Report of the High-Level Advisory Group
on Human and Robotic Space Exploration for Europe

Revolution Space

Europe's Mission for Space Exploration

“Europe should embark on a revolutionary endeavour which equally encompasses grand geopolitical, economic and societal benefits.

Our Report takes you on the journey to identify the striking and transforming effect of Human and Robotic Space Exploration and convince you about the visionary political decisions, European leaders have to take.”

Report of the High-Level Advisory Group on Human and Robotic Space Exploration for Europe

March 2023 - Council submission

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1. Europe's place in space

There is no better domain than space to demonstrate Europe's technological and societal prowess

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We stand at a pivotal point in European history. **Space is undergoing a revolution** comparable to the growth of the Internet 20 years ago. Like the Internet, the space revolution will affect all domains of life.

While current estimates of the global space economy stand between €350 – 450 billion, independent forecasts predict its value to reach €1 trillion before 2040.[i] Countries and regions that will not secure their independent access to space and its autonomous use, will become strategically dependent and economically deprived of a major part of this value chain. Europe's goal should be to **capture one third of this future market**.

For decades, Europe has dedicated itself to leading in the use of space for fundamental science, climate

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observation, precision navigation and weather monitoring. Because of this focus, it now stands as second to none, **in particular in Space for Earth** (Earth Observation, Navigation, Telecommunications) and Space Science to explore the Universe.

However, in the past 30 years, **Europe decided not to invest in leadership and autonomy in human space exploration. Instead,** it chose to pursue collaboration as a junior partner with NASA and, until a year ago, with Russia. Although this resulted in highly visible achievements, the **cost and consequences of such dependencies have now been brought into sharp focus**, given the collapsed relationship with Russia, and accelerated efforts of others. The U.S. and China have started a new global space race, and private actors have been developed through governmental programmes, with the clear objective to establish global leadership in segments such as launchers and broadband internet from space. The exponential increase of activity in shared orbits and unduly risky behaviour of certain actors, both governmental and private, threaten to block access to critical and limited resources. As a result, the international landscape is fundamentally **shifting from a period of international collaboration to a period of cooperation and competition**.

Europe must decide what role to play in this revolution: spectator, customer or leader? By leveraging its heritage as a beacon of international partnerships, Europe should develop global partnerships in space with significant geo-political and economic benefits for its economy and people.

A bold mission would galvanise and revolutionise the whole European economy, well beyond the space sector, and inspire a generation of Europeans to build the future. The Moon landing was a programme defining a whole generation. It mobilized 400.00 people from 20 different sectors across the entire US economy, creating future-shaping symbiotic public-private partnerships, the forces of which still resonate today.

More than 100 lunar missions have been announced by 2030, both by established and emerging space actors.[ii] At present, Europe is only leading two of them.

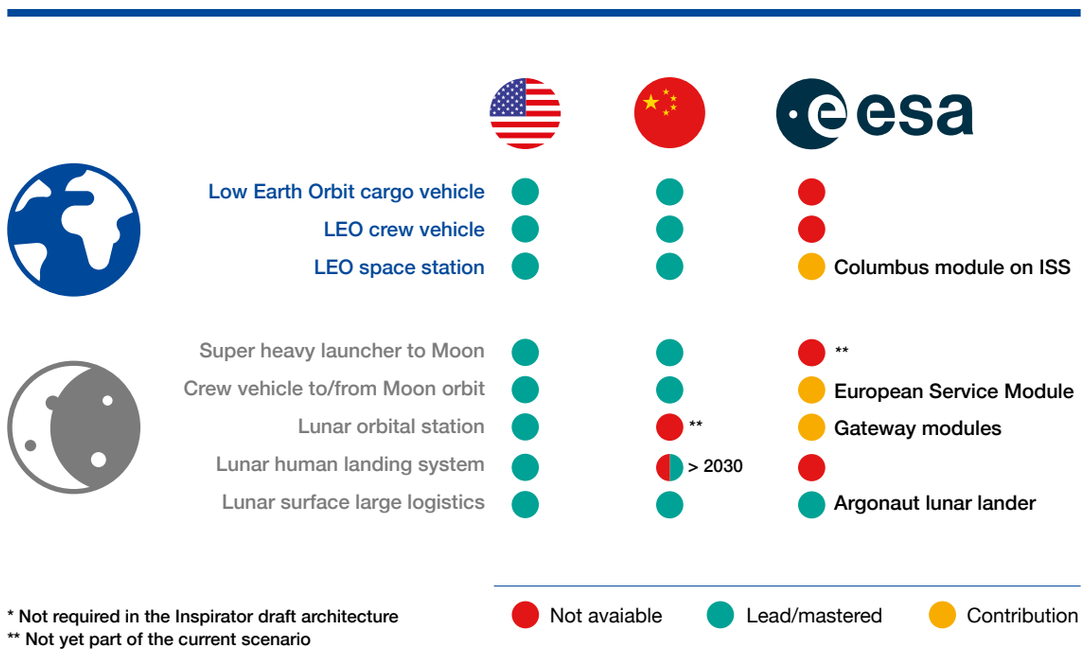


Figure 1: Where does Europe stand in space exploration - Comparative capabilities by 2030 (Source: ESA)

2. What's at stake for Europe

The ongoing race for geopolitical influence and future economic gain

An ongoing race for geopolitical influence and future economic gain is unfolding at an unseen pace and further accelerating. Heightened tensions around the world underscore the fact that Europe's security and prosperity increasingly rely on our ability to access and act in space.

The **sharp decrease in the cost of the entry ticket** to acquire space systems is making space a fiercely disputed field of economic competition, with new business cases, and new applications, alongside a contested environment from a defence standpoint.

As all non-European permanent Members of the UN Security Council (U.S., China, Russia) are space powers with autonomous human spaceflight capabilities and are soon to be joined by India, Europe's lack of ambition stands in isolation.

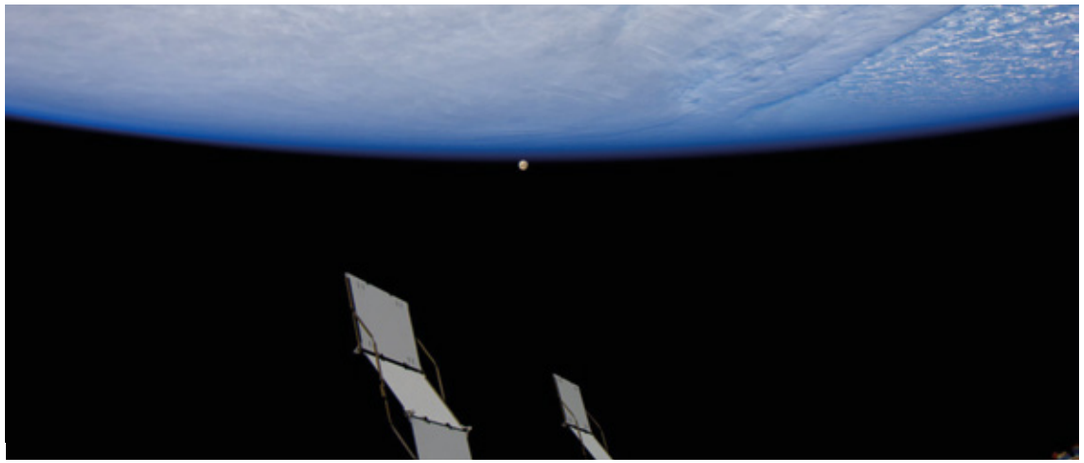
Furthermore, the drift of human space exploration to the private sector in the U.S. will be a game changer, as Europe will be forced to buy from or barter with non-European companies for its astronaut access to space.

In the meantime, European industry and talent are increasingly being acquired by foreign commercial businesses. Without its own capabilities, Europe's exploration timelines will forever be dictated by others, our space technology will fall behind, and our brightest talents will pursue their dreams elsewhere. Thus, the adage "if you are not sitting at the table, you are on the menu" risks becoming a harsh reality.

Should Europe decide to prevent this by boosting its ambitions in exploration, it cannot afford to wait. Any delay would **further accentuate the drain of talent and technology**, loss of European intellectual property, and lead to long-lasting international dependencies.

Developing and deploying autonomous capabilities is a task of a decade. If Europe wants to shape the world of the future, it needs to initiate a **process of transformation now. The amount of investment needed to compete is within reach in the context of Europe's economic output**, especially given that the average GDP share of space investment in Europe is just one fifth of that of the US and only one fifteenth of NASA's budget for exploration.

With the need for immediate action in mind, the question is not who is next to put their boots on the Moon, but rather who will sustain a long-term presence.



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"The cost of inaction would far outweigh the necessary investment to establish Europe as a strong and independent space actor.

For Europe to become a transformative player able to make a difference, truly grand goals and narratives are required, identifying, and exploiting the full strategic dimension of space and space exploration.

Europe needs to recognise that this entails prompt action to catch-up and leapfrog the competition, and shape the future in line with Europe's values."

3. The benefits of European autonomy in space exploration

European autonomy in exploration will unlock benefits across the following strategic domains

- Peace, security and cooperation
- Prosperity and wealth
- Society and inspiration
- Climate action and sustainability

Peace, security and cooperation for protecting Europe and its values

As noted in the 2022 EU Strategic Compass for Security and Defence,[iii] space is an increasingly contested domain, requiring the development of capabilities for prompt action. In the war in Ukraine, for the first time in history, space-based capabilities significantly changed the balance of the conflict. As activities increasingly move into and beyond Earth orbit, essential European security interests expand to lunar orbit, the lunar surface, and even beyond. European efforts to secure its space assets and its space services are still – even after the Russian attack on Ukraine – far too limited. All actors, the EU, ESA and their Member States have to face these security challenges and have to contribute to joint efforts and capabilities for Europe. This encompasses all space activities and capabilities, current and future. In this context, to safeguard its citizens and prosperity, Europe needs a secure flow of

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information about these increasingly contested domains, and the fundamental freedom to act if its interests are threatened.

Europe as an actor with an autonomous space presence will be better positioned in future governance discussions to protect its values beyond Planet Earth.

European autonomy in space exploration would also open **new opportunities for diplomacy, reinforcing Europe's partnership portfolio** through frameworks where Europe is not just a passenger but in the commander's seat. This can provide a European alternative for partners, who are interested in options beyond the U.S. and China and thus **contributes to a more stable, multipolar world.** For the future, we can foresee for example a European commercial crew capsule with a European astronaut as commander, and astronauts from Latin America, Asia and Africa onboard. This is the "European spirit" in space exploration as a strong partner open to the world.

Prosperity and wealth for European stability

In many forecasts, the paradigm shift in our human exploration of space will entail a **complete disruption of whole economic sectors, companies, and human activity at large.** Space-ready companies and countries will find themselves at a huge technological and competitive advantage.

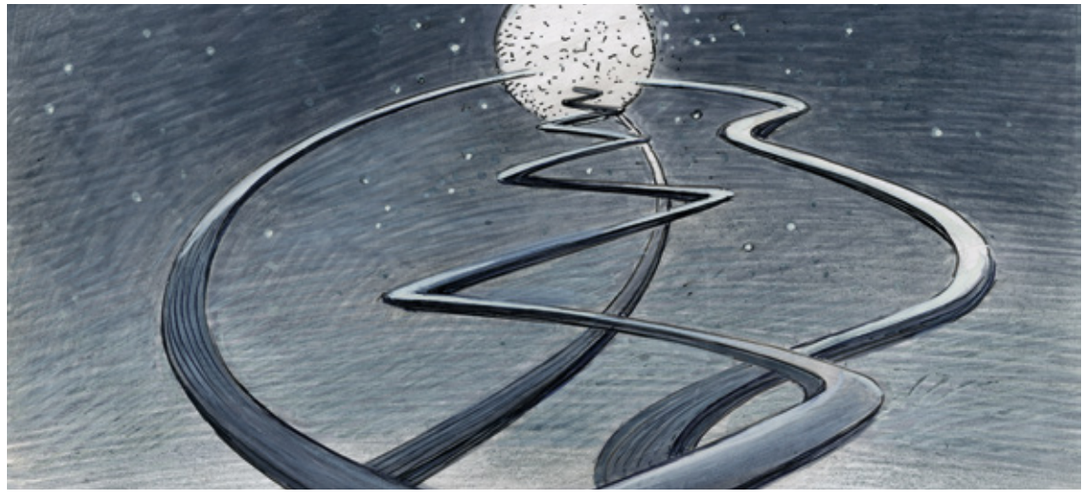
Substantially increasing investment in space and space exploration is a precondition if Europe

US$ 8.2 bn
FY 2019 and 2020
Average Moon-to-Mars Campaign Budget
NASA, 2021

US$ 20.1 bn
FY 2021
Moon-to-Mars Campaign Economic Output
NASA, 2022

93 000
FY 2021
Moon-to-Mars Campaign Jobs Generated
NASA, 2022

Figure 2: Budget, Economic Output and Jobs supported by the NASA Moon to Mars Campaign 2021 (Source: NASA)



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is to capture large shares of multiple commercial growth areas and ensure it does not miss out on economic developments with an excellent chance of high multiplier effects.

Only by attracting top talent and maintaining excellence can Europe sustain its long-term prosperity. A reinforced ambition will open new horizons of opportunity for European achievers, **eager to realise their talents.** Today European space and technology sectors are experiencing a shortage of talent due to foreign companies attracting educated, ambitious Europeans. To **counter the risk of increasing the brain-drain**, Europe must develop a daring exploration roadmap offering a tangible avenue for European companies to prosper and compete in an innovation-driven ecosystem and tilt the competitive field in Europe's favour. [iv]

Developing and owning capabilities, rather than being a supplier of parts for foreign systems, gives Europe the power to define and set conditions on intellectual property, thus preventing the leak of European knowledge.

Moreover, creating robust public demand would build confidence in European investors and help European companies raise larger rounds. Currently, the overall private investment in Europe is dwarfed in comparison to the U.S. Furthermore, the average size of European deals is significantly smaller. Consequently, companies will usually fail to attract the high level of private funding typically required in visionary space developments.

Given examples in other technology domains, **the potential cost of inaction would far outweigh the necessary**

US$ 15.7 bn

Impact of AI on the Global Economy up to 2030

PwC

70%

Economic impact of AI on Chinese and NorAm Economies

PwC

16%

Economic impact of AI on the European Economy

PwC

Figure 3: Projections of the Economic Impacts Artificial Intelligence up to 2030 (Source: PwC)

investment to secure European autonomy in space. Historically, a **passive approach in Europe led to the creation of foreign market dominance,** even in technology sectors where Europe was initially well positioned. Among many fields, artificial intelligence (AI), cloud computing and semiconductors are clear examples of where Europe missed out on potential markets with high-economic multiplier effects and strategic value.

As with the Internet 20 years ago, space today stands at an inflection point. Together with AI, it will affect all domains of life. Europe cannot afford to, once more, miss out.

Even more so, as the scale of necessary investment to develop autonomous exploration capabilities is **small when compared with R&D budgets of other industries.**

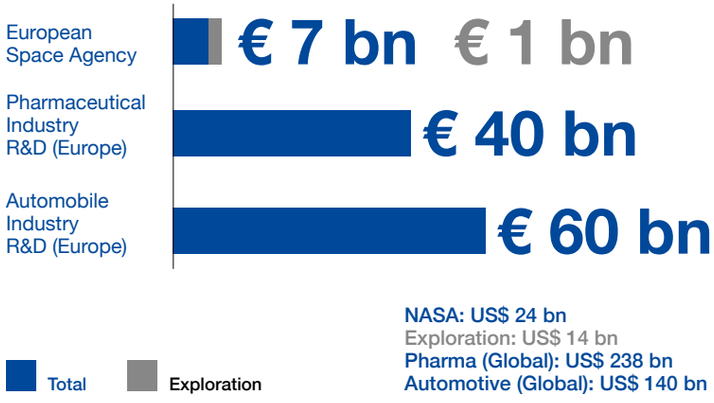

Figure 4: ESA Exploration Budget in comparison to R&D in other Industries (Europe) (Source: multiple)

Figure 5: Why am I pursuing a space-related career? (Source: ESPI)

Inspiration for all Europeans and beyond

Space can have a transformative role for European society at large. Europe's highly talented and thoroughly educated workforce is our asset. It is ready to innovate and break the glass ceilings. By pursuing autonomy in space exploration, Europe would provide a unique outlet to unlock European talent, and reverse the brain-drain by attracting the best and brightest from outside of Europe.

Autonomous human spaceflight capabilities would also **unlock further synergies between exploration and science**, through the best use of the know-how and the know-why as well as the full value chain of European scientific excellence, **while providing European science with a new window of progress through new capabilities and infrastructures**. The creative dynamic between science 'push' and technology 'pull' has been the prime driving force and the backbone of five decades of successful European advances in space.

Moreover, history has already provided an example where astronauts have proved crucial in repairing the Hubble Space Telescope's faulty optic.

The core role of science within exploration, as an enabler, driver, and opportunistic exploiter, should be sustained and enhanced. For example, the pace and scale at which science on the Moon can be conducted via a human-robotic partnership are incomparable to robot-only exploration, while the Moon could also be used as an enabling platform for seeing beyond the current horizon and providing opportunities for bolder and larger scientific missions that further assert European scientific excellence.

Europeans should be empowered to design, drive and deliver Europe's next milestone in space exploration. Responsibility, a sense of ownership and a can-do approach will attract young people to pursue careers in STEM. **Europe needs to learn to trust the young** – the average age in the Apollo 11 mission control room was 28.

Humans are born explorers, and Europe needs to leverage human nature, engrain the space dream into collective imaginary realms, and inspire individuals through bold collective ambitions.

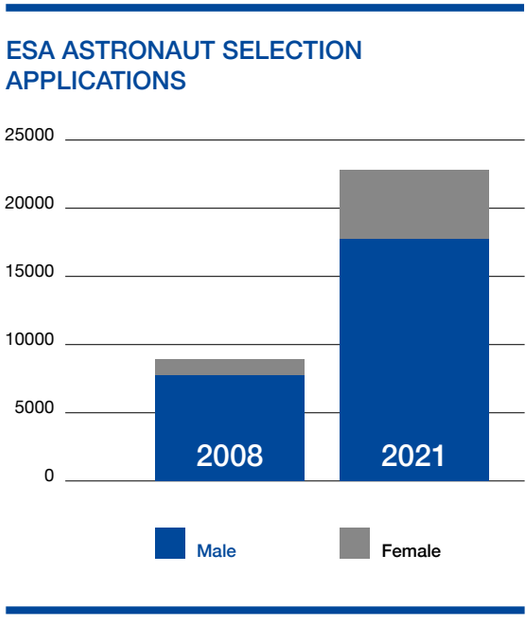

Figure 6: Number of applications to become an ESA Astronaut (ESA)

Space exploration and human spaceflight in particular are topics of great interest to the general public, with astronauts historically embodying the ideal of an explorer. Today, the interest in human spaceflight is increasing at a rapid pace, as shown by the **three-fold increase in applications for the ESA Astronaut Selection** between 2008 and 2021.

Space exploration has a unique dimension of attracting young people to the space sector. Providing **an avenue to materialize their dreams** is the key to retaining their talent in the longer term. NASA's Apollo programme showed how bold ambition matched with an appropriate budget correlates to a significant increase of graduates in technical and physical sciences PhDs in the U.S.

Climate action and sustainability – differentiators of European efforts

Space exploration should be aligned with Europe's efforts in tackling Earth's grand challenges. Future activities beyond Earth can serve as **practical demonstrators of how we can have a lower impact on our environment.**
A critical element of our **terrestrial transition to NetZero is the question of power generation**, currently representing the source of almost 75% of all

Grey Water Recycling Systems

A recycling system for 'grey water' – water previously used for washing or food preparation – **initially** developed **for the ISS and tested in Antartic bases,** supports **clean water distribution on Earth**.

LNG Boil-off Emission Reduction

During transport Liquid Natural Gas in the tank continuously evaporates causing increased emissions. The same **technology developed for freezers on the ISS** is now **used onboard** LNG tankers to reduce the loss through reliquification.

Figure 7: Technologies developed for the ISS result in innovative solutions on Earth (Source: ESA)

global greenhouse gas emissions. R&D for space exploration has already played a pivotal role in the improvement of high-efficiency solar arrays, with terrestrial solar power representing a crucial pillar of the energy transition towards carbon neutrality.

In this respect, ESA is currently studying if this technology can be moved into space to beam energy back to Earth. If an economically viable technology for space-based solar power can be found, it could play a major role in the energy transition, while technologies for operating space exploration missions, would help the development, deployment and maintenance of space-based solar power systems.

501 TWh

Total annual electricity consumption in Germany in 2021

Enerdata

800 TWh

Potential amount of annual energy output produced by space-based solar power by 2050

Frazer Nash

Figure 8: Potential effects of space-based solar power on Europe's energy supply by 2050 (Source: Enerdata, Frazer Nash, ESPI)

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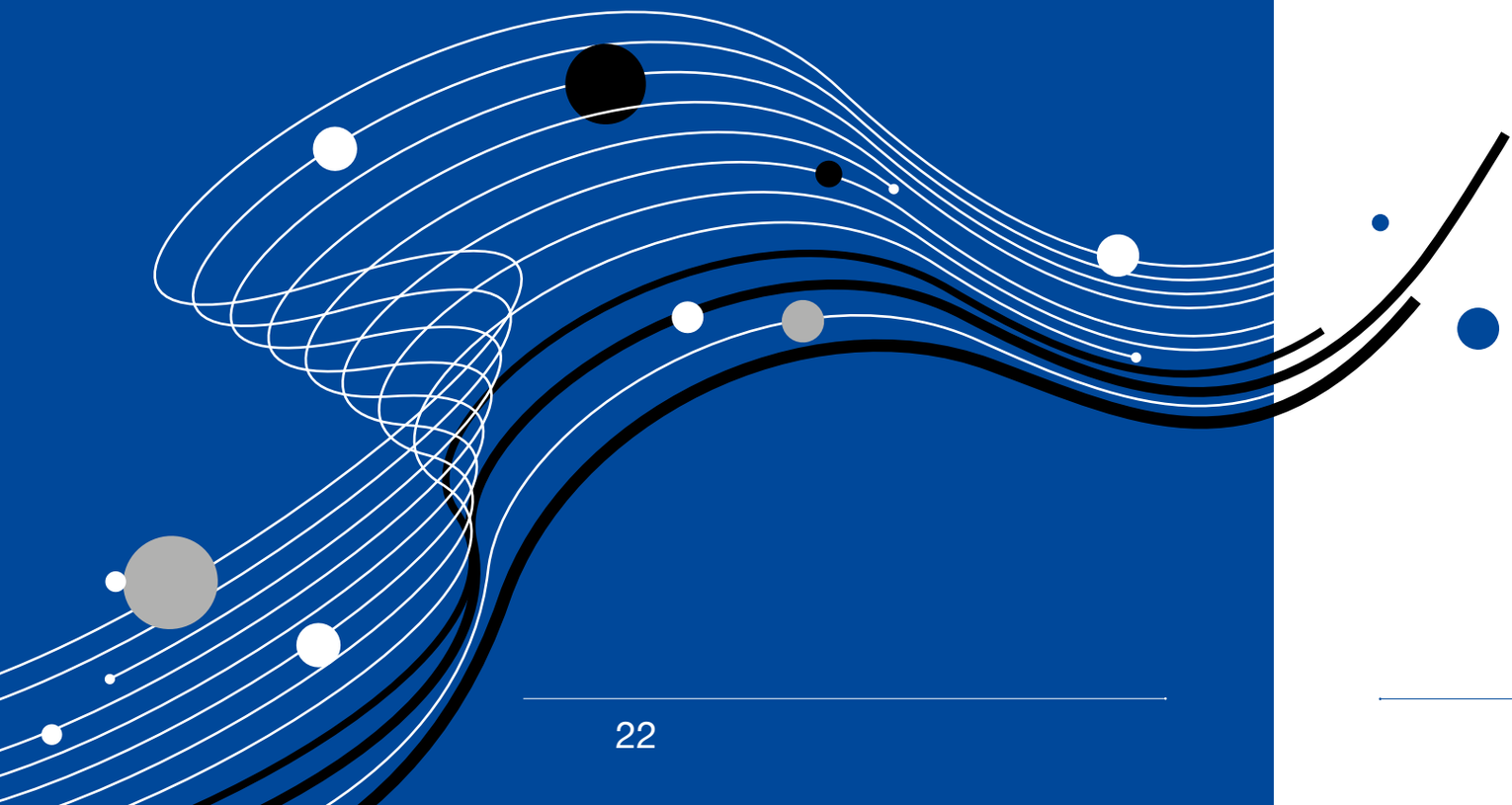
“Space is currently undergoing a revolutionary change, comparable to the internet economy 20 years ago, the consequences of which affect all domains of life. Europe cannot afford to miss a new potential golden age with high multiplier effects across the economy. Europe should translate its future autonomy in human and robotic space exploration into an **offer of strong and reliable partnerships** covering all world regions.

Europe should trust the young, and **empower the next generation** to design, drive and deliver Europe’s future milestones in space exploration, acting as binding agents within and across Member States, and thereby uniting Europe.

Sustainability and environmental stewardship must become the key differentiator on which European space exploration should build its identity and forge its strategy.”

4. A transformative European roadmap for space exploration

More than a space programme



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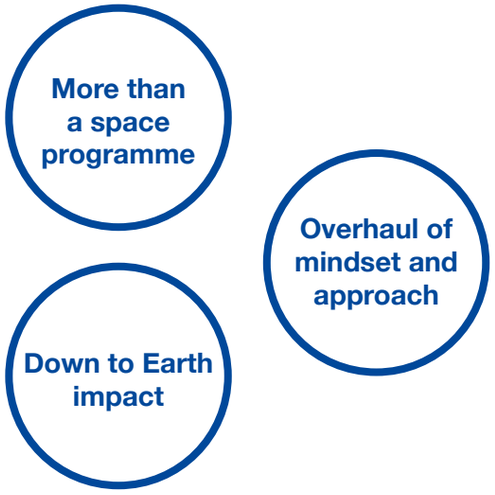
It is crucial that we **transform European space infrastructure development in the 21st century for those sectors which are becoming commercially mature and have a convincing business case**. In order to maximise the outcome of public investment it is crucial to **convert to a new procurement model** for large-scale infrastructure development.

Rather than designing, developing and operating space infrastructure a commercially-oriented procurement policy needs to be adopted: The public sector, through space agencies like ESA, shall define the requirements for large-scale infrastructure or missions, for example, a crew capsule, and encourage the private sector to propose the most innovative and cost-efficient solution. The public agency will be an anchor customer buying a service or product. In parallel, it will also develop technology building blocks to enable private companies to mature technologies needed to fulfil the services.

The long-term commitment by public agencies is crucial for the private sector to attract funding. The US Commercial Crew Program as well as the Commercial Cargo Program are examples that have developed a successful commercial industry.

For Europe to remain a prosperous and geopolitically relevant continent it must be scaled up with significantly increased political support and public funding, and by stimulating private investment in the European space ecosystem.



More than a space programme

Space Exploration is **more than a programme to master technological challenges**. It must also transform society in such positive ways that its value to the public is obvious. Space already touches every aspect of society, from entertainment and communications to navigation and commerce. Understanding the value of its influence – and the promise that autonomous human exploration capabilities would bring to all aspects of society is the key to generating belief in the future. In turn, this feeling is a necessary basis for confidence in our ability to take responsibility and shape the world positively.

To reinforce this message, space must expand its cooperation strategy and reach stakeholders beyond space and technical fields. “More than a space programme” means just this, we have to actively build a bridge between sectors and generations so that as many institutions and people as possible can see and benefit from the value of space and support its enhancement.

A symbiotic public-private ecosystem should not only strive for market creation but should also steer Europe towards a more sustainable and inclusive economy. In this context, green procurement for space should become an integral part of the Green Deal.

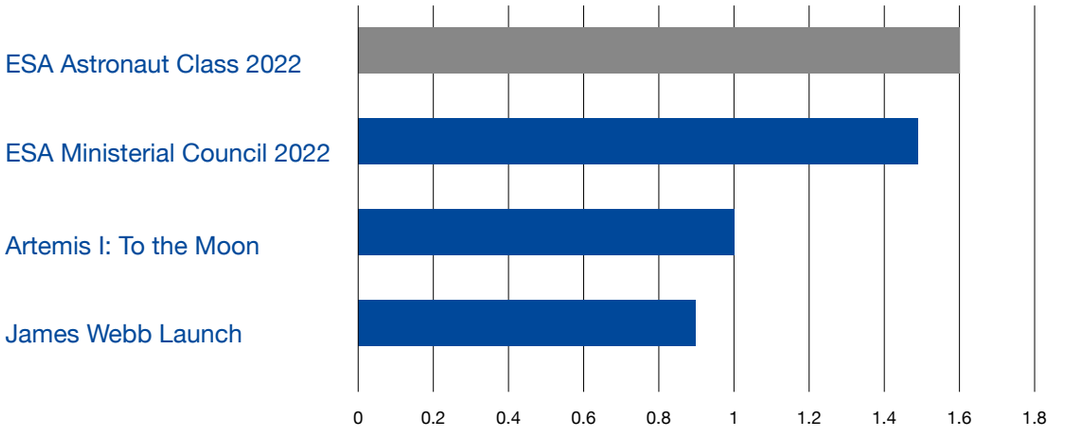


Figure 10: Global Reach of ESA Communication (Source: ESA)

423 million

Number of unique visits to an ESA-developed online app tracking the ISS position

ESA (Aggregated)

Figure 9: Public interest in the ISS tracker (Source: ESA - Aggregated)

An overhaul of mindset and approach

Europe needs to deeply transform its processes by building a framework that **kindles real competition between European companies, and aggressively fosters the emergence of new actors.** It is impossible to overlook that the major game-changer in space over the past few decades has been the emergence of new companies with often aggressive business models, such as those employed by SpaceX. They have completely reset the competition, and distorted market forces, largely thanks to a new procurement policy by NASA and the US Department of Defense, creating both a demand pull and a strong and competitive supply.

90%

of respondents completely (or tend to) agree that European investors take less risk compared with US funds

Boston Consulting Group

Figure 11: On risk-aversion of European investors (Source: Boston Consulting Group)

To be able to get back in the exploration race, **Europe must overhaul its approach and processes, otherwise, a reinforced ambition is unlikely to be deliverable.**

Such transformation must include private sector co-investment, new innovative financing structures, institutional challenge-based or service-based procurement, **alleviating procurement constraints**, and optimization of public-private financing models to stimulate private investment and industrial competitiveness. This has to be matched with sustained support to education providers, research and technology institutes and ensuring ESA's own transformation.

The right implementation framework to realise bold ambitions is key. It should be based on clear challenge-oriented public action towards a common goal. In this regard, the directionality, and conditionality of public investment are crucial to avoid monopolies and dependencies on individual actors.[vi]

To attract talent into public organisations, it is also critical to value the civil service and allow risk-taking and experimentation. Otherwise, there is a risk that talent will drain out of government and public service. A mission-based public policy approach provides a clear contrast to today's reality, as it enables personally rewarding careers for a new workforce.

This requires **the sharing of risks and benefits** between public and private actors. Success will be determined by designing tailored procurement tools, allowing public actors to push the envelope, and fostering a symbiotic industrial ecosystem that rewards merit as well as experience. In doing so, Europe can make the best use of the full chain of industrial know-how from established actors as well as new entrants. But most importantly, private investment and engagement will only happen if the public sector commits to a clear vision and associated strategy. **Public and private actors have a responsibility to get out of their respective comfort zones**.

Considering the fast-moving space landscape, **Europe should rapidly proceed, with clearly defined goals, and aggressive timelines**, demonstrating concrete achievements through early and frequent in-orbit demonstration/validation efforts, and reaching ambitious milestones in the short to medium term.

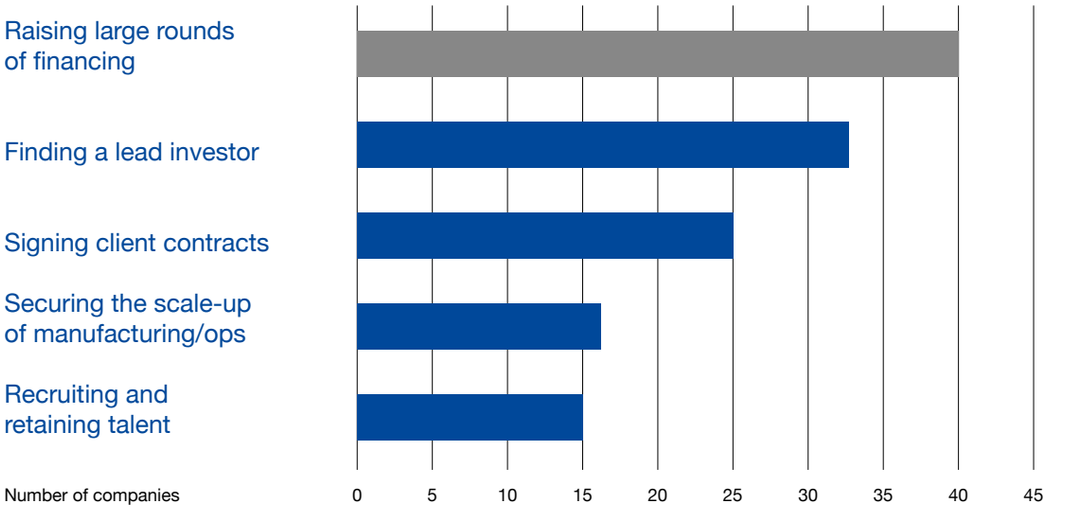


Figure 12: Biggest scaling-up challenges for European DeepTech companies (Boston Consultancy Group)

Mission-oriented innovation policy responds to major social and environmental challenges by identifying and articulating concrete problems that can galvanise production, distribution and consumption patterns across various sectors.

Mission-Oriented Innovation Policy, September 2017

Down-to-Earth impact

Mission-oriented approaches are powerful generators of benefits. Aligning missions to sustainable development goals can allow targeting the biggest socio-economic and environmental challenges we face today.[vii] **This has the potential to transform public-private partnerships with a view to co-creating and co-shaping markets** to help tackle the challenges faced while enabling economic growth.[viii] It recognizes that Innovation requires investment and risk-taking by both private and public actors.

Moreover, missions also offer an opportunity to harness the plethora of spill-overs created through innovation, investment, and scientific advancement in the space sector, as they generate serendipity. Sometimes unexpected benefits and discoveries overshadow the initial objectives. Notably, the induced and catalytic effects go far beyond the space sector and impact the wider economy at GDP level. **Cost-benefit analyses do not always take these lessons into account**, as some of the most innovation-enabling missions would have not been undertaken purely based on cost-benefit considerations. In that sense, ISS enables the science and future technologies needed for the exploration of the Moon and Mars.

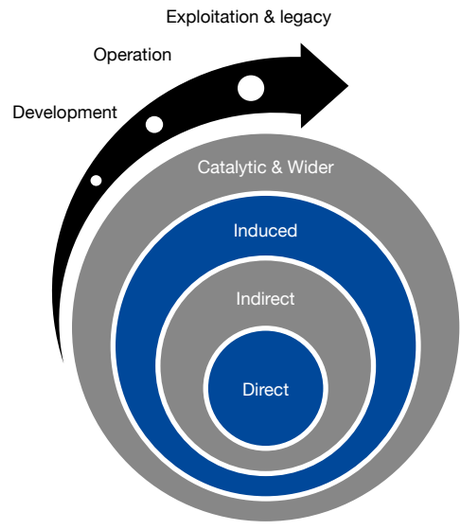


Figure 13: Economic impacts of an international lunar exploration endeavour (Source: London Economics)

“Space exploration is much more than a space programme.

Europe should engage in a bold and daring exploration programme to reinvigorate European values and project European leadership beyond space. Investing in leadership and autonomy can catalyse a wider societal mobilisation, gearing Europe’s society towards a can-do attitude and unlocking optimism for the future.

Only a truly transformative approach, fostering a vibrant innovation ecosystem through private sector co-investment, new innovative financing structures, and challenge-based procurement can lead to success.”

5. Europe's ultimate ambition

At a time when the global geopolitical order is shifting, **Europe must transform itself to enable a more prosperous, sustainable, and globally influential future**.

Doing so will require **bold and inspirational leadership combined with clear collective and collaborative actions in all domains, some of which are existential to Europe´s future.** There is a need, at political level, to reanimate and enhance the continent's communal identity, and implant a new sense of hope and optimism in its population for a commonly shared future. The next generation, faced with uncertain futures, needs to be inspired and empowered to design, drive and implement European ambitions.

As a Group, we recognize the need to address the acute climate and security challenges Europe faces. Next to these challenges, space exploration might look like a *"nice to have and ancillary issue"*.

Yet, not pursuing a bold exploration ambition and stimulating the space ecosystem would be a major error with long-lasting effects.

A bold European Mission for space would also allow Europe to build on its tradition as a normative actor in international relations and its successful heritage in securing peaceful relations. To do so for space as a global common, Europe should **enlarge its role in space diplomacy** and provide an alternative path to the currently unfolding dominance model with its dependencies.

While recognising the importance of collaborating with like-minded countries, Europe should strengthen its role by (i) **revitalising multilateral efforts in space governance**, (ii) **playing a leading role in space law development to ensure a rule-based order** in space, and (iii) pursuing a **new ethic for explored frontiers** to avoid repeating Earth-bound patterns.

The question for Europe is straightforward: can it afford to be left out of another technological revolution? Our answer is no.

Europe will lead the Revolution Space!

ESA should design and implement a European Space Mission to establish an independent European presence in Earth orbit, lunar orbit, on the Moon, and beyond, including a European Commercial LEO Station, Cargo and Crew Capabilities for the Gateway and the Moon, and sustained presence on the lunar surface.|

To do so, promptly mobilising resources and scaling up investment within and across Member States is crucial. This will contribute to Europe acquiring more than one third of the future €1 trillion Space Economy, comprising space applications and exploration.

We, therefore, propose three complementary and indivisible recommendations for ESA:

1 Act Visionary

Leverage heritage, and invest more to shape the future

Europe should establish autonomy in Earth orbit, on the Moon and beyond with human and robotic capabilities complementing each other;

Europe should extend its leadership in space applications and science into space exploration, with sustainability as the differentiating factor;

Europe should significantly increase the level of public investment to stimulate private funding to ensure that Europe protects its European geostrategic interests in space, and be part of future market opportunities and catch one third of the 1 trillion global space economy by 2040;

2 Act Differently

Transform the process, empower new actors, and increase competition

Europe should unleash entrepreneurship and intra-European competition to stimulate transformation of the whole European ecosystem and ESA itself;

Europe should pursue symbiotic public-private partnerships by embracing a culture of risk and reward-sharing, further lowering the cost of the entry ticket, reducing bureaucracy and fostering new sources of investment;

Europe should embark on a European Space Mission, integrating bottom-up industrial and academic innovation, education of the future generation and workforce, and leadership in international partnerships.

3 Act Now

Need for immediate action to secure opportunities

ESA should act now, despite current challenges and difficulties: postponing the decisions will further widen the competitive gap with our U.S. partner and China;

Europe should address and respond to acute security challenges confronted with, and safeguard peace and stability in Earth orbit and lunar environments;

Europe should use autonomy for increased international partnership, ensure its values are reflected in its strategic culture for exploration and secure a prominent role in international governance discussions;

These actions will stimulate hope, inspiration and a unified European space narrative for current and future generations.

As part of the European Space Mission, we are calling upon ESA to prepare for the 2023 Space Summit:

1. **A plan for a transformation and invigoration of the European space ecosystem and processes including a quantification of the induced and catalytic economic impact;**

2. **A scenario for independent and sustainable European human landing on the Moon within 10 years;**

3. **Proposals for visionary and transformative European flagship projects in space for the 2030s and beyond;**

Annex: The High-Level Advisory Group

A.1 Mandate of the High-Level Advisory Group

Following the release of ESA Agenda 2025 in April 2021 and the successful outcome of the High-Level Advisory Group on “Accelerating the Use of Space in Europe”, whose recommendations formed the basis of the Matosinhos Manifesto, the process to set up a group tasked with advising on possible options for European space exploration was initiated by the proposal welcomed at the February 2022 Space Summit. Following the decision taken by ESA Council in March 2022, ESA Director General received the mandate to establish a High-Level Advisory Group (HLAG) on Human and Robotic Space Exploration for Europe. As provided in the Terms of Reference - ESA/C(2022)110 Annex 1, the Group’s mandate is to provide the Member States with an independent and objective high-level assessment regarding the (i) (geo)political, (ii) economic and (iii) societal relevance of human and robotic space exploration for Europe and recommended options for a way forward.

A.2 Members of the High-Level Advisory Group

Stefania **Giannini**
Former Italian Ministry of Education University and Research

Anders **Fogh Rasmussen**
Former NATO Secretary General
Former Prime Minister of Denmark

Erling **Kagge**
Explorer - First person to reach the "three Poles" on foot
(North Pole, South Pole and Mount Everest)

Anna **Rathsman**
Chair of ESA Council
Director General at Swedish National Space Agency

Mariana **Mazzucato**
Professor, Economics of Innovation and Public Value at University College London; Founding Director, Inst. for Innovation and Public Purpose

Tomasz **Rożek**
Science Comunicator

Maria Theresia **Niss**
Member of the National Council of Austria, Chair European Inter-Parliamentary Space Conference (EISC) 2023

François **Schuiten**
Best-selling comic book artist

Cédric **O**
Former Secretary of State for the Digital Sector of France

Christoph **Schweizer**
Ceo, Boston Consulting Group

Chris **Rapley**
Professor of Climate Science at University College London, Chair of the European Science Foundation's European Space Sciences Committee

Saadia **Zahidi**
Managing Director of the World Economic Forum

All members of the High-Level Advisory Group have participated in their personal capacity. The final outcome is a shared collaborative understanding and does not fully encapsulate all personal views expressed during the meetings.

A.3 Meetings of the High-Level Advisory Group

This report provides a summary of discussions undertaken during the three meetings of the High-Level Advisory Group on Human and Robotic Space Exploration for Europe throughout 2022 and 2023:

Meeting	Date
#1	28-30 September 2022
#2	1-3 November 2022
#3	8-11 January 2023
#4	1 March 2023

Speakers in High-Level Advisory Group Hearings and Other Contributions

Discussions, reflections and work of the High-Level Advisory Group were further supported by experts, who shared their views, experience and expertise on factors, implications and possible futures relevant to Europe's ambition in space exploration at hearings during the first two meetings of the High-Level Advisory Group.

Name	Position
Luca Parmitano	Astronaut, European Space Agency
Scott Pace	Director, Space Policy Institute, George Washington University
Xavier Pasco	Director, Fondation pour la Recherche Stratégique
Valerie Chartrain	Founder, Mycelium Creative Studio
Angel Abbud-Madrid	Director, Center for Space Resource, Colorado School of Mines
Hélène Huby	Co-founder and CEO, The Exploration Company
Étienne Schneider	Frm. Deputy PM and Frm. Minister of the Economy, Luxembourg
Samantha Cristoforetti	Astronaut, European Space Agency
Ana Noronha	Director, Ciência Viva Lisbon
Rick Wylie	Reader, Applied Policy Science, University of Central Lancashire
Maren Hülsmann	National PoC - Germany, Space Generation Advisory Council
Stefan Selke	Professor, Transformative and Public Science, Furtwangen University
Thomas Pesquet	Astronaut, European Space Agency
Matthias Maurer	Astronaut, European Space Agency

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vii Mazzucato, M. (2018). Mission-oriented research & innovation in the European Union.
viii Mazzucato, M. (2019). Governing Missions in the European Union. European Commission, Directorate-General for Research and Innovation.

Figures References:

Figure 1: ESA, Where does Europe stand in space exploration - Comparative capabilities by 2030. February 2023.
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Figure 3: PwC, Sizing the prize. PwC's Global Artificial Intelligence Study: Exploiting the AI Revolution. What's the real value of AI for your business and how can you capitalise? 2017.
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Figure 6: ESA, Number of Applications to become an ESA Astronaut.
Figure 7: ESA, Unexpected spillover effects of technologies developed for the ISS, February 2023.
Figure 8: Enerdata Intelligence, Germany Energy Information. Frazer-Nash Consultancy, Frazer-Nash study shows space-based solar power could bring billions in benefit to Europe, and address energy vulnerability. August 2022.
Figure 9: ESA, Number of unique visits to a ESA-developed online app tracking the ISS position. February 2023.
Figure 10: ESA, Global Reach of ESA Communication. February 2023.
Figure 11: Boston Consulting Group, Can Europe Create Its Own Deep-Tech Giants?
Figure 12: Boston Consulting Group, Can Europe Create Its Own Deep-Tech Giants?
Figure 13: Greg Sadlier, London Economics, Economic impacts of an international lunar exploration endeavour. International Symposium on Moon 2020-2030.