billion, and employment was at about 2,400 full-time equivalents.



1. Nationally

PERFORMING OPERATORS

Performing operators include universities, GTS institutions, enterprises and cluster organisations that are engaged in space for a commercial and/or scientific purpose, including both upstream, downstream and activities in space.

AUTHORITIES

A number of the Danish ministries and government agencies are active users of data and products from space. Formalised cooperation has been established between the ministries through the establishment of the Interministerial Space Committee (DTR), chaired by the Ministry of Higher Education and Science. In addition, the Danish authorities support the sector with guidance, international marketing, knowledge transfer and matchmaking, for example via Innovation Centre Denmark (ICDK).

FOUNDATIONS

Public and private foundations grant funds for Danish space research, space innovation and technology development. Foundations also participate in public-private partnerships, such as ESA Business Incubator Denmark (ESA BIC DK), which has strategic collaboration with the Export and Investment Fund of Denmark (EIFO) and Innovation Fund Denmark to facilitate the enterprises' avenue to further funding.

2. European

EU PROGRAMMES

In the EU long term budget for 2021-2027, most EU space activities are gathered in a programme with four components: Galileo/EGNOS (position, navigation and time control), Copernicus (earth observation), GOVSATCOM/IRIS2 (secure satellite communication for authorities), and SSA (Space Situational Awareness). In 2023, the EU also had a new space programme. IRIS *(build-up of a satellite constellation to increase EU's capacity to deliver secure satellite communication to authorities).*

ESA

The European Space Agency (ESA) is intergovernmental collaboration consisting of 23 member states, established by a convention in 1975 for the purpose of developing and using space technology and space research. Denmark has been a member since the beginning and is today active in a large number of programme activities and space missions. Among other things, ESA has developed and designed EU's two large space infrastructures, the earth observation programme Copernicus and the satellite navigation system Galileo.

EUSPA

EUSPA is EU's agency for the space programme. EUSPA provides services under Galileo. GOVSATCOM, IRIS2 and SST, which i.a. warn satellite operators on the risk of collisions. EUSPA is also going to disseminate the use of data and services under EU's space programmes and promote the development of a European space ecosystem. Finally, EUSPA is responsible for security surrounding the space programmes.

EUMETSAT

EUMETSAT is an intergovernmental collaboration composed of 30 member states. Denmark has been a member since 1983. EUMETSAT is responsible for the operation of a system of meteorological satellites. Day and night, the satellites deliver weather and climate data to the member countries' meteorological services, including to the Danish Meteorological Institute (DMI).

3. Globally

UN

Denmark is a member of the United Nations' Space Committee; United Nations' Committee on the Peaceful Uses of Outer Space (UNCOPUOS), which is the most central international forum for the space area. The membership provides Denmark with the option of contributing to and influencing the development of new political and technical guidelines for the international space industry.

NATO

Denmark is a member of NATO (North Atlantic Treaty Organisation), which is a transatlantic association, connecting Europe and North America in a defence and security-policy alliance. In 2019, NATO declared space as an operational domain in line with land, air and cyber, and since then NATO has initiated more steps to strengthen the defence and security collaboration in the field of space.

SPACE AGENCIES

A space agency is typically a comprehensive, independent organisation dedicated to operating a nation's space programme, including i.a. mission planning and tendering space projects. Danish scientists and enterprises contribute to and cooperate on more space missions with space agencies all over the world, including in particular American NASA.

Strategic milestones up to 2035

The strategy will contribute to increase public utility of Danish space research, innovation and technology development. The goal is new solutions to society's climate, nature and biodiversity crisis, strengthening Danish defence

Milestones
As a basis for long-term priorities regarding Danish space research, the Danish government has defined three strategic milestones for the efforts. These milestones govern the national priorities and investments in space, both nationally, in the EU and through Danish membership of ESA and EUMETSAT.

The milestones are closely connected and mutually intensifying

MILESTONE 1

Stronger Danish research and innovation environments

Capacity must be built up in the Danish research and innovation communities. Talents must be attracted and developed, and space research and space technology must be dissipated to other relevant research areas.

MILESTONE 2

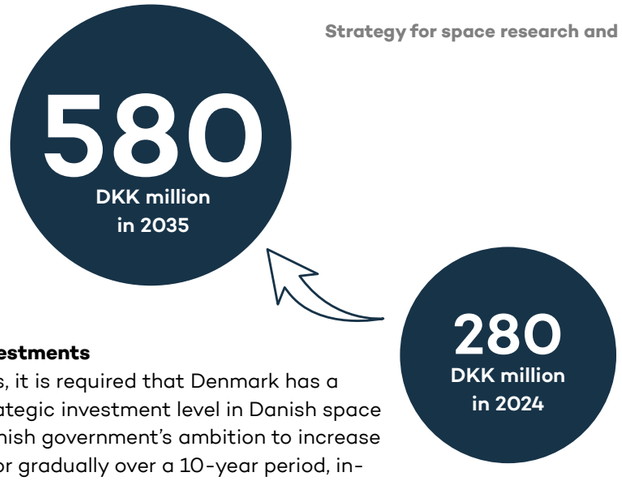
International collaboration to the benefit of Denmark

Denmark must play a greater international role and to a higher degree set its mark on the development in the EU in the field of space. At the same time, Danish space research and space technology must be protected against abuse, espionage, illegal acquisition activities and potential military use to the detriment of Denmark's security.

MILESTONE 3

Increased use of space research and space technology

Space research and space technology must increasingly be put to use for the benefit of Denmark's security, defence and preparedness, climate goals, nature and the environment as well as the Danish business community.



Larger and more strategic investments
In order to meet the milestones, it is required that Denmark has a larger, long-term and more strategic investment level in Danish space research. It is therefore the Danish government's ambition to increase investments in the space sector gradually over a 10-year period, including doubling the Danish contribution to ESA's optional programme activities from DKK 280 million in 2024 to DKK 580 million in 2035. A precondition for increasing the investments is that a build-up of capacity and gearing of the Danish environments takes place alongside the strategical initiatives.

In the coming years, nine tangible initiatives for developing the Danish space sector are launched. Following a mid-term review in 2030, more initiatives can potentially be launched if needed.

INITIATIVES

1. National space programme for research and innovation
2. Development of scientific instruments
3. Programme for national space missions

INITIATIVES

4. Danish participation in EU's space programmes and Horizon Europe
5. **International partnerships to the benefit of Denmark**
6. Protection of Danish research and technology

INITIATIVES

7. Strengthening of ESA Business Incubator Denmark
8. The role of authorities in developing a domestic market for space-based solutions
9. Efforts to commercialise Danish space research and technology development

Indicators are attaching to the milestones which enable an assessment of the strategy progress over the next 10 years. The milestones and indicators of the strategy will be monitored on an ongoing basis by the Ministry of Higher Education and Science Denmark.

INDICATORS

- More researchers, PhD and post-doc students within the field of space
- More cross-disciplinary projects so that space is extended to other research fields
- More Danish-led space missions selected and carried out

INDICATORS

- Increased participation in relevant EU programmes and Horizon Europe
- More operators receive ESA contracts and participate in international space missions
- More foreign industry contracts and more venture capital
- More collaboration agreements with authorities/space agencies in selected countries

INDICATORS

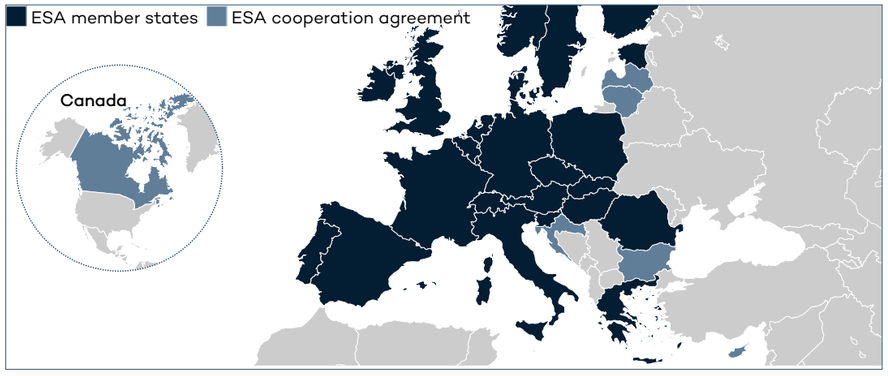
- The number of enterprises, including startups, in the Danish space industry increase
- Larger revenue in the Danish space industry
- Enterprises and authorities use more space-based solutions, i.a. within security, defence, preparedness, climate and the environment.

Larger and more strategic investments

With the strategy, the Danish government wants to create a framework for a larger investment level in Danish space research, innovation and technology development. It should be built up over time and be given strategic priority so that it contributes to building up capacity on the Danish research and innovation environments as a basis for increasing value creation in society as well as increased growth and revenue in the Danish business sector.

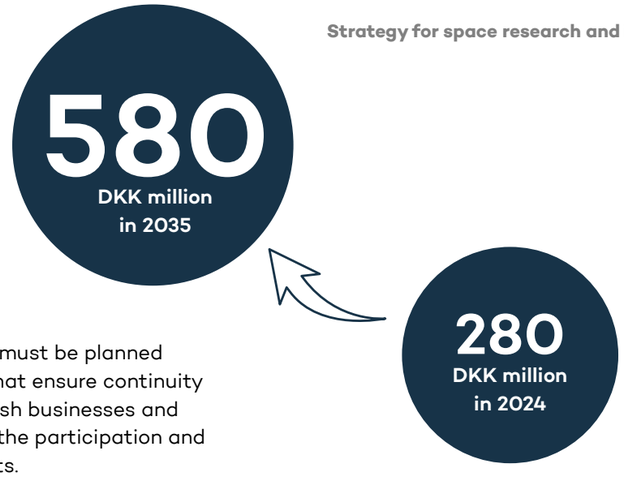
A more ambitious and long-term prioritisation of the Danish ESA-membership
A central part of the strategy is to increase the Danish ESA contribution substantially over time. The Danish government's ambition is that the Danish contribution to the optional programme activities of ESA is doubled over a 10-year period for the purpose of allocating more than half a billion DKK per year in 2035.

ESA plays an important role in the accumulation of competencies and research capacity in Denmark. ESA makes it possible for Danish businesses and research institutions to carry out research and technology development to an extent and importance that neither Denmark nor any other European country could do alone.



ESA is intergovernmental cooperation (currently consisting of 23 member states) established through a convention in 1975 for the purpose of developing and using space technology and space research.

The Danish membership of ESA benefits the Danish space sector broadly speaking - from basic scientific research of the universe to development of instruments for missions to the moon, Mars and the International Space Station (ISS), development of satellite technology and new methods for collecting and using space-based knowledge and data on earth. Danish operators have an option to bid for tenders under ESA's mandatory programme areas and under the optional ESA programmes in which Denmark participates. In the mandatory part, we find ESA's basic scientific programme which i.a. supports the early technology development and the new experimental ideas that can form the basis for new missions. The member countries contribute to the mandatory programme according to a key determined by the size of the GDP. ESA's programmes operate according to a principle of geo-return which means that ESA is obliged to grant suitable operators in Denmark contracts corresponding to the Danish contribution. The programmes support Danish operators throughout the value chain, from research and development activities to testing and demo of technologies and products in the market.



An increased investment level must be planned through multi-year priorities that ensure continuity and good conditions that Danish businesses and research institutions increase the participation and obtain attractive ESA contracts.

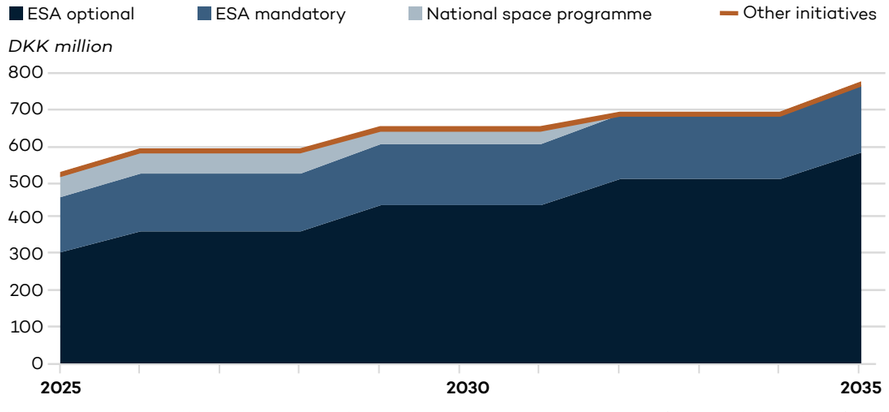
Every three years, at ESA's ministerial conferences, Denmark and other member countries accede to programme activities and funds for a three-year budget period. As preparation for the ministerial meetings, an assessment of the national capacity and demand for programme activities in ESA must be made for the purpose of ensuring that an additional investment level results in a high scientific, financial and societal return (see appendix with seven guiding principles for Denmark's long-term priority in ESA).

In addition, the long-term priorities in ESA must continuously take any structural and institutional changes to the European space programmes into account.

A new national space research programme
It is also the Danish government's ambition that DKK 60 million is targeted annually in the period 2025-2028, and DKK 40 million annually in the period 2029-2031 for implementation of a new national space research programme to build up capacity in the Danish research and innovation environments and contribute to promoting Danish space research, innovation and technology development within strategic priority areas (initiative 1).

The figure below gives an overview of the Danish government's expectations to a total financing level for space research, innovation and technology development with the strategy. This means that the entire financing increases by approximately 50% over a 10-year period from about DKK 522 million in 2025 to about DKK 771 million in 2035.

Total ambition level of the strategy, DKK million (2024-pl)



Comment: In the years 2025-2035 price development has not been taken into account (PL and HICP regulation) and neither have administrative contributions.

As part of the HERA project, ESA is going to send two small satellites into space to examine an asteroid, that NASA previously hit with a satellite in an attempt to change its orbit. The missions seek to enable us to defend against asteroids headed towards earth. The Danish enterprise GomSpace has produced one of the satellites, Juventas, which here landed safely in Florida from where it will be launched with a Falcon 9 rocket from SpaceX.

Photo: ESA

Stronger Danish research and innovation environments

Investments must be made in research, innovation and technology development in the space sector with a strategic and long-term perspective to accumulate capacity in the Danish research and innovation environments, attract and develop talent and disseminate space research and technology to other relevant research areas.

Denmark has proud traditions for research in scientific discoveries and technological development in the space sector. Within specific areas, this has placed Danish research institutions and companies at the very front as a valued partner in internationally recognised space missions in ESA and NASA. Strong research and innovation environments are essential, not only for scientific discoveries, but they also form the basis for development of new key technologies, start-ups and new solutions to the green transition and Denmark's security. At the same time, strong Danish research and innovation environments are drivers to attract foreign companies and venture capital to Denmark, and foreign investments can per se accelerate the development of innovative solutions.

By investing in national capacity-accumulating initiatives within research and innovation, it is the Danish government's ambition that Danish institutions and companies may participate to a larger extent in the scientific, technological and financial development taking form these years in the space sector. It applies particularly within areas in which the Danish positions of strength can be used, including within quantum technology, life science, green energy and environmental technologies, artificial intelligence, climate surveillance, digitalisation and the robot and drone sectors.

INITIATIVE 1

National space programme for research and innovation

Compared to other areas, the Danish research funding foundations - both private and public - make relatively limited investments in space research and innovation in the space sector specifically.

The Danish government therefore wants to establish a new national programme within space research and innovation under the Innovation Fund Denmark.

The main objective of the programme is to build capacity in the Danish research and innovation environments and boost strong private-public partnerships based on the actual projects supported by the programme.

It must be carried out through investments in the entire value chain - from talent development and attraction (PhD scholarships, post-docs) to ambitious research and innovation projects with high scientific, financial and societal impact and actual use cases/ demo projects which can disseminate and mature research findings for use and commercialisation.

The programme must be implemented via themed focus areas of relevance to the objective of the strategy, including new space-based green solutions, quantum and space-based communication as well as use of space data in combination with artificial intelligence, digital twins and supercomputers. The programme is to support both the strengths already possessed by Denmark within space technology and support areas in which Denmark can potentially build up future positions of strength.

ESA and the EU cooperate on the development of a new satellite programme which is going to give Europe access to secure communication based on quantum-key encryption.
Photo: ESA

Examples of strategic focus areas for implementation of the national space programme within research and innovation:

Green solutions
In a number of indicators for the impact of the research and public-private collaboration, Danish space-based green research is in the lead on a global level .[1] Space-based green researchcan be studies in climate, environmental, nature and biodiversity changes (such as development in wooded areas or ice sheet cover) over large distances and time via satellite data and pictures (earth observations) – among others. Space-based green research is also the preparation of wind maps based on satellite measurements, the use of positioning data from satellites for research into mobility, automation and precision agriculture and use of satellite data to improve weather and ocean prognoses for effective planning and forecasting.

Quantum technology
Denmark has a strong research position of strength in the quantum area with world-leading research communities and a budding Danish business sector. Further, with a national strategy for quantum technology (2023), the Danish government has made the framework of strengthening the entire ecosystem, from research and commercialisation to international collaboration and Denmark's security. At the same time, quantum technology includes a large potential for elevating security, power of resistance and the capacity in satellite-based services and communication. This is also reflected in the fact that in these years quantum technology is introduced in a number of EU's and ESA's space programmes and initiatives. This creates good preconditions for using Danish competencies and capabilities in both the space and quantum sectors for new solutions, i.a. within quantum encryption, quantum communication and quantum sensors.

Artificial intelligence, digital twins and supercomputers
Over the past years, a technological leap has been made within the use of machine learning and artificial intelligence having made it possible to use large quantities of satellite data. Simultaneously, e.g. with the collaboration of the Novo Nordisk Foundation and the Export and Investment Fund of Denmark (EIFO), a national centre for artificial intelligence has been established housing one of the world's most powerful AI supercomputers, which has created new potential for using space data. The supercomputer renders possible e.g. the development of advanced digital twins with the potential for supplying substantial contributions to the green transition and Denmark's security.

[1] *Source: Uddannelses- og Forskningsstyrelsen, 2022: Rumbaseret grøn forskning - Bibliometrisk analyse af Danmarks rumbaserede grønne forskning (Space-based green research - biometric analysis of Denmark's space-based green research)*

INITIATIVE 2

Development of scientific instruments

The access for Danish scientists and businesses to space often goes through international space missions under the auspices of ESA's Science Programme in which they contribute important technology and instruments. When a new mission is built, Danish and European businesses may bid for deliveries for the spacecraft, while the instruments are built and paid by instrument consortia comprising research institutions from participating countries.

The Danish government wants to strengthen and expand the capacity in Danish research institutions to develop scientific instruments, primarily in ESA, and thus enhance Denmark's participation in scientific missions.

The Danish government wishes to prioritise more funds for implementation through ESA's programme PRODEX over the coming years. PRODEX is a central measure for Danish scientists to obtain support for own activities in relation to development of scientific instruments. Through the programme, support can generally be sought for all phases for scientific instruments, facilities, hardware, etc., and for development of software using space. The programme also gives access to support of the research use of data which has not been a Danish priority so far.

The Danish Government will also initiate the preparation of a roadmap for Danish instrument development under PRODEX which seeks to support maximal scientific benefits and create an overview, structure and directions for the Danish priorities in a 10-year perspective.

INITIATIVE 3

Programme for national space missions

The Danish government will promote national space missions as a new strategic instrument through a new programme inspired by the scientific Ørsted satellite which is considered to be a significant driving force behind the development of today's Danish space sector. In the 1990s, the Ørsted satellite formed the foundation for a number of new technological and scientific competencies to be flown to and tested in space (i.a. current control, advanced stellar cameras and magnetometers, mapping of the earth's magnetic field and knowledge about system integration of satellites).

The programme for national space missions is going to contribute to enhancing the capacities in the Danish space sector by achieving results with a high scientific, financial and/or societal value creation. It may for instance be through new scientific or commercial breakthroughs, putting Denmark on the international space agenda, tying up closer international collaboration, increasing the growth layer of new startups and creating enthusiasm and interest for both science and space operations among children and young people. Thus, the space missions can have both a commercial and scientific aim.

The missions may also contribute to Danish defence, security and preparedness, the green transition and Danish businesses. By way of example, it may be to the benefit of the task solution of the Danish Defence and crisis management authorities, irrespective of whether it is about navigation in the icy Arctic waters, search, preparedness and rescue or military missions in prioritised areas, such as the Baltic Sea and Arctic regions. It may also be in the shape of better mapping of earth and thus the ability to measure and respond to changes in the climate, nature and biodiversity and enhanced weather and ocean prognoses.

The programme is anchored in the Danish Agency for Higher Education and Science and will i.a. be financed as part of the Danish contribution to ESA's optional programme activities. ESA provides Danish operators with access to required qualified assistance in relation to the technical solutions and project management of the mission, and the possibility to enter into international collaboration. The missions can also be co-financed by both private and public operators, nationally and internationally.

Over the coming 10 years, it is the ambition of the Danish government that up to four national space missions are selected and funded, including the Danish managed "Máni Mission" as the first potential national space mission. The Máni Mission entails large scientific and commercial perspectives aiming at improving earth's climate models and benefit future manned moon missions.

The Danish Agency for Higher Education and Science will, in cooperation with relevant authorities and a cadence following ESA's ministerial conferences every three years, call in project suggestions for implementing new national space missions.

Máni

Máni is the name of a Danish application to ESA about a mission to the moon. A Danish-managed consortium is behind the application, with the participation of i.a. the University of Copenhagen and Space Inventor A/S and a number of research institutions and businesses from Denmark and other European countries. The application arises from ESA's Space Exploration programme, and ESA has selected it to proceed together with a limited number of other applicants. A total number of two or three missions is expected to be realised.

The Máni Mission's purpose is to create multi-angular photometric observations of the moon which may have great importance to future manned trips to the moon, as the intention of the mission is to achieve a hitherto unseen picture resolution and level of detail of the moon's surface. In addition, technology and the actual measurements of the moon surface can be used to improve earth's climate models through better quantification of the earth's ability to reflect light (earth albedo).

With the scientific breakthroughs, the mission can provide visibility of Denmark as a space operator and create the fertile soil for new Danish positions of strength. Also, the mission will support innovation and growth in the Danish business sector, in that the Danish companies will deliver more of the critical components for the mission. Finally, a Danish moon mission may stir attention and enthusiasm for space operations and science in society and among children and young people.

The Ørsted mission launched in 1999 was epoch-making because it was the first Danish satellite in space, and because it simultaneously lifted the entire Danish space industry and research sector by virtue of the technologies and competences developed during the mission. Ørsted was to study the Earth's magnetic field.

Strategy for space research and innovation

ISS.
Danmark var med til at bygge rumstationen og sidenhen levere kritisk udstyr til astronauter. Mange danske forskere og virksomheder har brugt rumstationen til at udføre forsøg.

Foto: ESA.

International cooperation for the benefit of Denmark

Denmark should play a bigger international role in space research, innovation and technology development and to a greater degree influence the development in the area. At the same time, Danish research and technology must be protected against abuse, espionage, illegal acquisition activities and potential military use to the detriment of Denmark's security.

EU's space programmes and space infrastructure are important to the access of Danish authorities, scientists and businesses to space-based services, such as earth observation, positioning, timing and navigation services (GNSS) and communication. Denmark's contribution to building up the European space infrastructure is therefore important to Denmark's security and Europe's independent access to space infrastructure and services in a world characterised by geopolitical tension. It is also a central Danish priority in the EU and internationally that required initiatives are launched to ensure a more sustainable use of space, including by preventing space debris, to maintain space as a valuable resource to science, macroeconomics and security.

It is the ambition of the Danish government that Danish participation in international cooperation on research, innovation and development of space technology and services must be strengthened, both within the EU collaboration and with selected countries and operators outside the EU. In a situation with new great power competitions and security policy dynamics in space, there will also be increased need to include foreign political and security political considerations in the access to space technology.

INITIATIVE 4

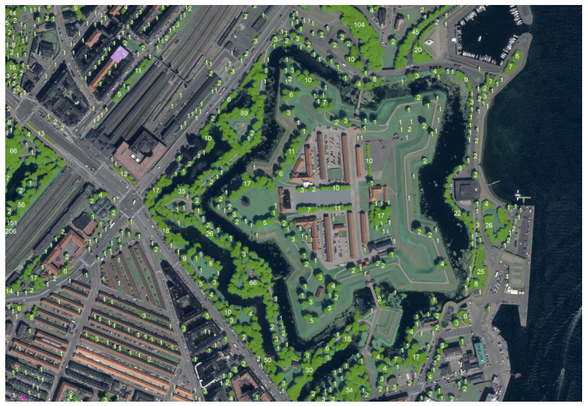
Danish participation in EU's space programmes and Horizon Europe

As Danish research and innovation environments build capacity in the space sector Danish operators should participate increasingly in the development of EU's space programmes. This is largely done through ESA programmes, which enable participation in European partnerships and consortia that provide solutions for the large tenders under the EU space programme. It is through ESA in particular that it is possible to participate in the development of the key technologies and solutions requested by the European Commission.

The research activities related to the development of EU's space programmes are performed in the context of Horizon Europe, which also focuses on inter-disciplinary solutions and collaboration products as a precondition for funding. Danish researchers, companies and authorities are therefore expected, over time, to also increase their participation in collaboration projects in the space sector under EU's Framework Programme for Research and Innovation, Horizon Europe, and in the space sector under the European Defence Fund (EDF) that support defence-related research and development activities.

To extend the Danish participation in both the space programmes, Horizon Europe, EDF and EUSPA, it is important to promote Danish interests in the framework of the EU. The Danish government will therefore work towards increasing influence on the formal and informal procedures and framework terms for participation in EU tenders, both under EU's space programmes, and also by promoting relevant advertisements in work programmes under Horizon Europe, EDF and EUSPA.

Furthermore, the option of co-financing Danish participation in relevant EU partnership, including Agriculture of Data and Euro-QCI, must be examined, and there must be focus on the national advisory efforts concerning the establishment of networks and consortia and application procedures. This will take place i.a. in the form of match-making and network events for Danish space operators in connection with new advertisements and upcoming working programmes in Horizon Europe in the space sector. On the part of Denmark, focus will be on the relationship between the space programmes, Horizon Europe and the European Defence Fund and through wise common EU approach to technology and double potential for use in the light of the global race for the technology development.



Tree cover map from Kastellet in Copenhagen developed by DHI Danmark based on AI training. The Horizon Europe project 100KTREEs is developing a tool to optimize the planting of trees and modelling of ecosystem services based on Copernicus data. By allocating financial value to the ecosystem services of the trees, such as reducing pollution, providing cooling, reducing noise and increasing biodiversity, the true value of the trees can be included in strategic and political decisions.

At the same time, Denmark will emphasize to support the EU in initiating required initiatives to ensure more sustainable and secure use of space, which is essential to maintain space as a valuable resource for science, economy and security. In that connection, an important Danish priority is the work with the EU's upcoming space law which is expected to establish a comprehensive and coherent legal framework for EU's space activities for the purpose of promoting i.a. security and sustainability in space, including the prevention of space debris.

EU's focus on space in a new geopolitical situation

The space programme in the EU has a budget of about DKK 111 billion (2021-2027) and comprises four elements: Galileo (positioning, navigation and dating), Copernicus (earth observation), GOVSATCOM (secure communication to authorities) and Space Situational Awareness (monitoring of space). The ambition of EU's space programme is to maintain EU's role as a global leader and stimulate European research, innovation, technology development, and growth.

Most recently in 2023, the EU has determined to invest in an independent European constellation of communication satellites - "Infrastructure for Resilience, Interconnectivity and Security by Satellite" (IRIS2). With a budget of about DKK 17.9 billion, IRIS2 will deliver encrypted communication to authorities and, over time, companies in the EU.

In the long term, it is the expectation that the EU will inject further investments in the space infrastructure. As part of the preparation for the next multi-year EU budget, the European Commission is e.g. identifying potential initiatives within the launch vehicle area and governmental earth observation services.

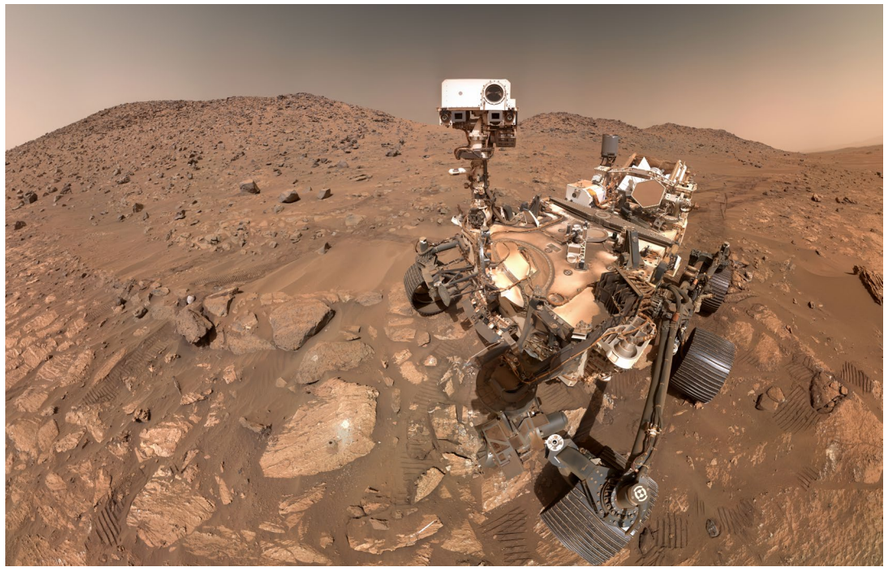
The space sector is increasingly addressed in other EU initiatives and contexts, in particular in the defence and security political arenas, where the EU has i.a. launched an EU space strategy for security and defence. The European Defence Fund (EDF) and the European Defence Agency (EDA) also focus on developing space capacities, which in the light of the geopolitical development should be expected to continue. Satellites will also be included in the roll-out of EuroQCI, EU's quantum communication infrastructure.

The changed geopolitical situation, with i.a. the war in Ukraine, has also stressed the need for resilient space systems secured against attacks that can be activated in security and defence situations, which the EU space strategy for security and defence is also an expression of.

INITIATIVE 5

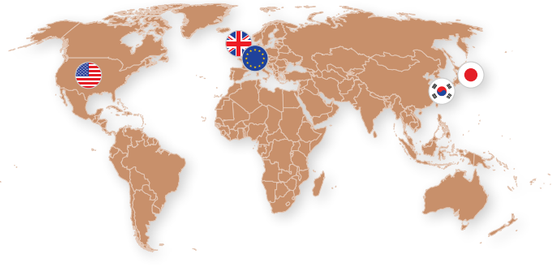
International cooperation to the benefit of Denmark

Some of the world's leading research and innovation environments in the space sector are located outside Europe, and therefore it is in Denmark's interest to enter into strategic collaboration with selected partners. Due to the close relationship g between space-based technology and geopolitical- and security policy considerations, international cooperation must take place in compliance with the guidelines from URIS[2], and based on reciprocity, serious risk assessments and thorough partner checks. Likewise, any relevant regulation must be observed. Thus, there are countries with strong research environments and ambitious goals regarding space where collaboration will be characterised by competition and complexity and cannot necessarily be based on mutual interests.



DTU and the University of Copenhagen have contributed to the development of important instruments for NASA's Perseverance Rover, which is taking samples and conducting experiments on Mars.
Photo: NSAS/JPL-Caltech/MSSS.

Outside the EU, it is particularly the United States, the United Kingdom, Japan and South Korea that stands out by large ambitions and strong environments for development and use of space technology, and where it is assessed that collaboration on research, innovation and technology development may be of special benefit to Danish interests. India and Israel also have big ambitions in the area. In that connection, it could be investigated further, how stronger collaboration can be to the benefit of Danish interests.



[2] URIS 2022 (The Committee on Guidelines for International Research and Innovation Collaboration)

Innovation Centre Denmark (ICDK) - the Danish innovation centres - are located in a number of the above countries and regions. The Danish government wants to exploit the global reach and network of the centres to strengthen Denmark's international partnerships with research institutions, authorities and companies in the space sector in countries outside the EU and thus give access to new knowledge, technology, talents and capital. Activities in the context of the innovation centres may be a mapping of local ecosystems, collaboration partners and financing sources, participation in relevant space conferences, arrangement of delegation visits for businesses and research institutions or talent development programmes focusing on innovation and entrepreneurship in partnership with private foundations, universities and companies.

Furthermore, the Ministry of Foreign Affairs of Denmark, via Invest in Denmark and in collaboration with the national cluster organisations, research institutions and other relevant parts of the national promotion of trade system, will identify and launch initiatives to attract foreign investments to the sector.

In parallel, the Danish government will look into the possibility of entering into strategic partnership agreements with authorities or space agencies in selected partner countries. The partnership agreements will be the framework of and facilitate cooperation at the institutional and business level and thus contribute to attracting more contracts to Danish operators.

There will be special focus on the collaboration with authorities, research institutions and companies in the United States. In that connection, Denmark accedes to the Artemis Accords, which is international collaboration on i.a. the use of the moon's resources, initiated by the US State Department and NASA.

Signing of the Artemis Accords
The Artemis Accords is a policy initiative developed by the American Foreign Ministry in cooperation with NASA, setting a common vision for the international partners in the American moon programme which is going to bring back humankind to the moon.

Signing of the accords strengthens Denmark's strategic partnership with the United States in the space sector to the benefit of both research and industry. The signing of the accords will be followed by an ambition for bilateral agreements with i.a. NASA, which are going to make it easier for Danish researchers, students, authorities and the industry to share knowledge and develop projects internationally.

Already today, Danish researchers work closely with NASA's research institutions on some of the world's most ambitious space projects on i.a. Mars and in relation to the James Webb telescope. It is still assessed that there is unused potential in areas such as earth observation, Science and Space Exploration.

INITIATIVE 6

Protection of Danish research and space technology

Denmark is an attractive international cooperation partner within a number of research and technology areas, including the space sector. This position is a significant basis for the development of new Danish research and technological solutions. However, at the same time Danish research institutions and knowledge-intense companies constitute attractive targets for espionage from or unwanted transfer of knowledge/technology to foreign states, including technologies that can be employed for military purposes.

Therefore, the Danish government will continue current initiatives to protect Danish research and technology, including within the space sector, while maintaining a dynamic international research environment in Denmark. It is the Danish government's goal that Denmark should still on par with the most restrictive countries in the EU and among like-minded countries, as long as Danish researchers are not precluded from the possibilities that their European colleagues have. At the same time, it still has to be possible to attract sought-after foreign talents and thus contribute to maintaining Danish positions of strength.

In general, the research security in Denmark has been strengthened. With the Guidelines for international research and innovation cooperation (URIS guidelines, see box) and close collaboration between relevant authorities and research institutions, Denmark has a good starting point. In the light of a significant and persistent threat environment[3] there is, however, need to pay attention to the security framework, including the awareness level and security organisation at research institutions and knowledge-intensive companies. Danish operators in the space sector must be able to draw on advice and assistance from relevant security authorities depending on the nature of the threat, so that Danish research is not used to promote foreign-policy targets from non-like-minded countries contrary to international law or Danish interests. Focus should be on launching security initiatives, including mitigation and tools to handle and decrease risks that counterbalance the threat against Danish research and innovation.

Recommendations for Danish universities and research institutions - URIS
In May 2022, the Ministry of Higher Education and Science Denmark's committee on guidelines for international research and innovation collaboration (URIS) published a number of recommendations which contain a new and stricter approach to international research cooperation. URIS recommends i.a. universities to identify and protect their research and investigate their international partners and delimit which research areas are subject to collaboration. Together with PET and other authorities, the Ministry of Higher Education and Science Denmark supports Danish universities' and research institutions' work with implementing the committee's guidelines.

[3] The national security and intelligence service PET, the assessment of the espionage threat against Denmark, the Faroe Islands, and Greenland

Photo: Adobe Stock, AI-genereret

Strategy for space research and innovation

Earthcare is a satellite which i.a. is to examine the importance of clouds to the global warming. The satellite is a part of ESA's programme for earth observation. The Danish company TERMA has contributed with software for testing the satellite.

Photo: ESA

Increased use of space research and technology

Denmark must to a greater extent transform space research and technology into innovative solutions to meet Denmark's security needs, contribute to solutions to the climate, nature and biodiversity crises and fulfil the business potential, including in the Danish space industry.

To reach the full potential of the space sector, the proper framework must be provided to transform research and technology development into innovative solutions. The use of space technology and space data in society must be increased, including by stimulating an attractive environment for development and demonstration of space technologies and space-based services. The Danish government has an ambition to increase revenue in the Danish space industry, and established companies outside the space sector should to a higher degree be able to use the potentials of space technology. It applies particularly within Danish positions of strength, including e.g. quantum technology, life science, green energy and environmental technologies, artificial intelligence, digitisation and the robotics sector.

The Danish government has taken its first step with the Agreement on the Package for Entrepreneurs, by which a number of initiatives have been launched to create a better framework for commercialisation of research in Denmark across research areas and sectors, which will also be of importance to the space sector and the growth layer of space companies in Denmark. This applies to i.a. the Danish government's ambition to improve business access to premises and facilities on campus in close contact with relevant research environments. With an amendment on the "Campus Act", the government will grant the universities more flexibility in relation to how they can offer companies, startups, etc. access to collaborate on research and innovation on campus. With the Strategy for Space Research and Innovation, the Danish government takes the next step to strengthen the growth layer in the Danish space sector.

INITIATIVE 7

Strengthening of ESA Business Incubator Denmark

ESA's Business Incubation Centre Denmark (ESA BIC DK) is a successful programme for entrepreneurship and innovation which has existed since 2020 and played a central role in creating a stronger culture for entrepreneurship in the space sector. ESA BIC DK was developed in partnership with the Danish Industry Foundation, The Otto Moensted Foundation and partners from the industry which ensures that the efforts are targeted at the industry's requirements. Companies that are enrolled in the programme become part of a 2-year incubation programme in which they are assigned to one of the four incubation environments anchored at the Technical University of Denmark (DTU), Aarhus University, Aalborg University and - from 2025 - University of Southern Denmark. The Export and Investment Fund of Denmark, ESA and Innovation Fund Denmark also participate in the selection of startups.

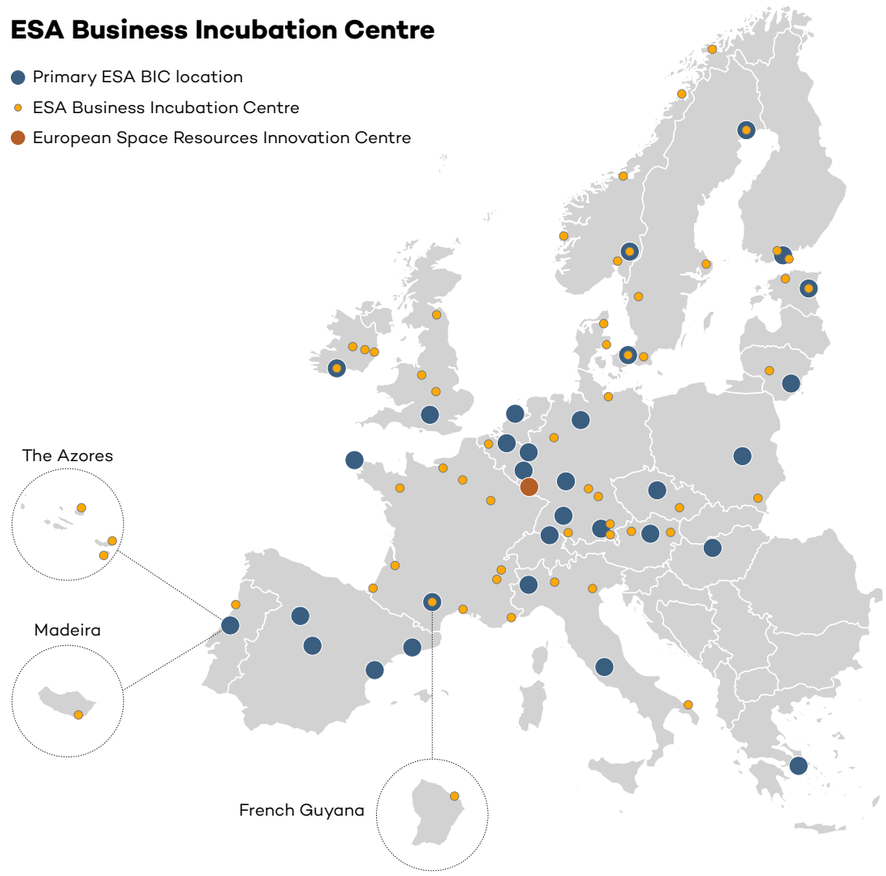
ESA BIC DK is also implementing a technology broker scheme to increase the number of companies that use space to optimise their products and services and attract new businesses to ESA's programmes. Based on ESA BIC DK's forecasts, it is expected that with the same efforts there is a basis for more than doubling the number of Danish companies in the space industry over the next 10 years - of which about 100 companies would be startups .

The Danish government therefore wants to retain the initiative, including the technology broker scheme, over the next 10 years.

First, the government will prolong the initiative to 2028 and also work to enhance it to include all Danish universities having an interest in participating and contributing. The continuation is backed up by the Danish Industry Foundation, which continues the investments in the development of the Danish ecosystem.

Future continuation and any extensions of the initiative must be determined and financed in connection with the Danish commitments to ESA's ministerial conferences. Financing needs and ambition level are adjusted with the other partners to the initiative, including ESA and the Danish Industry Foundation.

ESA Business Incubation Centre



The ESA BIC network is the largest network for European space-oriented startups. The network offers local commercial and technical support as well as a strong international community. In Denmark, the activities are distributed over three hubs at DTU, Aarhus University and Aalborg University. A fourth hub is being prepared at the University of Southern Denmark.

INITIATIVE 8

Development of a domestic market for space-based solutions

A number of Danish ministries and agencies are active users of data and products from space and have capacity and potential to develop the Danish domestic market for space-based solutions, for example through public-private partnerships or in the form of procurement of space-based services and services from companies.

Through the Interministerial Space Committee (DTR), more strategic collaboration will be established in order to i.a. speed up the authorities' use of satellite data. Among other things, focus must be on reducing barriers and facilitating new strategic partnerships on common authority requirements and solutions within green transition and Denmark's defence and security.

To the relevant extent, possibilities for co-financing can be incorporated, either through the national space programme in the context of Innovation Fund Denmark (initiative 1) or through relevant ESA programmes which may support new digital green solutions and the development and use of new dual use technologies. That can contribute to early testing and demonstration of relevant cases required to mature a sustainable business case, until the solution has been well tested and is directly applicable.

Throughout the work, DTR will focus on identifying material needs and requirements critical to society, potentials for collaboration about innovation and use of space-based data and services among the authorities and potential partnership models with companies and research institutions.

In addition, DTR will examine the need for establishing and investing in common space infrastructure on earth, i.a. earth stations to receive satellite data, and possibilities of common procurement and processing of space data with public users.

The Danish authorities
The competent national authority responsible for matters relating to regulation of Danish activities in outer space, including coordination and collaboration between Danish authorities with space-related areas of responsibility, is placed in the Ministry of Higher Education and Science Denmark through Royal decree dated 8 May 2015. Formalised cooperation between the ministries has been established through the establishment of the Interministerial Space Committee, chaired by the Ministry of Higher Education and Science Denmark.

INITIATIVE 9

Efforts to commercialise Danish space research and technology development

Today, there is an accelerating commercial development of the international space operations and space industry from which many new business models, types of use and business economics potential arise, including within production of materials, medicine, foods, robots and tourism and entertainment.

This development is fast, and thus it also requires strategic positioning if Danish businesses, institutions and authorities will have a share in the economic and technological growth.

In line with the build-up of capacity in the Danish space research and innovation environments, the Danish government will therefore launch a strategic initiative to support that the development will benefit Danish business community and society.

To speed up commercialisation of Danish space research and technology development, there is a need to highlight which commercial options the scientific, technological and economic development of space operations entail for the Danish business sector - both within and in particular outside the space sector. An important part of the work is to raise awareness of the potential applications of space technology so that Danish operators can better position themselves in the commercial development.

The efforts are implemented through Innovation Fund Denmark in the context of the national programme for space research and innovation under Innovation Fund Denmark, including i.a. implementation of actual roadmaps, use cases and demonstration projects, which can both target the efforts to the most obvious Danish positions of strength, and disseminate and mature research findings for application and commercialisation.

The Ministry of Foreign Affairs of Denmark will through the technology diplomacy effort, including through strengthened dialogue with relevant, foreign policy operators and the international space industry, also contribute to an increased knowledge level about the latest trends, potentials and possible foreign policy and security policy issues related to the rapid commercialisation of space technology.

New Space Economy
"New Space Economy" refers to a new era in space industry characterised by larger participation of private companies and entrepreneurs that drive innovation, commercialisation and economic growth in space. This differs from the conventional space industary which was primarily dominated by state operators such as ESA and NASA.

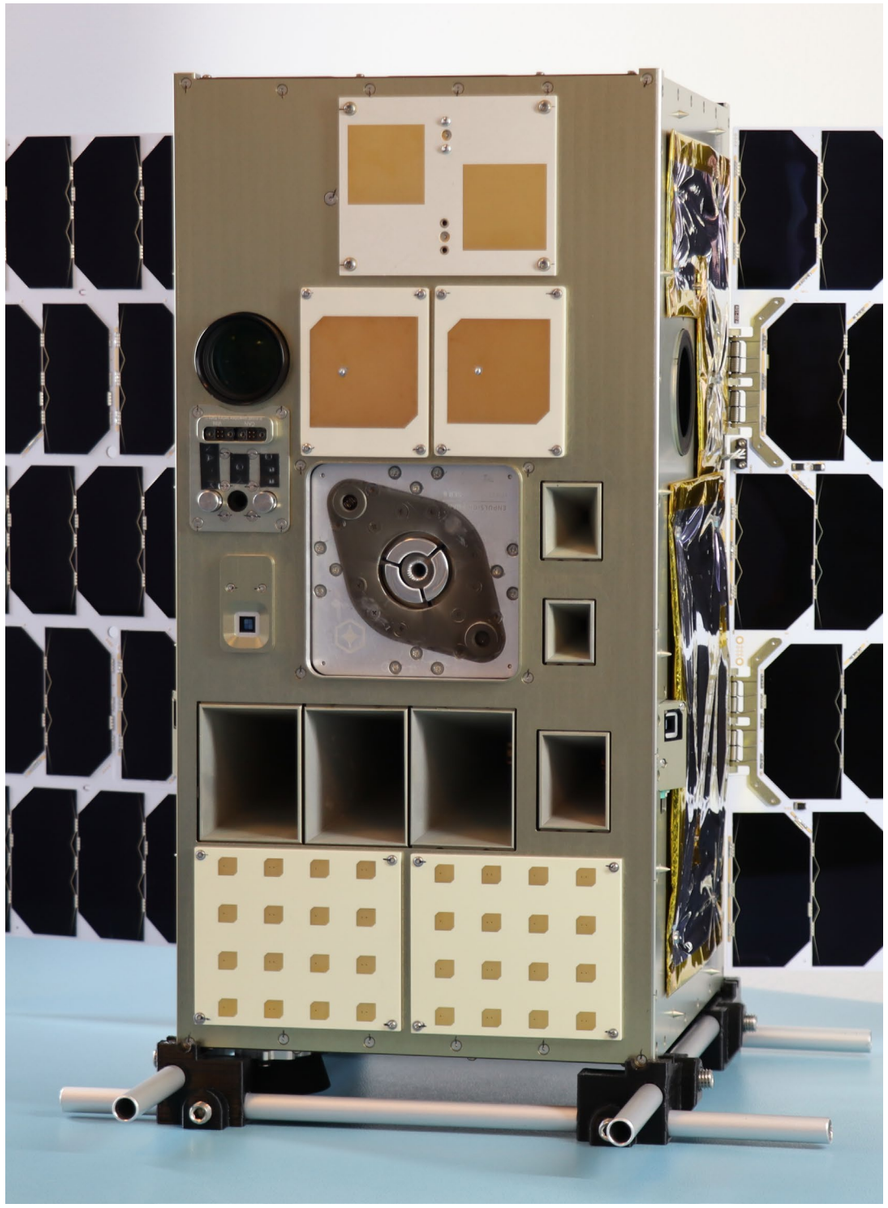
It also describes a development in which space goes from being a "final frontier" to becoming a "commercial frontier". The most recent forecasts of the global space economy estimate that the economy will grow from about USD 630 billion in 2023 to USD 1.8 trillion in 2040[4]. This growth is accelerated by new technologies, decreasing costs and a markedly rising interest from investors and private companies.

Starship is a launch vehicle, which is presently being developed by the American space company SpaceX. The aim is to build a 100 percent reusable launch vehicle. That can potentially be of great importance to space operations, i.a. because the price of launching to space is expected to decrease through reuse of the materials.

Photo: Official SpaceX Photos. Flickr

An example of what may be under way before 2030 is the reusable rocket "Starship" from the American space enterprise SpaceX. It is expected that the rocket can contain the same capacity as 10 lorries, and with daily launches it is expected to be able to freight goods and persons into space at almost the same price per kilo as air transportation. It can become a substantial driver of innovative product development and growth in many lines of industry. Also, a commercial alternative is prepared for the International Space Station (ISS), in which NASA and partners have decided to hand over the low Earth orbit (LEO) to the new space stations and decommission the ISS. In the commercial space stations, it is expected that there will be facilities for industrial development and production under zero gravity of i.a. advanced materials (such as optical fibres), elements of pharmaceutical products (such as proteins), ingredients to new types of food (such as crops) and advanced technologies.

[4] *McKinsey & Company: Space: "The $1.8 trillion opportunity for economic growth".*



Danish companies are good at producing small satellites. This Space 16U satellite from Space Inventor is the smallest type of satellite which has ever been sent into a geostationary orbit.

Photo: Space Inventor

Implementation of the strategy

The milestones and indicators for the strategy will be monitored on an ongoing basis by the Danish Ministry of Higher Education and Science. A midway assessment of the strategy will be made in 2030, and new initiatives can be launched on an ongoing basis according to need.

Implementation of the strategy requires increased activity and coordination of Denmark's public authorities in the space sector. The Government will therefore strengthen the competences of the Danish authorities and support an effective implementation of the strategy, including strengthened Danish interest representation and coordination across Danish Danish companies, authorities and institutions.
Today, Denmark has no national space agency, and the government believes that at present, Danish space interests can advantageously be elevated through the Danish Agency for Higher Education and Science in close cooperation with ESA. If, in the long term, more specific requirements arise that cannot be elevated with the present authority structure, the question of an establishment of a national space agency will be re-visited.

Dialogue Forum for Space-based Research and Innovation (DFRI)

The government will strengthen the dialogue with the many different operators in the space sector. The existing Forum for Space-based Research and Innovation (FRIF) will change its name to Dialogue Forum for Space-based Research and Innovation (DFRI) and be made the central forum for strategic discussions across sectors, including with the involvement and participation of educational and research institutions, public and private foundations, industrial associations, authorities and other central operators in the Danish space sector.

Today, FRIF works by bringing together the sectors and disseminating the knowledge of using space data, but DFRI must also in the future focus on advising the Ministry of Higher Education and Science Denmark on the implementation of the key action areas of the strategy and initiatives in broad terms, including Denmark's long-term commitment to and priorities in ESA, in the EU and in the collaboration with other international partners, including NASA. Likewise, DFRI may supplement and contribute with strategic contemplations and advice to the interministerial coordination in the Interministerial Space Committee (DTR).

The Danish Agency for Higher Education and Science will manage and serve the forum.

Appendix

7 Seven guiding principles for Denmark's long-term prioritisation in ESA.

1. A broad space agenda in ESA
The Danish contribution to ESA must have a broad investment profile in ESA's programmes and underpin that ESA will develop both the scientific and technological basis that Europe can act independently and be a central player, from exploration of our close solar system to new technology solutions on earth.

2. Long-term investments
The Danish contribution to ESA's selected technology and framework programmes must, to the widest extent possible, be binding over a number of years and thus contribute to Danish companies and researchers being able to position themselves in a long-term time perspective.

3. Capacity build-up
The Danish contribution to ESA should be used both to maintain and build up new competencies and capabilities, which are in demand from ESA and which have potential to support the national targets of the strategy.

4. Development of the Danish domestic market
The Danish contribution must contribute to strengthening the Danish domestic market for space technology, products and services, including in the Arctic regions. A well-functioning domestic market makes it possible to demonstrate and mature new technologies for the market before the technologies and products are marketed on a global level.

5. Prioritisation of ESA's framework programmes
ESA's framework programmes should be given priority to in the Danish contribution to ESA. The framework programmes provide ESA with the necessary flexibility and a possibility of placing the investments where they create the largest value to Europe and Denmark.

6. Complementarity and synergies between the national and the European agendas.
The Danish contribution to ESA should give priority to programmes in which complementarity and synergies can be obtained between national and European strategic goals, such as the green transition, European competitive power, strategic autonomy and security.

7. To the benefit of the entire society
The Danish contribution to ESA should not only be of benefit to development of the Danish space sector. Companies, researchers and authorities that are not primary operators in the Danish space sector, must to a greater extent than today, derive benefit from and access to the potential support and investment possibilities in ESA. That applies e.g. within the life sciences industry, the green energy sector, production of foods and the quantum, robot and drone sector in which the potential is assessed at being particularly large.