Volt’s Space Policy

A Collaborative and Exploratory Space Strategy for Europe

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I. Abstract

The European Space sector is a symbol of European integration and collaboration. It also contributes to the sustainable development of our economy, with every 1 euro invested in Space returning at least 3-4 euros, according to ESA. Europe is currently a world leader in earth observation and provides numerous opportunities for small and medium enterprises (SMEs). Despite this, it was identified that the European nations are lagging behind compared to other space-faring nations, particularly in Space exploration and human spaceflight. Furthermore, it is necessary to highlight the benefits that advanced Space exploitation activities of the full solar system will achieve, and our Space strategies should account for them. To achieve these visions, an ambitious exploratory agenda is necessary, European and international governance institutions should be adapted, and increased funding effort in the European Union is fundamental. Furthermore, the aspects of "Space balance", such as the rise of Space debris, traffic management and the environmental impact of industry, shall be addressed to ensure a sustainable use of Space. In addition, the Space industry should get onboard the environmental transition by highlighting and exploiting all the ecological benefits from Earth observation, Space mining, Space based solar power, planetary sciences research, and the planetary engineering sciences required for Mars terraforming.

II. Executive Summary

Space is of strategic importance for Europe, and Space needs the European Union. Investing in Space can improve our daily lives and the European economy by creating new technologies and jobs while supporting our policies and priorities.

The Space sector generated a global revenue of 271 billion dollars in 2019[1]. The European Union currently has a global competitive Space sector with satellite manufacturing capturing a third of the world market. Several SMEs in the European Union are dedicated to a variety of downstream Space applications. Services, such as Earth Observation, Navigation, and Communications, currently receive significant policy support because of their potential contribution to public goods, welfare, and national security. These technologies improve our daily lives considerably, from enabling satellite TV, internet and smartphone connections, to precision agriculture, disaster relief and improving meteorological predictions. They can also be key tools to mitigate climate change and environmental destruction while contributing to the Sustainable Development Goals. Although the benefits are clear within the Space industry, there is a need to increase citizen awareness to boost its public and private users and fully exploit the advantages in terms of new start-ups, applications and public support.

In addition to this, spaceflight and -exploration can bring major breakthroughs, and this policy aims at further increasing European ambitions to enable future advanced exploitation of the solar system for the benefit of all. Our EU policies should include the long term strategies of terraforming Mars, Venus, and fixing our planet; the full solar system, development of Space mining; and future energy concepts such as Space based solar power and nuclear fusion. Technology developed through programmes for physics and astronomy research and to explore Mars and the solar system can achieve major breakthroughs, producing spillover effects and new applications for Earth. The microgravity environment can bring advantages in the manufacturing of computer chips and in the biomedical field of research with the development of treatments,implants, and vaccines. Planetary defence will also allow us to prevent future asteroid impacts. Indeed, it could be the world's first natural extinction event preventable by humans. Finding and analysing extraterrestrial life in the solar system could bring incredible benefits for biology and medical fields while providing valuable insights into the origin of life on Earth and our role in the Universe. Space can also help to answer major questions, such as whether we are the only intelligent species in the Universe, and could provide major insights into the search for extraterrestrial intelligence. Such a contact could bring incredible technological and cultural breakthroughs. Future Space habitats could also allow us to shift the bulk of the heavy

[1] SIA, State of the Satellite Industry Report, 2019 https://sia.org/22nd_ssir/

polluting industries to Space and even allow humans to live there, while the terraforming of Mars will help us to develop the technology not only to live there, but to geoengineer earth, reverse climate change and foster its biodiversity. Therefore, we argue to push for larger human Space flight efforts and develop an autonomous European crewed Space transportation system.

In addition, the Space industry is rapidly changing with the exponential increase in investment from venture capital. It can be observed how citizen interest is shifting financial resources to this sector, where the next frontier awaits. This does not mean governments should recede from Space exploration. Rather, they should take the lead through commercialisation to enable the growth of a competitive Space industry and exploit the benefits of the Space market economy to reduce costs and increase Space access.

We should also remember that Space debris is rapidly increasing, and as with climate change, it will eventually reach an uncontrollable situation. The Kessler effect, the accumulation of loose material in Earth’s orbit, has the potential to destroy all of our Space assets and dreams while also causing irreparable damage to our world's fragile economy. International agreements currently do not deal with this issue, and the currently approved voluntary guidelines do not seem to produce a deceleration. With the rise of Space traffic, the issue will continue to deteriorate, and there is therefore a need for government intervention in the international field to develop a regulatory framework for collision avoidance, Space debris mitigation, and active debris removal.

The objective of this Space policy is to support and provide valuable recommendations for Volt members and leaders to achieve these Space objectives, while supporting public outreach and education.

How to read this document?

The introduction section contains the reasoning for a Space policy, main vision, goals, and relevance for each of Volt's 5+1 challenges. Each of the chapters in this policy document addresses one of the key policies for Space. At the end of each, the recommendations are summarised in tabular format. The last chapter specifies the relevance of the Space policy to Volt's mapping of policies portfolio, highlighting specific possible additions and its usefulness as an integrated policy.

III. Introduction

This Space policy proposal for Europe is based on two core values: the collaborative nature of Space, and the need for a larger exploratory vision to guarantee the advanced sustainable exploitation of Space resources. The following sections will address why Volt needs a Space policy, our vision, our goals, and the relevance of the Space policy to Volt's challenges.

A. Reasoning: Why does Volt need a Space Policy?

Volt's Space policy was created for various reasons, including:

- In general, Space policies are not addressed by political associations on campaign stages. We consider this a failure to empower citizens to address space-related aspects, benefits, and concerns. Political associations also have a responsibility to contribute to dissemination, outreach and education, allowing citizens to make informed decisions. In Europe, this is an unexploited communication channel.
- Europe is lagging in Space innovation and is being left behind in the new Space era, especially in Space transportation, human spaceflight, and Moon and Mars exploration.
- There is a global need to push the knowledge and technological frontiers, which calls for larger Space exploration efforts to eventually exploit the full benefit of human presence throughout the solar system to sustain economic growth, reduce inequality, increase our living standards and solve Earth's environmental problems.
- Humanity has to step up to address fundamental challenges and risks to preserve the legacy of life in the universe. By contributing to Earth observation programmes to study environmental issues, by becoming a multi-planetary species and by developing planetary protection systems and effective asteroid early warning systems, it will be possible to significantly reduce the chances of extinction of the Earth's biosphere.
- A sustainable Space balance is needed to achieve all these goals, and as for climate change, the Space debris problem has to be tackled before it is too late.

B. Collaborative and Exploratory Vision

Volt believes in a common Space policy that supports European integration and assists our citizens to overcome the global challenges of our era, such as climate change, while improving their quality of life. Furthermore, the international Space context is changing fast. Competition is growing since old and new actors - such as the US, Russia, China, and India - are engendering renewed challenges and ambitions in Space. Investment in Space militarisation is rapidly increasing and becoming comparable to the cold war race, undermining the peaceful uses of outer Space. The resulting in-space military tests could pose a threat to our orbital resources through the already high risk of an uncontrolled escalation of Space debris resulting from the increasingly crowded Earth's orbits and past unsustainable spacecraft designs. Therefore, there is a need for regulation comparable to aviation as for collision avoidance and sustainability.

At the same time, Space activities are becoming increasingly commercial because of greater involvement of the private sector. In fact, major technological improvements and new private companies - such as SpaceX, Virgin Galactic and Rocket Lab - are changing the traditional industrial and business models in the Space sector. These developments are making access to Space and the widespread use of Space technologies in our everyday lives easier and cheaper, as has been done with solar technology, medical tools, and fire-fighting equipment. Furthermore, Space flight activities enhance innovation by inspiring society. As an example, the Apollo programme led to an increase in science and advanced engineering degrees[2], which would later contribute to improving our world and achieving technological and scientific breakthroughs.

A common policy on Space is of strategic importance for Europe[3]. The Space industry does not only foster innovation, wellbeing and economic growth[4], but it also reinforces Europe's role as a global player and it is an asset for its security and defence, both inside and outside its borders. Space is inherently a transnational and global environment. As such, it requires strategic policies to maintain the geopolitical and market balance and, at the same time, it offers opportunities for greater international integration and collaboration. In fact, Space exploration and its resources have the potential to enable humanity to become multi-planetary, mitigate the risks of asteroid impacts, and contribute to solving our biggest challenges, such as the current energy and environmental crisis. It should be noted that Space is at the frontier of technology and research, using the best of our capabilities, and that these are the main drivers to sustain social productivity and economic growth in the information era[5].

Affordable space-access will not only provide worldwide internet-access, fast inter-continental travel, and enable Space tourism, but will someday allow us to shift heavy industries outside of our delicate world. Creating the resources needed by recycling available materials (In-situ resource utilisation) allows us to further explore

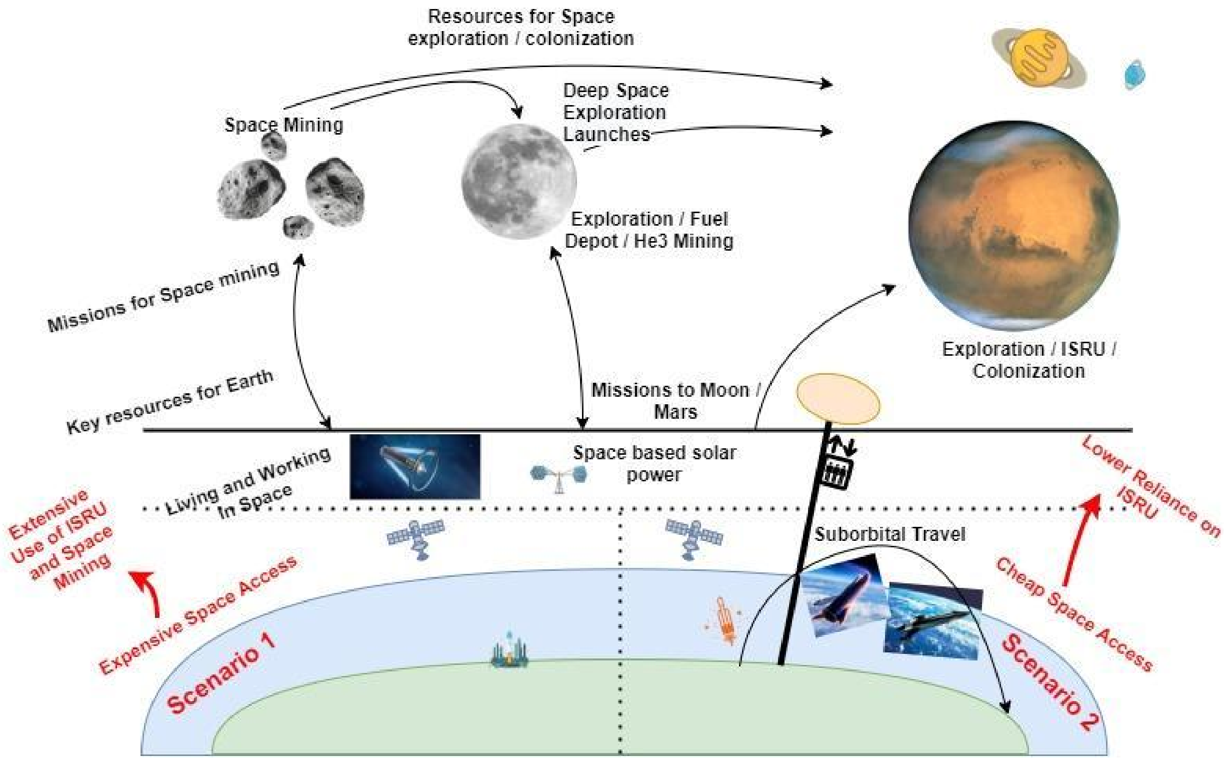
[2] NASA, 2015, Historical Studies in the Societal Impact of Spaceflight, p. 531.
[3] All member states have decided that integrating space into the European society and economy, encouraging a globally competitive European space sector, ensuring european autonomy in space access in a cost effective and sustainable way are major goals. European Ministers Ready ESA for a United Space in Europe in the Era of Space 4.0, ESA, December 2016.
[4] K. W. George, 2018, "The Economic Impacts of the Commercial Space Industry", Space Policy 47, 181-186
[5] Long, X. Scientific and technological innovation related to real economic growth, ISSN: 2516-1652

the solar system, and through asteroid mining, we will retrieve key materials such as cobalt and other rare earth-metals needed for our environmental transition. This would not only decrease their value, but would make new technologies available for everyone. The colonisation of Mars and other solar system bodies will foster innovation, leading to large breakthroughs in all knowledge fields that will benefit society through technological transfer, as for efficient water-scarce agriculture practises for desert regions. The subsequent terraforming activities - deliberately altering a planet's atmosphere to make it more suitable for humans - will also provide us with the tools to manage our Earth's climate and environment to prevent climate change, enhance biodiversity and assure its conservation and sustainability for millennia.

Furthermore, access to Space, the Moon and the outer solar system will allow for Space based solar power and unlock huge amounts of helium-3 reserves, which will be necessary to power an increasing population on a future resource depleted Earth, especially in the case of renewable energy not meeting all world demands. Primary energy consumption may double by 2100, while fossil fuel reserves may last for 100-150 years at-most[6]. Furthermore, because of the current environmental crisis, there is an approximate carbon budget of around 120 gigatonnes to limit the world's temperature below 1.5 degrees with a 66% probability[7], which means that only about 20% of the remaining fossil fuel reserves are available for consumption. Uranium reserves may help for some years, but eventually alternatives will be required. Fusion energy based on deuterium/helium-3 may provide the capability, the Moon and the Gas Giants the energy source, Space habitats and ISRU the infrastructure and Space transportation the means to get there.

[6] BP, Statistical Review of World Energy, available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/downloads.html

[7] IPCC, AR5 Synthesis Report: Climate Change 2014, available at https://www.ipcc.ch/report/ar5/syr/



Currently, the European Union is one of the world's leaders in exploiting earth observation technologies. In this exploratory policy, Volt wants to acknowledge these achievements, and increase efforts in human spaceflight,exploration, and science. Policy actions implemented now should account for long term strategic objectives of evolutionary growth, sustainable exploitation of the full solar system and reduction of our dependence on Earth's critical resources, starting with the European Union playing a pivotal role in human spaceflight, lunar and mars exploration missions along with our international partners[8][9]. These actions will also spillover with long term exploitation applications and technology transfer for the benefits of the Earth, as explained with Space based solar power, Space mining, and helium-3 reserves. To achieve all this, the legal, political, and technical challenges must be solved, such as enhancing our Space transportation sector with state-of-the-art sustainable Space access capabilities and autonomous crew capabilities, and enabling the development of suborbital commercial flight. In addition, it is necessary to ensure a "Space balance" to assure the long term sustainability of Space resources by solving the current Space debris issue, establishing traffic management regulations and guaranteeing a fair

[8] International cooperation is seen as key for achieving a sustainable space infrastructure and economy for solar system exploration and interstellar migration. Jones, R. M. Synthesis of a Space Infrastructure, Proceedings of Space 90, Second International Conference, Engineering, Construction and Operations in Space II, 1990

[9] Collaboration can enable large space projects in the post cold war era. Pedersen, K. S., Thoughts on international space cooperation and interests in the post-cold war world, Space Policy, 8(3), 205–220. doi:10.1016/0265-9646(92)90050-6

distribution of their benefits among our world citizens.

To conclude, Volt believes that to ensure Europe's and the world's prosperity, the European Space agencies and industry should increase their exploratory ambitions and become leaders in scientific, explorational, and human Space flight activities in Space. Expanding human presence into the solar system will allow for an open-ended future for humanity with prosperous growth in an environment unconstrained by energy, Space and material bounds[10]. This policy provides recommendations and guidelines to get there.

C. Space Policy Goals and Objectives

Our Space policy wants the European Union to be the leader in making humanity a Space faring civilization by proposing a deeply explorative and utilising agenda. We want a groundbreaking increase in efforts to research and develop technologies to explore the universe and to exploit Space resources, from our near-earth Space with fundamental applications for earth observation, climate change studies, communications and navigation, to Space mining for key resources, the use of space-based solar power for our energy needs, and the colonisation and terraforming of Mars and other celestial bodies. To achieve these goals, we believe that a collaborative and transparent policy is needed, supported by a long-term European plan to foster Space education. These goals can be summarised as follows:

- **Exploratory strategy**
  - Push for Space Exploration
  - Investment in infrastructure, innovation and technology development
- **Encouraging the collaborative nature of Space in Europe and abroad**
  - The European Union shall be an equal and key partner in international Space sciences and exploration missions
  - Encouraging international regulatory frameworks for sustainable Space exploration
- **Securing European strategic and autonomous capabilities**
  - Guaranteeing a cost-effective and sustainable European Space transportation infrastructure with crew-rated capabilities
  - Fostering European human Space flight activities
  - Launching ambitious Space exploration missions to the solar system
- **Sustainability**
  - Space Debris Mitigation
  - Contribution to mitigate humanity's environmental impact
  - Mitigation of the Space industry's ecological impact

[10] Hammond, W. E. , Space Transportation: A systems approach to analysis and Design, 1999

- **Investment in Public Goods**
  - Contribution to society and welfare
  - To sustain ambitious projects and enable commercialisation of Space
- **Space Culture**
  - Large public outreach
  - Support for Space education

D. Relevance for Volt's 5+1 Challenges

Volt Space Policy will serve the greater objectives of Volt. In order to do so, the goals of the policy are filtered through the 5+1 challenges that Volt aims to tackle with its activities.

1. Smart State

Governments should provide state-of-the-art public services for the benefit of their citizens and residents. Space science related achievements can improve transparency and decision-making thanks to high-quality real-time data produced by our Space infrastructure.

2. Economic Renaissance

European economies must be the engine of society's progress and allow for a decent living standard for everyone. Investing in the Space sector would foster the EU's leadership in innovation. The EU is investing over €14 billion in Space activities for the period 2021-2027. The return on investment is estimated to be really high compared to other possibilities. Indeed, it is estimated to have a direct return of €3-4 for every euro allocated.[11] Advanced exploitation capabilities from Space mining, Space based solar power and colonisation of other planets could result in even higher returns.

3. Social Equality

Space activities contribute to all the Sustainable Development Goals. One of its goals is to reduce inequality and ensure fairness. For example, the proposal for Space-based solar power or satellite internet mega constellations will allow energy to reach inaccessible places in less developed regions. The policy also calls for promoting women in Space and other STEM fields.

4. Global Balance

We want to establish policies in line with the Sustainable Development Goals. Space applications cover all the 17 SDGs, making it a fundamental domain to develop in order to tackle global challenges and strengthen the EU's global role. Satellite technology is key for understanding and mitigating climate change and for better forecasting to support renewable energy infrastructure. In addition, Space sustainability, or "Space balance" shall also be pursued, addressing the alarming rise in Space debris with mitigation, active removal and Space traffic management strategies, and by mitigating Space missions and launching environmental impact through eco-design principles.[12]

[11] EU space policy - Consilium (europa.eu)
[12] European Space Agency (ESA), Ecodesign, available at:https://www.esa.int/Safety_Security/Clean_Space/ecodesign

5. Citizen Empowerment

At the core of this Space policy is a 2 year policy process involving volters of all chapters. Furthermore, our policy addresses the need for larger outreach activities and education in Space studies to enable informed citizens who know about the benefits and opportunities that Space offers.

6. EU Reform

The policy addresses the need for greater collaboration in Space matters in the European Union, and a larger financial effort to achieve our exploratory and exploitation goals and to guarantee the technological transfer and involvement of non-space sectors. One of its core proposals is the creation of a European Union Space Agency encompassing ESA and EUSPA activities (TBD).

IV. Space as the next frontier for science and discovery

Since the beginning of the Space Age, access to Space has stimulated the development of brand-new branches of science that were previously unknown, from planetology to high-energy astrophysics, from exobiology to gravitational wave astrophysics. Consequently, deeper questions about our universe have followed. Recent technological advances, together with the leadership and reliability demonstrated by ESA and its international partners, brought us to the verge of a new epoch of scientific discovery, where answers to some of the most fundamental questions might be dealt with.

For instance, ESA's Planck satellite launched in 2009 performed an unprecedented mapping of the anisotropies of the cosmic microwave background radiation and it provided us with the most precise measurements of the main cosmological parameters, such as the density of matter and dark matter, the age of the universe and the Hubble constant. XMM-Newton, ESA's largest X-ray observatory, was launched in 1999, and it is still perfectly functioning and providing us an unprecedented view of the high-energy phenomena in the universe that shine in the X-rays, such as accreting black holes, supernovas, and galaxy clusters. The next decade will see the development and launch of new large missions led by ESA, just to name a few: the first space-based gravitational wave observatory LISA, the largest X-ray observatory ever made, Athena, and the astrobiology mission to Mars, ExoMars, that will land a rover on the red planet.

From this perspective, Volt believes that Europe should and can be a leading player in this endeavour. Innovative methods and technologies developed for science will provide a strategic competitive edge and benefits for our society and economy. Volt supports increasing EU funding in Space sciences, which is required to develop long-term research projects that will improve our knowledge of the physical world and that will keep Europe at the forefront of international research.

Volt supports ESA becoming a funding agency for Space research and cultural projects carried out by its member states. This would allow ESA to directly support Space research and outreach activities across Europe in a more harmonised and coordinated way. In fact, relying mostly on national agencies to fund Space research has shown several disadvantages, such as limited funding, dependence on the current national political choices, limited international collaborations, limited competition and risk aversion. This is why Volt **fully supports continued and increased funding in Space science from the EU and commercial entities**.

A. Space Physics and Astronomy

Space research is crucial for the technical development of humanity, like quantum communications, better air transport, better and cleaner energy management, mining asteroids, etc. Also, there is research that is not directly related to society in the short term, such as gravitational wave observation from Space, astronomy, or geodesy, but which could bring major breakthroughs and eventual life changing applications.

Talking about quantum communications, Chinese researchers, just in 2017, teleported information from Earth to a satellite over a distance of 1400 km[13]. This experiment can't be done horizontally (the maximum is 144 km, achieved in an experiment in Las Canarias, Spain[14]) because atmospheric turbulence breaks the quantum state.

Temperature and the absence of seismic vibrations make Space attractive for the study of gravitational waves. ESA already saw the potential of Space for these purposes with the project LISA (Laser Interferometer Space Antenna). Moreover, for technical reasons, Space and terrestrial gravitational wave observatories are not competitive, but complementary.

B. Search for life

Recent progress in the fields of astrobiology and astronomy, findings of possible

[13] Ren, J., Xu, P., Yong, H. et al., 2017 Ground-to-satellite quantum teleportation. Nature 549, 70–73, available at: https://doi.org/10.1038/nature23675
[14] Herbst, Thomas, et al., 2015, Teleportation of entanglement over 143 km, Proceedings of the National Academy of Sciences 112.46 (2015): 14202-14205.

habitable conditions on Mars and the Jovian Planet's moons or "icy worlds" and discoveries of extremophiles on Earth which can survive extreme environments have led to speculation that life may be thriving in the universe. Currently, large efforts are being focused on astrobiology research on Mars, after the discovery of several habitable hotspots and even systems of subsurface lakes resembling Earth's subsurface glacial lakes. The European Space Agency (ESA) is looking to launch the Exomars in collaboration with NASA. The primary mission goal is to determine if there has ever been life on Mars, and to better understand the history of water on the planet.[15] The launch has been delayed as the ESA originally collaborated with the Roscosmos Space Corporation, however the collaboration has been suspended as a result of the war in Ukraine.

Furthermore, exoplanet research has been progressing at advanced leaps since the first confirmed detection of an exoplanet in 1992, which has led to the discoveries of rare planetary systems and allows us to understand how common habitable planets are in the universe. Recently, potentially habitable planets have been discovered in our closest solar system, Alpha Centauri, which is raising these prospects. With the future launch of observation telescopes, it will be possible to study their atmospheres and perhaps obtain the first image of an Earth twin. Looking for habitable exoplanets is not only a merit of its own, but by studying their geology, atmosphere and ecosystems, it will be possible to further understand our planet's atmosphere and ocean dynamics, which could contribute to incredible advances in terms of climate science and planetary engineering. Up to now, there have been two dedicated ESA missions for exoplanet research, CoRoT and CHEOPS, while future missions such as Ariel and Plato are devised[16].

In addition to the search for life in our solar system and exoplanet detection, there have been research efforts in the search and detection of intelligent extraterrestrial life. If another civilization is present within our interstellar neighbourhood, as predicted by the Drake Equation, and would attempt to contact us, our current technological knowledge foresees two main methods: radio communication or sending interstellar probes[17]. Recently, the first two interstellar objects were discovered, Oumuamua and Borisov, which raises these possibilities[18] and calls for future rendezvous missions.

[15] European Space Agency (ESA), N° 6–2020: ExoMars to take off for the Red Planet in 2022, available at: https://www.esa.int/Newsroom/Press_Releases/ExoMars_to_take_off_for_the_Red_Planet_in_2022
[16] Exoplanet Mission Timeline:
https://sci.esa.int/web/exoplanets/-/60649-exoplanet-mission-timeline
[17] Bracewell, R., 1960, Communications from superior galactic communities, Nature 186, 670–671 (1960), available at: https://doi.org/10.1038/186670a0
[18] Loeb, Avi, 2020, Let's Search for Alien Probes, Not Just Alien Signals, Scientific American, Opinion, December 22, 2020, available at
https://www.scientificamerican.com/article/lets-search-for-alien-probes-not-just-alien-signals/

Furthermore, there have also been efforts to search for intelligent extraterrestrial signals, whether intentional or as a consequence of artificial “leakage” . Serious concepts to perform targeted searches and full sky surveys with current technology and within limited budgets have been proposed over the years, as with NASA’s Project Cyclops[19]. This project aimed to search for extraterrestrial beacons within the microwave “water hole” frequency window between spectral lines of hydrogen (1420 MHz) and the hydroxyl radical (1662 MHz), which is hypothesised as a potential communication channel. Workshops at the time also concluded that it was timely and feasible to perform serious searches with modest resources and enormous spillover benefits[20], and numerous leading scientists, including Carl Salgan and seven Nobel prize winners, urged a systematic worldwide search for extraterrestrial intelligence[21]. Research and development efforts continued with worldwide searches, including European Union member states and a NASA official SETI programme, with projects such as the HRMS search, which has currently studied a minuscule fraction of our galaxy. Future concepts include highly efficient ultraviolet receivers constructed directly in Space or on the Moon, preventing atmospheric absorption[22].

In the HRMS search, cost figures were considered unacceptable within the political sphere and prevented their continuation, forcing most SETI efforts to continue under the SETI Institute umbrella with the help of private donors, such as Paul Allen. Its high public interest combined with enormous media coverage combined with its small budget share compared to other NASA activities prevented broad geopolitical support. Only recently, a dedicated budget for technology-signatures search has been granted[23]. SETI research is essentially an easy political target[24], and requires adequate support. It is therefore necessary to increase European SETI research efforts, and we support the **creation of a European Space Agency (ESA) division for SETI research** and the **development of a long term comprehensive plan in combination with other Space agencies and the scientific community.**

Volt also supports the **inclusion of astrobiology sciences, including SETI research, in school curricula in all the European Union**.

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[19] NASA, 1972, Technical Report CR-114445 - Project Cyclops: A design study of a system for detecting extraterrestrial intelligent life

[20] Philip Morrison, John Billingham, John Wolfe, 1979, The search for extraterrestrial intelligence—SETI, Acta Astronautica, Volume 6, Issues 1–2, 1979, available at: https://www.sciencedirect.com/science/article/abs/pii/0094576579901437

[21] Sagan, C., Extraterrestrial Intelligence: An International Petition, Science, Volume 218, 1982

[22] Ross, M. et al., 2011, Optical SETI: Moving Toward the Light, in Searching for Extraterrestrial Intelligence - SETI Past, Present, and Future, Shuch, H. Paul, Springer-Verlag

[23] Kaufman, M., Technosignatures and the Search for Extraterrestrial Intelligence, available at: https://astrobiology.nasa.gov/news/technosignatures-and-the-search-for-extraterrestrial-intelligence/

[24] Garber, S. J., 1999, Searching for Good Science: The Cancellation of NASA’s SETI Program, Journal of the British Interplanetary Society, Volume 52

C. Policy Recommendations

R.1.1. Increase efforts for astrophysics and exoplanet research.

R.1.2. Favour the design and development of sample return missions as a means to further increase the European contribution to the world scientific community.

R.1.3. Creation of an ESA division for Search for Extraterrestrial Intelligence (SETI) research and development of a long term comprehensive plan in combination with other Space agencies and the scientific community.

R.1.4. Inclusion of astrophysics and astrobiology sciences, including SETI research, in school curricula in all the European union.

V. Space Balance: Space Debris and the Sustainable Use of Space

A. Space Debris and Space Traffic Management

Space might seem big enough, but the number of spacecraft populating it is following a near-exponential curve. Threats to the integrity of the orbital environment are driven by the development of large constellations, which enable excellent coverage and unparalleled resilience but also crowd key orbits, small cubesats with little safety margins[25], the persistent threat of uncontrolled/old/malfunctioning spacecraft, military demonstrations in which states wish to show their capability to destroy satellites, and the inherent risk of micro-meteoroids and larger objects.

The ever-increasing risk of collision would not only impact the colliding objects, but would create a chain reaction, known as the "Kessler syndrome,"[26] that would cascade to all objects in the same or neighbouring orbits. This not only puts the critical Space infrastructure (telecommunications, observation, navigation, weather forecasts…) at great risk, but would also prevent further use of the affected orbit.

Today, there are no formal regulations, nor incentives for the Space industry to build and operate responsibly, preventing such events. The US monitors orbits and shares the data with its partners; its FCC agency allocates frequency rights linked to the rights to operate in given orbits; startups such as LeoLabs provide a tracking service; and the World Economic Forum is providing a "Space Sustainability Rating" to rank satellites according to de-orbiting and debris mitigation strategies.

We, however, believe it is the role of independent institutions to preserve the integrity of orbits and their assets. Concretely, Europe should **spearhead the creation of an independent international body**, further described in Chapter 8, responsible for the following:

- ➢ Transparent and collaborative tracking and cataloguing of all objects in the Earth's vicinity, providing a consistent, complete and up-to-date characterization of objects;

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[25] See Swarm Technologies and FCC settlement, available at: https://www.theverge.com/2018/12/20/18150684/swarm-technologies-illegal-satellite-launch-fcc-settlement-fine

[26] Kessler, Donald J., Cour-Palais, Burton G., 1978, Collision frequency of artificial satellites: The creation of a debris belt, Journal of Geophysical Research, 83: 2637–2646

- ➢ Well-organised and sustainable allocation of orbits for new spacecraft;
- ➢ Traffic management with a defined "Space Code of Conduct", attributing manoeuvring priorities, and supporting legal issues and insurance cases;
- ➢ Enforce the legal obligation to design for safe collision avoidance manoeuvres and safe de-orbiting.

This regulatory body would ideally be gradually equipped with capabilities to use "Space tugs" positioned in critical orbits, to assist with de-orbiting and collision avoidance, through robotic and/or laser technology, and an advanced analytics centre to process the data and anticipate scenarios as ahead as possible. As a bridge to the aforementioned vision, we propose to:

- ➢ **Increase financial support to the Clean Space initiative**[27] and others for Space debris mitigation strategies, especially for projects aiming at direct removal of large objects, which **shall develop an operational removal system before 2030;**
- ➢ **All public Space activities should implement debris mitigation measures and mandatory decommissioning**. Private companies **could be subjected to national law penalties for non-conformance**[28] **and funding conditions** when accessing grants, loans and other government benefits;
- ➢ **Introduce regulations aiming at the mandatory decommissioning of all launched Space objects within the European and national laws**[29]**.** Regulations analogous to the Emission Trading System to impose mechanisms for monetary penalisation of debris generating techniques and processes could also be explored;
- ➢ **Use trade sanctions to ensure these regulations are met** and **push for an international agreement to set procedures and guidelines for automated collision avoidance systems** through ICAO and EASA;
- ➢ **Push for a UN Space Treaty to implement legally mandatory guidelines for Space debris mitigation** for all member states;
- ➢ **Raise awareness of the Space debris problem** to empower European citizens and their political and economic leaders so that they become aware of the

[27] European Space Agency (ESA), Clean space, available at: Clean Space
[28] Pelton, J. N., 2015, New solutions for the space debris problem. Cham: Springer
[29] Committee on the Peaceful Uses of Outer Space (COPUOS), Space Debris Mitigation Guidelines and European Space Agency (ESA), available at: ESA Space Debris Mitigation Compliance Verification Guidelines

potential global threat[30].

Furthermore, mega-constellations offer a unique Space architecture that can enable many applications, from precise navigation technology to worldwide internet access. Nevertheless, the increase of Space objects requires adequate traffic management and debris mitigation regulations as proposed in this text. In addition, **luminosity contamination assessments shall be performed for European Space missions** and adherence to regulations in European and national law shall be determined **following the assessments and recommendations from the astronomy community.**[31]

B. Eco-design principles and the Sustainable Use of Space

Space applications can have enormous advantages in combating climate change and environmental destruction. Nevertheless, within the Space industry the environmental burdens will continue to increase along with the expected growth in the sector as envisioned for this strategy. Although the impact of the industry remains low when compared to other sectors, it may still be possible to further reduce its impact and act as a technological symbol. As a result, along with all of our human activities, it is necessary to thoroughly investigate its potential impact for accountability. The United Nations Committee on the Peaceful Uses of Outer Space has adopted guidelines to ensure the long-term sustainability of the Space industry, with the 27th mentioning the use of technologies to minimise the environmental impact of manufacturing and launching Space assets[32]. In the European Union, inter-sectoral environmental regulations already affect some aspects of the Space industry, and some national legislation exists that particularly addresses the Space industry, as in France with the Space Operations Act, aiming to make operators responsible for the prevention of risks to humans and the environment[33]. Volt Europa already promotes ambitious actions to regulate and mitigate these environmental effects, which are applied to all industries, such as for climate change with the proposed Hybrid Emission System and strict emission reduction objectives. We therefore propose to **push for the adoption of these guidelines at national and European legislative levels to investigate and mitigate the Space sector's impact on humans and the environment with Life Cycle Assessments (LCA)**.

[30] Pelton, J. N.. 2015, New solutions for the space debris problem, Cham: Springer
[31] It is advised to keep close track of their recommendations and workshops, as of the recent UNOOSA workshop, available at Dark and Quiet Skies for Science and Society
[32] UNOOSA, Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on Peaceful Uses of Outer Space Adopted, Press Release, 2019
[33] Maury, T., Loubet, P., Serrano, S. M., Gallice, A., Sonnemann, G., 2020 Application of environmental life cycle assessment (LCA) within the space sector: A state of the art, Acta Astronautica, available at: doi: 10.1016/j.actaastro.2020.01.035

C. Policy Recommendations

R.2.1. Europe should **spearhead the creation of an independent international body** equipped with capabilities to use "Space tugs'' positioned in critical orbits, to assist with de-orbiting and collision avoidance, through robotic and/or laser technology, and an advanced analytics centre to process the data and anticipate scenarios as far ahead as possible. It would be responsible for:

1. Transparent and collaborative tracking and cataloguing of all objects in the Earth's vicinity, providing a consistent, complete and up-to-date characterization of objects;
2. Well-organised and sustainable allocation of orbits for new spacecraft;
3. Traffic management with a defined "Space Code of Conduct", attributing manoeuvring priorities, and supporting legal issues and insurance cases;
4. Enforce the legal obligation to design for safe collision avoidance manoeuvres and safe de-orbiting.

R.2.2. Increase financial support to the Clean Space initiative[34] and others for Space debris mitigation strategies, especially for projects aiming at direct removal of large objects, which **shall develop an operational removal system before 2030.**

R.2.3. All public Space activities shall implement debris mitigation measures and mandatory decommissioning. Private companies **could be subjected to national law penalties for non-conformance**[35] **and funding conditions** when accessing grants, loans and other government benefits.

R.2.4. Introduce regulations aiming at the mandatory decommissioning of all launched Space objects within the European and national laws[36][37]**.** Regulations analogous to the Emission Trading System to impose mechanisms for monetary penalisation of debris generating techniques and processes could also be explored.

R.2.5. Use trade sanctions to ensure these regulations are met and **push for an international agreement to set procedures and guidelines for automated collision avoidance systems** through ICAO and EASA.

R.2.6. Push for a UN Space Treaty to implement legally mandatory guidelines

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[34] European Space Agency (ESA), Clean Space, available at: [Clean Space]
[35] Pelton, J. N., 2015, New solutions for the space debris problem, Cham: Springer.
[36] Committee on the Peaceful Uses of Outer Space (COPUOS), Space Debris Mitigation Guidelines
[37] European Space Agency (ESA), available at: [ESA Space Debris Mitigation Compliance Verification Guidelines]

for Space debris mitigation to all member states.

R.2.7. Raise awareness of the Space debris problem to empower European citizens and their political and economic leaders so that they become aware of the potential global threat[38].

R.2.8. Perform luminosity contamination assessments for European Space missions and enforce regulations in European and national law **following the assessments and recommendations from the astronomy community.**[39]

R.2.9. Make operators responsible for the prevention of risks to humans and the environment[40], following the French Space Operators Act, **at national and European legislative level,** to investigate and mitigate the Space sector's impact on humans and the environment with Life Cycle Assessments (LCA).

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[38] Pelton, J. N., 2015, New solutions for the space debris problem, Cham: Springer.
[39] It is advised to keep close track of their recommendations and workshops, as of the recent UNOOSA workshop, available at: [Dark and Quiet Skies for Science and Society]
[40] Maury, T., Loubet, P., Serrano, S. M., Gallice, A., Sonnemann, G., 2020, Application of environmental life cycle assessment (LCA) within the space sector: A state of the art, Acta Astronautica, available at: doi: 10.1016/j.actaastro.2020.01.035

VI. Revolutionising European Space Transportation Sector

European Space Transportation has been incredibly successful with the development of the Ariane and Vega families. The Ariane 4 was able to capture more than half of the global commercial satellite market in 1997[41].

We are now entering the ”New Space” era and this picture is changing. There is a need for innovations in the Space access sector at the European level, as new actors have entered the global Space transportation industry, introducing technological breakthroughs, such as reusability and dedicated small satellite launchers. This has led to an aggressive reduction of launch costs in all market segments, which will foster the development of the Space industry but might threaten European competitiveness and autonomy. There are also new applications on the near horizon, from the launching of mega constellations, to the suborbital market with intercontinental travel, Space tourism and scientific research, which will depend on the development of new technologies and require ramping up European efforts to benefit from its market returns. Furthermore, we are currently in an ecological and climate crisis, which requires revolutionary transformation within the industry. Volt already proposes to include a carbon price in accordance with our 1.5 degree goals in all sectors, and Space transportation should also be accounted for. It is also necessary to conduct further lifecycle analysis to determine the full environmental impact before a matured Space access and suborbital travel industry is fully operational. The sector should also be involved in Space debris mitigation by adequately decommissioning all stages, as the upper stages represent 20% of the total Space debris.

In addition to reusability, new unconventional launch methods are being slowly developed which could revolutionise Space access, such as Space elevators, rocket-based combined air breathing propulsion and spaceplanes, sky hook concepts, and sled launch. It is important to also support the development of those, as in the long run, they will enable us to beat the rocket equation and guarantee affordable Space access. To bridge the gap, there are other more near term concepts, such as reusing rocket stages, air or balloon launches, and innovative strategies to reduce costs, from extensive use of 3D printing technology, to reducing subcontracting and revisiting the distributed production chain and the European geo-return policy. Introducing commercialisation and competition in the launch transportation sector with new private actors could also incentivise the development of newer, cost-effective concepts.

Although there are some current European projects and historical attempts, the investment in the development of these systems is minuscule compared to what is being done in the USA, China, or other countries (up to date, only American rockets

[41] Hammond, W. E, 1999, Space Transportation: A systems approach to analysis and Design

have been reused, and no small European rocket companies are operating). There are also many potential concepts, limited budgets and workforce, and therefore some sort of coordination is required.

The strategy therefore calls for an ambitious European coordinated roadmap to develop fully reusable and sustainable operational concepts with public-private partnerships, that could eventually hand over their operations to different companies to foster commercialisation and further reduce costs. In addition, it will foster European competitions for innovative launch and other Space exploration technologies to promote the investment of venture capital, based on the success of the X Prize challenge.

In addition, crewed launchers have not yet been developed in Europe, which threatens our strategic autonomy for human spaceflight. The development of the Ariane 5 was initially proposed to substitute the successful Ariane 4 for a human rated launcher, but the proposals for crewed upper stages were eventually abandoned, and there are no plans for a human rated Ariane 6. As mentioned in the next section this is key for Space exploration, to improve welfare and public health, and to enable key technologies to fight environmental destruction. **The strategy also calls for the development of European crewed launch systems.**

Furthermore, a network of spaceports with universal launch facilities will be required when Space tourism and intercontinental suborbital travel take off. Small spaceports for small launchers and sounding rockets are also being developed in northern Europe because of their privileged position for Sun Synchronous Orbits, and the policy should incentivise their construction. European spaceports for larger launchers may also be pursued, as although their non-equatorial position would reduce their performance, their simplified transportation logistics might allow for cost effective operations of reusable vehicles. We therefore propose to **push for the construction of spaceports in continental Europe**.

A. Advanced In-space Transportation: Propulsion and Power Sources

Considering in-space transportation, traditional chemical rockets, while powerful, have significant weight requirements. This calls for **advanced in-space propulsion concepts** such as **solar sailing and electric propulsion.** Electric propulsion devices produce far lower thrust than chemical rockets, but they are significantly more propellant efficient. The resulting spacecraft mass reduction allows for new mission profiles.[42] For electric propulsion, Europe currently funds these devices through the

[42] The electric propulsion devices have been used to cost-effectively extend the life times of low orbiting satellites such as GOCE.

EPIC project[43], part of the Horizon 2020 programme. **We recommend increasing funding for the follow up of this and similar projects.**

Another interesting venue to explore with respect to plasma propulsion is synergy with nuclear fusion research. The opportunities for synergy between fusion research and electric propulsion research are vast because both fields face similar questions when manipulating plasma[44][45]. If made available for human Space flight, this could drastically reduce trip times for interplanetary missions, such as an Earth-Mars mission, thus minimising radiation exposure for astronauts[46]. There are also additional technologies which might bring breakthroughs, such as fission propulsion, Magneto-Inertial Fusion[47] and the Mach effect thruster.

Currently, most satellites depend on solar panels for onboard power. Solar insolation decreases when moving further away from the sun[48]. This limits the available power for deep Space missions with solar panels. For missions further into the outer region of the solar system, it will be necessary to rely on Radio-isotope Thermoelectric Generators (RTGs)[49]. Since 2009, RTGs using Americium-241 as a heat source have been developed as part of an ESA funded programme[50]. Americium can be separated from spent nuclear fuel using current nuclear reprocessing. This way RTGs provide a market for the reuse of nuclear waste[51]. Furthermore, some electric propulsion concepts, such as VASIMIR and Magnetoplasmadynamic-Thrusters have high input power requirements (100-500 KW), which could be provided by a nuclear reactor. **Therefore, we encourage the further development and deployment of RTGs, and feasibility studies should be done on space-born nuclear reactors.**

B. Policy Recommendations

R.3.1. Implement an ambitious European coordinated roadmap to develop fully reusable and sustainable operational concepts for all parload market segments (big and small dedicated launchers) with public private partnerships, which could hand in their operations to different companies to

[43] European Space Agency (ESA), 2014-2020 EPIC project
[44] Comunidad de Madrid, Prometeo Project. Also see an example of a fusion research inspired plasma propulsion device is VASIMR
[45] An example of a fusion research inspired plasma propulsion device is VASIMR
[46] Aime P., Gajeri, M., Kezerashvili, R., 2020, Exploration of trans-Neptunian objects using Direct Fusion Drive.
[47] Several American Universities are investigating this concept in cooperation with NASA. For example the University of Washington,Princeton, University of Huntsville Alabama.
[48] https://en.wikipedia.org/wiki/Inverse-square_law
[49] https://www.space.com/692-esa-chief-europe-space-nuclear-power-options.html
[50] Ambrosi, R.M., Williams, H., Watkinson, E.J. et al., 2019, European Radioisotope Thermoelectric Generators (RTGs) and Radioisotope Heater Units (RHUs) for Space Science and Exploration. Space Sci Rev 215, 55 (2019), available at: https://doi.org/10.1007/s11214-019-0623-9
[51] Hammond W., 1999, Space Transportation: A Systems Approach to Analysis and Design

fostering commercialisation and further cost reduction while guaranteeing a successful social pay off.

R.3.2. Develop an European crewed launch system to guarantee strategic autonomy, support our human Space flight programme and to enable europe to participate in future intercontinental suborbital travel.

R.3.3. Introduce European competitions for innovative launch and other Space exploration technologies to promote the investment of venture capital.

R.3.4. Support research of the environmental impact of Space transportation infrastructure regarding ozone depletion, mesospheric and stratospheric cloud formation, global warming, environmental and human toxicity and Space debris mitigation.

R.3.5. Invest in future unconventional launch concepts such as skyhook systems, orbital airships, magnetically assisted launches, and Space elevators. Push for international collaboration for its development.

R.3.6. Push for the construction of spaceports in continental Europe for all launcher sectors to support the European launch industry and suborbital intercontinental travel applications.

R.3.7. Explore and devise a flagship exploration mission using advanced electric propulsion and solar sailing.

R.3.8. Support the development and deployment of RTGs for deep Space exploration missions.

R.3.9. Promote feasibility studies on novel advanced in-space propulsion and power concepts such as fusion propulsion, onboard nuclear reactors, the alcubierre drive and the mach effect thruster through the establishment of European advanced propulsion concepts directorate.

VII. European human spaceflight and robotic exploration

Europe has built world-class capabilities in exploration, whether on its own for robotics missions (Rosetta), or with international partners in human spaceflight through the International Space Station programme and its ecosystem. Exploration embodies the far future of mankind; it confronts us with the greatest unknowns while offering a horizon of possibilities. It stands for technological prowess and sovereign pride. It has managed in the last 3 decades to overcome national barriers and bring remarkable international cooperation; and Europe has heavily invested in occupying a significant seat in its development. All that has been done in the field so far is surely “exploratory”, but an age of “utilisation” will come. Its building blocks are assembling now, and Europe should not be left behind. Human spaceflight enables enormous flexibility when it comes to Space missions, and can bring significant advancements in life-sciences and medicine fields, as well as complementary advantages for in-orbit servicing operations, enabling satellite reparations and refuelling opportunities to extend mission lifetimes while fostering sustainability.

The future of human spaceflight is taking once again a geopolitical turn, as the US progressively disengages from the ISS and strives for the Artemis programme, hoping to onboard international partners along the way. As of today, only US defence partners have signed, with the exception of Luxembourg. Europe's investment should not have been made in vain, and more importantly, should not solely support the US interests now that we are acquiring means towards strategic autonomy. The following points could leverage Europe's achievements in creating a sustainable, inclusive Space economy, while preserving strategic, independent access:

1. Bridge ground industries (for example, pharmaceuticals, fluids, energy, construction/manufacturing, telecommunications...) with the Space industry to develop purpose-built modules (s) for large-scale production applications that take advantage of the unique Space environment. These applications can be divided into two categories: Earth Benefits and Space Benefits, with the latter focusing on developing sustainable trade in Space. These should also enable **crewed applications, which will be decided on a case-by-case basis and pending on member states' priorities, which may eventually replace the ISS European activities;**
2. Evolve Orion ESM and the EL3 plans (European Large Lunar Lander) into an independent capability for Europe to access the cislunar Space and the lunar surface. Institutions can support the infrastructure and stimulate surface utilisation for industries.

The EU should also **seek international collaboration for human spaceflight**, with elements on the critical path of the above solutions preferably operated by Europe, or at least, developed by European partners to ensure strategic autonomy. They should, however, have a level of compatibility with US Artemis and LEO commercialization initiatives, for safety redundancy, scale effect, and diplomatic reasons. Elements on the non-critical path may also be proactively open to the global community, including developing countries. We also propose that the programme **leverages the potential for commercialisation to reduce costs in the different segments and concrete business cases**, which may eventually take on the role of providing commercial Space stations for Europe and the rest of the world. The potential economic returns of these endeavours should satisfy long-term global societal development first and foremost, be fairly distributed among partners (whether EU or non-EU), and preclude the prevalence of one single player/nation.

A. Moon and Mars Missions as a first step for solar system exploitation and interstellar migration

The Moon and Mars missions aim to increase our knowledge of these terrestrial bodies; develop technologies and infrastructure for our long term solar system exploitation and interstellar migration objectives, exploit their unique resources, and eventually allow for self-sustaining human settlements. Despite their crucial role, no European crewed mission has landed on the Moon or on Mars. There is, however, a timeline to achieve this. According to the ESA website, the current timeline for Europe's Mars and Lunar programme is as follows[52]:

MOON:

- Orion with European Service Module — 2021
- Orion landing on the Moon — by 2024
- Gateway first European experiment — 2022 with the first module
- Gateway first ESA astronaut — mid 2020s
- Luna — mid-2020s
- European Large Logistics lander — by 2028
- First three European astronauts on the Gateway — second half of 2020s
- First European astronaut on the Moon before 2030

MARS:

- ExoMars trace gas orbiter — now
- ExoMars rover and drill — launching 2022, landing 2023
- Mars Sample Return:

[52] European Space Agency (ESA), European vision of exploration, available at: https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/European_vision_of_exploration

- First element, NASA Perseverance, rover — currently on Mars
- ESA's Earth Return Orbiter, Sample Fetch Rover and Transfer Arm — by 2026
- Landing of first martian samples on Earth — 2031.

As it can be seen, there are no official Mars landings, whereas NASA is leading with pioneering human exploration projects such as the Artemis programme and the Mars Direct and Semi-direct concepts.

It is fundamental to pursue further ambitious projects. The Moon's farside can mitigate the effects of earthshine and human electromagnetic emissions, allowing for ambitious astrophysical science. It is also seen as a test-bed for crew training and life sciences research, which may be complementary to the ISS or analogue missions on Earth. In addition, lunar material resources can be exploited to produce oxygen and water for life support and rocket propellants, making it an ideal servicing depot outside of Earth's gravitational well to sustain our solar system transportation infrastructure. In addition, He3 is available in larger quantities, which may allow for advanced fusion energy, which may sustainably solve our near term energy needs.

For our current civilization, Mars is a marvel. Its ideal location and acceptable journey times, in combination with its future potential habitability make it an ideal objective for early human expansion through the solar system. The planet is believed to have had vast ocean systems in its past. It is thought it may have supported simple lifeforms, and may possibly still do so in certain habitable spots and its subsurface lakes[53]. Mars is therefore a unique environment for astrobiological experiments and the search for extraterrestrial life.

Furthermore, due to its location, Mars is likely to become the main launching and control point for future asteroid mining and deep Space operations. When it comes to natural mineral resources, as well as fresh water, the supply of natural resources to be found in the asteroids could potentially resupply Earth's dwindling resources through deep-space mining. The natural jumping off point for such future operations would be Mars, specifically Mars' moons Phobos and Deimos. To guarantee Europe an equal share in the future wealth of the asteroids, we need an adequate infrastructure on these moons.

Mars will also significantly increase our knowledge of our own planet through comparative meteorology, hydrology, and planetary evolution and climate history.[54] These studies will not only allow for planetary engineering to make Mars habitable again, but will also serve as a testbed to increase our knowledge of these technologies for application on other planets and even on Earth to revert

[53] Water on Mars: discovery of three buried lakes intrigues scientists, nature, available at:https://www.nature.com/articles/d41586-020-02751-1
[54] Hammond, W. E., 1999, Space Transportation: A systems approach to analysis and Design

environmental destruction and climate change. These terraforming efforts could start as early as 2045 and be completed within 2 centuries.[55]Terraforming efforts to make humanity multi-planetary are also seen as necessary to maintain life as we know it in the universe by allowing for a "backup" of humanity and Earth's biosphere in the case of future extinction events.

In addition, the challenges of Moon and Mars exploration and colonisation will result in the development of innovative technologies which will foster economic growth in today's information era. The first missions will require groundbreaking advancements in life support and energy and food production in extreme environments. These could enable us to increase our food production yield in many of today's desertic regions, as at polar latitudes, deserts and even allow for oceanic cities, especially in less developed regions.

Space exploration is fundamentally a long-term investment, i.e., the return on investment from Space exploration is not immediately, but in the future. In other words, when planning a mission into outer Space, we do not expect to get much immediate financial gain (beyond the political gain and the P.R. opportunities attached to a successful Space mission), but we expect the net-gain in the long run to be more than worth it through eventual exploitation activities and technology transfer for non-space sectors and applications, both in political, PR, scientific and financial/economic terms.

The technology developed on the Moon and Mars (as life-support and environmental control technology) should be able to be applied on Earth to help us better deal with our terrestrial environmental problems. If we learn how to terraform the Martian dessert, there is no reason we cannot push back the Sahara as well. And if we learn how to scrub the excess CO2 from the Martian atmosphere, we can apply the same technology to fight the greenhouse effect on Earth. This advantage is already in line with some of the aims formulated by practically all the national and international (non-commercial) Space agencies, including ESA, as this sort of application of Lunar and Martian exploration for environmental studies can be considered a natural "next step" from such activities as geomonitoring. The UAE's Al-Amal Mars probe, which is in Mars' orbit is a good example of this kind of programme: One of its stated aims is to measure Mars' atmosphere in order to better understand global weather processes. In this way, Mars is very much "a sandbox" for geological/aerological and environmental studies, the end results of which should then be applied back on Earth. Just like GPS started out as Space technology, but eventually found its way into every smartphone on Earth, so can Mars and the Moon result in technological innovations that will make their way back to Earth.

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[55] Mars: Bringing a Dead World to Life, Life, May 1991, pp. 24-35

It is therefore key to **support the development of ambitious concepts for Moon and Mars exploration that leverage international collaboration with the European Union as a key and equal partner**. **Europe should push for an ambitious international Mars exploration programme that culminates with the landing and establishment of a permanent research outpost by 2040.**

B. Deep Space Exploration and Interstellar missions

In addition to the inner solar system, it is also fundamental to explore the solar system's gas giants and kuiper belt objects. Interior water oceans have been confirmed in some of Jupiter and Saturn's moons, and are even thought to have been present in the past of other minor planets, such as Ceres and Pluto. These ocean worlds raise the possibility of past and recent extraterrestrial life, and their huge quantities of water and other volatiles such as helium-3 may be key for future solar system exploitation. It is therefore necessary to **support an ambitious agenda which will culminate with the robotic exploration of the interior oceans of these worlds.**

Exploration of the icy gas giants, Uranus and Neptune, is also necessary to support our long term goals. Up to now, only Voyager 2 has performed a flyby of these planets, discovering surprising features such as Triton's geysers. Therefore, they remain relatively unexplored and the chances of major breakthroughs in planetary science are high. Recent exoplanet surveys have revealed a plethora of similar "icy worlds," as well as some surprising mini-Neptunes and super Earths.[56] This is leading to many questions about our solar system's formation, and by studying these planets, it will be possible to increase our knowledge of the evolution of our solar system and the habitability of the galaxy. **Europe should support flagship missions to study these icy worlds.**

Interstellar missions are also slowly becoming a reality and entering the agendas of key Space players, such as NASA and the Breakthrough initiative. It is necessary to **support technology development roadmaps to send exploration probes to proxima centauri and other solar systems, which will one day enable us to visit new habitable exo-worlds.**

C. Future of ISS and Space habitats

With the international Space station (ISS) expected to be discontinued at the end of the decade, it is necessary to start planning for the future of Space stations. The ISS has contributed to innovative discoveries in life science research and for

[56] Destination Uranus! Rare chance to reach ice giants excites scientists, Nature, March 2020, available at: https://www.nature.com/articles/d41586-020-00619-y

manufacturing in Space. It is now known that it's possible to plant in Space, and an upcoming mission will explore efficient extreme agriculture, which could have incredible applications to support food production in desert-like Earth regions with extreme environments and even on Mars.

Future commercialisation of Space station operations will build on the discoveries and infrastructure of the ISS and allow private industries to exploit its full potential. NASA and its partners are also planning to develop the Lunar Gateway, which will support the Artemis mission and deep Space exploration. The European Union should join these efforts and become an equal partner to guarantee its success and benefit from its research and applications.

In addition, previous studies have shown the potential applications and feasibility of large Space stations, such as the O'Neill cylinders[57]. These could support a growing human population, enable full Space exploration activities and allow the manufacturing of necessary Space infrastructure, e.g. for space-based solar power, astronomical observatories and mining. It is necessary to invest in a technological demonstration roadmap which can serve as a proof of concept and bring these Space habitats to reality.

D. Policy Recommendations

R.4.1. We propose to support the development of ambitious concepts for Moon and Mars exploration, based on international collaboration with the European Union as a key and equal partner.

R.4.2. Europe shall push for an ambitious international programme of Mars exploration, to be culminated in the landing and establishment of a permanent research outpost by **2040**.

R.4.3. Europe needs to strive to place European astronauts on the Moon and Mars.

R.4.4. Europe should bridge the gap between non-space industries (such as pharmaceuticals, fluids, energy, construction/manufacturing, telecommunications, and so on) and the Space industry in order to develop specific modules for large-scale production applications that take advantage of the unique Space environment. These applications may be divided into earth-based and space-based: developing sustainable trading in orbit. These should also enable crewed applications, to be decided on a case-by-case basis and depending on Member States priorities, which may eventually replace the

[57] Johnson, Richard D. and Holbrow, Charles, 1977, Space Settlements: A Design Study, NASA-SP-413, available at: http://large.stanford.edu/courses/2016/ph240/martelaro2/docs/nasa-sp-413.pdf

European ISS activities.

R.4.5. Europe should evolve the European Service Module (Orion ESM)[58] and the European Large Logistic Lander (EL3)[59] plans into an independent capability for Europe to access cislunar Space and the lunar surface. Institutions can support the infrastructure and stimulate the use of surface industries.

R.4.6. Europe should evaluate the leverage of commercialisation potential to reduce costs in the different segments and concrete business cases that may eventually take over the role of providing commercial Space stations for Europe and the rest of the world. The potential economic returns from these endeavours should primarily serve long-term global societal development and be distributed fairly among partners (whether EU or non-EU), precluding domination by any single player/nation.

R.4.7. Europe should seek international collaboration for human space-flight, especially on non-critical pathway elements that can be proactively opened to the global Space community.

R.4.8. We call for the guarantee of Europe's strategic autonomy in crew access to Space and robotic exploration of the Moon and Mars.

R.4.9. We recommend that Europe increase its research into effective radiation protection technology and survival in microgravity. One of the main dangers of any crewed journey outside our atmosphere and geomagnetic field is the threat of Space radiation on the one hand and bone decalcification and muscle atrophy on the other. An ideal location for this would be the surface of the Moon, which is still close to Earth (compared to Mars) but still requires several technological breakthroughs to become habitable; especially in the areas of radiation protection and the problem of keeping humans alive and healthy in an environment with minimal gravity.

R.4.10. Europe should implement an ambitious agenda for the full exploration of the solar system's ocean world, which will culminate in robotic exploration of the interior oceans.

R.4.11. Europe should perform a European flagship mission to explore the exploration of the ice worlds of Uranus and Neptune.

R.4.12. Europe should plan a technological roadmap for robotic interstellar missions to Proxima Centauri and other solar systems.

R.4.13. We propose to support the commercialisation of low Earth orbit

[58] Airbus, Orion ESM, available at: https://www.airbus.com/en/products-services/space/exploration/moon/orion-esm

[59] European Space Agency (ESA), European Large Logistic Lander, available at: https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/European_Large_Logistics_Lander

orbital Space stations.

R.4.14. Europe should step up efforts in the development, manufacturing and operation of the upcoming Lunar Gateway.[60]

R.4.15. Europe should support research into the manufacturing and application of future large Space settlements and a technology development roadmap, including demonstrators.

[60] European Space Agency (ESA), Gateway to the Moon, available at: https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Gateway_to_the_Moon and Lunar Gateway: Earth's guard post against asteroids? , available at: https://www.esa.int/Enabling_Support/Space_Engineering_Technology/Lunar_Gateway_Earth_s_guard_post_against_asteroids

VIII. Providing public goods and benefits to Europe and beyond

Large Space projects, from establishing a GPS network and an Earth observation system to the creation of large Space habitats, require large upfront investments, involve many positive externalities and may entail numerous risks that private companies are not always willing to assume. It is therefore key that governments take an active role in developing the necessary infrastructure to improve the lives of citizens by investing in key Space projects, and that these are backed by key political figures[61]. In addition, a broad political base is needed, which requires transparent political support and consideration of major public concerns. Commercialisation can further contribute to the development of these assets and even play a greater role in finding new business opportunities by building upon the inertia of government R&D and its infrastructure, as seen with the recent large increase in venture capital investment in suborbital travel and Space transportation.

A. Communications

Providing a European-based location and navigation service for citizens and businesses is essential to improving the quality of life of our citizens on Earth. Thanks to several services, such as communication and navigation, our satellites enhance the transmission of data and information so that it can be faster and its impact greater.

A simple example: faster and more wide-ranging transmission of data with broader signal coverage would enable the unmanned aviation sector to operate more safely. In concrete terms, this would mean supporting companies leading the efforts to integrate unmanned aviation into the European Single Sky and assuring the safe operability of unmanned aircraft systems (UAS) in urban and remote areas, from monitoring illegal fisheries to transporting vaccines. Volt believes that citizens' connectivity is crucial to engaging all people in an increasingly interconnected and globalised world.

Our telecommunications infrastructure should also be sustainable and compatible with radio astronomy and SETI research. These studies typically use passive strategies on key frequencies which can cover the full spectrum. Currently, the International Telecommunication Union is responsible for the allocation of these frequencies, and as the radio spectrum becomes more crowded with more and more applications, it becomes increasingly challenging for scientific research to compete with commercial or military users. It is therefore fundamental to push for a flexible frequency

[61] Hammond, W. E., 1999, Space Transportation: A systems approach to analysis and Design

allocation system by the International Telecommunication Union that guarantees temporary and permanent observation rights for the studies of these sciences, at least until an ambitious Space- or Moon-based radio astronomy observatory is developed.

B. Navigation capabilities

Navigation systems allow us to determine our precise position. The applications are diverse and range from the downstream use of geolocation services to the precise determination of the orbit of our Earth satellites. In Europe, the Galileo system is currently being deployed and used. Among the concepts currently under consideration is the augmentation of the global navigation satellite system (GNSS) system with LEO satellites[62]. These concepts should be supported and explored to complement our European Galileo system.

Navigation capabilities are not limited to the Earth. The Moon and Mars could also benefit from a navigation system, providing precise positioning and timing information to our robotic exploration systems and eventually to human settlers. It is therefore fundamental to push ahead with the implementation of these future navigation technologies on the Moon and Mars.

C. Earth Observation: Protecting Humanity

To the best of our current knowledge, our planet is the only one in the universe where life as we know it is possible, despite the groundbreaking scientific discoveries of thousands of exoplanets orbiting other stars. Since the beginning of the Space age, we have been able to observe our whole planet at once and to monitor the variation over time of global phenomena such as climate, desertification and water distribution. Because our planet is experiencing sudden and continuous changes, it is of paramount importance to monitor the sustainability of the growth of our population and economic system.

To achieve such an ambitious goal, Earth observation and climate monitoring with satellites are needed[63]. Reliable data, fast monitoring and global coverage are indeed fundamental requirements for the Earth observing programme, and this can only be achieved with a large fleet of coordinated satellites. Currently, 26 of the 50 essential

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[62] Lei Wang, Zhicheng Lü, Xiaomei Tang, Feixue Wang, LEO-Augmented GNSS Based on Communication Navigation Integrated Signal, 10.3390/s19214700

[63] J. Yang, P. Gong, R. Fu, M. Zhang, J. Chen, S. Liang, B. Xu, J. Shi, R. Dickinson, 2013, The role of satellite remote sensing in climate change studies, Nat. Clim. Change 3 (2013) 875–883, available at: doi: 10.1038/nclimate1908.

variables for climate change assessment are monitored by satellites[64]. An example of what Volt is aspiring to is the European Union's Copernicus Earth observation programme[65], coordinated and managed by the European Commission but implemented in partnership with the Member States, the ESA, the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Centre for Medium-Range Weather Forecasts (ECMWF), EU agencies and Mercator Océan. Copernicus aims to establish a wide range of Earth observation capacity by providing accessible information on our planet's environment to understand and mitigate the effects of climate change and ensure civil security on a global level. These achievements would guide service providers, public authorities, and international organisations to improve the quality of life of European citizens and the whole world, who would also have full, open and free access to this information. In this way, many new downstream services could be developed for the benefit of all.

As an example, satellite data from the Copernicus programme can be used efficiently to track national greenhouse gas emissions inventories and other pollutants, to support monitoring and verification tools and ensure the success of the Paris Agreement.[66] The European Commission is currently developing the technologies and systems needed, as with the CO2M mission, to have operational space-based instruments in a satellite constellation by the end of the decade that can track global emissions and land-use change with high temporal and spatial resolution, and use data-rich Europe as an excellent calibration tool. This is essential to evaluate the effectiveness of our strategies within the Energy Transition and Climate Change Policy, and to guarantee a stricter Emission Trading System compatible with the 1.5°C maximum global warming target, which requires immediate policy action. We therefore propose to **increase efforts to achieve the development of an observation-based greenhouse gas emissions monitoring and verification capacity system in a shorter period of time, so that we can efficiently realise our energy transition goals.**

It is indeed for ‘all’ that Volt calls for a stronger EU to be a positive global player that recognises what Copernicus embodies: Volt’s core values of cooperation, sustainability, solidarity and innovation. Moreover, Volt acknowledges that in the European Space sector it would be difficult, if not impossible, for a single European country to develop such a programme independently. Volt believes that only the EU, with the European Commission playing an essential role, will be able to achieve the

[64] CEOS, ESA, 2015, Satellite Earth Observations in Support of Climate Information Challenges, available at: http://eohandbook.com/cop21/files/CEOS_EOHB_2015_COP21.pdf
[65] Copernicus, Europe’s exe on Earth, available at: https://www.copernicus.eu/en
[66] European Commission, 2017, CO2 TF-B report: An Operational Anthropogenic Co2 Emissions Monitoring & Verification Support Capacity, available at: https://www.copernicus.eu/sites/default/files/2019-09/CO2_Red_Report_2017.pdf

vision, funding, and technology required to develop the most ambitious Earth observation programme ever.

D. Start-ups and increasing accessibility to European Space information from the Copernicus programme

There is also a need to increase the dissemination of Space technologies to develop a larger set of applications for our citizens. Recently, numerous Space start-ups have been emerging with the support of venture capital and numerous business incubators. We believe it is important to further develop more business incubators in Europe and to also align them with our long-term technological roadmaps for Space exploration and exploitation.

For example, in the context of Earth Observation downstream SSME and use of Copernicus data, it might not be sufficient to provide only raw data to the market, but also to develop key applications and platforms with public agencies to foster the dissemination of knowledge and know-how and to create incentives for the emergence of an efficient commercial sector. In addition, **a strong reference to privacy and data protection is missing**. Considering the EU's efforts to protect privacy and the fact that Earth observation and surveillance might pose a threat to it as technology advances and commercial applications in the downstream sector evolve, it would be useful to show our interests in citizens' data and privacy clearly.

E. Space, public health and pandemics

Following the Covid-19 pandemic of 2020, the global community realised that infectious diseases have been spreading across the planet since the beginning, just as the human population. The difference between now and the past is that we are strongly interconnected, a phenomenon that will only increase as transportation technology innovates and evolves. While the interconnectedness of a global ecosystem helps infectious diseases spread at a high pace, it has also led humanity to great achievements in various fields of scientific and cultural innovation, as well as closer international cooperation.

In fact, thanks to international cooperation, the collection and distribution of data is increasing, and it is becoming more available through satellite technologies and high-quality coverage systems, such as the Geographical Information System (GIS) and Earth Observation (EO).

A major European effort in gathering this data collected from Space would help

European scientists to develop more precise models to:[67]

- Analyse and track the risk of disease outbreaks;
- Monitor environmental factors such as air quality or human-animal or human-human interaction;
- Monitor the spread of infectious diseases geographically and quantitatively;
- Monitor the production and distribution of vaccines globally (via GIS).

With these tools, the European Union could take the lead in assessing the public health impact of diseases on its citizens and the rest of the world.

Volt believes that the EU can play an important role in monitoring the supply chain networks to counter the impact of diseases at any stage and any level of risk. To do so, the EU should invest in satellite technologies that help identify safe and viable transportation routes, as well as in unmanned aviation as a tool for delivering essential medical and subsistence supplies to hard-to-reach areas.

Volt's Space Policy promotes the use of electric, ergo zero-emission, automated transportation, unmanned aircraft systems and telemedicine as tools that enable immediate, rapid response. guaranteed by the reliability of Space technologies in a safe and predictive way.[68] Efficient use of these tools must be made through the use of the global navigation satellite system (GNSS), supported by LEO satellite constellations, and through the European Union's commitment to high coverage for communication networks using 5G.

These tools will enable healthcare providers in the EU to provide diagnosis and treatments with more accurate and timely information while providing healthcare services to as many patients as possible and mitigating the spread of infectious diseases or the deterioration of critical medical situations.

In summary, Volt is a proponent of Space as one of the main tools to achieve greater public health security and current and future pandemics. Warning systems linking Space data to public health facilities are needed to monitor and prevent future pandemics. According to Volt, these achievements should not be limited to the European Union, but should benefit the whole world in order to create beneficial and sustainable international cooperation.

[67] ISU, 2020, The role of space during pandemics, ISU Team Project report
[68] See the European Regulation (EU) 2019/947 and Regulation (EU) 2019/945) on UAS, available at: https://www.easa.europa.eu/regulations#regulations-uas---unmanned-aircraft-systems

F. Technology transfer, innovation and economic benefits

Volt believes in the positive spillover effect that Space has on the global and European economies. In terms of commercial spaceflight opportunities, spaceflight offers a new opportunity to spur socio-economic growth through the development of dedicated technological districts, new employment opportunities, specific educational programmes, and side business opportunities (e.g. edutainment, marketing and sponsorship, research spinoffs). Space has a major impact on the labour market in particular. Due to technological innovation trends in robotic applications for industrial purposes, many jobs would be at high risk of automation or could change significantly. Volt aims to lead the discussion on the future of aerospace jobs with industry and Member States to foster an organic labour market and the development of industrial innovation.

In this context, Volt supports technological spin-off opportunities. Many of the technological innovations developed for Space exploration can be found in everyday applications and specific R&D programmes for consumer goods. Supporting spin-off applications for Space technologies would foster the creation of new private-sector innovative start-ups and create new business ecosystems.

Information and capabilities derived from Space offer significant potential as a driver for new business. The aim of the Volt Space Policy is to encourage EU activities that provide sustainable space-based services and applications for new user communities and customers through interaction with innovative digital technologies such as IoT, machine learning, Big Data, autonomous driving, etc. The application of space-derived solutions would benefit and enhance the technological development of trending areas such as cyber security, smart cities, precision agriculture and fishing and climate change monitoring.

G. Fostering European Space commercialisation while leveraging on governmental involvement

The Space industry is becoming increasingly commercial as private sector revenues grow exponentially and non-European entrepreneurs bring in venture capital. This leads to a highly competitive global scenario and poses a challenge to the security of supply in the European Union.

This increase in Space commercialisation could bring enormous benefits by shifting spending towards optimal development in a competitive world, increasing Space cooperation in the international market and even enhancing global efforts to explore Space to Mars and beyond. Nevertheless, history shows that the involvement of the government is fundamental in the establishment of key infrastructures that enable exploitation of new territories for human involvement.

For this reason, **we suggest that commercialisation/privatisation should be used as a means to use the market economy to achieve specific targets, rather than as an end in itself**. **An efficient trade-off should be pursued** where European governments actively contribute to Space applications with high costs and risky infrastructure and technology development, uncertain demand and long pay-back periods, such as in Space transportation (new reusable crewed vehicles, Space lifts), Space exploration and Moon/Mars exploration missions and habitat construction, and in designing efficient regulations to foster private sector participation and contribute to optimal infrastructure development.

In addition, **the exploratory nature of Space activities should be highlighted and the "estimated return" should not be the only rationale when proposing government involvement in new Space assets.** Scientific and technological research and development should remain an important justification for Space investment. We should keep in mind that our civilisation is currently in an early exploratory phase within the five-phased evolutionary programme, preparing for eventual colonisation, resource exploitation and planetary engineering in the solar system. Our Space programmes should therefore be adapted accordingly. This is not only to go beyond Space, but also to provide us with the necessary capabilities to monitor and design our own planet and prevent catastrophic climate change and environmental destruction.

H. Policy Recommendations

R.5.1. The exploratory nature of Space activities should be highlighted, and the "estimated return" should not be the only rationale when proposing government involvement in new Space assets.

R.5.2. Europe should push for the International Telecommunication Union to guarantee temporary and permanent allocations for radio astronomy and SETI research.

R.5.3. Member States should promote European concepts for lunar and Martian navigation systems to support our exploration missions.

R.5.4. The augmentation of our European GNSS system by LEO satellites should be further explored.

R.5.5. We support the European Union's efforts in Earth observation and the Copernicus programme. The EU should take the lead in monitoring the atmosphere, oceans and environmental issues.

R.5.6. We should intensify our efforts to develop an observation-based GHG monitoring and verification capacity system in a shorter period of time to efficiently accomplish our energy transition goals.

R.5.7. Europe should increase the number of European Space incubators and projects.

R.5.8. Europe should incentivise the use of Copernicus data by developing key applications and supporting their dissemination to the public sector.

R.5.9. We recommend commercialisation/privatisation as a means to use the market economy to achieve specific targets, but not as an end in itself. In doing so, always consider how to contribute to reducing costs in key areas of Space transportation and to achieving our exploration goals.

R.5.10. Member States should organise outreach campaigns involving non-space industries and companies to provide training and knowledge on potential benefits of Earth observation and infrastructure, Space manufacturing, intercontinental travel, etc. to encourage participation and investment.

R.5.11. Use of Space technologies should be expanded to achieve greater public health safety in terms of public health and current and future pandemics. Warning systems linking Space data to public health institutions are needed to monitor and prevent future pandemics. According to Volt, such achievements should not be confined to the European Union, but should serve the whole world to create beneficial and sustainable international cooperation.

R.5.12. Member States should facilitate European competition with exploration goals and rewarding milestones based on perceived risks to guarantee short-term payoff. This will enhance the development of key technologies and their spillover effects by attracting venture capital.

R.5.13. Member States shall promote an efficient balance between public and private involvement in Space activities, e.g. with active competition in Space transportation, while guaranteeing a market by the government based on European autonomy and security. A prevention of perpetual monopolistic charters in all areas is needed.

R.5.14. Member States should create government programmes to develop Space infrastructure and technology with active involvement of the private sector and hand in its use and operation, to foster commercialisation while guaranteeing social benefits.

R.5.15. The focus should be on highlighting the explorative nature of Space activities when deciding on the development of new types of Space assets, and not only the exploitation/or short term profitability of investments.

R.5.16. Europe must push ahead with the promotion of international commercialisation partnerships to enhance cooperation with other nations in Space. The private sector should assume its responsibility as an international actor.

IX. European and planetary defence

A. European defence: Preserving the integrity of European Space infrastructure, integration and orbital access

Space assets are part of national and European critical infrastructure today. Satellites provide decision makers with secure communications; they provide imagery for critical decisions, from intelligence needs to monitoring agriculture and economic structures; they serve us all for positioning, navigation and timing. In the future, they will also serve as critical data relays for citizens, and the analysis derived from their signals and imagery will be embedded in a wide range of societal applications. In parallel, commercial players are populating Space with new business cases around the Internet and Internet-of-Things from the sky. All this makes Space infrastructure, as well as the optimal orbital locations of this infrastructure, a strategic matter.

Despite international agreements and public speeches about the peaceful use of Outer Space, the US, Russia and China have long recognised this strategic value and developed capabilities to undermine their geopolitical opponents. This is not only about surveillance and support of ground-based military assets or sending weapons over Space and identifying them from Space, but now also threatening satellites.

The first apparent sign of this affecting Europe came in 2017, when a Russian satellite came dangerously close to a French intelligence satellite. **Europe should have no interest in encouraging such behaviour,** and it has no power to stop the United States, Russia, or China from engaging in such behaviour. However, **Europe must ensure that its critical Space infrastructure and strategic orbital positions remain secure, now and in the long term.**

As a result, Europe should develop sufficient capabilities **to detect threats, whether from Space or from the ground.** This would require a combination of optical and radar instruments as well as a powerful analysis and management infrastructure that could be deployed from Space if necessary.

B. Peaceful uses of Outer Space

We believe in the continued peaceful use of Space for scientific and economic activities in accordance with Space law. While bodies brought into Space can contribute to strengthening the defence of European citizens and the European Union both inside and outside the EU borders, all developments should be in accordance with the Outer Space Treaty and the Space Preservation Treaty.[69] Space, the Moon and other celestial bodies should remain free of weapons of mass destruction,

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[69] United Nations, United Nations Treaties and Principles on Outer Space, available at: http://www.unoosa.org/pdf/publications/STSPACE11E.pdf

weapons testing of any kind and the establishment of military bases.

Recently, our transatlantic ally, the USA, opened a new debate in Space when they announced the establishment of a "Space Force". This sheds light on the recent trend towards the militarisation of Space, which could lead to a new arms race.[70] Weapons in Space are not completely banned under the Outer Space Treaty (OST) of 1967, which only regulates the use of nuclear weapons in Space.[71]

The militarisation of Space goes against our core values of a sustainable and prosperous Space industry and human expansion into the solar system. Regardless of the enormous number of casualties and environmental damage that a space-based weapon could cause on Earth, as well as the enormous cost and waste of resources for such a defence system, any potential use of weapons against a satellite could result in an enormous amount of Space debris, endangering the entire Space industry and its derivatives, as stated in the point on Space debris. **We will therefore urge the EU and the UN to approve Space demilitarisation treaties** such as the Preventing an Arms Race in Outer Space (PAROS)[72] and the Space Preservation Treaty.

A strategy to further secure our orbital assets should also ensure sustainable Space traffic management and acknowledge the risks of Space debris that any Space weapon tests or military campaign could generate in our near-Earth Space environment. The EU should therefore **ban all weapons tests or the use of weapons that could create Space debris** and **condemn foreign nations that do so,** taking necessary action under trade agreements and other international mechanisms.

It should also be noted that the use of Space weapons for military purposes must be kept separate from the use of Space weapons for research purposes. Some advanced propulsion concepts, such as pulsed nuclear fission or fusion propulsion, currently have an unclear legal status. The Orion project, which could have used our current nuclear arsenal for exploration purposes, was cancelled due to problems with the OST. These technologies could also have very real practical implications for the development of asteroid deflection concepts. These restrictions should be relaxed to allow the development of advanced technologies for our exploratory goals.

[70] Reaching Critical Will, Outer Space - Militarization, weaponization, and the prevention of an arms race, available at: https://www.reachingcriticalwill.org/resources/fact-sheets/critical-issues/5448-outer-space
[71] Federation of American Scientists, Prevention of an Arms Race in Outer Space, available at: https://programs.fas.org/ssp/nukes/ArmsControl_NEW/nonproliferation/NFZ/NP-NFZ-PAROS.html

[72] NTI, PAROS Treaty, available at: https://www.nti.org/education-center/treaties-and-regimes/proposed-prevention-arms-race-space-paros-treaty/

C. Planetary Defence

Technologies for asteroid detection and deflection will also be developed. These are currently in their infancy and we still do not yet have an effective warning system. Recently, an asteroid was detected just 24 hours before its flyby of Earth. Had this asteroid impacted over a city, it would have caused massive devastation, as it was predicted that it could have as much energy as the Tsar Bomb, similar to the Tunguska event in 1908, which flattened 2000 km^2 of the Siberian forest. In regards to Tunguska, it has been hypothesised that this later impact could have been caused by an iron-based asteroid grazing the Earth, which, if it had impacted, would have created a near extinction[73]. It is necessary to get serious about planetary defence and push for an active asteroid defence system. An asteroid impact could be the first extinction event that humans actively avoid.

D. Policy Recommendations

R.6.1. The EU should enhance its SSA and C4ISR capabilities to protect the EU's critical infrastructures in Space and on Earth.

R.6.2. The EU should develop and deploy common Space defence systems to achieve a key milestone towards the establishment of a Common Security and Defence Policy that fosters internal military cooperation and enables a stronger Union on the global stage.

R.6.3. The EU should strongly oppose the weaponization of Space, support the adoption of international treaties in favour of demilitarisation of Space and sanction foreign nations that take the opposite path.

R.6.4. Push for a reassessment of the OST to allow for the use of nuclear technologies in Space for peaceful advanced propulsion concepts and for asteroid defence systems.

R.6.5. We call for the implementation of a European concept for an active asteroid defence system and push for a global agreement on international efforts to establish an effective warning network and deflection strategy.

[73] Daniil E Khrennikov, Andrei K Titov, Alexander E Ershov, Vladimir I Pariev, Sergei V Karpov, 2020, On the possibility of through passage of asteroid bodies across the Earth's atmosphere, Monthly Notices of the Royal Astronomical Society, Volume 493, Issue 1, March 2020, Pages 1344–1351, available at: https://doi.org/10.1093/mnras/staa329

X. Advanced Space Exploitation

To date, humanity is exploiting a tiny, negligible fraction of what Space has to provide. The colonisation of the entire solar system will not only provide us with more resources to enhance our quality of life, reduce inequality and fight climate change, but the expansion of human settlements will also provide the basis for the development of new technologies, improved social structures and infinite possibilities for the social and moral development of humanity. These latter aspects will utilise the current "information era" to an unimaginable extent.

This chapter addresses the benefits of Space resources and advanced exploitation of the solar system and how we can get there.

A. Space Mining and In-Situ Resource Utilisation (ISRU)

Space mining could not only increase exponentially our exploration capabilities by utilising Space resources outside of our Earth's gravitational well[74], but its universal presence within the inner solar system and in the outer regions could also allow us to retrieve vast quantities of rare earths such as platinum, which are essential to achieving our energy and ecological transition goals, while ensuring sustainable resource extraction with a low carbon and ecological footprint.[75] The development of the **necessary technologies, the creation of new European companies to demonstrate the technologies and exploit these resources through public-private partnerships, and the development of a legal framework** to ensure commercial exploitation under the Outer Space Treaty **must be encouraged.**

Given the benefits that Space mining could bring to Space exploration and the energy transition, we propose to take a **progressive and egalitarian perspective on the ownership and use of Space resources**. Therefore, Space mining for sustainable exploration and use of the Earth could not be considered a national appropriation and the safe zones described in the Artemis Accords could be an excellent approach to perform the described operations in accordance with the OST. These Accords can be signed by the European Union **and we can set up a working group to develop an international regime for the utilisation and exploitation of Space resources within the framework of the United Nations**.[76] In addition, a mechanism should be created

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[74] Amara Graps + 30 Co-authors, In-Space Utilisation of Asteroids: Answers to Questions from the Asteroid Miners, ASIME 2016 White Paper

[75] Andreas Makoto Hein, Michael Saidani, Hortense Tollu, 2018, Exploring Potential Environmental Benefits of Asteroid Mining, 69th International Astronautical Congress 2018, Oct 2018, Bremen, Germany, available at: https://hal.archives-ouvertes.fr/hal-01910090/document

[76] Many initiatives are investigating this concept. For example The Hague International Space Resources Governance or the 2019 COPUOS proposal made by Belgium and Greece.

to ensure fair redistribution of resources while providing incentives for developing technology and the implementation of mining activities. This could guarantee that lower-income and less developed countries benefit from Space mining. In addition, in the context of commercialisation, mechanisms should be in place to ensure fair competition among a variety of actors while preventing long-lasting monopolies or property rights.

Space mining could be a breakthrough in Space exploration, as In-Situ Resource Utilisation (ISRU)[77] would allow, for example, water and fuel to be extracted and spacecraft and planetary components to be built directly outside the Earth's gravitational pull, **significantly reducing launch costs and promoting humanity's expansion in the solar system.** This is the key to a future human presence on the Moon. **Asteroids also pose a significant threat[78] to our world.** By developing these technologies, we would also enhance our planetary defences by increasing our knowledge of their internal structure and composition, which would allow us to plan missions to avoid any possible disastrous collision. Furthermore, building a robust commercial Space mining industry would improve our economy by bringing back huge amounts of rare earth elements such as platinum. A single asteroid could be worth billions.[79]

Asteroid mining could also be more sustainable by reducing the environmental impact associated with using Earth materials for Space missions, as the ISRU would be able to produce these components directly in Space. Additionally, mining rare earths in Space and bringing them back for terrestrial use, such as platinum for green technologies that aid environmental transition, could have a smaller carbon footprint, increase availability and be more profitable than mining directly on Earth.[80]

There are also many companies with advanced plans, such as Planetary Resources, Deep Space Industries, Orbital Sciences Corporation, Ispace and Bigelow Aerospace, many of which have already launched some demonstrator missions. A recent study by the Keck Institute study mentioned that by 2025 we could have the technology to

[77] Amara Graps + 30 Co-authors, In-Space Utilisation of Asteroids: Answers to Questions from the Asteroid Miners, ASIME 2016 White Paper
[78] Masterson, A., 2019, Space agency ups risk of asteroid-Earth collision, available at: https://cosmosmagazine.com/space/space-agency-ups-risk-of-asteroid-earth-collision/
[79] Business Insider, 2017, Goldman Sachs: space-mining for platinum is 'more realistic than perceived', available at: https://www.businessinsider.nl/goldman-sachs-space-mining-asteroid-platinum-2017-4/?international=true&r=US
[80] Andreas Makoto Hein, Michael Saidani, Hortense Tollu, 2018, Exploring Potential Environmental Benefits of Asteroid Mining, 69th International Astronautical Congress 2018, Oct 2018, Bremen, Germany, available at: https://hal.archives-ouvertes.fr/hal-01910090/document

retrieve a 500t asteroid[81] and that commercial asteroid mining could begin in 2040.[82] Furthermore, some countries, such as the US, Luxembourg and the UAE have already introduced favourable legislation that is inspiring and attracting new businesses. Despite all the potential benefits and regulatory pressure, there are some concerns with the 1967 Outer Space Treaty that could prevent commercial companies from mining asteroid resources, and although there is consensus among experts that it could be possible with its current formulation and with concrete "loopholes,"[83] it highlights the importance of reforming and updating this treaty. **In the absence of a clear international treaty, the European Union should also use trade agreements with third countries to provide certainty to commercial Space companies with granted exploitation patents and permissions.** These could be based on preliminary surveys and speculative values, which would also allow for partially financing these operations.

We will encourage companies and start-ups to develop and launch missions to the Moon, asteroids and other smaller bodies in the Solar System to demonstrate critical technologies such as In-Situ Resource Utilisation (ISRU) and asteroid capture. It will do so by proposing related missions to ESA, by setting up European competitions with financial rewards, similar to the Google Lunar X Prize,[84] and by funding grants, purchasing equity and reimbursing costs for research and development. We will also work towards favourable legislation in all EU Member States, as has already been done in Luxembourg[85] and the US, and work towards bilateral agreements with other countries. The aim is not only to bring certainty to future asteroid mining companies and ensure that Space resources are subject to the "common property right", but also to **regulate the sector to ensure high safety standards. We will also support the establishment of an international adjudicative body within the UN**, such as is being done with the United Nations Convention on the Law of the Sea (UNCLOS).

B. Space exploration to solve energy and material needs

Global energy demand is projected to increase by orders of magnitude in the next few

[81] Keck, Institute of Space Studies. Asteroid Retrieval Feasibility Study
[82] International Space University, 2010, ASTRA: Asteroid mining, Technologies Roadmap and Applications
[83] Andreas Makoto Hein, Michael Saidani, Hortense Tollu, 2018, Exploring Potential Environmental Benefits of Asteroid Mining, 69th International Astronautical Congress 2018, Oct 2018, Bremen, Germany, available at: https://hal.archives-ouvertes.fr/hal-01910090/document
[84] X PRIZE, The New Space Race, available at: https://lunar.xprize.org/prizes/google-lunar
[85] CNBC, 2018, Luxembourg leads the trillion-dollar race to become the Silicon Valley of asteroid mining, available at: https://www.cnbc.com/2018/04/16/luxembourg-vies-to-become-the-silicon-valley-of-asteroid-mining.html

decades. Although classical terrestrial renewable energies are an excellent source, their scalability might not be sufficient in the next centuries. Moreover, fossil fuels will eventually be depleted, and considering that we are constrained to consuming only 7 years of actual GHG emissions, they may soon be an unacceptable energy source. Nuclear fission technology poses other issues, and its fuel will eventually become scarce. Advanced breeding technologies may be able to extend the lifetime of these resources, but in the long term, we will run out of radioactive material and need other sources to support renewable energy.

1. Space Based Solar Power (SBSP)

Space Based Solar Power (SBSP) is one of these options, and one of the most promising, but still largely unexplored. The International Academy of Astronautics concluded in 2011 that SBSP is already feasible and could be realised in just 10 to 15 years.[86] Almost a decade has passed since, but efforts have been minimal.

Three factors force us to consider the SBSP: the growing world population, increasing per capita energy consumption, and the need to fight climate change.

Generating solar energy in Earth orbit, where sunlight is available more than 99,8% of the time, could be the most promising way to simultaneously address climate change and the increasing global energy demand. Indeed, the Earth receives only one part in 2.3 billion of the Sun's output, making SBSP by far the largest potential energy source available. Solar arrays in Earth's orbit could collect almost 10 times the energy of the same solar arrays installed on the ground. It can also guarantee global supply to hard-to-reach regions and low-income countries, which increases their capacity for democratisation and contributes directly to the sustainable development goals. At present, only the United States, China, and Japan are active in this field. The European Union must not be left behind. The EU has to invest in this promising technology and foster its research and development. Further, close partnerships with the private sector can be mutually beneficial to reduce costs.

2. Advanced fusion fuels

As humankind expands further into Space, we need to take advantage of the abundant resources. There is the possibility of using advanced fusion fuels such as He-3 for nuclear fusion. Although terrestrial reserves may eventually be depleted, He-3 is available along with other energy sources for extraction on the Moon and in almost infinite proportions in the outer solar system,[87] as in the Jovian moons, underlining the need for Space exploration.

[86] John C. Mankins, 2011, Space Solar Power, International Academy of Astronautics.
[87] Palaszewski, Bryan, Atmospheric Mining in the Outer Solar System, National Aeronautics and Space Administration, 2005

The first fusion reactors may be designed to use the hydrogen isotopes deuterium and tritium as fuel, because achieving net energy production would be easiest to achieve with these fuels. The drawback is that this reaction produces neutrons which damage the reactor wall over time. **Next generation fusion fuels such as He-3 promise to improve the state of art on this issue, as these reactions (known as aneutronic fusion) do not produce neutrons.**[88] The only difficulty is that the reaction rate is lower and higher temperatures are required. But with advances in superconductor technology, these conditions may well be met. Furthermore, the ionic fusion products could be captured in an electric field and their kinetic energy could be converted directly into electric power. This achieves higher conversion efficiencies than traditional Carnot processes.[89]

With this technology, it will not only be possible to further break through our current energy limitations on Earth and ensure a sustainable environment, but it will also provide infinite opportunities for Space exploration with advanced fusion propulsion concepts. Interstellar migration will finally be possible.

C. Policy Recommendations

R.7.1. The EU should incentivise the development of technologies required for Space mining and asteroid capturing for economic and planetary defence purposes.

R.7.2. The EU should establish a working group to develop an international regime for the use and exploitation of Space resources within the framework of the United Nations.[90]

R.7.3. In the absence of a clear international treaty, the European Union should use trade agreements with third countries to provide certainty for Space commercial companies with granted exploitation patents and permissions.

R.7.4. Member States should encourage companies and start-ups to develop and launch missions to the Moon, asteroids and other smaller bodies in the solar system to demonstrate critical technologies such as In-Situ Resource Utilisation (ISRU) and asteroid capture.

R.7.5. The EU should harmonise the legal framework for ISRU among its Member States and advocate for the establishment of an international adjudicative body within the UN to maintain the register for patents and permissions.

[88] Freidberg, 2007, Plasma Physics and Fusion Energy, p. 27, Cambridge University Press
[89] Wikipedia, Direct energy conversion, available at: Direct energy conversion
[90] Many initiatives are investigating this concept. For example The Hague International Space Resources Governance or the 2019 COPUOS proposal made by Belgium and Greece.

R.7.6. The EU should promote Space Based Solar Power (SBSP) and the creation of a European technology roadmap with targeted investments in the establishment of European start-ups in the field of Space energy.

R.7.7. The EU should push the development of nuclear fusion, especially using He-3 concepts, as it is available in large quantities in Space and will allow us to fully explore the solar system through advanced fusion propulsion concepts.

XI. Governance and Space institutions in the European and international context

European Space agencies need to be further integrated to improve efficiency, cooperation and synergies. Furthermore, it is also necessary to address the low level of investment in European Space activities compared to the international context,[91] which may reduce the benefits of the Space economy, some of which have been addressed in previous chapters. The Member States' combined military expenditure amounted to EUR 223.4 billion in 2018, equivalent to approximately 1.4% of the European Union's GDP.[92] If the EU spent 0.14% of EU GDP (EUR 22.34 billion) a year on the Space programme, we would be able to provide funding and achieve larger exploratory results. NASA's 2020 official budget is around 22 billion USD[93], which is approximately four times the ESA budget.[94] One of our key proposals is to link at least 1/10 of the funding for Space programmes and Space organisations to defence expenses.

Many of the issues addressed, such as the militarisation of Space, Space debris and traffic management, or human exploration of Mars and the Moon, fall within the scope of international Space cooperation and international law. In the interest of efficient policy application, the strategy should therefore distinguish between what it can achieve through European collaboration and its institutions and what it can pursue in the international context.

A. European Space institutions

The European Union hosts the largest number of Space agencies in the world. On the one hand, there is the European Space Agency (ESA), an intergovernmental entity in which not all Member States participate, and in which not only Member States participate. For example, Canada, Switzerland and Norway are participating in the ESA. Furthermore, the European Union recently announced the European Union Agency for the Space programme (EUSPA), which will create synergies between the various EU Space components. On the other hand, many Member States have their own Space agencies or comparable institutions, such as the German Aerospace Center (DLR) for Germany and the Centre Nationale d'Etudes Spatiales (CNES) for France.

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[91] According to EuroConsult, the EU contributes to 9% of global investment in space exploration. Larrea Brito, N., Clarence Dee, J. and Seminari, S., Global Prospect for Space Exploration: A Strategic and Economic Assessment, IAC - The CyberSpace Edition, 12-14 October 2020. IAC-20,A3,1,4x57292
[92] European Defence Agency, DEFENCE DATA, 2017-2018: Key findings and analysis
[93] The Planetary Society, NASA's FY 2020 Budget, available at: https://www.planetary.org/space-policy/nasas-fy-2020-budget#:~:text=NASA's%20budget%20in%20fiscal%20year,of%20all%20U.S.%20government%20spending
[94] European Space Agency (ESA), 6.49 Billion Euro in 2020, Funding, available at: https://www.esa.int/About_Us/Corporate_news/Funding

B. European Space Agency or Space Agency of the European Union?

ESA represents a successful model for integration and synergy inside and outside the EU. The agency provides the EU with a gateway to Space and is currently working with the EU to implement the Copernicus and Galileo programmes. Nevertheless, it should be noted that ESA is an intergovernmental entity outside the European Union and therefore subject to a different regulatory framework. It is funded by its members and, to a lesser extent, directly by the European Union. This decoupled approach has several advantages and disadvantages, which are explained in more detail below:

Advantages of a decoupled ESA/EU	Disadvantages of a decoupled ESA/EU
• **Decoupled from European politics**. A government Space agency like NASA may be more exposed to electoral cycles, which could affect the effectiveness of Space missions which typically require more than ten years from conception to execution. • **It may be easier to involve external EU countries**, although this could also be implemented in an EU-based agency (e.g. Norway's participation in the European Economic Area).	• **Low Political Integration**. It is difficult to link European political objectives and roadmaps with Space aspects. • **Geo-returns are linked**. Geo-return policy becomes easier to implement because members contribute directly, whereas the European Union's share will depend on European policy decisions. This would bring the disadvantages of a geo-return aspect with lower industrial efficiency and regional biases. Nevertheless, the geo-return policy might also be attractive. • **Lower EU legacy**. It might be more difficult to highlight the successes of the EU and the benefits of EU integration. • **Less subject to EU oversight.** With European political oversight, it is possible to include more comprehensive transparency and accountability regulations.

1. Push for a European Union led Space Agency

We recognise the need for the European Union to have its own Space agency. Indeed, in such a strategic sector, it is essential that the EU can act as a single voice through an institutionalised body to effectively represent our strategic interests.

We therefore advocate that what is done today by ESA and EUSPA can be done in the future by a fully European Union-led Space Agency - whether this is achieved by transforming ESA into an EU agency, by dissolving and re-founding it on paper only, or by transferring its responsibilities and tasks to a new, ad hoc created EU agency. This will ensure that ongoing scientific programmes are not interrupted and that ESA's bureaucratic structures are changed as little as possible. The states that are members of ESA but not of the EU (Norway, Canada, Switzerland, United Kingdom) are guaranteed a special partnership agreement that continues their current membership of ESA.

This will ensure that the Union has full control over its Space policy, while at the same time ensuring greater efficiency and better use of economic resources by bringing together the current EU institutions dealing with Space into a single body at a later stage.

At the same time, we believe that all geographical levels of the Union (not only EU-wide, but also local and national) should play a role in accordance with the principles of subsidiarity and distributed leadership. We support local space-related companies, initiatives and scientific activities.

C. Geo-return policy

To keep up in "New Space," Europe needs more cross-border cooperation, more speed, and more courage.

ESA was successful in the old world, where Space funding was provided by governments, resulting in a stable foundation for European (and global) Space activities.[95] The money for the Space industry was secure and did not encourage risk-taking in the development of new Space technologies. Consequently, the Space landscape has not changed significantly in the last 30 years.

The geographical return, or "Geo-return," policy is a fundamental pillar of ESA's structure. At **the heart of this concept is the desire of European nations to develop their high-tech sectors and engage in Space activities.** In other words, **ESA member states pay a membership fee to ESA and get equivalently valued high-tech Space contracts back for their industry under the Geo-return agreement.** This is the main incentive for smaller European countries to be members of ESA, as they are not able to compete for Space contracts on a competitive basis.

[95] Clemens Rumpf, 2015, Increased competition will challenge ESA's space authority, The Space Review, February 2, 2015, available at: https://www.thespacereview.com/article/2687/1

This policy is not aimed at increasing efficiency, but has other goals, such as the development of high-tech sectors in member nations.

This approach succeeded in preserving the status quo. Today, however, we are entering an era in which efficiency is the most important factor in Space contracting, as private investment accounts for an increasingly large share of the Space industry.

For the Ariane 6 launcher, ESA has scrapped its fundamental principle of Geo-return in order to compete with SpaceX cost standards. The significance of this step cannot be overstated.

Unlike ESA, **this dilemma does not exist a priori with the EU, as EU contracts are awarded on a more competitive basis.** Therefore, the EU has good reasons to strengthen its authority in European Space, as its infrastructure is already set up for a competitive market.

Nonetheless, **there are other areas where commercial considerations are not decisive. Science and exploration missions as well as human spaceflight are examples of such areas.** These areas have a good chance of experiencing a continuation of ESA principles because they strengthen Europe as a whole.

Based on several factors (including increasing internal competitiveness, maintaining fairness and political stability), we recommend moving forward with the progressive revision of the current Industrial Return Coefficient to increase market competitiveness and foster innovation. In this way, stronger innovation would emerge in all sub-sectors where commercial considerations are decisive. Political stability should be maintained by allowing Member States' industries the time they need to adjust to change through staggered reform.

D. Role of an International Space Agency (ISA)

We also want to call for the **establishment of an International Space Agency (ISA)** to enhance international collaboration and technology transfer. This would enable humanity to pursue goals of common interest in the exploration of Space exploration and the advanced exploitation of the solar system. This could be established within the United Nations or as an independent entity within the United Nations Office for Outer Space Affairs serving as a bridge. The agency could be responsible for promoting ambitious international Space missions and infrastructure, such as the development of future Space access systems like Space planes and Space lifts, the construction of Space habitats and space-based solar power satellites, and the coordination of an international human Space flight mission to Mars and its eventual colonisation. In addition, it may be crucial to advance sustainable development goals and enable the democratisation of Space by supporting current non-spacefaring nations and providing them with the necessary technologies and capabilities to ensure that no one is left behind in the race for new Space.

Increased international cooperation for such advanced projects would be an excellent symbol of world peace and cooperation that could enhance parallel efforts to combat climate change. It should be emphasised that the pursuit of such common interests for the benefit of all is difficult to achieve with national Space agencies with national interests. Apollo was primarily motivated by political competition rather than a desire to gain a competitive advantage in lunar exploration, which is comparable to US Artemis rhetoric about American Boots on the Moon with American rockets. Furthermore, the agency could:

- simplify project management of international programmes;
- contribute to the development of standards and principles for safer Space together with the proposed international tribunal;
- collect and disseminate Space information as a clearinghouse.

We would like to emphasise that the ISA will only be in charge of **executive and operational tasks.** Legal issues, such as Space traffic management, should be addressed by **a new international tribunal.**

E. International Regulatory Agency (IRA)

In addition to the International Space Agency, we also want the European Union to push for the development of an International Regulatory Agency (IRA), similar to the International Civil Aviation Organisation (ICAO) and the International Tribunal for the Law of the Sea (ITLOS).

The agency would promote the implementation of international on-orbit services, rendezvous, proximity operations, Space debris de-orbiting and safe disposal, as well as standards for technical interfaces, designs, operations and transparency to foster best practices, commercial participation and technological development to enhance these Space activities.

In the context of the introduction of Space tourism and international suborbital travel, it is not only important to develop sustainable and reusable crewed launchers, but also to define and harmonise aerospace law regulations to guarantee safety standards and prove jurisdictional support to incentivise their development. Europe should therefore **lay the basis of suborbital travel and Space tourism in European and national laws** and **push for international agreements to extend the scope of**

ICAOs or establish a new international civil association for suborbital travel and Space tourism. In summary, the deployment of these tribunals could create the necessary international framework for:

- Space debris mitigation;
- Space traffic management;
- Space transportation environmental impact;
- satellite light pollution regulations;
- safety standards for crewed missions, Space tourism and suborbital travel (together with ICAO);
- Space mining guidelines and regulations;
- planetary protection policy;
- standardisation and principles for safer Space, similar to the International Organisation for Standardisation (ISO) and the Consultative Committee for Space Data Systems (CCSDS).

F. Policy Recommendations

R.8.1. Europe's trade agreements with third countries shall be used to ensure the correct implementation and application of sustainable policies, practices and incentives for Space access, exploration and exploitation. This is of particular importance for the problem of Space debris, as there are currently no international treaties.

R.8.2. Europe should increase expenditure on European Space programmes and associations to at least one tenth of our defence expenditure. The level of funding, organisation and ambition in Space exploration and human spaceflight shall be at least comparable to that of NASA and CNSA.[96]

R.8.3. Member States should push for the creation of a European Union-led Space Agency, encompassing the current ESA and EUSPA activities, subject to a wider EU oversight and linked to long-term European policy objectives. This also applies to highlighting the benefits of the coupled approach.

R.8.4. On the basis of several factors (including increasing internal competitiveness, maintaining fairness and political stability), we recommend to go forward with the progressive revision of the current Industrial Return Coefficient to increase market competitiveness and foster innovation. his would create more pressure for innovation in all sub-sectors where economic considerations are decisive. At the same time, political stability should be kept in mind by giving Member States' industry the necessary time to adapt

[96] According to Euroconsult, the EU contributes to 9% of global investment in space exploration. Larrea Brito, N., Clarence Dee, J. and Seminari, S., Global Prospect for Space Exploration: A Strategic and Economic Assessment, IAC - The CyberSpace Edition, 12-14 October 2020. IAC-20,A3,1,4x57292

to change by staggering the reform.

R.8.5. Based on several factors (including political symbolism, the desire for world collaboration and the need for strategic autonomy), we recommend continuing the collaborative model for large Space missions and become an equal partner for human Space flight activities for Moon and Mars exploration, as well as developing a strategic autonomy in the development of cost-effective European crewed Space transportation and sustainable Space access systems.

R.8.6. Europe should push for the creation of an International Regulatory Agency (IRA) similar to the International Civil Aviation Organisation (ICAO) and International Tribunal for the Law on Sea (ITLOS), to promote the implementation of international standards for on-orbit servicing, rendezvous, proximity operations, Space debris de-orbiting and safe disposal, as well as standards for technical interfaces, designs, operations and transparency to foster best practices, commercial participation and technological development to enhance these Space activities.

XII. Education and outreach

Considering the scarce awareness of ESA among Europeans, we aim to increase the importance and relevance of its work for citizens.[97] Continuous education is one of the tools to provide the population with comprehensive information on Space activities and costs at every stage of life. We want to raise awareness of Space projects, their effects on global society and individuals, the opportunities that Space technology offers for everyday life and to stimulate economic growth. This task should not only be carried out by the ESA, but also by national and European institutions, which should work to ensure that Space as a discipline is easily accessible and available to everyone.

Considering that most Europeans share the feeling of the European Union as a central and competitive player in the Space arena, we want to make Space even more appealing for its citizens by investing in more interactive participation between the ESA and the public. This could be possible in various ways, such as the presence of European astronauts at public events or in schools, or the establishment of an official ESA Museum dedicated to European Space history. Through the museum, it would be possible to give our citizens a more tangible relationship with European Space activities - for example, through interactive tours, educational support, tours, movies and merchandising. Another source of information must be the national Space agencies and Member States. Thanks to language and geographical proximity, they can increase the impact of Space knowledge on their citizens, both through national programmes and space-related university studies. These studies should be as interactive and interdisciplinary as possible, ranging from science to history and from medicine to art. We believe that investing in culture and education gives Europeans access to knowledge that brings them closer to building a better Europe together.

A. Policy Recommendations

R.9.1. Member States should include more affordable Space studies in all educational levels' curricula, with a comprehensive review of Space science, engineering, and applications, as well as inclusion of Space aspects throughout the curricula, particularly in non-space-related areas where Space

[97] About 17% of the Europeans had never heard about ESA, and only 37% knew exactly what ESA is. This survey was carried out by Harris Interview in December 2018 on a sample of more than 5000 people in France, Germany, Italy, Spain and the UK (the five most populous ESA countries). Survey available at: https://www.esa.int/About_Us/Welcome_to_ESA/How_much_do_European_citizens_know_about_space

applications could bring synergies.

R.9.2. Member States must address the lack of female students in space-related studies and STEM subjects, as well as raise female students' awareness of Space issues and professions in order to motivate them to participate.

R.9.3. Europe should promote cooperation between ESA and European artists and the film industry, as well as provide financial incentives for filming at ESA locations.

R.9.4. We recommend the creation of an official ESA Museum dedicated to European Space history, which currently houses the ESA's archival documents (Historical Archives of the European Union, Fiesole, Italy).