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Directorate A - Economic and Scientific Policy
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ISSUES UNDERLYING SPACE EXPLORATION IN EUROPE

Briefing note

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EXECUTIVE SUMMARY

Since the launch of Sputnik 1 on 4 October 1957 that opened the space era, space exploration has become a central element of space agencies, particularly during the Cold War. Space exploration from its inception has emerged as an indispensable instrument to furthering national strategic, political, scientific and economic objectives that culminated in July 1969 with the U.S. human landing on the moon. However, after a long hiatus, space exploration has now become again an element of the political agenda of a growing number of countries around the world, and consequently, the space exploration environment is dramatically evolving. The recent catalyst for the paradigm shift in exploration is U.S. President George W. Bush's bold redirection of the U.S. civilian space programme to pursue the exploration of the moon, Mars and beyond.

Space exploration is an emblematic domain of space activities where traditionally only established space powers have been active. However, new actors are demonstrating great interest in it, principally for international prestige reasons and a will to demonstrate greater regional or even global (S&T) leadership, with an increasing number of them making ambitious plans. Indeed, while the first decades of space exploration were dominated by the United States and the U.S.S.R., several new actors are now becoming involved, principally for international prestige reasons, as well as socio-economic motives leading to an internationalisation of the space exploration context. All the existing and emerging space powers have made the decision to engage in robotic space exploration, while human exploration is a central element only of the exploration plans of major space powers with global aspirations.

While interests for space exploration are gaining momentum separate and often competing camps regarding the type of exploration to be conducted remain and continue to foster human-as-explorers *versus* robotic alternatives. However, in the context of understanding the Solar System, the relative strengths and weaknesses of each actor be it humans beings or robots, and particularly vis-à-vis the destinations and tasks to be performed need to be taken into account when deciding on future exploration missions. Furthermore, while in the first 50 years of spaceflight there was a clear dichotomy between humans and robots, the two sides tend to merge as robots are becoming increasingly sophisticated partners able to support humans in specific tasks. The right approach for the purpose of future space exploration will thus be a mix of both robots and humans.

Space exploration will allow the study of other planets and bodies in our Solar System both remotely and by direct *in situ* exploration providing critical information on how to better understand and mitigate key issues and Earthly problems. It will allow the advancement of scientific knowledge, foster the sustainable development of the Earth, ensure European and global security, reap the benefits of the political dimension of space exploration, and encourage innovation and economic developments. Space exploration will thus provide many benefits by generating increasing knowledge that can directly and indirectly help EU citizens to understand and mitigate some of the problems they may face presently, as well as in the future.

Global cooperation in space exploration could demonstrate a commitment to multilateralism and a willingness of taking on global responsibilities such as space security and reinforce EU's emergent space diplomacy. EU's Member States have been pursuing an initiative on the elaboration of a Space Code of Conduct on Outer Space Activities to strengthen existing agreements and codify new best practices for a safe and secure use of space.

It covers all activities including civil, military as well as future ones and from the very beginning, the European Union intended to elaborate an instrument open for adherence to all space-faring countries in order to reach a consensus to ensure the long-term sustainability of space activities.

Space exploration activities present already many socio-economic benefits for Europe. Besides the technological spinoffs, in particular, the development of the Automated Transfer Vehicle (ATV) programme that is providing an indispensable element of the supply-chain of the International Space Station (ISS), new high-value jobs have been created in Europe. Moreover, the very successful Jules Verne ATV mission has highlighted many new technologies and capabilities that can be adapted for future spacecraft development demonstrating the technological prowess of Europe in space activities.

While more and more countries are engaging in space activities, space exploration remains the realm of major space powers. It is a political and global endeavour in which Europe, including the European Union, can not be absent or play a minor role as space exploration is the most emblematic domain of space activities and by proxy of technological capabilities, and thus a mean to impress the world. Space exploration is a major element of space power, but also of overall national power.

Space exploration is a multi-faceted endeavour and a “grand challenge” like Climate Change or internal security where Europe has to play a significant role. In this context, the European Union can provide elements that its Member States (and the European Space Agency) cannot deliver (or not as well) on their own. Up-to-now, European space exploration programmes were largely based on scientific motives with limited political concerns. But to face the future, this needs to change as other space powers are linking space exploration and “high politics” like the United States and China; the European Union and its relevant bodies should thus engage in a substantial space exploration programme commensurate with high ambitions as visible and forward-looking activities would demonstrate its achievements and leadership abilities to the world and will confer some benefits in the form of international prestige and overall power, as well as direct socio-economic advantages such as support prosperity and growth. The involvement of the European Union could help to develop a politically-driven European space exploration strategy. It could support financially space exploration activities, inspire the next generation of scientists and engineers, but also reinforce the European identity and foster international ventures and European leadership.

INTRODUCTION

Space exploration is an emblematic domain of space activities where traditionally only established space powers have been active. However, following the changing geopolitics of space activities, new actors are increasingly becoming involved in space exploration for mainly international prestige reasons. For the purpose of this document space exploration is defined as an "open-ended project relaying on robotic and human activities extending access and a sustainable presence for humans in the Earth-Moon-Mars space, including the Lagrangian points and near-Earth objects". Space exploration is thus not a destination, but rather a process driven by political and socio-economic motives encompassing both robotic and human exploration activities. Consequently, an increasing number of space agencies have planned lunar and Martian orbiter and lander missions often in the context of preparations for future human exploration. As a complement to national endeavours, international cooperation has become a central element of the strategy of most countries involved in space exploration over the years. The space exploration context is therefore evolving and it is expected that space exploration in the next 20 years will present increasing challenges for Europe as well as opportunities for Europe to remain a major space power[1].

Europe (defined as the European Space Agency (ESA) and its Member States and national space agencies) has a long-standing tradition of space exploration. Furthermore, it has since 2001 a long-term plan for exploration, the so-called Aurora programme[2]. Today's European human spaceflight activities are based primarily on its involvement in the International Space Station (ISS) programme. ESA is a major partner in the programme with the orbital laboratory Columbus launched in 2008, and the operational cargo system Automated Transfer Vehicle (ATV). Because of the high expenditures associated with space exploration, most European involvement in this domain has been related to ESA missions, although several European countries are considering developing national robotic exploration missions.

Europe currently enjoys a strong position in the global "space hierarchy", but this might not be everlasting. To maintain a leading space role in the next two decades at least, besides "political will" a series of ambitious programmatic elements is needed to demonstrate clear leadership across a wide range of space sectors, including space exploration.

The decision to take vis-à-vis future space exploration comes in a special context with the unanimous support of the European Space Policy by 29 European Member States[3], but also because Europe through ESA has confirmed its position as a leading global player in space exploration with the launches of Columbus and ATV. However, Europe should not rest on these achievements. In an evolving space exploration context, new strategies and programmes have to be put forward to assert Europe as an indispensable and major actor in space exploration in the decades to come to be able to continue reaping the benefits of this future "grand challenge".

[1] Peter, N., (2008a)
[2] Several other solar system missions are also currently envisaged in the context of the Cosmic Vision 2015-2025. The Cosmic Vision is in search for understanding the Universe from the Big Bang, responding to questions on the conditions of life and planetary formation, as well as on the formation and functioning of the Universe.
[3] ESP (2007)

1. UNDERSTANDING THE SOLAR SYSTEM, WILL IT BE DONE VIA THE MEANS OF HUMAN BEINGS OR ROBOTS? IMPLICATIONS, BENEFITS, COST, POSSIBLE RESULTS, CONCENTRATION ON MISSIONS.

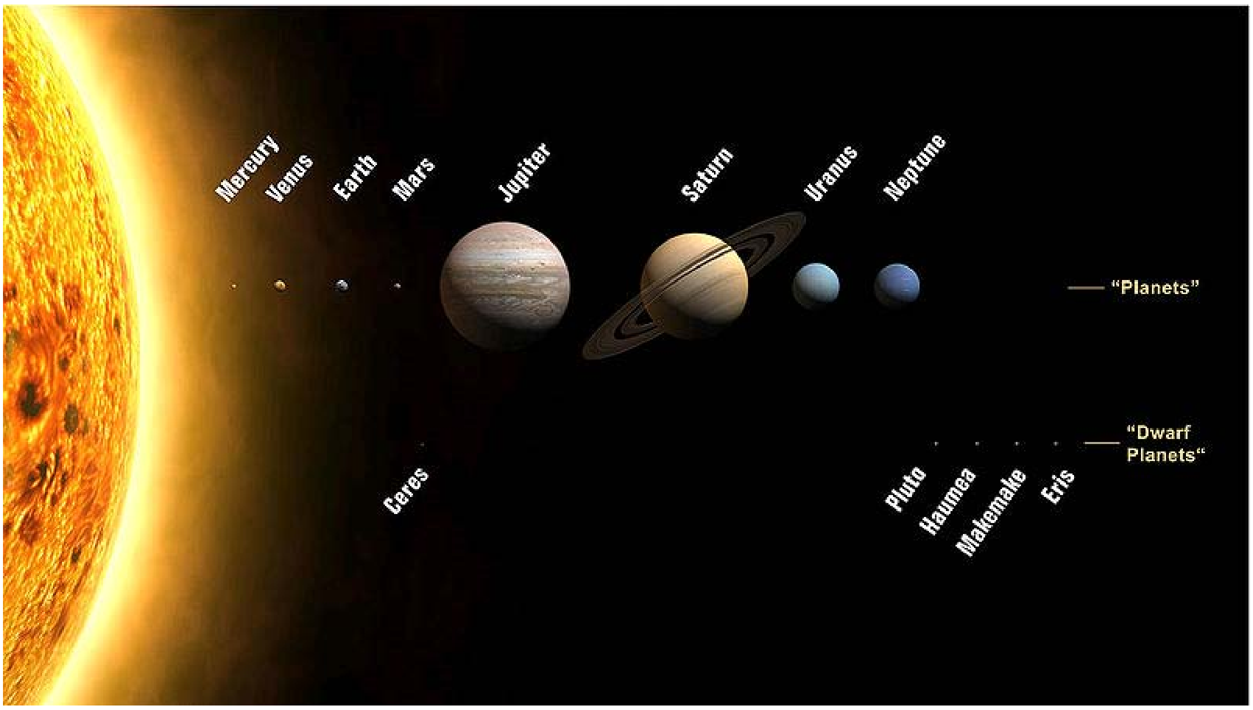
Separate and often competing camps of opinion regarding planetary exploration have fostered human-as-explorers *versus* robotic alternatives. Both sides have made credible arguments regarding the likelihood of mission success, science return, adaptability and relative costs etc. However, in the context of understanding the Solar System, the relative strengths and weaknesses of each actor, be it human beings or robots, should be evaluated in the framework of well defined circumstances. An appraisal needs therefore to be conducted taking into account both the destinations and tasks to be performed.

1.1 Destinations

The first element to consider in the appraisal of human beings versus robots is linked to the destinations in the Solar System to identify what type of missions can be performed by one or the other.

For the outer Solar System beyond the orbit of Mars or the asteroid belt, there is not yet adequate technologies to let human go there and thus those destinations are today out of reach for human exploration (Figure 1).

Figure 1 Planets and dwarf planets of the Solar System. Sizes are to scale, but relative distances from the Sun are not



Source Wikipedia

In the Inner Solar System, Venus is within reach in terms of travel time as well as Mercury (Table 1). However, both Venus and Mercury's conditions are so hostile that the survival of humans on their surface would not be possible[4]. This consequently leaves human exploration to the Moon (4 days) and Mars (6 months with current chemical fuel technology), possibly Near Earth Objects (NEOs)[5] and the near-Earth space area (Table 1).

When looking at robotic exploration, automated missions can be dispatched to all destinations in our Solar System despite the very long travel time of sometime more than a decade to reach the targeted destinations (Table 1).

Table 1. Potential human and robotic destinations in our Galaxy in order of their distances from the Sun.

Destination			Human access	Robotic access
Planets	**Dwarf Planets**	**Other**		
Mercury			Y	Y
Venus			Y	Y
Earth			Y	Y
		Moon	Y	Y
		Near-Earth space/Lagrangian points	Y	Y
Mars			Y	Y
	Ceres		Y	Y
		NEOs/Asteroid Belt	Y	Y
Jupiter			N	Y
Saturn			N	Y
Uranus			N	Y
Neptune			N	Y
	Pluto		N	Y
	Haumea		N	Y
	Makemake		N	Y
	Eris		N	Y

1.2 Tasks

The question of whether the benefits of human space exploration would outweigh the risks and costs is subjective and highly complex. The appraisal of human beings *versus* robots for our Solar System exploration needs therefore to be multidimensional to provide a better overview of advantages and weaknesses of those two types of space explorers (Table 2).

Table 2. Assessment of benefits of human or robotic exploration

Function	Humans	Robots
Exploration	X	
Science		X
Operations	X	
Communications	X	
Cost		X
Risk		X
Publicity/outreach	X	

1.2.1 Exploration

Robots can be sent where human beings can not go because they are expendable, run on less physical support and supplies, but also because the return of robots is often not required. Robots are however limited in function and need human guidance. Human beings could explore much faster, could react and follow-up on discoveries.

[4] Baumjohan, W., (2008)
[5] NEOs are defined as any asteroid or comet that can come close to the Earth's orbit with near in this case being defined as less than 1.3 Astronomical Units (AU).

Human beings are therefore far better explorers than robots now, and seem likely to remain so on the time scale of possible human space missions to the Moon, and even perhaps to Mars.

1.2.2 Science

Robots are extremely effective when accomplishing specific and pre-programmed tasks including science. *In situ* measurements done by robots have enlarged our knowledge exponentially about Earth's space neighbourhood and our Solar system. They are great at doing pre-programmed tasks or direct manipulation of their controls. Humans can however, make important decisions and use ingenuity to perform functions "on the fly" and respond better to the information in real time. Robots can thus not increase scientific knowledge as much as human beings can despite the progress in artificial intelligence (Cf. operations section). Human presence will allow accommodating unexpected discoveries and perform science activities.

1.2.3 Operations

Human beings performing Extra Vehicular Activity (EVA) and remote-controlled robotic missions operate on different operation timescales. Human beings' endurance and finite life support capacity limits the periodic EVAs to a few hours each, while robots may continue on with periodic command downlink for weeks or months. While the journey will be less complicated for robots despite the duration of the voyage, humans can solve problems and respond quickly to the unexpected. Thus, at the difference of robots that can only react to situations predicted at the time of their design and programming, humans have the ability to quickly recognise and take steps to avoid dangerous situations. Human beings' advantage is therefore their flexibility on tasks they can perform and their ability to reason to solve the problems that might arise. Human beings' involvement in planetary exploration brings a level of capability that are particularly suited for activities that require the techniques of intensive field study and tasks requiring complex physical articulation combined with expert knowledge and the ability to adapt to new situations. Human beings think and act laterally in ways that robots can not by being able to associate and merge different information to generate useful knowledge in real time and in an unplanned way, often based on intuition.

1.2.4 Communications

Because of the distance involved with space exploration and the inherent communications delays, particularly in the case of Mars mission (up to 44 minutes) robots must wait for further instructions before performing additional tasks while human beings are autonomous and do not need to wait for instructions. In robotic exploration, the wait or "latency" between command and response can therefore be problematic. Moreover, human beings are capable of independent, real-time reprioritization and re-planning in the field and can answer questions that can not be defined *a priori*, or which arise during the exploration.

1.2.5 Cost

Robotic missions are relatively economical as supplies and return trips are not required. Human beings, on the other hand, are fragile needing thus to be protected, and require a lot of supplies, food, fuel and more complex infrastructure leading to a higher cost for a human mission. It is therefore far cheaper to send a robot in outer space since human beings need much larger spacecraft with plenty of resources to sustain human life. Human beings' safety in space is incredibly expensive.

Already in Low Earth Orbit (LEO) having human beings doing experiments is considerably more expensive that letting robots perform them on an automated re-entry module like the Russian Foton-M[6]. The different in price becomes much larger if one compares robotic return mission to the Moon or Mars compared to s similar mission done by human beings.[7]

1.2.6 Risk

Robots can exist in hostile environment, weathering radiation and dust storms better than human beings. Moreover, in the case of the loss of a robotic probe it can be rebuilt, but human lives would be loss forever and human safety can not be guaranteed throughout the whole process of exploration. Robots are thus safer that people, and failed missions for Mars for instance (e.g. Beagle 2 and Mars Polar Lander) have not caused a single person to perish. Furthermore, machines can withstand harsh environment better than humans. Extended periods of operation in low gravity and exposure to cosmic and solar radiations also present unique physiological challenges for human beings that need to be taken into account in the context of future long-term space exploration. Long periods away from Earth raise thus important psychological issues for the crew. The potential for disaster is also greater given the priority of astronaut safety. Paradoxically it is in part the same risk elements that underpins the challenge and excitement associated with space travel, factors that contribute significantly to the high public interests in space exploration.

1.2.7 Publicity/outreach

Human space missions have always attracted interest due to the fascinating possibilities to explore new worlds, but also for the new stimulating challenges they present.[8] There is a glamour and excitement of human voyages as opposed to automated, robotic missions for the public. The spirit of adventure drives interests in the space programme and broad public enthusiasm could be sustained by human exploration to help maintain consistent, long-term funding. Robots excel at doing well defined task reliably in environment inimical to human life, but robotics in practice is far from the public perception.

The experiences of astronauts and cosmonauts over the past four decades have proven the merits and necessity of humans as space explorers. Complex tasks, scientific experimentation, repair and troubleshooting of equipment and hardware, for example, all require human capabilities and judgment. There are myriad of examples of human beings required for the success of space mission. The initially flowed Hubble Space Telescope is a particular salient example where astronauts repaired the faulty scope. Without human intervention the project would have been lost. Apollo lunar missions provide another example. Astronauts were imperative on the lunar surface for remedying unforeseen problems, such as repairing the rover vehicle. Human beings offer advantages in the exploration of space. However, they have their limitations and in the harsh space and planetary environment safety considerations will always limit the type of missions that can be performed by human beings.

[6] Baumjohan, W., (2008)
[7] Ibid.,
[8] The European Science Foundation (ESF) together with ESA and the European Space Policy Institute (ESPI) have undertaken a comprehensive trans-disciplinary investigation into the various aspects of "Humans in Outer Space" ranging from anthropology to sociology and the arts. The results are contained in Codignola, L. et al., (2008)

1.3 Conclusion

The question of how best to explore space with human beings or robots has never been settled. In the first 50 years of spaceflight there was a dichotomy between humans and robots, but if there is an increasing ambition to do more in space, the less of a dichotomy there is, and the more the two sides tend to merge. At present time, human beings are more efficient as explorers than robots. But the gap has closed considerably as robots are becoming increasingly sophisticated partners able to support human beings in specific scientific and operational tasks requiring for instance automated and repetitive processes.

Consequently, although the disagreement between the supports of the two approaches has been going on for long, it is outdated. The right approach for the purpose of future space exploration needs will thus be a mix of both robots and humans. As illustrated by the Royal Astronomical Society, "while the exploration of the Moon and Mars can and is being addressed by unmanned missions we have concluded that the capabilities or robotic spacecraft will fall well short of those of human explorers for the foreseeable future".[9] Robots even with the expected advances in robotics over the next 20 years will still lag human capabilities in real-time perception, planning, adaptation to unexpected or adverse circumstances.

The involvement of human beings in space exploration activities will also foster broad public support that is necessary for the sustainability of any long-term space exploration programme. Moreover, the use of autonomous robots alone will very significantly limit what can be learned about the Moon and Mars. It is thus considered that robots should be sent first as complement for future human missions and automated systems should help humans in in-space and on-surface operations or explore alone destinations where no human beings can go.

[9] Royal Astronomical Society (2005)

2. HOW CAN THE INCREASING KNOWLEDGE OF SPACE (FOR INSTANCE MARS OR THE MOON) HELP THE EU CITIZENS UNDERSTAND AND MITIGATE PROBLEMS (SUCH AS ENVIRONMENT, SECURITY, KNOWLEDGE TRANSFER...) WE FACE ON EARTH.

The study of other planets and bodies in our Solar System, and Mars and the Moon in particular, both remotely and by direct *in situ* exploration will provide critical information and help to better understand and mitigate key issues and Earthly problems.

2.1 The advancement of scientific knowledge

The Earth was formed during the genesis of the Solar System about 4.6 billion years ago. At present very little data are available regarding the atmospheric, oceanic or geological conditions on the pre-biological Earth. However, it is assumed that conditions on the young Earth were very hostile due to volcanism, radiation, and bombardment by comets and asteroids. Nevertheless primitive life, in the form of bacteria, emerged approximately 3.5 billion years ago[10]. Advances in chemistry and the findings of the last fifty years of research have opened numerous experimentally testable avenues on how life emerged and evolved and space exploration can help to answer those fundamental questions.[11]

Space exploration will, in particular, help addressing questions related to the origin of life, its evolution and existence beyond Earth. For instance, the presence of life is recognised to have the ability to modify the environment in which it evolves and life on other bodies in our Solar System, should it exist, may have a similar impact. The study of the co-evolution of life and planetary environment would therefore provide great benefits back on Earth. Investigating life's development might be useful to understand Earthly developments as certain physical and chemical conditions on other bodies in the Solar System could be considered analogous to our planet's environment in its early stages of development. Studies of life processes in other planets could thus provide answers to how life was formed and evolved on Earth and give insights into potential life that exists beyond our planet.

The investigation of the "are we alone" and "is there life elsewhere" questions will be a direct benefit from future space exploration. In our Solar System Mars represents the prime target for the search of life. Other objects such as Jupiter's Moon Europa and Saturn's Moon Titan are also investigated for life conditions. Mars is however thought to be one of the most favourable places for alien life to have evolved since conditions may once have been warmer and wetter than they are today[12]. It, consequently, presents the best chance to find extraterrestrial life extinct or existent. Several space missions are also directed to search for habitable planets and the signatures of life elsewhere in the universe like the COROT (Convection Rotation and planetary Transits) mission that allows searching for rocky planets outside our Solar System (also known as "exoplanets"). This mission is an important stepping stone in the European effort to find habitable, Earth-like planets around other stars.

Studying other planets and bodies will also help to provide a better understanding of fundamental geophysical process[13]. The geological record relating to the first one billion years of the Earth's history has largely been erased due to various erosion processes. However, Mars kept the record of the early evolution of a terrestrial planet.

[10] Chung, Y., et al (2009)
[11] Ibid.,
[12] Ibid.,
[13] Ibid.,

There are also other bodies such as the Moon that could potentially still have a record of this critical time period. For instance, the underlying regolith[14]of the Moon's surface has been identified as a natural archive in which the records of Near Earth Objects (NEOs) and solar activity are present, preserving a record of the main events that have taken place in the Solar System during the last 4.5 billion years. Historical records of meteor impacts, solar activity and other external influences can thus still be found on the lunar surface or buried in the lunar regolith and they will provide new information of the early geological developments of the Earth.

The Moon could also be used to perform astronomical observations that are either impossible or severely degraded from locations on Earth or in orbit due in particular to the Moon's extremely sparse atmosphere. Astronomical observations at radio-wavelengths would offer major insights into the origins of our Universe. Other areas of astronomical research that would benefit from a lunar location include observation of cosmic rays etc. Astronomical observatories on the Moon would thus allow the advancement of scientific knowledge by allowing the detection of the "Dark Ages", the time before the fist starts and galaxies began to form[15].

2.2 The sustainable development of the Earth

The global environmental situation on our planet is alarming and represents a major topic on the agenda of international politics. Humanity faces a number of important environmental problems including global warming, climate extremes, over-exploitation of natural resources and pollution. In this overall context, space exploration can play a major role understanding and mitigating those problems.

Synergies between space exploration and the preservation of Earthly ecosystems do exist[16]. Protecting life on Earth requires similar concepts and information as investigations of life beyond the Earth, including the expansion of human presence in space. Instrumentation and data handling to observe both planetary objects and the Earth are based on similar techniques. Moreover, while planetary surface operations are conducted under different conditions, the technology to probe the surface and subsurface of both the Earth and other planets requires similar tools, such as radar, seismometers, and drilling devices etc.

A synergy of Earth and space science can also help to provide concepts (based on recent scientific data) on how ecosystems respond to rapid rates of change and determine possible directions by which the Earth and its biosphere (including human beings) will co-evolve in the future[17]. This approach might allow humanity to halt the destruction of its own habitat and the decline of biodiversity on Earth, while addressing a variety of related economic and energy-related scenarios. Likewise, the education and awareness of society can benefit tremendously from knowledge of the overall habitability of our Solar System, including steps taken to prevent biological cross-contamination (planetary protection) that would underlying the uniqueness and fragility of our Planet[18].

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[14] In soil science "regolith" is a layer of loose, heterogeneous material covering solid rock. Nearly the entire lunar surface is covered with regolith that has been formed by the impact of large and small meteoroids and the steady bombardment of micrometeoroids and the impact of space weather breaking down surface rocks. The regolith is generally about 4-5 meters thick in *mare* areas and 10-15 meters in older *highland* regions.

[15] ESA (2007)

[16] Chung Y., et al (2009)

[17] Ibid.,

[18] Ibid.,

Bridges between the Earth-centric and space-centric communities should thus be built to help better understand and mitigate key issues and Earthly problems.

Some technologies required for future human exploration may also contribute to the implementation of sustainable development policies (e.g. management of resources, waste and energy etc.). Space exploration can help to address problems on Earth including the improvement of the living conditions. Innovations required for space exploration, especially in the areas of waste management, advanced energy systems and sustainable life support systems (e.g. water and air recycling and processing, telemedicine and food production etc.) have potential applications in the field of sustainable development, health and environment protection back on Earth. These address the basic needs of European citizens and can also offer potential solutions for developing countries.

Engaging in space exploration would also increase our knowledge and understanding on how terrestrial life and particularly human beings can adapt and survive beyond our planet. It will also allow considering how to establish a new habitable environment on the Moon or Mars to prepare for an eventual scenario of humans leaving the planet.

2.3 Ensure European and global societal security

Apart from the missions to improve our knowledge of the Solar System and the sustainable protection of our habitat, ensuring European and global societal security is another element that can benefit from space exploration, particularly by better understanding extra-terrestrial threats like the impact of space weather on human activities and the risks of collision with NEOs.

Space weather is a phenomenon caused by radiation and atomic particles emitted by the Sun and stars, which impacts our everyday lives. The definition most frequently quoted is the one coming from the U.S. National Space Weather Programme where space weather is defined as: "conditions on the Sun and in the solar, wind, magnetosphere; ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health"[19]. This definition illustrates that space weather is a collection of complex physical phenomena and affects the general society. At first glance, the Sun's effects on technology do not seems too obvious, but our increasingly technology-dependent society is sensitive to solar activity and to changes in this activity since space weather affects a broad range of technologies[20]. It is important to underline that given the nature of space weather and its wide ranging effects the cosmic causes behind many technical system malfunctions have long been ignored and "invisible", as a result, cosmic causes behind many technical system malfunctions were not recognised[21]. A better understanding of space weather events is therefore necessary and space exploration can provide new data and information on this phenomenon. The consequences of space weather can be divided into two main categories depending on their localization of occurrence: space based and on-Earth consequences.

- Satellites are usually in orbit for several years depending of their purpose (science missions, telecommunications etc.) and are exposed to the short and long-term effects of space weather. Numerous findings establish a clear link between space weather and its effects on electronic components onboard satellites. Streams of energized particles can upset or damage a satellite's sensitive electronic components or solar arrays.

[19] Mathurin, J., and Peter, N., (2006)
[20] Ibid.,
[21] Ibid.,

Space weather effects can range from clockwork inaccuracies on Global Positioning Systems (GPS), individual instruments to complete satellite failures (e.g. Anik E-1). Along with a loss of orbital altitude pointing perturbations might also be experienced. An inoperative satellite not only entails losses arising from material damage and business interruption, but also to the satellite operator's customers and damage to its corporate image, which may have enormous economic consequences[22].

- For a long time the telegraph and later the telephone communications were the most susceptible on-Earth technological systems to space weather problems. However, the effects of space weather are diverse and they include electronic and power transmission failures etc. Critical ground infrastructures such as the global networked banking systems or telecommunications networks can also become dysfunctional due to a solar event. However, space weather not only affects the functional integrity of technical systems in space and on Earth, but may also endanger human life and health[23].

A Near-Earth Object (NEO) is any asteroid or comet that can come at less than 1.3 Astronomical Units (AU) close to the Earth's orbit[24]. There are two types of NEOs, comets and asteroids. The Earth has a long and violent history of collisions with extraterrestrial bodies such as asteroids and comet nuclei (e.g. Tunguska event). Thus, there is clear evidence that asteroids and comets impacts have occurred on the Earth and will continue to happen in the future. NEOs have been thus colliding with the Earth since its formation, but the threat has only recently been recognized and accepted by the international community, both in scientific institutions and by the governments[25]. Additionally, it is believed that only a small percentage of NEOs have been detected up to now. While the threat is not yet well understood, it is however acknowledged that the impact of NEOs on the Earth could lead to catastrophes in a direct or indirect way representing a significant risk to human and other forms of life[26]. These effects depend mainly on:

- The characteristics of the asteroid or comet (size, speed, mass, material composition and strength, trajectory)
- The characteristics of the impact site (land, ice or ocean, latitude, types of rocks)

Impacts have a huge range in severity and frequency, and the means to predict and mitigate them vary accordingly. It is generally considered by the scientific community that small NEOs below 30 meters usually burn up in the atmosphere although some meteorites may reach the ground, while objects below 100 meters may explode in the atmosphere producing ground change due to shock waves. There are many environmental effects that can arise from the impact of a large asteroid or comet (diameter 1 kilometer or more) with the Earth.

Various scientific studies have been conducted in order to determine potential consequences of NEOs impact on Earth. For categorizing the Earth impact hazard associated with newly discovered NEOs a decision tree has been developed to break down the problem into manageable sub-categories where each branch of the tree corresponds to a particular class of NEO threat scenarios for which response options would be similar.[27]

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[22] Ibid.,
[23] Ibid.,
[24] One AU is the distance between Earth and Sun (about 149,597,870 kilometers).
[25] Peter, N., et al (2004)
[26] Ibid.,
[27] ISU (2002)

Another important tool for categorizing the Earth impact hazard associated with newly discovered NEOs is the Torino Scale which is equivalent to the “Richter Scale” but for NEOs.

One major step in assessing any NEO hazard is to identify the threatening object and to characterize it early enough, before the possible impact, in order to design and operate mitigation missions to protect the Earth. Space exploration, including space-based NEO observation systems, could significantly help ground-based search activities which may have many constraints such as daylight, clouds and light pollution from cities or phases of the Moon. Discovery of a NEO, while crucial, is however the very beginning of a long process for an accurate characterization of orbital parameters[28]. *In situ* exploration is also very important to gain more information about its mass distribution, shape, internal structure, surface gravitation, centre of gravity, chemical composition, and other parameters. In some cases manned characterization missions should also be considered since human presence at/on the NEO offers higher adaptability, and hence higher mission effectiveness. Engaging in space exploration missions will thus allow better detecting and preparing for charting options for threatening NEOs to protect EU citizens.

2.4 The political dimension of space exploration

Space exploration has now become an element of the political agenda of a growing number of countries around the world, and consequently, the space exploration environment is dramatically evolving[29]. Firstly, space exploration is an emblematic domain of space activities where traditionally only established space powers have been active. However, new actors are demonstrating great interest in it, principally for international prestige reasons and a will to demonstrate greater regional or even global (S&T) leadership leading to an internationalisation of space exploration activities[30]. Secondly, space exploration has evolved from a “space race” between the two major space powers, the United States and the Soviet Union (now Russia) during the Cold War, towards a more diverse set of actors. This new era of space exploration in the post-Cold War era is based on a more cooperative approach symbolized by the ISS, still under assembly in space[31].

Many recent reports and studies argue for greater international cooperation in space exploration to achieve capabilities that lead to a sustainable, beneficial and affordable programme[32]. However, it is worth indicating that enriching the scientific and technological expertise through worldwide cooperation will lead to benefits reaching far beyond space exploration activities alone. International cooperation in large space exploration endeavours will also demonstrate a willingness to engage in peaceful and fruitful relations as “Earthly politics” will be reflected in space and will have therefore reverberating effects[33]. A truly international space exploration endeavour will allow an increased cultural understanding and interdependency reducing the risks of tensions and conflicts among the partners involved. In this context, it is worth mentioning that besides national programmes, in the five years since the announcement of the U.S. Space Exploration Policy in January 2004 that spurred the renewed interests for space exploration, many countries have expressed an interest in cooperative exploration programmes. Formal discussions of the goals, capabilities, and timelines for future space exploration have taken place among major space agencies.

[28] Ibid.,
[29] Peter, N., (2008a)
[30] Peter, N., and Stoffl, K., (2009)
[31] Ehrenfreund, P., et al (2008)
[32] Correll, R., and Peter N., (2005)
[33] Peter, N., (2008a)

This illustrates the paradigm shift in space exploration and indicates that international cooperation is now becoming central to any long-term space exploration strategy. In particular, the result of the work between representatives of fourteen space agencies should be mentioned. On 31 May 2007 a 25-page report "Global Exploration Strategy - The Framework for Cooperation" was released as the first product of an international coordination process among these agencies[34].

The increased knowledge of space can thus help to better understand and mitigate problems faced on Earth by space threats (space weather and NEOs), but also improve the overall security of EU citizens by providing various opportunities to respond to global security challenges by fostering international cooperation to increase global interdependencies. Cooperation in space exploration, and particularly human spaceflight, is often perceived as a symbol of the relations between countries in general and demonstrate "good will" as illustrated in the U.S. decision to include Russia in the ISS programme in the early 1990s.

Finally, global cooperation in space exploration could demonstrate a commitment to multilateralism and a willingness of taking on global responsibilities such as space security and thus reinforce EU's emergent space diplomacy. Illustrating the fact that space security in Europe has become an issue of growing interest, a series of high-level conferences and reports have been taking place or released in recent months. Moreover, EU's Member States pursued also an initiative on the elaboration of a Space Code of Conduct on Outer Space Activities (hereinafter referred to as Space CoC) to strengthen existing agreements and codify new best practices for a safe and secure use of space. The aim of this initiative is to lower the risks of misinterpretation of incidents occurring in space, to avoid collisions and deliberate explosions and to provide reassurance through improved information exchanges, transparency and notification measures[35]. The project of the CoC aims firstly to strengthen the existing United Nations treaties, principles and other arrangements, as the subscribing parties would commit to comply with them, to make progress towards adherence to them, to implement them, and to promote their universality. Secondly, the CoC aims to complement the aforementioned UN texts by codifying new best practices in space operations including measure of notification and of consultation that would strengthen the confidence and transparency between space actors and contribute to developing solutions that would permit the performance of space activities and access to space for all.

The discussions on a Space CoC were initiated by Italy and further developed during the German Presidency of the Council of the European Union (first half of 2007) in order to build consensus about an instrument below treaty-level.[36] The idea was generated as an item of arms control. However, the concrete issues identified in the E-Task Force under the Portuguese Presidency had a number of overlaps with the civil use of outer space. The Portuguese Presidency drafted a first version of an EU CoC in the second term of 2007. An updated version entitled "Best Practices guidelines for / Code of Conduct on Outer Space Activities" was circulated in the first quarter of 2008, with elements to be commented upon by March 2008[37]. The document was eventually agreed upon in the EU working group on UN Disarmament (CODUN) at the end of the Slovenian Presidency in June 2008[38].

[34] The fourteen agency signatories are the national space agencies of Australia, China, Canada, France, Germany, India, Italy, Japan, Russia, South Korea, Ukraine, the United Kingdom and the United States and the 18-country ESA.
[35] Peter, N., (2008b)
[36] Ibid.,
[37] Rathgeber W., and Remuss N.-L., (2009)
[38] Ibid.,

Additionally, the Netherlands proposed a document, indicating the next steps regarding discussions with key partners and identifying modalities for promoting the document in the relevant international forums[39]. The EU's CoC proposal became a French Presidency priority and the draft text of the CoC was supported by the Council of the European Union on 8-9 December 2008.

The EU's CoC consists of a Preamble and 12 Articles subdivided into four sections: I. Core Principles and Objectives, II. General Measures, III. Co-operation Mechanisms and IV. Organisational Aspects[40]. The EU's CoC is based on the principles of: (1) freedom of access to space for all for peaceful purposes; (2) preservation of the security and integrity of space objects in orbit; (3) due consideration to the legitimate defence interest of States.[41] Additionally, it provides for the following general principles (Art. 2): "the freedom of access to, exploration and use of outer space and exploitation of space objects for peaceful purposes without interference, fully respecting the security, safety and integrity of space objects in orbit"[42]. The main objectives of the CoC is thus to strengthen the safety, security and predictability of all space activities, *inter alia* by limiting or minimising harmful interference in space activities. It covers all activities including civil, military as well as future ones.

From the very beginning, the European Union intended to elaborate an instrument open for adherence to all space-faring countries in order to reach a consensus to ensure the long-term sustainability of space activities. Briefings on the CoC were conducted, with the United States, Russia, China as well as others. As the CoC is voluntary and open to all States it aims to lay down the basic rules to be observed by States. It is envisaged that at the end of the consultation process an *ad hoc* conference would be organised in order for States to subscribe the Code. While the CoC is not intended for negotiation at any international forums, the Czech EU Presidency continues to inform multilateral bodies such as the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), the Conference on Disarmament (CD), ESA and others on progress with this initiative.

2.5 Innovation and economic developments

Many EU citizens are unaware of the benefits of space activities in general, and space exploration in particular, and do not see a personal benefit. However, thousands of "spin-offs"[43] that improve life and security on Earth and stimulate the economy are discussed in the literature. Spin-offs have invaded many areas of consumers including the computer technology, manufacturing, health and medicine, public safety, transportation and many others all providing benefits to EU citizen's everyday life. Among the highlights that EU Citizens can thus relate to are: air-quality monitors, water-purifying systems, breast-cancer detection, microlasers, radiation insulation, energy-storing systems etc.

Spinoffs from earlier manned spaceflight programmes have been quite impressive in the medical field, including:

- Automatic blood-pressure measuring devices;
- Scratch-resistant lenses for eyeglasses;

[39] Ibid.,
[40] The full text of the CoC for outer space activities is available at the address: http://register.consilium.europa.eu/pdf/en/08/st17/st17175.en08.pdf
[41] Space CoC (2008)
[42] Ibid.,
[43] A spinoff is a commercialised product incorporating space technology or "know how" which will benefits the public.

- Nitinol, an alloy with a strong ability to spring back into shape from the tightest contortion which improved in particular dental braces;
- LEDs, Light-Emitting Diodes;
- Artificial limbs;
- Infrared Ear Thermometers;
- 03-Ozonizer, a sterilisation device based on technology used on the ISS has applications in dentistry and medicine;
- Heart pacemakers work through electronic monitoring similar to that used to operate satellites.

However, if human beings were to be involved in future space exploration missions the outstanding opportunity to increase knowledge of life sciences through investigations that would be made possible has to be underlined. Fundamental physiology and medicine could be improved, and this deeper understanding applicable to life sciences back on Earth where space-related advances and medical spinoffs would be of considerable benefit to the general population. Applied microgravity research presents also a series of benefits to answer some of the key societal issues such as preventive medicine, pharmaceuticals, botany, artificial ecosystems, etc. Research into mental and neurological diseases will also progress and will, consequently, greatly assist the quality of life of aging populations with consequent effects on the general economy of the European Union.

Other applications already under development on Earth might also be enhanced by their use in space as for instance telemedicine and remote surgery etc. providing also future benefits for EU citizens.

2.6 Conclusion

While space exploration presents many challenges to robotic and human explorers they will provide nonetheless many benefits back on Earth by generating increasing knowledge that can directly and indirectly help EU citizens understand and mitigate Earthly problems they may face in present times, as well as in the future.

Planet Earth is currently the only known habitable world in our Solar System and beyond. Although life may have existed as early as 3.5 billion years ago, human beings reside only since a short time span on Earth (about 2 million years), and only in the last 200 years human beings have changed their habitat dramatically up to a point were it raise the issue of how long Earth can balance resources, pollution and a growing population rate[44]. However, the knowledge gained through space exploration can help to better understand and mitigate those key issues and Earthly problems and provide consequently direct benefits to EU citizens.

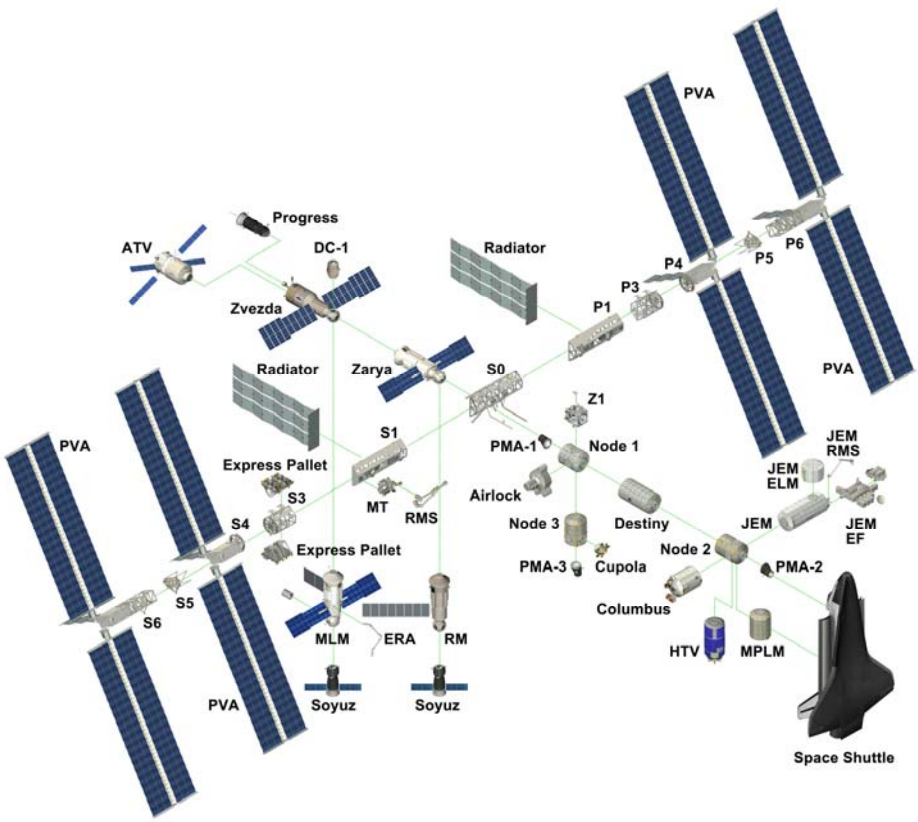
[44] Chung, Y., et al (2009)

3. THE SOCIO-ECONOMIC ASPECTS OF THE SPACE SECTOR

3.1 Has the successful unfolding of the Automated Transfer Vehicle 'Jules Verne' demonstrated the added value entailed in its mission and the value of the EU industry and skilled work force?

With the successful launch in April 2008 of the first ATV on-top an Ariane 5 Europe is now providing an indispensable element of the supply-chain of the ISS. Completing the orbital laboratory Columbus launched on 7 February 2008 onboard the Space Shuttle Atlantis (Figure 2), the ATV is a multifunctional spacecraft that combines the fully automatic capabilities of an unmanned vehicle with human spacecraft safety requirements.

Figure 2 Current ISS infrastructure



Source ESA

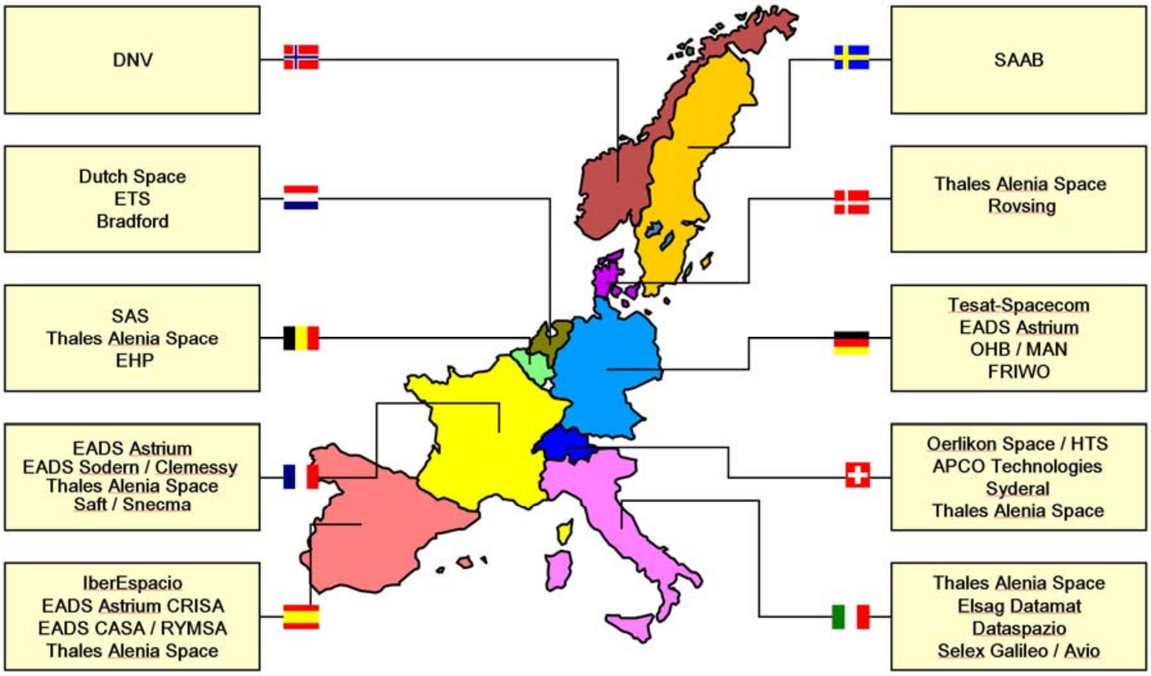
The ATV is the most complex vehicle ever developed in Europe and represents the European share of ISS operations and plays a vital role in Station servicing, but is also a way for Europe to pay its share in ISS running costs by spending money within the European industry rather than by cash transfers to its international partners.

The ATV project is an optional programme of ESA with 10 countries involved in this project (Belgium, Denmark, France, Germany, Italy, The Netherlands, Norway, Spain, Sweden and Switzerland) out of all 18 ESA Member States (Figure 4). It involves dozens of companies and numerous of technicians and engineers under the prime contractorship of EADS Astrium[45].

[45] ESA website http://www.esa.int/SPECIALS/ATV/index.html

In addition to EADS and its affiliates, the other European companies involved in the ATV programme include Thales Alenia Space, Oerlikon Space, Dutch Space (now part of EADS Astrium), Snecma (part of the SAFRAN group) Man and others. It also implicates the cooperation of 8 companies from Russia, whose main contractor is RSC Energia (Figure 3).

Figure 3 Geographical distribution of ATV industrial team in Europe



Source ESA

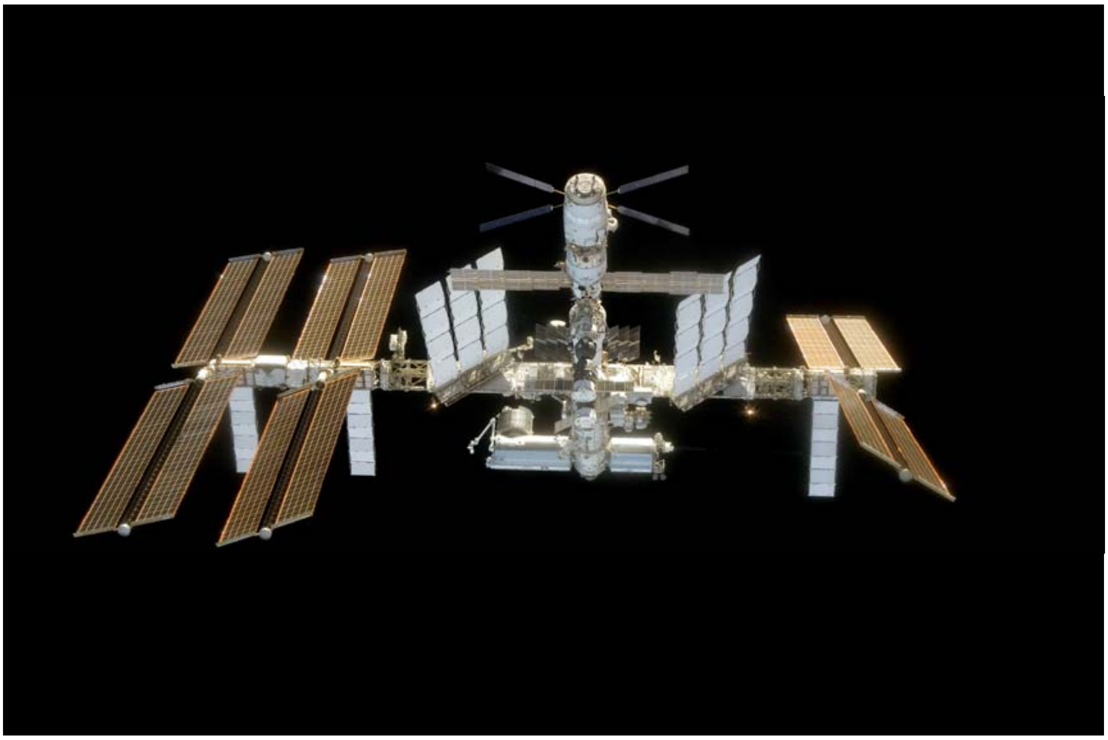
With the development of the ATV programme new high-value, high-wage manufacturing and engineering jobs have been created thought Europe (Figure 3) and it helped the development of domestic manufacturing capabilities complementing the critical space transportation infrastructure that ATV provides. The complex tasks of developing the ATV capabilities have also indirect impacts on industrial competitiveness by demonstrating Europe's prowess in a cutting edge high-technology sector. Europe is consequently now able to reap the benefits of the investment made in human spaceflight.

The ISS depends on regular deliveries of experiment equipment and spare parts as well as food, air and water for its permanent crew for use by the whole station and the ISS partners. The ATV allows providing all of that. Furthermore, once docking is achieved, ATV is an intrinsic part of the ISS for up to 6 months, becoming an extension of the Station providing extra living space to ISS crew members. The ATV remains docked to the Russian Service Module (Figure 2 and 4) as a pressurised and integral part of the ISS complex until a controlled re-entry into the Earth's atmosphere where it burns high-above the Pacific Ocean, disposing, in the process, of waste material no longer needed on the Space Station. The ATV carries 7.7 tonnes of cargo to the Station and 6.4 tonnes in a destructive re-entry. It holds several tanks containing up to 840 kilogrammes of drinking water, 860 kilogrammes of re-fuelling propellant for the Station's own propulsion system (306 kilogrammes of fuel and 554 kilogrammes of oxidizer), 4700 kilogrammes of propellant re-boost and 100 kilogrammes of gas (oxygen, nitrogen and air) and 5500 kilogrammes of dry cargo mass[46]. The ATV is therefore an essential mission and serves as cargo carrier, storage facility and as "tug" vehicle to raise the Space Station's orbit every so often.

[46] Ibid.,

As a logistic re-supply vehicle the ATV is important since 2008, but it will be fundamental from 2011 once the Space Shuttle retires as the ISS partners will lose a major capability to return equipment to Earth for replacement or upgrade.

Figure 4 ATV docked to the ISS



Source ESA

Jules Verne was the first of the five ATVs planned to be launched through the next ten years. ESA's second ATV has been named Johannes Kepler in February 2009 and is scheduled for launch to the International Space Station in mid-2010. The ATV Johannes Kepler is currently under production at EADS Astrium in Bremen (Germany).

3.2 Conclusion

The very successful Jules Verne ATV mission has highlighted many new technologies and capabilities that can be adapted for future spacecraft development. The next logical step will be the development of the capability to return payloads and goods from the ISS and any future orbital infrastructure. Once the capability of bringing back cargo from space has been demonstrated it can be transformed with more complex modifications and additional technologies in a crew transportation system. Furthermore, some of the very same technologies developed for the ATV may also enable the on-orbit repair and servicing of satellites. All those future development will continue to improve Europe’s competitiveness acquiring and developing new technologies and nurturing a skilled workforce.

The ATV programme provides therefore considerable direct and indirect benefits for the European society such as strengthening the image and capabilities of the European space industry and the development of a highly qualified workforce.

3.3 Why should a leading power as the EU aspire to invest in space activity coupled with high human capital and specialised research establishments?

Europe currently enjoys a strong position in the global "space hierarchy" due to the versatility of its activities that cover the complete spectrum of space activities, including space exploration, but this might not be everlasting due to the evolving space context[47]. To maintain a leading space role in the future, Europe must demonstrate clear leadership across a wide range of space sectors, including space exploration by having ambitious space plans and objectives of high appeal for its stakeholders, as well as for potential international partners.

While more and more countries are engaging in space activities leading to an internationalisation and globalisation of space activities, space exploration remains the realm of major space powers[48]. It is a political and global endeavour in which Europe, including the European Union, can not be absent or play a minor role as space exploration is the most emblematic domain of space activities and by proxy of technological capabilities, and thus a mean to impress the world. Space exploration is therefore a major element of space power[49], but also of overall national power.

Europe (defined as ESA and its Member States) has a long-standing tradition of space exploration and has participated with outstanding success in many exploratory activities on its own and in partnership with other space-faring countries.

- Europe has been actively participating in human spaceflight since the flight of Vladimir Remek in 1978 (from, at that time, Czechoslovakia) within the framework of the Soviet Intercosmos programme. Many Europeans have since flown with the United States and Russia. Today's European human spaceflight activities are based primarily on its involvement in the ISS programme (orbital laboratory Columbus and the operational cargo system Automatic Transfer Vehicle). Europe is however fully dependent on international partners to send astronauts in space and access the ISS.
- Due to the high expenditures associated with robotic space exploration, most of European involvement in this domain has been related to ESA missions. However, most recently ideas and proposals came up within Europe for exploration missions performed and funded within the framework of national or bilateral programmes. Several European countries are developing future robotic missions to the Moon. For instance, the United Kingdom is developing MoonLITE and Germany Lunar Exploration Orbiter, both being Moon orbiter missions.

However, while Europe has participated in many robotic and human exploration activities on its own or in partnerships, contrary to the plans of the major space-faring countries and particularly the United States, Europe has not yet made space exploration a top priority. Europe can nonetheless play a significant role in future space exploration if there is a "political will" to invest resources commensurate with the challenge and provide high-level political support.

[47] Peter, N., and Stoffl K., (2009)
[48] Peter, N., (2008a)
[49] Space power is the "total strength and ability of a State to conduct and influence activities to, in, through and from space to achieve its goals and objectives (security, economic and political) to affect desired outcomes in the presence of other actors in the world stage and if necessary to change the behaviour of others by exploiting the space systems and associated ground-infrastructure as well as political leverage it has garnered". Peter, N., (2008c).

To pull its weight, Europe (the European Union including all relevant bodies, Member States, ESA and national space agencies) needs therefore to make the most of their combined resources at both the European and national levels. Drawing on their respective strengths, all actors need to work together to maximise the collective impact of Europe, because unsatisfactory coordination between the different actors and policies means that the Europeans will lose potential leverage internationally, both politically and economically[50].

Space exploration is a global undertaking that will receive increased visibility in the decades to come. In an evolving multi-polar space context, Europe including the European Union should not lose its credibility as a reliable partner in space and create the impression that it is only a follower. Future space exploration activities will be a highly symbolic representation of Earthly powers and overall national standings and will undoubtedly be a persuasive method of demonstrating national power to the rest of the world. Therefore, the European Union needs to be actively involved in space exploration, because what is at stake is the future agenda-setting power of Europe in the international system, its abilities to shape the priorities and timing of events, and its abilities to attract the best partners and remain the "partner of choice", and the abilitiy to reap the benefits from future enabling opportunities wherever it supports European space exploration objectives, but also wider European Union policies goals.

Space exploration is a multi-faceted endeavour and a "grand challenge" like Climate Change or internal security and Europe's contributions to space exploration have therefore to be visible, strong, strategic, ambitious and sustained. In this context, the European Union can provide elements that its Member States (and ESA) cannot deliver (or not as well) on their own.

3.3.1 Develop a politically-driven European space exploration strategy

The involvement of the European Union in space exploration activities can help the development of a common vision and long-term strategic plan for space exploration by playing an unifying role and bridging the different stakeholders gap. In particular, it could allow the emergence of an exploration strategy based on ambitious political goals (international relations, Lisbon Agenda etc.) that could reinforce existing plans such as ESA and Member States plans, by providing a clear political ambition for this endeavour as up-to-now Europe's space exploration programmes were based largely on scientific motives with limited political ambitions. A technological and destination roadmap alone, as it has been developed in the past, will not result in the creation of a successful long-term space exploration for Europe. The European Union's involvement can therefore provide greater political sustainability to a European space exploration plan.

- EU's involvement can provide greater political sustainability to a European plan by providing a politically-driven European space exploration strategy and the support of EU institutions.

3.3.2 Space exploration for prosperity and growth

In a time of global economic crisis, investments in Science, Technology and Innovation can help strengthen the future capabilities of countries. Space exploration and particularly the space infrastructures needs (access to space and orbital infrastructure) will provide new opportunities for research and innovation.

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[50] Peter, N., and Stoffl, K., (2009)

Innovative techniques, technologies and products or systems developed will also have many applications back on Earth allowing the maintenance of Europe's long-term proficiency to compete, innovate and succeed in an increasingly challenging global economic environment. New markets and products could be generated with the help of the European Union in traditional sector such as support services to space exploration activities like telecommunication systems or even the mining industry to other unexpected markets, all providing benefits for the European Union knowledge-based economy of the future and the European society at large. It can also help to attract foreign high-skilled students, scientists and investors,

- The European Union can facilitate the emergence of a dynamic private sector in Europe by creating the conditions for a sustainable space industry, encouraging the emergence of entrepreneurial activities, and the involvement of Small and Medium Enterprises (SMEs) etc. as well as attract large, non-space industrial companies from many traditional fields.

3.3.3 Support financially space exploration activities

European overall investment in space exploration is currently limited when taking ESA and Member States' investments altogether. However, investment by the European Union in this field following the French Presidency conclusions (11-12 December 2008) where space technology and services derived from it are identified as element of the European plan for Innovation, could be beneficial to fulfill European ambitions in space exploration by providing additional financial resources helping to maintain Europe's leading position in the global "space hierarchy" by allowing engaging in ambitious programmes..

- The European Union with the development of the European Research Area and the reflection on the future of the Lisbon strategy beyond 2010, the future Financial Perspectives and the Eighth Framework Programme could provide future budgetary resources for space exploration activities.

3.3.4 Inspire the next generation of scientists and engineers

The design, developments and operation of space systems can help strengthen the engineering and scientific capabilities of Europe. Space exploration may provide an overall limited number of jobs, but those jobs are of the highest professional level and can be regarded – and used – as attractive models for raising the engineering work force throughout Europe and inspire the next generation to embrace S&T careers. Visible and ambitious space exploration activities supported by the European Union can help to motivate European students at all levels, especially at the University-level, to embrace S&T disciplines.

- The EU's involvement could help to develop specific curricula at university level as part of the Lifelong Learning Programme 2007-2013 and its follower as well as other programmes, but also raise the profile of space studies in Europe.

3.3.5 Reinforce the European identity

While strong European institutions are likely to foster strong space programmes through enhanced political visibility and budgets, successful and ambitious space exploration programmes can help to reinforce the building of a European identity. As stated on 9 May 1950 by Robert Schuman "Europe will not be made all at once, or according to a single plan. It will be built through concrete achievements that first create a de facto solidarity"[51].

[51] Schuman, R., (1950)

Space exploration can be one of those achievements. Space exploration, with the help of the European Union, could be a brick in the process of the European construction and serve as a building block of a European identity as it can help to promote the awareness of a common European identity around an objective which offers a high profile to Europe and pride to its citizens, but also demonstrate increased confidence in future capabilities. The European Union's involvement could enable the enhancement of the European cultural sphere in the 21st century and promote European values.

- The support of the European Union, including in the domain of human spaceflight that are challenging endeavours offers opportunities to further strengthen European ties and foster European identity.

3.3.6 Foster international ventures and European leadership

Demonstrating increased European assertiveness in space exploration by conducting an ambitious exploration programme will enhance European diplomatic, economic and scientific relationships through the strengthening of existing partnerships and the development of new relations[52]. However, while international cooperation is a major element of any long-term space exploration strategy it should not only be considered through the prism of technical capabilities alone. Political advantages can be provided by the European Union due to the fact that it is a centre of gravity in international affairs and in S&T.

- The European Union has the ability to shape its external policies into multi-dimensional comprehensive cooperation strategies that could prove beneficial to develop a resilient European space exploration strategy and can use its emrging space diplomacy to foster international ventures and reinforce European leadership.

3.4 Overall Conclusion

Europe, with the value added from the European Union, should engage in a substantial space exploration programme commensurate with high ambitions as visible and forward-looking activities would demonstrate its achievements and leadership abilities to the world and will confer some benefits in the form of international prestige and overall power. Up-to-now, European space exploration programmes were largely based on scientific motives with limited political concerns. But to face the future, this needs to change as other space powers are linking space exploration and "high politics" like the United States and China and the involvement of the European Union is thus crucial. An ambitious and visible space exploration programme has to be put forward to allow Europe to remain a major space actor, but also a centre of gravity in international cooperation by attracting the best partners to cooperate with Europe to increase the capabilities and possibilities of European projects (e.g. financial, technical, etc.), but also non-traditional space actors. Global cooperation in space exploration could demonstrate a commitment to multilateralism and a willingness of taking on global responsibilities reinforcing EU's emergent space diplomacy such as with the elaboration of a Space Code of Conduct on Outer Space Activities that strengthen existing agreements and codify new best practices for a safe and secure use of space to ensure the long-term sustainability of space activities. Europe has demonstrated a solid set of space capabilities, and is progressively acquiring other key ones, but difficult and far-reaching choices regarding the shape and scope of the future European exploration programme are needed. Steering European exploration will mean facing some tough strategic choices that go beyond simple levels of funding for Research and Development (R&D).

[52] Peter, N., (2008a)

Europe will need to make choices about which areas of exploration it wants to specialize in as other actors build up their capabilities, but also decide on with whom to partner. Europe cannot avoid the necessity to have a long-term political view of its ambitions and actions in space exploration. Those decisions will set the direction; scope and size of the exploration programme for the next 5 to 20 years, and will affect the competitiveness of Europe in many S&T domains, but also its external policy. The definition of the European role in space exploration is therefore ultimately a political decision made by all current and future stakeholders calling for a necessary involvement of the European Union and its relevant bodies.

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ACRONYMS

ATV	Automated Transfer Vehicle
AU	Astronomical Unit
CD	Conference on Disarmament
CODUN	EU working group on UN Disarmament
COROT	Convection Rotation and Planetary Transits
EADS	European Aeronautic Defence and Space Company
ESA	European Space Agency
EU	European Union
EVA	Extra Vehicular Activity
GPS	Global Positioning System
ISS	International Space Station
LEDs	Light-Emitting Diodes
LEO	Low Earth Orbit
NEOs	Near-Earth Objects
R&D	Research and Development
SMEs	Small and Medium Enterprises
S&T	Science and Technology
UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space