



EUROPEAN SPACE AGENCY.  
ELEVATING THE FUTURE OF EUROPE.

# ESA STRATEGY 2040

IN DEPTH | Edition 2025

→ THE EUROPEAN SPACE AGENCY



# ESA STRATEGY 2040

STRATEGY OF THE EUROPEAN SPACE AGENCY | IN DEPTH

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# ESA'S VISION, MISSION AND VALUES

The European Space Agency is dedicated to fostering cooperation among European States in space research and technology, aiming to advance scientific knowledge and operational space applications. Our mission drives us to push the boundaries of exploration and innovation. At the same time, our vision focuses on benefiting humanity and nurturing a sustainable, inclusive, and prosperous future in space and on Earth.

## VISION

UPLIFTING EUROPEAN ASPIRATIONS  
FOR A BETTER TOMORROW.

## MISSION

LEAD AND ORCHESTRATE EUROPEAN SPACE  
EXCELLENCE TO BUILD A MORE PROSPEROUS,  
RESILIENT, INDEPENDENT AND INSPIRING LIFE  
FOR ALL OF EUROPE.

## CORE VALUES

The enduring success of ESA hinges on its strategic choices and investments today, along with our unwavering commitment to our five guiding Core Values, which are integral to everything we do:

### 1 EXCELLENCE

We deliver outstanding space solutions for Europe through our talented workforce.

### 2 RESPONSIBILITY

We act transparently and with accountability and are committed to quality and sustainability.

### 3 INSPIRATION

We ignite the enthusiasm of Europeans to cultivate a world-class space sector.

### 4 INCLUSION

We value diversity and treat everyone with respect and fairness.

### 5 COOPERATION

We work well together and with our industry to strengthen European space capabilities and grow global partnerships, driving a prosperous and autonomous European space ecosystem.

# FOREWORD BY THE CHAIR OF THE ESA COUNCIL

Since its establishment in 1975, the European Space Agency has been at the forefront of global space research, technology, and exploration. Over the decades, the unwavering trust of our Member States has been critical in jointly shaping ESA's world-class achievements, including breakthrough scientific missions, cutting-edge technological advancements, the development of unique space infrastructures, as well as secure access to space. The resulting creation of new applications we all use in our day-to-day lives provides essential services and innovations for Europe and its citizens. Finally, through robust international collaborations, ESA has ensured that Europe remains a key player in space.

As we look to the future, it is evident that the landscape of space activity is evolving rapidly. Across the globe, space is increasingly recognised as a vital component of national strategies for resilience, technological advancement, and economic growth. Public investment in space is rising at unprecedented levels, and the commercialisation of space activities has brought the private sector to the forefront of space innovation. The convergence of space technologies with digitalisation, as well as the growing intersection between space and defence, is reshaping the industry in ways unimaginable just a decade ago.

For Europe to maintain its leadership position and role as a globally trusted partner in this highly competitive and strategic domain, we must be prepared to meet these shifts with renewed ambition and enhanced investment. Space technologies are not just tools for exploration and discovery; they are essential pillars for economic growth, scientific advancement, national security, and societal resilience. As a result, there is a growing understanding of the importance of space for our society across Europe and that we must position ourselves together to ensure long-term autonomy, global competitiveness, and sustainable growth.

It is in this spirit that the Strategy 2040 has been crafted. This document is more than just a roadmap; it is ESA's bold vision for the future, outlining clear objectives that will enable Europe to expand its reach and capabilities in space. Through a focused set of goals and targeted investments, Strategy 2040 positions ESA to unlock new markets, enhance Europe's resilience, and ensure that European space efforts continue to serve as an engine of innovation, technological leadership, and societal progress.

By building on our legacy of success, fostering collaboration, and embracing the opportunities ahead, ESA as an intergovernmental organisation will continue to federate and serve European space research and development efforts, enabling a new generation of innovations. This will allow Europe to become stronger, more competitive, and ready to lead in this critical domain of the future. Strategy 2040 marks the beginning of this next great chapter in ESA's mission, ensuring that Europe's space sector remains a powerful vehicle for progress and prosperity.

As Chair of the ESA Council, I invite you to explore this strategy, confident that it will chart a path for Europe to thrive in the dynamic and rapidly expanding space environment of tomorrow.



**Renato Krpoun**  
Chair of the ESA Council

# FOREWORD BY THE ESA DIRECTOR GENERAL

Societies worldwide are undergoing profound transformations, driven by unprecedented global challenges and technological breakthroughs. Europe stands at a pivotal moment, facing new economic and societal implications arising from a shifting geopolitical landscape. In this context, space has rapidly become a distinguishing element for any prosperous nation, defining societies and economies through sustainable growth, resilience, security, STEM advancement, competitiveness, and global influence. Those who fail to harness the full potential of space risk relegation to supporting roles on the world stage.

Over the past 50 years, the European Space Agency has delivered remarkable successes, propelled by a commitment to excellence. However, international competition is intensifying, reducing industry profitability and pressuring Europe's position in the global market. Continuing business as usual would accelerate this decline. Now, more than ever, ESA must adapt to new challenges and act as the catalyst for the transformation of the European space sector, just as it has done over the past five decades.

Europe's leading politicians recognise the strategic importance of space and are seeking ways to better serve their citizens and economies through space initiatives. Europe has the capacity to transform itself into a global space leader—alongside the US, China, and India—by implementing a smart strategy with clearly identified and quantifiable milestones along a sustainable growth path.

In this document, ESA presents its strategy towards 2040, tailored to the European space sector and aspiring to maximise societal benefits from a world-leading position in several domains. We define ambitious objectives for five strategic goals: (1) Protect our planet and climate, (2) Explore and discover, (3) Strengthen European autonomy and resilience (4) Boost European growth and competitiveness, and (5) Inspire Europe.

By pursuing these strategic goals, ESA will enable Europe to address key societal needs, stand shoulder-to-shoulder with global players, and advance the frontiers of science and technology. This will empower European industry to access new profitable growth markets and contribute to a sustainable future for Earth. Leading in new markets will generate spillover growth in other key sectors with civil and dual-use applications—from healthcare to IT and materials science—originating from space-based research.

In line with Agenda 2025, ESA is implementing a transformation process to better prepare itself and the European space sector for the future. But this is only a first step. Europe must commit to new areas of investment and establish clear rules of engagement among ESA, the EU, and national agencies, increasingly engaging industrial actors and funding entities. Despite the challenging geopolitical and budgetary context, Europe must innovate and grow to overcome these hurdles. Space is one of the most effective and impactful levers to achieve that.



**Josef Aschbacher**  
ESA Director General

As Europe's creator of success in space, ESA stands ready to catalyse and enable this ambitious vision for 2040 and beyond. By ensuring that Europe—through space—can lead rather than fall behind, we reaffirm our commitment to excellence and innovation, driving progress where the stars guide us.

# ESA'S NEXT SPACE STRATEGY

Since the late 1970s, the **European space sector has developed as a relatively modest niche sector within a mostly predictable institutional, technological and commercial environment.** This allowed European public decision-makers and industry to plan with a high degree of confidence, and it led to the gradual development of European space capabilities through a growing albeit limited investment. Space was treated as a high-tech domain, driven by demanding one-off projects and narrowly defined programmes that required tailored approaches in terms of technology design, implementation and industrial capacities.

Within this stable context, **ESA has, since its establishment in 1975, developed globally renowned expertise and created an integrated European industrial landscape.** It has pioneered **world-class space technologies, missions, and programmes** in nearly all traditional domains of space activities, such as:

### Space science

- ESA strongly pursued excellence and leadership in space science through its mandatory Science Programme, achieving significant milestones in the fields of Solar System science, astrophysics, and cosmology, answering the most pressing science questions of our time.
- Key missions have included Giotto, Huygens, Rosetta, Planck, Gaia, Juice and Euclid, contributing to our understanding of, e.g. comets, Jupiter and Saturn's moons, the Milky Way, and cosmology in terms of the Universe's composition, age and expansion rate.
- ESA also contributed significantly to the James Webb Space Telescope, enhancing insights into the early Universe, galaxy formation, and the atmospheres of exoplanets.

Credit: ESA/Euclid/Euclid Consortium/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi

### Earth observation

- ESA laid the technological and industrial foundations for the European Union's Copernicus programme with pioneering work in the 1990s, particularly through the ERS and Envisat satellites.
- ESA developed the space and ground segment of the Copernicus programme, the world's most comprehensive Earth observation (EO) programme. Its Sentinel satellites generate over 25 terabytes of new data per day, giving humanity an unprecedented overview of planet Earth and its climate.
- ESA R&D activities have enabled significant progress in Earth system science through its Earth Explorer missions and in advancing the accuracy of weather forecasting models through its meteorological satellite programmes.



Credit: ESA/ATG Medialab

### Space exploration

- Together with its astronaut corps, the Columbus laboratory on the International Space Station (ISS) is a cornerstone of European space exploration efforts in Low Earth orbit. Five Automated Transfer Vehicles (ATVs) have provided cargo delivery and orbit-boosting capabilities to the ISS.
- ESA supports NASA's Artemis programme through the European Service Module (ESM) propelling every NASA Orion spacecraft, on the critical path bringing safely American and European astronauts safely to the Moon and beyond.
- The ESA ExoMars Trace Gas Orbiter (TGO) is making an inventory of the atmosphere of Mars and mapping subsurface signatures of water, while relaying around 60% of all data sent from Mars to Earth across all space agencies worldwide (including from NASA rovers).

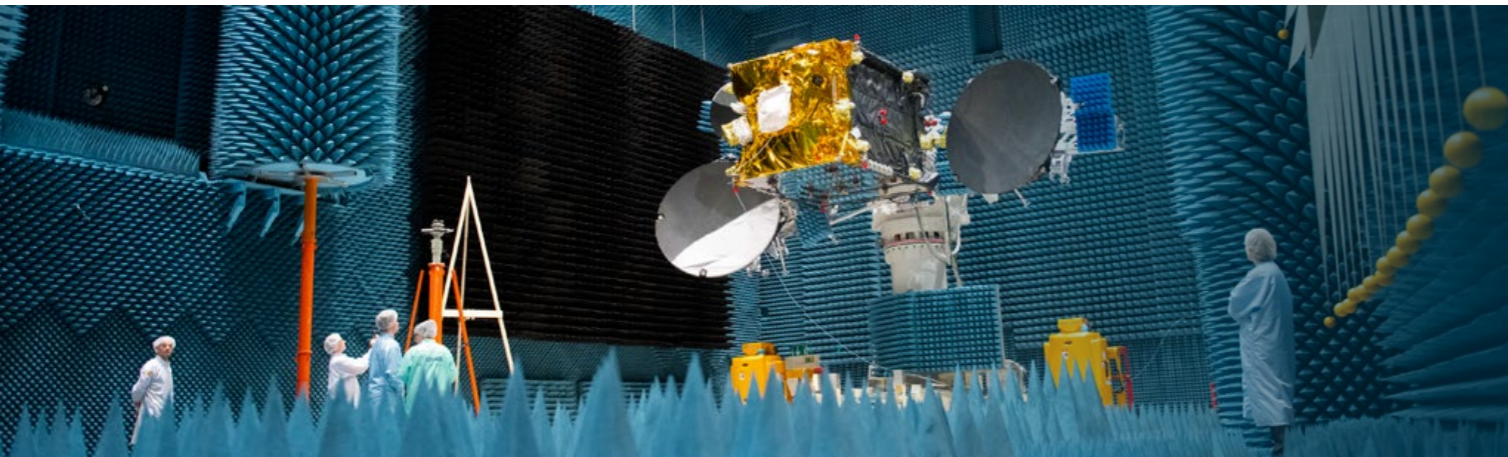
Credit: ESA/NASA



# REPOSITIONING FOR THE FUTURE

## Positioning, Navigation & Timing

- The Galileo satellite system offers superior precision compared to other Global Navigation Satellite Systems (GNSS), including the American GPS and the Chinese system Beidou.
- Galileo's Positioning, Navigation & Timing (PNT) services support various applications, from transport to agriculture and search and rescue, enabling 10% of the EU's GDP and serving over four billion smartphones worldwide. Galileo also supports critical security and defence applications and is vital for Europe's strategic autonomy and resilience.



Credit: ESA/S. Corvaja

# ESA'S NEXT SPACE STRATEGY

## Space transportation

- The Ariane and Vega launchers have positioned Europe as a reliable provider of commercial satellite launch services. For a long time, this enabled Europe to dominate the accessible share of the global space transportation market.
- With the inaugural flight of Ariane6 and the return to flight of Vega-C, Europe's autonomous access to space is re-established, but Europe is under increasing pressure due to market disruption caused by new players introducing reusable and scalable launch solutions and new rocket propulsion technologies.
- ESA with its expertise and its programmes is responding to the challenges by developing R&D and preparing the European space transportation sector for the future.



Credit: ESA/S. Corvaja

## Connectivity

- ESA has long been strongly involved in satellite communication by transforming R&D into commercial products through its ARTES programme. This has long enabled European satellite manufacturing industry to capture a large share of the commercial satcom market, dominated by geostationary satellites supported through ESA Core Competitiveness and Partnership Projects such as Neosat and Novacom including the adoption of software-defined satellites.
- Continuous investment in optical communication technology places Europe in a leading position in the global market and paves the way towards quantum communications.
- ESA is contributing to the development of the EU's Resilience, Interconnectivity and Security by Satellite (IRIS<sup>2</sup>) constellation which will provide robust and encrypted operational telecom services and IoT communication for government applications.



Credit: ESA/D. Lopez

## Ground segment engineering, Operations and Space safety

- ESA is the trusted provider of sovereign and secure operations for Europe's institutional missions, with demonstrated ground segment engineering and mission operations capabilities, including comet and planetary landings, world-first astrodynamics achievements, and targeted satellite re-entry, all built on decades of experience.
- Through the Zero Debris Charter, ESA is promoting the sustainable use of space by tackling the growing threat to the future use of crucial orbital regions posed by space debris. In parallel, ESA is also working on demonstrating the potential of active debris removal capabilities.
- ESA is developing space safety capabilities in space weather services and planetary defence is preparing for the paradigm shift towards a circular economy in space, including in-orbit servicing.



Credit: EESA / Filippo Concaro

# REPOSITIONING FOR THE FUTURE

## The European space ecosystem

- ESA has played a critical role in establishing a pan-European space ecosystem through its industrial policy and decades of investment in innovative technology development. This is reflected in the existence of several competing Large System Integrators (LSIs), a broad industrial base with many Small and Medium-sized Enterprises (SMEs) and new startups.
- With a public investment share of only 11% of the global market (civil and military combined), Europe captures about 12% (€5.6 billion) of the global upstream market value and 23% (€83 billion) of the overall downstream market. European space industry is a net contributor to the European trade balance thanks to the global export of complete satellite systems, launch services, equipment and subsystems.
- Over 1500 companies have been established through the ESA Business Incubator Centre network (BIC); the largest of its kind in Europe.



Credit: Getty Images

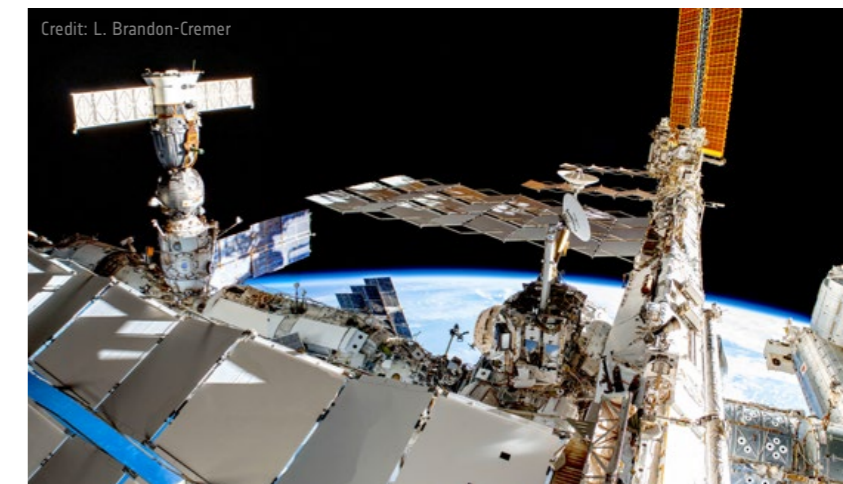
# ESA'S NEXT SPACE STRATEGY



Credit: SpaceX

As we look ahead, the European space sector faces unprecedented challenges, marking the end of a period of stability and the onset of rapid, transformative shifts in the global landscape. **The era of stability which has enabled these European successes to be developed, implemented and grown has come to an end.** Four overall trends are driving this phase transition:

- There is a **rapid and worldwide increase in public investment in space**. The US remains the uncontested leader in space with around 64% of the global share, while China – currently accounting for about 12% – is rapidly ramping up its public investment in all space domains, activities and technologies. Europe's 11% of the global share is not representative of its intellectual and economic strength. Also, investment in space from the rest of the world has surged significantly, rising from €163 million in 2020 to €566 million in 2023, with notable contributions coming from Canada, India, Israel, and Australia. As a result, Europe is steadily falling behind despite the gradual increases in European spending on space over the last few decades.
- **Commercialisation is radically expanding the role of the private sector in space, which in turn impacts the pace and scope of innovation.** Increased participation by private companies and fast growth among innovative startups combined with the pursuit of disruptive innovation is typically referred to as 'New Space'. The sector is marked by new business models, concentrations, vertically integrated players alongside disruptive technologies, shorter delivery times, and a higher appetite for risk. Space projects are increasingly relying on public-private partnerships and commercial demand, moving away from the traditional model of multilateral international collaboration by space agencies. Private companies are increasingly leading the development of groundbreaking disruptive technologies, such as reusable launchers, but only a handful have been able to create and reshape markets with new and more competitive services for both government and private customers.
- **Space technologies and markets are increasingly crucial for the economy thanks to the digitalisation of society.** Compared to the past, space-based services are much more central in day-to-day life, as exemplified for instance by ubiquitous use of satellite services for navigation and communication in transport, weather forecasting, and



Credit: L. Brandon-Cremer

# REPOSITIONING FOR THE FUTURE

the use of timing signals on global financial markets. As a result, space is becoming increasingly linked to the cyberspace realm, effectively hitching the space economy wagon onto the vast high-speed train that is the digital economy. Direct communication from space to handheld devices and secure communication services are the next steps in this unfolding process. This development is allowing the space industry to tap into new and larger funding sources, which in turn further intensifies the commercialisation of space. To access these growth markets, space actors need to possess adequate industrial capacity, access to capital, and the ability to innovate and scale up fast from R&D and technology demos to operational services, to use first-mover advantage.

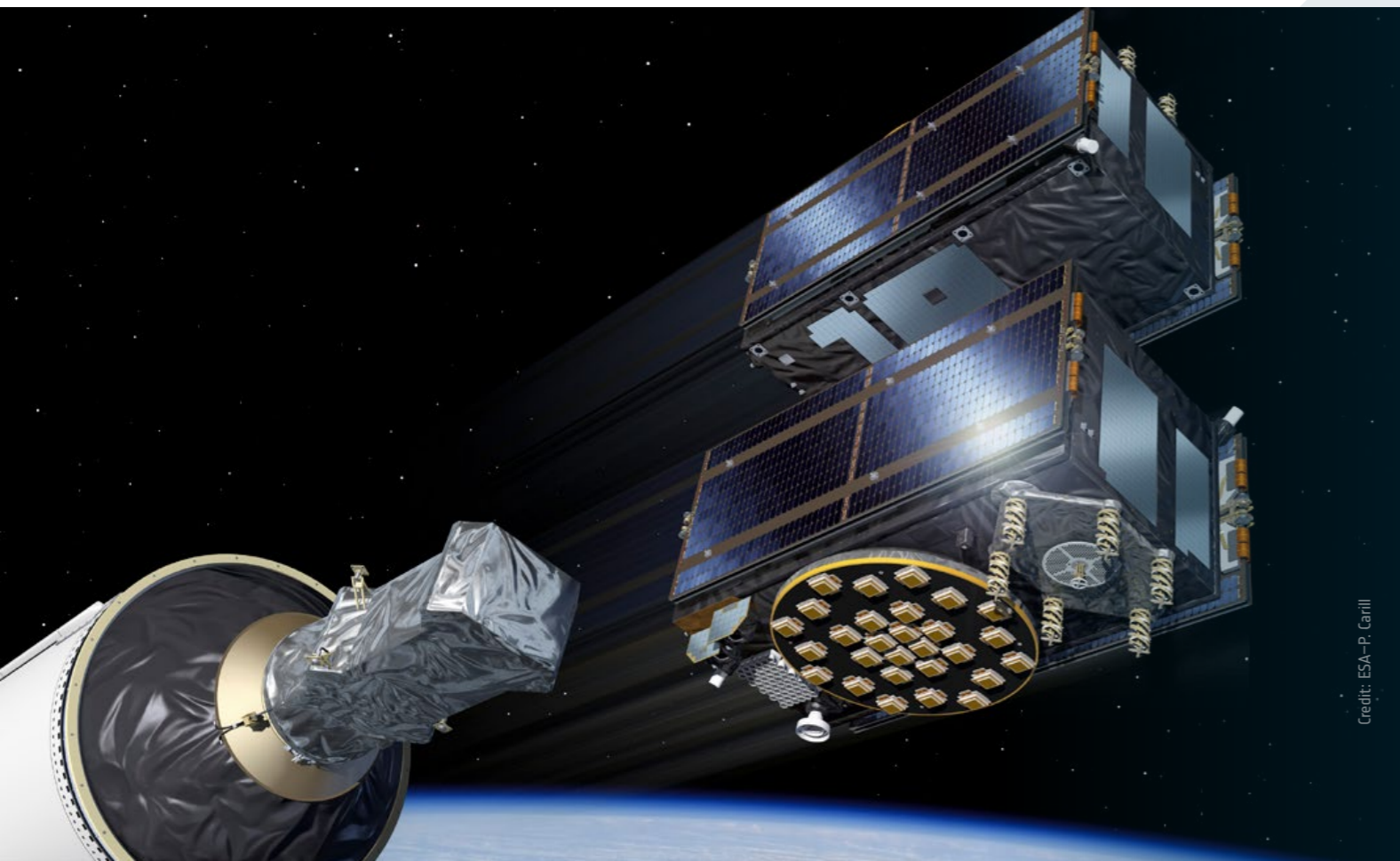
→ **There is a growing emphasis on space technologies for defence and security purposes.** The convergence of space technologies and defence in Europe has seen significant growth, particularly after Russia's invasion of Ukraine in 2022. The conflict has underscored the strategic importance of space for military applications, including surveillance, communication, navigation and defence. In response, European countries have substantially increased defence spending and have placed greater emphasis on developing and protecting space-based assets. Nations like France, Germany, and Poland have announced major investments to strengthen their military capabilities, including space technologies, as part of their broader defence strategies. The European Union has also integrated space into its defence policies, aiming for greater coordination and resilience against emerging threats like cyberattacks and anti-satellite systems.



Credit: Getty Images

The unfolding of a new playing field of space activities signals a **new level of maturity in the global space sector, which has evolved into a highly strategic, full-fledged economic domain.** This change heralds unprecedented opportunities for Europe. In 2023, the global space economy amounted to US\$630 billion per year and estimates indicate it could reach up to US\$1.8trillion by 2035, corresponding to an average growth rate of 9% per year<sup>1</sup>. According to a wider definition, which considers the impact of space on the broader

1. Space: The \$1.8 Trillion Opportunity for Global Economic Growth [https://www3.weforum.org/docs/WEF\\_Space\\_2024.pdf](https://www3.weforum.org/docs/WEF_Space_2024.pdf)



Credit: ESA - P. Carril

# ESA'S NEXT SPACE STRATEGY

economy, the estimated value of the space sector already stands at over US\$3 trillion today. According to the OECD, space technologies today support 11 of the 16 most frequently designated critical infrastructures in OECD countries, including transport, energy and food supply, health and public safety.<sup>2</sup>

**Space and high-tech markets now increasingly feature head-to-head competition between institutional and private actors as well as competition within the institutional and private sectors.** The resulting paradigm shift, while offering a wealth of opportunities, also poses a risk for the growth of European industry. **Europe is losing ground quickly, particularly compared to the US and China.** Reinforcing Europe's position requires a focus to channel R&D efforts: space can provide a unifying and reinforcing trigger for this. First, this is because space programmes bring together several key enabling technologies such as nanotechnology, biotechnology, cyber, AI, quantum and, material science. Secondly, because space is relevant for many diverse societal domains such as resilience, sustainability – in a world that is faced with climate, natural resources and biodiversity crises, health, connectivity, energy, safety, resilience, transport, and agriculture. Positioning space to tap into these new **opportunities requires strong, unified and fitting responses from European actors.**

**As a first step, in 2021 ESA defined 'Agenda 2025',** focusing on the most urgent needs in the areas of ESA-EU relations, commercialisation, safety and security, and ESA programmes. It also started a transformation process boosting ESA's effectiveness and attractiveness through structural reforms. Sixty actions were defined that are under implementation, including an EU-ESA agreement for the EU Multiannual Financial Framework for 2021-2027 and the next implementation phases of the Copernicus and Galileo programmes. A new directorate focuses on commercialisation, including support to New Space developments and setting up venture capital agreements. To boost European capabilities in the disrupted domain of space transportation, ESA has started a European Launcher Challenge and an ISS Cargo Return Service Competition. In parallel, new initiatives have been established in space sustainability with the Zero Debris Charter and the Space Safety programme. To advance the utilisation of space in Europe, ESA hosted several high-profile political events aimed at boosting Europe's space ambitions through the adoption of various Resolutions. These events included the Space Summit 2022, which resulted in the Matosinhos Manifesto<sup>3</sup>, the ESA Council at Ministerial Level 2022, the Space Summit 2023 with its Resolution on 'Lifting Europe's Ambitions for a Green and Sustainable Future, Access to Space and Space Exploration'<sup>4</sup>, and the Space Council meeting in 2024. While these initiatives have created significant momentum, **further efforts are needed as Europe is at a crossroads.** It can decide to keep its investments level stable or growing at a very modest pace at best, which de facto comes down to a de-investment. This would imply significant risks for Europe in terms of competitiveness and future growth potential. To address its future needs adequately, **Europe instead needs a clear and ambitious strategic vision for space paired with a significantly ramped-up investment effort.** Such a strategic vision must account for the transformation of the global context, anticipate changes and disruptions, and address future needs with a systemic perspective and an agile, flexible decision-making process aimed at clear, ambitious long-term goals. This will help Europe in safeguarding and expanding its competitiveness, growth, autonomy and resilience, and in providing smarter solutions for societal needs

**With this Strategy 2040, ESA lays out a strategic blueprint for its future activities and priorities for the medium- to long-term,** putting the agency in a position to support and help realise the European space agenda by:

- 1. Ensuring that ESA's space activities and programmes can optimally respond to the diverse societal needs and policy priorities at local, regional, national and European level,** addressing both the needs of its Member States and the EU. To achieve this, the strategy's goals have been crafted to directly correspond to key societal needs where space and ESA can make significant contributions.
- 2. Ensuring Europe remains and grows as a top-tier global space actor through clearly defined objectives and corresponding leadership roles,** by maintaining leadership in current domains of excellence, developing R&D for all space domains, re-establishing its competitive edge in the domains where it is falling behind and, expanding Europe's space capacities in newly emerging markets and in areas where its scope of ambition has been historically modest. This aspiration will underpin all future space activities ESA proposes, designs and implements.
- 3. Creating a clear vision and coherent narrative for ESA's space programmes** that facilitates strategic decision-making and programme implementation across multiple funding cycles. This refers to the ESA Council meetings at Ministerial Level, where the agency's future programmes are decided upon and subscribed to by its Member States, to the activities performed in partnership with the EU and, to synergies with space activities and technology innovation at national level and in cooperation with international partners.

2. [https://www.oecd-ilibrary.org/sites/fa5494aa-en/1/3/1/index.html?itemId=/content/publication/fa5494aa-en&\\_csp\\_=fc1ad0ab064ad99d8868789e9cd71b-b8&itemIGO=oeed&itemContentType=book](https://www.oecd-ilibrary.org/sites/fa5494aa-en/1/3/1/index.html?itemId=/content/publication/fa5494aa-en&_csp_=fc1ad0ab064ad99d8868789e9cd71b-b8&itemIGO=oeed&itemContentType=book)

3. [https://esamultimedia.esa.int/docs/corporate/ESA\\_C\\_2021\\_176\\_EN.pdf](https://esamultimedia.esa.int/docs/corporate/ESA_C_2021_176_EN.pdf)

4. *Lifting Europe's Ambitions for a Green and Sustainable Future, Access to Space and Space Exploration*

# IDENTIFICATION OF KEY EUROPEAN SOCIETAL NEEDS

Formulating an ESA strategy that can optimally serve Europe's space agenda and overall policy priorities requires a comprehensive knowledge of the space sector and, a clear understanding of the purposes space capabilities need to serve in the future. While the agency has a strong in-house knowledge of the space sector in terms of technology development and market evolution, the process of identifying the most pressing European societal needs and the potential of space to serve them called for a dedicated analysis. To this end, ESA performed a prospective analysis of ongoing trends, European political priorities and existing national space policies.

A thorough analysis of key sources from international organisations, government agencies, major private actors, and research institutions identified key global trends and challenges. These include the impacts of climate change and environmental degradation, the energy transition, geopolitical instability and conflicts, economic volatility and technological disruption, public health crises, demographic shifts and urbanisation, public mistrust in science, technological advancements and cybersecurity, and potential resource scarcity. A list of sources of the documents used to perform this analysis is included in Annex 1.

Further, an analysis of recent reports and speeches by prominent European political leaders has revealed key policy priorities and needs that will impact the European agenda over the coming years. This revealed that in recent decades, the status of Europe in the world has been shrinking<sup>5</sup> economically (relative size of economies, share of wealth), technologically (semiconductors, solar panels, electrification, cloud, AI) and geopolitically (role in the resolution of crises, influence). Across the continent, Europe's political leadership is clearly calling for action as the world will increasingly revolve around data flows and depend on emerging and disruptive technologies, representing new opportunities for Europe as a global leader<sup>6, 7</sup>. Bolstering Europe's competitiveness and industry through forward-looking industrial policy is also recognised as a key priority, with space among the top five strategic sectors alongside AI, quantum computing, biotechnology, and renewable energy<sup>8</sup>. Political priorities also include the impacts of climate change and environmental degradation, geopolitical instability and conflicts, economic volatility and technological disruption, public health crises, demographic shifts and urbanisation, technological advancements and cybersecurity, resource scarcity, and the energy transition. Based on the analysis of the corpus of documents in Annexes 1 and 2, ESA has identified overarching societal needs with strong potential for space contributions. These needs include ensuring the sustainability of life on Earth, enhancing Europe's leadership in science and technology to drive innovation and competitiveness, strengthening the resilience of European society and its economy, and promoting European cohesion along with expanding its global reach and they have helped drive the narrative and structure the goals for Strategy 2040.

## Sustainability of Life on Earth

The sustainability of life on Earth is under increasing threat due to climate change and biodiversity loss, primarily driven by human activities. Europe, being the fastest warming continent—with temperatures rising at approximately twice the global average rate<sup>9</sup>—faces a critical challenge in combatting these existential threats. Recognising this urgency, the European Union has set ambitious targets through initiatives like the **European Green Deal**, aiming to make Europe the first climate-neutral continent by 2050.

Ensuring that Europe is the first climate-neutral continent in the world<sup>10</sup> requires a multi-faceted approach involving policy measures, technological innovations, conservation and restoration efforts, and changes in human behaviour. In Europe, most national space strategies emphasise environmental and resource management, focusing on integrating space services and solutions into plans for green transitions. Extreme weather events and the need for self-reliance in our energy supply have driven policy shifts toward stronger climate commitments. National strategies highlight the transformative role of space-based assets in protecting the environment and managing resources sustainably. Equally, the upcoming Second Horizon

5. HR/VP Josep Borrell's Blog Post on Why European strategic autonomy matters posted on 3 December 2020.  
6. Speech by President of the Republic of Finland Alexander Stubb at Hertie School in Berlin on 8 May 2024.  
7. Franco-German Ministerial Council, For a strong and sovereign Europe, 28th May 2024.  
8. Speech by French President Emmanuel Macron on Europe at the Sorbonne University on 25 April 2024.  
9. European State of the Climate 2023, Copernicus Climate Change Service.  
10. Franco-German Ministerial Council, For a strong and sovereign Europe, 28th May 2024.



Europe Strategic Plan for 2025-2027<sup>11</sup> emphasises research and innovation as pivotal tools in addressing climate change and environmental degradation.

Programmes such as the Copernicus Earth observation system play a transformative role in monitoring environmental changes, aiding in disaster response, and supporting sustainable resource management. With clear ambitions in developing industrial skills to contribute to sustainable development and humanitarian action<sup>12</sup>, efforts are focused on using satellite data in land and water management, urban planning, and optimising renewable energy sources like solar and wind<sup>13</sup>. Yet, there is a strong recognition of the need to do more. Solutions are also needed to sustainably steward the space environment itself, and keep it free from debris and pollution. Providing technical solutions to develop and implement regulatory measures will ensure Europe continues to lead in the responsible and sustainable use of space.

11. The second Horizon Europe strategic plan 2025-2027.  
12. Luxembourg 2023-2027 National Space Strategy.  
13. Luxembourg 2023-2027 National Space Strategy.

# IDENTIFICATION OF KEY EUROPEAN SOCIETAL NEEDS

## Europe's Leadership in Science and Technology for Innovation and Competitiveness

Science, technology, and innovation are essential for long-term prosperity and global competitiveness. Enhancing Europe's position in these areas involves fostering a strong education, research, and development ecosystem, promoting collaboration between academia, industry, and government, and ensuring adequate funding for cutting-edge projects. In an increasingly competitive world, the reindustrialisation and competitiveness of Europe need to be fuelled by strong, cohesive engagement in R&D and innovation to compete globally. Investments in space science and exploration missions, satellite technology, and related research spur innovation across sectors like telecommunications, navigation, materials science, and biotechnology. Space science programmes contribute to global knowledge, inspire future generations, and enhance Europe's competitive edge. European sovereign control over data and services from space is crucial for industrial progress and competitiveness. Europe must promote networking and knowledge transfer through flagship projects and collaborative strategies to bolster research and commercialisation<sup>14</sup>. The integration of space-based solutions into non-space sectors underscores the broad applicability and benefit of high-tech developments initiated in space endeavours<sup>15</sup>. European countries must create a favourable environment for financial growth in the space sector, including diversified funding mechanisms, foreign investment, and international partnerships<sup>16</sup>. A concerted effort across Europe, involving technical expertise, programme implementation, and operational systems, is required to develop shared European assets, integrate commercial capabilities, and respond to national priorities within a European ambition. In the 2024 report 'The future of European competitiveness' it is suggested that one approach to stimulating Europe's growth and competitiveness is to mobilise €750–€800 billion annually to enhance its potential through stronger research and innovation. This significant investment is proposed to close the gap with other actors such as the US and China, potentially securing Europe's leadership in key technological and industrial sectors.<sup>17</sup>

## Resilience of Europe's Society and Economy

In an increasingly vulnerable, uncertain, complex, and ambiguous world, the resilience of European society and its economy is paramount. This is especially true in the face of the growing number of crises and disasters resulting from climate change, geopolitical instability and conflicts, economic volatility, public health crises and hazards originating from space (e.g. space weather, near-Earth objects). According to the European Environment Agency (EEA), from 1980 to 2020, weather and climate-related extremes resulted in economic losses exceeding €450 billion, averaging about €11 billion per year<sup>18</sup>. In terms of loss of human life, these events caused over 85 000 fatalities during the same period, with heatwaves being particularly deadly.

In 2023, Europe experienced some of the most severe climate-related disasters in recent history. The summer of 2023 saw unprecedented heatwaves across Southern Europe, with temperatures exceeding 45 °C in countries like Spain, Italy, and Greece<sup>19</sup>. These heatwaves led to massive wildfires, particularly in Greece, Spain, and Portugal. The Evros wildfire in Greece became the largest recorded in the European Union, burning over 81 000 hectares<sup>20</sup>. Heat-related illnesses increased, with preliminary estimates suggesting thousands of excess deaths across Europe due to extreme heat. Severe flooding also impacted Central and Eastern Europe. In August 2023, Slovenia faced catastrophic floods described as the worst natural disaster in the country's history, estimated to have caused €1 billion of direct damage to the economy and total indirect costs of €9.9 billion.<sup>21</sup>

The European Space Agency and the broader European space sector play a crucial role in enhancing this resilience. For instance, the Meteosat and MetOp satellites operated by the European Organisation for the Exploitation of Meteorological Satellites (Eumetsat) deliver realtime weather information essential for predicting extreme weather events; Copernicus provides vital

data for monitoring environmental changes, predicting natural disasters, and supporting climate change mitigation efforts; Galileo offers Europe autonomous navigation capabilities, essential for transportation, emergency response, and various commercial applications. During the 2023 Slovenia floods, the Copernicus Emergency Management Service (CEMS) was activated to supply detailed satellite imagery to aid rescue operations and damage assessments and in wildfires, satellites like Copernicus Sentinel-2 monitor fire progression, helping firefighting teams allocate resources effectively.

Building resilience involves enhancing the ability to withstand and adapt to adverse events, ensuring that social, economic, infrastructure, and security systems can recover swiftly and efficiently. This requires a comprehensive approach that includes diversifying economies through initiatives like the European Green Deal, promoting sustainable practices, improving disaster preparedness and response via programmes like ESA's Civil Security from Space, strengthening social safety nets, ensuring cybersecurity—especially for space assets—and bolstering security capabilities. Space technology plays a crucial role in this comprehensive approach.



14. Switzerland's Space Policy 2023.  
15. Germany's Federal Government's new Space Strategy.  
16. UK's Space Industrial Plan.  
17. The future of European competitiveness: Report by Mario Draghi.  
18. Economic losses from climate-related extremes in Europe.  
19. Record Heatwaves Sweep Across Southern Europe.  
20. Wildfires: biggest rescEU aerial firefighting operation in Greece.  
21. 2024 Country Report – Slovenia.

# IDENTIFICATION OF KEY EUROPEAN SOCIETAL NEEDS

The dual-use nature of space assets enhances resilience and defence capabilities, making them integral to resilience planning. Around the world, space powers receive clear requirements and related funding from the security and defence sector, a trend that is expected to increase towards 2040. However, at European level no such mechanisms are yet in place highlighting a fragmentation of the public sector – this is an anomaly that shall be corrected. Recent European strategies reflect a growing emphasis on resilience and security, reducing strategic dependencies, and making Europe a global leader in key areas such as 'net zero' technologies, AI, quantum technologies, space and aeronautics, biotechnology, chemicals, robotics and, mobility,<sup>22</sup> while recognising the dual-use potential of space activities, technologies and applications<sup>23,24</sup>. There is a push for integrating civil and resilience activities, leveraging dual-use technologies for both defence and civil benefits. Ensuring sovereign access to space and data sovereignty requires a strong industrial technology base, and cooperation on defence-relevant space technologies strengthens Europe's industrial base<sup>25</sup>.

## European Cohesion and Global Reach

In a world that is becoming increasingly fragmented, Europe's ability to act as a united force is more crucial than ever. The continent faces growing geopolitical divisions, economic disparities, and global uncertainties, all of which threaten to weaken its influence on the world stage. To remain a key player in promoting stability, peace, and prosperity both within and beyond its borders, Europe must strengthen its internal cohesion and reinforce its global reach. This requires deeper cooperation among European nations, anchored in shared values such as democracy, human rights, and sustainability. Without such unity, Europe's voice risks being drowned out in the clamour of competing powers, leaving it with little influence in shaping international norms and addressing global challenges.

However, achieving this unity is no easy task. Europe is a diverse and complex region, where national interests and political priorities often clash. Different nations face different challenges, from economic pressures to migration, from security concerns to political instability. This diversity of experiences and perspectives can complicate efforts to foster a common European vision. Moreover, some nations may resist pooling sovereignty, preferring to prioritise their own agendas over deeper integration, which further complicates the challenge.

At the heart of this unity lies the need for stronger collaboration, not just politically and economically, but also culturally and ethically. Europe's shared values form the foundation of its identity, and they can drive meaningful cooperation across multiple arenas. Whether it's managing external relations, responding to crises, or addressing complex global problems like climate change, the continent's success hinges on its ability to work together. A cohesive Europe is better equipped to extend its influence globally, to play a leading role in diplomacy, and to help set the international agenda in areas like security, human rights, and environmental stewardship.

Space technologies are a powerful tool in this pursuit of unity and global leadership. The unique nature of space-related endeavours offers Europe a path toward greater regional cohesiveness and international collaboration. Space missions and scientific research require not only technical expertise but also shared resources, strategic planning, and close partnerships between nations. This kind of collaboration fosters trust, encourages the exchange of knowledge, and strengthens relationships within Europe. As countries come together to tackle common scientific goals, they also build deeper bonds that can enhance cooperation in other areas.

Developing space capacities and capabilities is thus recognised as a key priority by ESA Member States to address societal needs towards 2040. However, more ambition is required at the European level<sup>26</sup>, considering science and technology as crucial for transforming economies and societies<sup>27</sup>. This necessitates decisive actions<sup>28</sup> and a whole-of-Europe approach to space,

deeper financial market integration, enhanced procurement, and addressing the full spectrum of space activities. Crucially, the multiplier effect of a concerted diplomatic action that could reconcile different European interests, enhance Europe's global standing and overall soft power and multiply its effectiveness in prosecuting shared foreign policy objectives is missing.



Credit: contains modified Copernicus Sentinel data (2017), processed by ESA

22. Franco-German Ministerial Council, For a strong and sovereign Europe, 28th May 2024.

23. Switzerland's Space Policy 2023.

24. Contract of objectives and performance [State-CNES] 2022 - 2025.

25. Germany's Federal Government's new Space Strategy.

26. Speech by French President Emmanuel Macron on Europe at the Sorbonne University on 25 April 2024.

27. Statement by Prime Minister Kaja Kallas at Asia Tech x Singapore 2023 on 06 June 2023

28. Franco-German Ministerial Council, For a strong and sovereign Europe, 28th May 2024

# ESA GOALS AND OBJECTIVES

Building on the societal needs outlined above, **ESA has identified five overarching goals to guide its efforts through 2040**, ensuring that space serves Europe in the most impactful and strategic way possible. These goals reflect ESA's commitment to addressing Europe's priorities, fostering innovation, and driving forward advancements that enhance the well-being, resilience, and prosperity of European citizens through space exploration, technology, and services.

- 1. PROTECT OUR PLANET AND CLIMATE** advance space capabilities to serve the societal needs of addressing climate change and environmental degradation, to spearhead space sustainability and to protect Earth from space-borne hazards originating from space such as asteroid impacts and space weather events.
- 2. EXPLORE AND DISCOVER** further advance Europe's leadership in Earth and space science towards the next frontiers and ramp up Europe's ambition and capacities in space exploration of low Earth orbit, the Moon, Mars and beyond; pushing the boundaries of human knowledge and inspiring future generations of scientists and explorers.
- 3. STRENGTHEN EUROPEAN AUTONOMY AND RESILIENCE** develop and integrate new space solutions, applications and services that further increase European strategic autonomy and resilience for the benefit of citizens.
- 4. BOOST EUROPEAN GROWTH AND COMPETITIVENESS** ignite innovation, unlock new markets, and boost European prosperity and economic growth through reindustrialisation, industrial capacity building and increased competitiveness.
- 5. INSPIRE EUROPE** kindle curiosity and passion for space among Europe's citizens and foster a more united and cohesive European space ecosystem through renewed partnerships and structural reforms, enabling Europe to better leverage its space capabilities in international diplomacy.

For each of these five goals ESA has identified specific objectives and corresponding technology advances that shall be made over the course of the coming decades to achieve them. By pursuing objectives for each goal, ESA will lay the foundations and provide the framework that will enable Europe to gradually strengthen its role and position over the coming years and decades. Furthermore, the goals and objectives provide the blueprint for defining a comprehensive roadmap for ESA's future endeavours. Implementing ethical guidelines for space activities will ensure that ESA's activities are conducted responsibly and with consideration for their long-term effects.

The five goals in the ESA Strategy 2040 were formulated to reflect ESA's unique position as the space agency for its 23 Member States and the key role it serves in implementing EU space programmes. This combination of roles requires addressing a wide range of objectives and interests, balancing the diverse priorities of its Member States through a distinctive framework with optional programmes. ESA's comprehensive coverage of most space programme domains further shaped the goals to ensure alignment with its multifaceted mission. **While the goals are not hierarchical nor have an order of priority, they are strongly interconnected:** Goals One, Two and Three focus on thematic priorities and societal needs, Goal Four serves as a transversal enabler, and Goal Five provides an overarching vision to inspire Europe. This interconnected design ensures coherence and collaboration across all dimensions of ESA's activities.

Further, the goals and objectives defined reflect Europe core values, such as: the use of space for peaceful purposes; stability and prosperity; a focus on strong public services; regard for the strong historic role of research and educational institutions; and the preference for multilateral solutions to complex problems. In addition, ESA is dedicated to ensuring that its space activities contribute positively to the well-being of future generations, in alignment with the UN Declaration on Future Generations.

Whereas the five goals and their objectives elaborate 'what' the Agency wants to achieve in the coming 15 years, 'how' these goals and objectives will be achieved is an equally important part of the ESA Strategy 2040.

**Many of the strategic actions needed to achieve the goals and objectives can be implemented through existing ESA structures** such as the ESA Council, the Programme Boards and, the Science Programme Committee. These are identified throughout the strategy under the sections 'strategic actions' for each of the five goals. Work will take place within these existing structures to ensure full programmatic alignment between ongoing and future activities and Strategy 2040. The **ESA Long-Term Plan** will be updated to converge on the strategy while considering the needs and financial capabilities of Member States for realistic and sustainable planning. In line with its role, this will enable it to function as the financial and operational backbone, providing a cohesive roadmap, allowing for the optimisation of the use of the agency's resources, to ensure the continuous consolidation of programme implementation and the preparation of corresponding funding by Member States.

In many cases, this implementation will require strong and intensified cooperation among the different actors in the European space ecosystem which includes Member States (including national space agencies), the EU (including EUSPA), industry, the financial sector, and academia.

**Alongside domain-specific actions, ESA is setting up larger transversal reforms which are crucial to delivering all objectives successfully.** This includes the ongoing implementation of the ESA Transformation, stronger ESA-EU cooperation and intensifying commercialisation and partnerships. These three elements are elaborated in final chapter of the ESA Strategy 2040.

## GOAL

## OBJECTIVES

### PROTECT OUR PLANET AND CLIMATE

# 01

- Develop the technologies, missions, applications and services that will enable progress in acting to address climate change, degradation of the environment and pressure on natural resources.
- Spearhead a greener, circular economy in space with global standards for sustainability and a zero debris environment.
- Position Europe as a global leader in space safety by expanding capabilities in space weather services and planetary defence.

### EXPLORE AND DISCOVER

# 02

- Elevate ESA's global leadership in Earth and space science to unravel the mysteries of our planet and the Universe.
- Expand ESA's unique capabilities and roles in the new space exploration era in low Earth orbit (LEO), around and on the Moon, and towards Mars.

### STRENGTHEN EUROPEAN AUTONOMY AND RESILIENCE

# 03

- Secure autonomous and competitive access to and mobility in space through new (potentially including reusable) transportation systems and services
- Develop next-generation technologies and systems in connectivity, PNT, and EO for a more connected and safer future for citizens.
- Develop state-of-the-art space solutions for the prediction and management of natural and anthropogenic disasters and emergencies.

### BOOST EUROPEAN GROWTH AND COMPETITIVENESS

# 04

- Accelerate innovation by spearheading the development of cutting-edge competitive European space technologies in key strategic domains.
- Strengthen industrial capacity and competitiveness to unlock new markets and drive economic growth, fostering a more prosperous society.
- Position Europe as a commercial hub in the booming global space economy, attracting significant private investment.
- Establish Europe as a space research hub, by leveraging world-class technical facilities and, by investing in and attracting top STEM talent.

### INSPIRE EUROPE

# 05

- Reinforce the European space ecosystem through world-class project management and intensified cooperation among key European stakeholders.
- Position ESA as a model for leveraging space activities inclusively to inspire young people and future generations from diverse backgrounds.
- Enable ESA Member States and the EU to harness space capabilities for greater influence in international diplomacy and global affairs.

As humanity navigates the 21<sup>st</sup> century, we confront profound existential risks driven by several sustainability challenges. Climate change remains humanity's largest challenge in the 21<sup>st</sup> century. The World Economic Forum's Global Risks Report 2024 named three key climate issues as critical challenges facing humanity: extreme weather events, critical change to Earth systems, and biodiversity loss and ecosystem collapse.<sup>29</sup>

The knock-on effects of these issues on the environment, food security and natural resource availability are some of the reasons why EU member states have, with the European Green Deal, agreed to reduce greenhouse gas emissions by 55% by 2030 from 1990 levels and become climate neutral by 2050.<sup>30</sup> The United Kingdom, Norway and Switzerland have formulated similar ambitious objectives to become climate neutral in the coming decades. European politicians declared climate as a political priority and have expressed clear calls for actions to address the most pressing issue of our time. Space is an essential part of providing answers to climate science questions, in supporting climate and Earth action, including compliance monitoring from space and, through the implementation of new solutions to strengthen climate adaptation measures.

Solutions are also needed to sustainably steward the near-Earth environment to avoid it becoming unusable in the future due to the rapidly increasing danger of space debris.<sup>31</sup> It has been estimated that the number of active satellites in orbit could go up from about 10 000 in 2024 to 60 000 by 2030. Given that satellites have a limited lifetime, this risks creating tremendous pressure on the safe and sustainable use of the near-Earth environment in space. Travelling at speeds exceeding 30 000 kilometres per hour, even the tiniest item of debris can inflict considerable damage. This growing danger risks threatening operating satellites and orbiting infrastructure and poses significant risks to the safety of astronauts in space, as well as increasing risk on ground stemming from re-entering objects. ESA is committed to developing a zero debris approach to its missions, with a goal to stop adding new debris in orbit by 2030, and is encouraging others to follow similar paths through the facilitation of the community-led Zero Debris Charter initiative. Achieving this objective will require new technical solutions to be developed and will require industrial design processes and operations to be adapted. Further, ESA is also committed to supporting the demonstration and implementation of active debris removal technologies and missions.

A third sustainability risk is coming directly from space in the form of space weather events and asteroids. Solar storms can endanger astronauts and satellites, and disrupt communications, power grids, satellite navigation systems and any services relying on GNSS on Earth. This makes space weather a matter necessitating constant vigilance, with spacecraft watching for events on the Sun that may cause trouble on Earth in the following minutes and days. ESA is committed to developing technology and the capability to provide owners and operators of critical spaceborne and ground-based infrastructure with timely and accurate information to enable mitigation of the adverse impacts of space weather. In the coming years, ESA will reinforce its space weather prediction and forecast capabilities to ensure that the increasing reliance of society on space services does not carry significant risks in terms of resilience. In parallel, awareness is also needed to detect and track Near-Earth Objects (NEOs). While impacts from large asteroids are incredibly rare, small- and medium-sized rocks are far more common in the Solar System and can still do serious damage. ESA conducts regular observation campaigns to look for potentially dangerous NEOs, predicts their orbits, produces impact warnings when necessary, and is involved in potential mitigation measures.<sup>32</sup> Capabilities in this domain shall be further reinforced to ensure that any substantial risk can be predicted and, eventually, mitigated through active asteroid deflection.

ESA's goal to **Protect our planet and climate** consists of three objectives, each crafted to address the challenges outlined above. Pursuing this goal will ensure Europe continues to lead in the use of space, responsibly and sustainably, to address the protection and management of Earth.

29. World Economic Forum's Global Risks Report 2024.

30. [https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC\\_1&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF)

31. Among the 34260 objects monitored in orbit, only about 25 percent are operational satellites; the rest are debris like defunct satellites or discarded rocket stages, or fragments. Furthermore, there are estimated to be around 130 million fragments too small to track, ranging from 1 mm to 1 cm.

32. Of the half a million asteroids currently detected in our Solar System over 25 000 are NEOs, over 1000 of which are in ESA's risk list, meaning that they merit close follow-up observations.

# PROTECT OUR PLANET AND CLIMATE

# 01

OBJECTIVE 1.1

**Develop the technologies, missions, applications and services that will enable progress in acting to address climate change, degradation of the environment and pressure on natural resources.**



**PURPOSE**

To enable the quantum leap from monitoring to deeply understanding and accurately predicting environmental changes; to understand extreme events, natural hazards and their impacts, and to pioneer revolutionary adaptation strategies through cutting-edge Earth observation solutions.

**OVERVIEW**

By 2040, ESA will support Europe in maintaining its role as a global leader in sustainability and in remote sensing. Advances in Earth observation missions to improve our climate understanding such as quantum sensing technologies, a gravity mission to fully provide water cycle monitoring services, integrated space-air-Earth swarm sensors, in-orbit AI and computing technologies, and multi-orbit constellations will become prerequisites for managing our home planet sustainably. All of this will be underpinned by the use of space-based systems to foster scientific understanding of the processes of Earth's natural systems.

These solutions will enhance infrastructure management and support the implementation of regulations governing energy production, agriculture, deforestation, land use, industrial processes, waste management, transportation, and biodiversity.

Furthermore, ESA will develop a fully integrated 'Earth control room' built on a long-time series of space-based data and Earth system models to create digital twins of our planet to understand and anticipate climate change tipping points, provide realtime data, and predictive management tools to its Member States.

**STRATEGIC ACTIONS**

**1 Advance Earth observation technologies, missions and system architectures:**

- a. Develop the general and EO-specific technologies needed to maintain and reinforce Europe's global leadership role in this space domain.
- b. Develop next-generation satellites with enhanced capabilities for high-resolution, high-frequency data collection while enhancing the conditions for commercial actors to complement institutional missions.
- c. Innovate sensor technologies to improve the accuracy of environmental monitoring and increase the number of variables and parameters which can be measured with remote sensing.
- d. Stimulate a thriving EO ecosystem where ESA (or other public entities such as the EU and Member States) act as anchor customers for mission development across Europe.
- e. Develop a comprehensive system architecture for a pan-European approach with distributed elements owned by other partners.

**2 Identify and monitor critical climate change and environmental tipping points by the early 2030s:**

- a. Develop new observation missions and enhance predictive modelling capabilities to better understand environmental and climate change tipping points and their dynamic interplay within the Earth climate system.

- b. Fully embed machine learning and Artificial Intelligence (AI) in digital twins of our Earth system to analyse vast datasets for early warning signals.

**3 Support development of climate change mitigation and adaptation strategies:**

- a. Continue advancing the design and implementation of space-based solutions with predictive capabilities leveraging long-term data records, such as digital twins of the Earth system scheduled for 2030, to enable decision-making on strategies for mitigating climate impacts and, leveraging satellite data for realtime decision-making.
- b. Develop accurate environmental forecasts to support formulations of adaptive measures to build resilience in vulnerable regions.

**4 Reinforce collaborative efforts:**

- a. Strengthen partnerships with international organisations such as the EU and Eumetsat, national space agencies, and commercial entities to maximise the use of Earth observation data and derived information and services.
- b. Promote international data sharing and collaborative research initiatives to address global environmental challenges.

**5 Support policy development and implementation:**

- a. Provide scientific data to support international policy-making, compliance monitoring and evolution and support the United Nations (UN) Sustainable Development Goals (SDGs).
- b. Develop and support the capacity for policymakers to monitor and evaluate the effectiveness of environmental regulations and initiatives until 2040, and beyond.

**KEY TECHNOLOGY DEVELOPMENTS**

Developing advanced technologies ensures Europe remains at the forefront of Earth observation missions. Leveraging breakthroughs in remote sensing capabilities, including quantum-based methods and onboard intelligence, will provide highly accurate and timely environmental data critical for understanding and mitigating ecological changes. Ultra-compact high-performance satellites with integrated functions will minimise launch costs and optimise data collection efficiency, enabling unprecedented Earth observation capabilities. Very Low Earth Orbit (VLEO) satellites will offer high-speed broadband connectivity while high-resolution observations will enhance environmental monitoring with power-efficient instruments.

Moreover, the role of AI-driven innovations in enhancing the engineering and operational processes of space missions cannot be overstated. These innovations will revolutionise space missions, facilitating continuous environmental monitoring without ground intervention. Autonomous collaborative operations in multi-agent systems will enable comprehensive data collection and analysis, significantly improving our ability to monitor environmental changes. AI-driven innovations will further enhance space-mission engineering and operational processes, improving predictive analytics and realtime decision-making for effective environmental monitoring and mitigation strategies.

The digital revolution will also be vital in this advancement by implementing high-fidelity digital twin representations of systems and environments. This will enable advanced analytics, cost-effective solutions, optimised environmental monitoring and predictive capabilities. By developing these technologies, Europe will maintain its global leadership in the field of Earth observation, contributing to global environmental sustainability and technological innovation.

OBJECTIVE 1.2

**Spearhead a greener, circular economy in space with global standards for sustainability and a zero debris environment.**



Credit: Spacejunk3D, LLC

**PURPOSE**

To promote safe and sustainable space utilisation by championing innovation in advanced infrastructure and services and setting global standards for the sustainable use of space.

**OVERVIEW**

ESA is dedicated to spearheading a zero debris future by 2030 and to enable the establishment of a circular economy in space from 2040. This commitment will initiate a profound transformation within ESA, revising its space debris mitigation requirements and policies, and ensuring all missions and projects align with the zero debris ambition. The core question driving this transformation is: 'What is an acceptable amount of debris to generate?' The ideal answer is zero. To achieve this, ESA is implementing a zero debris approach for its missions and has facilitated the drafting of the Zero Debris Charter, collaborating with over 100 global partners to build a shared vision for space debris mitigation and remediation. This charter promotes capacity-building activities to achieve a zero debris future by 2030. The ESA Zero Debris approach includes:

- **Updated policies and technical requirements.**
- **Ensuring the safe disposal of space objects.**
- **Reducing the time objects remain in orbit.**
- **Avoiding in-orbit collisions.**
- **Preventing satellite break-ups.**

By 2030, ESA aims for all its missions to ensure a collision probability below 1 in 1000 throughout the life of the spacecraft, and maintain a 99% or higher likelihood of successful disposal, among other requirements. These stringent measures are part of ESA's broader strategy to lead in sustainable space operations, providing a competitive edge to the European space industry and ensuring the long-term sustainability of space activities. Beyond 2030, ESA aims to champion the establishment of a circular economy in space, ensuring long-term orbital sustainability through in-orbit servicing, in-orbit assembly, in-orbit manufacturing and in-orbit recycling

**STRATEGIC ACTIONS**

**1 Contribute to ensuring a zero debris space environment**

- a. Debris mitigation: Develop new technologies to prevent the creation of new debris.
- b. Debris remediation: Innovate and deploy advanced technologies to safely and efficiently remove space debris from low Earth orbit (LEO) and geostationary orbit (GEO)..
- c. Develop key technological enablers and support the emergence of a global coordination framework for space debris removal activities and space traffic management.

**2 Promoting a cleaner and greener space sector**

- a. Regulatory adherence: Ensure space activities comply with evolving environmental legislation to maintain sustainable operations.
- b. Lifecycle assessment: Evaluate future missions based on their environmental impact throughout their entire lifecycle.
- c. Sustainability practices: Implement sustainable practices in satellite design (eco-design), production, and operations to minimise environmental impact (e.g. sustainable propulsion) and, to ensure space-debrisneutrality by 2030.
- d. Ensuring the preservation of dark and quiet skies.

**3 By 2040, fully embed circular economy principles in space**

- a. Develop circular economy principles for a net-zero debris footprint and sustainable satellite design.
- b. Develop key technological enablers for the future growth markets of in-orbit servicing, in-orbit assembly, in-orbit manufacturing and in-orbit recycling

**KEY TECHNOLOGY DEVELOPMENTS**

Developing key technologies for sustainable space operations is critical to ensuring Europe remains at the forefront of space technology. Achieving a circular and sustainable space economy involves:

- **Maintaining a net-zero debris footprint.**
- **Enabling in-orbit servicing, in-orbit assembly, in-orbit manufacturing and in-orbit recycling.**
- **Designing satellites that neutrally impact Earth's ecosphere throughout their lifecycle.**

Highly autonomous systems are essential, including autonomous operations for efficient debris removal and developing large-scale autonomous distributed space systems, like swarm constellations. Protecting dark and quiet skies for astronomical research necessitates minimising light and radiofrequency pollution through innovative designs and materials. These technologies are crucial for a sustainable future in space and will offer the potential to develop spin-off technologies and applications, ensuring long-term benefits and a competitive edge for Europe in the global space industry.

OBJECTIVE 1.3

**Position Europe as a global leader in space safety by expanding capabilities in space weather services and planetary defence.**



**PURPOSE**

To establish ESA as a global benchmark in space safety, ensuring the development of advanced capabilities to protect the Earth and our assets from disruptions caused by space weather events and Near-Earth Objects' impacts. By setting industry standards and pioneering innovative technologies, ESA aims to secure our planet's future and drive advances in the space sector.

**OVERVIEW**

As humanity's reliance on space-based services and infrastructure grows, so does our vulnerability to space weather events, which can disrupt satellite communications, global navigation satellite systems, and terrestrial power grids, posing a significant risk to our modern technological infrastructure. Similarly, NEOs – asteroids and comets that come close to Earth's orbit – carry the risk of catastrophic impacts that could have severe consequences for life on Earth.

With its advanced technological infrastructure and significant economic dependency on space-based services, Europe is particularly at risk. A moderate solar event could cause over €15 billion in damages and lost services in Europe alone. Historical near misses, such as the 2012 solar event, underscore the critical need for proactive measures in space weather preparedness. Such events could be catastrophic without robust systems and advanced monitoring and forecasting capabilities, affecting everything from communication networks to power grids and financial services.

ESA recognises the urgent necessity of addressing these hazards and is committed to positioning Europe as the global leader in the protection of the planet. ESA aims to set the international standard by developing and deploying advanced strategies and technologies. This involves safeguarding Earth's infrastructure and driving innovation and economic growth within the space sector.

To achieve this, ESA will focus on creating comprehensive monitoring and forecasting systems for space weather and NEOs. Through international collaboration, cutting-edge research, and the deployment of state-of-the-art missions, ESA will lead the effort to protect our planet. This leadership will secure European interests and provide valuable contributions to global planetary defence initiatives.

**STRATEGIC ACTIONS**

**1 Advance operational space weather services:**

- a. Establish a comprehensive space weather service network including ground-based and space-based instruments (e.g. dedicated missions to Sun-Earth Lagrange points) by the mid-2030s.
- b. Supporting the establishment of operational space weather service for Europe through transitioning mature service elements into an operational framework as a progressive action from 2025 to 2040.

**2 Improve NEO Detection and Monitoring:**

- a. Develop a network of survey telescopes dedicated to NEO detection by the early to mid-2030s.
- b. Facilitate continuous advances in NEO tracking and mitigation technologies

**3 Strengthen NEO fast-reconnaissance and deflection:**

- a. Cement European leadership in fast-reconnaissance missions to study and develop strategies against potential asteroid impacts by 2030.
- b. Develop European capabilities for hazardous NEO deflection in the 2030s.

**KEY TECHNOLOGY DEVELOPMENTS**

By 2040, ESA aims to lead the global effort in space weather and planetary defence through significant technical advances. Developing propulsion technologies for missions beyond Earth's orbit will enhance efficiency and reach, enabling new missions and markets. Implementing high-speed travel technologies will ensure rapid response capabilities for planetary defence. Highly autonomous systems will reduce mission costs and increase operational efficiency. Designing resilient space missions will ensure they can withstand natural and human-made hazards. Innovating deep space power sources will support long-duration missions. Enhancing secure and autonomous operations for space assets will improve responses to space weather events, reducing the impact on citizens and the economy. Utilising cutting-edge materials and manufacturing processes will result in durable and efficient spacecraft. Exploring commercial opportunities in asteroid mining will leverage planetary defence technologies to drive economic growth. By integrating these advances and fostering international collaboration, ESA will set the benchmark for safeguarding Earth and exploring new frontiers in space.

**The 'Explore and discover' goal is of crucial importance to asserting Europe's leadership in Earth science, space science and exploration. This goal is set to propel Europe to the forefront of the space ecosystem, by placing it in a strategic position for future endeavours. With a focus on excellence, innovation, leadership and collaboration, ESA strives to elevate Europe's scientific and technical capabilities and secure a central role in advancing space science and exploration from low Earth orbit to the Moon and ultimately Mars for the decades to come.**

# EXPLORE AND DISCOVER

# 02

By addressing some of the most profound scientific questions of our time, ESA missions will continue to push the boundaries of our knowledge, investigating the complex dynamics that define Earth processes and the Universe, probing the formation and evolution of our Solar System and beyond, and, ultimately, helping us understand our place in the cosmos.

The Earth system behaves as a single, highly coupled system comprising physical, chemical and biological components and processes, on which humanity is now having significant effects. There are complex interactions and feedback loops between the components that cross traditional disciplinary boundaries of study, and take place over a wide range of spatial and temporal scales. Even in the absence of external forcing, the Earth system exhibits considerable natural variability, which needs to be understood and distinguished from the human-induced trends such as anthropogenic climate change.

New space science and exploration missions will guarantee ESA and Europe a leading position in the international arena of new space discoveries. Breakthrough results will be possible thanks to significant technological innovation, resulting in the delivery of excellent mission performance and reliable scientific data. ESA's portfolio of current and future missions spans a variety of scientific objectives, including: investigating the complexities of the Sun's behaviour and its impact on the Earth and the Solar System overall; observing and probing the interior, surface and surroundings of Mercury, Venus and Mars to clarify their evolution and distinct characteristics with respect to Earth; visiting giant planets and their moons to gain insights into their formation, structure and potential habitability, and search for signs of extraterrestrial life; investigating complex cosmic processes by observing the Universe at a multitude of wavelengths and by detecting gravitational waves with a space-based observatory.

ESA's goal is to solidify Europe's position as a pioneering force in space exploration. By establishing a sustained presence in low Earth orbit (LEO) and soon on the Moon, Europe will play a crucial role in the new era of space exploration embraced by major world-leading countries. This will involve enhancing Europe's capabilities in LEO through advanced satellite technologies. Europe will continue its participation in the ISS and post-ISS space stations. Collaborative international projects will also be key. The necessary infrastructure will be built to support operations in cislunar space. A continuous presence on the Moon will be established, focusing on scientific research. Technologies for sustainable lunar habitation will be developed. The infrastructure to support cislunar space operations will include (heavy lift) transportation systems, communication, and navigation. Surface mobility will also be a focus. Finally, preparations will be made for human and robotic missions to Mars, including developing innovative technologies and conducting pioneering robotic exploration missions.

By launching ambitious missions that use cutting-edge technologies, ESA will maintain a strong presence in key areas of space science and exploration. With this strategy, ESA aims not only to advance our understanding of the Universe, but also to excite future generations, foster international cooperation, and make a substantial contribution to the progress of scientific knowledge, bringing benefits and prosperity to society at large. ESA's work today will shape the future of space exploration and scientific discovery and serve as a source of inspiration and learning for generations to come.



## OBJECTIVE 2.1

## Elevate Europe's global leadership in Earth and space science to unravel the mysteries of our planet and the Universe.

Credit: ESA/Hubble/ESA/ESA/NASA, image processing by J.-C. Cuillandre (CEA Paris-Saclay), G. Anselmi

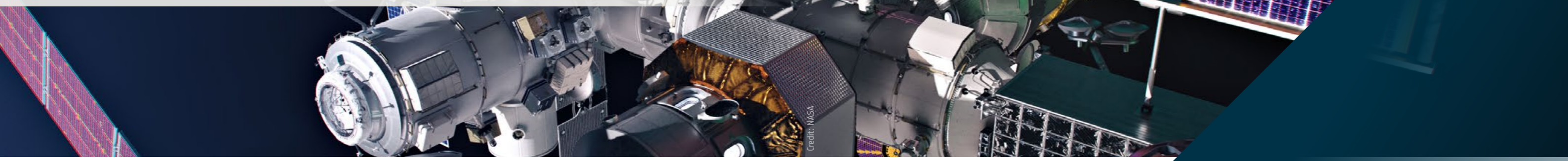
### KEY TECHNOLOGY DEVELOPMENTS

The access to advanced manufacturing, quantum technologies, digital innovations, deep space power sources, and autonomous systems will drive the success of Voyage 2050 missions, enabling ESA to unlock new scientific frontiers and inspire future generations. Specifically:

- Advanced manufacturing will use AI and smart chemistry to develop new materials and implement in-orbit assembly and *in situ* manufacturing capabilities for long-duration space missions;
- Quantum technologies will enhance space applications through quantum networks and sensors, improving observational capabilities;
- Breakthroughs in remote sensing with quantum-based methods will improve space science observation capabilities;
- The digital revolution will bring digital twins and AI-driven innovations for mission planning and operations, enhancing mission autonomy and reducing reliance on Earth-based control;
- Robust Solar System internet navigation and communication systems will ensure reliable and secure networks for interplanetary missions;
- Deep space power sources will advance solar and nuclear power technologies to support long-duration missions and develop energy-efficient hibernation systems to reduce power consumption;
- Innovative propulsion systems will focus on efficient and sustainable space travel technologies to support long-duration and deep space missions.

## OBJECTIVE 2.2

## Expand ESA's unique capabilities and roles in the new space exploration era in low Earth orbit, around and on the Moon, and towards Mars.



## PURPOSE

Europe's exploration initiatives are driven by science, economic benefits, international cooperation, and the inspiration for future generations. The efforts focus on making distinctive contributions to sustain human activity in LEO and soon around and on the Moon, laying the groundwork for pioneering missions to Mars. By fostering a sovereign attitude and a leadership mindset, ESA intends to ensure that Europe keeps up with the challenge and remains competitive as other nations accelerate their pace.

## OVERVIEW

Europe boasts a deep-rooted history of both human and robotic exploration, including its scientific and technology aspects. Building on its numerous accomplishments to date, ESA aims to position Europe as a leader in global space exploration, investing in a prosperous future for the benefit of citizens.

By embracing self-determination and securing a strong European presence in LEO and on the Moon, Europe will not only push the boundaries of science and technology but also enhance its economic positioning. The benefits of these missions, such as high-quality job creation, technological spin-offs, and potential resource exploitation in the long run, promise to be substantial. The ambition is Europe-wide and encompasses national activities. It fully aligns with ESA's overarching goal of using space to foster innovation, economic growth, and societal advancement, while enhancing scientific knowledge.

International collaboration is more than an advantage for the ESA exploration strategy, it is an essential component. It enables the pooling of resources, sharing of risks, and harnessing the expertise of global counterparts. Through cultivating a cooperative environment with other space agencies and private companies worldwide, Europe aims to lead in specific domains while remaining a valued partner in others. This will provide substantial geopolitical benefits, as being at the forefront allows Europe to shape its unique perspective and influence humanity's exploration trajectory. Therefore, a coherent, unified, and fully coordinated approach is crucial for Europe to advocate for sustained and responsible use of outer space in its programme execution.

Activities in LEO and lunar missions serve as essential groundwork for ultimately pioneering history making expeditions to Mars. Europe's daring and visionary strategy<sup>32</sup> is vital in the highly competitive global space arena, marked by renewed ambitions from established space-faring nations, an influx of new countries with high aspirations, and private space companies ramping up their investments and increasing their global influence.

Finally, space exploration – due to its inherently inspiring nature and power for fascination– will constantly spur efforts to push the technological boundaries as well as having a cultural and even a philosophical dimension capable of captivating and engaging the younger generation. The ambitious ESA exploration programme will demonstrate that 'space is the place', act as a powerful catalyst for STEM education and careers while infusing an optimistic, can-do attitude, creating a shared sense of purpose and optimism across the continent about the potential of the next generation in shaping the future within a shared global endeavour.

<sup>32</sup> Explore2040 - ESA/C(2024)34.

## STRATEGIC ACTIONS

### 1 Strengthen European access to and presence in LEO:

a. Sustainable operations and unlocking commercial opportunities:

- Expand European participation in the 2030s post-International Space Station ecosystem, to ensure continued European presence in LEO and a seamless transition to future space station infrastructures, in the 2030s-40s, in the interest of science and for de-risking the deep-space habitation needed for the big leap to Mars.
- Support the development of future space stations, enabling European industries to take leading roles in these new ventures and secure European participation in the LEO economy.

b. Sovereign capabilities:

- Explore new opportunities for collaboration and develop sovereign and autonomous European services for transporting cargo and eventually crew to LEO, reducing dependence on external providers and enhancing Europe's strategic autonomy towards 2040 and beyond.

### 2 Build-up infrastructure to support robotic and human operations for science and exploration around the Moon and on its surface in the 2030s:

a. Orbital and surface infrastructure:

- Develop European capabilities for logistics operations on the lunar surface, including habitats, innovative mobility, power generation and distribution, and resource prospecting and possibly utilisation.
- Provide essential infrastructure for the cislunar environment, such as communication networks, navigation systems, and to support sustained lunar surface exploration and utilisation.
- Participate in the lunar Gateway, contributing modules and technologies that enhance the station's capabilities and ensure European presence in lunar orbit to perform research and prepare for deep space exploration.

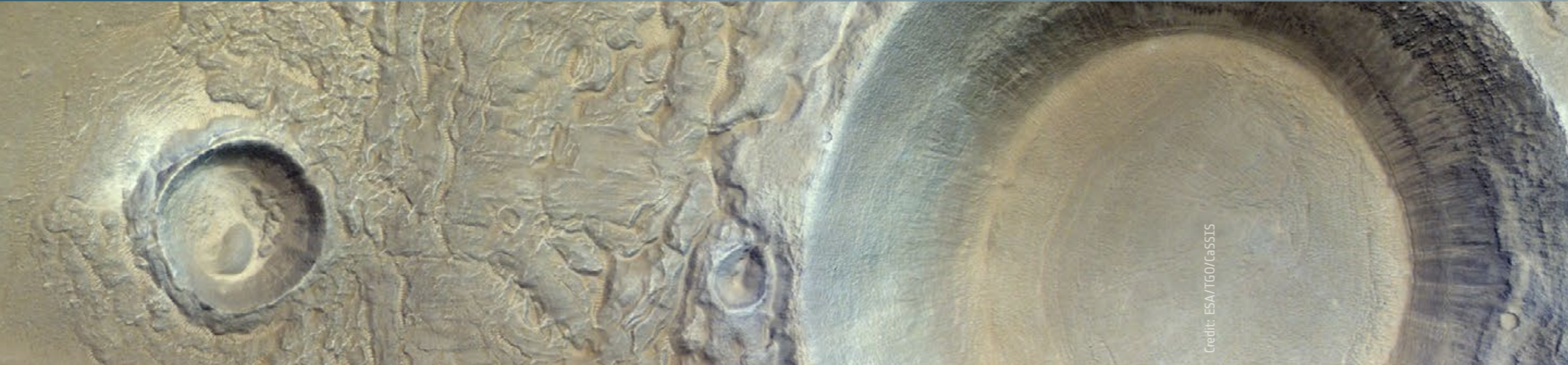
b. Cislunar and lunar surface transportation:

- Fly the Argonaut lunar lander to deliver scientific instruments and logistic supplies to the Moon's surface. Explore and potentially implement the evolution of its capabilities towards the delivery of heavier payloads to build up surface infrastructures.
- Continue Europe's pivotal role with the European Service Modules (ESMs) propelling the international Artemis crews to the Moon and back before 2030.

### 3 Continue robotic exploration of Mars to build up the capabilities for Europe to play a significant role in the future human exploration of Mars and to keep yielding scientific discoveries:

- a. Conduct robotic missions to Mars, in the 2030s, enabling groundbreaking discoveries about the history of the Solar System and the origins of life itself, as well as to pave the way for human exploration by deploying essential communication and navigation infrastructure, scouting for landing sites, studying the martian environment, and testing new landing systems and surface survival and mobility technologies.

## OBJECTIVE 2.2



Credit: ESA/TGO/Cassini

b. Leverage technologies and scientific knowledge gained from ground-based autonomous habitation analogues and lunar missions to prepare for deep space travel. Focus on key enablers, such as self-standing medical and life support systems, vast recycling, energy management, radiation protection, or AI-driven autonomous operations.

#### 4 Foster stronger international collaboration in exploration:

- Leverage Europe's unique technological and industrial strengths to develop human-rated orbital platforms, new transportation systems, and lunar surface operations that align with Europe's long-term exploration goals.
- Strengthen partnerships with historical and new international institutional Partners and private entities to share knowledge, reduce costs, and enhance mission success.
- Advocate for European leadership in international frameworks by aligning missions with global exploration objectives while retaining the strategic autonomy to execute European-led missions.

### KEY TECHNOLOGY DEVELOPMENTS

The integration of innovative technologies, as outlined in the TEC Vision 2040, is crucial for achieving these objectives. Many of the technological capabilities have strong links with other ESA space activities and programmes.

- Innovative robotics and mobility, and utilising local resources will benefit both sustained robotic and human missions, synergetic with bottom-up purely science-driven missions and activities.
- Power generation technologies will address the energy needs for extended missions.
- Advanced medical, life-support, circular processes, and performance technologies will enable the increased presence of humans in space. Improved medical systems, creation of safe environments, and support for physical and mental well-being during extended missions will facilitate seamless deep space travel and the establishment of permanent bases on the Moon and Mars.
- New launcher capabilities (potentially including heavy lift and reusable systems), high-efficiency refillable propulsion systems and advanced manufacturing techniques within the STS remits are critical for long-distance travel and creating durable spacecraft.
- Establishing robust interplanetary communication and navigation networks - through CSC - will enable missions and ensure coordination and safety.

Key themes such as advanced propulsion and transportation systems, surface mobility and robotics, power sources, deep space autonomous habitation, and entry, descent and landing (EDL) have potential synergies beyond space, benefiting sectors like health, mobility, energy, resilience, and advanced aeronautics.

The agency is dedicated to strengthening Europe by addressing the key societal needs of autonomy and resilience. A first key pillar in this regard is having guaranteed autonomous and competitive access to and mobility in space, free from external dependencies.

# STRENGTHEN EUROPEAN AUTONOMY AND RESILIENCE

# 03

ESA will focus on securing this key requirement by developing state-of-the-art and scalable transportation systems in cooperation with European space industry. This objective is fundamental in safeguarding Europe's interests and in maintaining a robust presence in space.

Secondly, ESA will strengthen and further improve Europe's space-based secure telecommunications, hyper-precise navigation and Earth observation capabilities. Developing the next generations of these infrastructures and their applications and services, in strong cooperation with the EU, is key in building a secure, responsive and connected future for European citizens. ESA's work in this area is crucial as we strive to improve space-based information systems to ensure seamless compatibility with ground infrastructure and networks. Continued leadership in these areas is also crucial for Europe to position itself as a key global player in space, able to strengthen Europe to cooperate on equal footing with other spacefaring actors such as the United States, Japan, or India.

Lastly, and building on the points above, ESA aims to develop new space solutions that will revolutionise European crisis response. These will help safeguard European citizens through advanced satellite responsiveness and monitoring, data analytics, and realtime connectivity to first responders in the field, a strategy set to transform reactivity and the prediction and management of natural and human-made disasters. This approach will provide unparalleled precision and efficiency in crisis response, enhancing Europe's resilience, preparedness and protecting its citizens and critical infrastructures from various threats and crises.

## OBJECTIVE 3.1

## Secure autonomous and competitive access to and mobility in space through new transportation systems, solutions and services.

### PURPOSE

To secure Europe's autonomous access to and mobility in space by developing state-of-the-art transportation systems, enhancing capabilities while increasing sovereignty and resilience in the space domain.

### OVERVIEW

Space has become an indispensable part of modern society, influencing everything from communications and navigation to environmental monitoring and defence. ESA recognises the strategic importance of maintaining and significantly enhancing Europe's capabilities in space to ensure autonomy and resilience in an increasingly competitive and complex global environment. By 2040, ESA aims to establish Europe as an indispensable actor in the space transportation sector, through groundbreaking advances in space transportation technologies.

To achieve this vision, ESA will focus on securing and strengthening continuous autonomous access to space, which is crucial for civilian and defence applications and for including exploration missions beyond LEO. Developing advanced, state-of-the-art transportation systems will enable Europe to launch and operate its satellites and other space assets independently, reducing reliance on non-European entities and mitigating risks associated with geopolitical uncertainties.

Innovation will be at the heart of this transformation. By fostering a culture of innovation and investing in cutting-edge technologies, ESA will drive the development of scalable infrastructure integrating (potentially reusable) launch and in-space transportation systems, very high thrust as well as low-cost green propulsion technologies, and sustainable space operations. These advances will enhance Europe's strategic capabilities and create new opportunities for commercial growth and collaboration.

Public-private partnerships will play a pivotal role in this endeavour. By leveraging the strengths of both sectors, ESA aims to cultivate a dynamic and competitive space industry that can respond to emerging challenges and opportunities. Collaboration with private companies will spur innovation, reduce costs, and accelerate the deployment of new technologies, ensuring that Europe remains at the forefront of space exploration and utilisation.

By achieving these strategic objectives, ESA will secure Europe's autonomous access to space and drive the next generation of space exploration and commercialisation. This ambitious vision will ensure that Europe remains a global leader in space technology, contributing to its citizens' security, prosperity and well-being, and strengthening its position on the world stage.

### STRATEGIC ACTIONS

#### 1 Develop advanced space transportation systems:

- Scalable infrastructure, potentially integrating reusable launch and in-space transportation systems.
- Low-cost, green propulsion technologies.
- Through feasibility studies for very high thrust propulsion and very heavy launch system performance capabilities, to enable exploration and large-scale infrastructure deployment.
- Incremental deployment of space transportation solutions from 2030 onwards.

#### 2 Stimulate commercial in-orbit services in low Earth orbit (LEO):

- Innovative technologies for in-orbit data storage, processing, manufacturing, refuelling, servicing, and debris removal.
- Support for commercial missions and European institutional mission scenarios through public-private partnerships.

#### 3 Ensure autonomous European space access and resilience

- Ensure Europe's continuous autonomous access to space through the realisation of a paradigm shift whereby launch services are increasingly procured as a service.
- Increase launch systems performance capabilities to enable Europe's non-dependence for exploration missions beyond LEO.
- Develop a scalable 'Hub-and-Spoke' network approach for space logistics through new launchers and space tugs.
- Integrate dual-use space assets into resilience planning.

### KEY TECHNOLOGY DEVELOPMENTS

Developing advanced technologies is essential for Europe to secure autonomous access and mobility in space. Deep space power sources will see advances in solar arrays, nuclear power for propulsion, and innovative power conditioning units, ensuring reliable energy supply for long-duration missions under extreme conditions. Highly autonomous systems will revolutionise space missions through self-assembly, multi-agent operations, and adaptive decision-making, enabling extended-duration operations without ground intervention and optimising power and data resources.

Focus on constructing large space structures using *in situ* manufacturing and advanced robotics will allow for efficient deployment of satellites and probes for telecommunications, enhanced Earth observation, and ambitious scientific missions. Innovative propulsion technologies will support new missions and markets, including very high thrust, green and low-cost methods. Very high thrust chemical, high-power electric and nuclear propulsion will enable large payload crewed or cargo deep space missions.

Advanced manufacturing and materials development will be driven by AI and smart chemistry, creating innovative materials and manufacturing techniques for *in situ* space construction and enhanced performance. A circular and sustainable space economy will focus on zero debris operations and recyclable satellite designs, implementing sustainable practices with next generation launch and in-space transportation systems and robust satellite designs. Resilient space systems with secure supply chains and accurate space situational awareness will be developed to withstand natural and human-made challenges, ensuring continuous operation and mission fulfilment.

## OBJECTIVE 3.2

## Develop next-generation technologies and systems in connectivity, PNT and EO for a more connected and safer future for citizens.



### PURPOSE

To establish a robust, secure and interconnected European sovereign infrastructure by advancing space-based information systems and ensuring their seamless integration with other space-based assets and terrestrial networks.

### OVERVIEW

As we move towards 2040, ESA aims to strengthen and expand Europe's role as a space technology and infrastructure leader. The advent of the quantum revolution will enable the development of the quantum internet for which satellites are necessary for the interconnection of quantum devices at long distances. By enhancing telecommunications, navigation, Earth observation and security systems, Europe will build a strong foundation for a safe, secure and connected future. This objective focuses on improving space-based communication systems, ensuring their seamless integration with ground infrastructure and networks to support various applications, from emergency response to autonomous driving.

In a society increasingly dependent on data and information exchange and with a trend towards more autonomous means of travel, there is a need for connectivity at all times and everywhere on land, in the air and at sea, and protection against cybersecurity and other threats to ensure the safety of European citizens and security in communications. Terrestrial telecommunication networks alone cannot guarantee the required coverage, resilience, and security.

ESA is devoted to building space communication solutions that complement and enhance the terrestrial networks with advanced space technologies that enable direct communication from space to handheld devices, vehicles on-the-move and using post-quantum security schemes such as quantum key distribution (QKD).

Through international collaboration and the development of resilient space systems, ESA aims to create a safer and more secure Europe.

### STRATEGIC ACTIONS

#### 1 Strengthen competitiveness, autonomy and leadership of Europe in global markets:

- Development of disruptive concepts and technologies, anticipating or addressing market trends and evolutions.
- Development of competitive European critical technologies, space and ground products and end-to-end solutions for multi-orbit connectivity space systems.
- Foster standardisation and industrialisation, achieving readiness for production at scale.

#### 2 Develop the next generation of secure and resilient connectivity capabilities and infrastructures well before 2030:

- Improve existing systems: assess and upgrade current telecommunications infrastructure to ensure performance, robustness and resilience.
- Develop next-generation technologies: invest in research and development of cutting-edge telecommunications technologies to enhance Europe's competitive edge.

c. Develop direct space-to-device communication solutions and seamless integration with terrestrial networks.

d. Develop quantum-resilient cryptographic security solutions.

#### 3 Advance PNT capabilities throughout the 2020s and 2030s:

- Develop the next generation of PNT systems towards millimetre ranging and picosecond timing accuracy, thus improving services by an order of magnitude to safeguard European PNT leadership and enable new market applications and services.

#### 4 Develop the next generation of space technologies, satellites and system architecture for the Copernicus programme.

#### 5 Develop resilience architecture and infrastructure to respond to crises and threats

- Based on the experience of developing major European flagships with and on behalf of the EU, ESA will further develop cooperative projects, for example combining Earth observation, connectivity, PNT, on-board edge computing and AI as well as integrating a mesh of sensors to enhance Europe's resilience in case of disasters and security threats.

#### 6 Lay the foundations of the quantum internet:

- Develop space systems for the interconnection at long distances of quantum devices: computers, sensors and clocks

#### 7 Ensure spectrum sustainability:

- Implement spectrum monitoring systems to support an environment free from RF interference.

#### 8 Prepare the development of a 'Solar System Internet':

- Decentralised connectivity: Collaborate with international partners to develop a decentralised Solar System Internet, building on the Moonlight programme to provide secure and interoperable communication and navigation services.
- High-throughput communications: Deploy high-throughput RF and optical communications for space and ground systems.
- Deep-space positioning: Implement precise deep-space positioning, navigation, and timing (PNT) capabilities to support a variety of missions.
- Transportation management: Support the integration of PNT into transportation networks and autonomous driving management.
- Critical infrastructure: Ensure stronger resilience in the operation of critical infrastructure.

## OBJECTIVE 3.2

## Develop next-generation technologies and systems in connectivity, PNT and EO for a more connected and safer future for citizens.



### KEY TECHNOLOGY DEVELOPMENTS

Advances in key technology areas aligned with ESA's Technology Vision 2040, which will drive the enhancement of Europe's telecommunications, navigation, and security systems. The development of next-generation quantum technologies will play a critical role, introducing quantum networks, sensors, and advanced atomic clocks to significantly improve navigation, communication, and security systems. A further development of optical communication technologies for space-to-space, space-to-ground, and space-to-air vehicles is a necessary precursor for next-generation quantum communication technologies. In parallel, security for space systems will be fortified through quantum-resilient cryptography, scalable protection solutions, and enhanced situational awareness, safeguarding space assets against evolving threats.

Building resilient space systems is of critical importance. Secure supply chains, comprehensive space situational awareness, and robust design methodologies ensure that these systems can withstand natural and human-made adversities. Interoperable platform development (both ground- and space-based) is key for resiliency by enabling deployment of a 'system of systems' approach. The integration of digital technologies and shorter space technology development cycles will revolutionise space system engineering and operations. Utilising digital twins, advanced modelling, and AI-driven innovations will optimise system delivery, reduce costs, and enhance operational efficiency.

Advances in delay/disruption tolerant and network-centric communication architectures, high-throughput RF and optical communications, precise deep-space PNT capabilities, and ultra-large satellite architectures will enable the deployment of a robust Solar System Internet and establish a reliable and secure network across the Solar System. Breakthroughs in remote sensing capabilities will leverage smart sensors and onboard intelligence to provide high-accuracy, timely data for environmental monitoring and strategic applications, enhancing Europe's observational capacities.

The development of ultra-compact, high-performance satellites will support large constellations for global connectivity and observation, utilising advanced manufacturing techniques, standardised interfaces, and integrated avionics. Additionally, aerodynamically efficient satellite platforms and sustainable propulsion systems will enable the provision of high-speed broadband connectivity and high-resolution Earth observation from VLEO.

These unified technological advances will ensure that Europe remains at the forefront of space technology, fostering a secure, resilient, and interconnected infrastructure that supports various applications and maintains European autonomy in critical space domains.

## OBJECTIVE 3.3

## Develop state-of-the-art space solutions for the prediction and management of natural and anthropogenic disasters and emergencies.

(credit: contains modified Copernicus Sentinel data (2024), processed by ESA)

### PURPOSE

To ensure seamless provision and stability of critical services and enhance crisis response capabilities of Europe, safeguarding citizens with precision and efficiency. ESA aims to develop the state-of-the-art satellite connectivity solutions, satellite monitoring and data analytics needed to revolutionise the prediction and management of natural and human-made disasters.

### INTRODUCTION

In an era of increasing natural and human-made threats, the need for robust crisis response and continuity of critical services has never been more pressing. ESA is dedicated to fortifying Europe's autonomy and resilience by developing advanced space technologies and, by creating synergies with other existing and upcoming capabilities in Europe based upon a shared understanding of its Member States. This objective will position Europe at the forefront of disaster management and critical service continuity by 2040.

By integrating state-of-the-art satellite monitoring and sophisticated data analytics, ESA will enable user communities and civil authorities to predict and manage disasters with unparalleled accuracy. Natural disasters, such as floods, earthquakes, wildfires, and human-made crises, including industrial accidents, cyber threats, and war, pose significant risks to European citizens and infrastructure. Using advanced satellite technologies and realtime data analysis, together with realtime connectivity to first responders in the field and operational centres, ESA will enhance Europe's ability to efficiently anticipate and respond to these threats.

GNSS (i.e. Galileo and EGNOS) will remain critical technologies and infrastructures for navigation in our modern-day societies in 2040, with the security component of those infrastructures becoming more and more prominent, both in terms of safety and of strategic autonomy for Europe. A continuous need to invest in the evolution and enhancement of these GNSS systems in Europe is thus essential to ensuring performance, resilience, and increased robustness, in particular in view of the unfolding of the quantum age.

The strategic implementation of these technologies will contribute to protecting lives and property and ensure uninterrupted functioning of essential services such as communication networks, energy supplies, transportation systems, food supply, and healthcare services. By incorporating advanced monitoring and analytics, ESA aims to bolster Europe's defensive and responsive measures against the destructive impacts of war, ensuring the safety and resilience of its citizens and infrastructure.

Through international collaboration and the development of resilient space systems, ESA aims to contribute to a safer and more secure Europe, capable of withstanding and quickly recovering from any crisis.

### STRATEGIC ACTIONS

#### 1 Improve existing crisis prevention and response capabilities by continuing to advance capabilities in connectivity, EO and PNT through existing programmes:

- Advance space-based communication systems to support rescue operations, to ensure uninterrupted and high-throughput connectivity and near-real time response during emergencies.

- Deploy the capabilities necessary to monitor and react fast to environmental changes and assess impacts on agriculture, water resources, and urban areas, and, to monitor critical infrastructure such as power plants, water supply systems, and transportation networks to ensure their integrity and functionality during crises.
- Prepare Europe for the future of PNT and so preserve and increase the benefits of the GNSS - and wider space-based PNT - sector for European society, including supporting the EU for the implementation of its programmes aiming at the development, maintenance and enhancement of the backbone GNSS infrastructure.

#### 2 Develop secure and resilient infrastructure:

for resilient and secure digital communication across land, air, sea and space, collaborating with the European ecosystem to deploy space-to-device systems and applications in the areas of smart cities and urban management, food security, access to resources, IoT, autonomous driving, telemedicine, and intelligent energy supply.

#### 3 Prepare a future European-level resilience initiative:

by mapping current assets, identifying performance gaps, gathering user requirements, proposing solutions for a system architecture and, preparing a programme to develop and implement initial demonstrations of services.

### KEY TECHNOLOGY DEVELOPMENTS

To achieve the objective of enhancing crisis response and critical service continuity, several key technological developments will be leveraged leading to breakthroughs in remote sensing capabilities, ultra compact high-performance satellites, in-orbit processing, Very Low Earth Orbit (VLEO), smart operations ground segment, resilient space systems, quantum technologies, Solar System Internet, navigation and communication systems, AI-driven innovations in space technologies, and digital revolutions for space. Developing and deploying a network of high-resolution Earth observation satellites with secure realtime data transmission capabilities will be essential. These satellites will utilise smart sensors, adaptive payloads, and autonomous decision-making systems for persistent monitoring, combined with aerial and ground systems, including IoT (federation of systems). Integrating AI-driven innovations to enhance the processing and analysis of satellite data is crucial, with predictive analytics used to forecast natural disasters and optimise crisis response, ensuring timely and effective actions.

Additionally, focusing on developing resilient space systems, quantum technologies, advanced manufacturing, and AI-driven solutions will be critical. Another key aspect is promoting a circular and sustainable space economy to minimise environmental impacts.

Fostering partnerships with international space agencies, European institutions, and private sector entities to share data and resources is imperative. At the same time, strong interaction with user communities is necessary for developing user-driven systems. Engaging with local and national governments will align satellite monitoring initiatives with public safety objectives, enhancing overall collaboration. These technological advancements will ensure the seamless continuity of critical services and improve crisis response capabilities, safeguarding European citizens with precision and efficiency. By leveraging these technologies, ESA aims to revolutionise the responsiveness, prediction and management of natural and human-made disasters, ensuring Europe's autonomy and resilience in the face of various threats.

**ESA is dedicated to establishing Europe as a global hub in space technologies and aims to ignite innovation and unlock new markets for space goods and services to support economic growth throughout Europe. By concentrating on four primary objectives, ESA will foster a competitive and dynamic European space industry, attract world-class talent and investment, and set global standards in space technology and services.**

# BOOST EUROPEAN GROWTH AND COMPETITIVENESS

# 04

A first step and objective needed to achieve this is to lead the way in innovation and advancement in space technologies. Through strategic investments in developing selected competitive European space technologies, ESA, together with its European partners, will allow Europe to remain a global leader in research and development. This will foster a thriving European space industry that drives technological excellence and discovery, ensuring sustained economic growth and leadership in space technology.

The second objective is encouraging innovation, creating new markets, and boosting economic growth by building a competitive European space industry that sets global standards. ESA together with its European partners will foster an environment that supports the creation of new markets within the European space sector and strengthening the competitive position of European players in established commercial markets, including in established application domains such as navigation, Earth observation, connectivity, weather forecasting and emerging markets such as deep-space connectivity and the LEO economy (in-orbit servicing, etc.). By excelling in these fields, Europe will lead in technology and service development, ensuring robust economic growth and positioning itself as a global standard-setter and leader in the space industry.

The third objective is crucial to transforming Europe into a pivotal commercial hub in the global space economy and attracting more private investments. ESA is planning to support its Member States in developing policies and initiatives that create a more attractive investment climate for private entities, offering incentives and reducing barriers to entry. This will attract significant private investments, bolstering Europe's economic position and ensuring sustained growth and innovation within the space sector.

The fourth objective focuses on Europe attracting and retaining world-class talent, including researchers, students, and professionals. ESA aims to make Europe the global epicentre for cutting-edge research and growth in space. By implementing programmes and initiatives that draw top-tier talent from around the world, Europe will solidify its reputation as the premier destination for space-related expertise and innovation. This influx of talent will drive forward-thinking research and development, contributing significantly to Europe's leadership in the space sector and to Europe's growth potential, productivity and competitiveness.

OBJECTIVE 4.1

**Accelerate innovation by spearheading the development of cutting-edge competitive European space technologies in key strategic domains.**



**PURPOSE**

To position Europe as a key player in space technology, and to lay the foundations of future applications, services and commercial markets, ESA will invest in the development of technologies with significant growth potential.

**OVERVIEW**

ESA aims to spearhead the innovation and advancement of cutting-edge competitive European space technologies. This objective is designed to drive global research and development leadership, foster a thriving space industry, and position Europe at the forefront of technological excellence and discovery. By focusing on this objective, ESA will create synergies to bolster other strategic objectives, enhancing Europe's overall space capabilities.

This objective supports other strategic objectives in several impactful ways. First, by advancing innovative propulsion and remote sensing technologies, ESA can undertake more ambitious scientific missions, enabling the exploration of our Solar System and beyond. This will provide valuable data for scientific research and contribute to our understanding of the Universe. Additionally, developing green propulsion technologies and implementing a circular economy in space will ensure that ESA's activities are environmentally sustainable. This aligns with the broader goals of minimising ecological impact and promoting sustainability in all space operations.

Moreover, as ESA leads in developing advanced space technologies, it will attract international partnerships and collaborations, facilitating cooperation with other spacefaring nations. This global leadership will not only enhance knowledge sharing, resource pooling, and expertise to address common challenges and achieve shared goals, but also stimulate economic growth by creating new industries, jobs, and markets. By fostering innovation, ESA will enhance Europe's competitiveness on the global stage, attracting investment and driving technological advancements across various sectors.

Furthermore, by developing resilient space systems and advanced security technologies, ESA will play a crucial role in protecting its space assets from potential threats. This will ensure the reliability and sustainability of space operations. The deployment of high-speed broadband connectivity through VLEO satellites will provide internet access to remote and underserved areas, supporting social development by bridging the digital divide and enhancing communication infrastructure. Lastly, pursuing ambitious space missions and technological innovations will inspire future generations of scientists, engineers, and technologists. Educational programmes and outreach initiatives will encourage young people to pursue careers in STEM fields.

By focusing on these strategic actions, ESA will ensure that its technological advances support broader strategic aims, from enhancing scientific research and exploration to fostering sustainable development and international collaboration. This comprehensive approach will drive technological excellence and discovery for decades, ensuring a prosperous and innovative future for Europe's space endeavours.

**STRATEGIC ACTIONS**

As part of the ESA 2040 Technology Vision, ESA will explore and develop the following key enabling technologies:

- 1 Innovative propulsion:**
  - a. Develop green and low-cost propulsion technologies, including hydrogen peroxide storability, beamed energy propulsion, and nuclear propulsion, to enable new missions and minimise environmental impact.
  - b. Introduce atmosphere-breathing propulsion in extremely low orbits and very high-power electric propulsion to support large cargo missions.
  - c. Innovate in-space cryogenic propulsion and water propulsion for the asteroid belt *in situ* resource utilisation (ISRU), enhancing the sustainability of deep space missions.
- 2 Astro architecture:**
  - a. Pioneer large space structures manufactured and assembled directly in space, enhancing telecommunications, Earth observation, and scientific missions.
  - b. Utilise advanced robotics for assembly and supporting technologies for functional verification, ensuring long-term sustainability and efficiency for large-scale space constructions.
- 3 Very Low Earth Orbit (VLEO):**
  - a. Enable high-speed broadband connectivity with latency comparable to terrestrial networks and high-resolution Earth observation with compact, power-efficient instruments.
  - b. Develop aerodynamically efficient satellite platforms and green propulsion systems for long mission lifetimes, complemented by cost-efficient satellite final assembly lines for mass production.
- 4 In situ surface exploration:**
  - a. Advance capabilities for robotic and human exploration of planetary surfaces, focusing on surface mobility, autonomy, and resource processing.
  - b. Integrate power and communication approaches, instrumentation, and payload capabilities adapted to extreme environments, supporting comprehensive planetary exploration and sample return missions.
- 5 Ultra compact high-performance satellites:**
  - a. Revolutionise satellite design to minimise launch cost and enhance performance through advanced manufacturing and integration of functions.
  - b. Develop ultra-compact thermal systems, integrated avionics, and advanced propulsion systems to support high-performance satellite constellations.

OBJECTIVE 4.1

**Accelerate innovation by spearheading the development of cutting-edge competitive European space technologies in key strategic domains.**



STRATEGIC ACTIONS

**6 Advancing remote sensing:**

- a. Achieve breakthroughs in remote sensing capabilities, leveraging advanced RF and optical instrumentation, quantum-based methods, and embedded intelligence for autonomous observing systems.
- b. Develop advanced sensing technologies and distributed instrumentation to support persistent monitoring and autonomous decision-making, enhancing the strategic value of remote sensing.

**7 Solar System Internet navigation and communication systems:**

- a. Establish a robust network across the Solar System, providing secure and interoperable communication and navigation services.
- b. Innovate high-throughput RF and optical communications, precise deep-space positioning, and ultra-large satellite/system architectures for comprehensive Solar System connectivity.

**8 Circular and sustainable space economy:**

- a. Implement a circular economy in space, achieving net zero debris footprint and designing satellites with a neutral impact on the Earth's ecosphere.
- b. To support sustainable space operations, focus on novel launch systems, robust satellite designs, and the four Rs of in-orbit servicing (remove, reuse, refurbish, recycle).

**9 Hypervelocity endeavours:**

- a. Develop capabilities for high-speed vehicles for efficient ground-to-orbit transportation and deep space missions, supported by advanced materials and propulsion technologies.
- b. Innovate interplanetary space vehicle architectures and autonomous navigation systems to ensure safe and efficient high-speed travel across space environments.

**10 Highly autonomous systems:**

- a. Enable advanced missions through autonomous space systems, including large-scale distributed systems, in-orbit self-assembly, and multi-purpose robotic exploration.
- b. Enhance intelligent decision-making, adaptability, and resource optimisation for long-duration, autonomous space operations.

**11 Dark and quiet skies:**

- a. Ensure global satellite services while protecting astronomical research and cultural significance by minimising optical and RF interference.

- b. Develop special designs, coatings, and operational modes to reduce satellite constellations' optical signature and RF interference.

**12 Energy-efficient hibernation systems:**

- a. Reduce power consumption for deep space missions through advanced hibernation systems and low-power technologies.
- b. Innovate low-power microelectronics, functional hibernation avionics, and flexible solar arrays to support energy-efficient space operations.

**13 Space oases:**

- a. Develop autonomous habitats beyond Earth that are self-sufficient, resilient, and capable of supporting human life.
- b. Focus on autonomous resource production, advanced life-support systems, and efficient resource management to support long-term human presence in space.

**14 X-plorers: Humanity's evolution:**

- a. Facilitate humanity's evolution into an interplanetary species through enhanced medical, life-support, and mental well-being technologies.
- b. Innovate advanced design, training, and operations technologies to support seamless interplanetary travel and exploration, ensuring the health and performance of space explorers.

OBJECTIVE 4.2

**Strengthen industrial capacity and competitiveness to unlock new markets and drive economic growth, fostering a more prosperous society.**



**PURPOSE**

To foster economic growth, we must build a more competitive and larger innovative space industry, upstream and downstream, that delivers sustainable and competitive space solutions and contributes to the setting of global standards, positioning Europe at the forefront of technological and commercial development of space systems and applications servicing the society and economy.

**OVERVIEW**

Encouraging innovation, promoting the exploitation of space solutions and seeding new markets are essential to building a competitive industry that sets global standards and leads the space sector, delivering efficient and sustainable space-based applications, boosting European economic growth. By leveraging Europe's strengths and investing in cutting-edge research and the development of new space systems and new space-based applications, ESA aims to drive significant economic benefits and ensure long-term sustainability demonstrating the unique value of space in contributing to the competitiveness and growth of the European economy.

To build a truly competitive and world-leading space industry, it is crucial not only to foster innovation but also to ensure the scalability of these innovations through robust industrialisation practices. This means moving beyond current approaches and developing innovative mass manufacturing techniques and efficient supply chains to rapidly produce space systems and applications at scale. By creating streamlined supply lines, Europe can ensure the swift and cost-effective production and distribution of essential space technologies. Mass manufacturing capabilities will allow Europe to meet growing demand efficiently, ensuring that space solutions are accessible and affordable for various sectors.

The strategic initiatives under this objective will help Europe maintain its competitive edge and pave the way for leadership in the global space sector. Innovation will be at the heart of these efforts, fostering an environment where new markets can flourish, and economic growth can thrive. By opening new economic avenues in industries such as pharmaceuticals, automotive, and other high-tech sectors, ESA will contribute to a diversified and resilient European economy.

Furthermore, this objective emphasises the importance of collaboration between space and non-space industries, encouraging cross-sector partnerships that will integrate space solutions into broader commercial applications. Through these efforts, Europe will be well positioned to meet future challenges, creating a prosperous and technologically advanced society.

**STRATEGIC ACTIONS**

**1 Foster cross-sector partnerships and private investment across Europe:**

- a. Cross-sector partnerships: Developing partnerships with non-space industries in the public and private sectors to integrate space research into broader commercial applications. This will attract traditional sectors to the space economy, leveraging space infrastructure and data to enhance commercial applications on Earth for non-space industrial sectors.
- b. Private investment initiatives: Implementing novel methods to attract private investments, such as public-private partnerships, venture funds for space startups, and incentive programmes for investors, will boost the commercial viability of space ventures in Europe.

**2 Facilitate market access and innovation:**

- a. Guidance and technical support: Guiding traditional European companies in integrating into the space sector through technical support and partnership opportunities.
- b. Incentive programmes: Establishing incentive programmes to stimulate innovation and market access will enable European companies to compete globally.
- c. Investment in R&D: ESA will significantly invest in research and development in all space domains to drive technological advances and support emerging space technologies in Europe.
- d. Support mechanisms: Providing funding, technical assistance, and partnerships to European space companies and higher education institutions to position them as global leaders in terrestrial and space domains.
- e. Guidance and technical support: Guiding European companies in developing space solutions addressing the needs of non-space markets
- f. Support mechanisms: providing funding, technical and business support including matchmaking with non-space players operating in Europe and worldwide and fostering demonstrations of the unique value of space addressing user needs in terms of cost reduction, efficiency, safety and sustainability

**3 Promote space technology and industrialisation:**

- a. Initiate dedicated initiatives focused on industrialising space technologies, shifting from small-scale development to large-scale manufacturing.
- b. Establish a coordinated network of manufacturers, suppliers, and logistics hubs across Europe that specialise in space technology production

**4 Optimise ESA processes:**

- a. Agile funding cycles: Utilising ESA's mid-term funding cycles to support new innovative programmes and respond quickly to emerging challenges and opportunities.
- b. Streamlined processes: Optimising governance processes of ESA-EU cooperation to facilitate faster decision-making and implementation of space initiatives, ensuring that Europe remains competitive in the fast-evolving space industry while preserving the interests of its Member States.

**5 Build strategic new partnerships with the EU and national entities:**

overall, the public sector in Europe is playing a key and important role in this field. The role of the public sector in Europe is mostly based on a combined effort between ESA, the Member States and the EU, working in very close collaboration with other European actors including national actors.

OBJECTIVE 4.3

**Position Europe as a commercial hub in the booming global space economy, able to attract significant private investment.**



Credit: Getty Images

**PURPOSE**

To position Europe as a major player in the global space economy by fostering further commercial and industrial involvement, forming strategic partnerships, and creating a more attractive environment for private investment in the space sector.

**OVERVIEW**

ESA is dedicated to transforming Europe into a leading commercial hub within the global space economy by 2040. This objective focuses on encouraging the participation of commercial and industrial entities, establishing strategic alliances, and enhancing the appeal for European private investments in the European space sector. ESA's initiatives aim to maintain Europe's forefront position in space exploration, research, and commercialisation. By leveraging Europe's strong industrial base, cutting-edge technological advances, and rich talent pool, ESA intends to create a vibrant and sustainable space economy that attracts substantial private investments. These private investors will play a crucial role in driving economic growth, fostering innovation, and enhancing Europe's global competitiveness in the space sector. Through collaborative efforts and strategic initiatives, ESA seeks to build a robust ecosystem that supports developing and commercialising new space technologies, ensuring that Europe remains a key player in the ever-evolving global space landscape.

**STRATEGIC ACTIONS**

- 1 Systematically explore commercial opportunities and growth paths:**
  - a. Increase ESA capabilities, with the support of partners, in scanning and assessing the commercial potential of new space business sectors such as space resource utilisation (e.g. asteroid mining) and the growing in-orbit servicing economy. This shall enable a more systemic approach in terms of technology, access to finance and upscaling, allowing European companies to enter and grow in these future oriented markets.
- 2 Work with Member States and the EU to attract private investments by expanding and supporting:**
  - a. Public-private partnerships (PPPs): Implement PPPs to share risks and rewards between public and private entities, lowering entry barriers and fostering collaboration.
  - b. Venture funds and incentive programmes: venture funds for space startups and incentive programmes for investors to boost the commercial viability of space ventures in Europe.
  - c. Incentive programmes: Develop programmes offering a range of financial and non-financial benefits, grants, and co-investment schemes. ESA could work with Member States to assess the potential effectiveness of tax incentives schemes to boost strategic initiatives.
- 3 Ensure efficient programme implementation and short innovation cycles:**
  - a. Responsive R&D programmes: Implement short funding cycles to develop and deploy innovative programmes and technologies quickly, enabling quick responses to emerging challenges and opportunities.
  - b. Transparent and inclusive processes: Streamline governance and decision-making processes to ensure transparency and inclusiveness, reduce bureaucracy, and foster a competitive market environment.

**IMPLEMENTATION FRAMEWORK**

ESA will adopt a more mission-oriented approach with concrete goals and milestones to achieve these strategic actions, galvanising public and private sectors around shared objectives. Key components include:

- Capacity building and talent development: Support higher education institutions, research institutes, and technology centres in developing necessary skills and knowledge, attracting and retaining top talent in the space sector.
- Challenge-based procurement: Drive innovation through challenge-based procurement policies. These policies invite private companies to propose solutions for specific missions and projects, with ESA serving as an anchor customer. This role not only provides a guaranteed market for private companies but also encourages investment in new space technologies and services, reducing the financial risks associated with space ventures.
- Sustainability and circular economy: Emphasise sustainability in all initiatives, develop technologies for sustainable space exploration, and promote a circular economy in space activities.

**PRIVATE INVESTMENT FOCUS**

- 1 Anchor customer procurement schemes:** These schemes provide a guaranteed market for private companies, encourage investment in new space technologies and services, and reduce the financial risks associated with space ventures.
- 2 Co-funding models:** Leverage public funds to attract private investment through innovative co-funding models, supporting startups and SMEs and fostering a dynamic space industry.
- 3 Risk-sharing mechanisms:** Develop risk-sharing mechanisms, including insurance schemes, investment guarantees, and co-investment opportunities, to enable private participation in high-risk, high-reward space projects.
- 4 Investment in emerging technologies:** Prioritise investments in AI, quantum computing, and advanced manufacturing, offering new opportunities for private European investors and maintaining Europe's cutting-edge position in space innovation.
- 5 Help to promote a stable business environment in Europe:** Ensure stability and predictability in the space business environment through a clear regulatory framework, intellectual property protection, and tax incentives.

OBJECTIVE 4.4

**Establish Europe as a space research hub, by leveraging world-class technical facilities and, by investing in and attracting top STEM talent.**



PURPOSE

Position Europe as the global epicentre for cutting-edge research by fully harnessing Europe's premier research and test facilities and, by investing in a stronger European talent pool through top-tier talent acquisition, collaboration and academic excellence.

OVERVIEW

ESA is committed to keeping Europe as the leading hub for space by 2040. This objective focuses on two key elements for success. A first key objective is to harness and optimise the capabilities of Europe's premier research and test facilities. By capitalising on these assets, ESA seeks to solidify Europe's position as a global leader in space innovation, ensuring the development of cutting-edge technologies and groundbreaking scientific discoveries. The second objective is to develop, attract and retain world-class researchers, students, and professionals. By promoting innovation, collaboration, and academic excellence, ESA aims to ensure Europe's prominent position in global space affairs.

A network of state-of-the-art facilities underpins ESA's engineering and scientific prowess, each contributing uniquely to the agency's overall mission:

- **ESTEC (European Space Research and Technology Centre):** In Noordwijk, Netherlands, ESTEC is the cornerstone of ESA's technical and operational support. It is responsible for the design, development, and testing of spacecraft. The centre's comprehensive infrastructure includes simulation laboratories, test facilities, and integration halls, ensuring that spacecraft meet the highest performance and reliability standards.
- **ESRIN (European Space Research Institute):** Situated in Frascati, Italy, ESRIN is a hub for Earth observation. It processes and analyses data from Earth observation satellites, providing invaluable information for environmental monitoring, disaster management, and climate research. ESRIN's advanced data processing capabilities enable it to turn raw satellite data into actionable insights.
- **ESAC (European Space Astronomy Centre):** Based in Villanueva de la Cañada, Spain, ESAC is dedicated to space science missions. It is the primary data archive for ESA's astronomy and planetary missions. ESAC supports mission operations and data analysis for various scientific endeavours, from studying the cosmos to exploring our Solar System.
- **EAC (European Astronaut Centre):** Located in Cologne, Germany, EAC is the training ground for Europe's astronauts. It provides comprehensive training programmes covering all aspects of human spaceflight, from physical conditioning to mission-specific training and simulations. EAC ensures that European astronauts are fully prepared for their missions.
- **ESOC (European Space Operations Centre):** In Darmstadt, Germany, ESOC is ESA's main mission control centre. It oversees spacecraft operations in orbit, ensuring their health and safety. ESOC's expertise in satellite attitude and orbit control, communications, and deep space tracking is critical to the success of ESA's missions.
- **ESEC (European Space Security and Education Centre):** Situated in Redu, Belgium, ESEC focuses on cybersecurity and education. It provides secure communication links for ESA missions and offers educational programmes to inspire the next generation of space professionals.
- **ECSAT (European Centre for Space Applications and Telecommunications):** Located in Harwell, United Kingdom, ECSAT supports the commercialisation of space technologies. It fosters partnerships with industry and promotes the use of space data and services in various sectors, driving economic growth and innovation.

STRATEGIC ACTIONS

**1 Reinforce and leverage world-class research facilities:**

ESA continues investing in developing and enhancing state-of-the-art research facilities across Europe. These facilities will be equipped with the latest technologies and infrastructure to support advanced space research and innovation. Providing access to top-tier facilities will attract leading researchers and professionals to Europe. The following actions will be pursued:

- a. Expanding the ESA footprint across its Member States:** by further strengthening existing sites and establishments and, by starting new initiatives at strategically relevant locations in consultation with Member States. One recent example of this is ESDI (European Space Deep-Tech Innovation Centre): a new initiative being set up in Villigen, Switzerland, to promote the development of technologies in quantum research, data science, and material science. ESA will also work with public and private R&D actors, including higher education institutions to reinforce the competitiveness of Europe by addressing the skills gap, but also strengthen the research potential and opportunities of those actors. A reinforced cooperation between ESA and higher education institutions can contribute to Europe's competitiveness in space and its strategic autonomy, and provide cover for challenges ESA encounters that are related to space and for which external expertise might be useful (e.g. quantum, cyber). This would allow developing national and local capabilities needed to grow the various ecosystems in respective regions to create space-related jobs and speed up the adoption of the space solutions in the European economy.
- b. Empowering Member States:** in addition to utilising ESA's facilities, it is also key to collaborate more strongly with Member States' facilities to maximise Europe's space capabilities, such as DLR in Lampoldshausen, specialising in propulsion systems and environmentally friendly fuels, which are crucial for developing next-generation propulsion technologies that are both efficient and sustainable; CNES Centre Spatial de Toulouse, focused on orbital systems, playing a vital role in the development and management of satellite systems, contributing to advancement in satellite communication, navigation, and Earth observation; and ASI's Space Science Data Centre (SSDC), which supports vital scientific data processing and analysis for space missions, furthering Europe's leadership in space research by enabling collaboration across multiple international space programmes. Moreover, novel facilities and initiatives in other European nations, such as the Swedish Space Corporation in Kiruna, renowned for its expertise in launching and managing scientific research payloads; Estonia's Tartu Observatory making strides in space research and small satellite development, to name just two, highlight the broad, pan-European effort to advance space exploration and technological innovation. ESA aims to work more closely with these facilities to promote joint projects and research initiatives, share knowledge and expertise, and coordinate resource utilisation, ensuring that we all benefit from each other's strengths.
- c. Leveraging new and emerging test and launch facilities:** to further enhance Europe's space capabilities, ESA, in addition to the use of Europe's Spaceport in Kourou, French Guiana for microlaunchers, will leverage new and upcoming test and launch facilities such as Andøya Space Centre in Norway to provide versatile launch services for sounding rockets and small satellites, supporting research and commercial missions in polar and near-polar orbits; El Arenosillo Test Centre in Spain, specialising in missile and rocket testing, offering advanced facilities for developing and validating propulsion systems and other aerospace technologies; Esrange Space Centre in Sweden, a leading site for suborbital launches, satellite tracking, and data reception; and the Sutherland and SaxaVord Spaceports which are set to become the first UK vertical launch sites, providing key facilities for launching small satellites into low Earth orbit, enhancing Europe's launch flexibility.



The fifth goal is dedicated to building a more cohesive and effective European space ecosystem that not only advances technological and economic progress but also inspires Europe by igniting curiosity and passion for space among its citizens. Given the dynamic changes and competition worldwide, Europe must foster a united front in space exploration, innovation, and leadership, ensuring that Europe remains at the forefront of global space endeavours.

# INSPIRE EUROPE

# 05

In a similar way as the Apollo programme inspired people in the United States, instilling a strong sense of national achievement, pride, and technological advancement, Europe can ignite a continental vision that pushes the boundaries of what is possible in space. By captivating the public imagination through ambitious missions, groundbreaking discoveries, and engaging educational programmes, ESA aims to motivate the next generation of scientists, engineers, and entrepreneurs. Apollo's success not only marked a quantum leap in technology, but also established the US as a global strategic, military, and economic power, demonstrating how bold action in space can translate to leadership on the world stage. For Europe, embracing this challenge could cement its place as a leader in global space exploration and innovation, reinforcing its geopolitical strength, economic resilience, and technological supremacy through collective ambition and bold vision.

To achieve a more united and inclusive European space governance, better mirroring the already integrated and unified industrial ecosystem, ESA will continue to serve its Member States and collaborate closely with their respective space agencies and national ecosystems, the European Union, and other, key institutional stakeholders. Therefore, the first objective emphasises fostering rapid, effective, and efficient decision-making processes and the development and operational deployment of space activities. By streamlining these processes and avoiding duplications, Europe can enhance its leading position in the global space arena, ensuring that all efforts are aligned towards common goals and maximising the potential of European collective resources and expertise.

Europe's existing world-class research and test facilities play a key role in driving innovation in the space sector. Leveraging these facilities to their full potential, we will ensure they serve as the bedrock for pioneering research and development activities. By doing so, Europe can maintain and enhance its position as a space technology and innovation leader, continuously pushing the boundaries of what is possible in space.

To ensure streamlined collaboration worldwide, ESA will position itself as the unifying force, championing European cooperation and leadership on the global stage. This involves building and solidifying strategic partnerships with international space agencies and organisations. ESA aims to ensure a cohesive and influential European presence in global space affairs through these partnerships. This unified approach will amplify Europe's voice in international space and foster a more collaborative environment that encourages shared successes and advancement in space exploration.

Goal Five of ESA's Strategy 2040 is building a more cohesive and efficient European space ecosystem through unification, innovation, and strategic collaboration with industry and higher education institutions. Only by working with our Member States, by leveraging world-class European facilities, and by positioning ourselves as a unifying force in global space affairs will we ensure that Europe remains a leader in space exploration and innovation, inspiring a united and forward-thinking Europe.

## OBJECTIVE 5.1

## Reinforce the European space ecosystem through world-class project management and intensified cooperation among key stakeholders.

### PURPOSE

Collaborate with other European stakeholders unifying the European space ecosystem and fostering rapid, effective, and efficient operations to drive Europe's leadership in the global space arena.

### OVERVIEW

In the rapidly evolving global space sector, ESA is committed to strengthening the European space ecosystem to foster efficiency and resilience. Through close collaboration with ESA Member States, the European Union, and other key institutional stakeholders, ESA aims to underpin Europe's leadership in space, by streamlining decision-making, development, and operational deployment of space activities.

The relationship between ESA and the European Union will continue to evolve over the next 20 years, guided by the strategic input of ESA Member States and the established cooperation framework with the EU. This evolution will ensure that ESA's unique expertise is fully utilised in serving the interests of European taxpayers.

This objective emphasises the importance of evolving the roles of ESA Member States from detailed control to strategic guidance, strengthening ESA-EU relations, leveraging programme management expertise, and facilitating European cooperation. By encouraging collaboration in ambitious projects among all institutional actors, ESA seeks to solidify Europe's position at the forefront of global space exploration, research, and commercialisation, ensuring ambitious space objectives are met by 2040.

### STRATEGIC ACTIONS

#### 1 Strengthening/Fostering a cohesive and efficient European space ecosystem:

ESA aims to support the creation of a more unified, efficient, and resilient European space ecosystem. By collaborating closely with its Member States, the European Union, and various institutional stakeholders, Europe can drive industrial leadership in the global space arena through rapid, effective, and efficient decision-making, development, and operational deployment of space activities. Further, ESA's industrial policy allows for the balanced growth of the overall European ecosystem for space activities, which in turn creates increased resilience and competition.

#### 2 Improving Member States' engagement:

Member States play a critical role in the success of ESA's initiatives. To adapt to the increasingly commercialised space sector, their roles should evolve from detailed control to strategic guidance and oversight. This shift will empower ESA to execute its programmes more effectively while aligning with national priorities, fostering a more collaborative and efficient approach.

#### 3 Strengthening ESA-EU relations:

establishing a stable, inclusive, and structural long-term partnership between ESA and the European Union which transcends the limitations of individual EU Multiannual Financial Framework (MFF) cycles. This strong partnership should position ESA as the primary implementing agency for all EU space programmes, ensuring the full utilisation of its unique technical, scientific, and project management expertise. At the same time, it is crucial to safeguard the interests of all ESA Member States and preserve ESA's autonomy as an independent and capable space organisation.

#### 4 Leveraging programme management expertise:

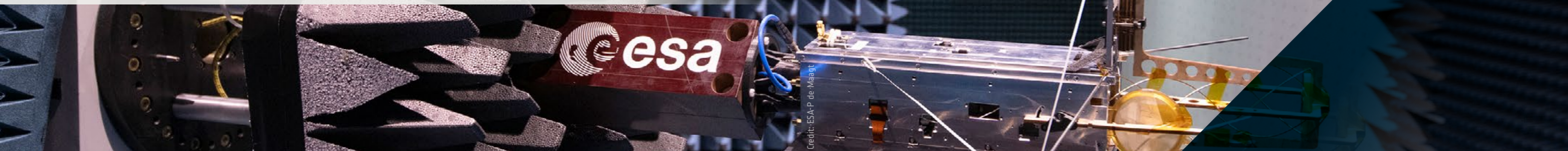
ESA's unparalleled experience in managing complex, pan-European, long-term, world-class space programmes is a cornerstone of its success. By coordinating across diverse stakeholders and utilising the collective expertise of Europe, ESA ensures successful project delivery.

#### 5 Demonstrating capabilities through strategic initiatives:

to ensure Europe's leadership in the space sector, ESA's strengths must be fully leveraged. A prime opportunity to demonstrate these capabilities is the continuation of GNSS and Copernicus flagship programmes as well as the IRIS<sup>2</sup> programme, which may require adjustments based on lessons learnt in its current phase. ESA and its Member States, in cooperation with the EU, must define ESA's role in the next phase, demonstrating ESA's adaptability and leadership in the evolving space landscape

## OBJECTIVE 5.2

## Position ESA as a model for leveraging space activities inclusively to inspire young people and future generations from diverse backgrounds.



## PURPOSE

Establish ESA as a global role model in leveraging space activities to inspire young minds, spark interest in STEM fields, promote the spirit of exploration, drive sustainable development, and pioneer innovation. Empower the next generation to tackle global challenges and create through inspiration and meaningful actions

## OVERVIEW

Space has a unique ability to inspire, embodying the limitless potential of human curiosity, innovation, and collaboration. From uncovering the mysteries of distant planets to monitoring Earth's climate, space activities present a powerful platform to engage young minds, demonstrating how science, technology, and imagination can address real-world challenges. It serves as a universal stage for advancing STEM education, promoting sustainability, and championing diversity, proving that anyone, regardless of background, can contribute to humanity's most ambitious endeavours. Further, ESA's missions and programmes are also vital in providing citizens and decision-makers with reliable, scientific and evidence-based information and insights on our planet, climate, and the Universe. By connecting with space, young people are not only enchanted by its wonders but also driven to shape a brighter future, propelled by the same pioneering spirit that fuels exploration beyond our planet.

## STRATEGIC ACTIONS

### 1 Transform ESA education and outreach activities to inspire young minds:

- Develop partnerships with educational institutions to create interactive hubs and platforms that connect young people with ESA missions, fostering hands-on engagement through resources, workshops, and virtual experiences.
- Collaborate with educators to better integrate space science, sustainability, and real-world applications into STEM curricula, inspiring students to connect exploration with addressing global challenges.
- Showcase innovative sustainable technologies and use ESA's Earth observation data to educate and inspire youth about climate action, biodiversity, and sustainability.
- Utilise cutting-edge technologies like VR/AR to provide immersive experiences that bring the excitement of space technology and exploration directly to young audiences.

### 2 Foster youth engagement by connecting STEM learning to real-world challenges:

- Engage young people in shaping space exploration through programmes that incorporate their ideas into ESA missions, provide advisory platforms, and promote collaboration on global priorities.
- Inspire future space professionals with initiatives like simulated astronaut training, hands-on challenges, and mentorship opportunities with ESA experts.
- Support initiatives at international conferences and innovation competitions to empower youth to address real-world space challenges, fostering creativity, collaboration, and leadership in STEM and sustainability.

### 3 Reinforce diversity, equity, and inclusion initiatives to harness the full potential of European space talent:

- Further expand efforts and initiatives specifically for women and girls pursuing STEM education and careers.
- Provide funding grants and mentorship to underrepresented and underserved communities across Europe to ensure equal access to space-related education and learning and career opportunities.
- Highlight diversity of ESA staff, astronauts, engineers and scientists through media campaigns to inspire young people from all backgrounds to see themselves in STEM careers.

## OBJECTIVE 5.3

## Enable ESA Member States and the EU to harness space capabilities for greater influence in international diplomacy and global affairs.

### PURPOSE

Establish the agency as a central force promoting European unity and leadership on the global stage by: a) delivering space capabilities to support informed policy-making, decision-making, and international engagement ('space for diplomacy'); and b) enhancing strategic coordination and partnerships with governments, space agencies, non-member state institutions, and international organisations, ensuring a strong European presence and influence in global space affairs ('diplomacy for space').

### OVERVIEW

ESA will remain a key player, trusted facilitator, and unifying force in international space collaboration. By doing so, it will empower European stakeholders by delivering and enabling space capabilities, infrastructure, services, and data, while fostering unity among European actors in global space affairs. Through a cohesive strategy aligned with the foreign policy objectives of its Member States, ESA will amplify Europe's geopolitical influence and global reach, solidifying its leadership in the space sector and beyond, and highlighting its innovation and excellence in space exploration, science, and technology.

### STRATEGIC ACTIONS

#### 1 Pursue strategic partnerships as means to undertake ambitious space programmes; strengthen international relationships; and advance the peaceful exploration and use of outer space in times of rising global challenges:

- Initiate and lead joint high-profile missions in strategic domains that require the pooling of resources and expertise, including in Earth observation, Solar System exploration, science, safety and sustainability.
- Diversify and multiply the agency's space cooperation portfolio by deepening collaboration with established partners and engaging with new partners based on shared long-term objectives and mutual benefits.
- Maximise Member States' investments and pursue strategic relationship-building for attaining complementary objectives and benefits such as securing ground-based tracking and network infrastructure or forming systems of systems.

#### 2 Promote international cooperation, space governance coordination and strategic capacity-building:

- Align with European global interests by ensuring that ESA's programmes and activities reflect and underpin foreign policy goals of its Member States, including climate action, humanitarian efforts and global security.
- Support global space governance by participating in, and contributing to, international forums; providing expertise and advise for international space law, policy, coordination and exchange; and advocating for the responsible and sustainable exploration and use of outer space.
- Sustain international development and capacity-building goals by integrating space technologies, services and data into initiatives that address global challenges such as disaster response, environmental monitoring, and sustainable development.

#### 3 Enhance ESA's status as a trusted and attractive international partner:

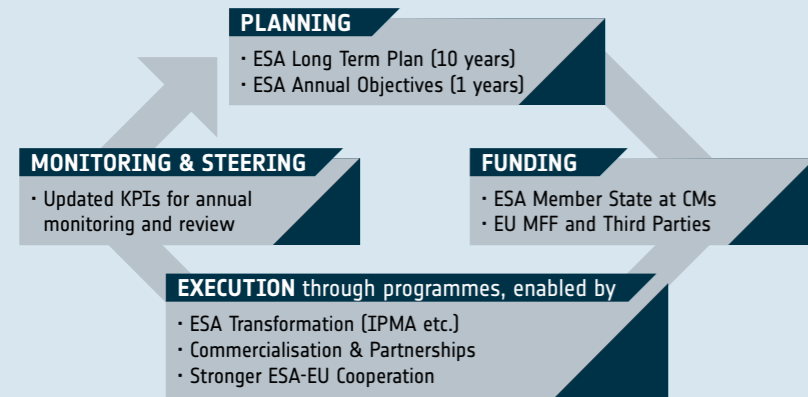
- Shape international space cooperation by offering interesting and forward-looking opportunities; leveraging ESA's track record in international relations; driving strategic initiatives and setting standards; and showcasing technical and scientific prowess.
- Strengthen European competitiveness through international collaboration by capitalising on European space sector strengths; investing in strategic enablers and unique selling points; articulating global demand signals; opening new opportunities for engagement; balancing collaboration and innovation; and promoting space as a tool for geoeconomic benefits;
- Inspire present and future generations by advancing cooperation in global science and exploration as well as a sustainable future in space and on Earth; promoting education partnerships and career opportunities.

In pursuing the above in a coordinated manner and through multi-dimensional international engagement that considers developments affecting Europe and the world, ESA's Strategy 2040 will amplify the voice and presence of its Member States and the EU in space and strengthen their influence and reach in global matters overall.

# WAY FORWARD

The ESA Strategy 2040 will be implemented through ESA's well-established programmatic framework, with the ESA Council and its subsidiary bodies (including the various Programme Boards and the Science Programme Committee) serving as the governing bodies overseeing programme implementation.

## GOVERNANCE | Council & Programme Boards



The five strategic goals, along with their objectives and associated strategic actions, will be integrated and reflected into ESA's planning, funding, and programme management processes to ensure alignment with the strategy's vision. Furthermore, annual monitoring and steering mechanisms will be adapted to incorporate these elements, enabling continuous assessment, effective governance, and timely adjustments to maintain progress toward the strategy's objectives.

## Upcoming Council meetings at Ministerial level, CM25 and CM28

The ESA Council meetings at Ministerial level in 2025 and 2028 will serve as critical milestones in advancing the ambitious objectives outlined in Strategy 2040. These meetings will provide pivotal opportunities for ESA to secure Member States' commitments and align resources towards shared goals. To this end, ESA's programme proposals for these meetings will be meticulously crafted to reflect the strategic priorities of Strategy 2040, ensuring alignment with its long-term vision. Complementing this, the ESA Long-Term Plan (LTP) will be updated to converge on the strategy, given that its new iteration will be central to solidifying the agency's planning and approach for the coming decades. By providing continuity in the development and implementation of both ongoing and new ESA programmes, the LTP will establish a cohesive roadmap that will guide the organisation toward its goals and objectives while considering the needs and financial capabilities of Member States for realistic and sustainable planning.

In fact, the LTP is more than a planning tool—it is the financial and operational backbone of ESA's strategy. It defines the necessary pathways for funding, resource allocation, and inter-directorate coordination, enabling ESA to work cohesively toward common goals. For the Member States, the LTP serves as a comprehensive framework to synchronise their national investments with ESA's long-term vision, fostering a more unified and collaborative approach across the agency's diverse stakeholders. Moreover, the LTP will be instrumental for the space industry, offering clarity and certainty about future initiatives and opportunities, thereby supporting robust planning and innovation within the sector.

In tandem with the LTP, Strategy 2040 is designed as a dynamic, living document that will evolve in response to the ever-changing global landscape. By adapting to shifts in geopolitical, technological, and environmental conditions, as well as addressing unforeseen challenges, Strategy 2040 ensures ESA remains at the forefront of the space sector. Together, these two foundational instruments—Strategy 2040 and the LTP—aim to provide a comprehensive framework for preparing both Member States and the space industry for the future. They encourage not only alignment but also innovation, fostering an environment in which ESA can lead transformative advancements in space exploration, scientific discovery, and industry growth over the coming decades.

To ensure that the high level of ambition presented in this strategy can be delivered successfully in today's rapidly changing environment, the agency will evolve structurally. The starting point for these ongoing reforms is ESA's legacy of 50 years of achievements in space. While ESA's unique features and model shall fully remain core to its future successes, **significant adjustments to the agency's operational approaches are essential.** Actions in this direction started in 2021, with Agenda 2025, which announced an ESA Transformation process, a much stronger emphasis on commercialisation in ESA programmes and, stronger ties between ESA and the EU.

### ESA Transformation

A first key element in this respect is a comprehensive ESA Transformation, which shall improve the agency's internal structures and methods to reinforce its ability to implement an increasing number of programmes on project schedule and within budget. This initiative focuses on modernising programme implementation, procurement and the internal processes to strengthen

ESA's ability to achieve its mission.

Central to this effort is the establishment of the Independent Project Management Authority (IPMA), which provides a strategic, independent project management oversight mechanism. This body monitors compliance with managerial rules and project baselines, ensures viability in planning and resource allocation, and identifies risks with mitigation strategies. The IPMA's oversight directly addresses key challenges, such as managing optimism bias in proposals, enhancing the quality of project execution, and ensuring alignment with ESA Council and Participating States' decisions on cost and schedule.

The transformation also integrates enhanced collaboration mechanisms among key agency boards and managers while adopting a matrix approach to streamline resource allocation. This includes optimising workforce and resource planning and expanding shared services in areas such as IT, HR, and Procurement. By standardising processes and increasing efficiency, ESA is better positioned to reduce delays and improve outcomes across its programmes. The implementation of the transformation is ongoing, and its impacts will ramp up significantly as of 2025.

Another critical challenge is the modernisation of ESA's procurement and geo-return rules, which must be a continuous process. These rules have been vital to ESA's success at the service of creating a strong European space sector during the last 50 years. They have evolved over time, and they must continue to evolve to better reflect the realities of an ever-faster changing space environment. By updating these frameworks, ESA can foster a more competitive, innovative, and flexible space industry, ensuring that all Member States continue to benefit from their investments into ESA programmes.

Through these structural reforms, ESA is reinforcing its internal capacity to deliver world-class space programmes effectively and efficiently, which in turn is needed to ensure future success in implementing its ambitions from now to 2040.



Credit: ESA/JP. Sebirot

# WAY FORWARD

## Commercialisation & Partnerships

The growing commercialisation of space activities is reshaping the role of traditional space agencies, driving them to adapt to a rapidly evolving ecosystem. Historically, space agencies have been the primary drivers of space exploration and innovation, often leading missions and developing technologies in-house. The rise of private sector involvement, with new entrants and New Space approaches and business models growing, is shifting the focus towards a more collaborative and market-driven approach. In 2023, European space startups raised nearly €1 billion, posting remarkable growth in less than a decade (€18 million was raised in 2014). To support and leverage this trend, ESA will enhance its role as enabler and catalyst for commercialisation. While the full strategic reorientation on commercialisation is still being elaborated, the following principles will become more central to ESA's activities:

- **Procuring services over goods:** for some activities and domains, ESA will be transitioning from purchasing hardware to buying services (e.g. satellite imagery, data analytics, or launch services). This will allow ESA to take advantage of the private sector's efficiencies and innovation while focusing on strategic priorities and less-mature technologies.
- **Anchor tenancy:** acting as an early and reliable customer for emerging services or data, ESA can reduce market entry risks for private companies, helping to establish viable commercial markets and bringing a more standardised process to certain procurement activities.
- **Stimulating NewSpace approaches:** by fostering partnerships, offering grants, and providing access to testing facilities or expertise, ESA will support the growth of New Space enterprises and approaches (including for established actors). This helps create a vibrant ecosystem of startups, SMEs and large system integrators capable of driving innovation and competitiveness.
- **Promoting industry autonomy:** providing industry with greater freedom in the project execution of selected domains enables companies to explore innovative approaches, reduce costs, and accelerate timelines. ESA will still act as strategic advisor, offering technical expertise and ensuring alignment with overarching goals, while increasingly allowing industry to take the lead on design and implementation.

By embracing these approaches, ESA will not only support the growth of a dynamic commercial space sector but also ensure that public investments in space yield broad societal and economic benefits. This shift will allow ESA to focus its

resources on pioneering missions, scientific research, and addressing global challenges, while empowering industry to drive the commercialisation of space and to build up its capacity in case of a gradual ramping up of space investment in Europe.

## Stronger ESA-EU Cooperation

ESA is actively working to evolve its relationship and cooperation models with the European Union to jointly strengthen the European space sector. This evolution will be guided by strategic input from ESA Member States and the established cooperation framework with the EU, ensuring that ESA's unique expertise is fully utilised for the benefit of European taxpayers.

Despite the growing role of private and commercial players in space, the public sector remains the dominant force in shaping the sector, both in Europe and worldwide. Governments globally account for over 80% of the demand for space infrastructure, and in Europe this figure stands at 70%. With ESA and the EU as the largest institutional actors in the European space sector, strong, effective, and adaptable ESA-EU cooperation is essential to advancing a robust European space agenda. To achieve this, building on the unique and complementary strengths of both organisations while streamlining funding and operational models will be essential. This ensures that Europe remains at the forefront of space innovation, resilience, and sustainability.

ESA has a long history of collaboration with the EU, serving as the R&D and technical implementation agency for operational space programmes like Copernicus, Galileo, and, more recently, the IRIS2 secure telecommunications initiative. The partnership has also expanded into critical areas such as Earth observation science, the DestinE initiative, climate action, access to space, and space commercialisation. Moving forward, ESA plans to deepen these existing areas of collaboration and broaden the partnership into new domains, fully aligning with European policy priorities. These priorities include achieving strategic autonomy, advancing climate action, fostering digital innovation, and bolstering resilience – key drivers of European progress over the next two decades.

It is increasingly clear that space assets inherently serve dual-use purposes and are critical for ensuring security and resilience. ESA's ability to address dual-use challenges, such as disaster response, food security monitoring, secure communications, secure navigation, system cybersecurity and critical technologies, among others, positions it as a vital partner for Member States and the EU in addressing evolving societal and security needs. Programmes like Galileo

exemplify ESA's capability to design and manage systems that meet both civil and the most demanding security requirements.

In line with its extensive technical expertise, cutting-edge infrastructure, and decades of programmatic experience, ESA is uniquely equipped to develop innovative solutions to the evolving challenges faced by Europe. Over the next 20 years, ESA aims to secure a more significant role in implementing space activities funded under the EU Multiannual Financial Framework. By working closely with the EU and Member States, ESA will help ensure clear delineation of responsibilities, optimise synergies, and fully leverage complementarities between the two organisations. Several potential models for this evolving partnership will be explored to ensure that ESA's expertise is fully utilised while maintaining the autonomy of ESA and protecting the interests of all its Member States. These efforts will strengthen Europe's leadership in space, enhance resilience, and deliver lasting value for European citizens, taxpayers, and commercial markets alike.

# CONCLUSION

Strategy 2040 represents a bold and visionary blueprint for the future of the European Space Agency, addressing the rapidly evolving landscape of global space activity. As the world increasingly looks to space as a critical domain for economic growth, technological innovation, national security, and environmental sustainability, ESA's strategy offers a comprehensive, forward-thinking approach to ensure Europe remains at the forefront of these developments.

The space industry has become essential for economic progress, scientific discovery, and societal resilience. Space-based technologies are now integral to daily life, underpinning sectors such as communications, navigation, climate monitoring, and defence. With Strategy 2040, ESA aims to position itself as a leader in these domains by leveraging space as a driver of prosperity and technological leadership. This strategy provides a clear pathway for the agency to enhance its competitive edge and autonomy while ensuring its space sector continues delivering tangible benefits to European citizens.

One of the cornerstones of this strategy is ESA's commitment to addressing critical societal needs. The first of these is 'Protect our planet and climate'. ESA recognises that space-based technologies are essential in addressing the global environmental challenges of climate change, biodiversity loss, and resource scarcity. Through advanced Earth observation capabilities and the development of new technologies, ESA will enable Europe to lead in monitoring and mitigating the impacts of these threats. By spearheading space sustainability initiatives and promoting a zero debris environment, ESA ensures that the space domain remains viable and safe for future generations. Additionally, ESA is taking proactive steps in planetary defence, developing capabilities to detect, monitor, and potentially deflect hazardous Near-Earth Objects, ensuring the planet's safety from space-borne threats such as asteroids and space debris.

Strategy 2040 emphasises the importance of 'Explore and discover' as a key driver of scientific progress, focusing both on science and exploration. ESA's Earth science missions will continue to push the boundaries of our knowledge of our home planet and its complex geophysical processes. In exploration, ESA will expand its roles around and on the Moon, developing the technologies necessary for a sustained presence on the lunar surface and preparing for future missions to Mars. The strategy also prioritises planetary science, with missions to explore the icy moons in search of potential habitability and deeper knowledge of planetary systems. In addition, ESA will lead efforts to advance our understanding of the universe by exploring the most energetic and fundamental forces that shape cosmic events, ensuring Europe remains at the forefront of space science and discovery.

The strategy also places a strong focus on enhancing European autonomy and resilience. As the global competition in space intensifies, it is imperative for Europe to maintain independent access to space, ensuring that it can protect its critical infrastructures and defend its strategic interests. ESA will develop next-generation space transportation systems, satellite communication networks, and space-based security technologies to safeguard Europe's assets on Earth and in space. This will strengthen Europe's autonomy in space operations and protect its citizens.

Economic growth and competitiveness are also key pillars of Strategy 2040, addressed through 'Boosting European growth and competitiveness'. Space is becoming an increasingly commercial domain, with private enterprises playing a pivotal role in shaping the future of the industry. ESA recognises the need to support and stimulate Europe's space industry, fostering innovation and unlocking new markets. Through targeted investments in cutting-edge technologies, such as artificial intelligence, quantum computing, and large-scale satellite manufacturing, ESA will create new opportunities for European companies and position Europe as a commercial hub for the global space economy. This approach will drive economic growth, create high-quality jobs, and ensure Europe's long-term prosperity in the space sector.

Beyond technological and economic progress, Strategy 2040 also seeks to 'Inspire Europe' by igniting curiosity and passion for space among its citizens and fostering a more united European space ecosystem. ESA aims to captivate the public imagination through ambitious missions, groundbreaking discoveries, and engaging educational programmes, motivating the next generation of scientists, engineers, and entrepreneurs. Simultaneously, the strategy emphasises strengthening partnerships among European space stakeholders—including national space agencies, the EU, industry, academia, and the financial sector—to create synergies that amplify Europe's impact on the global stage. This collaborative approach not only inspires individuals but also promotes a sense of shared purpose and unity across the continent. Space has the power to both ignite dreams and bring people together, and ESA is committed to ensuring that Europe harnesses this potential to shape the future of this boundless frontier. Furthermore, this strategy emphasises the importance of space in diplomacy, using Europe's space capabilities to promote international cooperation, peace, and global governance.

At its core, Strategy 2040 is not just a strategy for ESA but a vision for Europe. It aligns with Europe's broader political and economic priorities, from addressing climate change and sustainability goals to enhancing digital and technological sovereignty. By investing in space, Europe is investing in its future – securing its position as a global leader, protecting its interests, and ensuring the well-being and prosperity of its citizens. ESA's strategy is designed to respond to the most pressing challenges of our time, providing the tools and solutions to enable Europe to navigate the complexities of the 21st century and beyond.

Moreover, Strategy 2040 is a strategy of ambition. It reflects ESA's determination to embrace future opportunities and push the boundaries of what is possible. By setting clear objectives and defining a roadmap for the coming decades, ESA ensures that Europe remains competitive, resilient, and innovative in the face of global challenges. This strategy is a call to action for European leaders, policymakers, and the public to recognise the critical importance of space and support the investments necessary to realise Europe's full potential in this domain.

This Annex provides background information on the methodology used to develop the ESA Strategy 2040 and its Goals and Objectives.

## **Annex 1 – Identification and prioritisation of critical societal, economic and environmental needs**

The Five Goals and their respective objectives, as well the proposed strategic actions outlined in this strategy, were identified through a prospective analysis of trends, which in turn were identified based on reference publications studying the global trends that are impacting or will impact the world by 2040 and drivers of change that will shape the space sector by 2040.

There are several reputable sources for analysing future global trends and challenges. These sources often provide comprehensive reports and insights based on extensive research and expert analysis. Here are some of the most recognised sources that have been used in this work:

- UN Development Programme (UNDP) Human Development Report: human development metrics and future trends.
- UN Environment Programme (UNEP): environmental trends and sustainability challenges.
- EU European Strategy and Policy Analysis System (ESPAS): Global trends and how they affect Europe.
- World Economic Forum (WEF): Global Risks Report.
- PricewaterhouseCoopers (PwC): Global Megatrends.
- Organisation for Economic Co-operation and Development (OECD): OECD Economic Outlook

These sources provide valuable information and diverse perspectives on future global trends and challenges. They utilise various methodologies, including quantitative data analysis, expert consultations, scenario planning, and trend analysis, to forecast future developments and identify potential challenges and opportunities.

On this basis, the following key global trends and challenges have been identified:

- Climate change and environmental degradation
- Geopolitical instability and conflicts
- Economic volatility and technological disruption
- Public health crises
- Demographic shifts and urbanisation
- Technological advancements and cybersecurity
- Resource scarcity and energy transition.

In addition, the same sources identified how space capabilities would be of help in addressing future needs:

- **Climate Monitoring and Environmental Management:** Space capabilities are crucial for tracking climate variables, greenhouse gas emissions, and environmental degradation. Satellites provide high-resolution imagery and data, enabling better management of natural resources and environmental protection.
- **Disaster Response and Management:** Space technologies enhance disaster preparedness and response through accurate weather forecasting, realtime disaster monitoring, and efficient resource allocation. Satellite communication systems ensure connectivity during emergencies, facilitating coordination and relief efforts.
- **Global Connectivity and Communication:** Satellite networks bridge the digital divide by providing internet access to remote and underserved regions. This connectivity supports economic development, education, healthcare, and disaster response.
- **Security and Defence:** Space-based surveillance and reconnaissance capabilities are essential for national security, providing realtime intelligence and situational awareness. Satellite navigation systems support military operations, border security, and critical infrastructure protection.
- **Innovation and Economic Growth:** Space exploration and technology drive innovation across multiple sectors, from telecommunications to materials science. Investments in space missions stimulate technological advancements, fostering economic growth and enhancing global competitiveness.
- **Urban Planning and Smart Cities:** Space technologies support the development of smart cities through monitoring urban sprawl, traffic management, and infrastructure health. This contributes to more sustainable and efficient urban environments.
- **Healthcare and Telemedicine:** Space capabilities enable telemedicine solutions, improving access to healthcare services in remote areas. Satellite data aids in monitoring health trends and managing public health emergencies.

In addition, the ESA Strategic Foresight and Planning Office conducted a study to identify the main drivers of change which will shape the space sector, ESA and its system of actors, and assess their potential impact on this system in the medium and long term<sup>31</sup>. By considering the global space sector, the study aimed at anticipating potential shifts in the external environment of the European space sector but also to identify shifts within the sector. Those drivers of change were identified as significant external or internal forces originating from within various domains that can positively or negatively shape or influence the development of the European space sector. They were defined and assessed through four stages: search and discovery, classification, sense-making, and assessment through the engagement of wide consultation of about forty experts from different disciplines covering the full spectrum of the STEEPLE-V framework.

A total of 59 drivers have been identified, which encapsulate the key forces shaping the global space sector's future, 25 of which will have a major impact on the space sector by 2040.

The combination of global trends and transformations in the space sector with the drivers of change allowed for prioritisation of needs according to the potential positive impact that the evolution of the space sector in the coming years can have in addressing these needs.

31. "Identification of medium-to long-term drivers of change for the European Space Sector", ESA Strategic Foresight & Planning Office, June 2024

## Annex 2 – Analysis of the current European space landscape and outlook

### 1. List of Analysed Speeches and Documents of Europe's Political Leadership

The speeches and documents in the list below were carefully reviewed to ensure that all key elements in terms of policy needs and priorities are reflected within the ESA Strategy goals and objectives. This analysis was carried out by the European Space Policy institute (ESPI).

- Convention for the establishment of a European Space Agency following the Conference of Plenipotentiaries, held in Paris on 30 May 1975 notably Article 2 paras. a), c).
- Enrico Letta, Much More than a Market – Speed, Security, Solidarity, April 2024
- Framework Agreement between the European Community and the European Space Agency adopted on 6 August 2004
- HR/VP Josep Borrell's Blog Post on Why European strategic autonomy matters posted on 3 December 2020
- Mario Draghi, The future of European competitiveness – A competitiveness strategy for Europe, September 2024
- Mario Draghi, The future of European competitiveness – In-depth analysis and recommendations, September 2024
- Speech by Federal Chancellor Olaf Scholz at the Charles University in Prague on Monday, 29 August 2022
- Speech by Foreign Minister Annalena Baerbock at the Business Forum of the 20th Conference of the Heads of German Missions on 6 November 2022
- Speech by Foreign Minister Annalena Baerbock at the opening of the Conference of the Heads of German Missions on 9 September 2023
- Speech by French President Emmanuel Macron on Europe at the Sorbonne University on 25 April 2024
- Speech by President of the Republic of Finland Alexander Stubb at Hertie School in Berlin on 8 May 2024
- Speech by Prime Minister Kaja Kallas at Asia Tech x Singapore 2023 on 6 June 2023
- Speech on Security by Prime Minister Rishi Sunak at Policy Exchange on 13 May 2023
- Statement by Polish Prime Minister Donald Tusk on a proposed future air-defence system supported by French-built Polish national satellite assets
- Versailles Declaration adopted at the Informal meeting of the Heads of State or Government on 10 and 11 March 2022

### 2. Quotations from national space policy documents and reports and their alignment with the Five Goals defined for the ESA Strategy 2040

The table below maps how quotations from national space policy documents from ESA Member States and recent European reports are aligned with the Five Goals defined in this ESA strategy. This mapping was performed by ESPI in cooperation with the ESA Strategy Department and serves to illustrate how Strategy 2040 is closely aligned with national strategies to create strategic coherence across Europe and to ensure that no key elements were not reflected. The ESA Member States are listed in alphabetical order.

# ANNEX

Quote	Country	Link	Aligned with goals
"Sustainability indicators will be developed and applied to assess and appropriately steer Austrian space activities in ESA and at the national level"	Austria	<a href="#">Austrian Space Strategy</a>	1
"Austria will advocate for the development of a quality seal for sustainable companies in the space sector and will develop a roadmap for this."	Austria	<a href="#">Austrian Space Strategy</a>	1
"A roadmap for a "Powered by Space Data" label for space-based services developed in Austria will be created."	Austria	<a href="#">Austrian Space Strategy</a>	4, 5
"The Austrian space sector will increasingly collaborate with Austria's diplomatic missions abroad."	Austria	<a href="#">Austrian Space Strategy</a>	5
"We must consider future developments from a user's perspective. The take-up of these services will be quicker if they are easy and simple to use."	Then EC Executive VP Sefcovic	Keynote Speech, Brussels, 2024	4
"Introducing new services and improving interaction with users requires constant adaptation of our underlying satellite infrastructure, including to make them more secure, and bring in new technologies such as AI or quantum."	Then EC Executive VP Sefcovic	Keynote Speech, Brussels, 2024	3, 4
"By simulating natural and human activity, using an unprecedented amount of data, innovative Earth system models and cutting-edge computing, we will be able to develop and test future scenarios ... that knowledge will allow us to take smarter decisions and design more effective policies, save lives and money, and reinforce Europe's industrial and technological capabilities."	Then EC Executive VP Sefcovic	Keynote Speech, Brussels, 2024	1, 2, 3, 4
"I strongly think that we need to create a single market with teeth."	Enrico Letta	<a href="#">Much more than a market</a>	4
"Europe cannot, and should not, cede its role as a manufacturing leader to others."	Enrico Letta	<a href="#">Much more than a market</a>	4
"achieving greater coherence and synergy of research and development in order to optimise the use of resources available in Europe, including the network of technical centres."	ESA / EU	Framework agreement between the EC and ESA	5
"The world is increasingly dependent on space, not only economically but also in terms of well-being and security. The strategic and military role of space has grown rapidly. Space activities are playing an increasingly important role in the functioning of our society and daily life. Location and time data, telecommunications and remote sensing are the most important services obtained from space."	Finland	Finland Space Strategy 2030	3,4
"Space activities are playing an increasingly important role in security and defence policy, and this provides an operating environment for the intensifying competition between major powers."	Finland	2030	3
"Space activities are a dual-use environment as the capabilities that they create can be utilised for both civilian and military purposes and there is no clear distinction between the capabilities offered for these two areas."	Finland	Finland Space Strategy 2030	3
"The rise of NewSpace reinforces the regalian aspects of space, where the role of the State remains primordial. In this context, and while space activities are inherently dual, they make an essential contribution to the strategic autonomy of France, and more broadly of Europe, by guaranteeing the autonomy to assess situations and make decisions, as well as the freedom of action to government and military authorities."	France	ÉTAT- CNES   2022 - 2025	3
"Implement actions enabling the valorisation of dual and defence activities carried out by CNES in the space domain for the benefit of civil and space applications."	France	<a href="#">ÉTAT- CNES   2022 - 2025</a>	3

"The Federal Government is committed to ensuring that federal, state and local authorities are optimally informed about the potential of earth observation data have easy access to the data, are trained in its application and use this data actively and routinely in their work processes."	Germany	<a href="#">German Federal Space Strategy</a>	1
"Goal to ensure constant and reliable availability of space-based data, services and products for the state, economy and society...this requires adequate protection of all segments of these infrastructures and the technologies required for them in the future."	Germany	<a href="#">German Federal Space Strategy</a>	3
"Where possible, we use synergy potential, e.g. in the area of dual-use technologies."	Germany	<a href="#">German Federal Space Strategy</a>	3
"European space travel should contribute to Europe's technological and strategic sovereignty. Excellence and competitiveness are the pillars of the ability to contribute to international projects."	Germany	<a href="#">German Federal Space Strategy</a>	3, 4
"EU public contracts should be awarded in such a way that they further strengthen European competition, promote innovation and, where possible, are used for the sustainable use of space and support the promotion of sustainable development on Earth. The openness of the contract tender for SMEs and startups should be ensured."	Germany	<a href="#">German Federal Space Strategy</a>	1, 2, 4
"Anchor customer models can provide entrepreneurial security and at the same time facilitate access to private capital."	Germany	<a href="#">German Federal Space Strategy</a>	3, 4
"Through the transfer of know-how and technology from German space research, not only the space industry but also numerous other sectors and application areas benefit from the high-tech developments in space travel."	Germany	<a href="#">German Federal Space Strategy</a>	3, 5
"Space travel and digitalisation are mutually dependent. The data, services and products generated by space travel are also a driver of digitisation."	Germany	<a href="#">German Federal Space Strategy</a>	3
"The implementation of competitive tenders and the inclusion of SMEs and startups in the programme will enable a lasting impact for the entire European ecosystem."	Germany	<a href="#">German Federal Space Strategy</a>	5
"Use cooperation to promote common interests in the international context and to increase the ability to act."	Germany	<a href="#">German Federal Space Strategy</a>	5
"We want to expand international cooperation and strategic partnerships with selected partners, with the aim of reducing technological and economic dependence on certain key technologies and enabling joint research activities. To this end, we are strengthening the development of bilateral and multilateral cooperation."	Germany	<a href="#">German Federal Space Strategy</a>	3, 5
"The Mediterranean region, in fact, is of particular political and strategic interest for Italy, which wants play a relevant role in order to defend and enhance its national interests through Space Diplomacy."	Italy	ASI Document of Strategic Vision for Space 2020-2029,	5
"It is necessary to define a space diplomacy which envisages strengthening international cooperation and national supervision at the highest institutional levels of all the international organisations in the sector, in order to ensure a constant and influential Italian presence, through active participation in the United Nations, ESA, European Commission and in joint programmes with NASA and the Space Agencies of other countries."	Italy	Government guidelines on space and aerospace	5
"an adequate diplomatic support should be guaranteed in order to allow the country playing an active role in international fora to define a shared framework of international governance for Space."	Italy	National Security Strategy for Space	5
"Special attention is also needed towards the countries of the enlarged Mediterranean, some of which are also members of the European Space Institutions. The Mediterranean region, in fact, is of particular political and strategic interest for Italy, which wants and must play a relevant role in order to defend and enhance its national interests through Space Diplomacy, space technology put at the service of the area, bilateral collaborations and training."	Italy	Document of Strategic Vision for Space 2020-2029	5

# ANNEX

"What could be termed as a Space Innovation (and Valorisation) Diplomacy becomes the pretext for promoting the national interest, fostering the development of critical and strategic technologies, enriching it with collaborations, validating national visions on innovation, and sharing issues of global interest such as Sustainable Development Goals also through the implementation of Mission Oriented Policies/Programmes."	Italy	Document of Strategic Vision for Space 2020-2029	5
"The Polish economy and public institutions will have access to satellite infrastructure enabling them to meet their needs, especially in the field of security and defence."	Poland	Polish Space Strategy 2027-2030	3
"It should be emphasised that building human resources and creating favourable conditions for the development of the space sector in Poland are horizontal activities, and their implementation will contribute to increasing competitiveness, developing a digital economy and meeting Poland's needs in the area of security and defence."	Poland	Polish Space Strategy 2027-2030	3
"It should be emphasised that increasing the Polish contribution to ESA's optional programmes to the average level applied by the Agency's other member states is the main instrument for increasing the competitiveness of the Polish space sector, but it can and should facilitate the implementation of the other specific objectives of this Strategy. Thanks to a higher participation in optional programmes, Polish companies can acquire or develop technologies useful for security and defence needs or create applications responding to the expectations of Polish users."	Poland	Polish Space Strategy 2027-2030	3
"To develop the technological competences of the Polish space sector, it is necessary to acquire the widest possible knowledge about existing and planned solutions and areas developed by potential partners and competitors from other countries. The best (though not the only) tool for this is the European Space Technology Harmonisation process."	Poland	<a href="#">Polish Space Strategy 2017-2030</a>	5
"Our core vision is to support Slovenian space and non-space industries to seize the significant commercial opportunity of the space sector, while providing new resolve regarding efforts towards digitalisation and the green transition across all economic sectors."	Slovenia	Slovenian Space Strategy	1
"Switzerland will develop its own capabilities in particular in the areas of space situational awareness (SSA) and GNSS signal assessment ... Developments in the military use of outer space will be increasingly monitored and assessed and, where needed, suitable measures will be put in place."	Switzerland	<a href="#">Space Policy 2023</a>	3
"The Confederation will promote networking and knowledge and technology transfer between science and businesses, as well as interdisciplinary research and innovation cooperation. This can be achieved namely through flagship projects that bring together many different players in Switzerland."	Switzerland	<a href="#">Space Policy 2023</a>	5
"There is a central effort to use satellite data decisively for land and water management and urban planning, and for optimization of new energy systems (solar and wind forecasts)."	The Netherlands	<a href="#">Space Agenda</a>	1
"National emergency services are currently highly dependent on land-based communications systems for data and voice connections... This can be done by using secure ones on the one hand satellite navigation (such as Galileo's Public Regulated Service (PRS)) and on the other hand through the use of alternative sources of positioning and timing."	The Netherlands	<a href="#">Space Agenda</a>	3
"The Netherlands is investigating centralization of all operational and security aspects of national and European satellite systems to prevent fragmentation of expertise."	The Netherlands	<a href="#">Space Agenda</a>	3
"Optimal use of synergy between civil and military activities. Reinforcement 4: Ensure optimal use of civil and military space activities by safeguarding this both in policy and in implementation."	The Netherlands	<a href="#">Space Agenda</a>	3
"The government wants to focus more explicitly on space diplomacy. The (inter) national institutions established in our country also explicitly examine the role that Earth observation can play, for example in criminal cases of the International Criminal Court and in compliance with international agreements (also in the field of disarmament)."	The Netherlands	<a href="#">Space Agenda</a>	5

"Delivering groundbreaking variable liability insurance and finance incentives, including variable liability limits, for responsible space operators to reward sustainable practices and drive innovative approaches to sustainable space operations."	United Kingdom	<a href="#">Space Industrial Plan</a>	1
"We will ensure that the UK embeds civil defence dual use at the heart of our approach to government procurement."	United Kingdom	<a href="#">National Space Strategy</a>	
"The UK will expand existing dual-use sensor and data networks, adding the ability to task sovereign sensors, understand space weather, and exploit space surveillance and tracking data."	United Kingdom	<a href="#">National Space Strategy</a>	3
"develop a small constellation of Intelligence, Surveillance and Reconnaissance satellites and explore other new initiatives to protect and defend the UK, pulling through advanced technologies from R&D to operation and exploring opportunities for dual civil and defence use."	United Kingdom	<a href="#">National Space Strategy</a>	3
"Developing cross-government initiatives to provide additional support, a more ambitious approach, or an accelerated plan in the short-term to deliver national space capability goals in SDA, IOSAM, Space Data for Earth applications, PNT, and satellite communication technology."	United Kingdom	<a href="#">Space Industrial Plan</a>	1, 3
"new government strategic engagement model: move towards building more strategic, two-way relationships with a longer-term focus through targeted engagement and information sharing."	United Kingdom	<a href="#">Space Industrial Plan</a>	5
"Embedding the Supplier Code of Conduct and space sector model behaviours across activity in the sector to reflect our expectations for how businesses and government should act in the UK to deliver our goals."	United Kingdom	<a href="#">Space Industrial Plan</a>	4, 5
"Launching the first industry-led sustainability standards for space and designing incentives for their adoption by industry."	United Kingdom	Space Industrial Plan	1
"Implementing a new Private Investment Framework for Space...Initiating a joint action plan with the finance and commercial space sectors to unlock London as the leading global space finance hub..."	United Kingdom	Space Industrial Plan	4
"Assessing the use of more flexible, non-R&D funding vehicles to ensure we have the right support available across the entirety of the sector."	United Kingdom	Space Industrial Plan	4
"Identifying export opportunities overseas for UK companies through DBT and UK Defence and Security Exports (DSE)"	United Kingdom	Space Industrial Plan	4
"Work with government's Strategic Suppliers to unlock innovative space solutions, link them up with SMEs and support them in becoming greater users of space in delivering public contracts." (use of UK space services)	United Kingdom	Space Industrial Plan	3, 5
"The UK has played a leading role on the international stage to improve the global governance of space. We will build on this work and continue to play a leading role within the UN and with international partners to promote responsible space behaviours and to reduce the risk of unmanaged escalation and unintended conflict between States."	United Kingdom	The National Space Strategy in Action	1, 5

# ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
ALCE	Latin American and Caribbean Space Agency
ARRAKIHS	Analysis of Resolved Remnants of Accreted galaxies as a Key Instrument for Halo Surveys
ARTES	Advanced Research in Telecommunications Systems
ASI	Italian Space Agency (Agenzia spaziale italiana)
ATV	Automated Transfer Vehicle
BIC	Business Incubator Network
CM	ESA Council meeting at Ministerial Level
CNES	French national space agency (Centre national d'études spatiales)
CSC	ESA Directorate of Connectivity & Secure Communications
CSG	Guiana Space Centre (Centre Spatial Guyanais)
DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
EAC	European Astronaut Centre
EC	European Commission
ECSAT	European Centre for Space Applications and Telecommunications
EDL	Entry, Descend and Landing
EEA	European Environment Agency
EGNOS	European Geostationary Navigation Overlay Service
EMS	Emergency Management Service
EO	Earth Observation
ERS	European Remote Sensing satellite
ESA	European Space Agency
ESAC	European Space Astronomy Centre
ESEC	European Space Security and Education Centre
ESM	European Service Modules
ESOC	European Space Operations Centre
ESPAS	EU European Strategy and Policy Analysis System
ESPI	European Space Policy institute
ESRIN	European Space Research Institute
ESTEC	European Space Research and Technology Centre
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EUSPA	European Union Agency for the Space Programme
GDP	Gross Domestic Product
GEO	Geostationary Orbit
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HEI	Higher Education Institution
IoT	Internet of Things
IPMA	Independent Project Management Authority
IRIS2	Resilience, Interconnectivity and Security by Satellite

ISRO	Indian Space Research Organisation
ISRU	In-Situ Resource Utilisation
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
JUICE	Jupiter Icy Moons Explorer
KASA	Korean AeroSpace Administration
LEO	Low Earth Orbit
LISA	Laser Interferometer Space Antenna
LSI	Large System Integrator
LTP	Long-Term Plan
MFF	Multiannual Financial Framework
NASA	National Aeronautics and Space Administration
NEO	Near-Earth Object
OECD	Organisation for Economic Co-operation and Development
PLATO	PLANetary Transits and Oscillations of stars
PNT	Positioning, Navigation & Timing
PPP	Public-Private Partnership
PRS	(Galileo) Public Regulated Service
QKD	Quantum Key Distribution
R&D	Research and Development
RF	Radio frequency
SDG	Sustainable Development Goals
SME	Small and Medium-sized Enterprises
SMILE	Solar wind Magnetosphere Ionosphere Link Explorer
SSA	Space Situational Awareness
SSDC	Space Science Data Centre
STEM	Science, Technology, Engineering and Mathematics
STS	ESA Directorate of Space Transportation Systems
TEC	ESA Directorate of Technology, Engineering and Quality
TGO	Trace Gas Orbiter
THESEUS	Transient High-Energy Sky and Early Universe Surveyor
U.S.	United States (of America)
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VLEO	Very Low Earth Orbit
VP	Vice President
WEF	World Economic Forum

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