Volt’s Space Policy
A Collaborative and Exploratory Space Strategy for Europe
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1. 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€ invested in space returning 6€, according to ESA. Europe is currently a world leader in Earth Observation and provides numerous opportunities for Small and medium enterprises. Despite these, it was identified that Europe is lagging behind compared to other space-faring nations, particularly in space exploration and human spaceflight. Furthermore, it is necessary to highlight the benefits which 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 its 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 life and the European economy by creating new technologies and jobs while supporting our policies and priorities.

In 2019, the Space sector generated a global revenue of 271 Billion Dollars\(^1\). 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. Such services, as Earth Observation, Navigation and Communications, currently receive a large policy support because of its 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 their 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 these, spaceflight and explorations 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 policy strategies should include the long term strategies of terraforming Mars, Venus and fixing our planet, colonization of 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 manufacturing of computer chips and in the biomedical field of research with the development of treatments, implants and vaccines. Planetary defense 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

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\(^1\) SIA “State of the Satellite Industry Report”, 2019
https://sia.org/news-resources/state-of-the-satellite-industry-report/
cultural breakthroughs. Future space habitats could also allow us to shift the bulk of the heavy 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. We therefore 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, but 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 could inhibitate all of our space assets and dreams, and produce 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 for 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 proceeding 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 Volt needs a Space Policy?

Volt’s space policy was created for various reasons, including:

- Volt does not have a space policy. In general, this is not addressed by political associations at campaign stages. We consider this a failure to empower citizens to address space aspects, its benefits and its 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 frontier, 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 programs 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, questioning the peaceful uses of outer space. The resulting in-space military tests could pose a threat to our orbital resources through the already high
risks of an uncontrolled escalation of space debris resulting from the increasingly crowded earth orbits and past unsustainable spacecraft designs. There is therefore 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 a larger 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 the access to space and the widespread use of space technologies in our everyday life easier and cheaper, as was done with solar technology, medical tools, and fire-fighting equipment. Furthermore, space flight activities enhanced innovation by inspiring society. As an example, the Apollo programme led to an increase in science and advanced engineering degrees, which would later contribute to improve our world and achieve technological and scientific breakthroughs.

A common policy on space is of strategic importance for Europe. The space industry does not only foster innovation, wellbeing and economic growth, but it 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 will enable humanity to become multi-planetary, mitigate the risks of asteroid impacts, and will 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, exploiting the best of our capabilities, and that these are the main drivers to sustain social productivity and economic growth in the information era.

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. In-situ resource utilisation will provide the means to further explore the solar system, and through asteroid mining we will

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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.
5 Long, X. “Scientific and technological innovation related to real economic growth”, ISSN: 2516-1652
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 which will benefit society through technological transfer, as for efficient water-scarce agriculture practices for desertic regions. The subsequent terraforming activities will also provide us the tools to consciously re-engineer our Earth’s climate and environment to prevent climate change, enhance biodiversity and assure its conservation and sustainability for millenia.

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 in 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 temperature below 1.5 degrees with 66% of 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.


Currently, the European Union is one of the world 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 pivotal role in human spaceflight lunar and mars exploration missions along our international partners\(^8\). 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, legal, political and technical challenges shall be solved, such as enhancing our space transportation sector with state of art sustainable space access capabilities and autonomous crew capabilities, and for 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 distribution of its

\(^8\) 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
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. This policy provides recommendations and guidelines to get there.

C. Space Policy Goals and Objectives

Our Space policy wants the European Union to be leaders in making humanity a space faring civilization by proposing a deeply explorative and exploitative 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 colonization 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

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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 space industry’s ecological impact

❖ **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

The 6 Space Policy Goals for Europe
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 on the 5+1 challenges that Volt aims to tackle with its activity.

1. Smart State

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

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. At the moment the EU is investing over €12 billion in space activities for the period 2014-2020. The return on investment is estimated to be really high compared to other possibilities. Indeed, it is estimated a direct return of €3-4 for every euro allocated. Advanced exploitation capabilities from space mining, space based solar power and colonization of other planets could result in even higher returns.

3. Social Equality

Space activities contribute to all 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.

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11 EU space policy - Consilium (europa.eu)
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

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 which know about the benefits and opportunities that space offers.

6. EU Reform

The policy tackles the need for larger collaboration in space matters in the European Union, and a larger financial effort to achieve our exploratory and exploitation goals, and to guarantee a 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

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demonstrated by ESA and its international partners, brought us at the verge of a new epoch of scientific discoveries, 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 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, supernova, 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.

In this perspective, Volt believes that Europe should and can be a leading player on this endeavor. 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 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 the possibility for ESA to become a funding agency for space research and cultural projects to be performed by its member states. This would allow ESA to directly support space research and outreach activities across Europe in a more harmonized 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 are researches that are 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 1400 kilometers distance\(^{13}\). 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 waves observatories are not competitive, but complementary.

**B. Search for life**

Recent progress in the fields of astrobiology and astronomy, findings of possible 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 speculations that life may be thriving in the universe. Currently, large efforts are being focused towards 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 and the Roscosmos Space Corporation are currently planning to launch Exomars in 2022, whose 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.\(^{15}\)

Furthermore, exoplanet research is progressing at advanced leaps since the first confirmed detection of an exoplanet in 1992, which is leading 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


\(^{15}\) N° 6–2020: ExoMars to take off for the Red Planet in 2022, link accessed on 23/12/2020 https://www.esa.int/Newsroom/Press_Releases/ExoMars_to_take_off_for_the_Red_Planet_in_2022
missions for exoplanet research, CoRoT and CHEOPS, while future missions as Ariel and Plato are devised.

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, with radio communication or by sending interstellar probes\(^\text{16}\). Recently, the first two interstellar objects were discovered, Oumuamua and Borisov, which rises these possibilities\(^\text{17}\) and calls for future rendezvous missions.

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\(^\text{18}\). 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), hypothesised as a potential communication channel. Workshops as the time also concluded that it was timely and feasible to perform serious searches with modest resources and enormous spillover benefits\(^\text{19}\), and numerous leading scientists, including Carl Salgan and 7 Nobel prize winners, urged for a systematic worldwide search for extraterrestrial intelligence\(^\text{20}\). R&D efforts continued with worldwide searches including European Union member States and a NASA official SETI program, with projects such as the HRMS search\(^\text{21}\), which have currently studied a minuscule fraction of our galaxy. Future concepts include highly efficient ultraviolet receivers constructed directly in space or in the Moon, preventing atmospheric absorption\(^\text{22}\).

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\(^{21}\) H. Paul Shuch “Searching For Extraterrestrial Intelligence: SETI Past, Present, and Future”, 2011, Springer-Verlag

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 with enormous media coverage combined with its small budget share compared to other NASA activities prevented broad geo-political support. Only recently, a dedicated budget for techno-signatures search has been granted\textsuperscript{23}. SETI research is essentially an easy political target\textsuperscript{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 to develop a long term comprehensive plan in combination with other space agencies and scientific community.

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

\textbf{C. Policy Recommendations}

\hspace{1cm}\textbf{R.1.1.} Increase efforts for astrophysics and exoplanet research.

\hspace{1cm}\textbf{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.

\hspace{1cm}\textbf{R.1.3.} Creation of ESA division for Search for Extraterrestrial Intelligence (SETI) research and develop a long term comprehensive plan in combination with other space agencies and the scientific community.

\hspace{1cm}\textbf{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 amount 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 by 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 neighboring orbits. This not only puts the critical space infrastructure (telecommunications, observation, navigation, weather forecast...) 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 cataloging of all objects in the Earth vicinity, providing a consistent, complete and up-to-date characterization of objects

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• Well-organized and sustainable allocation of orbits for new spacecraft

• Traffic management with a defined “Space Code of Conduct”, attributing maneuvering priorities, and supporting legal issues and insurance cases

• Enforce the legal obligation to design for safe collision avoidance maneuvers 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 center 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 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 shall implement debris mitigation measures and mandatory decommissioning. These could be enforced to private companies through national law penalties for non-conformance 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. 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 to all member states.

• Raise awareness of the space debris problem to empower european citizens and its political and economical leaders so that they become aware of the

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27 European Space Agency (ESA), “Clean Space”
potential global threat\textsuperscript{30}.  

Furthermore, mega-constellations offer a unique space architecture which 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, \textit{luminosity contamination assessments shall be performed for european space missions} and adherence to regulations in european and national law \textit{following the assessments and recommendations from the astronomy community}\textsuperscript{31}

\section*{B. Eco-design principles and the Sustainable Use of Space}

Space applications can have enormous advantages to combat climate change and environmental destruction. Nevertheless, also within the space industry the environmental burdens will continue to increase along the expected growth in the space industry 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. It is therefore necessary to properly investigate its potential impact for accountability along with all of our human activities. The United Nations Committee on the Peaceful Uses of Outer Space already adopted some 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\textsuperscript{32}. In the European Union, inter-sectoral environmental regulations already affect some aspects of the space industry, and some national legislation exists which particularly address 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\textsuperscript{33}. Volt Europa already promotes ambitious actions to regulate and mitigate these environmental effects applied to all industries, such as for climate change with the proposed Hybrid Emission System and strict emission reduction objectives. We therefore propose to \textit{push for the adoption of these guidelines at national and european legislative level to investigate and mitigate the space sector impact on humans and the environment with Life Cycle Assessments (LCA).}

\textsuperscript{31} It is advised to keep close track of their recommendations and workshops, as of the recent UNOOSA workshop on \url{Dark and Quiet Skies for Science and Society}  
\textsuperscript{32} UNOOSA, \textit{“Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on Peaceful Uses of Outer Space Adopted”}, Press Release, 2019  
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 advanced analytics center to process the data and anticipate scenarios as ahead as possible. It would be responsible for:

1. Transparent and collaborative tracking and cataloging of all objects in the Earth vicinity, providing a consistent, complete and up-to-date characterization of objects
2. Well-organized and sustainable allocation of orbits for new spacecraft
3. Traffic management with a defined “Space Code of Conduct”, attributing maneuvering priorities, and supporting legal issues and insurance cases
4. Enforce the legal obligation to design for safe collision avoidance maneuvers and safe de-orbiting

R.2.2. **Increase financial support to the Clean Space initiative**\(^\text{34}\) 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. These could be enforced to private companies through national law penalties for non-conformance\(^\text{35}\) 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**\(^\text{36,37}\). 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.

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\(^{34}\) European Space Agency (ESA), “Clean Space”


\(^{36}\) Committee on the Peaceful Uses of Outer Space (COPUOS), “Space Debris Mitigation Guidelines”

\(^{37}\) European Space Agency (ESA), “ESA Space Debris Mitigation Compliance Verification Guidelines”
**R.2.6.** Push for a UN Space Treaty to implement legally mandatory guidelines for space debris mitigation to all member states.

**R.2.7.** Raise awareness of the space debris problem to empower European citizens and its political and economical leaders so that they become aware of the potential global threat.

**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.

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

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39 It is advised to keep close track of their recommendations and workshops, as of the recent UNOOSA workshop on Dark and Quiet Skies for Science and Society.
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 a half of the global commercial satellite market in 199741.

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 in the near horizon, from 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 requires 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 be also 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 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 these, 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 doing in USA, China, or other countries (up to date, only american rockets have

been reused, and no small rocket european companies are operating). There are also many potential concepts, limited budget 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, which could eventually hand in their operations to different companies to foster commercialisation and further reduce the 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 takes 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. For electric propulsion, Europe currently funds these devices through the

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42 The electric propulsion devices have been used to cost-effectively extend the life times of low orbiting satellites such as GOCE.
EPIC project, 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. If made available for human space flight this could drastically reduce trip times for interplanetary missions, such as an Earth-Mars mission, thus minimizing radiation exposure for astronauts. There are also additional technologies which might bring breakthroughs, as fission propulsion, Magneto-Inertial Fusion 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. 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). Since 2009, RTGs using Americium-241 as a heat source, have been developed as part of an ESA funded program. Americium can be separated from spent nuclear fuel using current nuclear reprocessing. This way RTGs provide a market for the reuse of nuclear waste. 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

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43 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
foster commercialisation and further cost reduction after 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 as skyhook systems, orbital airships, magnetically assisted launches, and space elevators. Push for international collaboration for their 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 to 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 “utilization” will come, its building blocks are assembling now, and Europe should not be left behind. Human space-flight enables an enormous flexibility when it comes to space missions, and can bring significant advancements in life-sciences and medicine fields, and 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. 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. Taking the lessons learnt from the ISS, bridge ground industries (for example pharmaceuticals, fluids, energy, construction/manufacturing, telecommunications…) with the space industry to develop purpose-built module(s) for production applications at scale, making use of the unique space environment. These applications may be divided into Earth benefits and Space benefits: developing sustainable trading in orbit. These should also enable crewed applications which will be decided on 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 utilization for industries.

The EU should also seek international collaboration for human space-flight, with Elements on the critical path of the above solutions preferably operated by Europe or at least, shall be developed by European partners to ensure strategic autonomy. They
should however have a level of compatible interfaces to US Artemis and LEO commercialization initiatives, for safe 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 the role of providing commercial space stations for Europe and the rest of the world. The potential economic returns of these endeavors should satisfy long-term global societal development first and foremost and 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

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 its 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 & Lunar program is as follows:

MOON:

- Orion with European Service Module — 2021
- Orion landing on the Moon — by 2024
- Gateway first European experiment — 2022 with 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:
  - First element, NASA Perseverance, rover — currently on Mars

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52 ESA, “European vision of exploration”, online, [Accessed on 25/02/2021] https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/European_vision_of_exploration
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 landing, whereas NASA is leading with pioneering human exploration projects such as the Artemis program or the Mars Direct and Semi-direct concepts.

It is fundamental to pursue further ambitious projects. The Moon 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 analog 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.

Mars is a marvel for our current civilization. Being the 4th planet near the sun, its 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 in certain habitable spots and its subsurface lakes. 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 & 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 the knowledge of our own planet through comparative meteorology, hydrology, and planetary evolution, climate history. These studies will not only allow for planetary engineering to make mars habitable again, but will also serve as a testbench to increase our knowledge on these

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53 “Water on Mars: discovery of three buried lakes intrigues scientists”, nature, accessed on 02/03/2021 https://www.nature.com/articles/d41586-020-02751-1
technologies for application in other planets and even on Earth to revert environmental destruction and climate change. These terraforming efforts could start as early as 2045 and be completed within 2 centuries.\textsuperscript{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 colonization 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 for life support, 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, and 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 \textit{more} than worth it through eventual exploitation activities and technology transfer for non-space sectors and applications, both in political, P.R., scientific and financial/economic terms.

The technology developed on the Moon & Mars (as life-support & 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 desert, 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 & 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 has just (19th February 2021) reached orbit around Mars, is a good example of this kind of program: As 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

\textsuperscript{55} “Mars: Bringing a Dead World to Life”, Life, May 1991, pp.24-35
result in technological innovations that will make their way back to Earth.

It is therefore key to support the development of ambitious concepts for Moon and Mars exploration which leverage on international collaboration with the European Union as a key and equal partner. Europe shall push for an ambitious international Mars exploration program which 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 gas giants and kuiper belt objects. Interior water oceans have been confirmed in some of Jupiter and Saturn's moon, 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 its 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 performed a flyby of these planets, discovering surprising features such as Triton's geysers. Therefore, they remain relatively unexplored and chances of major breakthroughs in planetary science are high. Recent exoplanet surveys have detected a relatively abundance of similar “icy worlds”\(^{56}\), and even of surprising mini-Neptunes and super Earths. This is leading to many questions on our solar system formation, and by studying these planets, it will be possible to increase our knowledge on the evolution of our solar system and habitability of the galaxy. Europe should support flagship missions to study these icy worlds.

Interstellar missions are also slowly becoming a reality and entering in the agenda of key space players, as for 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**

As the international space station is 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

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\(^{56}\) “Destination Uranus! Rare chance to reach ice giants excites scientists”, Nature, March 2020, https://www.nature.com/articles/d41586-020-00619-y
contributed to innovative discoveries in life sciences research and for in-space manufacturing. It is now known that it's possible to plant in space and an upcoming mission will study efficient extreme agriculture which could have incredible applications to support food production in desertic earth regions with extreme environments and even in Mars.

Future commercialisation of space station operations will build among ISS discoveries and infrastructure and allow private industries to explore their 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, past studies showed the potential applications and feasibility of large space stations, as the O'Neil cylinders. These could support a growing human population, enable full space exploration activities and allow for in-space manufacturing of necessary infrastructure, such as for space based solar power, astronomical observatories and mining. It is necessary to invest in a technological demonstrator roadmap which can serve as proof of concept and bring these space habitats to reality.

### D. Policy Recommendations

**R.4.1.** Support the development of ambitious concepts for Moon and Mars exploration which leverage on international collaboration with the European Union as a key and equal partner.

**R.4.2.** Europe shall push for an ambitious international Mars exploration program which culminates with 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.** Bridge non-space industries (for example pharmaceuticals, fluids, energy, construction/manufacturing, telecommunications…) with the space industry to develop purpose-built module(s) for production applications at scale, making use of the unique space environment. These applications may be divided into Earth benefits and Space benefits: developing sustainable trading in orbit. These should also enable crewed applications which will be decided on case by case basis and pending on member states priorities, which

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may eventually replace the ISS European activities.

**R.4.5.** 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 utilization for industries.

**R.4.6.** Leverage on the potential for commercialisation to reduce costs in the different segments and concrete business cases, which may eventually take the role of providing commercial space stations for Europe and the rest of the world. The potential economic returns of these endeavors should satisfy long-term global societal development first and foremost and be fairly distributed among partners (whether EU or non-EU), and preclude the prevalence of one single player/nation.

**R.4.7.** Seek International collaboration for human space-flight, especially on non-critical path elements which can be proactively opened to the global space community.

**R.4.8.** Guarantee European strategic autonomy in crew space access and lunar and Mars robotic exploration.

**R.4.9.** One of the main dangers of any crewed trip 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. To find a solution to this problem, we recommend Europe increase its research into effective radiation shielding technology and microgravity survival. An ideal location to do this would be the surface of the Moon, which is still close to Earth (relative to Mars) but nevertheless requires several technological breakthroughs to be made habitable; especially in the fields of radiation shielding and the problem of keeping human beings alive and healthy in a minimal gravity environment.

**R.4.10.** Implement an ambitious agenda for the full exploration of the solar system ocean worlds which will culminate with the robotic exploration of the interior oceans.

**R.4.11.** Perform a flagship European mission for the exploration of the icy worlds of Uranus and Neptune.

**R.4.12.** Plan a technological roadmap for robotic interstellar missions to Proxima Centauri and other solar systems

**R.4.13.** Support the commercialisation of low Earth orbit orbital space stations.

**R.4.14.** Increase European efforts in the upcoming Lunar Gateway development, manufacturing and operations.
R.4.15. Support research in the manufacturing and applications of future large space settlements and a technology development roadmap including demonstrators.
VIII. Providing public goods and benefits to Europe and Beyond

Large space projects, from the establishment of a GPS network and an earth observation system, to the creation of large space habitats, require large upfront investment, involve many positive externalities and may have numerous risks which 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 citizens’ lives by investing in key space projects, and that they are backed by key political figures. In addition, a broad political base is needed, requiring transparent political support and consideration of major public concerns. Commercialisation can further contribute to the development of these assets, and can even take a larger role in finding new business opportunities by building upon governmental R&D inertia and its infrastructure, as seen with the recent large increase in venture capital investment in suborbital travel and space transportation.

A. Communications

Providing citizens and business actors with a European based location and navigation service is critical in order to improve the quality of our citizens’ lives on Earth. In fact, thanks to several services, like communication and navigation, our satellites enhance the transmission of data and information making their transfer faster and their influence wider.

By providing a simple example, a faster and wider transmission of data with broader coverage of signal, would enable the unmanned aviation sector to conduct safer operations. This would mean, in practical terms, fostering the companies that are leading the efforts to integrate unmanned aviation in our European Single Sky and assuring safe operability of UAS into urban and remote areas, from monitoring illegal fishery to transport of vaccines. In fact, Volt thinks that providing citizens with connection is critical to get everyone involved in an always more intertwined and globalized world.

Our telecommunications infrastructure should also be sustainable and compatible with radio astronomy and SETI research. These studies typically employ passive strategies over key frequencies which can range the full spectrum. Currently, the International Telecommunications 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

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with commercial or military users. It is therefore fundamental to push for a flexible frequency allocation system by the International Telecommunications Union which guarantees temporary and permanent observation rights for the studies of these sciences, at least until an ambitious space based or Moon radio astronomy observatory is developed.

B. Navigation capabilities

Navigation systems allow us to determine our precise position, with huge applications ranging from downstream use of geolocation services, to the precise orbit determination of our Earth satellites. Europe is currently deploying and using the Galileo system. Certain concepts currently under study include the augmentation of the GNSS system by using LEO satellites\(^{59}\). These concepts should be supported and explored to augment our European Galileo system.

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

C. Earth Observation: Protecting humanity

At the current state of our knowledge, our planet is the only one in the Universe able to sustain life as we know it, despite nowadays groundbreaking scientific discoveries of thousands of exoplanets orbiting around 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 of global phenomena over time, such as climate, desertification, and water distribution. Because our planet is experiencing sudden and continuous changes, it is paramount to monitor the sustainability of the growth of both our population and economic system.

To achieve such an ambitious goal, Earth observation and climate monitoring with satellites is needed\(^ {60}\). Indeed, reliable data, fast monitoring, and global coverage are fundamental requirements for the Earth observing programme, and this can only be achieved with a large fleet of coordinated satellites. Actually, 26 of the 50 essential

\(^{59}\) Lei Wang, Zhicheng Lü, Xiaomei Tang, Feixue Wang, “LEO-Augmented GNSS Based on Communication Navigation Integrated Signal”, 10.3390/s19214700

variables to assess climate change are monitored with satellites\(^6^1\). An example of what Volt aspires is the European Union’s Earth observation programme Copernicus that is 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), and the EU Agencies and Mercator Océan. Copernicus aims at a wide range 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 organizations to improve the quality of life of the European citizens and the whole world who would also have full, open and free-of-charge basis access to that information. This would thus allow many new downstream services to be developed for the advantage of all.

As an example, satellite data from the Copernicus programme can be efficiently used to track national greenhouse gas emissions inventories and other pollutants to support monitoring and verification tools and ensure the success of the Paris Agreement.\(^6^2\) The European Commission is currently developing the technologies and systems, as with the CO2M mission, required to have operational space-borne instruments within a constellation of satellites tracking global emissions and land-use change with high temporal and spatial resolution by the end of the decade, which can 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 guarantee a stricter Emission Trading System compatible with the 1.5C of maximum global warming target which requires immediate policy action. We therefore propose to **increase efforts to accomplish the development of an observation-based GHG monitoring and verification capacity system in a shorter period of time to efficiently accomplish our energy transition goals**.

It is indeed for ‘all’ that Volt calls for a stronger EU to be a positive global player that recognizes what Copernicus embodies: Volt’s core values of cooperation, sustainability, solidarity, and innovation. Moreover, Volt acknowledges that in the European space field 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 vision, funding, and technology required to develop the most ambitious earth observation program ever attempted.

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D. Startups and Increasing Accessibility to European space information from the Copernicus programme

It is necessary to also increase the dissemination of space technologies to develop a larger set of applications for our citizens. Recently, a large number of space startups are arising with the support of venture capital and numerous business incubators. We believe that 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.

In the context of Earth Observation downstream SSME and use of Copernicus data, for example, it might not be enough to just provide raw data to the market, but to also develop key applications and platforms with public agencies to increase the dissemination of knowledge and know how and incentivise the appearance of an efficient commercial sector. In addition, a strong reference to privacy and data protection is missing. Considering the effort the EU puts into privacy, and that Earth observation and surveillance might be a threat to it as technology progresses and commercial applications in the downstream sector evolve, it would be useful to show our interests in citizens’ data and private lives.

E. Space, Public Health and Pandemics

Following the Covid-19 pandemic of 2020, the global community has realised that infectious diseases spread across the planet as well as the human population has been doing since the very beginning. The difference with the past is that nowadays we are strongly interconnected, a phenomenon that will only increase as transportation technology will innovate and develop further. While interconnectivity of a global ecosystem helps infectious diseases to spread at a high pace, it also led humanity toward great achievements in several fields of scientific and cultural innovation as well as tighter international cooperation.

In fact, thanks to international cooperation, data collection and redistribution is growing and it is becoming more available via satellite technologies and high quality coverage, such as the Geographical Information System (GIS) and Earth Observation (EO).

A major European effort in collecting this data collected via Space would help European scientists to develop more precise models to\textsuperscript{63}:

\begin{itemize}
  \item analyse and track the risk of outbreaks
  \item monitoring environmental factors, such as air quality or human-animal or
\end{itemize}

\textsuperscript{63} ISU, “The role of space during pandemics”, ISU Team Project report, 2020.
human-human interaction

- monitor the spread of infectious disease, geographically and quantitatively
- Monitor the production and distribution of vaccines globally (via GIS)

Through these tools, the European Union could lead in assessing the impacts that diseases might have on the public health of its citizens and the rest of the world.

Volt believes that the EU can play a major role in tracking the supply chain networks in order to counter the impacts of diseases at any stage and hazardousness level. In order to do so, the EU should invest in satellite technologies that help identifying safe and viable transportation routes, and also in unmanned aviation as a tool to deliver critical medical and subsistence supplies in hard-to-reach areas.

Volt’s Space Policy promotes the use of electric, ergo 0 emissions, automated transportation, unmanned aircraft systems, and teledicine as tools that would provide an immediate rapid response guaranteed by the reliability of Space technologies in a safe and predictive way. An efficient use of these tools has to come from the use of GNSS, backed by LEO satellite constellations, and, through the European Union commitment, via a high coverage for communication networks supported by 5G.

These tools will enable the EU healthcare providers to perform diagnosis and treatments with more accurate and punctual information, while, at the same time, provide healthcare services to as many medical patients as possible while mitigating the spreading of infectious diseases or the degeneration of critical medical situations.

In conclusion, Volt is a proponent of Space as one of the main tools to achieve greater safety in terms of public health and, present and future, pandemics. It is necessary to have warning systems connecting space data with public health institutions to monitor and prevent future pandemics. According to Volt, such achievements shall not be confined to the European Union, but the whole globe shall benefit from them in order to create a more beneficial and sustainable international cooperation.

**F. Technology Transfer, Innovation and Economic Benefits**

Volt believes in the positive spillover effect that space has on the global and European economy. As far as commercial spaceflight opportunities are concerned, spaceflight is providing a new opportunity to spur socio-economic growth through development of dedicated technological districts, new jobs opportunities, specific educational

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programmes, and side-business opportunities, such as edutainment, marketing and sponsorship, research spinoffs). Especially on the job market, space has a huge impact. In fact, due to technology innovation trends in robotic applications for industrial purposes, many jobs would be subject to high risk of automation or may experience significant changes. The purpose of Volt is to lead the discussion on the future of jobs in aerospace with industry and Member States in order to foster an organic job market and industrial innovation development.

In this context, Volt supports technological spin-off opportunities. Indeed, space industry and research can also lead to spin-off business applications in non-space industries: many of the technology innovations primarily designed for space exploration can find usage in everyday applications and in specific consumer goods R&D programmes. Supporting spin-off applications for space technologies would foster the creation of new private-sector innovative startups, creating new business ecosystems.

Space derived information and capabilities offer significant potential as an engine for new business. The aim of Volt Space Policy is to encourage EU activities that will deliver sustainable space-based services and applications to new user communities and customers through the 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 fields such as cyber security, smart cities, precision farming and fishing, climate change monitoring.

G. Fostering European Space Commercialisation while leveraging on governmental involvement

The space industry is becoming increasingly commercial with revenues from private sector activities growing exponentially and the involvement of venture capital from non-european entrepreneurs. This is leading to a highly competitive global scenario and challenging the security of supply of the European Union.

This increase in space commercialisation could bring enormous benefits by shifting spending to the optimal development in a competitive world, increase space cooperation in the international market, and could even enhance the global space exploration efforts to Mars and beyond. Nevertheless, history suggests that government involvement is fundamental when establishing key infrastructure to enable the exploitation of new territories for human involvement.

Following this rationale, we suggest to consider commercialisation/privatisation as a means to use the market economy to achieve specific targets, but not as an end
by itself. An efficient trade off shall be pursued, with European governments actively contributing to space applications with high costs and risky infrastructure and technology development, uncertain demand and long payoff periods, as in space transportation (new crewed reusable vehicles, space elevators), space science, and Moon/Mars exploratory missions and habitats constructions, and with the layout of efficient regulations to foster the participation of the private sector to contribute to an optimal infrastructure development.

Furthermore, the exploratory nature of space activities should be highlighted, and the “estimated returns” should not be the only rationale when proposing government involvement in new space assets. Science and technology research and development should remain as an important justification for space investments. We should be reminded that our civilisation can be classified currently at an early exploratory phase within the five-phased evolutionary program, where we are preparing for an eventual colonisation, resource exploitation and planetary engineering of the solar system. Our space programs should therefore be adjusted accordingly. This is not only to move beyond space, but to provide us with the necessary capabilities to monitor and engineer 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 returns” should not be the only rationale when proposing government involvement in new space assets.

**R.5.2.** Push to guarantee temporal and permanent allocations for radio astronomy and SETI research through the International Telecommunications Union.

**R.5.3.** Push for European concepts of lunar and Martian navigation systems to support our exploration missions.

**R.5.4.** Explore the augmentation of our European GNSS system by LEO satellites.

**R.5.5.** Support the European Union Earth Observation efforts and the Copernicus program. The EU should lead in the monitoring of the atmosphere, ocean and environmental issues.

**R.5.6.** Increase efforts to accomplish the development of 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.** Increase the number of European space business incubators and projects.
R.5.8. Incentivise the use of Copernicus data by also developing key applications and supporting its dissemination across the public sector.

R.5.9. Consider commercialisation/privatisation as a means to use the market economy to achieve specific targets, but not as an end by itself. Consider always how it can contribute to reduce costs of key space transportation areas and to reach our exploration goals.

R.5.10. Organise outreach campaigns involving non-space industries and companies to provide training and knowledge on potential benefits from earth observation and infrastructure, space manufacturing, intercontinental travel, etc. to enhance participation and investment.

R.5.11. Exploit space technologies to achieve greater safety in terms of public health and, present and future, pandemics. It is necessary to have warning systems connecting space data with public health institutions to monitor and prevent future pandemics. According to Volt, such achievements shall not be confined to the European Union, but the whole globe shall benefit from them in order to create a more beneficial and sustainable international cooperation.

R.5.12. Create european competitions with exploration goals and rewarded milestones based on perceived risks to guarantee short payoff. This will enhance the development of key technology and its spillover effects through the attraction of venture capital.

R.5.13. Push for an efficient trade off of public-private involvement in space activities, as with active competition in space transportation while guaranteeing a market by the government on the basis of european autonomy and security. Prevent perpetual monopolistic charters in all areas.

R.5.14. Create government programs to develop space infrastructure and technology with active involvement of the private sector and hand in its usage and operation to foster commercialisation while guaranteeing a social payoff.

R.5.15. Highlight the explorative nature of space activities when deciding for novel space assets development, not only the exploitation/or short term return on investments factor.

R.5.16. Push for international commercialisation partnerships to enhance space collaboration with other nations. Private sector should assume its responsibility as international actors.
IX. European and Planetary Defense

A. European Defense: Preserving the integrity of European Space Infrastructure, integration and orbital access

Space assets are today part of national and European critical infrastructure. Satellites provide secure communications to decision-makers; imagery for critical decision-making, from intelligence needs to agriculture and economic patterns monitoring; positioning, navigation and timing for all of us. Tomorrow, they will serve as critical data relays also for citizens, and the analytics derived from their signals and imagery will be embedded in a large range of societal applications. In parallel, commercial players are newly populating space with new business cases around the internet and internet-of-things from the sky. All of these make space infrastructure, as well as the optimal orbital locations of this infrastructure, strategic.

Despite international agreements and public speeches on the peaceful use of outer space, the US, Russia and China have long recognized this strategic value, and have developed capabilities to undermine their geo-political opponents. It is not only about surveillance and supporting ground based military assets, or sending weapons over space and identifying them from space, but now about threatening satellites.

The first apparent sign of this affecting Europe came in 2017, when a Russian satellite dangerously approached a French intelligence satellite. Europe should have no interest in encouraging such behaviors, nor does it have any power to stop the US, Russia or China from pursuing such activities. However, Europe must ensure that its critical space infrastructure and strategic orbital slots remain secure, now and in the long run.

Europe should therefore develop sufficient capabilities to identify threats, whether space or ground-based. This would involve a combination of optical and radar instruments, as well as a powerful analytics and management infrastructure, and to protect its assets if required, from space.

B. Peaceful uses of outer space

Volt believes in a continued peaceful use of space for scientific and economic activities in accordance with space law. While the bodies brought up into space can aid in strengthening the defence of European citizens and the European Union both inside and outside the EU borders, all developments should be done in accordance with the Outer Space Treaty and the Space Preservation Treaty. Space, the Moon and other celestial bodies are to remain free of weapons of mass destruction, testing of weapons of any kind and establishing military bases.

Recently, our transatlantic ally USA opened a new debate in space when they announced the establishment of a “Space Force”. This casts a light on the recent tendency towards space militarization that could lead to a new arms race. Weaponry in space is not fully banned as per the Outer Space Treaty (OST) from 1967, as it only tackled the use of nuclear warfare in space. **Space militarization goes against our core values** of a sustainable and prosperous space industry, and human expansion through the solar system. Notwithstanding the tremendous amount of casualties and environmental damage that a space based weapon could cause on Earth and the tremendous expenses and waste of resources on such a defence system, any potential use of a weapon against a satellite could trigger an enormous amount of space debris, putting at risk the whole space industry and its derivatives as stated in the space debris point. **Volt will therefore urge the EU and the UN to approve space demilitarization treaties** such as the Preventing an Arms Race in Outer Space (PAROS) and Space Preservation Treaty.

A strategy to further secure our orbital assets should also ensure sustainable space traffic management and acknowledge the space debris risks that any space weapon tests, or military campaign could provoke in our near Earth space environment. The EU should therefore **ban any weapon testing or use which could create space debris**, and **condemn foreign nations performing these**, taking the necessary actions through trade agreements and other international mechanisms.

It shall also be noticed that the use of space weapons for military purposes shall be separated from exploratory purposes. Some advanced propulsion concepts, such pulsed detonation fission or fusion propulsion, are currently under an unclear legal status. The Orion project which could have made use of our current nuclear arsenal for exploration objectives was canceled over concerns with the OST. These technologies could also have real practical implications for the development of asteroid deflection concepts. These restrictions shall be relaxed for the proper development of advanced technologies for our exploratory goals.

**C. Planetary Defense**

Technologies for asteroid detection and deflection shall also be developed. These are currently at their infancy, and we still do not have an effective warning system. Recently, an asteroid was detected just 24 hours before its closest Earth flyby, if this asteroid would have impacted over a city, it would have had generated 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 km2 of the Siberian forest. Regarding the Tunguska, it was hypothesised that this later impact may have been caused by an Earth grazing iron based asteroid, which if it had impacted, would
have created a near extinction event\textsuperscript{66}. It is necessary to get serious about planetary defense and push for an active asteroid defense system. An asteroid impact can be the first extinction event actively avoided by humans.

It is important to highlight that Dinosaurs went extinct because they didn’t have a space program.

\textbf{D. Policy Recommendations}

\textbf{R.6.1.} The EU should increase its SSA and C4ISR capabilities to protect the EU’s critical infrastructures in space and on Earth.

\textbf{R.6.2.} The EU should develop and deploy common space defense systems as a key milestone towards the establishment of a truly CSDP which will foster internal military cooperation and enable a stronger Union on the global stage.

\textbf{R.6.3.} The EU should strongly stand against space weaponization, supporting the adoption of international treaties in favour of space demilitarization and sanctioning foreign nations taking the opposite path.

\textbf{R.6.4.} Push for a reassessment of the OTS to allow for the use of nuclear technologies in space for peaceful advanced propulsion concepts and for asteroid defense systems.

\textbf{R.6.5.} Implement a European concept for an active asteroid defense system and push for a World agreement on an international effort for the establishment of an effective warning network and deflection strategy.

X. Advanced Space Exploitation

Up to know, humanity is exploiting a tiny negligible fraction of everything space can provide. Colonization throughout the solar system will not only provide us more resources to enhance our living quality, reduce inequality, and fight climate change, but an expansion of human settlements will be the seed to develop new technologies, enhanced social structures and infinite opportunities for human social and moral development. These later aspects will capitalize on the current “information era” to unimaginable levels.

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, but its universal presence within the inner solar system and in the outer regions could allow us to retrieve vast quantities of rare-earth materials, such as platinum, which are essential to meet our energy and ecological transition goals while ensuring a sustainable extraction of resources with a low carbon and ecological footprint. These capabilities shall therefore be considered essential in global space exploration and climate change efforts, and there is a need to incentivise the development of the required technologies, the appearance of new European companies aiming at demonstrating the technologies and exploiting these resources with public-private partnerships, and the development of a legal framework which can guarantee the commercial exploitation within the Outer Space Treaty.

Given the benefits that space mining could bring for space exploration and energy transition, we propose to take a progressive and egalitarian perspective towards the ownership and use of space resources. Therefore, space mining for sustainable exploration and Earth usage could be considered not to be national appropriation, and the safety zones described in the Artemis Accords could be an excellent approach to perform the described operations in accordance with the OTS. These Accords may be signed by the European Union, and we could pursue a working group for the development of an international regime for the utilization and exploitation of

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67 Amara Graps + 30 Co-authors, “In-Space Utilisation of Asteroids: Answers to Questions from the Asteroid Miners”, ASIME 2016 White Paper
space resources within the United Nations. In addition, a mechanism to guarantee a fair redistribution of resources while maintaining incentives for developing technology and performing mining operations should be pursued. This could guarantee that the lower incomes and less developed countries benefit from space mining. In addition, in the context of commercialisation, mechanisms to ensure fair competition among a variety of actors while preventing long lasting monopolies or property rights should be in place.

Space mining could be a breakthrough in space exploration as In-Situ Resource Utilisation (ISRU), for example, would allow them to extract water and propellant and build spacecraft and planetary components directly outside of Earth's gravitational well, considerably saving on launch costs and promoting human expansion through the Solar System. This is key for future human presence on the Moon. Asteroids are also a significant threat to our world. By developing these technologies we would also enhance our planetary defences by increasing our knowledge on their internal structure and composition, which would allow us to plan missions to avoid any possible disastrous collision. Furthermore, the establishment of a robust commercial space mining industry would improve our economy by bringing back enormous amounts of rare Earth materials such as platinum, as a single asteroid could be worth billions.

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

There are also numerous 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, and a recent Keck’s institute study mentioned that by 2025 we could have the technology to

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69 Many initiatives are investigating this concept. For example The Hague International Space Resources Governance or the 2019 COPUOS proposal made by Belgium and Greece.
70 Amara Graps + 30 Co-authors, "In-Space Utilisation of Asteroids: Answers to Questions from the Asteroid Miners", ASIME 2016 White Paper
retrieve a 500 t asteroid\textsuperscript{72}, and that by 2040 commercial asteroid mining could begin\textsuperscript{73}. Furthermore, some countries, such as the USA, Luxembourg and UAE, have already introduced favourable legislation inspiring and attracting new ventures. Despite all the potential benefits and regulatory push, there are some concerns with the Outer Space Treaty from 1967 which could prevent commercial companies from mining asteroid resources, and although there is consensus among experts on that it could be possible with its current formulation and with concrete “loopholes”\textsuperscript{74} that highlights the importance to reform and update this treaty. Furthermore, in the absence of an internationally clear treaty, the European Union shall use trade agreements with external countries to provide security for space commercial companies with granted exploitation patents and permissions. These could be based on preliminary surveys and speculative values, which would also allow to partially finance these operations.

Volt will encourage companies and start-ups to develop and launch missions to the Moon, asteroids and other minor bodies in the Solar System to demonstrate critical technologies such as In-Situ Resource Utilisation (ISRU) and asteroid capturing. It will do so by proposing related missions to ESA, by creating European competitions with financial rewards, similarly to the Google Lunar X\textsuperscript{\textregistered} Prize, and by funding grants, purchasing equity and reimbursing costs for research and development. We will also work on favourable legislation in all EU member states, as has already been done in Luxembourg and USA, and look for bilateral agreements with other countries. The aim is not only to bring certainty to future asteroid mining companies and ensure space resources are subject to the “common property right”, but to regulate the sector to ensure high safety standards. We will also support the establishment of an international adjudicatory body within the UN, such as it is done with UNCLOS.

\textbf{B. Space Exploration to Solve Energy and Material Needs}

Global energy demand is projected to increase by orders of magnitude in the next decades. Although classical terrestrial renewable energies are an excellent source, their scalability in the next centuries might not be enough. In addition, fossil fuels will eventually be depleted, and considering that we are constrained to consume only 7 years of actual GHG emissions, it may soon be an unacceptable energy source. Fission

\textsuperscript{72} Keck, Institute of Space Studies. “Asteroid Retrieval Feasibility Study”
\textsuperscript{73} International Space University, “ASTRA: Asteroid mining, Technologies Roadmap and Applications” 2010
technologies present other issues and its fuels will eventually become a scarcity. Advanced breeding technologies may be able to extend the lifetime of these resources, but in the long run we will run out of the radioactive material and other sources will be required to support renewable energy

1. Space Based Solar Power (SSP)

Space Based Solar Power (SBSP) is among these options, and remains one of the most-promising, but still largely unexplored. The International Academy of Astronautics in 2011 found that SBSP is already feasible and it could be realized in as little as 10-15 years. Almost a decade has passed since, but efforts have been minimal.

Three drivers force us to take into account the SBSP: growing global population, increasing per-capita energy consumption, and the need to fight Climate Change.

Harvesting solar energy in GEO, where sunlight is available more than 99,8% of the time, can be the most promising way to simultaneously tackle 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 GEO could collect almost 10 times the energy of the same solar arrays installed on the ground. Moreover, it can guarantee global supply to less accessible regions and low income countries, increasing its democratisation capabilities and directly contributing to the sustainable development goals. At present, only the United States, China, and Japan have been doing activities on this matter. The European Union cannot be left behind. The EU has to invest in this promising technology fostering its research and development. Further, close partnerships with the private sector can be mutually beneficial to lower costs.

2. Advanced fusion fuels

As humankind strives further into space, we shall need to utilize abundant in-situ resources. There is the possibility of utilizing advanced fusion fuels such as He-3, for nuclear energy fusion. Although its Earth reserves may eventually deplete, together with other energy sources, He-3 is available for extraction on the Moon and in almost infinite proportions in the outer solar system, as in the Jovian moons, highlighting the need for space exploration.

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 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 because these reactions (called aneutronic fusion) do not produce neutrons\textsuperscript{77}. The only difficulty is that the reaction rate is lower and higher temperatures are required. But with advances in super conductor technology, these conditions may very well be possible to meet. Furthermore the ionic fusion products could be captured in an electric field and their kinetic energy could be directly converted to electric power. Hence achieving a higher conversion efficiency than traditional Carnot processes\textsuperscript{78}.

With this technology, it will be not only 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 be finally possible.

C. Policy Recommendations

R.7.1. The EU should incentivize the development of technologies required for space mining and asteroid capturing for economic and planetary defense purposes.

R.7.2. Pursue a working group for the development of an international regime for the utilization and exploitation of space resources within the United Nations\textsuperscript{79}.

R.7.3. In the absence of an internationally clear treaty, the European Union shall use trade agreements with external countries to provide security for space commercial companies with granted exploitation patents and permissions.

R.7.4. Encourage companies and start-ups to develop and launch missions to the Moon, asteroids and other minor bodies in the Solar System to demonstrate critical technologies such as In-Situ Resource Utilisation (ISRU) and asteroid capturing.

R.7.5. The EU should harmonize the legal framework of ISRU among its member states and advocate for the establishment of an international adjudicatory body within the UN, owner of the register for patents and permissions.

R.7.6. Promotion of Space Based Solar Power and creation of a European

\textsuperscript{78} Direct Energy Conversion
\textsuperscript{79} Many initiatives are investigating this concept. For example The Hague International Space Resources Governance or the 2019 COPUOS proposal made by Belgium and Greece.
technological roadmap with focused investments in the creation of European space-energy startups.

**R.7.7.** Push for the development of nuclear fusion, particularly concepts using He-3, as it is available in vast 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

There is a need to further integrate European space institutions to enhance efficiency and collaboration, and increase synergies. Furthermore, it is also necessary address the low investment in European space activities in comparison to the international context, which is potentially reducing the benefits that the space economy may bring, some of which have been addressed in previous chapters. The combined military expenditure of the member states amounted to €223.4 billion in 2018, representing ca. 1.4% of European Union GDP. If the EU would spend annually just 0.14% (22.34 Billion) for the space programme, we would be able to provide funding and to achieve larger exploratory results. The current official budget of NASA is around 22 Billion USD, that is about 4 times more than the ESA Budget and around 5 times more in budget per capita. One of our central proposals is to couple the SPACE PROGRAMS and SPACE ORGANISATIONS financing to defence expenses as at least 1/10 of it.

Many of the highlighted issues, such as space militarisation, space debris and traffic management, or human exploration of Mars and the Moon fall in the scope of international space cooperation and law. For efficient policy applications, 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 harbours the largest number of space agencies in the world. On the one side, there is the European Space Agency (ESA), an intergovernmental entity where not all European Union Member States (MS) participate, and where not only MS participates. For example, Canada, Switzerland and Norway are part of the European Space Agency. Furthermore, the European Union recently announced the European Union Agency for the Space Programme (EUSPA), which will create synergies between the different EU space components. On the other hand, many MS have their own space agencies or analogous institutions, such as DLR for Germany and CNES for France.

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80 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
81 European Defence Agency, “DEFENCE DATA, 2017-2018: Key findings and analysis”
84 Self elaboration.
B. European Space Agency or Space Agency of the European Union

ESA represents a successful model of 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 on implementing the Copernicus and Galileo programmes. Nevertheless, it should be noted that ESA is an intergovernmental entity external to the European Union, and therefore subject to a different regulatory framework. It receives funding from its members, and directly from the European Union through a smaller share. This decoupled approach has different pros and cons, which are highlighted as follows:

<table>
<thead>
<tr>
<th>Advantages of a decoupled ESA/EU</th>
<th>Disadvantages of a decoupled ESA/EU</th>
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<tbody>
<tr>
<td><strong>Decoupled from European politics.</strong> A governmental space agency like NASA may be more exposed to electoral cycles, which might detriment space mission effectiveness which typically require more than 10 years from concept to execution.</td>
<td><strong>Low Political Integration.</strong> Difficult to link European political objectives and roadmaps with space aspects.</td>
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<tr>
<td><strong>Can be easier to include external EU countries,</strong> although these could also be implemented in an EU based agency (eg. Norway’s involvement in the European Economic Area)</td>
<td><strong>Geo-returns linked.</strong> Geo-return policy becomes easier to implement, as there is a direct contribution from its members, whereas the European Union share is subjected to European policy decisions. This would bring the disadvantages of a geo-return aspect with lower industrial effectiveness and regional biases. Nevertheless, geo-return policy might also be attractive.</td>
</tr>
<tr>
<td><strong>Lower EU Heritage.</strong> May be more difficult to highlight EU successes and link the benefits of EU integration.</td>
<td><strong>Less subject to EU oversight.</strong> If European political oversight, it may be possible to include larger transparency and accountability regulations.</td>
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(1) Push for a European Union led Space Agency

Volt recognizes the need for the European Union to equip itself with its own space agency. It is indeed essential, in such a strategic sector, that the EU can act as a single voice through an institutionalized body to efficiently represent our strategic interests.

**Volt works therefore to ensure 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
gained by making ESA an EU agency, by dissolving and refounding it only on paper,
or by transferring its responsibilities and tasks to a new ad hoc created EU agency.
This will be done ensuring that the current scientific programmes are not interrupted,
and with the least alteration of ESA’s bureaucratic structures. A special partnership
agreement will, of course, be guaranteed to the States which are members of ESA but
not of the EU (Norway, Canada, Switzerland, United Kingdom), in continuity with their
current membership of ESA.

This will ensure that the Union has full control over its space policy, while also
ensuring greater efficiency and better use of economic resources by unifying,
subsequently, the current EU institutions dealing with space under one single body.

At the same time, Volt believes that all geographical levels of the Union (not only
EU-wide, but also local and national) should play a part, according to the principles of
subsidiarity and diffused leadership. Volt endorses local space-related companies,
initiatives and scientific activities.

C. Geo-return Policy

Europe certainly needs more cooperation across its borders, more speed, and more
courage to keep up in "New Space".

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. 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 much in the last 30 years.

The geographical return, or “Geo-return,” policy is a fundamental pillar of ESA’s
structure. At the core of this concept is the desire of European nations to develop
their high technology sectors and to 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 to their industry as part of the Geo-return
agreement. This is the major incentive for smaller European countries to be a
member of ESA since they don’t have the capability to bid for space contracts on a
competitive basis. This policy does not aim to increase efficiency but has other goals,
such as developing high-tech sectors in member nations.

This approach was successful in preserving the status quo. However, today we are

85 Clemens Rumpf, “Increased competition will challenge ESA’s space authority”, The Space
entering an era where efficiency becomes the primary driver for awarding space contracts because private investment makes up an increasing portion of the space economy.

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

Unlike ESA, the EU does not have this dilemma to begin with because contracts from the EU are awarded on a larger competitive basis. The EU therefore has a strong case to increase its authority in European space since its infrastructure is already set up to meet 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 for such fields. These areas have a good chance to experience a continuation of the ESA principles because they strengthen Europe as a whole.

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. That way there would be a stronger force towards innovation in all the sub-sectors where commercial considerations are decisive. At the same time, keeping an eye on political stability by giving the time needed to the member states' industry to adapt to the change staggering the reform over time.

D. Role of an International Space Agency

Volt also wants to call for the establishment of an International Space Agency (ISA) to enhance international collaboration and technology transfer. This would allow humanity to pursue common interest goals in space exploration and 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 in charge of promoting ambitious international space missions and infrastructure, as development of future space access systems such as space planes and space elevators, construction of in-space habitats and space based solar power satellites, and coordinating an international human space flight mission to Mars and its eventual colonization. In addition, it may be key to push for the sustainable development goals and allow for the democratisation of space by supporting current non-space faring nations and providing them with the required technologies and capabilities, ensuring that no one
is left behind in the new space race.

The increased international cooperation for such advanced projects would be an excellent symbol for world peace and cooperation, which could enhance parallel efforts in combating climate change. It should be highlighted that the pursuit for such common interests for the benefit of all is difficult to achieve with national space agencies with national interests. Apollo was mostly a result of political competition rather than seeking true exploration benefits, which can be analogous to USA Artemis rhetoric on American Boots on the Moon with American rockets. Furthermore, the agency could:

- Simplify project management of international programs
- Contribute to the development of standards and principles for safer space along with the proposed international tribunal.
- To collect and distribute space information, as a clearinghouse

We want to highlight that ISA itself shall be only responsible for executive and operational tasks. Judicial issues, such as space traffic management, should be addressed by a new international tribunal.

**E. International Regulatory Agency/Entity**

In addition to the International Space agency, Volt also wants the European Union to push for the development of an International Regulatory Agency (IRA), similar to the International Civil Aviation Organization (ICAO) and International Tribunal for the Law on Sea (ITLOS).

The agency would push for the implementation of international on-orbit servicing, rendezvous, proximity operations, space debris de-orbiting and safe disposal, 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 lay down and harmonise the air and space law regulations to guarantee safety standards and prove jurisdictional support to incentivise its development. Europe should therefore develop the basis of suborbital and space tourism travel in European and national laws, and push for international agreements to extend ICAOs scope or develop a new international civil association for suborbital travel and space tourism. In summary, applications of these tribunal could address the
required 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 Organizations for Standardization and the Consultative Committee for Space Data Systems

F. Policy Recommendations

R.8.1. Europe’s trade agreements with external 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 space debris issue because of the current lack of international treaties.

R.8.2. Increase expenditure in the European Space Programs and Associations to be at least 1/10th than our expenditure in Defence. The level of funding, organization and ambition in space exploration and human spaceflight shall be at least comparable to NASA and CNSA.¹⁰⁶

R.8.3. Push for the creation of a European Union led Space Agency encompassing current ESA and EUSPA activities and subject to a larger EU oversight and linkage to long term European policy objectives. Highlight 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. That way there would be a stronger force towards innovation in all the sub-sectors where commercial considerations are decisive. At the same time, keeping an eye on political stability by giving the time needed to the member states industry to adapt to the change staggering the reform over time.

R.8.5. On the basis of several factors (including political symbolism, the desire

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¹⁰⁶ 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
for world collaboration and the need for strategic autonomy) we recommend
to go forward with the collaborative model for large space missions and
become an equal partner for human space flight activities for Lunar and Mars
Exploration, and to develop a strategic autonomy with the development of
cost effective European crewed space transportation and sustainable space
access systems.

R.8.6. Push for the creation of an International Regulatory Agency (IRA) similar
to the International Civil Aviation Organization (ICAO) and International
Tribunal for the Law on Sea (ITLOS), to push for the implementation of
international standards for on-orbit servicing, rendezvous, proximity
operations, space debris de-orbiting and safe disposal, 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 Europeans have about ESA, Volt aims to give more relevance and credit to what it does for its citizens. Continuous education is one of the tools through which a wider information on space activities and costs can reach the population at every stage of its life. In fact, Volt wants to raise awareness on space projects, their effects on the global society and individuals, on the possibilities offered by space technology to everyday life and to spur economic growth. This task should be carried out not only by the ESA but also by national and European bodies that should commit to making Space, as a discipline, easily approachable and accessible to everyone.

Considering that most of the Europeans share the feeling of the European Union as a pivotal and competitive player in the Space arena, Volt wants to make Space even more appealing for its citizens by investing in a more interactive involvement between the ESA and the public sphere. This would be possible in several ways, such as via assuring the presence of European astronauts in public events or in schools, or via the establishment of an official ESA Museum dedicated to European space history. Through the museum, it would be possible to give our citizens the chance to get a more tangible bond with the European Space activities - such as interactive tours, educational supports, tours, movies, merchandising. Another source of information must come from the national space agencies and Member states. In fact, they can increase the impact of space knowledge on their citizens thanks to the language and the geographical proximity, both via national programmes and via university's studies based on Space. These studies should be as interactive and interdisciplinary as possible, spanning from science to history, and from medicine to art. Volt believes that investing in culture and education will grant Europeans access to a knowledge that will bring them closer to building a better Europe, together.

A. Policy Recommendations

R.9.1. Position affordable space studies among school curricula at all educational levels with a comprehensive review of the space sciences, engineering and applications, and implement space aspects transversally among the full curricula, specially in non-space areas where space

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87 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). [https://www.esa.int/About_Us/Welcome_to_ESA/How_much_do_European_citizens_know_about_space](https://www.esa.int/About_Us/Welcome_to_ESA/How_much_do_European_citizens_know_about_space)
applications could bring synergies.

**R.9.2.** Tackle the lack of female students in space related studies and in STEM fields. Increase awareness of space matters and professions among female students to incentivise their participation.

**R.9.3.** Promote cooperation between ESA and European artists and the film industry. Provide financial incentives for filming at ESA locations.

**R.9.4.** Creation of an official ESA Museum dedicated to the European space history where the ESA archival documents are currently located (Historical Archives of the European Union, Fiesole, Italy)