B 3 The German Space Sector Between Old and New Space

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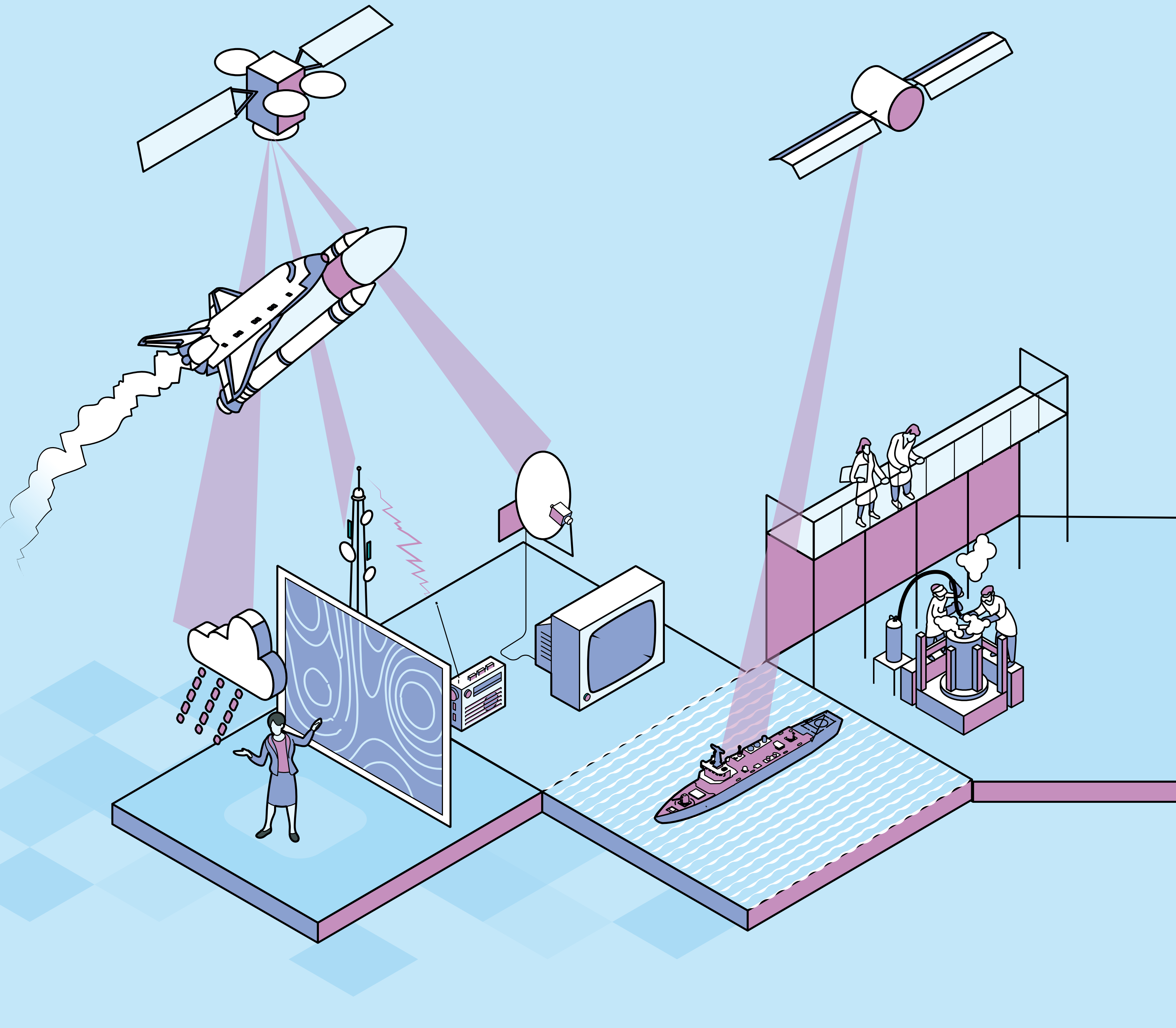
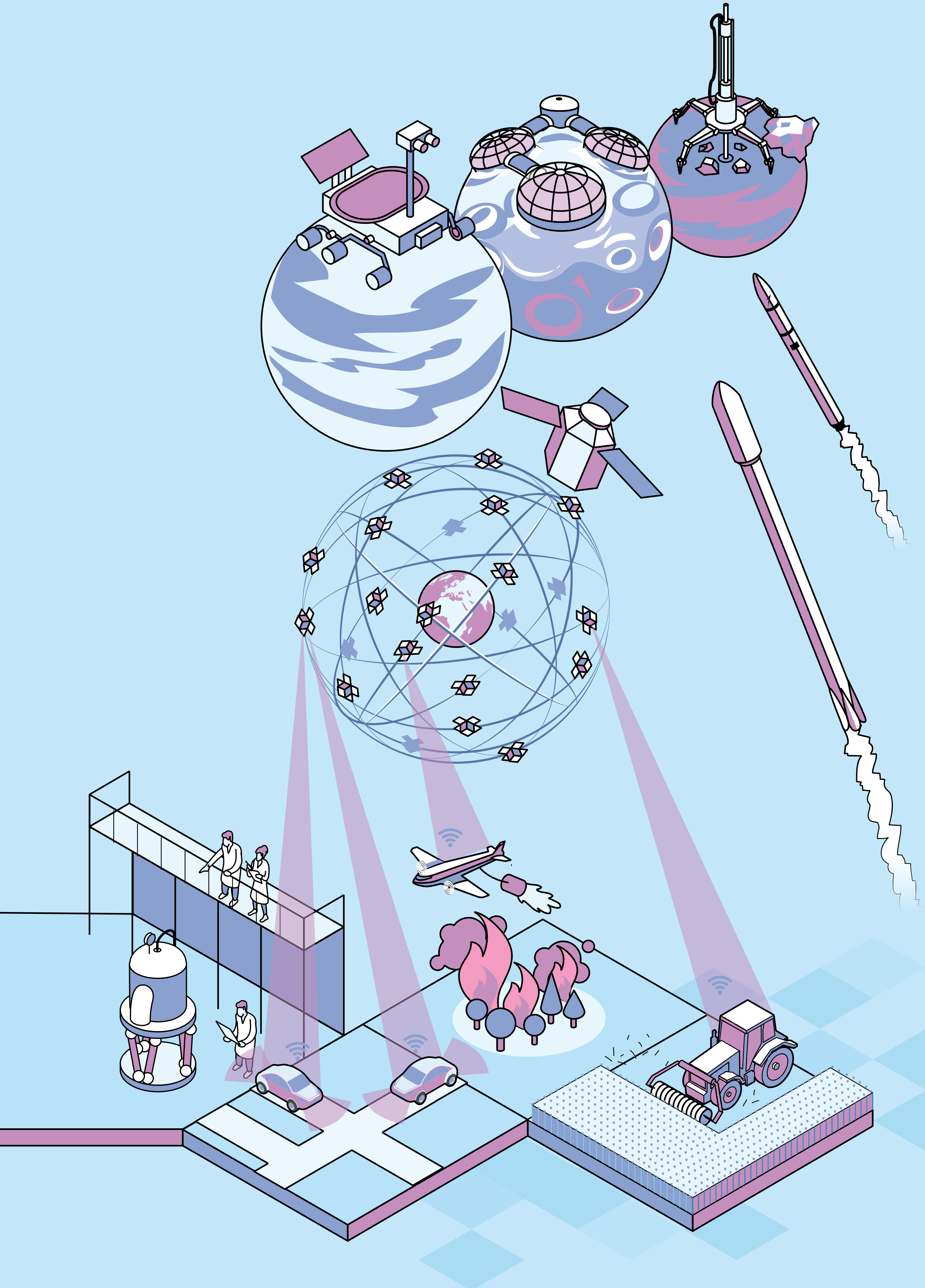
The space sector has changed rapidly worldwide in recent decades. Having been mainly state-managed until the 2000s, a strongly private-sector driven space industry is currently developing. However, the state still plays an important role – not least because of the high strategic relevance of space activity for the economy and society as well as the preservation of technological sovereignty. However, the space industry in Germany and Europe operates in an environment determined by pronounced national and supranational interests, a complex funding landscape and, in Germany, uncertainty about the future regulatory framework.





B 3 The German Space Sector Between Old and New Space

The space sector has changed rapidly worldwide in recent decades. Having been mainly state-managed until the 2000s, a strongly private-sector driven space industry has developed in the last decade. However, government agencies continue to play an important role, on the one hand as the driving forces behind major space programmes, and on the other hand as demanders of technologies and services for the civil and military sectors, especially for satellite communications, navigation, and Earth observation.

Space activities and technologies are of huge importance to modern society. Many people associate space activity primarily with basic research and exploration. However, the benefits of space activity now go far beyond this. Satellites have become indispensable for modern communication and navigation. Earth observation data are no longer only of military interest, but also assist in climate change research and disaster prevention. Products and services based on space developments are used in all areas of life. Equally, technologies developed in space are used in many other business sectors. This illustrates the cross-cutting nature of space technologies.

The growing importance of space flight is leading to an increase in both governmental and private activities in space. In turn, this creates new challenges such as collision avoidance and the removal of space debris, for which innovative solutions are needed. This results in opportunities particularly for start-ups and small and medium-sized enterprises (SMEs) to enter new markets.

An analysis of space patent activities shows that the European space industry can certainly keep up with US-American activities (cf. B 3-3). Nonetheless, Germany is lagging behind in terms of the regulatory framework for the successful commercial use of space flight. Hence, there is an urgent need for an interdepartmental space strategy adapted to the new realities of the space industry, which, among other things, emphasizes the strategic importance of satellite systems as critical infrastructure. In addition, Germany needs a space law to provide companies with a secure legal framework for their investments.

Increasing global challenges make it ever more important to maintain technological sovereignty in the European Union. Therefore, the joint use of satellite services for civil and military purposes should also be given greater focus.

B 3-1 Transformation of Space Flight

Blurring Boundaries between Old and New Space

Until the early 2000s, all space activities were essentially conducted by national and supranational space agencies such as NASA and Roscosmos. These traditional space activities, now called Old Space, had their beginnings in the 1950s and 1960s, when the two great powers, the Soviet Union and the USA, competed for technological leadership in space. National prestige played a considerable role in this.[317] But soon other objectives of public interest were pursued: on the one hand, military reconnaissance through satellite technology was of outstanding interest to the nations operating in space. On the other hand, space flight offered opportunities to observe the Earth from a new perspective for scientific purposes as well as to research the effects of weightlessness on living beings and materials.

However, all these objectives could only be pursued with public funding due to their high costs and the lack of private markets. In the USA, the corresponding contracts were specified by NASA and awarded to large companies such as Martin or Grumman.[318] From the mid-1970s onwards, other Western states followed this example,[319] awarding contracts to aerospace companies where the costs plus a fixed profit margin were borne by the state.[320] Although public contracts with high technical and specific requirements were carried out by private companies, no sales markets existed as yet to commercially exploit the technological developments beyond government demand.

This changed in the early 2000s, when private actors became increasingly active in space and have since been driving the commercialization of space activity with verve. This development gave rise to a new kind of space flight, New Space,[321] a term that stands for the commercialization of space activity and the growing number of private actors in the space sector. For one thing, the new private providers are tapping into new markets and customers with innovative services. For another, they are also fulfilling public contracts that had previously been performed by established companies. In addition, private-sector actors are emerging as demanders. The fact that public contracts are now also being awarded to young companies is not least due to the technology-open formulation of the tenders, enabling marketable innovations.[322] The space industry has now reached a new stage of development where private suppliers and customers operate on new markets based on the rules of the market economy. However, states continue to play a vital role as customers for products and services in both the military and civil sectors. They also act as contracting authorities and financiers of the space agencies. The dovetailing of traditional space activities with the markets of the new space industry blurs the boundaries between Old and New Space.

European Context Important for German Space Activities

In Germany, the Federal Ministry for Economic Affairs and Climate Protection (Bundesministerium für Wirtschaft und Klimaschutz, BMWK) oversees the Federal Government's space policy (cf. figure B 3-1). One of the Federal Government's objectives is to create framework conditions for an internationally competitive aerospace industry in Germany.[323] In this, the Federal Government is supported by the Coordinator of German Aerospace Policy based at the BMWK.[324] Under the Space Flight Tasks Transfer Act (Raumfahrtaufgabenübertragungsgesetz), administrative tasks in the field of space were transferred from the Federal Government to the German Aerospace Center (DLR) within the Helmholtz Association – the largest research centre for aerospace in Germany. Tasks include implementing the space strategy, developing and managing the national space programme, and representing German space interests at the international level, especially at the European Space Agency ESA. Other tasks include technology transfer, commercialization of space activity and promotion of the innovation potential of SMEs, which are handled at the DLR in an institution separate from research operations: the German Space Agency at the DLR.[325] To fulfil these tasks, the German Space Agency has the Federal Government's space budget at its disposal and awards funding and grants for space projects to science and industry.

At the same time, the DLR is active in space research with 20 of its total of 55 research institutes and generated revenue of €519 million in 2021.[326] This makes the DLR a key player in space research in Germany (cf. B 3-3). The DLR's research institutions are active in everything from basic research to product development. The Space Agency and the research institutions are assigned to different boards at the DLR. As both units belong to the DLR, the Space Agency cannot award contracts directly to the in-house research institutions, even though relevant expertise is concentrated there. The research institutions can only participate in the awarding of contracts through subcontracts from other parties. This means that the potential of the research institutions is not fully exploited.

Due to the cost-intensive nature of space activities, many projects are not implemented at the national level, but at the European level. This means that, in addition to the German institutions, the European institutions play a key role. The European Commission decides on and coordinates the space policy of the European Union (EU) and prepares a space programme every seven years, most recently for the period from 2021 to 2027. The implementation of the EU space policy is carried out by ESA and the EU Space Programme Agency (EUSPA), established in 2021.[327] EUSPA was created in connection with the new EU space programme and will in future be

Fig. B 3-1 Schematic representation of the actors in the German space sector

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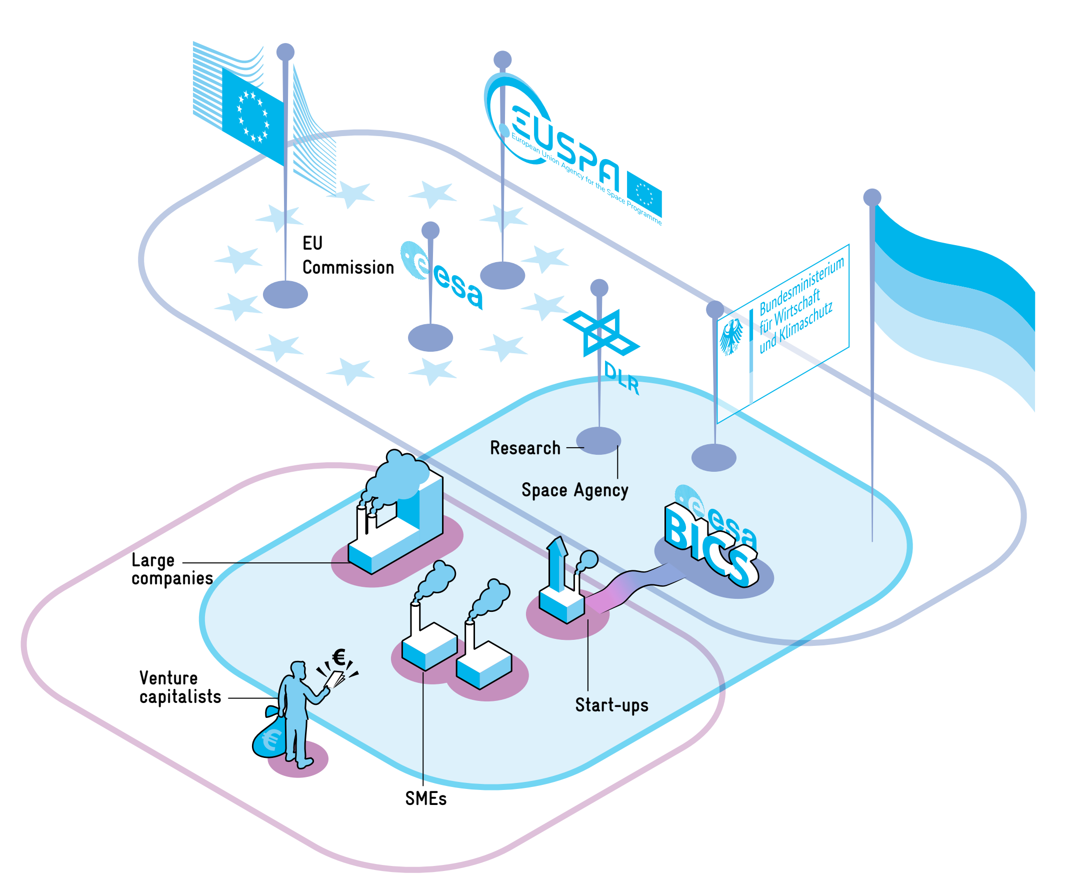

Source: Own representation.

responsible for market development, the operation of all EU space components[328] and their safety accreditation. EUSPA thus takes over responsibilities that previously lay with ESA. EUSPA, unlike ESA, is an agency of the EU and was established to ensure that the EU's investments in space flight result in value-adding activities for the EU.[329] In contrast, ESA is a space agency that is independent and autonomous from the EU. It should be noted that ESA's member states and those of the EU are not identical. Of ESA's 22 member states,[330] Norway, the UK and Switzerland are not members of the EU, while eight EU states are not part of ESA.[331] However, ESA, established in 1975, holds much of the space expertise in Europe and therefore remains responsible for the technical design and development of the EU's space programmes.[332] It also conducts major space exploration missions independently and in cooperation with national space agencies. ESA's member states commit to funding the space research programme based on the respective national gross domestic product (GDP) and may voluntarily participate in further commercial and scientific programmes of ESA.[333] Although ESA and EUSPA have different objectives, duplicate structures may arise if the two agencies' areas of responsibility are not clearly delineated.

Private Space Actors Mainly in Upstream Segment

According to the DLR's space catalogue (Raumfahrtkatalog), around 400 companies were active in the German space industry in 2018. These included both pure space companies and companies with a space division.[334] The German Aerospace Industries Association (Bundesverband der deutschen Luft- und Raumfahrtindustrie, BDLI) estimates that the German space industry will have a turnover of € 2.4 billion in 2021. Due to delivery bottlenecks, a pandemic-related reduction in the number of launches and delays in the construction of Ariane 6, turnover fell by € 0.6 billion compared to 2017. In contrast, the number of employees has remained almost constant at 9,300 over the same period.[335]

The activities of space actors can be divided into two segments: upstream and downstream. The upstream provides the scientific and technological basis for space programmes and space activities. This includes research on, and the development and production of, launch vehicles, spacecraft, satellites, control and command centres, and related parts and components. As such, the upstream segment provides a basis for downstream products, which includes any form of terrestrial use of space capacities such as data and signals from satellites.[336]

Among the space actors listed by DLR, 58 percent are active in the upstream, 19 percent in the downstream, and 16 percent in both segments.[337] The two largest German space companies are the Large System Integrators (LSIs) Airbus Defence and Space GmbH and OHB System AG, whose business model is to integrate subsystems into a whole.[338] In addition, 293 SMEs are listed by DLR, of which 103 are less than ten years old.[339] Some companies, such as Exolaunch, Mynaric, and Morpheus Space, emerged as spin-offs from research operations and offer upstream products.

Industry interests are represented nationally by the BDLI, the Federation of German Industries (Bundesverband der deutschen Industrie, BDI) with its New Space Initiative, and the German Society for Aeronautics and Astronautics (Deutsche Gesellschaft für Luft- und Raumfahrt, DGLR). In addition, there are four space cluster initiatives in Bavaria, Berlin/Brandenburg, the Lake Constance region and Bremen, which promote regional networking between politics, science, and industry.[340]

Start-ups in particular rely on venture capital providers and private investors in addition to public and European funding. Most investors are based in the USA, where the majority of all investments in early-stage space companies still take place. In Europe, most business angel and venture capital investors active in the space industry come from the UK. Investors from other European countries, including Germany, are much less represented.[341] ESA has initiated the ESA Business Incubation Centres (ESA BICs) to provide financial support and advisory services to early-stage start-ups. To this end, the ESA BICs are located in the participating member states at locations relevant to space ventures – in Germany, for example, in Bremen and at several Bavarian locations.[342]

Manifold Value-adding and Utilization Potential of Space Activities

The first activities in space began in the late 1950s in the USA and the Soviet Union in the upstream segment with the development of communication, navigation, and Earth observation satellites for military and scientific purposes (cf. box B 3-2). In addition, the first commercial applications quickly developed in the downstream segment, which were initially usually commissioned by the state – primarily in the field of satellite communications. For example, the first satellite-based live television broadcast was transmitted already in the early 1960s. By now, the use of satellite communication for commercial purposes is widespread: satellite television, radio and telephony, and soon a global satellite-based Internet.[343] These applications are mainly demanded by private users, but are also important for state actors.[344] Satellite communication competes with terrestrial infrastructures such as fibre optic cables and transmission towers, but in view of the increasing networking of devices in the Internet of Things, it is to be expected that the development of a powerful communication infrastructure will become an important driver of commercial satellite communication systems.[345]

Satellite-based navigation was initially only used for military purposes and for determining the position of warships. It was not until the late 1960s that navigation satellites could also be used commercially in the downstream segment.[346] Nowadays, people around the world can use navigation services as well as positioning and timing systems using GPS or Galileo for orientation. The transformation in the transport system, especially through autonomous driving and sustainable logistics, as well as a growing demand for location-based services and innovations in precision agriculture, suggest increases in demand in this area.[347]

In the 1950s, developments in the category of Earth observation were still mainly driven by science. Earth observation data were also used for weather forecasting and cartography as early as the 1960s.[348] Meanwhile, the large amount of such data[349] enables a wide range of downstream applications, such as tracking global changes due to climate change quickly and over a wide area. Authorities can use satellite data to improve spatial planning, track illegal activities, and manage disasters and crises. Private-sector players include agriculture, which can use it to determine the irrigation needs or maturity of crops, and various industries, allowing them to track logistics chains and find out about competitors' activities.[350] Earth observation still accounted for a very small part of global downstream revenue in 2016, at 1.65 percent,[351] but it has been gaining in importance ever since. Above all, the generally free access to scientific Earth observation data is driving the development of new business models in the downstream segment.[352]

Box B 3-2 Classification of Space Activities and Technologies[353]

The OECD classifies space activities into the following separate categories:[354]

Satellite communication comprises the development and use of satellites and related subsystems to send signals to Earth. These systems form the basis for satellite-based TV and radio services, satellite-based voice services and data transmission as an alternative to terrestrial networks.

Positioning, navigation, timing involve the development and use of satellites and related subsystems to determine location and time for terrestrial applications. Satellite-based navigation is an elementary technology, for example, in land, air and maritime transport, and is increasing in importance because of technological developments such as autonomous driving.

Earth observation involves the development and use of satellites and related subsystems to generate data from observation of the Earth's surface, such as data on environmental changes and human activities. Technological developments in recent years have significantly increased the supply of and the demand for products in this field. Examples include military applications as well as the provision and analysis of climate data.

Space transportation includes the development and use of launch vehicles and related subsystems. In addition to launch vehicles, this field also includes spaceports, space tourism, and interorbital transport.

Space exploration includes the development and use of crewed and uncrewed space vehicles such as spacecraft, space stations, rovers and probes to explore the universe beyond Earth's atmosphere, for example, the Moon, Mars, and asteroids.

Science includes scientific activities related to space flight and the study of space phenomena and other celestial bodies. Examples include research in astrophysics and space-related life sciences.

Space technologies includes specific space system technologies that are used in various space missions. Examples include space nuclear systems for power and propulsion and solar electric propulsion.

Generic technologies or components that may enable space capabilities includes technologies that were not initially intended for use on a specific space system or for a specific space application but may then lead to new products and services, such as artificial intelligence and data analytics software.

In addition, the development of further space activities is to be expected in the future, which are not yet explicitly assigned to the above-mentioned categories. These include, in the medium term, technologies for collision avoidance in space and, in the long term, technologies in space mining and the manufacture of objects in space, so-called in-orbit manufacturing.[355]

While some categories clearly belong to either the upstream or the downstream, e.g. transport to space belongs to the upstream, most include elements of both the upstream and the downstream segment. In satellite communications, for example, the development and production of satellites is part of the upstream, while their use, for example, for satellite telecommunication services and satellite-based Internet, is part of the downstream.

The demand for communication, navigation, and Earth observation services in the downstream segment is expected to continue to grow. Especially the utilization potential in the public sector has hardly been identified and exploited.[356] A functioning satellite infrastructure is also of foremost importance for a high-performance Internet of Things and autonomous driving over a wide area.

In the upstream segment, established large companies have long implemented the specific technical demands of the space agencies. In the 2000s, emerging private companies started to greatly reduce the cost of manufacturing launch vehicles (most notably SpaceX) and payloads through the use of standardized components,[357] miniaturization, mass production, and reusable parts.[358] The miniaturization of payloads[359] has spurred the development of microlaunchers[360] that can deliver these payloads directly into target orbit at the desired time.[361] Cost degression and weight reduction foster competition in the upstream segment between new and established companies.[362] Meanwhile, innovations in the upstream segment are enabling business models in both segments. One example of an upstream business model is space tourism, which will continue to be the preserve of a small group of very wealthy individuals well into the future.[363] Further commercial potential lies in the mining of resources on asteroids and planets. Associated with this are visions of populating other planets, but this is likely to be of secondary relevance in the near future due to exorbitant costs and unsolved technical problems.

Being public goods, some potential uses of space activities cannot be commercialized without government demand. These include the protection of the Earth from meteorite and asteroid impacts,[364] the removal of space debris and traffic management in space to avoid collisions.[365] This opens opportunities for companies to develop and market technological solutions to these problems.

The diversity of potential uses of space activities demonstrates their cross-cutting nature. The technologies developed in this field are applied far beyond the space industry. These include innovations in the field of robotics and sensor technology. Accordingly, the INNOspace initiative of the German Space Agency aims to strengthen the transfer between the space industry and the non-space industry.[366]

B 3-2 Special Characteristics of Space Markets

Market Structures Highly Concentrated in Parts of Upstream Segment

The development of large launch vehicles in the upstream segment is associated with high investment requirements and long research and development periods. Large companies have an inherent competitive advantage here over SMEs and start-ups, as they can produce a wider range of components and exploit synergies.

Innovations in the upstream and downstream segments are mutually reinforcing. Cost reductions in the upstream[367] facilitate the construction and cost-effective operation of space infrastructures, which in turn unlocks additional profitable business models in the downstream segment. The resulting increase in demand for satellites, launch vehicles, and ground stations in the upstream segment leads to further production advantages through economies of scale.[368] Initial public procurement may be required to trigger these positive reinforcement effects between the upstream and downstream segments.

In parts of the upstream segment, monopolistic or at least highly concentrated market structures can emerge, which negatively affect the downstream segment. In addition to high fixed costs, the number of providers is restricted by the limited capacity of the relevant low earth orbit and a limitation of available radio frequencies.[369]

Satellite Systems as Critical Infrastructure of Strategic Importance

Not only private-sector activities in the downstream segment are dependent on a functioning space infrastructure. It is also essential for an increasing number of government tasks.[370] Satellite-based systems are required where the quality, applicability, and availability of Earth-based alternatives have their limits. For example, radio and wired data transmission are currently still common alternatives to satellite-based communications.[371] Although substitutes for satellite-based navigation are available and used in aviation, they are not suitable for private navigation applications. No terrestrial alternatives are available in the field of Earth Observation.

The space sector is of strategic importance because a large number of private and public actors depend on a functioning space infrastructure. This justifies calls for a minimum level of technological sovereignty at national or at least European level. The space sector has been identified as a critical infrastructure in the EU's Critical Entities Resilience Directive. The associated security obligations are expected to come into force in Germany in 2023 as part of the Critical infrastructures 'umbrella law' (Kritische Infrastrukturen Dachgesetz, KRITIS).[372]

Space-related services such as satellite transports are not provided by all countries but are available on the international market. Yet recent developments like the loss of Russian space transport services due to the war in Ukraine and the increased dependency on SpaceX due to delays in Ariane 6 illustrate the fragility of access to transport options for payloads. Dependencies of this kind can go hand in hand with a loss of technological sovereignty. However, the desire to ensure independence by way of a domestic space infrastructure must be weighed against the high costs of space activities and the inefficiencies of building parallel national infrastructures. This often leads to solutions at the European level, as demonstrated by Galileo, Copernicus, and other programmes.[373]

Civil-military Use of Space Flight with Potential

Like many other so-called dual-use technologies, space technologies can be used for both civilian and military purposes.[374] This has ambivalent consequences for commercialization. A potential military use increases government demand for space products and services, thereby increasing the potential for commercialization. Likewise, there is potential for synergy effects, such as in the joint civil-military use of space infrastructures. This can make projects profitable that would not pay off if used exclusively for civilian purposes. The potential for military use means that there is often an interest in maintaining or expanding production capacities either domestically or at least in cooperation with partner nations. However, military usability also means that sales to other countries are possible only to a limited extent due to export regulations or, in light of increasing geopolitical tensions, only with a high degree of uncertainty. The uncertainty of international business opportunities for space products limits their commercialization potential.

Against the backdrop of these tensions, physical security and cybersecurity of space infrastructures are also increasingly coming into focus.[375] As communications and navigation capabilities are heavily dependent on satellites, these critical infrastructures could be increasingly exposed to potential military attacks.[376] Private space activities could thus find themselves exposed to increased business risk.

B 3-3 Space Patent Activities

In the following, patent activities and market shares in the space sector are examined globally and compared to other countries to describe Germany's position in international competition. Patent applications are an important indicator of the innovative strength of an industry and the nations involved. The basis for this is a study conducted by the Commission of Experts on transnational patent applications[377] in the space sector for the period from 1980 to 2018.

Patent Activities Increasing Worldwide

The number of transnational patent applications in space technologies has increased significantly worldwide since 1980 (cf. figure B 3-3). The USA is mostly ahead of France and Germany over the entire period from 1980 to 2018. In the 2000s, Japan and China managed to catch up. A significant increase in patent applications has been observed in the USA, especially since 2001. Countries such as France, Japan, and, to a lesser extent, Germany have also seen a strong increase in patent applications since 2005. Adding up the patent applications of the ESA member states or the EU 27 including the UK[378] shows that European patent activities have been at a higher level than those of the USA in most years since 1980.

A distinction between the upstream and downstream segments reveals that there have been more transnational patent applications in the upstream segment worldwide over the entire period.[379] Furthermore, significant growth rates in global patent activity were observed in the upstream technologies from 2010 onwards, but in the downstream technologies not before 2014. The reason for this time lag is that developments in the downstream segment can only emerge after a successful development in the upstream segment.

Fig. B 3-3 Number of transnational space patent applications of selected countries and regions 1980–2018

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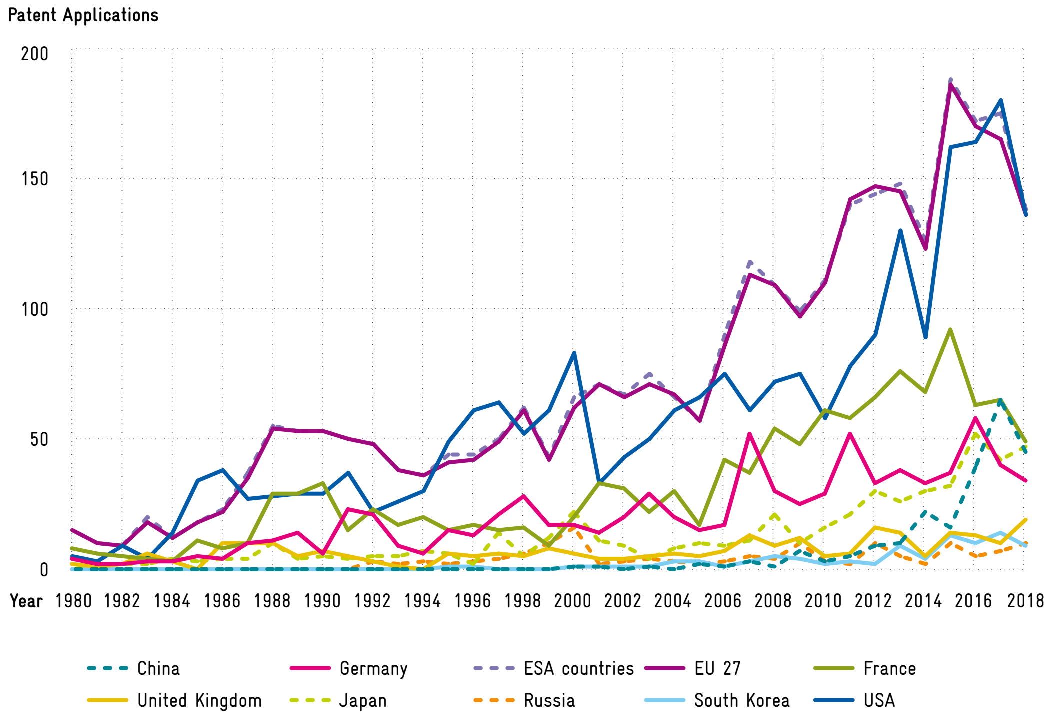

Source: PATSTAT. Own calculations.

High Quality of German Space Patents

Based on the analysis of highly cited transnational patent applications in the field of space flight with at least ten citations[380] as a quality characteristic, Europe was able to catch up with the USA in the period from 2000 to 2018 (cf. figure B 3-4). In the country comparison, the USA leads by a clear margin. Germany is only just behind France in third position. Between 2000 and 2018, the number of highly cited transnational patent applications in the field of space technologies from Germany increased by a factor of 1.49 compared to the period from 1980 to 1999. Thus, Germany has the highest change factor (CF) of the three leading filing countries. South Korea and Russia have larger change factors but are at a lower level in absolute terms. These figures suggest that Germany is a strong innovator in space technologies.

Germany Specializing in Transportation and Navigation

An analysis of transnational patent applications for the categories defined by the OECD (cf. box B 3-2) shows that most patent applications between 1980 and 1999, both worldwide and in Germany, were in the categories of space transportation, satellite communications, navigation, and Earth observation (cf. figure B 3-5). The most dynamic development, measured by the change factors, can be seen worldwide and in Germany in the categories of navigation and Earth observation.

The normalized relative patent shares (RPS) reflect the degree of specialization of the countries within the space technologies. Figure B 3-6 illustrates the development in the four categories with the highest number of worldwide patent applications. From 1980 to 1999, Germany shows a below-average degree of specialization in these categories.

Between 2010 and 2018, Germany then specialized in transportation and navigation. The ESA countries considered in the analysis (Germany, France, the UK) jointly cover all four categories with their specializations, while the USA only specializes in transportation and satellite communications.

Large Companies and Space Agencies Lead in Patent Applications

Among the organizations with the most transnational patent applications in the field of space technologies, Airbus leads with 695 patent applications, well ahead of Thales and Boeing (cf. figure B 3-7). The 25 strongest applicants include large companies, most of which are active not only in astronautics but also in aeronautics and armaments, as well as a few space agencies and research institutions. These include, in particular, the French space agency CNES in fourth place and the DLR in 12th place.[381] The 25 strongest applicants account for a share of 50.7 percent of the total transnational patent applications between 2000 and 2018.

Looking at the patent applications with German participation, the ten strongest applicants mainly include large organizations whose main activity is in aerospace (cf. figure B 3-8). The list is headed by Airbus, followed by the DLR. The DLR, the Fraunhofer-Gesellschaft and the Technical University of Dresden are the only research institutions among the top 10 applicants. In addition to these organi-

Fig. B 3-4 Number of highly cited transnational space patent applications of selected countries and regions 1980–1999 and 2000–2018

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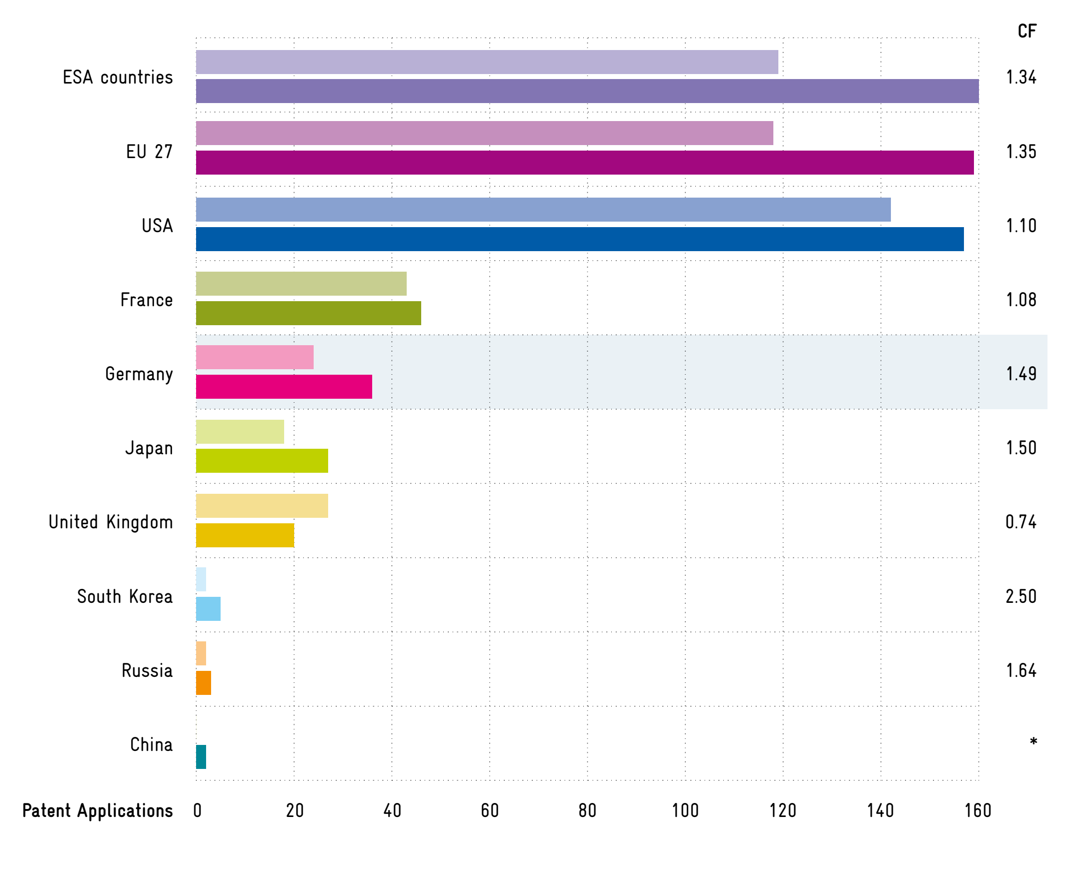

* is used if no change factor (CF) can be calculated due to a lack of data. The lighter shade shows the number of patent applications in the years 1980–1999, the darker shade those in the years 2000–2018.
Legend: The USA had a total of 142 highly cited transnational patent applications in the space field in the period 1980–1999 and a total of 157 in the period 2000–2018. This corresponds to a change factor of 1.10.
Source: PATSTAT. Own calculations.

zations, Henkel, a company not directly involved in the aerospace industry, is also listed, in 7th place.[382] The only younger German companies[383] that filed transnational patents between 2000 and 2018 are Exolaunch and Morpheus Space, each with one patent application.

B 3-4 General Conditions for the Space Industry in Germany

New Space Strategy Initiated

The Federal Government's currently valid space strategy dates from 2010 and therefore takes insufficient account of many current developments, in particular the increasing commercialization of space activity.[384] In autumn 2022, the Coordinator of German Aerospace Policy launched the process of drawing up a new space strategy. An impulse paper by the BMWK on the new space strategy from October 2022 defines six priority fields of action.[385] Commercialization in the space sector is at the forefront of the impulse paper and throughout all the fields of action named there. In contrast to the 2010 space strategy, however, the need for a German space law is not mentioned. Since the space sector relies heavily on government contracts, the current lack of clarity about the new space strategy increases the already existing uncertainties about the market potential of their business models, especially for SMEs and start-ups.

Fig. B 3-5 Number of transnational space patent applications by OECD classes worldwide and in Germany 1980–1999 and 2000–2018

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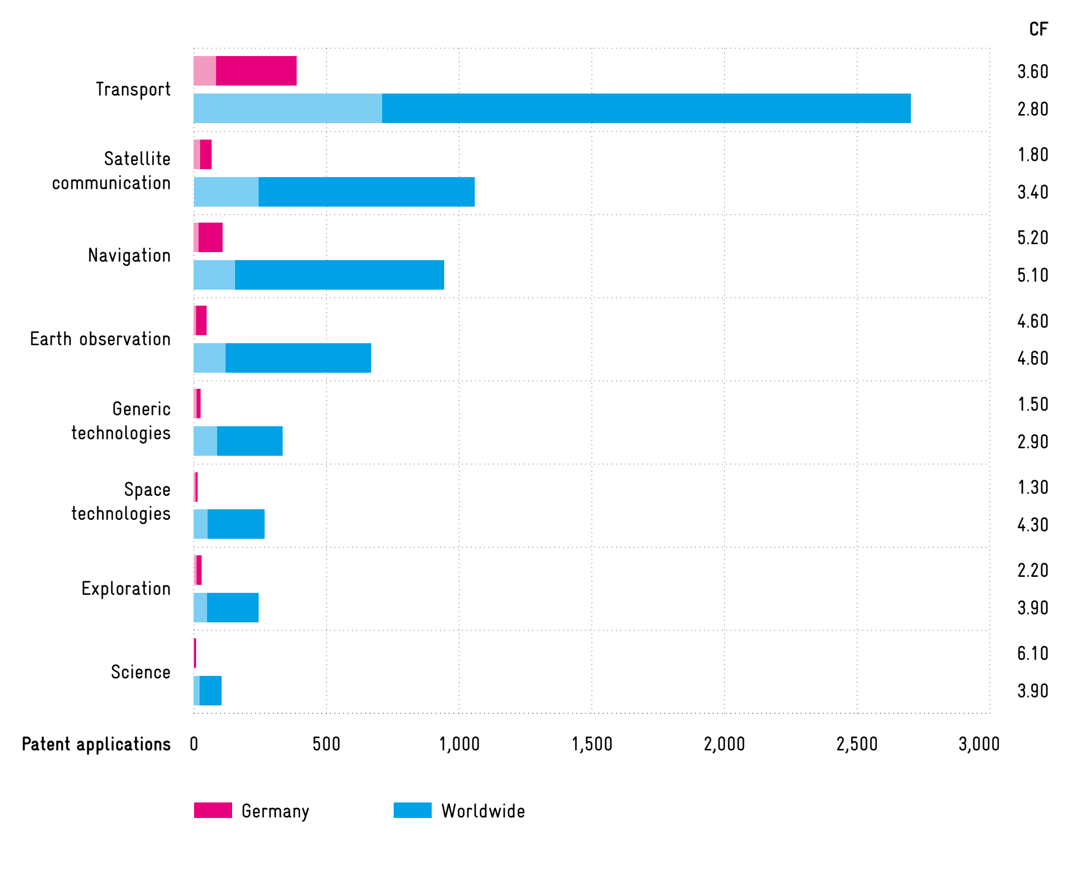

The lighter shade shows the number of patent applications in the years 1980–1999, the darker shade those in the years 2000–2018.
Legend: In the field of transport, just under 710 transnational patents were filed worldwide in the period 1980–1999, compared to a total of 1,992 applications for the period 2000–2018. The change factor (CF) shows that the number of patents in transport has increased by a factor of 2.80 worldwide.
Source: PATSTAT. Own calculations.

German Space Law Not Yet in Sight

Under international law, the German state bears responsibility for all space activities on German territory and by German actors, including non-state actors. This responsibility includes liability for damage to third parties. However, a national space law that regulates at least core elements such as a registration and licensing obligation as well as private (co-)liability is still missing. A national register for space objects does exist, but in the absence of a law, there is no registration obligation. In this respect, Germany is failing to adequately fulfil its obligations under international law arising from the Outer Space Treaty of 1967. A uniform space law at the EU level is not to be expected.[386] Nevertheless,

Fig. B 3-6 Normalized relative patent shares of selected countries by OECD class 1980–1999 and 2000–2018

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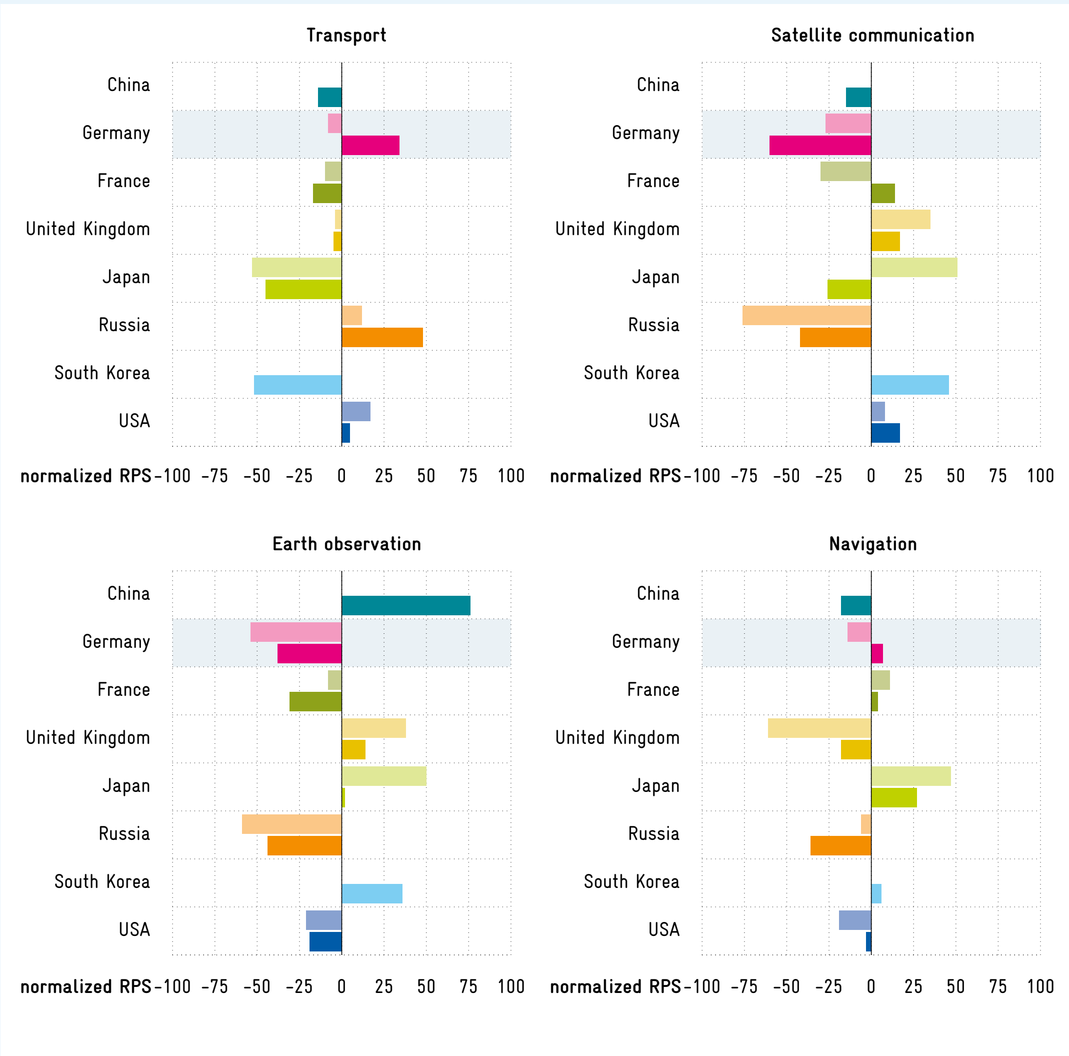


Normalized RPS of the individual classes measured against all space patents. The lighter shade shows the normalized RPS for the period 1980–1999, the darker shade that for the period 2000–2018. No RPS can be calculated for China and South Korea for the period 1980–1999. The (non-normalized) RPS for technology field j in country i is calculated as follows: $RPS = (p_{ij}/\sum_i p_{ij})/(\sum_j p_{ij}/\sum_{ij} p_{ij})$.
The normalized RPS is calculated from the (non-normalized) RPS as follows: Normalized RPS= 100 * tanh ln (RPS). Cf. Sievers and Grimm, 2022.
Legend: The USA has a normalized RPS of 17 for transport in the period 1980–1999. This is based on a non-normalized RPS of 1.184. This value indicates that the USA's share of all space patents in the field of transport during this period is 118.4 percent of the USA's share of all space patents – which is above average.
Germany has a normalized RPS of -38 for Earth observation in the period 2000–2018. This is based on a non-normalized RPS of 0.667. This value indicates that Germany's share of all space patents in the field of Earth observation during this period is 66.7 percent of Germany's share of all space patents – which is below average.
Source: PATSTAT. Own calculations.

there are calls for coordination at the European and wider international level to prevent a race to the weakest regulation.[387]

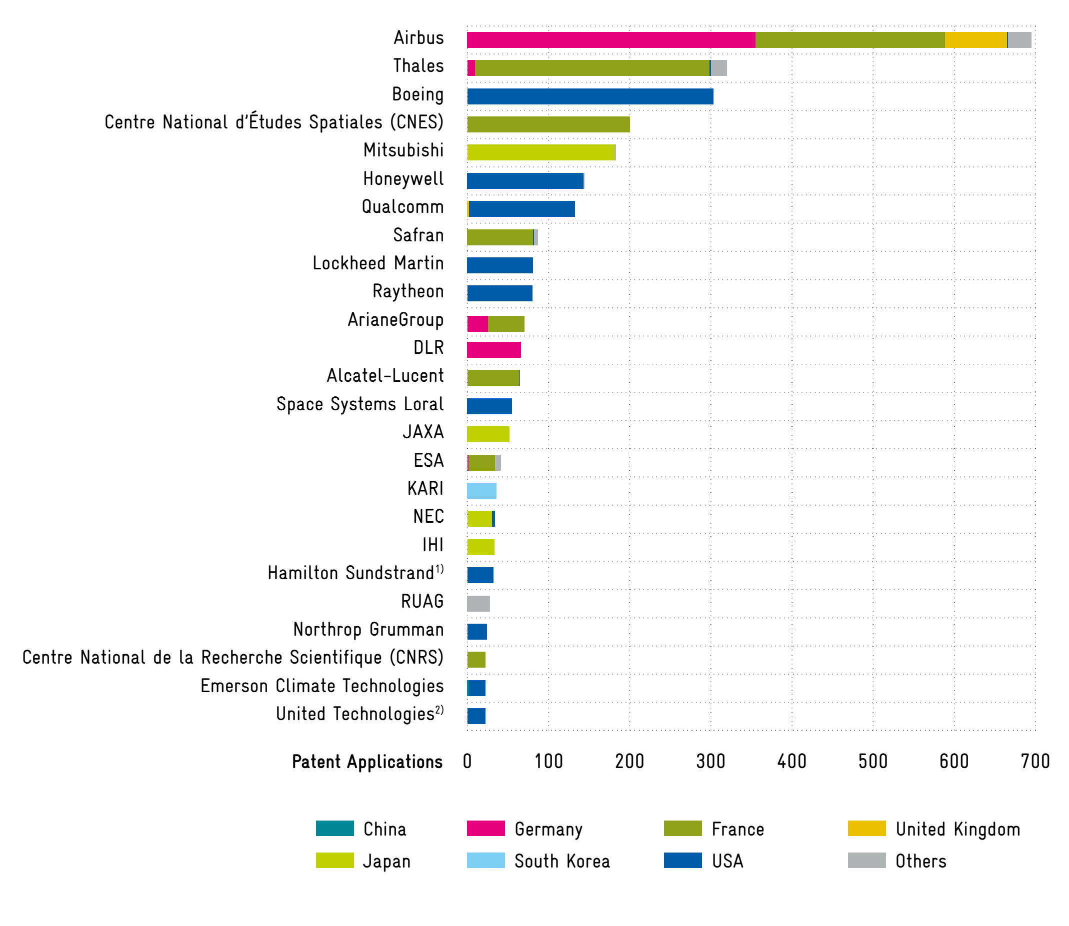
To ensure that private actors adequately address the risks of their space projects, national space laws typically provide for (co-)liability coupled with compulsory insurance. If the state is held liable for damage by a private actor, the state can take recourse against the perpetrator up to the amount of the compulsory insurance. If the actor is held liable for the damage under civil law, they are liable up to the amount of the compulsory insurance, above which the state is liable as guarantor. High liability limits can lead to insurance costs that represent a barrier to market entry, for example for micro-satellite projects.[388] Internationally, liability limits around € 60 million are common.[389]

A study commissioned by the Commission of Experts[390] identifies further elements that a national space law should contain as a minimum, such as regulations on the avoidance and disposal of space debris. It also advocates the establishment of an authority with sufficient budget and staff to be responsible for licensing procedures and monitoring the legal framework.

The Satellite Data Security Act of 2007 regulates private remote sensing and the commercialization of data in Germany. The law provides for a mandatory permit for the generation of security-relevant data

Fig. B 3-7 Number of transnational space patent applications by top applicants 2000–2018

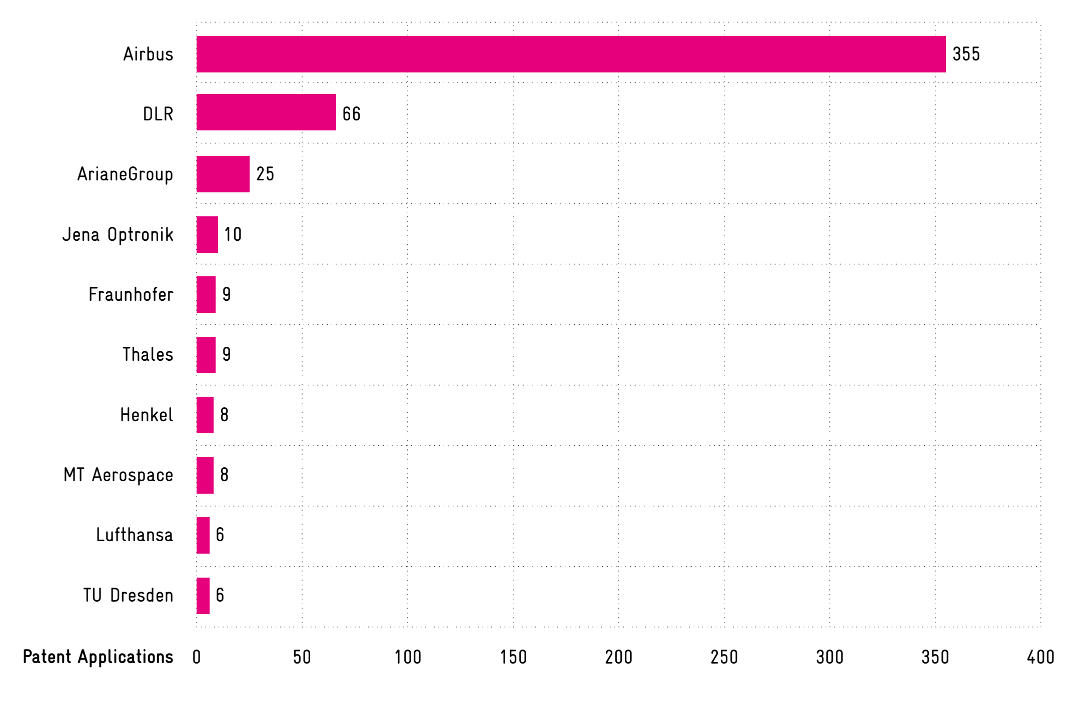
Download Data



[1] Hamilton Sundstrand was merged with Goodrich Corporation in 2012 to form UTC Aerospace Systems.
[2] United Technologies was merged with Raytheon in 2020.
The patent applications of the institutions are arranged based on participation of the selected countries.
Source: PATSTAT. Own calculations.

Fig. B 3-8 Number of transnational space patent applications by German organizations 2000–2018

Download Data



For multinational companies such as Airbus, ArianeGroup and Thales, the respective patent applications of the German subsidiaries are counted.
Source: PATSTAT. Own calculations.

with high information content, such as high-resolution imagery. However, the technical thresholds in the associated ordinance, above which a sensitivity check of Earth observation data must take place, are no longer up to date. For example, data for which a permit is still required in Germany is freely available on the market. This weakens the competitive position of German data providers.[391]

Public Funding Focused on Europe

Funding for space projects in Germany can be provided by the Federal Government, within the scope of the National Programme for Space and Innovation (Nationales Programm für Weltraum und Innovation, NPWI), as well as by the EU and ESA. A cross-cutting topic in these funding programmes is the commercialization of space activity, which is to be promoted on the one hand by supporting start-ups and SMEs and on the other hand by supporting technology transfer. Examples of specific support for new companies and SMEs include the ESA BICs and the EU's € 1 billion CASSINI programme, as well as the INNOspace initiative and the German Space Agency's Microlauncher competition.[392]

Through the NPWI, projects and contracts worth € 340 million will be implemented in the German space sector in 2023, whereby the NPWI currently still follows the 2010 space strategy. An evaluation of the NPWI for the period from 2011 to 2018 identified a focus on projects in the upstream segment. According to the evaluation report, 44.7 percent of programme funds were allocated to large enterprises, while SMEs received only 4.4 percent. 49.8 percent of programme funds went to research institutions.[393]

In 2022, the German budget for ESA was € 1,017.5 million. France was the strongest contributor to ESA with € 1,178.2 million,[394] even though Germany had promised higher contribution payments than France at the past ESA Ministerial Council conferences.[395] Comparing the countries' contributions to their respective GDPs, the high importance of the space industry for France becomes particularly evident. For example, France and Germany spent 0.043 percent and 0.027 percent of their GDP respectively on ESA in 2021.[396]

By way of geographical return, ESA invests amounts roughly equivalent to the national contribution to ESA's budget in the context of industrial contracts in each member state. The principle of geographical return of funds is seen as necessary by both policy makers and industry to provide incentives especially for small member states to participate in ESA's programmes. At the same time, large companies, most notably Thales and Airbus, have set up subsidiaries in different member states and at different points in the value chain.[397] This makes it possible for a considerable proportion of ESA contracts to be awarded to these same large companies in compliance with the principle of geographical return. The large companies in turn award subcontracts taking into account the ESA procurement rules including the SME participation rate.[398] A control of the award procedures by ESA is intended to prevent[399] large companies from favouring their own subsidiaries in the award process.

The EU Space Programme estimates a budget of € 14.88 billion over the period 2021 to 2027, in which Germany indirectly participates with around one fifth in accordance with its share of the EU budget.[400] It is intended to reinforce the European space infrastructure, especially in the fields of Earth observation, satellite navigation, and space research.[401] The awarding of EU contracts by EUSPA does not follow the principle of geographical return, as is the case with ESA, but via competitive tenders.

In addition to the limited participation in ESA and EUSPA contracts, the development of space start-ups and SMEs in Europe is also hampered by the lack of access to venture capital. This increases incentives for companies to move at least part of their operations to the USA, for example Morpheus Space.[402] While countries such as France and Luxembourg have already established public space venture capital funds, Germany has the DeepTech & Climate Fund, which supports companies in the growth phase. However, this fund does not have sufficient resources and expertise to finance deep-tech projects in the space sector.[403]

Space Industry Calls for State as Anchor Tenant

Calls from the German space industry for contracts with the Federal Government as an anchor tenant, like the US-American model, have intensified in recent years (cf. box B 3-9).[404] The industry hopes that this will provide it with the necessary financial resources as well as a certain degree of planning security for the implementation of its commercial projects. The idea is that the state, instead of giving public grants to companies, creates demand by ordering space products and services that are of public benefit. Such public anchor tenancy contracts can provide positive signals to private investors, which is of particular importance for emerging companies.[405] On the other hand, there is a risk that governments will continue to subsidize products that are not marketable in the long term. NASA already takes this problem into account in its anchor tenancy contracts. As a public contracting authority, it reserves the right to terminate contracts prematurely if agreed conditions or milestones are not met by the contractor (cf. box B 3-9). In Germany, however, the US-American anchor tenancy model can only be replicated to a limited extent due to European tendering rules.

B 3-5 Recommendations for Action

Commercialization in the space sector means that space products and services are increasingly being used by private companies as well as end consumers. Nevertheless, public demand will remain important for the space industry in the future – not least because space activities have a high strategic relevance for the state and technological sovereignty must be preserved, especially in the fields of satellite communications, navigation, Earth observation, and transportation to space. In terms of innovation activity in aerospace, Europe is on a par with the USA. However, companies in the space industry in Germany and Europe are still operating in an environment determined by pronounced national and supranational interests and a complex funding landscape. In Germany, companies are also confronted with uncertainty about the future regulatory framework. Moreover, start-ups and SMEs in the space industry are struggling with financial difficulties, which are particularly acute in the case of technologically sophisticated products with long development cycles. Given the increasing importance of space activities for the state, economy, and society, the Commission of Experts recommends the following measures:

Swiftly Launch the Space Strategy

- In view of the strategic relevance and increasing international importance of space activities, the Federal Government must swiftly adopt and implement the space strategy. It must be closely coordinated with the objectives of the Future Strategy for Research and Innovation.
- The current and future fields of development and action to be taken into account in the space strategy concern various ministries. The Federal Government must therefore create suitable structures for interdepartmental cooperation in the implementation and further development of the space strategy.
- Likewise, the Federal Government must take a position in its strategy on how to improve the security of critical infrastructures in space.

Coordinate Public Demand and Intensify Cooperation between Civilian and Military Actors

- The Federal Government should coordinate public demand for innovative products and services of the space industry across ministries. An institution such as the Competence Centre for Innovative Procurement can play a key role in this.
- Cooperation between civilian and military actors in the provision and operation of space infrastructure should be intensified and synergies created through joint use.
- The Federal Government should consider concluding anchor tenancy contracts for clearly specified but technologically open contracts with companies in the space industry and in coordination with the space agencies. An anchor tenancy contract must be preceded by a competitive procedure and clear criteria must be defined as to when funding is continued or terminated.

Improve General Conditions for Private Actors

- Germany should adopt a national space law that regulates the approval and monitoring of space activities, the registration of space objects, and liability in the event of damage.
- The infrastructure required to implement this space law should be integrated into the German Space Agency. The Space Agency, in turn, should be disaffiliated from the German Aerospace Center (DLR) and set up as an independent actor.
- It should be reviewed how the financial and staff resources of the DeepTech & Climate Fund can be increased to enable investments in deep-tech projects in the space sector.

Box B 3-9 The US-American Anchor Tenancy Model[406]

To support commercialization in the space sector, the USA has introduced the anchor tenancy model as a procurement tool for NASA. As an anchor tenant, NASA procures products from a commercial company as needed so that this company becomes profitable.

The contracts have a maximum term of ten years and include a fixed price. The prerequisites for a contract with NASA as an anchor tenant are that

- the (technical) requirements for the mission are met,
- the product is cost-effective,
- there is a potential or existing customer base for the product,
- the company is not dependent on the government as a long-term customer,
- the product has been competitively procured, and
- private capital is at risk in the venture.

In the event of non-performance or anticipated non-performance of the contractual agreement, NASA reserves the right to terminate the contract. Examples of companies that have NASA as an anchor tenant include Axiom Space and Collins Aerospace for the development of the spacesuit on the planned lunar mission and SpaceX for crew transportation to the ISS.

A European Approach to Space Flight

— Technological sovereignty in the field of space must be thought of in European terms to keep efficiency losses to a minimum.

— The Federal Government should lobby the EU to ensure that the critical space infrastructure used in the European network is effectively protected.

— The Federal Government should work towards a clear and complementary division of tasks between ESA and EUSPA.

— The possibility of relaxing the principle of geographical return of ESA funds in favour of efficiency criteria should be examined.

— The Federal Government should work towards organizing military reconnaissance in a European network and exploit synergies between civil and military use.

— The Federal Government should also lobby the EU for free access to data generated in space, as is already possible within the scope of the Copernicus project.