Title: Thesis 1 – Status of Civilization and Quality of Life

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Abstract - Introduction

What is Quality of Life (QoL), and why we have titled the SRI IV World Congress on it?

Quality of life is a broad concept, including all of the life's aspects of us, human inhabitants of the third planet of this Solar System. Of course, the very basic conditions – such as food, shelter, dresses, health, and education – are key aspects that cannot be ignored, and largely depend on economic and cultural development. Yet, for the quality of life, the condition of our mind, our psychological status, both at the individual and the relational level, and the respect of commonly recognized ethical principles, are also relevant. For that, a decent subsistence situation is a necessary but not sufficient condition.

The perception of QoL is not the same everywhere, on our planet. In western post-industrial Countries there's now a general lack of confidence and hope in the future. In eastern emerging societies – now characterized by an impetuous industrial development – the sentiment is quite different: people are looking at the future with great anticipation and hope. At least from this point of view, their QoL's index (should we be able to measure it) may be considered better, since having hope and confidence in the future is maybe the biggest factor of the QoL. So, what makes the difference? They are still living, on average, at a lower standard and their social and economic environment is promising, while the West has a higher standard on average, but the trend has been negative for a significant time. It is the hope for a better life in a foreseeable future, based on their industriousness and effort, while in the West only an ever-shrinking minority can enjoy improvements thanks to their merit in actually making something, while some are becoming richer and richer through financial speculation and pure exploitation of the work of others. It is the enthusiasm of pursuing a better future instead of the fear of losing the privileges acquired by the previous generations. In the East they still believe in the story of the rising tide that raises all the boats, and in hard work that brings a better life. In the west only the big boats are still floating, and hard work seems to be useless, and soon to be replaced by the AI, by the way.

We, at Space Renaissance, consider human development as a holistic concept where the body and the mind should grow together in harmony. Every social process – progress or regression, crisis or renaissance, war and peace – depends on the *inner condition* of the people. Economic development, justice, equity, peace, and respect for the environment contribute to improving well-being and the broader quality of life. Taking such development to space is the way to make these conditions possible, calling all the people of good will to contribute to this immense shared goal. Hope in a fruitful future, in which survival is secured, social growth is favored by great economic development, more job and business opportunities for all, means less social fear. Less social fear means to "give peace a chance", to say it with a John Lennon's very popular song.

The signs of a possible incoming implosive crisis of civilization are now evident, as the fast decline of the international law system, the persistence and exacerbation of many territorial and resource wars, the explicit and arrogant resumption of imperial pretensions by some super-powers, and the crisis of the global world leadership. The above awful epochal catastrophe might be reverted, should we be able to show a horizon of hope to humanity, that can defeat the fear, and give back faith in the future, where humans can restart "growing and multiply". And yes, we want to give credits to that eastern progressive mood, as a modern promethean manifesto: a reconfirmed signature to the value of human intelligence, and capability to thrive, going over challenges and natural limitations.

From our humanist point of view, none of the 8.5 billion human lives should be lost, during this troubled birth of a Solar Civilization: condition to have success in such an epochal enterprise is to conserve the great richness of the human patrimony, 8.5 billions of thinking beings, each one endowed with a brain and a heart: the *people of good will*! The greatest richness humanity ever had!

Should we allow hoarders and warmongers to waste such a great treasure? Should we allow them to divert and channel that good will into personal fortunes and taking up weapons and killing one another?

Only the kick-off of civilian space development in proper time – before 2030 – can assure that such hope in the future may be realized.

Quality of Life needs space. The hope in the future needs space. Human creativity needs space. Human thought needs space. Human spirituality needs space. Non-human forms of life living on this planet also need space, in order their terrestrial environment may be improved by recovering some of its natural characteristics.

According to our analysis, developed during the SRI 3rd World Congress, in 2021, the expansion of civilization into space should kick-off before 2030. Should that deadline be broken, civilization would incur serious risk of a dramatic and likely irreversible implosive crisis. Considering the actual geopolitical situation, the above is dramatically confirmed and reinforced. The world situation is characterized by substantial uncertainties on all the most sensitive areas: the fast decline of the international law system, the persistence and exacerbation of many territorial and resource wars, the explicit and arrogant resumption of imperial pretensions by some super-powers, and the crisis of the global world leadership. A very powerful space race has begun, yet so far it seems to be dominated by several concerning tendencies. Our update of the civilization status will cover all of these worrying conditions.

Yet, humanity needs to kick off the process of expanding beyond the Earth's atmosphere, the only prospect for improving the Quality of Life, if not the survival of civilization itself.

Therefore, we will go ahead properly in this direction, notwithstanding all the uncertainties.

Our Thesis will therefore focus on a few issues that we consider paramount priority, from our humanist point of view, 100% in the interest of our referent social subjects: humans, and the other species living on this planet, their living conditions, and the quality of their (our) life.

1. **Resources** – The overshoot day and the unsustainable energy demand
2. **Beautiful life in space** – Quality of Life, ergonomics, beauty, greenery, redundancy, places for cultivating serenity and joy.
3. **Space Policy –** Space 18th SDG, priority to geo-lunar industrialization and settlement, mining, fuel production in space, orbital debris recovery and reuse, enhancement of the Outer Space Treaty[101], by solving its ambiguities and adding ethical rules for commercial and industrial civilian space activities.
4. **Science & Tech** – Human requirements for space habitats and vehicles, protection from cosmic and solar radiation, simulated gravity, redundant design.
5. **We speak for the Space Settlers** – Space resources property and utilization, the rights of the space settlers.
6. **Space as Inspiration –** The starred sky has inspired humanity since its beginning: the oldest civilizations all cultivated astronomy and created stories and myths about the celestial bodies and the open sky, perceived as the place of heaven. When space travel became possible, after the initial rivalry a cooperation spirit arose since the Apollo-Soyuz mission and went on with the ISS – it shall not end! Space offers a broad range of philosophical references, including space romanticism, the Overview Effect, space brotherhood, and Immanuel Kant's universal ethical concepts.
7. **Space Peace –** We propose a total ban of any weapons in space.
8. **The Space Launch Window** – We shall go now, while we have the capabilities. Using space tycoons to boost civilization expansion into space.

Scope and co-authoring of this paper - This paper is intended to be used, during next 5 years, towards 2031, as an essential guideline for the SRI and the SR Academy works and initiatives, dealing with Outreach, UNOOSA, IAF, projects development and participation.

The paper is largely based on the work done by the Space Renaissance Academy's Committees during the 2021-2026 mandate. Namely:

- The Space Philosophy & History Committee, chaired by Marie-Luise Heuser
- The Space Policy Committee, chaired by Dennis O'Brien
- The Space Tech & Industry Committee, chaired by Werner Grandl
- The Space Habitats Committee, chaired by Jerry Stone
- The Living in Space Committee, chaired by Joe Pelton
- The Target Young Generations Committee, chaired by Ghanim Alotaibi

1 2026 Status of civilization

1.1 Changes in the current situation compared to 2021

The Congress Thesis 1 of our previous Congress[1], in June 2021, reported some key conditions, that we can summarize and compare to the nowadays' situation.

The 2021 Thesis analyzed the main vulnerabilities determining "The global civilization risk during next 10 years, towards 2030". Distrust in the future scored the first place: "… since few decades of the past century, we see a sense of distrust in the future, distrust in good will and ultimately in human intelligence itself, and the sentiment that the whole human enterprise has led to ecologic disaster." Nowadays we may observe that such a distrust isn't equal in the world. In eastern emerging societies people are looking at the future with great anticipation and hope. Even in the western society, the negative mood caused by ecologic concerns is maybe now in progress of being superseded. Yet, unfortunately, we are not witnessing a new wind of creativity and innovation: rather the fear of a third world war is gaining momentum, outclassing any other fear.

The 2021 document then was reviewing "The risks created by the tremendous conjunction of the multi-crises". The global economic deep crisis, the climate emergency, with increased extreme meteorology events, floods, and melting of perennial ices. The resources of our planet clearly showing their scarcity, in addressing the needs of 8 billion citizens. The yearly consumption 1,5 times the available resources on our planet. The energy sources not sufficient for the sustainable development of 8 billion citizens. Employment's deep crisis over many decades. Employment in western societies was in deep crisis due to relocation of production to recently industrialized countries, advent of automation and artificial intelligence, predominance of pure financial economy over the industrial economy, the crisis of the concept of industry itself, due to the massive ecological and environmentalist concerns. Already in 1996 Viviane Forrester discussed the "redundancy of the workers"[2], now more evident, with the accelerated advent of robotics and artificial intelligence.

None of the above multi-crises have seen a betterment, yet they have worsened, as shown by the status of the UN 17 SDGs (see section Status of the UN 17SDGs). And, in the 2026 scenario, they risk to just be forgotten, while a global military confrontation becomes more possible.

We wrote, in 2021: "All of the above crises are ferociously attacking equitable human civilization, questioning the mainstream social models, and undermining the achievements that an expansive industrial society had assured to the citizen of the advanced countries, and which had provided the peoples of emerging countries with an objective to aim for. Each of these crisis points acts as a feedback on the other crisis points, feeding social conflicts and the possibility of resource wars, for the control of the residual few resources."

In 2021 we also mentioned *"the risk of extensive cultural damage in the philosophical cage of the closed world"*. The awareness that finite resources can no longer support us generates a generalized fear of the future, fueling the belief that the next generation will face worse conditions than our own. This creates a zero-sum game where individuals feel useless and redundant, driving a desperate search for survival that empowers unscrupulous mafias and neomedieval social models. As the unavailability of decent jobs causes aspirations to shipwreck, the resulting economic endemic crisis paves the way for authoritarian regimes to ascend, leading to the fragmentation of international cooperation in favor of insular tribal societies. The above is dramatically more evident in 2026. Horrible genocides are being tolerated, crazy territorial wars are tolerated as well, in a general decline of the human lives' value.

A generalized risk of progressive decline of freedom, democracy, and respect of ethics[3] was also foreseen, and it is dramatically confirmed nowadays.

As to Anti-humanist ideological misconceptions[4] we might observer that they have not worsened, maybe their poisonous influence has somehow decreased, but not because more positive visions are taking over, in the popular conscience. Opposite, an even worse ideology is stealing the show: war. Instead of *"learning sustainability on Earth before going to space"*, many will be attempted, now to say that *"we should learn living in peace before going to space"*. Nothing wrong, about learning sustainability and learning to live in peace, of course. It is the first-and-then that's wrong. Also, we believe that only expanding into space humanity may reach to a higher ethical level, supported by the great abundancy of the solar system resources. That will inspire tranquility in the minds of the majority, like a gentle soft wind over troubled waters.

The impossible replacement of fossil by renewable sources was well described. The trends of the recent years confirmed and reinforced such analysis. The advent of artificial intelligence and the impetuous development of the electronic society is now clearly demonstrating that we cannot sustainably generate on Earth the needed amount of energy, nor to develop the industrial processes to manage the extraction and processing of the minerals needed to produce the electronic components.

Our 2021 Thesis also gave an idea of what it could be a Civilization implosion[5], due to a devastating cumulative effect of the multiple crises, and to several immature attempts to simplify a complex and not simplifiable society. We are now faced to a vertical fall of the world leadership, and the fight of all against all to raise in control.

1.2 Status of the UN 17SDGs

The United Nations' assessment of the 17 Sustainable Development Goals (SDGs) indicates that the world is "severely off-track" to achieve the 2030 Agenda. Despite some areas of progress, only about 18% of the targets are currently on track, while nearly half are progressing too slowly, and approximately a fifth are regressing below 2015 baseline levels.

The latest UN reports, including the 2024 and 2025 editions of the Sustainable Development Goals Report, describe the current status as a "global development emergency". Progress has been severely hindered by compounding global crises: conflicts and geopolitical tensions; climate chaos, with 2024 marked as the hottest year on record and CO_2 levels at unprecedented highs; Economic instability, including record-high debt servicing costs for low- and middle-income countries; and the lingering impacts of the COVID-19 pandemic. Progress across the specific goals is highly uneven.

Significant strides have been made in SDG 3 (maternal/child health, HIV/malaria prevention), SDG 4 (education access, gender gap reduction), SDG 7 (electricity access, renewable energy growth), and SDG 17 (internet connectivity, data systems). Progress in these areas is often fragile and unequal, with millions still lacking basic services. Global health progress has decelerated alarmingly since 2015.

Over half the world's population is now covered by social protection. Women hold 27% of parliamentary seats globally (up from 22%). Nearly half of the targets, including aspects of SDG 5 (gender equality) and SDG 8 (decent work), are moving too slowly. The informal workforce remains large (57.8% in 2024).

None of the 17 SDGs are fully on track to be achieved by 2030. Progress on close to a fifth of the targets is actively reversing. Over 800 million people still face extreme poverty and hunger (SDG 1 & SDG 2), a number higher than in 2015. Progress on climate action (SDG 13) is severely lacking, with CO_2 levels the highest in over two million years. The UN emphasizes that the current incremental and fragmented changes are insufficient and calls for urgent, science-based transformations, political leadership, and substantial financial investment to get back on track.

The UN's Sustainable Development Goals Report 2025 assesses progress across 17 goals based on available target trends since 2015, categorizing them as improving (↑ moderate/on-track progress), regressing (↓ below baseline), or stalled/insufficient (→).

SDG	Goal Description	Assessment	Trend
1	No Poverty	Extreme poverty affects 9% globally (down slightly from 10.5% in 2015), but working poverty hit 244 million in 2024; low-income countries show minimal social protection gains at 9.7% [6]	→
2	Zero Hunger	Hunger rose to 9.1% (757 million people) in 2023; child stunting fell to 23.2%, but food insecurity impacts 2.33 billion.[7]	↓
3	Good Health	Maternal mortality dropped to 197 per 100,000 live births (from 228); under-five mortality at 37 per 1,000; HIV infections down 39% since 2010, yet 9.3 million lack treatment.[8]	↑
4	Quality Education	Upper secondary completion rose to 60% (from 53%); 754 million adults are illiterate, mostly women; learning outcomes are declining in many areas.[9]	→
5	Gender Equality	Women hold 27% parliamentary seats (up from 22%); unpaid care work is 2.5 times higher for women; child marriage persists at 20% for young women.[10]	→
6	Clean Water	Safely managed water access at 74% (up from 68%), but 2.1 billion lack it; water stress is severe in regions like Northern Africa.[11]	→
7	Affordable Energy	Electricity access at 92%; renewables at 17.9% of energy; clean cooking at 74%, leaving 2.1 billion reliant on polluting fuels.[12]	↑
8	Decent Work	Unemployment at record-low 5.0%; informal employment at 57.8%; youth three times more likely unemployed.[13]	→
9	Innovation & Infrastructure	Data show stalls. R&D spending has been stagnant for over 30%; infrastructure access lags in low-income areas.[14]	→
10	Reduced Inequalities	Data shows stalls. Income inequality persists; between-country gaps are narrowing slowly.[15]	→
11	Sustainable Cities	Data show stalls. Urban population growth strains housing; air quality improving in some regions.[16]	→
12	Responsible Consumption	Data show stalls. Material footprint rising; recycling rates below 20% globally.[17]	→
13	Climate Action	Data show regression. 1.5°C threshold crossed in 2024; emissions still increasing.[18]	↓
14	Life Below Water	Data shows stalls. Ocean acidity up 30%; protected marine areas at 8%.[19]	→
15	Life on Land	Data show stalls. Deforestation slowed, but biodiversity loss is accelerating.[20]	→
16	Peace & Justice	Data shows regressions. Conflicts intensified; human rights defenders' killings are high. 120 million displaced; conflicts at record highs.[21]	↓
17	Partnerships	Data show stalls. ODA at 0.37% GNI; South-South cooperation growing.[22]	→

Table 1. UN assessment of the 17 SDGs achievement

As evident in Table 1, only two SDGs mark progress since 2015, three SDGs mark regression, and 12 are stagnant, not progressing at all.

The three SDGs that SRI identified as key[23] to the achievement of the others---7, 8, and 9—only SDG 7 (Energy) is in modest insufficient progress, while SDG 8 (Employment) and SDG 9 (Industrial development) are stalling.

As far as the Energy availability is concerned, being this topic strictly connected with the industrial and economic growth, we may foresee an incoming crisis, due to the huge electricity demand determined by the supercomputers to feed artificial intelligence, which appears to be one of the key leading industrial sectors. Also see a dedicated section in this document (Errore. L'origine riferimento non è stata trovata.).

The 17 SDGs were very well defined and argumented, to tackle the many global challenges that humanity is facing. However, the very poor score obtained by the UN 2030 Agenda, 10 years after its launch, and just 5 years before the deadline, may be depicted as a failure. As SRI analyzed, the addition of an 18th SDG, focused on Civilian Space Development, would be the sole measure capable of reversing the ongoing trend, and allow meaningful steps upward in the achievement of the 17 SDGs.

1.3 Resources – The Overshoot Day

The Earth Overshoot Day[24] marks the date when humanity's annual demand for ecological resources and services exceeds what Earth can regenerate in that same year. Beyond this date, humanity operates in an "ecological deficit," effectively "borrowing" from future generations by depleting natural stocks and accumulating waste (primarily carbon dioxide). The calculation specifically focuses on biologically productive resources and the capacity of ecosystems to absorb waste. It distinguishes between *regenerative* biological resources and *non-renewable* materials:[25]

- Life-Supporting (regenerative) Resources are the primary focus. They include food (cropland, fishing grounds), timber and fiber (forests), and grazing land for livestock.
- Energy Sources include primarily through the carbon footprint. This measures the amount of forest land required to sequester the CO2 emissions generated by burning fossil fuels.
- Minerals and Industrial Raw Materials are generally not included in the core calculation because they do not regenerate within human timescales. However, the *energy* and *land* used to extract and process them (e.g., the CO2 emitted or the built-up land for the mine) are captured in the carbon and built-up land footprints.

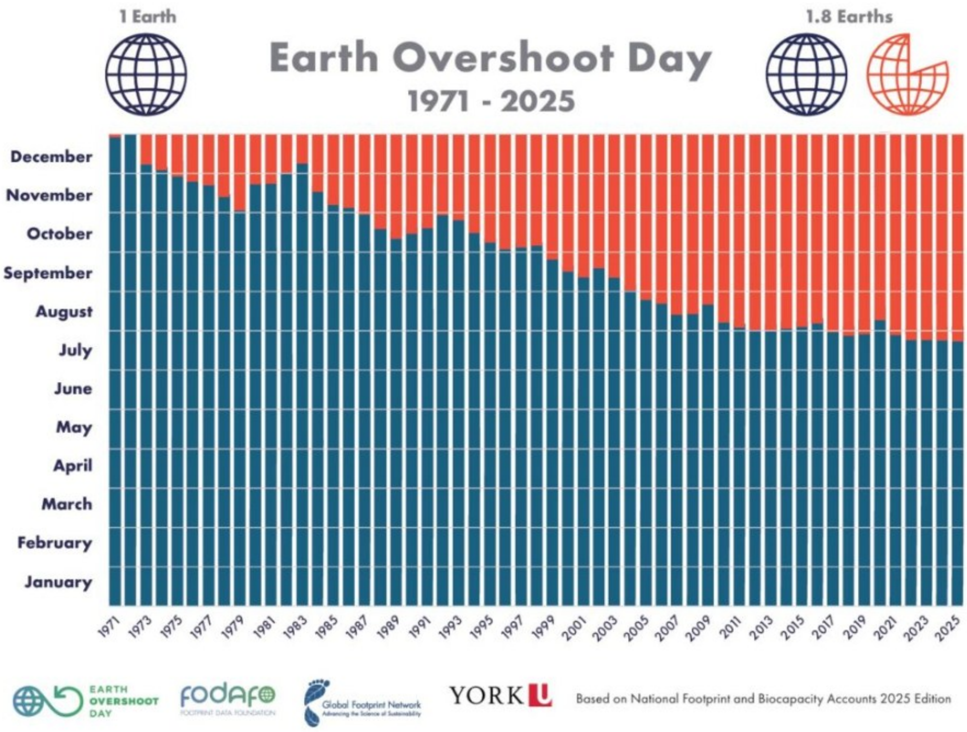

Figure 1. Overshoot Day 1971 – 2025[26]

The calculation is based on the Ecological Footprint, which is divided into several sub-categories. While specific yearly percentages can vary slightly based on updated UN data, the historical breakdown is approximately as follows:

Category	Typical Contribution	Description
Carbon Footprint	~60%	The land required to absorb CO_2 emissions from fossil fuels.
Food & Fiber (Cropland/Fishing)	~25–30%	Area needed to produce crops for food, animal feed, and fibers (like cotton).
Forest Products (Timber)	~10%	Area needed to supply wood, pulp, and timber products.
Built-up Land	<5%	Area covered by human infrastructure like roads and buildings.
Grazing Land	<5%	Land used for raising livestock for meat, dairy, and wool.

Table 2. Contribution of different components to the Ecological footprint

The carbon footprint is the largest and fastest-growing component, currently making up about **60%** of humanity's total ecological footprint. Reducing this category is considered the most effective way to Move The Date later into the year.

Despite any possible considerations about Earth’s resources consumption, the Overshoot Day shows evidently that humanity needs very much more than what Earth can offer. The solution is simple: go outside, and start using extraterrestrial resources.

1.4 Energy

We are reporting here large parts of a paper presented at the 76th IAC in Sydney: “3xE, Energy Economy, Environment”[27].

1.4.1 Energy demand is growing fast

Energy is rapidly achieving a primary position as a factor of sustainability. An increasing demand for energy supply already characterized industrial society, and it was satisfied by traditional fossil sources, which were the most convenient when environmental requirements were limited to polluting agents, with unevenly distributed levels of restriction. The fast-growing economy of China and later India mostly relied on coal to increase electrical production. During the last decades, general concerns about climate change have started the so-called "energy transition", pushing the phase-out of all greenhouse gas (not to be confused with pollutants!) emitting technologies. More recently, the development of the electronic society – based on the global communication infrastructure – brought a very large spread of new technologies, such as electronic money, mass video communication, electric mobility, and now artificial intelligence, supported by supercomputers, big servers, and big data farms. All of these technologies require a very huge energy supply and bigger storage capabilities. Such a development is seriously questioning the green transition strategies, conceived by most governments to contrast climate change. The global energy demand – supposed to be decreasing by the above policies – is instead rising, very much more than expected. Renewable sources are growing, but fossil sources are growing too, and the two of them, together, cannot pair with the quickly increasing demand. In fact, overall GHG (Green-House-Gases) emissions are increasing despite all the declared efforts to reduce them. The energy market is also heavily impacted by the geopolitical situation, which is playing an uneven role in different areas of the world, especially for the natural gas market, whereas natural gas is the fossil fuel with the lowest GHG impact, and gas-fired plants can be built very quickly. Innovative solutions are dramatically needed, or the energy bill will necessarily grow uncontrolled, with critical social impacts, in a gloomy scenario where the benefits of the electronic society and freedom of mobility will be progressively restricted to privileged classes. It must be noted that after years of stagnation due to opposition by some environmentalist groups and wrong choices about the size and typology of the plants, nuclear fission energy is now recognized as a non-GHG emitting technology and it is quickly moving towards innovative solutions like small modular reactors (SMR) to reduce costs and the so-called fourth generation of fast reactors to solve once for all the "nuclear waste" problem, allowing as well a substantial reduction of the need of new mining for uranium. In the energy sector, Civilian Space Development can propose a wide range of solutions. As a short-term enterprise, new big data farms could be shifted from Earth into orbit, in the Cislunar region and on the Moon. This would reduce their environmental impact avoiding producing and dissipating huge amounts of energy on Earth. From a mid-term perspective, important industrial settlements might be installed at Earth-Moon Lagrange Points. All of these settlements will benefit from solar power directly collected in space, 365/365 days, 24/24 hours, without seasonal limitations and without the energy absorption of the atmosphere. Moon facilities can use small nuclear reactors to keep the energy flowing during the 14 Earth days of the lunar night, keeping the advantage of removing the impact of these facilities on the earthly environment. This paper explores the case for big data farms in Earth Orbit, on the Moon, and the Cislunar region.

As reported by the IEA – for the current year, "Electricity 2025"[28], global power demand is rising faster and faster every year. Most of the increase is due to the fastest growing economies, and more than half of the total to the People's Republic of China (54%), whose power demand is growing faster than its economy (7% vs. 5%). This is due to rapid growth in electricity intensive manufacturing of "clean energy technologies", rising use of air conditioners, increasing diffusion of electric vehicles and expanding data centers. India is also significant but it accounts only for 10%. Advanced countries (USA, Europe, Japan) experienced a flat power demand in recent years, or even a decline, but now they are facing a restart of the increase: the declining power demand by industry and the increased efficiency of electricity use (e.g. the use of LED lighting) is now overridden by electric vehicles, air conditioners, heat pumps and data centers. The manufacturing of PV modules, batteries and EVs in China consumed in 2024 a total of 320 TWh of electricity, roughly as much as the total electricity use in Italy. The big change in the overall scenario concerns the explosive growth of consumption for cooling and data centers, which reversed the trend in the USA. In the European Union the situation is comparable with the US, except that in recent years there was a significant fall in demand, which just restarted growing in 2024.

The recent decline and failure of the green transition shows evidently that fossil fuels will not fade away for long time. More likely, fossil and renewable sources will try, together, to pair the quickly raising energy demand. Yet they will be largely insufficient.

In the global energy scenario, industrial use prevails as the main cause of increase of electricity demand, and the "green transition" is, somewhat ironically, the main cause, since the production of batteries, EVs, heat pumps and other "clean" equipment is the main driver of the increase. Moreover, the "energy transition" is mostly based on electrification, that is on using less fuels and more electricity for the final users of energy, and an extensive use of e-fuels, that is synthetic fuels produced through an intensive electric energy input – in fact, the energy value of e-fuels is created by using electricity for their production.

Energy demand was flat or decreasing a few years ago, due to COVID19 pandemics, and it is now growing due to a larger use of air conditioning and to data centers. That is is very significant in the US and Europe. The current size of data centers, being built for companies like Google, Amazon, Microsoft and several others, can easily reach a nominal energy capacity in the range of 132 to 250 MW per site and GW scale is envisaged. This means a large local impact on availability and cost of power. Each data center must rely on a local emergency power source, to avoid data loss in case the main power source fails. Therefore, each data center comes with a set of emergency generators, typically diesel engines, with a capacity comparable with the total capacity of the data center. Manageability of local impact on other users depends upon existence of a strong interconnected grid available, and the price structure of electricity is nation based, like in Europe.

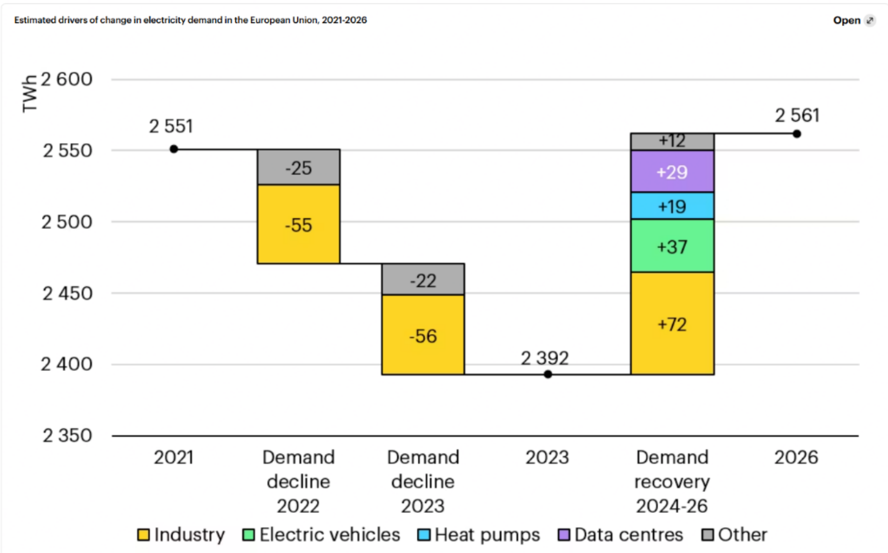

Figure 2. Variations in Electricity demands 2020-2026[29]

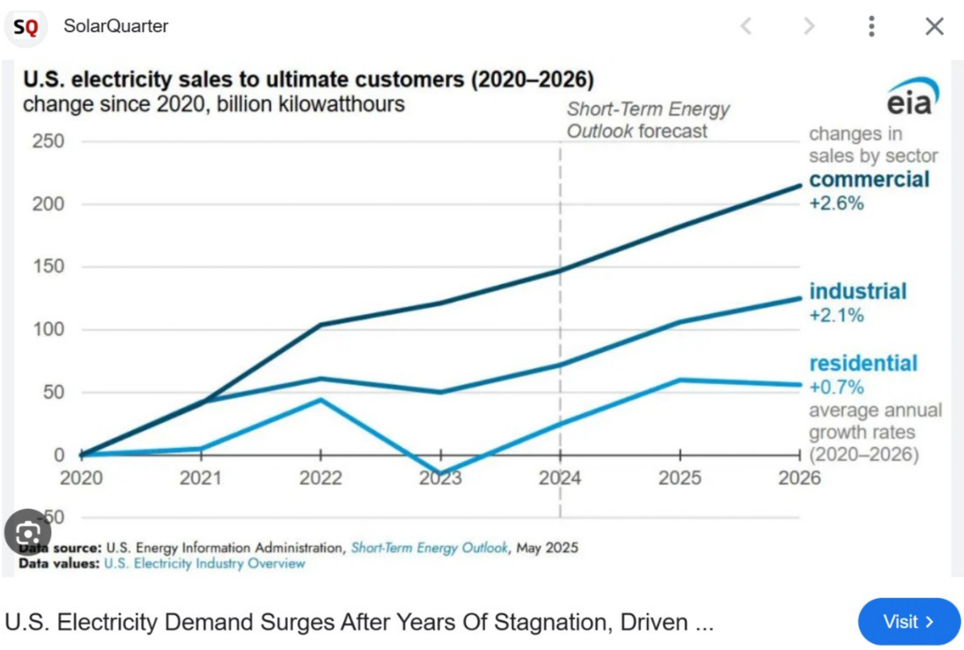

Figure 3. US Electricity sales 2020-2026[30]

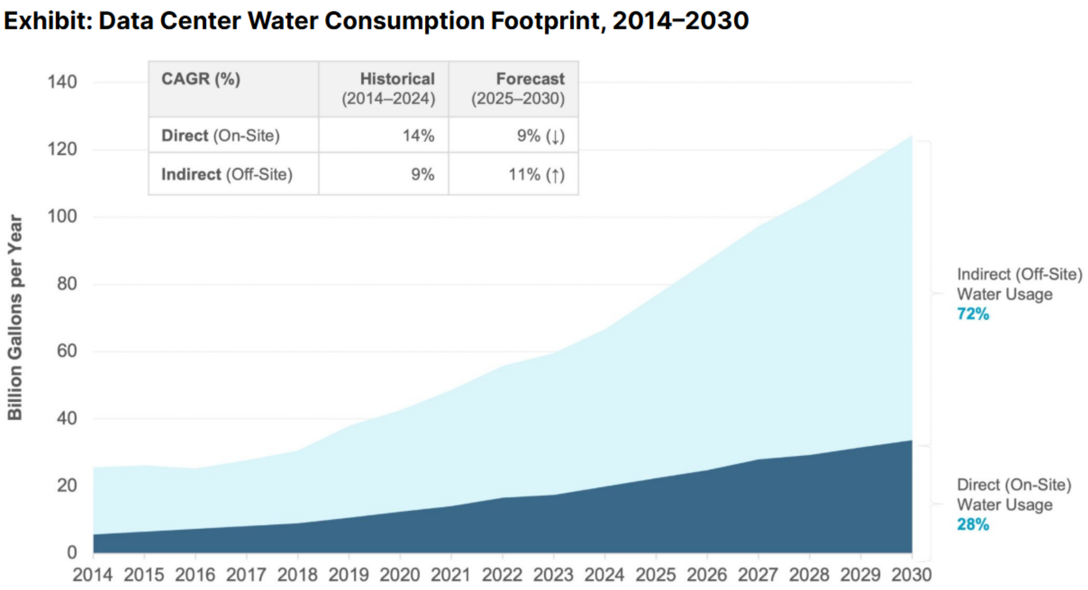

Figure 4. Water consumption by Big Data Centers 2014-2030[31]

In areas where the grid is weakly interconnected and grid operators and power producers have a narrower base, like in the US, the impact on the other local users may be significant in terms of price and availability of electricity. However, the impact of new datacenters, both in the US and in Europe, is similar to the impact of any new industrial plant, not that common during the last years.

In any case, data centers need a firm power supply available 24/24, 7/7, which implies that they add to base load, and non-dispatchable power sources like wind or solar are not suitable to support them, whereas hydro, nuclear and of course combustion are. Gas fueled combined cycles, which combine a short construction time with high efficiency and relatively low emissions, might candidate to contribute at least in part the new energy demand. Of course, they still emit GHG, but only one third the emission of a coal fired plant for the same electricity production. Non GHG emitting base load generators mainly means nuclear that, with small reactors of new generation, might represent a valid competitor.

However, any terrestrial solution, though innovative, presents problems of scalability, to reach the level of the 21st Century's energy demand.

All projects on the Earth's ground consider power sources on the ground. More than the resources availability – including oil and other energy sources, both renewable and not – ~~are~~ the extraction processes ~~that~~ are environmentally devastating and unsustainable. Processing is also critical, maybe more than extraction, for the new materials.

1.4.2 Space Based Solar Power?

For a long time, the space community has been discussing the concept of Space Based Solar Power (SBSP). The idea of collecting solar energy in space, where it is available 24/7 and its unitary power is higher, due to the absence of an atmosphere filtering out a part of it, is enticing. Notwithstanding the advantages of placing them in space, PV panels would be quite large anyway, but placing them in space would save the occupation of large ground areas and they would not require strong supporting structures, thanks to microgravity.

1.4.2.1 Adverse factors

There are adverse factors as well. The orbit must make solar radiation available all the time, otherwise the advantage of eliminating the day/night cycle vanishes. Energy must be converted into a transmissible form, the most commonly proposed is microwaves, to be beamed across a significant distance. The wavelength must be chosen in such a way as to reduce atmospheric absorption, including the effect of cloud covering – this is the main reason for favoring microwaves. The energy density at ground level must be kept low to avoid damage to living things, environments, electric equipment and so on. Therefore, the receiving antenna, which usually contracted in rectenna, must be very large and a significant electric system is required to collect electric power and feed it into the electric grid. This means that the ground infrastructure is large anyway and requires a lot of space on the ground, which limits the advantage of not having PV panels. The electrical system, in fact, is essentially the same size of the one required by the PV panels. The “rectenna” is even larger in terms of footprint, even if it does not shade the area below it as much space. Recently an alternative was raised, about using PV panels on the ground to collect energy beamed from infra-red transmitter satellites[32][33]. Such a solution poses several disadvantages, even worse than the microwaves option. First of all, a low efficiency, as described below. Furthermore, it is doubtful that a panel optimized for visible light can work as well with infrared with an acceptable efficiency. Other issues might come from atmospheric absorption and weather conditions.

The conversion of power from electricity to microwaves and back again is currently only available for low values of power. Scaling the solution to the high values required to make a dent into the energy market is not an immediate option. Some demonstrations have been made around the kilowatt range over some kilometers. Reaching the gigawatt range implies a sizing increase of 1 million times, and distances in space must be thousands of kilometers since low Earth orbit is not suitable for this application. The end to end efficiency reached as per today’s experiments is around 50% with microwaves and 15% with laser.[34]

Using laser to transmit from space to Earth is problematic due to the associated risk of weaponization and atmospheric absorption. An extremely low efficiency is the most significant factor: it would be necessary to multiply the panel areas in space five or six times to have a given amount of energy available at the ground level. Microwaves remain the only suitable choice in a practical time span. The US Army declares that its Scope-M microwave experiments have reached 95% efficiency, but a prudent estimate of 50% is preferred by the authors of the referenced report.

Beaming power is not the same as transmitting data: a stable connection between two large devices, managing a huge amount of energy, is required, instead of a quickly shifting, reroutable connection between small devices. Adding this to the requirement to have the orbital station in permanent sunlight, geostationary orbit is the only practical choice. Some are proposing Molniya orbits[35], but this would require multiplying the orbital part, typically as three satellites, and constantly adjusting the aim of the power beam. The multiplication of the satellites is a decisive disadvantage, making this solution only valid for very specific uses.

1.4.2.2 Active proposals to initiate SBSP and raising political opposition

Having said that, there are several active proposals to initiate SBSP. The first stage shall be a demonstrator in orbit, just to show the feasibility of the solution. These demonstrations may be completed within the current decade[36]. Notwithstanding the optimistic plans that some companies declare, for the obvious reason of attracting investment, reaching the level of large-scale systems cannot be expected in a few years. In fact, within the planning of current power generation markets, SBSP is still non-existent. It is seriously considered only within the space community. Even so the energy hunger of data centers is moving some big data/AI companies such as Meta, to look for alternatives, but their indicated time span is not realistic: their installations need megawatts and gigawatts, which SBSP development cannot achieve for several years. Following the solutions being currently implemented for data center projects, it is clear that the first choice is the most classical quickly deployable power source, the gas turbine. In the case of Meta’s new 5 GW data center, named Hyperion[37], to be located in Louisiana, three new combined-cycle power plants will be built by Entergy, Louisiana’s energy utility. Combined cycle plants, which recover heat from the exhaust of the gas turbine to produce steam and then more electricity, require a little longer to be built than simple cycle gas turbine plants, but they can reach record efficiencies of more than 60%. In the meanwhile, Amazon turns to geothermal combined with PV solar plus storage for its 700 MW data center in Nevada[38].

Since some political opposition to the expansion of data centers on Earth is already apparent[39], the question is, will it be politically feasible to demonstrate or install large rectennas across territories?

1.4.2.3 Niche sectors where SBSP may contribute

In consideration of these prospects, there still remain niche sectors where SBSP may contribute in some years: for example, in reaching isolated installations or communities. Given low levels of power, steering the beam to cover scattered users even for limited durations becomes feasible, which also means bringing electricity to remote locations at short notice. This potential has engaged the interest of the military: the US armed forces are among the organizations most interested in SBSP[40], since they may need to supply power to remote locations at short notice and without depending on ground supplies. From the military point of view, it makes sense having power satellites available to supply bases across the world. Cost is not necessarily an issue for military purposes while the lack of dependence on ground supplies that can be threatened by the enemy is very attractive.

This type of research and development dynamic is definitely not new. It is often the case that the military funds a solution that will later extended to civilian use. A development path for SBSP leading out with military use, then moving to supplying remote communities and subsequently extending to larger public energy users can be considered realistic.

1.4.2.4 SBSP to feed cislunar space industrialization

Looking ahead, the primary need to develop scale SBSP is undoubtedly the industrialization of cislunar space, in this way allowing the use of lunar or asteroid materials to build infrastructures. There are significant factors which counter the concept of launching from Earth the extensive materials that are needed for SBSP as well as any other large industrial infrastructure. Even if launchers such as SpaceX Starship can reduce significantly the cost per kg to orbit, the launch of thousands of huge rockets every year would generate significant environmental impact. Even if the rocket is completely reusable, Starship launch involves 5000 t of propellant (or more with future versions), which currently is methane, whose combustion emits carbon dioxide. Certainly hydrogen-powered rockets would solve the problem, but all current designs envisage methane for the first stage, which requires the largest amount of propellant. Starship also uses this type of fuel for the second stage. Other designs use hydrogen, but only for the second stage (New Glenn by Blue Origin, Nova by Stoke Space).

SBSP can be competitive only if the materials come from space, specifically from the Moon. This concept was correctly predicted by Gerard O'Neill about 50 years ago[41]. We can add that the most suitable use is in space itself, for space industrialization and settlement.

SBSP can therefore be considered as one of the motivations to develop space industrialization more than a reason to lower launch costs, which are recently lowering at a significant pace.

1.4.2.5 Moving big energy users to space, and developing industry in space

The idea of launching to space the foreseen user systems, starting from data centers, is already being pursued. As described in the paper presented by SRI at IAC 2025[42], putting data centers in space can save both land occupation and environmental impacts due to cooling systems. This rationale is substantially true for all types of industrial applications: as long as the industry is on Earth, all the energy it uses will always remain on Earth, eventually transformed into heat due to the hard laws of thermodynamics.

In general, beaming energy to Earth from space and using it in terrestrial locations means adding to an overall environmental burden while developing industry in space with the use of in-situ resources (from the Moon, asteroids and comets) does not. This is an objective that SRI has been pursuing since the beginning of its activity. Such concepts are also well argumented in an SRI position paper issued in early 2024[43].

SBSP can provide an important bridge solution and formative contribution during the opening phases of cis-lunar development, even if it does not obtain as decisive a role as other sectors, such as data transmission and data processing. Once structural materials and elements begin to be sourced from mined space-based resources we can foresee the emergence of a complex service industry located in space, sending down data rather than energy or materials. The only material products to be transported down to Earth will be those technological products that can be more easily manufactured in microgravity. This will reduce the environmental impact of industrial applications to almost nil, opening the way to the only definitive solution of the development vs. environment long term conundrum.

1.4.3 Moving energy users from Earth to outer space

The advantages of collecting solar power in space, anyway, are still there and we do not deny them. The point is using it in space, not down on Earth. We can propose this motto: Rather than moving energy from space to Earth, move energy users from Earth to space. A system in space, like a data center or any other resource consuming activity, removes all the impact on Earth: power production, waste heat emission and even soil occupation (a data center of 132 MW may occupy 35 hectares, including its cooling system). More than that, all technology is already available, some crucial components have already been tested in space and some pilot systems are already in orbit. It must be clear that data centers in space may not be competitive for all uses in a short time, and launch cost is still a decisive element. They will not probably replace their equivalent on Earth but just complement them, and in the medium-longer run they can be the base of an industrial ecosystem in space. It is also essential that the production of most materials, after the initial phase, can be progressively moved to space (in orbit or on the Moon).

In another part of this paper, we will analyze the case of building Big Data Centers in space. And this is an option already being considered by big investors and space dealing corporates.

Just worth to mention, here, that the key requirements of a big data center in space are substantially solved. Energy is abundant, directly from the Sun, 24/24, 7/7, 365/365. Cooling is also largely available, by exposing large radiators to the very low temperature in open space. Fast connection is also available in orbit, and between orbit and Earth (Low Orbit at least), by optical connection.

1.5 The "rare" elements

The current industrial trends have shifted the needs of raw materials, increasing the importance of several elements along with more traditional ones like iron and copper. Lithium, as well as some other elements like cobalt, is required in large quantity for batteries, which from small electronic devices have moved to cars and vehicles in general as well as energy storage to support the grids against the instability generated by non-programmable energy sources like solar and wind. Rare earth elements are used mostly for permanent magnets in electric motors, since the most extensively used type for traction is the permanent magnet synchronous. Other elements, like gallium, are essential for electronic components. These elements, including the rare-earth ones, are not rare at all. Neither they are concentrated, they are rather dispersed everywhere, though more present in some countries (China, first). The processing industry, instead, is concentrated in some countries, namely China (see Figure 6), while in western countries it is very difficult to get permission for extraction and processing (see the case of lithium in Serbia), due to their environmental impact. Also, many reserves of these elements might be not yet identified, due to environmental restrictions. It must be considered that the concentration of the useful elements is low in raw ore. A large amount of material must be removed and brought to the processing plants that are necessary to extract and concentrate the useful elements. These plants need specific technology, time and investment. Opening new mines heavily affects vast areas of territory but nonetheless it is easier and quicker than building processing plants, which in their turn use precious resources like water, consume a lot of energy and generate severe pollution.

The demand for this kind of elements is raising as fast as the energy demand, due to the ramping production of electronic components, batteries for electric cars, drones, and all the growing production of automated machines, including robots.

These developments make the transition away from fossil fuels more difficult and cause a high environmental impact, undermining the advantages of electrification. Rather than scarcity of these elements on Earth surface, the extraction and processing processes are the most controversial and unsustainable aspects of the modern industrial development. if confined within Earth's boundaries. Worth to recall, these elements are largely present on the Moon and asteroids – in the latter they are available in more concentrated form than on Earth. Therefore, it is much better to invest in a space race than to devastate land and pollute air and water to increase their production on the Earth!

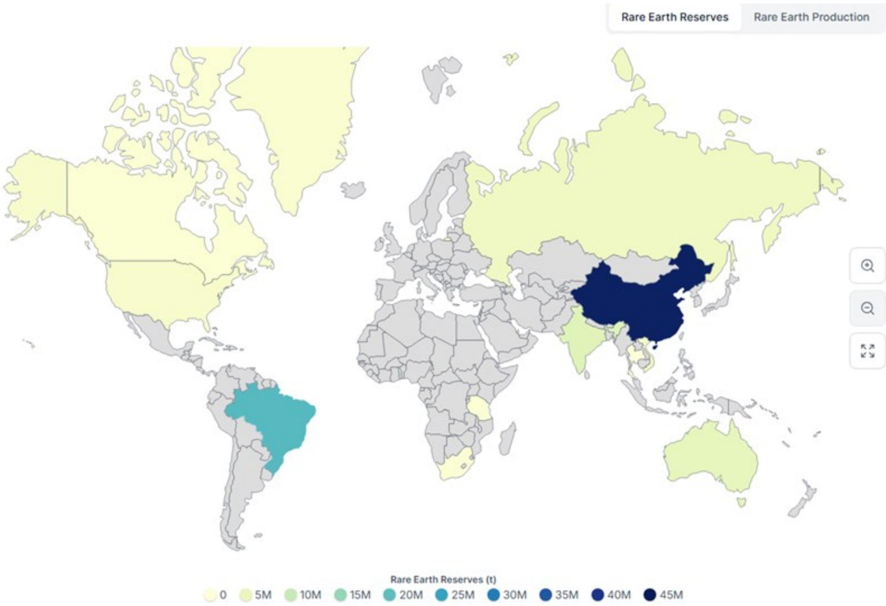

Figure 5. Rare Earths identified reserves

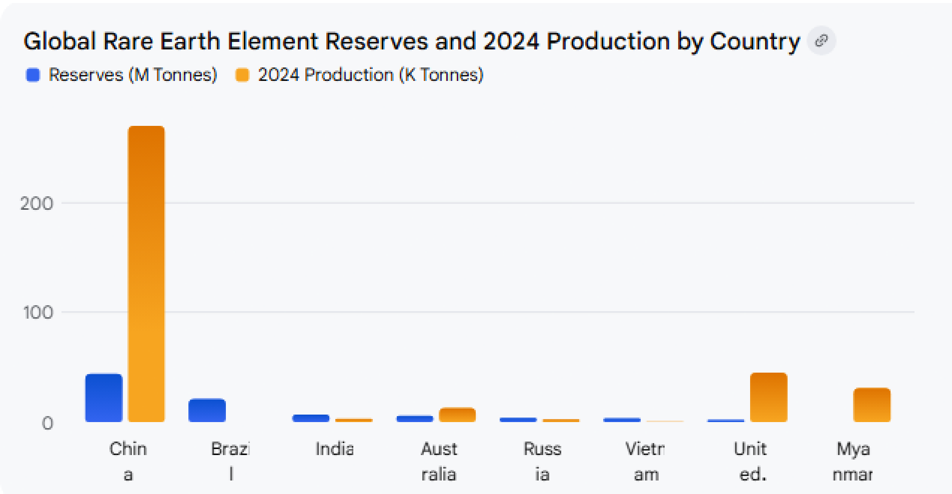

Figure 6. Rare Earth Elements production 2024

When looking at the chart, consider that Figure 1Figure 6 shows the quantities of material explored and defined, but we know that there are large quantities that remain unaccounted, because they haven't yet been identified for extraction purposes. E.g. Europe, which has a large quantity of these elements, isn't included because no mining company here conducts targeted exploration for extraction.

1.6 Geopolitics and civilization global risk

The geopolitical situation is characterized by the crisis of the current hegemonic power, the USA, which due to internal reasons has become unable to exercise its role of unique global leader, dating back from the fall of the USSR (1991). The second biggest power, China, is neither able nor willing to take the lead, so there is a leadership crisis which presumably will bring a new order based on a group of leaders rather than just one.

The history of the last years show a substantial decline of the United Nations and of some summit structures like G7 (formerly G8) or G20.

It has been reported that the Trump administration, in the secret version of the National Strategy, considered a "Core 5" or "C5" group as a planned elite, hard-power forum comprising the United States, China, Russia, India, and Japan. It is intended to function as a major, strategic alternative to the G7, focusing on pragmatic, thematic summits rather than traditional, value-driven, Western-aligned democratic partnerships

Significantly Europe is excluded, to underline its marginal role among the powers of the world. On the other hand, such a restricted table would allow the superpowers to directly discuss controversial issues, and maybe to put an end to conflicts, first of all the Ukrainian war.

In the general context of Near and Middle East, the recent US and Israeli aggression against Iran clearly showed how all the rules created to limit conflicts and manage international relations, first of all the Charter of the United Nations, have now lost any last shred of value.

The fragile agreement reached to stop the situation of Gaza, which cannot be described as a war but calling it with the correct name is not allowed, included the creation of "Board of Peace", whose interpretation differs substantially even among those who have adhered to it. Some say that it has been established to replace UNO and make it obsolete, in the name of a private and personalistic setting instead of a global community of nations.

It is safe to say that the system of international conflict management established after World War II has totally collapsed, and every country now feels free to pursue its own interest by any means, including military aggression. Other forms of conflict are widespread, especially on the economic side: sanctions, customs tariffs and so on. This is due to the fact that the greatest power, the global hegemonic nation, has openly stated that it does not attribute any value to those institutions and has started a policy of blunt aggression at all levels, to mask its dwindling actual power. If the leading power is firmly holding its role, it does not need to be aggressive, because the others recognize who is the chief of all. It becomes aggressive when it feels its grasp on world power slipping away.

On the other side, all the 5 major powers cited above recognize that outer space is where development can proceed further and the future leadership will be disputed. Each of them has a significant space program considering business and industry rather than science and exploration.

Unfortunately, the last cooperative enterprise in space, the ISS, is nearing its end and no replacement of the same kind is envisaged. The main lunar programs already in place, Artemis and ILRS, include international cooperation, but intended as a participation of minor players alongside the leader.

At the same time, the military use of space is now decisive on the battlefield on Earth - see for instance the essential role of satellite communications and data gathering for the Ukraine-Russia conflict.

The first paragraph from the April 2025 edition of the US Space Force doctrine:

National space-power ***is the totality of a nation's ability to exploit the space domain in pursuit of prosperity and security****. Comparatively, national space-power is the strength of a nation's ability to leverage the space domain for diplomatic, informational, military, and economic purposes, relative to our adversaries and competitors. As reflected below, access to and exploitation of the space domain multiplies a nation's strength across all instruments of power.*

1. *Space exploration and research strengthens diplomatic power by bolstering national prestige and generating opportunities for peaceful multinational cooperation and the advancement of human knowledge.*
2. *United States (US) space capabilities are critical to obtaining information for adequate exercise of the instruments of national power.*
3. *On the modern battlefield, space-power has become a prerequisite for global deterrence and power projection, critical to our Nation's military power.*
4. *The US commercial space industry is a rapidly growing segment of the economy with limitless potential to amplify the economic power of the United States.*

In this era of sustained strategic competition, maintaining a competitive edge through superior national space-power is critical to securing our Nation's strategic interests in, from, and to space.

Point 1 talks about peace and cooperation, but the following ones tell the truth. Space is essential for obtaining information (2) and is a prerequisite for deterrence and power projection (3), which in military jargon means attacking whomever we want wherever we want. Space is recognized to have **limitless potential** to amplify economic power (4): take note, economic power, not just economy. The conclusion clearly says that the purpose is to secure the national strategic interest.

This is an official document of the US Department of War. The limitless potential of space is openly recognized, and the purpose they have is to harness it for the national interest.

China does not publish documents like this, but it is safe to suppose that it is totally in line with these concepts. No doubt that Russia and India are as well. Little doubt that Japan is, given the nationalistic stance of the current government. By the way, Japan has just started a broad initiative for the industrialization of the Moon, involving all the major Japanese industry conglomerates, like JGC, Toyota, Mitsubishi etc. (See the presentation at Turin Moon Village Workshop and Symposium, 3-4 December 2025).

In conclusion:

1. the most powerful nations are already convinced of the importance of space and seek development there;
2. they consider space as a theater of competition, both economic and military;
3. militarization of space is a fact.

The role of organizations that want to foster peaceful and cooperative development in space is very difficult, and it is clear that a solid strategy for peace is strongly needed and must be implemented immediately, in the proper places.

Even if the UN is weak and abandoned, it is still a public scene where advocating peace is appropriate. Other nations, out of the list of five, may help, since it is clear that middle and small powers do not share the awful ideas of the big. Maybe Japan can be drawn out of the group of five, since peaceful ideals are still strong in the country. The recent speech by Canadian Prime Minister Carney about the middle powers uniting against the big is somehow promising.

Non-governmental organizations have no material power, but it is possible to enroll middle and small nations by publicizing initiatives of "space for peace". It is a uphill battle, but it is worth to be fought – to use a military like language.

1.7 Environment

There is not a single square kilometer of land, on Earth, which is not impacted by human presence. Not even the vast frozen lands of Antarctica, not even the deepest forests, not even the tips of the mountains.

The highest peak, Chomolungma, or Mount Everest, is littered with human waste, left there by innumerable climbers, and even some human frozen corpses. The ice of Antarctica includes pollutants from the atmosphere, brought down by the snow. Forests, or what remains of them, are full of signs of humanity, and recently it was discovered that the Amazonas was inhabited long ago by forgotten civilizations.

Roads and railways cross every land, cultivated fields and meadows are constantly expanding, replacing former wilderness. Even in Africa, the famous wild animals live in forests and savannas that are in fact large parks tended by humans. The bushes of Australia are inhabited by hosts of foreign animals imported by humans. The deserts of Arabia are bristling with oil and gas rigs.

It is true that resources are not running out, that there are plenty of minerals as well as areas of land where to grow crops: there is still plenty of oil and gas, rare earths are not rare at all and so on. But this abundance can be obtained only at the price of squeezing off everything else.

The famous critical materials that are needed for the energy transition, our promise of a more "sustainable development", require digging out immense quantities of earth and treating them in huge industrial plants to extract those precious substances. There is still plenty of oil and gas, at the price of “fracking” underground, spoiling water reserves and devastating land further.

It is not a question of exhausting all resources: we can still find more. The price is transforming the whole planet in an industrial and industrial-style agricultural wasteland and eliminating all the other, the non-human, inhabitants of the planet.

Even if the human population is growing less and less – but still growing – if we are going to allow everybody to enjoy a “developed” lifestyle, we shall squeeze the Earth like a sponge. Do we really want to live on a devastated planet?

Of course, two thirds of the Earth are occupied by the sea. We are not dwelling on it permanently (yet), but we are depleting it of edible fish, to the point of growing fish in enclosed cages to supply to the lack of wild ones. All sorts of non-edible animals are killed as “by-catch” in the millions. Krill, the food of the whales, is not edible for humans but is caught to feed captive fish.

Our waste is washed to the sea by the rivers, to the point that immense islands of indestructible plastic occupy large areas where the swirl of the currents gathers them.

Now some want to start extracting minerals from the untouched sea bottom, the only place that was still somewhat intact. Even the most inaccessible abyss will be dredged for the precious metal nodules, as well as the Arctic and the Antarctic ocean, bringing desolation to places whose life we do not know at all.

As the climate is changing, due to the use of fossil fuels, and, more in general, to our development in a closed environment, new opportunities come to exploit underwater oil and gas fields in the Arctic region, unfettering further use of fossil fuels in a vicious circle, so the squeezing of the Earth can go on.

The third realm, the air, is now affected by our combustion emissions to the point of slowly heating the climate. All efforts to revert this process are just illusions, greenhouse gases are still increasing and we have just seen how these virtuous attempts are in fact damaging the land, through the extraction of the minerals that are needed to convert our vehicles and other devices from combustion to battery powered electrical. And the purification processes require so much energy that they are causing a further increase in emissions, since renewable sources are not suitable to power industrial processes, due to their total lack of programmability – with the exception of good old hydropower, which devastates the land in other ways, by occupying valleys with artificial lakes and changing the regime of the rivers.

The expression “saving the planet” might be criticized, but it makes sense if we mean “saving the biosphere from human overexploitation”. Even excluding Mars and some moons of the giant planets, which may have some life of their own, the asteroids, the comets and most moons have no biosphere and plenty of useful materials: moving there is the correct way to save our way of life without wrecking our planet.

1.8 What makes the need for expansion more evident

1.8.1 The Space Launch Window

Humanity shall start expanding into space now, while capacities exist, in areas of this planet. The “launch window” for stepping toward the stars is supported by the great development of space science and technology, but it is conditioned by the social, financial, and environmental situation. Such a window may close very quickly, as the world’s social and environmental conditions will keep worsening while there will be 9 or 10 billion of us, locked up in one single planet. Even before that, resource and territorial conflicts might progressively expand the war fire up to saturate all inhabited region on Earth.

Counting the positive conditions, we observe that determined subjects exist inside the main blocks, over the continents. In the so-called democratic world – btw characterized by a substantial obsolescence of democracy as an effective governance model – a generation of space entrepreneurs appeared from the nursery of space advocacy, motivated by the humanist ideals advanced by the movement. Some of these are the richest guys of the world. That means something: the new space economy allowed them to grow up at the top of the wealth. A major problem is clearly raising, associated to the condition of being at the head of a financial empire: you cannot hide from the government. And this is a problem that any entrepreneur knows very well, whatever the size of their capital: you need contracts to survive and keep your investment capacities, so you cannot oppose the chief of the government, even when they are oppressive tyrants, warmongers and totally irresponsible persons. Not for the first time in history, space visionaries had to choose between being allowed to work or to be trashed as “enemies of their homeland”. However, often thanks to the delirium of omnipotence of the dictators, the space visionaries are working, and they are building what is needed to kick-off civilian space development, even if their inventions will maybe be used for non-civil goals. Leonardo da Vinci was obliged to design war-machines, too.

In other regions of the world, where ruling ideologies are different (yet the real governance is not that different), a firm determination to move to the Moon, establishing permanent basis and start working on lunar resources, is shaping a robust space program. While the western race to space seems to be inspired by profit, the eastern program is motivated by social need to assure new space and resources to the industrial and economic development of their nations. The common rationale, animating both the western and the eastern political leaders, is the will of planting their flag on the Moon, and establishing their national domain outside Earth, because they have perfectly understood that who dominates space also dominates Earth. Exactly like, a few centuries ago, the powers of that time had understood that dominating the seas means dominating the mainland.

The conditions and capabilities to hit the launch window exist. Not sure if the madness of the rulers will abort the whole process.

1.8.2 Culture and civilization

“*Fatti non foste a viver come bruti, ma per seguir virtute e canoscenza*” (“You were not made to live like brutes, but to follow virtue and knowledge”, Dante Alighieri)

The recent and less-recent history of humanity shows clearly which are the mainsprings that drive progress: Moving, Discovering, Learning, Knowing (MDLK). Through animal, water, mechanical, and finally the electrical power, the inner profound human aspiration to culture and sociality has demanded an ever-increasing energy bill. During the last decades, an increasing awareness of the environmental issues has brought to a radical shift toward a progressive electrification of our societies. Industrial automation, electronics inside the majority of our daily-use products, electrical mobility, electronic money, electronic communication, and ultimately artificial intelligence and robotics, that means supercomputers and big data centers, as seen at Energy and The “rare” elements. We have soon discovered that electrification doesn’t solve the environmental issues at all: we have just moved some polluting and consumption from some place to other ones. The thermal and energetic burden was moved from the streets to more remote places. And, paradoxically, the new technologies the extraction and the manufacturing processes have proven to be even more harmful and energy-intensive than the previous ones.

The above history shows clearly that the huge and growing need for energy of our cultural society cannot be satisfied within the boundaries of our mother planet, and that it would be outrageous to ask such a sacrifice to mom. She could die. Or, her biome could die.

The simple answer given by the green ideologists is: we don’t want mother Earth to die! So, let us stop consuming and polluting! Yet, they don’t seem to have a realistic global picture: a minority of humanity is consuming and polluting very much, while the majority are still living at a lower level of wellbeing. Should all humans begin start living at that lower level? It cannot work.

Yet, with the advent of big pandemics (COVID19) and big wars and genocides, another simple answer is getting momentum: let’s kill many million people! But that would not be enough. Some billion people should die, to match the required reduction of consumption and pollution. How many billions? Should we really try making proper calculations? Could we still call ourselves humans, after having accepted such a gigantic holocaust?

As humanists, we cannot believe that the majority of the people can accept one or both the above “solutions”. Both of them are not only anti-human, and totally disregarding the value of human life. They are also totally opposed to any progress, yet they both condemn our species to a catastrophic regress, to the stone age or worse. The first solution is utterly socially wrong: the long-dreamed wellbeing would be stolen to the emerging societies, and the achieved lifestyle would be stolen to the industrial societies. I just would like to remind that the majority of the citizens are not consuming at the same level of the richest ones, and they do their best to pollute less, given their urban infrastructures.

The second solution is worth of the worst butchers in history. We neither need to discuss it.

As the natural history written by Krafft A. Ehricke and other philosophers shows, the history of life on our planet is an history of progressive liberation, through biological evolution first, and through scientific and technological progress, later. Now it is clear that the aimed cultural level of our age can be reached only if we start expanding outside Planet Earth's limits, and later cutting the umbilical cord with Mother Earth.

The primary stakeholder of such a grand social process is the whole human society.

While the economy closed within Earth's atmosphere is a zero-sum game, where any new restart of industrial development clashes with the environment, the industrial development in space will relaunch global economy, and the social lift will finally move upward again, in all Earth's Countries, heading to achieve most of the UN 17 Sustainable Development Goals.

Cross-Cutting Benefits of Civilian Space Development are manifold. Energy sustainability, since solar energy abundance in space replaces fossil dependence. New industrial frontier decouples growth from Earth's resource limits, assuring economic resilience. A great environmental relief is achieved, reducing Earth impact by offloading heavy industry and energy production. And, of course, civilizational survival: expanding into space diversifies habitats, preventing systemic collapse.

2 Perspective of human expansion into outer space

2.1 A beautiful life in space – space habitats design requirements

From a humanist point of view, living in a rotating habitat in free space – as designed by Gerard O'Neill during 1970's – is very much better than living on a planetary surface. Such a choice allows a quick space economy raising, and an enhanced quality of life (in a broad meaning, from safety, to health, to well-being and great and glorious life experience). Among the main advantages of living in an artificial spinning habitat, vs. a lunar surface city: simulated gravity for human health and physiological needs; sunlight/energy available continuously; the habitat can be moved away from incoming killer cosmic objects. In essence, O'Neill habitats represent the continuation of the Enlightenment and Renaissance spirit—the belief that human reason, ethics, and creativity can shape environments that preserve freedom, dignity, and beauty. Living on the Moon or Mars, in contrast, means adapting to alien, hostile worlds that inherently restrict human flourishing, and, therefore, the quality of life. Design should push well over survival and safety. Habitats shall be beautiful, ergonomic, large and comfortable, and designed to offer a high and glorious life style. Green and water shall be abundant and shaped in harmonious style. These requirements hold the same priority of safety and construction-robustness. Beauty and art are the essence of civilization. If we build sterile, purely functional habitats, we would export only survival—not culture. A humanist vision of space demands that we carry into orbit the full richness of human experience: joy, creativity, love of form, and the pursuit of happiness. Human requirements for space habitats include health, freedom, social, industrial.

When developing space design concepts we should always start with human requirements: their rights, their health, their life, and their hopes for a better future. We work to allow people life to become better, not worse! There is no doubt that traveling and living in space *like astronauts* would be quite a poor life. An astronautic experience could be exciting, of course, if it is for a short duration.

Our duty – as humanist space advocacy organizations – is dual: to accelerate the development of the technological means to get our dreams into reality, and to contribute philosophically well-conceived requirements, to make the quality of life of the space communities really high-level, even better than what we have on Earth surface. So many terrestrials will be curious and eager to go there and being pioneers of the new world, artificers and artisans of the Civilian Space Development.

2.1.1 Living in free space vs. planetary surface

In 1969, physicist Gerard K. O'Neill asked his Princeton physics students, "Is the surface of a planet really the right place for an expanding technological civilization?". The answer he and his students derived was "no," leading to his vision of large, rotating space habitats for a vast and free human civilization, using materials from the Moon and asteroids, and solar energy.

Other space designers developed similar concepts. An excerpt from a book published in 1986 by NSS[44]: Arthur C. Clarke (1954 “Islands in the Sky”) detailed many features of living in a large station in space, made primarily of materials launched electromagnetically from the Moon. Aerospace engineer Darryl Romick (in 1956), advanced a proposal for a giant space station that was, in effect, a space colony, a clear precursor to O’Neill’s space settlements. Dandridge M. Cole (1963) had described habitats in hollowed-out asteroids and in metal-skinned colonies made from them, and had outlined the concept he called “macro-life.” Cole’s vision of a cylindrical space colony is quite similar to O’Neill’s early designs, and space writer James E. Oberg still calls space colonization “the Tsiolkowsky-Cole-O’Neill concept.” Krafft A. Ehricke proposed mobile colonies he called “andro-cells,” and a Lockheed Corporation design for a “space city” had appeared in the early 1970s.

The Ehricke’s roadmap to civilization expansion into space was not opposite to the O’Neill’s vision. Yet he conceived a different priority: his Lunar city Selenopolis, and the Moon industrialization, would come first, and andro-cells in free space in a more advanced stage.

Several scientific challenges stand out on both solutions, planetary surfaces and free-space habitats. Cosmic and solar radiation hit both. Considering that the Moon and Mars are not endowed by a magnetic field like the Earth’s one, the problem of protection from space radiation shall be solved however. Advanced studies are going on about electro-generated magnetic fields, to protect habitats and entire celestial bodies[45]: if it will be possible to create an artificial magnetic field for Mars, it will for sure be possible to create one of such things for smaller constructions. However, other solutions were investigated, to achieve a safe protection from radiations. On an O’Neill infrastructure, many meters of ground will be placed on the peripheral internal surface, and that will constitute a protection. Habitats carved inside asteroids will be protected as well, by solid “walls” of rocks all around the internal habitat. Water walls will be a valid protection too. And even air, in large quantity, is considered a protection, as Earth’s atmosphere does on our birth-planet.

Resources are both on planets, and on asteroids. We will have to work on the Moon, and on Mars, definitely. Mars will be the obvious logistic pole between the inner solar system and the beyond – asteroid belt, Jupiter Moons, and more. Yet, the settlers will not be obliged to inhabit on the surface of celestial bodies. They may work in industrial settlements on the surface, to extract and maybe partially process the resources. But large rotating habitats may be built everywhere around, in the Earth-Moon Lagrange points, in the Mars orbit, and so on. People may work on the surface during limited shifts (e.g. 1 or 2 weeks per month), and comfortably live in free-space cities the rest of their time. Part of the materials processing will likely be more conveniently done inside the industrial area of the habitats, namely the central hub, where many processes can profit of micro or zero gravity.

As far as energy is concerned, the Sun – at least inside the inner solar system – pours out abundant and free energy 7/7, 24/24, 365/365, on free space habitats. Not so on the Moon, where a 15 days night switches off the sun each month. Small nuclear reactors can be used both on the Moon and on free-space habitats, when located far away from the Sun.

2.1.2 Life & Health protection from cosmic radiation and low gravity

Astronaut Scott Kelly spent a year in the International Space Station, from March 2015 to March 2016. He was exposed to microgravity and radiation, which had detrimental effects on his health. His book, "Endurance," describes some of those detrimental effects[46]. Long-term space habitation causes significant, potentially irreversible damage to human physiology. We will need to mitigate those effects to make space travel safe enough for civilians. Mitigation is possible. Microgravity can be solved by providing rotational gravity. Radiation can be solved by shielding. It seems likely that providing adequate shielding will make space ships and habitats more difficult to build than we had expected, but at least it is doable.

The "Twin Study," which compared Scott Kelly to his Earth-bound brother Mark, highlighted profound genetic and physical changes. Key findings included Genetic Alterations. Scott experienced telomere elongation (a biomarker of aging) while in orbit, which rapidly reversed and even over-shortened upon his return. Researchers also noted chromosomal inversions and DNA damage, increasing long-term risks for cancer and cardiovascular disease. Due to Physiological Stress, Scott developed retinal thickening, carotid artery swelling, and shifts in his gut microbiome. His immune system remained in a state of "high alert" throughout the mission. Post-flight testing showed a persistent reduction in speed and accuracy across nearly all cognitive exams, a trend that did not immediately recover upon his return. In his memoir *Endurance*, Kelly describes his body as being in a state of "crushing pressure," with joints and muscles protesting gravity. His legs became "swollen and alien stumps" as blood pooled in his lower extremities, a painful reminder of the body’s lack of adaptation to Earth’s gravitational well after a year in microgravity.

In a video-clip he released to the Gateway website[47], we can also see the conditions the Scott’s legs were, during the first days after his return to the bottom of the gravitational well. Something nobody would like to experience, indeed.

There is another very bad point, from an anthropological point of view: staying long time in space – as an astronaut – has a strong demotivating effect, on human psychology: if you stay in space enough time, you never want to go back there. We don’t want generations of depressed space pioneers, that will curse the day when they abandoned the Earth’s ground.

These findings suggest an anthropological dilemma. While humans may eventually adapt to space conditions, the physiological "cost" of that adaptation might make returning to Earth impossible. A "space settler" would likely face permanent confinement to a wheelchair or suffer extreme physical agony if they attempted to visit Earth. Furthermore, the psychological impact cannot be ignored. The combination of intense physical stress and cognitive slowdown suggests a potential for profound demotivation among long-term pioneers. To avoid a future of depressed settlers who regret leaving Earth, we must find ways to ensure that space habitats are not just survivable, but capable of maintaining the fundamental biological and psychological integrity of the human species. To address the severe physiological and genetic risks of long-term stay and travel in space, research is focused on two primary technological fronts: Simulated Gravity and Radiation Shielding.

Developing SG is critical to preventing muscle atrophy, bone loss, and fluid shifts that lead to conditions like Spaceflight-Associated Neuro-Ocular Syndrome (SANS).

Centrifugal Force is the most mature concept involves rotating a spacecraft or habitat to create outward force that mimics gravity. Rotating Wheels, Torus, Cylinders, and Spheres were designed since early 1900s: Tethered Habitats were also designed, to achieve a first essential test equipment, to experiment simulated gravity: a mass-efficient approach using a long tether to connect two modules (e.g., a habitat and a spent rocket stage) that rotate around a common center, providing gravity without a massive structural ring.

Protecting against Galactic Cosmic Rays (GCR) and Solar Particle Events (SPE) requires moving beyond traditional aluminum, which can produce harmful secondary radiation when struck. [12, 13]

- Passive Shielding (Hydrogen-Rich Materials): Hydrogen is the most effective element for blocking space radiation because it has no neutrons and a high electron density.
    - Polyethylene: A lightweight, hydrogen-rich plastic frequently used in sleeping quarters.
    - Water Walls: Using the ship’s water supply (fresh or waste) as a protective layer around crew habitats.
    - In-Situ Resources: For planetary stays, using lunar regolith + polymer mix or natural lava tubes can provide thick, natural protection.
- Active Shielding (Magnetic & Electrostatic): These systems mimic Earth's magnetic field to deflect charged particles.

- Magnetic Deflection: Superconducting magnets (like Magnesium Diboride) create a protective "bubble" around the craft.
- Electrostatic Shields: Lightweight "Gossamer" structures that use electrical charges to repel incoming ions.
- Personal Protective Equipment (PPE): Wearable solutions like the AstroRad vest use selective shielding to protect the most radiation-sensitive organs while allowing mobility.

In a video-clip he released to the Gateway website[48], we can also see the conditions the Scott's legs were, during the first days after his return to the bottom of the gravitational well. Something nobody would like to experience, indeed.

There is another very bad point, from an anthropologic point of view: staying long time in space – as an astronaut – has a strong demotivating effect, on human psychology: if you stay in space enough time, you never want to go back there. We don't want generations of depressed space pioneers, that will curse the day when they abandoned the Earth's ground.

2.1.3 A non-mere-utilitarian-safe approach to space habitats design

So far the design of space habitats – orbital space stations – was intended to satisfy some essential requirements, such as isolation from the void of space, safety, enough room for scientific research activities. The intended users of such environments were military astronauts, to be there for missions no longer than six months, in few cases one year.

In his already mentioned book "Endurance", astronaut Scott Kelly claimed the insufficiency of some subsystems of the ISS, first of all the breathable air recycling system. The ISS air recycling system was designed to support its maximum capacity of nine astronauts, although it typically provides oxygen for a crew of six. The system works to recover oxygen by processing exhaled carbon dioxide, and it supplements this with a high-temperature waste processing system that can break down trash into usable gases. The water recycling system was designed to provide fresh water for a crew of six, as well. Kelly talks about periods in which 10 astronauts were living on the ISS for months, suffering headache due to excess of carbon dioxide. In another case, the air recycling system was out of order, and the backup system was in a critical status as well, so Scott had to work in very precarious conditions to recover the system, while cargo from Earth were also experimenting delays and faults.

Should permanent inhabitants of space habitats suffer for similar limitations? Life-supporting systems should be designed upon a larger redundancy concept, with more than one only backup. Life-supporting materials – such as water and oxygen in first place – should be sized according to a very large redundancy criteria. Let's say a "flamboyance" criteria[49].

2.1.4 Freedom and human rights

When we decide to go outside, to live in a space community, none of our human rights should be disattended or denied. Often, being space enthusiast, we don't think that human beings are different, each human is unique, and might have very different routes, evolution and changes, during anyone own life. So, it may happen that Peter is enthusiast to go living on the Moon, and he decides to enroll for participating in a pioneer settlers' community. Yet, after a couple of years living there, his mind could change. E.g., his beloved girlfriend partner – who two years before was well determined to reach him – nowadays has a new job on Earth, and her previous decision is now in doubt. Peter is in a deep dilemma, and is seriously considering going back to Earth… But wait: doctor said that, after two years living in lunar gravity (0,6 G), his physiology might not adapt again to earthly gravity. As a minimum, he would be constrained to a wheelchair and rehab therapy for a long period. That will affect his whole professional and personal life…

If the space community's habitat where Peter had joined was endowed by simulated 1 G gravity, he would now be fully free to leave back to Earth, and to keep his relationship and love. Decision to migrate and to return is a human right, even if not always respected. On Earth, some countries have strict immigration laws.

However, the right to migrate and come back should not be hindered by physical conditions. So, simulated gravity is a factor of freedom, not only of health protection.

Physiological and social requirements were the main focus of Gerard K. O'Neill's design of rotating space colonies. O'Neill required 1g simulated gravity because it simultaneously preserves human biology, natural social behavior, inter-generational development, and economic practicality. This made 1g not a preference but a mandatory condition for his vision of "truly human life beyond Earth."

Basic freedom requirements were considered equally important. If settlers will be used to less-then-1g gravity they couldn't exercise this fundamental human right, should they change their mind about space migration, and wanted to return living on Earth. That strikes at the ethical and political foundations of O'Neill's space colony vision. Freedom — both physical and personal — is deeply linked to the gravity environment the colonists would live under.

For O'Neill, maintaining 1 g simulated gravity was not just a matter of health or habitability — it was a principle of liberty and human rights. A colony whose inhabitants physically cannot return to Earth would violate one of his central ambitions: that humanity's expansion into space increase freedom, not diminish it.

Freedom of migration is not the only rationale for the 1g mandatory requirement. O'Neill also mentions a key industrial sector that will expand proportionally to human settlement in the Solar System: tourism, two ways. Earthly citizen will want to visit the colonies, and the settlers will like to visit Earth. The tourism industry will be a key pillar of the solar society economy: we definitely don't want visitors coming to Earth from space communities to have an uncomfortable experience, due to the Earth's gravity!

2.1.5 Psychology, Ergonomics, Well-being, Well-interacting, Privacy

Future space habitats must transcend mere survival, evolving from "life-sustaining" to "life-glorification" systems. Beyond radiation shielding and simulated gravity, these environments must support a quality of life that rivals or exceeds Earth's. Residents require spacious, fully-equipped private flats—complete with kitchens and bathtubs—rather than cramped cabins.

Design priorities include expansive common areas like agoras and meeting rooms, optimized for ergonomics and social connection. Aesthetics are critical: relaxing colors, soft lighting, and abundant seating should minimize anxiety while fostering community. Environments must balance privacy with social spaces, offering diverse settings for entertainment, sport, and relaxation. Crucially, residents should have the autonomy to choose when to view outer space or retreat into a familiar, terrestrial-style interior. By merging safety with beauty and comfort, these habitats will ensure that space life is not just a mission of endurance, but a vibrant, desirable way of living.

2.1.6 Green environment, gardens, and water mirrors

Beyond sustenance and oxygen, a vibrant green environment is essential for the psychological and biological health of space settlers. NASA acknowledges, as reported in a recent article[50], that while plants provide critical vitamins—like Vitamin C—that degrade in prepackaged food, their aesthetic value is equally vital. "Pioneering astronauts" have already proven that fresh flowers and gardens on the ISS provide a necessary emotional link to Earth, mitigating the isolation of deep space.

However, a truly sustainable habitat must go beyond small hydroponic trays to recreate an authentic terrestrial biome. This requires integrating selected animal varieties and, crucially, large-scale water systems. As Portuguese researcher Dinis Afonso Ribeiro suggests, we must develop a "culture of water" in space[51]. Small reservoirs are insufficient for self-supporting ecosystems; nature requires vast volumes of water to allow life to "root" and ramify, distributing nutrients as it does on Earth.

In large-scale spinning habitats, such as O'Neill cylinders, the physics of centrifugal force allows for the inclusion of rivers, lakes, and even seas. These bodies of water serve multiple roles: they act as thermal regulators, provide radiation shielding (due to their hydrogen content), and offer essential recreational spaces for the human mind. Whether in free-floating infrastructures or terraformed Martian valleys, the presence of expansive water is not a luxury but a requirement for long-term settlement.

Ultimately, space life must move from "survival mode" to ecological immersion. By surrounding inhabitants with lush gardens and flowing water, we ensure that space becomes a home rather than a laboratory. Learning to reproduce these complex, water-dependent ecosystems is the final key challenge in the roadmap to permanent space colonization.

2.1.7 Beauty, ergonomics and comfort are not low priority

In a rotating space habitat, beauty, ergonomics, and leisure are not luxuries—they are biological and psychological imperatives. Survival requires more than oxygen; it demands "life-glorification" systems that prevent the stress, isolation, and depression inherent in closed environments. Ergonomics and comfort must be central, with tools and layouts adapted to human proportions to minimize fatigue. Redefining comfort through optimal lighting and restorative spaces ensures that a station feels like a "home" rather than a laboratory. Sports and play serve as essential "medicine," fostering community bonds and providing a psychological safety valve through competition and movement, especially in unique zero-gravity central hubs. Furthermore, arts and culture give meaning to the human experience in orbit. Music, theater, and painting are vital for maintaining collective identity and emotional health. If we build purely functional, sterile habitats, we export survival but not civilization. A humanist vision of space demands environments that support joy, creativity, and the pursuit of happiness. By prioritizing aesthetic richness, arts, and social play, we transform a mechanical structure into a living world where humanity does not merely persist, but truly flourishes.

2.1.8 Culture, education, arts

To foster a flourishing civilization, space habitats must provide dedicated infrastructures for education, art, and spiritual expression. Facilities should range from joyful children's classrooms to "edutainment" centers for all ages. Architectural design must prioritize versatility: soundproofed studios for private practice, theaters for public performance, and grand halls for scientific or philosophical symposia. Crucially, non-institutional spaces should be available to encourage free research and communal religious rituals, supported by advanced collaborative technologies.

From a philosophical perspective, as Dr. Marie-Luise Heuser explains[52], space habitats represent a radical departure from earthly social constructs. Going beyond Michel Foucault and Gaston Bachelard, Heuser argues that while terrestrial spaces distinguish between 'public and private,' a space habitat introduces a sharper dichotomy: the vibrant, bounded 'inside' versus the boundless, uninhabitable 'outside.' This existential shift requires a deliberate approach to social architecture.

As she pointed out, a central challenge lies in the tension between unity and plurality. Designers must decide whether the habitat should preserve Earth's diverse languages, religions, and traditions or evolve into a single, unified culture. This impacts every structural decision:

- Cultural infrastructure: should there be separate schools and places of worship for different ethnic or linguistic groups, or integrated "universal" spaces?
- Identity and history: how will the habitat honor Earth's history while simultaneously giving rise to a new "space philosophy"?
- Social Inclusion: how will architecture reflect shifting views on gender, diversity, and educational hierarchies?

In a freedom-oriented design, the answer lies in maximum flexibility and respect for choice. Some pioneers will seek to conserve their ancestral traditions, while others—transformed by the "Overview Effect" and space life—will forge entirely new spiritual or cultural communities. To protect this 100% freedom, the physical habitat must be an "open infrastructure" capable of hosting both the preservation of the old world and the birth of the new. By designing for diversity rather than homogeneity, we ensure that the habitat is a true home for the full spectrum of human experience.

2.1.9 Space Medicine and Health-Care

Dr. Susan Jewell suggested the following infrastructures for keeping inhabitants in good health, both physical and mind: Infirmary; Hospital with emergency room, surgical equipment, and intensive care; Tele-Health and Tele-Surgery; Pharmacy, with all medicines suitable to recover from space and non-space-related illnesses; Remote assistance, by Avatar, for emergency and sanitary personnel know-how upgrade; Tele-robotics; Microgravity and hypo-gravity countermeasures; Radiation protection systems; Artificial Intelligent medical systems and tools.

2.1.10 Bootstrapping industrial production in the geo-lunar space

Kicking-off the geo-lunar space industrialization is key, to commence Civilian Space Development, and human expansion into outer space.

The geo-lunar space (roughly the volume between Earth and Moon, including GEO, Lagrange points, and cis-lunar orbits) is emerging as a *new industrial zone* for the 21st century. Several industrial activities, technically possible, economically convenient, and potentially profitable in that region, are essential for building a sustainable space economy.

Some high value, low mass products are feasible with current or near-term technology and justify launch costs due to their high economic value per kilogram:

- Satellite Manufacturing, Servicing in Orbit, Additive Manufacturing, Energy Relays
- Orbital Debris Recovery and Reuse
- Propellant Production & Depots
- Lunar & Asteroid Mining and Material Refinement

2.1.11 The gifts of free space

Full Human Freedom and Self-Determination are assured, by the absence of any planetary gravity well. O'Neill habitats are free in space, not bound to a planetary surface. This means freedom of movement, expansion, and association, without the geopolitical or environmental constraints of planets. Each habitat can be designed as a small, autonomous society, fostering pluralism, diversity, and experimentation in governance and culture—key humanist values. Even more important, any space migrant will be free to go back living on Earth, should they change their mind for any possible personal reasons.

Earth-like Living Conditions may be achieved by design. Simulated gravity can be set to 1 g, preserving human health and avoiding the debilitating effects of low gravity found on the Moon (0.16 g) or Mars (0.38 g). Sunlight and day-night cycles may me modeled by means of mirrors and shutters, to reproduce natural illumination, allowing circadian rhythms, agriculture, and psychological well-being. Or, in alternative, different day-night cycles may be set, upon individual or collective requirements. Comfort and aesthetics may be pursued by integrating parks, lakes, and cities with Earth-like beauty—rather than the sterile, confined, and dusty environments of planetary surfaces.

The free space environment provides many gifts, not yet fully appreciated. Writes A. V. Autino, author of this paper[53]: "It is only in the extraterrestrial space that humans can escape the many physical limits of this planet: gravity, attrition, time constrains, season cycles, resources finiteness, territory, environmental constrains. Settling out of the terrestrial atmosphere and gravitational well we will achieve a very greater degree of freedom."

Moving from a free space habitat will be very much cheaper than moving from any planetary surface. Motion is nearly effortless due to the absence of gravity and atmospheric friction. A small amount of energy can move objects across hundreds of thousands of kilometers—suggesting that future space trade could transport vast cargoes with minimal fuel. As Gerard O'Neill noted, a quarter of terrestrial transport energy is lost to the constraints of gravity and attrition. Space, therefore, offers a radically more efficient transportation domain, opening immense industrial and commercial possibilities. Inflatable, ultra-thin materials may be used for large orbital structures provides a structural lightness of space engineering. Freed from gravity and wind, such “extraterrestrial technologies” can achieve immense size and strength with negligible mass. O’Neill calculated that a space-based solar reflector the size of a football field could weigh less than a car yet generate energy equivalent to burning millions of barrels of oil over decades—demonstrating that zero-gravity industry could outperform any Earth-based system in durability, efficiency, and cost. Space also holds the key to solving the energy problem forever through space solar power plants. In free space, solar panels receive constant sunlight at full intensity—about 1,400 W/m², 24 hours a day—without interruptions from night, weather, or seasons. These installations could continuously feed clean energy to space habitats. Beyond energy, space resources offer immense material wealth. The asteroid belt, rich in metals, silicates, and carbon compounds, could supply all the raw materials needed for habitats, machinery, and industrial production—far more easily than mining Earth’s deep crust.

A “golden age” will flourish in space, where abundant sunlight and limitless energy foster comfort, creativity, and beauty. Space habitats could enjoy perpetual illumination and power, supporting agriculture, arts, and well-being far beyond Earth’s constraints. This “space green revolution” would use solar energy, closed ecosystems, and space farming to produce vast amounts of food without pollution or pesticides—sustaining billions while restoring Earth as an ecological sanctuary.

2.1.12 Sustainability and economic logic

From the sustainability and economic logic point of view O’Neill colonies, being located in the Earth–Moon system, can process lunar and asteroid materials, while maintaining easy and continuous energy access from the Sun. Designed from the start for circular, self-sustaining ecosystems, the free space habitats will foster responsible environmental stewardship, working as closed ecological loops. Based in a boundless space, habitats will be free to expand, when population and food production needs will grow. Proximity with Earth will assure easier logistics for trade, culture, and family connections.

2.1.13 Cultural and Human Flourishing, a step beyond survival

Conceived according to Human-centered design, environments can be tailored for education, art, and community life, supporting mental health and creativity. While Moon and Mars bases are mainly about endurance, O’Neill habitats represent the expansion of civilization and humanism into space, a step beyond survival, turning space into a living domain rather than a frontier of struggle. A symbol of liberation, moving into free space embodies the humanist ideal of freedom from natural limits, replacing adaptation to harsh worlds with the intelligent transformation of the cosmos into humane environments. In essence, O’Neill habitats represent the continuation of the Enlightenment and Renaissance spirit—the belief that human reason, ethics, and creativity can shape environments that preserve freedom, dignity, and beauty. Living on the Moon or Mars, in contrast, means adapting to alien, hostile worlds that inherently restrict human flourishing.

2.2 Some urgent advances, science, technology and policy

Human requirements for space habitats and vehicles, protection from cosmic and solar radiation, simulated gravity, redundant design.

2.2.1 Redundant and humanist design

As already addressed in A non-mere-utilitarian-safe approach to space habitats design, so far the design of space orbital space stations was intended to satisfy some essential requirements, such as isolation from the void of space, safety, enough room for scientific research activities. Such design criteria was 100% informed to the paradigm of space exploration.

Human space flight was intended to be done by military trained astronauts, during missions no longer than six months, in few cases one year.

Life support systems were sized primarily based on budgetary constraints, in a context where human life and health were not paramount requirements. Onboard the ISS, for instance, the breathable air recycling system capacity was dramatically insufficient, and has caused headaches and other ailments to astronauts. One only backup system is on the ISS, and in some cases this was cause of critical situation, when both systems suffered for malfunctions.

From a humanist point of view, such a setup should never be acceptable, when human lives are involved in the process. However, that will not be acceptable, in the frame of civilian travel and residence in space.

Life-supporting systems should be designed upon a larger redundancy concept, with larger capacity parameters, and more than one only backup. Life-supporting materials – such as water and oxygen in first place – should be dimensioned according to a very large redundancy criteria.

2.2.2 Space waters management

Also, as soon as it will be possible to get water from asteroids and cometoids mining, a water cycle different from the simple direct recycle of human wastes should be conceived, allowing more nature-like processes to be included in the production of drinkable waters. It will be very-much interesting, for this scope, to explore as soon as possible the entanglement among different water processes, at least:

- Drinkable water
- Sanitary water
- Water for radiation shielding
- Waste waters
- Water for space-agriculture
- Water for habitat lakes, rivers and gardens
- Water for fish farming

As the space habitats will raise in size and capacity, the complexity of the life-supporting systems (air and water first) will reach a level of complexity similar to the Earth's one.

Yet, from the very beginning, civilian space habitats should be designed having in mind humanist requirements, fully informed to human rights, and protection of life and health.

In a 2023 article[54], NASA has communicated that 98% of waste waters recovery was achieved on the ISS, where a new Water Processor Assembly (WPA), integrated with the Water Recovery System (WRS), both assembled in the Environmental Control and Life Support System (ECLSS). In the article we learn that "Each crew member needs about a gallon of water per day for consumption, food preparation, and hygiene such as brushing teeth." Supposing the article was talking about US gallon, it means less little than 4 liters, and hygiene seems to be limited to teeth brushing. No shower at all (!). Of course, they are still thinking in terms of "crew members". Also, the article reports that "the idea of drinking recycled urine might make some people squeamish". But the team stress that "the end result is far superior to what municipal water systems produce on the ground", and "The processing is fundamentally similar to some terrestrial water distribution systems, just done in microgravity." Of course, in microgravity. Nobody seems to be thinking about life-support systems in simulated gravity regimes, nor thinking about taking showers!

Another article (September 2025)[55], published on Space.com talks about the same issue: "The water recovery systems used in space employ some of the same principles as Earth-based water treatment. However, they are specifically engineered to function in microgravity with minimal maintenance. These systems also must operate for months or even years without the need for replacement parts or hands-on intervention." From the article, we learn what NASA is thinking about, beyond ISS, as far as life-supporting systems are concerned: astronauts on Mars. So, astronautics and exploration, yet. Seems that new commercial orbital stations – that should be designed for civilian tourists! – or lunar settlement after ARTEMIS and ILRS, do not enter their programs in any ways.

A very comprehensive paper[56], published in January 2026 by a Sudafrican research team, offers a wider look on the issue of space water management. Interestingly, the paper mentions some technological advances in water recycling: bioregenerative systems, promising sustainable solutions for space habitats, and nanotechnology for advanced filtration, autonomous systems for real-time water quality management, and artificial intelligence (AI) to enhance these systems' overall efficiency and reliability. For the first time we see the term "quality" to appear in a system-design context. This is promising, indeed.

China Manned Space Agency (CMSA) is aiming to create an Earth-like habitable living environment in space[57]. Life-support systems on the Tiangong orbital station regulate the air pressure, oxygen content, wind speed, temperature and humidity, among others, inside the spacecraft. It also reduces noise in the cabin with sound absorbing covers, sound insulation panels, vibration isolators and shock pads. Sweat and urine of taikonauts are purified into drinking water, and oxygen is produced by electrolyzing recycled water. Water is produced by exhaled carbon dioxide and hydrogen from water electrolysis.

As we may read in these and other articles and papers, the main concerns related to water and life-support systems, during the exploration age, were the following:

- Minimizing the quantity of water to be brought in space stations from Earth
- Minimizing the quantity of water to be added or generated to space stations
- Minimizing the maintenance and consumable parts replacement
- Making the systems to work in micro-gravity

Thinking in perspective of civilian space settlements, several changes apply. First of all simulated-gravity habitats will not need to use micro-gravity constrained systems. Earth systems that use gravity in filtration techniques can be used. Bigger O'Neill style environments will allow a more Earth-like environmental management, including waters cycles. Using In Situ Resources, from the Moon and asteroids/cometoids, will make the settlers less constrained than the today astronauts.

2.2.3 Protection from solar and cosmic radiation

Together with simulated gravity, protection from solar and cosmic radiation is the highest priority, in an ideal agenda for Civilian Space Development.

From the Thesis 1[58] of the 2021 SRI 3rd World Congress: *"Hard radiation, coming from the sun and from remote supernovae, is very dangerous in space, and represents a serious threat to human life and health, and to any forms of life that we will bring with us during our expansion outside Earth. On Earth surface, these radiations are less dangerous, because the atmosphere acts as a shield as does the magnetic terrestrial field. The amount of radiation which reaches Earth is tolerated, by humans. […] Earth owns a magnetic field, due to its liquid metallic nucleus, but Mars does not, since its nucleus is colder, and almost solid. Cosmic radiations could become dangerous on Earth surface too, due to: particularly high sun flares, unexpected changes of the protection conditions, Earth's magnetic field inversion of the magnetic poles, a process that occurred in the past, causing immense environmental catastrophes, and which could be already in progress. The risk represented by cosmic radiations should be considered potentially high on Earth, and extremely dangerous in space, with progressive increase of the danger, according to different protection conditions: Earth surface, Low Earth orbit, Geo-stationary Earth orbit, Within Van Allen Belt, mid-way between Earth and the Moon, Moon surface, Cislunar space Outside magnetic Earth, 1.5 million km from Earth, Mars orbit, Mars surface, Beyond Mars, Asteroid Belt, and beyond The mitigation of the cosmic radiations risk requires a program of immediate action, giving high priority to scientific research for protection technologies and suitable strategies, both on Earth and in space. […] The aim is to study and develop both active and passive shields that work with high efficiency. Active shields are those that create a deflection of the radiation through the production of a strong magnetic field, and thus protect a whole living module. Passive shields, instead, are characterized by absorbing the radiation, and generally consist of special garments/covers for astronauts and/or equipment."*

Significant advancements in protecting human life against space radiation have occurred in the last five years.

Some physical advances are in the field of astronautics. The AstroRad vest[59], a wearable shield designed to protect vital organs with high radiation sensitivity. It was flight-tested on the International Space Station (ISS) and during the Artemis I mission (launched late 2022) to evaluate its ergonomics and protection levels in deep space. Biological and pharmacological countermeasures are also researched, including radioprotectors & mitigators drugs, personalized stem cells, and dietary interventions.

Yet, of course, we cannot think that ordinary space citizens should be obliged to wear individual protective vests, or to follow special diets or be subjected to lifelong pharmaceutical protocols. In the perspective of civilian space development and settlement, structural solutions are very much more important.

Research has moved beyond traditional aluminum toward materials that do not produce "secondary radiation" (showers of particles created when cosmic rays hit heavy metals). Hydrogen-Rich Polymers[60]: High-density polyethylene and other low-atomic-number materials are now the gold standard because hydrogen atoms lack neutrons and are more effective at stopping heavy ions without creating secondary fragments. Nanotechnology: Boron Nitride Nanotubes[61] (BNNTs) are considered a premier next-generation material for protecting astronauts from space radiation in habitats, offering a lightweight, strong, and highly effective alternative to traditional aluminum shielding. Due to their unique atomic structure—containing boron and nitrogen—BNNTs excel at absorbing high-energy neutrons, which are produced as secondary radiation when cosmic rays strike space structures. Studies have demonstrated that Boron Nitride Nanotubes (BNNTs) and graphene oxide can reduce radiation exposure by up to 45% while being significantly lighter than lead.

While still in the "infancy" stage, there has been renewed momentum in Active Shielding—using magnetic or electrostatic fields to deflect charged particles, similar to Earth's magnetosphere. Active shielding is now viewed as a necessary supplement to passive mass shielding for long-duration Mars missions. NASA has recently refined designs for the Deployed Electromagnetic Radiation Deflector Shield (DERDS)[62], which uses superconducting magnets to create a protective "bubble" around a spacecraft.

The NASA's Human Research Program (HRP) includes 4 elements:

- Human Factors and Behavioral Performance - Characterizes and mitigates behavioral health and performance for future missions to the Moon, Mars, and beyond.
- Human Health Countermeasures - Assesses the effects spaceflight has on the human body and develops safeguards to deal with those changes.
- Space Radiation - Ensures that crewmembers can safely live and work in space without exceeding acceptable radiation health risks.
- Research Operations and Integration - Plans, integrates, and implements services for HRP research in Earth-based simulations, the International Space Station, and other platforms.

In the frame of the NASA's 2026 program and budget, the research on countermeasures against Space Radiation is embedded in the ARTEMIS and Mars programs, and specifically in areas like Advanced Exploration Systems, for technologies for long-duration missions (lunar and Mars), Moon to Mars Strategy, specifically for Mars-focused programs, where cosmic radiation mitigation is a primary research driver, Human Surface Mobility. The HRP receives 130 to 150 $millions yearly. Space Radiation is considered a "red risk" at NASA, and HRP a critical safety program.

However, a very small percentage of the 2026 NASA allocated budget – 27,5$bn – is dedicated to HRP and to the radiation protection, a mere 0.5%. It means that we are still in the exploration paradigm age. The funds targeted to support civilian space development and settlement, in general are still a very small fraction of the support given to exploration and, now, to the national military primacy in space.

In its last Ministerial meeting, 26-27 November 2025, ESA decided a budget of 22.3€bn over 3 years 2026-2028, 30% over the previous period. On a 2026 budget of 8.26€bn, ESA will spend 818€m for Human Exploration Research. In that frame, the research on space radiation protection is embedded. The total Space Safety budget for 2026-2028 three years is 955€m, that's about 320€m per year. Let's consider that the Space Safety area covers 100% worth activities like asteroid monitoring. Yet it is easy to see that funding for radiation protection falls likely around some tens of € million.

Space Renaissance does not claim to quickly revert this reality in two weeks (though that's what we should need). We just advocate a better consideration for the civilian space development, to enhance the priority of the "red" research strains, and assign them a better budget, e.g. 10x, from 150$M to 1.5$bn, at least.

2.2.3.1 Passive protection

Passive radiation shielding relies on physical mass to block or attenuate Solar Particle Events (SPEs) and Galactic Cosmic Rays (GCRs). Passive technologies are currently the only flight-proven solutions for long-term protection. For space radiation shielding, low-Z materials with a low density of neutrons and the highest density of electrons per atom are preferred. Hydrogen, for example, is the best material for shielding against space radiation as it has the highest density of electrons per nucleon and no neutrons, which is superior at slowing down high-energy protons and reducing the production of dangerous secondary radiation[63]:

- Hydrogen-rich Polymers: High-Density Polyethylene (HDPE) is a primary choice due to its high hydrogen density and structural stability.
- Water: Water is an excellent shield and can be integrated into "water walls" or storage systems surrounding living quarters.
- Consumables: Strategically placing food, wet wipes, and other hydrogen-rich supplies around the habitat hull provides "free" additional shielding.
- Composite Materials: Layered systems of aluminum (for structure) and polyethylene or lithium hydride (LiH) are often used to balance strength and shielding efficiency.[64]

On the Moon, explorers can leverage local resources to provide massive shielding that would be too heavy to launch from Earth[65]:

- Regolith: Lunar soil (regolith) is the most practical shielding material. Habitats can be buried under several meters of regolith to achieve Earth-like protection levels.
- Lava Tubes: Utilizing naturally occurring underground volcanic tunnels offers substantial protection from both radiation and micrometeoroids.
- Sintered Regolith: 3D-printing or solar-sintering regolith into solid bricks or shells can create custom protective structures for surface habitats. [2, 14, 15, 16, 17]

For space travel or deep-space habitats, the shielding research only focused on astronautic requirements, so far. The spacecraft's limited mass budget was the main concern[66]. Some covered items include Storm Shelters, small, heavily shielded "safe room" where the crew retreats during intense solar flares; Multipurpose Shielding, designing the spacecraft so that the propellant, water tanks, and equipment (like batteries) are located between the exterior hull and the *crew cabin*; Wearable Shielding, personal protective equipment, such as the StemRad AstroRad vest, provides targeted protection for radiation-sensitive organs during solar events; Self-Shielding, optimizing the habitat's interior layout so that the "mass-density" is highest where astronauts spend the most time, such as sleeping quarters[67].

Life protection from radiation in the Artemis program is a multifaceted challenge, involving passive shielding, wearable technology, advanced monitoring, and strategic mission planning to safeguard astronauts traveling beyond Earth's protective magnetic field. The Artemis I mission successfully demonstrated that the Orion spacecraft's design, along with specific operational maneuvers, can effectively mitigate radiation risks to acceptable levels for lunar missions.

The most recent research for life protection in space is in the frame of the ARTEMIS program. Radiation exposure for Artemis missions is expected to remain within NASA's safety limits (3% or less increased risk of cancer mortality), thanks to these protective measures:

- Orion Spacecraft Passive Shielding, incorporating shielding materials, such as hydrogen-rich plastics (polyethylene), designed to slow down or block high-energy radiation particles.

- Operational Maneuvers & Positioning: During the Artemis I mission, a 90-degree turn of the Orion spacecraft while passing through the inner Van Allen belt reduced the radiation dose inside the cabin by 50%.
- Built-in "Storm Shelter": In the event of a Solar Particle Event (SPE)—a sudden, intense burst of solar radiation—astronauts will use a designated, more heavily shielded area within the Orion crew module as a "storm shelter".
- Crew-Made Shielding: NASA plans to have crew members on missions like Artemis II use stowage bags containing supplies to create a "makeshift storm shelter" in the central part of the module, increasing the surrounding mass.
- AstroRad Vest: Tested during Artemis I, the AstroRad vest (developed by StemRad and Lockheed Martin) is a wearable, radiation-shielding garment designed to protect sensitive organs from SPEs. The vest uses Hexagonal, specialized materials to block proton radiation.
- Real-time Monitoring & Dosimetry: Orion is equipped with Hybrid Electronic Radiation Assessor (HERA) sensors, which act as a "Caution and Warning System" that alerts the crew to take action during high radiation events. Crew members will also wear personal active dosimeters, such as the Crew Active Dosimeter (CAD).
- MARE Experiment (Phantoms): Artemis I carried two mannequins, "Helga" (unprotected) and "Zohar" (wearing the AstroRad vest), to compare radiation exposure, providing critical data on how to protect the human body, particularly sensitive tissues.
- Future Surface Protection: For long-term presence on the Moon, habitat modules may be covered with at least 50 cm of lunar soil (regolith) to provide necessary protection.

Space Renaissance recommend the major space agencies, and possibly space enterprises, to establish more advanced research programs, clearly oriented to space settlement and development, and not just for astronautic exploration, both for free-space habitats and lunar or Mars surface industrial settlements. Such programs should not be considered "long-term" programs, just working with concepts, yet they should be established as urgent and top-priority programs, endowed with funds accounted in the range of billions, not of few millions.

As a very promising line of development for passive shelters and habitats, both for lunar surface and free-space, we refer to a long-lasting research and analog experimentation conducted by Enrico Dini, CEO and founder of D-Shape[68], using several 3d printing techniques, in collaboration with La Normale University of Pisa, Sitael S.p.A.:

- Lunar regolith simulant and proper ink (binding glue), using a big plotter (3x6 meters)
- Lunar regolith simulants and proper polyurethane foams, combined with inflatable chemically rigidizable containing forms
- Lunar regolith sintering process

See in Figure 7, Figure 10, Figure 11, Figure 12 some conceptual views of habitats building for free-space and lunar surface, as described in a presentation given at ESA 2020-2030 Symposium.[69]

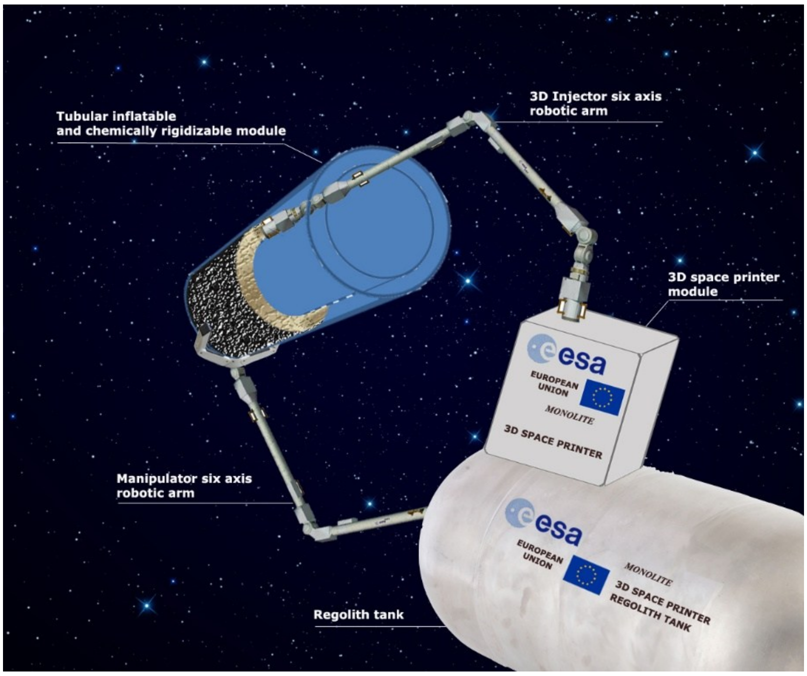

Figure 7. Building of a cylindrical habitat module in free-space (concept)

In Figure 8 a conceptual view of a rotating space habitat, endowed with simulated gravity, composed by inflatable structures filled by poly-u-regolith mix. See also Figure 7. In the already quoted paper for ESPI[68]

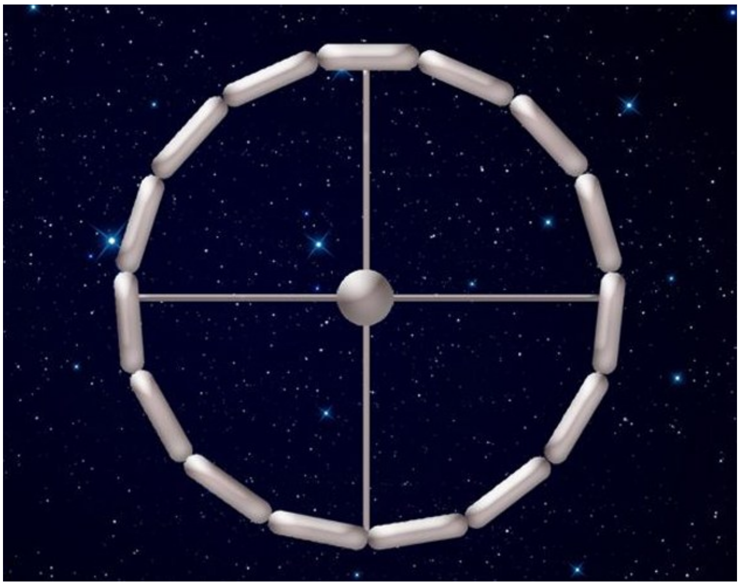

Figure 8. A rotating space habitat composed by inflatable+poly-u-regolith modules

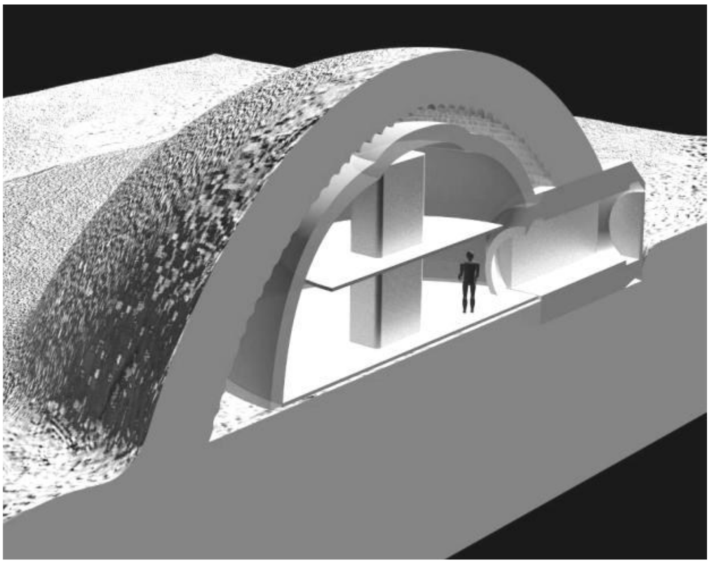

Figure 9. Lunar habitat covered by a 3d printed regolith shelter (artistic view)

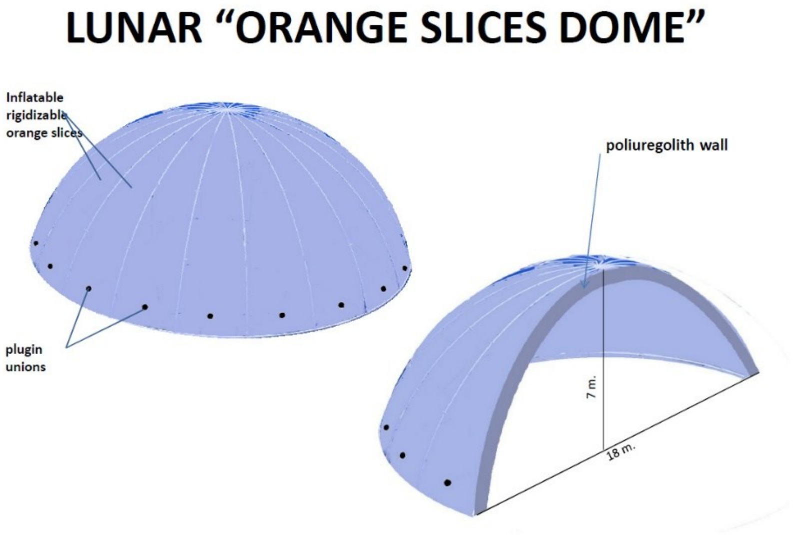

Figure 10. Dome, composed by inflatable+poly-u-regolith slices concept

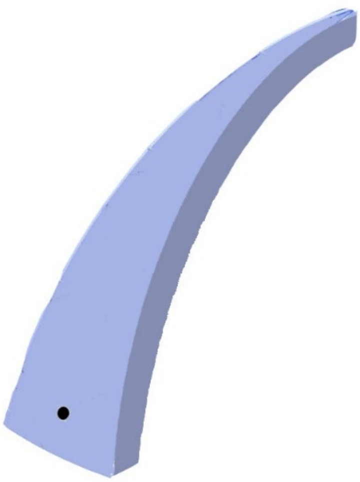

Figure 11. Inflatable+poly-u-regolith single dome slice, concept

INFLATABLE CONTAINMENT STRUCTURES

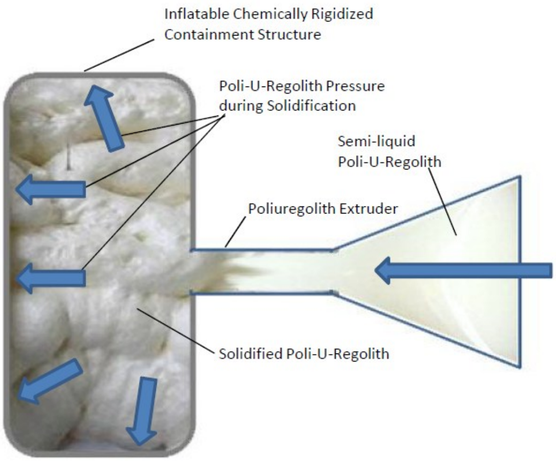

Figure 12. Inflatable Chemically Rigidized Containment Structure (ICRS) Concept

SRI advocates similar projects to be very much better funded, in order to accelerate the development of civilian space infrastructures.

2.2.3.2 Active protection

There are conceptual studies also to create an artificial magnetosphere for Mars[70]. Joe Pelton and James Green have co-authored a paper postulating the concept[71].

SRI endorses these studies, and calls for a substantial increase in funding for this research, that might provide the solution to large space habitats and interplanetary spaceships too.

2.2.4 Simulated gravity, general concept

Core Challenge - The human body is naturally adapted to Earth's gravity and biosphere. Prolonged exposure to microgravity in outer space causes severe health risks, including bone demineralization, muscle atrophy, and orthostatic intolerance. To enable long-term human settlement, engineers must design artificial environments in free space that provide simulated gravity through rotation.

Simulated Gravity and Structural Engineering - Simulating gravity requires careful calculation of a habitat's rotation rate and radius to prevent the Coriolis acceleration from disturbing the human vestibular sense.

Optimal Parameters: A theoretical "comfort box" for inhabitants requires a minimum rotation radius of roughly 220 meters and a maximum rotation rate of about 2 rounds per minute.

Testing Facilities: Initial rotating orbital stations, such as the "Island Zero" concept, are necessary to test the physiological impacts of various rotation rates.

The Roto-Joint Problem: Space stations require a crucial joint to connect rotating living areas with non-rotating elements like central hubs, docking harbors, and solar arrays. This can be solved using a magnetic liquid rotary seal, which utilizes an oil-based "ferrofluid" with iron filings held magnetically in a labyrinth seal to prevent air loss in a vacuum.

Construction Technologies and Materials - Initial space stations in Low Earth Orbit (450 to 500 km) will rely on modules lifted from Earth via reusable rockets or spaceplanes. Inflatable materials save launch weight and volume. Rigid aluminum or carbon fiber modules can be fully equipped prior to launch. Long-term construction will heavily rely on In Situ Resource Utilization (ISRU):

- Lunar Resources: Elements like iron, aluminum, titanium, and water can be extracted from lunar regolith. Regolith, mixed with polymers rich of hydrogen (for shielding from hard space radiation purpose) can be melted under high pressure into "lunarcrete" (fused bricks) to build domes and shelters.

- Asteroid Mining: Factories located in cis-lunar space could process Near Earth Asteroids to produce building materials, air, and rocket fuel.

Habitat Geometry - Three primary geometric structures are defined, for large-scale habitats:

- Torus (e.g., Stanford Torus). Considered the most feasible initial shape due to its lower air and water volume requirements compared to other shapes.
- Cylinder. Requires a highly stable structural framework (metal or composite shielding "wall") to withstand internal air pressure and external forces from thrusters or meteorite impacts, and for radiation shielding as well.
- Sphere (e.g., Island One): Provides a limited 1g habitable area restricted to its equator and requires managing a massive internal air volume. The less suitable to provide a uniform habitable environment.

Shielding and Artificial Climate - Space habitats must protect inhabitants from constant cosmic rays and frequent solar flares.

- Radiation Shielding: Dense materials are required; for example, every 1 g/cm2 of shielding reduces the annual radiation dose by about 3.4 rem. A 0.12 m layer of fused rock shields against cosmic rays, while a 3.0 m layer is needed to block solar flares.
- Multi-layer Hulls: Habitats will utilize multi-layer construction, such as an outer foam-glass layer for thermal insulation (+18°C to -10°C) and micrometeorite protection.
- Climate Control: Large glass windows are discouraged due to radiation exposure, thermal loss, and meteorite risks Instead, habitats should capture sunlight using parabolic mirrors, beaming it through a central window onto a distribution cone Mechanical shutters can then be used to simulate day and night cycles. Optical fibers might also be used to bring the solar light inside the habitats.

Ideal Locations - The most convenient locations for these massive space habitats and factories are the Lagrange Points within the Earth-Moon system, specifically the highly stable L4 and L5 points.

2.2.5 Simulated Gravity Orbital Station

(based on the work by Werner Grandl)

Werner Grandl and Clemens Böck are working since 2017 on the design of a modular orbital station called AGOS (Artificial Gravity Orbital Station). Although there is done much research on inflatable structures, e.g. by Bigelow Aerospace, we propose hard-shell aluminum structures for the AGOS modules. Metal-frame hard-shell modules can be lifted into LEO with their entire furniture and equipment, air locks, etc., whereas pneumatic structures are empty after inflation. AGOS would be assembled in orbit by astronauts and assisting robots. The remains of ISS could be used as a „site hut" and storage facility during assembling.

The initial stage 1 of AGOS contains four rotating living modules with 0.9 G, four zero-gravity central modules (two of them rotate), a docking module, connecting tubes and structural framework to stiffen the entire structure. The modules have 7 meter in diameter and 14 -18 meter length. The non-rotating framework carries 1600 m² solar panels. Two joints connect the rotating elements with the non-rotating parts of the station. The entire initial stage will have approx. 270 tons. Including the transport of robots, tools, etc., it will take 15 launches to establish stage 1.

Due to its modular design AGOS can be enlarged by „plug in" of additional modules and structural framework. The possible final stage will be a closed ring of 32 living quarter modules with a maximum crew of about 180 persons.

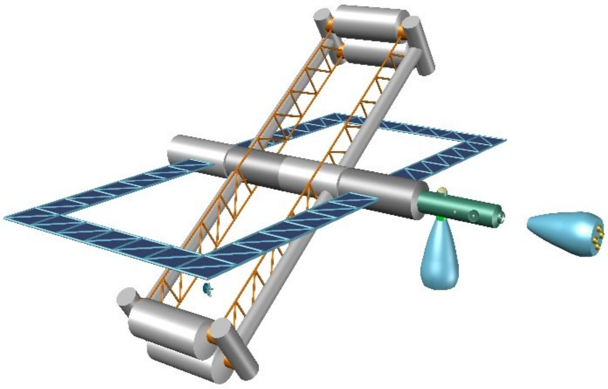

Figure 13. AGOS initial stage 1, crew 24

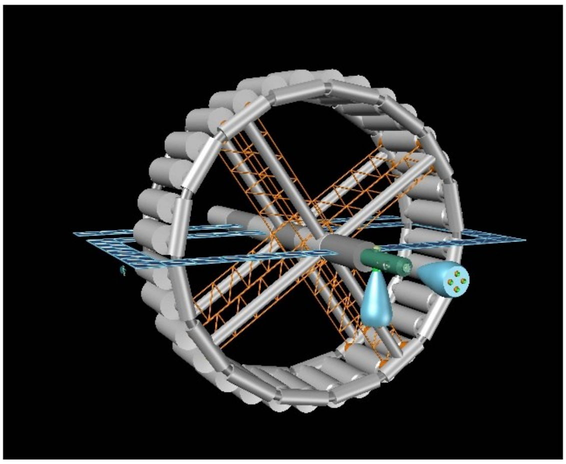

Figure 14. AGOS final stage, crew 180

AGOS dimensions:

- length 78 m, span 102 m,
- rotation radius 40 m
- rotation rate 4.3 rpm

2.2.6 Island Zero

(based on the work by Jerry Stone)

"Island Zero" is a concept conceived by Jerry Stone in the frame of the British Interplanetary Society, for an initial rotating orbital station[72]. The project's scope includes:

- To proof Simulated Gravity (SG) feasibility and start experimenting with SG.
- Testing and validating the theoretical "comfort zone" parameters – 220 m. radius and 2 rpm rotation speed
- Testing various rotation rates, to identify parameters suitable for particular purposes, such as medical, elderly hosting, industrial needs.

Here is a comprehensive summary of the Island Zero project based on the broader work of Jerry Stone and the British Interplanetary Society:

Background and Origin - In 2013, Jerry Stone initiated the SPACE Project (Study Project Advancing Colony Engineering) at the British Interplanetary Society (BIS). The project's primary goal was to update the famous 1970s space settlement concepts proposed by physicist Gerard K. O'Neill—specifically the "Island One" design, which envisioned a massive free-space habitat housing 10,000 people.

The Core Concept of Island Zero - The project team quickly realized that jumping straight into constructing a colossal habitat like Island One was practically impossible. They needed an intermediate, smaller-scale gateway station to act as a stepping stone. This precursor station was designated "Island Zero".

Primary Objectives also include:

- **Medical and Gravity Research:** O'Neill's original designs assumed space habitats had to rotate fast enough to simulate standard Earth gravity (1g). Lately, the Island Zero design has included other levels of gravity, e.g. 0.9g or 0.8g and lower, for particular needs, and simulating lunar and mars gravity as well, for astronaut training purposes.
- **Construction and Assembly Base:** Before you can build a city in space, you need somewhere to house the construction crew and the manufacturing assembly plants. Island Zero is designed to serve as this orbital construction camp. Its workforce would process materials mined from the Moon or near-Earth asteroids to eventually construct the larger Island One.

Design and Feasibility

Unlike the International Space Station, where crews suffer physical degradation (like bone density loss) from zero gravity, Island Zero would rotate to produce simulated gravity. The conceptual design features a central node with modular units extending outward like spokes on a wheel, connected by an outer ring. Importantly, the Island Zero project is deliberately restricted to using current technology and affordable booster rockets, ensuring that it remains a practical, achievable "bootstrap" for humanity's expansion into space rather than pure science fiction.

In Figure 16 and Figure 17 two concept views of Island Zero are represented. In both we can see an external ring (1g simulated gravity), three lower G modules, and a central hub (zero G) . in Figure 18 another possible configuration, with a curved connection between the external ring and the central hub.

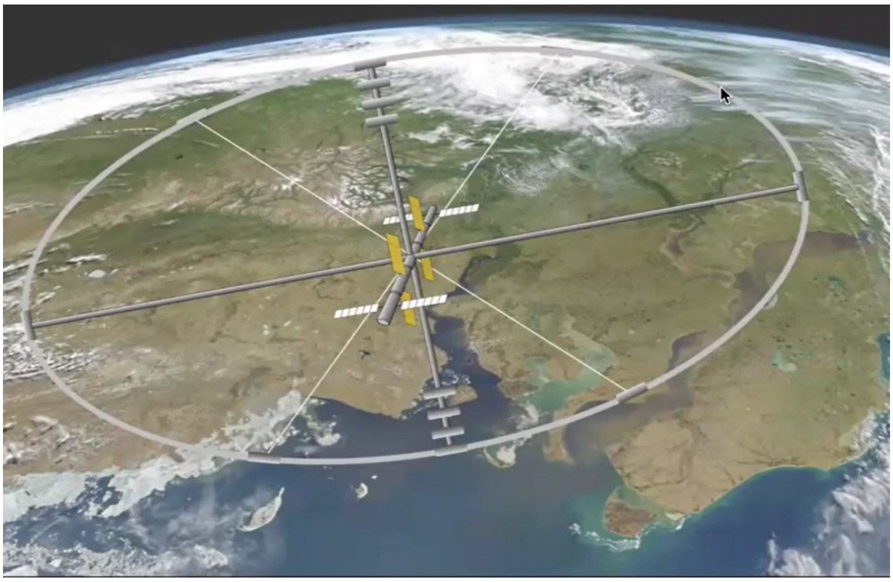

Figure 15. Island Zero artistic view

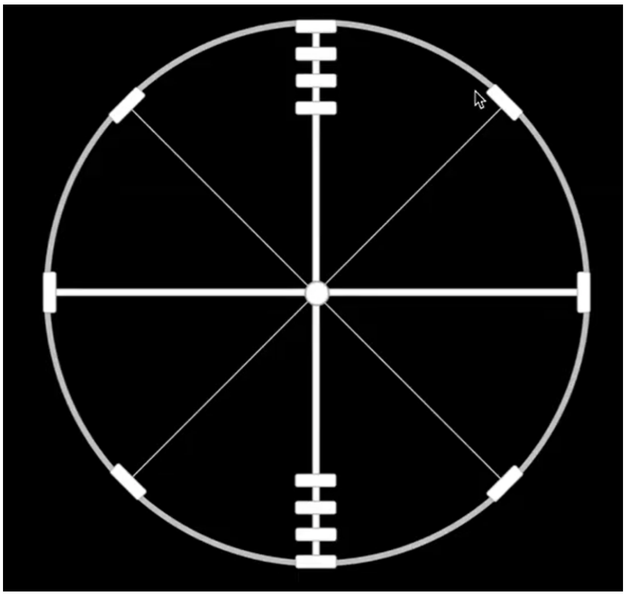

Figure 16. Island Zero extended model - front elevation

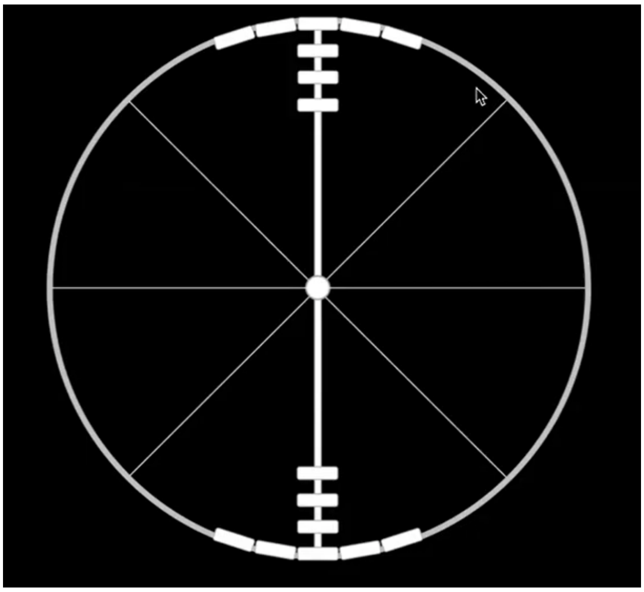

Figure 17. Island Zero regrouped model - front elevation

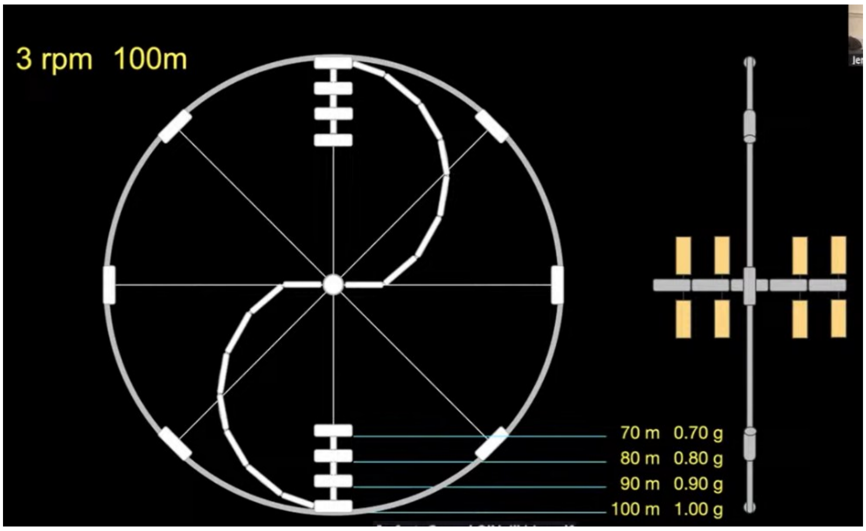

Figure 18. Island Zero curved connection model

2.2.7 SRI statement on the Island Zero project requirements

SRI valuates Island Zero an excellent project, very much timely and urgent. From the kick-off of manned space flight, in the 1960s, space agencies have experimented zero gravity, while simulated gravity has not seen any test, so far (June 2026). SRI consider experimentation with simulated gravity to be in huge delay, and that it shall be initiated as soon as possible.

This statement does not represent a differentiation, since the Jerry Stone's design actually includes an external 1g ring, that perfectly matches the SRI requirements. This statement is a clarification about the basic requirements that motivate and justify this or similar projects.

While we proudly defend and promote Island Zero, the project of our SRI Board member Jerry Stone, as the first and only existing proposal of a simple, we might say "low-cost", initial demonstrator of a simulated gravity infrastructure, we cannot help but hope that other similar projects will come to light soon, in order to accelerate the enhancement of human settlements in the geo-lunar space and beyond.

During a recent SRI webinar[73], we refined the SRI position on the 1g requirement. While lower G levels are useful for several reasons, SRI maintains the key requirement of 1g for any rotating manned infrastructure, as argumented by Adriano V. Autino in his presentation at the mentioned webinar, for the reasons summarized hereafter:

- As mentioned by Gerard K. O'Neill in his famous book "The High Frontier"[Errore. Il segnalibro non è definito.], 1g is necessary for human right to migrate to space colonies and conserve physiological capacities to return to Earth, should migrants decide so, after some years.
- Also, as mentioned by O'Neill as well, a two-ways tourist flux will take place, some years after human expansion into the solar system kick-off. That will be a relevant industrial development, and tourists shall feel comfortable coming back to visit Earth from colonies.
- Normal average space settlers should be free to choose a 1g environment where to grow their children
- SRI doesn't think that the "best and healthier" G-level for normal average people may exist or should be searched.
- Though of course gravity levels lower-than-1g might be useful for particular medical needs and for elderly comfort.
- Yet people shall be free to choose 1g or other G levels, according to their own needs and existential decisions.
- Proper experimentation is needed, to proof and validate the radius and rotation speed minimum parameters, to assure a comfort zone vs. Coriolis effect.
- SRI maintains that reducing the cost of design and construction is not a sufficient reason to renounce to 1g.

Also, SRI thinks that the prolonged strategy of *experimentation in microgravity*, which has now lasted for 60 years, putting the health and the lives of astronauts at risk, should finally leave the field to the new paradigm of space settlement. In such a new paradigm, civil rights will have to have a more prominent role, and be placed before the purposes of scientific experimentation.

Claiming to find a gravity level "optimal" for everybody is a liberticide purpose: who should be taken as guinea-pigs for experimentation? Will a large representative champion of different populations, including different ages, different health and physical conditions (sports practitioners, ...), different lifestyles?

SRI will keep on endorsing and supporting the design and development of Island Zero, with a strong recommendation to keep on comply with the above described humanist requirements.

In summary, we are not proposing 1g *in alternative* to lower gravity levels. SRI sticks, in full agreement with Gerard K. O'Neill, that:

- 1g gravity level shall be assured available in any civilian simulated-gravity habitat
- Gravity levels lower than 1g shall be implemented as well, for particular needs (medical or industrial)
- The experimentation primary scope shall be to understand which combination of rotation speed and habitat radius is best, to assure a large comfort-zone at 1g gravity level.

SRI maintains that an experimentation to find an "optimal G level" is a nonsense, for the reasons listed above, but mainly because it includes the option of non-implementing the 1g ring.

The point ***is not*** having 1g **OR** lower gravity levels.

The point ***is*** having 1g **AND** lower gravity levels.

The aim to search for an ***optimal*** gravity level is functional to the OR option, and it is a serious liberticide option. Why? Because, should any "optimal" gravity level be found, it will orient a design of the habitats based on non-democratic criteria, where some options are excluded. Note: we don't care if the excluded option would be 1g or less-than-1g. Should anyexperimentation find that 1g is optimal, lower gravity levels should be included however.

2.2.8 Space-to-space vehicles

(based on the work by Werner Grandl, et Al)

The expansion of human activity into outer space through programs like ARTEMIS and ILRS, and further programs oriented to live and work in space, necessitates a new class of vehicles designed exclusively for vacuum travel within the cis-lunar region and the broader solar system. Unlike traditional space vehicles, these Space-to-Space Vehicles (STSV) are not required to withstand atmospheric re-entry or high-gravity launches from Earth, allowing for radical shifts in design, material usage, and assembly.

Key Design Challenges and Requirements

Transitioning from short-term orbital stays to long-duration civilian travel introduces several critical requirements:

- **Simulated Gravity:** To prevent physiological degradation such as bone demineralization and muscle atrophy, STSVs must provide artificial gravity through rotation.
- **Radiation Shielding:** Beyond the protection of Earth's magnetosphere, vehicles require advanced shielding—potentially using structures embedding water or hydrogen rich elements—to protect against cosmic rays and solar flares.
- **Civilian Comfort:** Future transport must provide hotel-like amenities, including private rooms, central dining, and independent life support systems for safety and redundancy.

Proposed Vehicle Concepts

We are shifting toward a modular approach to space transport, beginning with cis-lunar infrastructure and extending to deep space:

- **The Space Cruiser:** a preliminary civilian STSV (100 m length) featuring three rotating modules providing **0.5 g**. It is designed to carry 18 passengers and 6 crew members on 6–7 day trips between Earth and lunar orbits.
- **Multipurpose Space Cruiser (MPSC):** an enlarged design for 36 passengers and 12 crew, capable of acting as a mobile space station for Mars missions. It features adjustable gravity (0.4 to 0.8g) and attached landing craft for planetary descent.

Infrastructure and Propulsion

- **Assembly and Materials:** Vehicles will be assembled in Low Earth Orbit (LEO) using prefabricated rigid modules or inflatable structures delivered by reusable launchers. Construction might feature lightweight aluminum frameworks and carbon fiber interiors.
- **Propulsion Evolution:** While cis-lunar travel can utilize chemical H_2/O_2 engines—potentially sourced from lunar minerals—deep space travel will require nuclear thermal propulsion or fusion.
- **The Helium-3 Advantage:** Deuterium-Helium3 fusion is highlighted for its high energy density (3.5×10^{14} J/kg). Though rare on Earth, Helium-3 is abundant in lunar regolith, offering a sustainable fuel source for future plasma-beam propulsion.

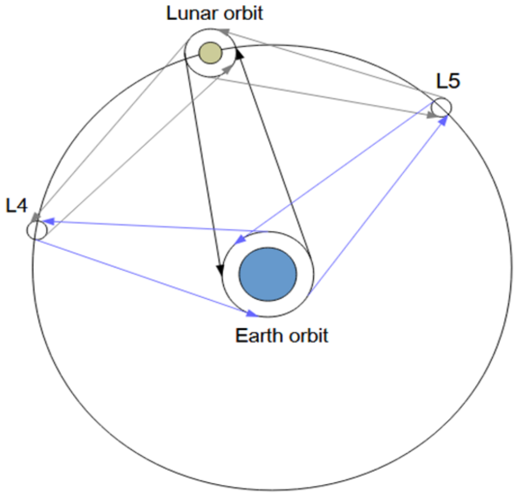

Figure 19. Future flight tracks of Space-to-Space Vehicles (STSV) in cis-lunar space

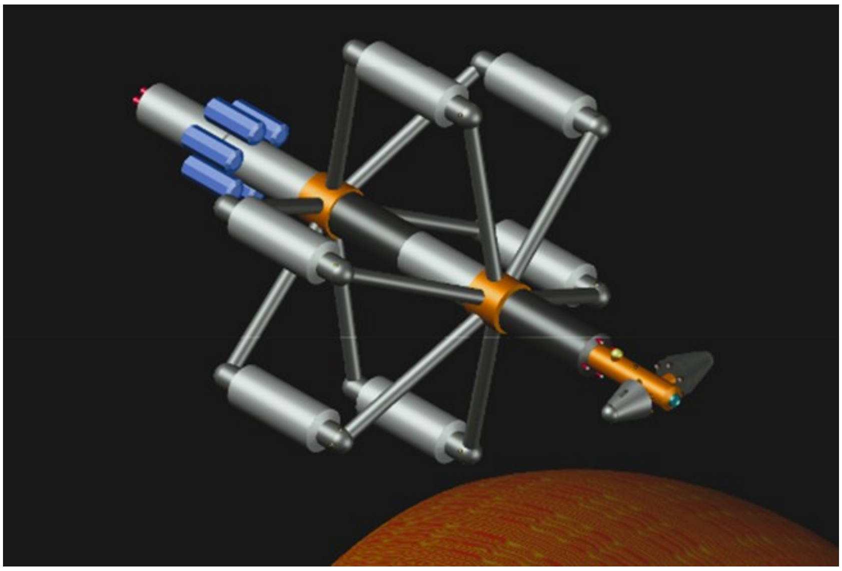

Figure 20. advanced Space Cruiser in Mars orbit (© W. Grandl)

2.2.9 Geo-lunar industrialization – the Lagrange Space Factory

(based on the work by Werner Grandl, et Al)

This section is mostly based on a paper[74] presented by W. Grandl and A. V. Autino at IAC 2024 in Milano.

SRI fosters a transition from Earth-centric industry to a cislunar industrial ecosystem to solve terrestrial crises, including resource depletion, energy shortages, and anthropogenic global warming. By shifting heavy industry into space and utilizing resources from the Moon and Near-Earth Asteroids (NEAs), Earth can be restored to a "green paradise" while human civilization expands without "limits to growth". Key resources identified include:

- Lunar Regolith: Contains aluminum, iron, and titanium for construction, plus Helium-3 for future nuclear fusion.
- Volatiles and Water: Located at the lunar South Pole, providing hydrogen, methane, and water ice for life support and propellant.
- Asteroid Ores: Rich in siderophile elements (gold, platinum, nickel) and lithophile elements (rare-Earth elements).
- Orbital Debris: Approximately 130 million objects that can be recycled into metal powders for 3D printing or reused as structural components.

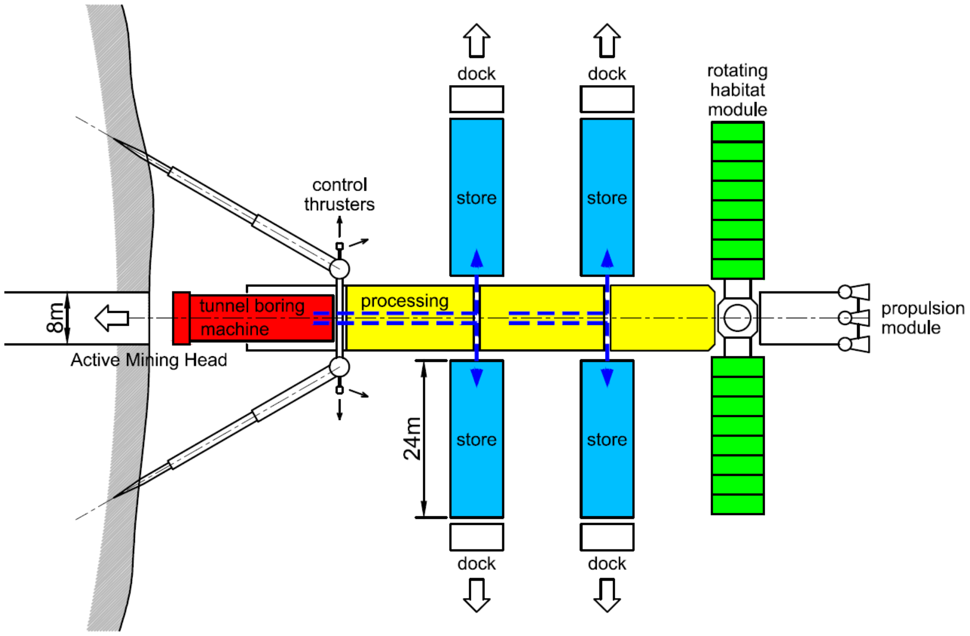

Figure 21. Manned mining station for asteroid mining

2.2.9.1 The Lagrange Space Factory (LSF)

The Lagrange Points of the Earth-Moon system, specifically L4 and L5, are the ideal locations for the first space factories because they offer gravitational equilibrium and stable positioning.

The LSF is designed as a modular, linear structure that can be extended along its longitudinal axis to increase industrial output.

- AGMU (Artificial Gravity Manned Unit): The initial "living" section of the factory, housing a crew of 48. It consists of eight rotating modules providing 0.9 g to ensure the health of engineers and craftsmen, connected to four zero-g central modules.
- Central Communication Tube: A non-rotating 7-meter diameter tube that runs the length of the LSF, containing all essential wiring, piping, and plumbing.
- Factory Units: Individual factory modules are 54 meters long with a 24 \times 36 meter diameter, providing a volume of 46,600 m^3 each. These units remain in zero-g to facilitate specialized manufacturing and metallurgical processes.

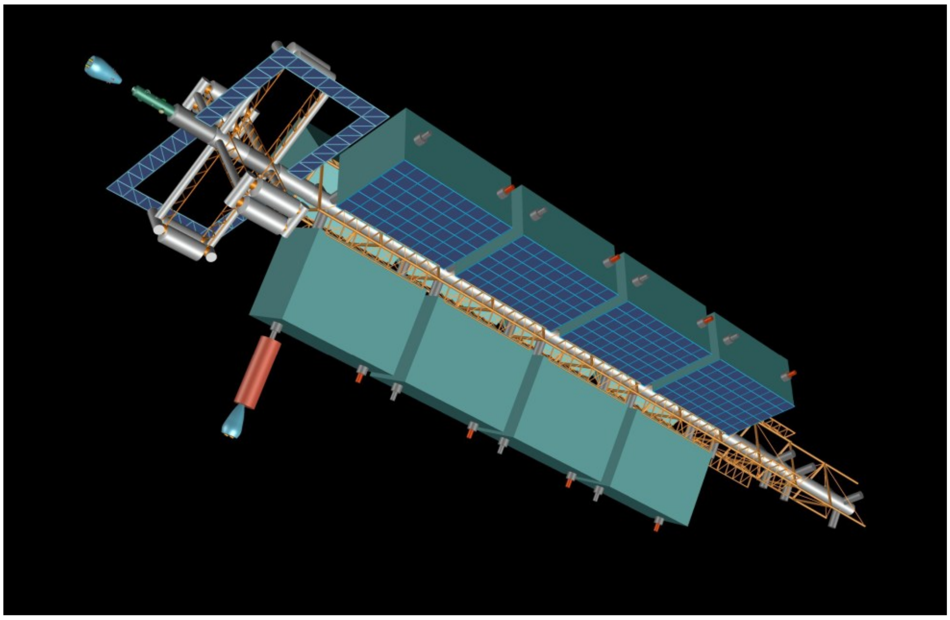

Figure 22. LSF design: 12 factory units fixed to a central structural framework

The LSF serves as the central hub for a complex logistics network:

- Lunar Supply: Regolith is packed into containers and launched from the Moon via an electromagnetic mass driver to lunar orbit or L1.
- Debris and Asteroids: Unmanned cargo spaceships ship orbital debris from Earth and asteroid ore from NEAs directly to the LSF.
- Outputs: The factory produces tubes, trusses, and sheets of steel and aluminum. Oxygen is generated as a by-product of regolith processing, while regolith slag is pressed into bricks for space construction. High-tech products are created using recycled orbital debris transformed into metal powder for 3D printing.

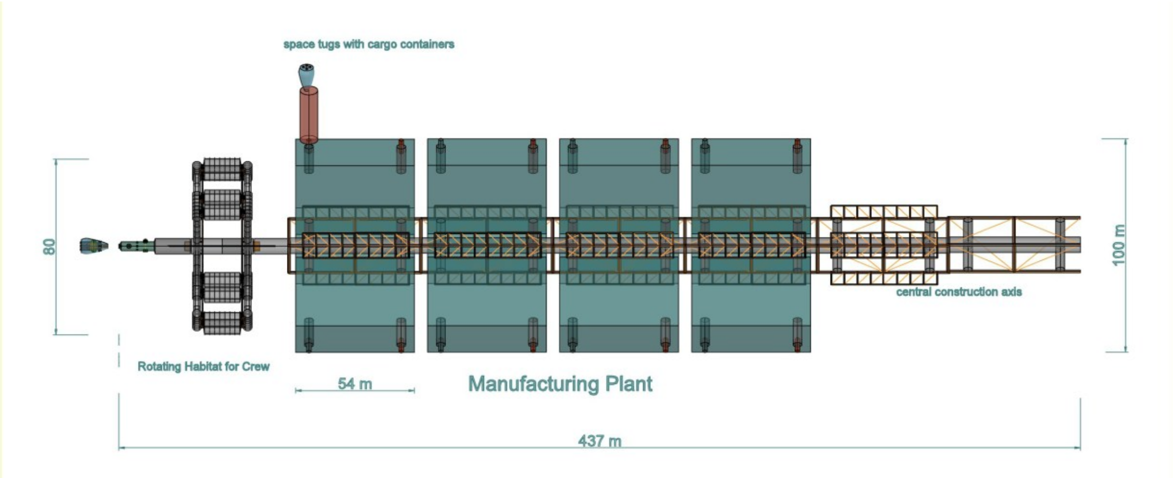

Figure 23. LSF side view (X-ray): the structure can be extended along its central axis

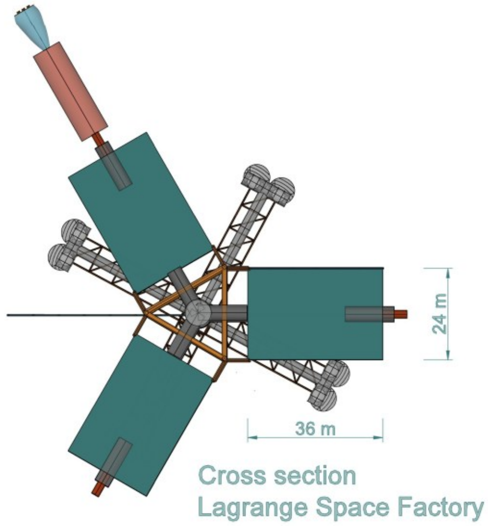

Figure 24. LSF cross section: factory units(green), central framework (orange), cargo spaceship (red), central communication tube and rotating AGMU (grey)

2.2.9.2 Economic and Operational Model

- Private-Public Partnership: The paper suggests that the basic infrastructure (AGMU and central framework) be financed by public-private partnerships, while individual factory modules are financed and docked by private companies.
- Automation: Operations are intended to be performed primarily by Artificial Intelligence and robotic machinery, with the human crew acting in a supervisory capacity.

2.2.9.3 Masterplan and Legal Considerations

Critical milestones might include:

- 2035: A new LEO station with simulated gravity.
- 2040: A manned lunar base with ISRU (In Situ Resource Utilization) and a mass driver.
- 2045: First stage of the LSF begins processing debris and lunar material.
- 2060-2065: Mining of NEAs begins, and the LSF expands to process asteroid ores.

As legal proposal, addressing the current ban on owning celestial bodies, SRI proposes a system of limited licenses for private companies to exploit specific areas of the Moon or asteroids for definite periods. Ultimately, this industrialization could foster global peace by redirecting capital from armament toward space enterprises.

2.2.10 Orbital Debris - from Problem to Opportunity

Orbital Debris represent a huge and increasing threat to space navigation. Some technological expedients are now applied for avoiding the proliferation of new debris, such as devices to deorbit the satellites at the end of their operative life, in-orbit maintenance and refueling to lengthen the satellites' life. However, the number of artificial objects in orbit is exponentially growing, with the big communication constellations, and now the rising star of the big-data centers in orbit.

As argumented in Anzaldúa & Autino paper[75] presented at IAC 2023 (Baku), historical approach to orbital debris—viewing it as a mere waste management problem and an expense—has led to the current crisis of over 130 million debris objects. Most of these are inactive dangerous wreckages, that pose a severe threat to manned spacecraft and operational satellites. Meaningful cleanup will only begin when debris is treated as a valuable asset to be collected, reprocessed, and reused, similar to how terrestrial waste became a profitable industry.

As already recognized by the most intelligent countries on Earth, our waste ceases to be a problem when we begin to consider it a resource. Unfortunately, the same concept hasn't yet been recognized in orbit. It's definitely time, and long overdue, to move in that direction.

The issue presents different technological challenges, according to the different sizes and characteristics of the debris.

SRI urges Governments and Space Agencies to allocate more funds to the associated research, to help solving the different challenges, i.e. big wreckages recovery and reuse, small debris collecting, all debris types reprocessing and repurposing.

A decisive modernization of the legal framework is needed.

- The "Big Sky" Theory and the Outer Space Treaty (OST): Early spacefaring nations operated under the assumption that space was vast enough that debris would never be a problem. Consequently, the 1967 Outer Space Treaty did not address the practice of leaving upper rocket stages and waste in orbit.
- Ownership and Liability: A primary legal hurdle is that according to current international space law, objects in space remain the property of the launching state. This complicates "salvage" operations, as one entity cannot simply collect another's "trash" without permission.
- Gap in Current Regulations: While agencies like ESA have introduced "Zero Debris" strategies and "Space Debris Mitigation" requirements, these focus largely on preventing *new* debris rather than creating a legal framework for the profitable recovery of *existing* debris.
- The agencies' space policy should transition toward a Circular Space Economy (CSE), which could have a net value of $1.2 trillion.

2.2.10.1 Redefining Debris as "In Situ Orbital Resources" (ISOR)

SRI suggests a cultural and legal shift: viewing debris and Near Earth Objects (NEOs) not as junk, but as In Situ Orbital Resources.

A more sophisticated classification system is needed, beyond just "size". A chemical classification (polymers, metals, alloys, etc.) will help industries conceptualize different recovery and reuse techniques.

The value of orbiting materials is huge. Launching 1kg of material to orbit historically costed approximately $20,000. The millions of kilograms of material already in orbit represent a massive "sunk cost" that can be reclaimed. Objects in orbit already possess "orbital velocity." It is far cheaper to move existing orbital mass to new locations (like the Moon) than to launch new mass from Earth's gravity well.

2.2.10.2 Development of Orbital Infrastructure

Several "orbital products" and facilities should be considered:

- Orbital Workshops and Garages: Developing manned or robotic facilities to capture, disassemble, and reprocess debris into raw materials, such as powders for 3D printing in space.
- Fuel Production: Reprocessing the thousands of tons of aluminum from spent rocket stages to produce rocket propellant in orbit. This could drop space transportation costs below $100/kg.
- Salvage and Logistics: Promoting "Space Logistics" services like those currently offered by Northrop Grumman's Mission Extension Vehicles (MEV) to extend the life of existing satellites rather than letting them become debris.

2.2.10.3 Legal and business ecosystem modernization

- Adopting Maritime Salvage Principles: maritime law is a potential model for filling gaps in the 1967 Outer Space Treaty, particularly regarding the "salvage" of defunct objects for reuse.
- Mandatory Removal and "Zero Debris" Policies: The authors support the European Space Agency's (ESA) "Zero Debris" strategy, which recommends:
- Mandatory active debris removal services for all space missions.

- Mandatory clearance of valuable orbital regions immediately after the "end of mission".
- Recognition of GNSS regions (Global Navigation Satellite System) as protected, valuable orbital zones.
- Incentivizing Inertization and Recycling: Drawing a parallel to EU asbestos regulations, the authors suggest that commissions should promote research into "inertization" and recycling rather than simple disposal or de-orbiting.

2.2.10.4 An Orbital Debris “Cap and Trade”

The creation of a Space Salvage Entity would inaugurate a new age of modern governance in the geo-lunar space region. An SSE will open the way to an international/multilateral market-based system, to reduce creation and spur the clean-up of orbital debris by creating a financial incentive to do so (the trade), and a limit (the cap) to the allowed polluting operations. That would also stimulate a more decisive growth of the private sector holding the mission of repairing and enhancing satellites, to elongate their operative life by refueling and maintenance. Such an industrial sector is already in place[76]. We also retake and share this recommendation, already advanced to COPUOS in 2018 by the unforgotten David Dunlop[77]: eventually convene an International Space Anti-Dumping and Salvage Convention, informed by customary international law & maritime tradition & law to codify & refine what has evolved from actual orbital debris clean-up practices over the years.

2.2.10.5 Commercial Proposals and Business Models

Orbital workshops will go through an evolutionary process:

- from mitigation to remediation
- from deorbiting to gathering
- from mere expenditure to investment and profit
- from small compact service satellites to more complex settlements, providing maintenance and more sophisticated services
- from debris elimination to recovering
- from debris destruction to reprocessing and reuse
- from merely simple automated to manned complex infrastructures

A possible roadmap for a Circular Space Economy (CSE), which could potentially reach a net value of $1.2 trillion includes:

- Commercial Tiered Product Classes: a progression of "products" that the debris industry can sell:
- Risk Mitigation: Selling de-orbiting and anti-collision services to satellite operators to protect their existing assets.
- Structural Recovery: Recovering upper rocket stages (e.g., from Ariane 5) to use as hulls or walls for orbital hotels, lunar stations, and research facilities, saving over 50 billion Euros in transport costs.
- In-Orbit Fuel Production: Reprocessing thousands of tons of aluminum debris into rocket propellant, which could significantly lower space transportation costs.
- Raw Material Feedstock: Grinding debris into powders to serve as "raw" material for 3D printing in space workshops.
- Infrastructure for "Space Logistics": The commercial model relies on the development of specialized infrastructure, including:
- Orbital Garages and Workshops: Manned or robotic facilities for satellite maintenance, refueling, and life extension.
- Scrap Yards and Demolition Yards: Dedicated "salvage orbits" or parking areas where large debris is held for future industrial use.

- Inflatable Hangars: Lightweight, large-volume enclosed spaces where human technicians can work on debris without being tethered, protected from radiation and micrometeorites.
- Market Segmentation: the "Active Space Debris Removal" market is already emerging, with major players like Northrop Grumman (via Mission Extension Vehicles), Astroscale, and Clear Space leading the way in commercial orbital services and logistics.

SRI urges major space agencies (NASA, ESA, JAXA, CNSA, ROSCOSMOS) to shift their focus from mere "mitigation" (preventing new debris) to "remediation and reuse". By fostering a market for orbital salvage and reprocessing, the "space debris tragedy" can be transformed into the primary driver of cislunar industrial development and future human settlement.

2.2.11 Lunar and asteroid mining, producing propellant in space

(Werner Grandl)

Our Moon contains a number of natural resources which can be used for a future industry in space. Metals like aluminium, iron and titanium are abundant in the form of oxides even in the upper layers of regolith near the lunar surface. Gerard O´Neill has proposed in the 1970s to use an electromagnetic mass driver to catapult containers filled with regolith into lunar orbit for further processing. e.g. in a Lagrange point factory (described in The Lagrange Space Factory (LSF)). When metals are extracted from oxides we get oxygen as a by-product. Furthermore, the lunar south pole region contains some quantities of volatile compounds like hydrogen, sulphur dioxide, formaldehyde, ammonia, methane, mercury, sodium and water ice. By the use of these resources one can produce propellants for spaceships in situ. Last not least in the lunar regolith helium-3 has been trapped during millions of years of solar wind influx. This helium isotope is rare on Earth but abundant on the Moon and can be used for future nuclear fusion reactors.

Within the last decades approx. 20,000 Near Earth Asteroids (NEAs) have been detected. Their sizes range from several meters to some hundred meters or even kilometers in diameter. There are three main classes of NEAs, the *Amors*, the *Atens* and the *Apollos.* The Amors are orbiting the Sun beyond Earth´s solar orbit, whilst the Atens can be found closer to the Sun and approaching Earth by 98% of the Sun-Earth distance. The Apollos are the most numerous group of NEAs and some intersect the Earth´s solar orbit and could cause collisions. This group of asteroids is in the long run a real threat to life on our planet and in the past indeed some asteroid impacts have occurred, the largest one has extinguished the dinosaurs. For this reason, we have to develop methods of detection and deflection techniques for hazardous asteroids. But we can use these technologies also to modify some asteroid´s orbits and to exploit their mineral resources. Some asteroids are nickel-iron asteroids, containing also other metals like gold and copper. Others are called carbonaceous asteroids and carry also water-ice and even organic molecules. Even rare Earth elements can be found in some NEAs. The mining of NEAs will be a crucial contribution to a future industry in space and provide a big amount of material to build human habitats in space.

2.3 Space Tourism

(with a contribute by Sam Coniglio and Patrick Collins)

Space Tourism enjoyed great popularity during the first decade of the twenty-first Century. Inside the space community, ST was considered the trigger of the opening of the space frontier. Everybody expected it to takeoff at mass level during the 2010s. With the growth of the market the tickets' price was expected to decrease, following a path similar to the one that characterized civilian aviation during the previous Century. Accordingly, progressive investments brought in technological advancements, with a meaningful improvement of key parameters, like passengers capability, protection from space radiation, and ergonomics. The new spacecrafts were also expected to connect point-to-point destinations on Earth surface, reducing the transcontinental transportation time to one or few hours.

In our 2011 Congress Thesis Issue 1[78], we had assigned top priority to Space Tourism, as a decisive factor: "… SRI indicates the following themes, as priority for the next four years: (i) space tourism – both suborbital and orbital; (ii) space based solar power; and (iii) Geo-Lunar region industrialization, as the three main leverages suitable to begin building the space industry, market and economy."

In our 2016 Congress Thesis 1[79] we acknowledged the failure: "It didn't happen, so far." We also wrote that Space Tourism, as a 100% private initiative, might have been too weak to open the space frontier alone. And we indicated the possible need for public investment, to support the few brave entrepreneurs in their mission. We also indicated – from 2011 – the key role of geo-lunar space industrialization. That is now somehow happening, though in a context of extremely critical and dangerous geopolitical conjuncture, in which the militarization of space risks becoming the dominant factor.

Other factors have penalized Space Tourism within the realm of public opinion. Critical voices have been raised against it, depicting space tourism as a very expensive toy for rich people. Such criticism reflects a substantial ignorance of the real relevance of space tourism[80]. Space tourism is the only industrial branch, so far, of which the mission is to enable civilian passengers to travel in space, and to be able to use comfortable and ergonomic accommodation, such as orbital and lunar hotels. Space tourism is not based on a military exploration paradigm, it evolves from civil aviation, in which attention to passengers' health, wellbeing[81], and civil rights, is a consolidated tradition, supported by strict regulations and standards. This is very different from the endless experimentation which astronauts must endure as part of their role.

The Final Resolution[82] of the SRI 3rd World Congress in 2021 includes this goal: "Support the space tourism industry and their effort to develop civilian space travel and accommodations (hotels), taking profit of the huge aeronautic experience".

We also wrote (2016) that "The main need, still unfulfilled, remains cheap, fully reusable, space transportation, which is the key for opening outer space to tourism and all other civilian activities. Until this key milestone is achieved, civilian space travel will not be economically feasible. Space will remain the prerogative of governments, for military purposes." This condition has changed since 2015 when reusable rockets started flying, with SpaceX successfully launching and recovering the first Falcon 9. As a result, the space market has completely changed: it is now very much more open to private companies, and the space economy is now growing fast.

Yet, has human space-flight advanced accordingly? This is a different issue. We are witnessing an exponential increase in satellite launches. And we are also seeing a worrisome military interest in Earth orbits, the Moon, and the Earth-Moon Lagrange points. The ARTEMIS consortium and the ILRS coalition are targeting the Moon for astronautic exploration and scientific research, in the best case, and for affirming military outposts. Robotics, Artificial Intelligence, and automated technologies seem to be preferred in the majority of cases, including very innovative programs, like the deployment of big data centers in space.

Are civilian passengers and workers included, in the new space race, based on the new space economy? This is a quite controversial question. Space Tourism seems to still be the only industrial branch having civilian space flight in its mission.

That's why SRI will keep on working for the following goals:

1. To foster a better understanding in general public opinion of the key role of space tourism for the opening of the space frontier to private citizens, for settlement and industrial development
2. To solicit governments to support space tourism enterprises with friendly taxation, grants, and employment support
3. To solicit space agencies to better fund the research necessary to improve the space flight conditions, such as protection from solar and cosmic radiation, and simulated gravity.

Samuel Coniglio, Vice President of the Space Tourism Society[83], explains that the space tourism industry is far larger than just orbital and sub-orbital flights. His organization categorizes six levels of "space experiences," as they call them, that include Earth-based experiences: visiting science centers and planetariums, playing computer flight simulators, participating in Analog Astronaut programs to Antarctica and the other extreme parts of Earth, taking parabolic aircraft flights, and going on high altitude balloon flights.

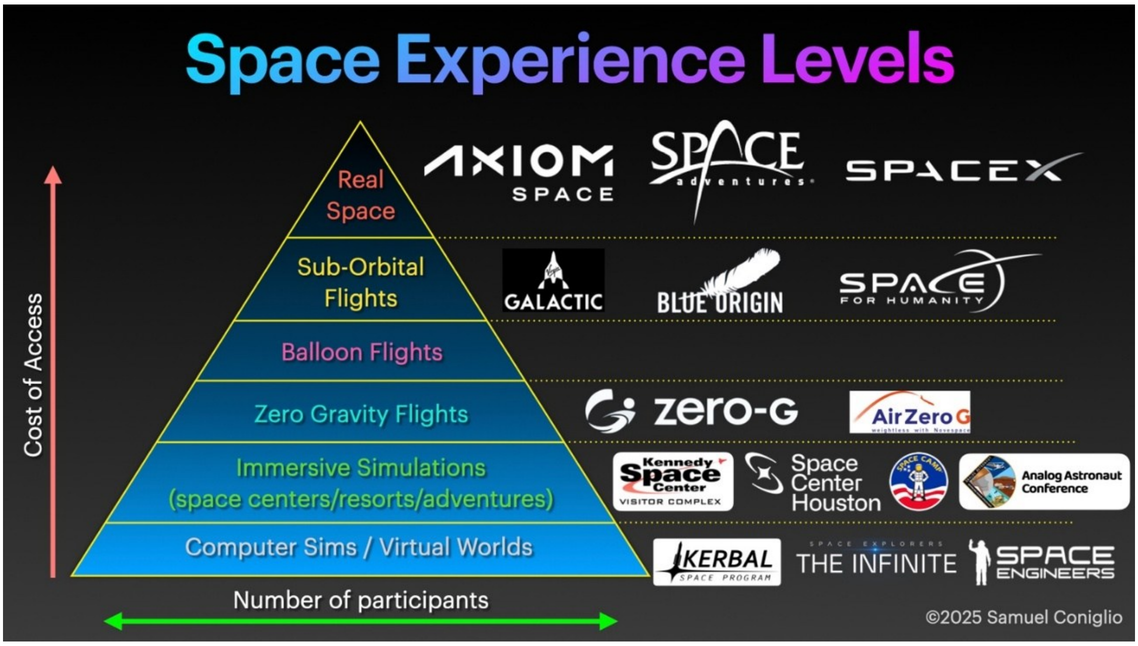

Figure 25. Space Experience Triangle, as proposed by the Space Tourism Society.

For the sake of history, the following companies have successfully launched passengers into space, either for momentary joyrides or for several day or more:

- Between 2001 and 2009, **Space Adventures** has facilitated spaceflights for 9 private citizens on 10 orbital missions to the International Space Station (ISS) using Russian Soyuz spacecraft. One client, Charles Simonyi, flew twice. These pioneering passengers included Dennis Tito (2001), Mark Shuttleworth (2002), Greg Olsen (2005), Anousheh Ansari (2006), Charles Simonyi (2007 & 2009), Richard Garriott (2008), Guy Laliberté (2009). More recently, Japanese nationals Yusaku Maezawa and Yozo Hirano flew aboard Soyuz MS-20 to the ISS in December 2021.
- In October 2021, **Russia** successfully launched actress Yulia Peresild and director Klim Shipenko to the International Space Station (ISS) to film scenes for "The Challenge," the first feature-length film shot in orbit. The duo spent 12 days on the ISS shooting the movie before returning to Earth. In a bid to spruce up its image and diversify its revenue, Russia's space programme revealed this year that it will be reviving its tourism plan to ferry fee-paying adventurers to the ISS.
- Between December 13, 2018 and June 2024, **Virgin Galactic** has completed 12 sub-orbital space flights, successfully taking 32 people to the edge of space. Following these missions, which included both company test pilots and commercial, private customers, the company has paused flights to develop its next-generation Delta class spaceships, with commercial service expected to resume in late 2026.
- Between July 20, 2021 and January 22, 2026, **Blue Origin**'s New Shepard program has completed 38 total flights (including test flights) and 17 crewed missions, carrying a total of 98 humans to space. This includes 92 unique individuals, with six passengers having flown twice. The program is notable for having flown several high-profile individuals, including Jeff Bezos, William Shatner, and Katy Perry. Blue Origin announced a pause in the New Shepard program in January 2026 for a planned two-year hiatus in order to reallocate resources to its lunar landing program.
- Between April 2022 and June 2025, **Axiom Space** has flown 16 people to space across four dedicated, private missions utilizing SpaceX Crew Dragon capsules to the International Space Station (ISS)
- As of early 2026, 12 private passengers have flown on **SpaceX** missions excluding Axiom and Space Adventures. These all-amateur missions were aimed at orbital research, a polar orbit, and the first commercial spacewalk, rather than ISS tourism:

- **Inspiration4 (2021):** 4 passengers (Jared Isaacman, Hayley Arceneaux, Christopher Sembroski, Sian Proctor).
- **Polaris Dawn (2024):** 4 passengers (Jared Isaacman, Scott Poteet, Sarah Gillis, Anna Menon).
- **FRAM2 (2025):** 4 passengers (Chun Wang, Jannicke Mikkelsen, Rabea Rogge, Eric Philips)

2.4 Space Resources

By Dennis O'Brien.

SRI supports [or notes] the following principles that are currently being considered by the United Nations' COPUOS Working Group on Legal Aspects of Outer Space Resource Activity.

Start using the enormous resources and energy of the solar system, in the perspective of settlement, and not of a new colonialism.

- **Free Access**: "Space resource activities should be carried on in a manner that preserves free access to all areas of outer space, including the Moon and other celestial bodies" Free access is a core principle for SRI. This principle seeks to minimize the effect of resource activities on diminishing that.
- **Appropriation**: "The extraction and/or utilization of space resources in full compliance with these Principles does not inherently constitute national appropriation." This is essential. It allows for the private ownership of resources removed from in place.
- **Safety Zones**: "States conducting carrying on / out space resource activities shall ensure that measures related to safety and emergency assistance are not used as a basis for establishing "safety zones" or any arrangements that could amount to de facto appropriation of outer space or its resources." This seems aimed at mitigating the effect of "safety zones" in the Artemis Accords.
- **Sustainability for Future Generations**: "In developing, planning and carrying on space resource activities, States should take all necessary and feasible measures to: to the greatest extent feasible and practicable, ensure that the use of space resources such activities are sustainable and realize the objectives of equitable access to the benefits of the exploration and use of outer space, including space resource activities, for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment, including the Moon and other celestial bodies, for future generations." Sustainability benefits future settlements/settlers.
- **Remediation**: "To the greatest extent feasible and practicable, remediate all areas affected by their space resource activities and restore them to their original condition upon the completion of such activities.
- **EIA's**: "States shall develop and apply international reporting standards and environmental impact assessment procedures for space resource activities in order to enhance transparency, monitoring and accountability." EIA's and related matters will probably be a matter of national law until there is an agreement on an international process (ATLAC possible precursor).
- **Sharing Information**: "States should disseminate and publish for the public and the international scientific community, through appropriate channels and as soon as possible, the scientific results of their space resource activities" There is a tension between sharing information and protecting intellectual property. Intellectual property is not mentioned in anywhere in the document.

2.5 Space Policy: A Sustainable Civilian Future in Space

This section presents a comprehensive framework for advancing a civilian, peaceful, and sustainable expansion of human activity into outer space. SRI advocates for an expansionist approach centered on human settlement, industrial development in cislunar space, and the creation of a space-based economy that benefits all humanity.

This section emphasizes a principles-based ethical framework over rigid regulatory systems. It identifies urgent priorities including orbital debris mitigation, prevention of space weaponization, legal clarity for space resource utilization, and the protection of human life in space environments.

SRI further proposes the establishment of an 18th Sustainable Development Goal (SDG) dedicated to peaceful space development and calls for expanded participation by emerging and non-spacefaring nations. This section also outlines key legal clarifications needed under existing international frameworks and emphasizes the importance of recognizing the rights of future space settlers.

The central thesis is that expanding human civilization into space—guided by ethical principles, international cooperation, and inclusive development—will significantly enhance quality of life on Earth and in space, enabling long-term sustainability in the solar system.

Formulating a coherent and prioritized space policy is increasingly complex in the current geopolitical and astropolitical environment. Nevertheless, the urgency and scale of ongoing developments in space activities require a structured and forward-looking policy framework.

SRI supports a civilian-oriented expansion into space, aimed at enabling human settlement and fostering a sustainable space economy. While recognizing the substantial benefits already provided by space-based technologies—such as telecommunications, Earth observation, and climate monitoring—our Thesis focuses on the next phase of development: permanent human presence and industrial activity beyond Earth.

SRI works on behalf of the greatest stake-holder, the whole human society. Some sectorial stake-holders sometimes might give priority to fully automated space technologies, for the sake of a short-term return of investment. SRI wants to remark, for example, that short-sighted policies based on short-term earning have brought to the current extremely critical debris congestion in Earth orbits, while a greater human active presence could have allowed a better stewardship of the interface between Earth and Cosmos.

2.5.1 Strategic vision for space development

SRI advocates for an expansionist and civilian-oriented policy:

- Human settlement in space as a middle-term objective, moving first meaningful steps before 2030
- Rapid development of a civilian space economy
- Strong participation from the private sector
- Coordinated oversight by public institutions

While private investment is essential, public actors—including national governments, agencies, and international organizations—can help articulate global interests and sustainability goals, assuring due priority to the common interests of all the 8.5 billion human beings, and the other sentient species living on Earth. Public institutions should prioritize funding and coordination in the following areas:

- Human health and life protection in space
- Sustainable space habitats development
- Radiation shielding technologies
- Simulated gravity rotating space stations

These investments are critical to enabling a safe and scalable human presence beyond Earth.

2.5.2 Governance Framework: A Principles-Based Approach

Current international space law lack enforcement mechanisms and faces geopolitical fragmentation. The absence of a supranational authority creates uncertainty, in a controversial discussion frame. While the Outer Space Treaty (OST) states that any activities in outer space are placed under responsibility of states, there is no over-national authority, so far, entitled to assure the respect of the OST. Such a supranational authority is considered desirable, on one hand, to manage the most critical key issues – such as orbital debris, space situational awareness, celestial bodies' territory non-appropriation. Yet, great concerns are expressed, mainly by emerging space countries, that any supranational authority may be led by the big powers, determining unequal and unfair benefits from space development to all Earthly Countries.

Two main concerns recurred at the Legal SubCommittee 65th session[84], in April 2026, in many of the speeches held by COPUOS's member states and permanent observers (NGOs and Intergovernative organizations): the big risks represented by orbital debris and space weaponization. The works of some working groups – such as ATLAC[85] and the Working Group on Legal Aspects of Space Resource Activities[86] – focused on the use of the space resources, namely on the Moon, in view of the ARTEMIS[87] and ILRS[88] initiatives' development. Discussion concerned how to assure the application of some Outer Space Treaty provisions, such as the non-appropriation concept, specially referring to the private sector industrial and commercial activities.

The above complex situation does not appear to be solvable in the near terms, for sure not in time to assure agreed rules before the cislunar economy will start. In the current geopolitical situation, the most likely scenario will see the big space powers competing to occupy the best Moon's locations. It is not possible while we are writing to foresee if the Outer Space Treaty will be respected. In the same time, powerful weapons will be launched to Earth orbits, recently indicated as a new theatre of war by the strategists of the major Earth's powers. Considering the recent cheeky neglecting of the international laws on Earth's surface by some of the biggest planetary powers, it is quite possible that the OST will be simply ignored, if not publicly and ostentatiously disowned.

We reaffirm our 100% support to the Outer Space Treaty[101], our commitment to outreach it in all communities where we can access, and doing our best to update it.

SRI also recognizes the United Nations as the only international recognized authority where old and new agreements may be discussed and come into force, for universal ratification and application.

In the current situation, witnessing the financial crisis of the U.N.[89] and its space branch, UNOOSA, SRI advocates for a reinforcement of both, in order to allow such institutions to play their role of harmonizers and enablers of human broad collaboration. Specifically, the empowerment of UNOOSA may contribute to enhance the United Nations' public image, showing that this international assembly has strong strategic vision for the future of civilization.

SRI has recently expressed criticism, by means of a Conference Paper[90], to the U.N. Space 2030 Agenda[91], adopted by the General Assembly on 2021, remarking that only the satellite technologies supplying services to Earth are considered, while civilian space development and space settlement are totally absent. SRI has proposed several amendments to the UN Space 2030 Agenda, the main one a 5th Overarching Objective, Civilian Space Development. We are restlessly engaged to reinforce the U.N. sustainable development Agenda, and the U.N. Space Agenda, looking beyond 2030, including Civilian Peaceful Space Development.

2.5.2.1 A ban to any weapons in space

SRI is firmly against the militarization of outer space, of the Moon, and all celestial bodies. SRI also advocates for a ban of any weapons in space, and proposes to forbid military or however offensive use of any device conceived for civil use (e.g. laser to destroy small dangerous orbital debris). After a good reflection on this topic, since any device in space can be used as a weapon in simple ways, the proposal to implement a provision against the so-called dual-use is worthless, since any space vehicle or device can be easily used as a kinetic weapon. Also see The Definitional Challenge of Space Weapons and the Case for a Principles-Based Approach.

2.5.2.2 Ethical Governance

In the current geopolitical conjuncture, SRI proposes a governance model based on shared ethical principles, rather than coercive regulation. Core principles include:

- Transparency

- Confidence-building measures
- Due regard for others
- Avoidance of harmful interference

This framework relies on reputational accountability, where non-compliant actors risk exclusion from international cooperation and economic opportunities.

2.5.2.3 Inclusivity and Global Participation

As the world witnesses a permanent space revolution, space-emerging countries no longer need to endure the long, slow road traveled by pioneers. Non-space-faring countries deserve the same opportunities as pioneer countries. They should not be limited to space technologies supporting agriculture and disaster recovery. They instead deserve advanced space development, as all have rights to development and social growth, as outlined in the U.N. resolution on the human right to development[92], 1986.

All nations, including emerging and non-spacefaring countries, should have equitable access to space development opportunities. This includes:

- Technology transfer and capacity building
- Participation in advanced space activities
- Access to scientific and operational data
- Sharing know-how to help capacity building

However, intellectual property rights must be honored (see below).

2.5.3 Legal Clarification and Policy Development

Key Areas of Legal Ambiguity[93]

To support sustainable growth, SRI identifies four priority areas for clarification:

1. **Ownership of Extracted Resources** - Resources removed from their natural location may be owned under national law without constituting territorial appropriation.
2. **Jurisdiction Over Space Installations** - Facilities should remain under the jurisdiction and control of the authorizing state.
3. **Intellectual Property Rights** - Legal protections must be acknowledged/respected to support innovation and investment.
4. **Due Regard and Environmental Protection** - Activities should include transparency, registration, environmental impact assessments, and long-term sustainability considerations while avoiding harmful interference with the activities of others.

Effect on Private Actors

Private sector participation is essential for scaling space development. Legal certainty will promote investment, innovation, and long-term planning.

2.5.4 A Space-Based Sustainable Development Goal

SRI proposes the adoption of an 18th Sustainable Development Goal[94] focused on civilian and peaceful space development.

2.5.4.1 Objectives of the Campaign

- Recognize space as a driver of sustainable development

- Increase public awareness of global space governance
- Give public visibility to UNOOSA-COPUOS
- Strengthen international cooperation frameworks
- To help UNOOSA-COPUOS acknowledging U.N. as an international system based on open discussion, shared ethical principles, and promoting effective ways out of the global crisis

2.5.4.2 Current Progress

Since its launch in 2023, the initiative has:

- Gained support from over 120 organizations[95]
- Achieved recognition in international forums
- Contributed to policy discussions at global governance platforms

2.4.5 Geo-lunar space industrialization

SRI is devoted to boost all initiatives to kick-off the geo-lunar industrialization as soon as possible.

A possible phased development approach:

PHASE 1

- **Orbital Debris recovery and reuse**, producing materials for space manufacturing and propellant in space. See Orbital Debris - from Problem to Opportunity
- **Big Space Based Solar Power Plants**, essential to feed orbital data centers and the first orbital manufacturing workshops.

PHASE 2 – Lunar resources utilization. Following the Moon settlements by the ARTEMIS and the ILRS initiatives, and the India's programs, lunar resources mining will increase the production of materials for building the cis-lunar and Earth orbit infrastructures. See Lunar and asteroid mining, producing propellant in space

PHASE 3 – Asteroid Resource Development. Access water and materials for large-scale space industry.

A well-conceived coherent plan should be subject of an international design activity, targeted to harmonize the efforts from all countries, and assure the know-how sharing necessity for building capacities everywhere.

SRI points out that reaching the milestone of propellant production in space, will determine the second step of the space revolution, the first one having been reusable rockets. Finding fuel in orbital stations, instead of bringing it from earth, will dramatically decrease the cost of any space mission. The achievement of precious minerals like gold and titanium in big quantities from Near Earth Asteroids will allow giant steps in electronic technologies, benefiting from superconductivity of such materials. Not to talk about the huge quantities of water contained in cometoids and other near-earth objects.

2.5.5 We speak for the Space Settlers

(based on the work by Dennis O'Brien)

SRI emphasizes the importance of recognizing the rights and interests of future space settlers[96]. Key principles include:

- Application of universal human rights in space
- Protection of future communities' autonomy and development
- Inclusion of settlers' rights in future agreements

SRI also argues that space resources should primarily support space-based development, rather than extraction for terrestrial consumption, accordingly to a new-colonialist policy[97].

To this end, the Declaration of the Right to Development[92], adopted by the UN General Assembly in 1986 speaks loud and clear. Article 1 of the Declaration states that “The right to development is an inalienable human right by virtue of which every human person and all peoples are entitled to participate in, contribute to, and enjoy economic, social, cultural and political development, in which all human rights and fundamental freedoms can be fully realized.”

We also acknowledge the Universal Declaration of Human Rights[98] of 1948 and its applicability to individuals working and living in outer space. Acknowledging these rights will benefit both the people of Earth and those who settle elsewhere.

In 2024, Space Renaissance International became a Permanent Observer at the UN’s Committee on Peaceful Uses of Outer Space (COPUOS). Since then, we have participated in several sessions, including the Scientific & Technical Subcommittee and the Legal Subcommittee. At every session, over a hundred delegates from around the world gathered to represent their own country’s present and future interests. But there was no one to represent the future interests of the settlers.

This is not to say that the countries and their delegates are wrong or uncaring. It is proper for representatives of a sovereign state to give the interests of their country and its people the highest priority. That is how institutions of international governance function. There is an assumption that such a process, and the requirement for consensus decisions, will ensure that the interests of all humanity will be served.

But will they?

Humanity is more than just a sum of its national interests. We have dreamed about the heavens since before countries existed. We wrote about traveling in outer space before we could fly. In October 1957 most of humanity stood outside at sunset, looking to the west to watch a blinking light pass far overhead, the tumbling upper stage booster of the world’s first artificial satellite, Sputnik. Some felt an increase in Cold War anxiety, but most of us felt awed and inspired. All the dreams of the writers and the poets – indeed, of all humanity – suddenly seemed within reach.

Then came the Space Race, as the Earth’s two great powers – and the two dominant ideologies – sought to prove that their system was the best to lead humanity to the to the New Frontier. Although people still dreamed, almost all space activity was controlled by national governments. Even after we reached the Moon, governments maintained their monopolies. When the Space Shuttle began service, the U.S. government required all domestic satellites to use it for launches. Even though other countries joined in – most notably China and the member states of the European Space Agency – the dream of civilians building a new life in space seemed unattainable.

But in January 1986 the Shuttle Challenger exploded on liftoff. After a thorough review, the U.S. government decided that it must open the launcher market to private industry. But it kept the monopoly on human spaceflight, as did other governments. The Soviet/Russian government focused on space stations, the first settlements in space. Other governments followed suit, culminating in a joint venture (without China) to build the International Space Station. In November 2000, humanity began its continuous presence in outer space with the arrival of Expedition 1.

But human spaceflight was still a government monopoly, till two events occurred. In February 2003, the Shuttle Columbia disintegrated on its return to Earth. In response, the U.S. government finally decided to relinquish its monopoly on human space flight. But it would still be the sole funding source and mission controller, as the private sector had not yet developed the technology needed for an economically sustainable human presence in space.

All of that changed in 2015. On December 22, Space Exploration Technologies, aka SpaceX, a U.S. corporation, successfully landed a reusable booster from Earth orbit after deploying satellites there.

Do you remember where you were that day? More importantly, do you remember what you felt the moment the booster touched down safely? Once again the dreams of the writers and the poets, indeed the dreams of all humanity, seemed achievable. Despite the war, suffering, and neglect that that dominated the world – and still does – humans looked to the skies and began to believe that they really could build a better world. In the deepest, most universal sense, they began to have hope.

SpaceX announced its reusable booster program in 2011. In anticipation of this development, a group of visionaries met in northern Italy in 2010 to found Space Renaissance International, a nonprofit organization dedicated to fulfilling the dream of a sustainable civilian presence in outer space, not just as government contractors, but as free citizens of the galaxy.

SRI held its first World Congress in 2011 and has since convened them every five years. 2026 marks the fourth, SRIC-IV, and its scope has greatly expanded. At the third Congress in 2021, the attendees decided to augment the United Nations' 17 Sustainable Development Goals by proposing an 18th SDG: the civilian development of outer space. Since then, 120 civilian organizations from around the world have joined the 18th SDG Coalition.

The Coalition has allowed SRI to speak on behalf of those on Earth who seek to create a space civilization. But as we began to observe the member states of COPUOS speak on behalf of their present and future interests, we began to realize that we needed to speak for the future interests of those who would live and work in outer space. We needed to speak for the settlers.

At the meeting of the Legal Subcommittee in 2025, we made that announcement to the world. This year we are going a step further; we are declaring on behalf of the settlers their intention to become autonomous, then independent. Even as we promote the 18th SDG, we will also work to make sure the interests of those future settlers and settlements are not compromised.

Humanity's departure from the home world offers a rare opportunity, a clean slate, a chance to restore people's hope. It is not too early to begin to consider the settlers and settlements as we develop outer space policies. They are counting on us. In many ways, we are the settlers. Let us do our best to create that shining city on the hill that will light the way for all.

2.5.6 Protection of Human Life and Health

Ensuring human safety is a foundational requirement for long-term space activity. Priority research areas include:

- Radiation protection
- Artificial gravity systems
- Long-duration habitat sustainability

SRI calls for a substantial increase in global investment in these areas.

See Protection from solar and cosmic radiation and Simulated gravity, general concept.

2.5.7 Conclusion

Human expansion into space represents both an opportunity and a responsibility. A sustainable and inclusive approach—guided by ethical principles, legal clarity, and international cooperation—can transform space into a domain that benefits all humanity.

SRI's policy framework emphasizes urgency without sacrificing long-term vision. By aligning public and private efforts, clarifying legal uncertainties, and prioritizing human well-being, the global community can ensure that space development contributes meaningfully to the future of civilization.

SRI acknowledges the contributions by members of the *Space Philosophy & History Committee*, the *Space Technology & Industry Committee*, and the *Space Policy Committee* in the development of this section.

2.6 Space Communities' Governance

Gerard K. O'Neill wrote few but very inspiring words about governance of space communities[99]: *"In contrast, and very much by intent, I have said nothing about the government of space communities. There is a good reason for that: I have no desire to influence or direct in any way, even if I could, the social organization and the details of life in the communities. I have no prescription for social organization or governance, and would find it abhorrent to presume to define one. In my opinion there can be no ''revealed truth" about social organization; there can only be, in any healthy situation, the options of diversity and of experimentation. Among the space communities almost surely there will be some in which restrictive governments will attempt to enforce isolation, just as such governments do on Earth. Others, hopefully the majority, will permit travel and communication. Within the brief time of twenty years, during which transatlantic air travel has gone from the unusual to the commonplace, we have seen how powerful a lever it has been for the transmission of experience from one country to another, especially among the fraternity of young people. Logically, if the cost of transportation between the communities becomes as low as it is now projected to be, travel between most of the communities of space will be far more frequent than it is now between nations on Earth, and people will be able to form their own opinions, on the basis of direct observation, as to what constitute successful or unsuccessful experiments in government. With energy free to all, materials available in great abundance, and mobility throughout the solar system available to an individual community, it should be more difficult in space than it is on earth for an unsuccessful government to argue that its failure is due to unavoidable circumstances of location or resources."*

We feel very much in agreement with these simple concepts, namely (i) not to suggest any social model to the settlers, and (ii) being very much curious and hoping about experimentation of new governance models and good practices.

A space habitat, even composed by a few hundred inhabitants only, may be considered a small village, with some added peculiarities. E.g.: it is not part of any province or county, it is not subject to a single national government, yet it is likely built by a consortium of different private and public stakeholders, from different countries. The community will have to decide which law should apply, and which constitution represents the legal backbone, which previous experiences can be considered, as guiding good practices. International maritime laws might be considered, as well as the Outer Space Treaty, other space treaties, ARTEMIS Accords, ILRS, etc. A limited number of citizens allows direct-democracy governance if the citizens decide so. Proper rooms and systems shall be designed, to allow citizens to exercise their democratic participation in the governance of the habitat. Proper facilities should be provided, to allow the democratic election of representatives. The habitats should provide proper infrastructure to allow both internal and external communications, for audiovisual meetings and networking.

2.7 Peace on Earth, and beyond

2.7.1 The Definitional Challenge of Space Weapons and the Case for a Principles-Based Approach

Building on Dr. Gülin Dede's ongoing research on a principles-based ethical approach to space governance[100], SRI advances the following position.

Humanity is facing a historical crisis, when just a slight shift can cause massive changes that can last for decades, even centuries. The closest parallel occurred five centuries ago, when the Age of Exploration became the Age of Imperialism. Then, as now, countries with advanced technology sought to control the resources of "new" worlds, creating a legacy of war, suffering, and neglect that is still being felt today.

We are concerned that humanity is about to repeat that pattern. There are some who assert that whoever gets to a place first gets to make the rules and can establish resource exclusion zones. Others have declared outright that space is a warfighting domain. Meanwhile, humanity is being challenged by other issues. Every day we wake up to news of worsening climate change, increasing social unrest, and rising international tensions. To that has now been added the threat of conflict in outer space. The people of Earth have begun to lose faith in their governments, their private institutions, even in humanity itself. They are beginning to lose hope.

Our duty is nothing less than to restore that hope, to counter the despair of war and violence and neglect, to give the people of our planet a future they can believe in. We should do everything within our collective power to promote peace and prosperity in outer space, as it may be the best way to promote peace and prosperity on Earth.

A central challenge in addressing space weaponization lies in the absence of an agreed definition of what constitutes a "space weapon." While certain systems, such as anti-satellite (ASAT) capabilities, are widely recognized as destabilizing, the majority of space technologies remain inherently dual-use. Satellites designed for communication, navigation, servicing, or debris removal may equally possess the technical capacity to interfere with, disable, or manipulate other space assets. This functional ambiguity complicates any attempt to establish clear legal or regulatory boundaries, as the distinction between civilian and military applications is often contingent on use rather than design.

Existing international legal frameworks, most notably the 1967 Outer Space Treaty (OST)[101] (see Articles III, IV, IX), provide only partial guidance. While the Treaty explicitly prohibits the placement of weapons of mass destruction in orbit (Article IV), it does not address conventional weapons. Moreover, broader obligations under international law, including the requirement to conduct activities in accordance with international peace and security (Article III) and the principle of due regard and avoidance of harmful interference (Article IX), remain open to interpretation in the context of emerging technologies. As a result, the legal regime governing space activities does not offer a comprehensive or operational definition of weaponization.

Efforts within multilateral disarmament and space governance forums have repeatedly encountered this definitional gap as a core obstacle. Discussions under the Prevention of an Arms Race in Outer Space (PAROS)[102] has been a permanent item on its agenda (Item 3) since 1982, though formal negotiations for a treaty remain deadlocked due to a lack of consensus on a Program of Work. See:

- The Resolution adopted by the General Assembly on 2 December 2024 [on the report of the First Committee (A/79/406, para. 20)] 79/19 Prevention of an arms race in outer space[103].
- Report of the Conference on Disarmament 2025 session[104]
- "Treaty on prevention of the placement of weapons in outer space and of the threat or use of force against outer space objects"[105] Draft, 29 February 2008

Similarly, more recent United Nations initiatives, most notably the Open-Ended Working Group (OEWG) on Reducing Space Threats through norms, rules and principles of responsible behaviors (UNGA Resolution 75/36)[106], have implicitly acknowledged this challenge by **shifting the focus away from object-based definitions toward the regulation of behaviors in orbit**. This evolution reflects a growing recognition that technological classification alone cannot adequately capture the complexities of contemporary space systems (UNGA, 2020; OEWG Reports, 2022–2023)[107].

Because the group failed to adopt a consensus report (largely due to disagreements involving Russia and China over the "responsible behavior" framework), the General Assembly later adopted Resolution 78/20 in December 2023. This resolution acknowledged the OEWG's work and paved the way for a new working group (2025–2028) to continue the discussion.

Session	Dates	Primary Focus
Session 1	May 2022	Stocktaking of existing legal/normative frameworks.
Session 2	Sept 2022	Current and future threats to space systems.
Session 3	Jan/Feb 2023	Norms to prevent interference and collisions.
Session 4	Aug/Sept 2023	Final report negotiations (ended without consensus).

Table 3. OEWG Sessions

In this context, a rigid, object-based definition of space weapons is unlikely to provide a viable pathway forward. Instead, SRI advances a principles-based approach as a more effective and adaptable governance framework. Rather than attempting to categorize technologies as inherently civilian or military, a principles-based approach focuses on the conditions and manner in which space systems are used. It builds on existing legal and normative foundations—such as transparency, confidence-building measures, due regard, and the avoidance of harmful interference—and extends them into a more operational framework for responsible conduct in space.

SRI is in favor of continuing the discussion, in the new working group (2025–2028), and at UNOOSA COPUOS if the topic is admitted among the scope of the Committee, and reach as soon as possible to an international agreement, on a universal ban to all weapons in space. PAROS[102], and the text proposed by China and Russia on the 12 February 2008 to the Conference on Disarmament[105] might be considered starting base.

SRI proposes the ban of all weapons in space, with the following observations:

- **Right of self-defense**. Self-defense implies the capacity to exercise it, i.e. it implies the presence of some kind of weapon. Article 51 of the U.N. Charter is intended for Earth, where weapons are taken for granted. While the presence of weapons on Earth is an undeniable historical fact, the displacement of weapons in space must be considered a totally new event, never occurred so far and that shall never occur. Since there is none international, over-national or meta-national entity in charge, and having capacities, to control the respect of the signed treaties, it would be not only useless, yet also counterproductive to establish any regulatory organism over the member states. Any violation of the signed treaties (OST and subsequent) will be condemned and branded as a publicly shameful violation of international ethics.
- **A signed agreement on Universal Weapon Ban** shall be amended only by a majority of 2/3 of having right to vote.
- **Space weapon**: a space weapon is any device located in outer space on its own, on board a space or planetary vehicle of any kind or a space base (in orbit or located on or below the surface of a natural body) whose primary purpose is to do harm to human beings or to destroy, damage or disrupt the integrity or the normal functioning of structures, vehicles and other objects in outer space, on the Earth or in the Earth's atmosphere, or to eliminate a population or components of the biosphere which are important to human existence or inflict damage on them.
- **Ban on space weapons** . The States Parties undertake not to place in orbit around the Earth any objects carrying any kinds of weapons, not to install such weapons on or below the surface of celestial bodies and not to place such weapons in outer space in any other manner.
- **Ban on offensive use of any space asset**: The States Parties undertake not to use any space asset under their control to deliberately harm humans, or to destroy, damage or disrupt the integrity or the normal functioning of structures, vehicles and other objects in outer space, on the Earth or in the Earth's atmosphere, or to eliminate a population or components of the biosphere which are important to human existence or inflict damage on them.

This approach aligns with the emerging international trend toward behavior-based governance, as reflected in the OEWG process and related diplomatic efforts. By prioritizing conduct over classification, it allows for the mitigation of risks associated with space weaponization while preserving the flexibility necessary for legitimate civil, commercial, and scientific innovation. At the same time, it offers a pathway to bridge the longstanding deadlock in disarmament discussions by reframing the debate: from defining "what a weapon is" to agreeing on "what constitutes responsible and unacceptable behavior" in space.

Ultimately, the adoption of a principles-based approach does not replace existing legal frameworks but rather strengthens and operationalizes them. Since any space device can be used offensively, instead of referring to the concept of "dual-use", the principles-based approach expressly prohibits offensive actions performed with any device, it supports international stability, and reinforces the foundational objective of space governance: the peaceful, sustainable, and inclusive use of outer space for the benefit of all humankind.

2.8 Space as Inspiration for peace, love and compassion

The starred sky has inspired humanity since its beginning: the oldest civilizations all cultivated astronomy and created stories and myths about the celestial bodies and the open sky, perceived as the place of heaven. When space travel became possible, after the initial rivalry a cooperation spirit arose since the Apollo-Soyuz mission and went on with the ISS – it shall not end! Space offers a broad range of philosophical references. We work in continuation of the great cultural tradition of collaboration in space, initiated with the 1975 rendez-vous between Apollo and Soyuz, and continued with the International Space Station. A new *cosmic humanism*, inspired by our philosophical humanist roots, the Overview Effect and the human sentiment of reciprocal assistance in space, similar to the analog feeling in the Earth's oceans.

2.8.1 From mythology to our days, sky was never a limit

[based on the work by A. Cavallo and A. V. Autino]

All traditions have stories about the creation of the world, the first times and how humanity was originated and where art and culture came from. Some themes that are often recurring are the fall from a previous blissful condition, the theft or the donation of arts from the gods, and the journey of a hero.

2.8.1.1 Greek and Asian mythology

In Greek mythology, the Titan Prometheus stole fire from the gods and gave it to humanity, a defiant act that enabled human civilization, leading to his severe, eternal punishment by Zeus, who chained him to a rock where an eagle ate his regenerating liver daily. This myth symbolizes humanity's pursuit of knowledge, exploration, and progress.

Similarly, Homer's Odyssey can be read as an evolutionary travel by its main character Ulysses (or Odysseus according to the Greek original), who, forced to a long journey to reach home, catches every opportunity to learn about the places and the people he meets. The story was then elaborated by Dante Alighieri[108]. who put him in hell due to his behavior in the war of Troy but describes favorably his last adventure as a final exploration challenge. Ulysses was described as a master of deceit and this is the reason why he is in hell in the "*bolgia*" of the deceivers. But he was also known for his aspiration to adventure and knowledge, and Dante makes him tell the episode of his courageous death – completely invented by Dante himself as far as we know. Some critics see a negative judgment about this defiant enterprise, but this is not consistent with all Dante's work, according to reliable evaluations[109]. Below we call him Odysseus, as we go back to the original narration by Homer.

In the Asian culture, almost the same value, the aim for exploration, knowledge, cultural development, are championed by Sun Wukong[110] (The Monkey King), a Chinese cultural archetype. Sun Wukong is a monkey born from a stone who acquires supernatural powers through Taoist practices. A symbol of intelligence, freedom, and irreverence toward unjust power, an enduring folk hero, beloved by children and intellectuals alike. His defiance of Heaven speaks to the desire for freedom and individuality within a hierarchical Confucian world. Like Prometheus, he steals peaches of immortality, defying Heaven. Like Ulysses, he undertakes a Journey to the West, to satisfy his great curiosity of the world and of the unknown.

Gun, Fuxi and Nuwa are other cases of Chinese rebel-heroes, bringing culture and methodologies to humanity. Gun, a demigod, tries to stop the flood with methods disapproved by Heaven, stealing self-expanding clay from the gods. Fuxi and Nuwa teach humanity skills like writing and hunting.

But it is time to come back to the first true Western author – if he ever existed and was just one and not a collection of contributors: Homer.

While the Iliad is still more rooted in an ancient world where men are glorious warriors with a complex relation with the gods, the Odyssey can be considered the starting point of a new civilization, the real dawn of the West.

Right at the beginning Odysseus is introduced as a "multi-faceted man", not just a warrior but one who "very long went wandering after he ruined the sacred citadel of Troy, and of many people saw the cities and knew the mind".[111] "Multi-faceted" is just an attempt to translate "*polytropos*", which indicates his complexity as well as his shrewdness in one untranslatable word. Odysseus first encounters ordinary difficulties, then he arouses the wrath of Poseidon, the god of the sea, which causes more troubles despite the constant help of Athena. In most episodes, it is clear that he is constantly interested and curious about the natural and supernatural beings he meets as well as the unknown places where he is pushed. Not by chance, his enemy is a god of wrath and violence and his friend is the goddess of intelligence born from the head of Zeus.

Along his epic travel, Odysseus meets both monsters and threats and blissful characters and communities.

Odysseus is not a single-dimension hero, only looking for glory and pleasures: he is a man who cares most for two things: his personal life with his wife in his land, and to know the people and the world. In his adventures he always wants to explore more, and this often puts him in troubles.

On the other hand, it is also beautiful the glimpse on the discovering of many small communities, like micro-utopias scattered throughout the Mediterranean, which for those times was as large as the geo-lunar space is for us today... An inspiring anticipation of what the first space communities might look like, as incubators of new social, economic, and cultural models, in which many technologies and methodologies can be experimented, for the benefit not only of space communities, but of Earth's communities as well.

Coming back to Odysseus, he is one of us, longing for simple family life as well as knowledge of the world – not at all an epic hero craving for fame and a godlike condition. Despite being often called "divine", he is very human even in his constantly suspicious attitude. Neither he's a saint, just an average person, like the ones we try to reach, and in whose interest we are speaking and acting. As Odysseus arrives in Ithaca, Athena appears to him disguised as a shepherd[112], and he first asks where he has arrived and then tells her a faked story about his identity and the circumstances of his arrival. Athena then reveals herself laughing and mocks him for trying to deceive her as well! This dialogue between Odysseus and his divine protector shows how he is at the same time a cunning common man and yet fully familiar even with the goddess, who returns the familiarity. when Athena reveals herself to Odysseus, she only looks like a woman, "beautiful and great and knowledgeable of splendid works"[113]. So, Athena, goddess of intelligence, is one who makes things with knowledge, not just one who contemplates with wisdom. And this is another reason for our liking very much Homer and his main character, Odysseus: his main reference is Athena, goddess of intelligence. That means a high degree of appreciation for human intelligence, creativity, and undertaking, and that's not a novelty, the Greek culture was deeply humanist!

Therefore, with the Odyssey the age of the Titans and the great heroes, who were half-gods, has ended: Odysseus is still a hero, but a human one, aspiring not to be the most glorious and powerful but to learn about people and places and then to live in peace with his family, in the middle of the troubles of life. His other strength, in fact, is patience: "endure then, my heart, way more terrible things you endured!".[114] The human era had begun.

The Hellenistic world has also given us the first stories about space travel! Lucian of Samosata, a Hellenistic Syrian writer of the II century A.D., in his humorous novel "the True Story" tells of space travel towards all the celestial bodies known at the time. The story, narrated in first person, begins with the leading actor sailing off with a well equipped ship in the Atlantic Ocean, beyond the columns of Hercules (like Odysseus in Dante's version). In the introduction, Lucian obviously compares his story with the Odyssey. Cause and motivation of the voyage are "intellectual curiosity, wish of new things, and the desire to know the end of the ocean and who are the inhabitants of the other side"[115]. The protagonist and his crew is then brought by storms to outer space and they can visit all the celestial bodies known in that time. While flying, they can see the planets as islands and they are amazed understanding that one of those islands is the Earth itself! The first place where they arrive is the Moon, but at first they do not recognize it, as they are seeing it as they never did before. They are captured by people riding three headed vultures and brought in presence of the local king, who explains to them that they are on the Moon. And the story goes on with more interplanetary adventures.

The interesting point is that the Earth is described as just one among several different "islands" in space, each of them inhabited by strange people and animals. Not only this is arguably the first science fiction story ever written, but the conceptions that Lucian exposes are quite modern: the Earth is not an exception and there are populated worlds in outer space. But other even more advanced conceptions were already there in the East.

The idea that our Earth is just one among many worlds is in fact present in Buddhist literature. For instance, in chapter XV of the Lotus Sūtra[116], Buddha Śākyamuni explains that there is an inconceivable number of worlds in every direction, where he and the other Buddhas have taught and will teach Dharma for an inconceivable duration of time. In the Buddhist view, each world has an independent origin, duration and end. The Flower Ornament Sūtra speaks of these multiple universes in terms similar to the idea of multiverse in the string theory of modern physics, adding another dimension to the multiplicity. There is not, anyway, a conception of travel between different worlds. The Buddhas are born willingly as manifestation bodies in each world, and common sentient beings can of course be reborn everywhere, but they have no control on the process.

On a more ideological layer, many of the theoretical models including Plato's ideal states described in "Republic" and "Laws", were elaborated in times of crisis and social tension. In the Greek-Roman time it was allowed and frequent that the organization of the state and the political regimes were discussed and compared. Devising a project for a perfect state was definitely possible. Things changed during the Middle Ages, when the earth was considered as a damned place, the only people of culture were priests and monks and the ideal place could only be in heaven. Not by chance, first Renaissance Humanism brought back ideas about a better world down here. Also helped by the arrival of Greek scholars fleeing from the Turkish invasion of the Eastern Roman Empire, the knowledge of ancient Greek became common among the scholars. It became possible to read the ancient Greek authors in their original texts and not only in Latin commentaries written by religious people.

2.8.1.2 Renaissance and utopia

The word *Renaissance* indicated the return of a purer form of the Greek-Roman culture, freed from the interpretation of the Church. Knowing Greek and mastering Latin better, with new philological competences that allowed to distinguish the ancient texts from the medieval ones, the intellectuals of the Renaissance could easily see, for instance, that the famous "Donation of Constantine", where the Roman emperor allegedly transferred authority over Rome and the western part of the Roman Empire to the Pope, was a fake, as ascertained by Lorenzo Valla.

A new literary genre, based on the representation of an ideal world, was created in the time of the Renaissance. An ideal journey of the reason to distant lands, where the distance is real and ideal at the same time. Sir Thomas More in 1516 entitled "Utopia" his famous book about an ideal place with desirable institutions and a new social model. While Plato directly described his proposals as the ideal state to be realized, More prudently placed his model in a remote, non-existing place. which does not exist in real experience, but which exists in the expectations and hopes of those who do not identify themselves with the society of their time. Tommaso Campanella did the same with his "City of the Sun".

The word 'utopia' was invented by Thomas More from the Greek ou-topos which literally means 'no place' or 'nowhere'. The term has had success and has become a generic word typically describing an imaginary community or society that possesses highly desirable or nearly perfect qualities for its members. But in the current usage it is also intended to be unfeasible. In More's intention, utopia did not mean an unfeasible society, yet a desirable social model that was never experimented so far, but nothing prevents to be experimented. By the way, the almost identical Greek word eu-topos means 'a good place', therefore the term eutopia represents even better what we aim for.

2.8.2 Space travel from Renaissance to the contemporary world

The Renaissance on Earth produced an evolution of human thinking, including The Enlightenment and Romanticism, both of which have fueled humanity's efforts to leave the home world. The Enlightenment focused on rational thought, empiricism, objectivity, and the scientific method, which advanced the engineering necessary for off-world activity. Romanticism, on the other hand, tended more toward subjectivity, imagination, intuition, and passion, which fueled a creative era of speculative fiction that continues to this day.

The inspirational thread for space travel had originated with the works of Nicholas of Cusa, Copernicus, and Kepler, as well as Giordano Bruno's philosophy, which were soon followed by literary journeys to the moon grounded in the new astronomy. This finding is due to the academic work of Dr. Marie-Luise Heuser[117] who also leads the SRI Philosophy Committee.

While the development of science and technology, essential to make space travel feasible, started in the era of Enlightenment, philosophers and scientists of the time ignored the idea of space travel, which arguably seemed to them a worthless, unfeasible dream.

During the XIX century, while the world of science and technology was developing faster and faster, creating the premises that later became essential for spaceflight, a split occurred between those who were enthusiastic about this material progress and those who were not, seeing a risk of dehumanization and reckless exploitation of people, and a huge cultural loss. Romanticism reacted to the perceived excesses of Enlightenment and it kept the space dream alive, especially by the contribution of F. Schelling, as per the studies of Dr. Heuser [118]. However, it was above all economists influenced by Romanticism who drove the process of industrialization forward, such as Friedrich List in Germany. Furthermore, the Romantic movement gave a significant impetus to the development of modern mathematics, which became crucial to rocket science.[119]

In parallel, while the scientific world kept considering space travel unreal, around mid-century the idea of progress produced the new literary genre, initiated by Jules Verne and continued by H.G. Wells and others, which received 100 years ago the name of “Science Fiction”[120]. The cultural split was still there, as the few space pioneers that started developing precise ideas and devising experiments were isolated and found difficulties in obtaining the support of the industry and the institutions. In the 1920s, broad, culturally rooted space exploration movements emerged in Russia and Germany, which ultimately led to the development of rockets capable of reaching space.[121]

We could go on with the stories and the vicissitudes of the space pioneers: how hard it was to be accepted and to get the industrial resources and the financial support they needed and so on. But this exceeds the purposes of this Thesis and shall be developed under the guidance of our philosophy committee, led by Dr. Heuser.

It is enough by now to have clarified why we recall the Renaissance and how we are using here the words utopia/eutopia, for the purpose of exposing the general concepts that inspire us in our promotion of the expansion of humanity into outer space.

2.9 The Space Renaissance, a new, feasible, eutopia

Since the modern world is now facing an existential crisis that may lead to something totally different and possibly, alas, regressive, the idea that brought to the foundation of Space Renaissance was essentially to revive again civilization by building upon ideas that were present in the past to build a new civilization that is firmly founded on a consistent tradition. More than that, this renewal of civilization shall encompass all the elements of humanity: not just science and technology, which are associated with space in the mainstream view, but art, poetry, music as well. As ancient Greece had the ideal of being “good and beautiful” and the Renaissance again merged all the concept, being represented by characters like Leonardo da Vinci, the master who joined arts and engineering, we conceive the new off-Earth civilization as a new flourishing of all that humanity can express.

Perhaps even the current age, characterized by a deepen global crisis of the civilization, might spur humanist thinkers to conceive a new utopian narrative, or better an eutopian one: no more unfeasible utopias, finally feasible ones, based on the learned lessons from utopias of the past, which have failed, due to basically two key reasons:

1. the illusion to realize them within the boundaries of our closed world
2. all of the utopias of the past required 100% consensus for their realization.

Our key reason for betting on a space *eutopia*, is that the Solar System virtually unlimited resources will provide the basic platform to make it statistically feasible.

Some basic assumptions[122]:

1) All of the utopias so far failed – and/or demonstrated to be unfeasible – due to the fact that they were conceived within the limits of our mother planet, in a context of limited resources.
2) Any utopia, trying to develop in a closed system, leads to authoritarian social regimes and ultimately to tyranny.
3) Both socialist and libertarian utopias cannot be realized in a closed system, with scarce resources.
4) Opposite, expanding into the solar system, humanity can give birth to many experimental societies, based on different social models.
5) Totalitarianism can only grow up in closed systems[123][124][125][126]
6) Democracy and freedom need open world and abundance of resources.
7) Though several science fiction authors wrote about galactic empires, totalitarianism cannot grow up in an open world, and space is by definition an open world, impossible to be closed, fenced, garrisoned.

The space *eutopia* doesn't need 100% consensus. People will be free to migrate to outer space or remain on Earth, or even to come back to Earth if they decide so. Virtually unlimited space communities can develop in the solar system, around the main planets or big moons and the Asteroid Belt. An immense variety of social models can be experimented, in total freedom. Such cultural diversity is the natural base of a resilient robust thriving civilization.

A compelling causal chain of Space Eutopia:

[CLOSED SYSTEM / EARTH] ➔ Scarce Resources ➔ Zero-Sum Competition ➔ Absolute State Control ➔ Totalitarianism / Tyranny

vs.

[OPEN SYSTEM / SPACE] ➔ Endless Resources ➔ Positive-Sum Growth ➔ Infinite Social Models ➔ Democracy, Freedom & Resilience

SRI remains firmly on the side of humanity, on the side of Prometheus, defending scientific and technological restless work, on the side of Odysseus, seeking new horizons for development and always new learning, evolving through the claim of freedom towards enlightenment.

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