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SPACE EXPLORATION 2025: GLOBAL PERSPECTIVES AND OPTIONS FOR EUROPE

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Space Exploration 2025: Global Perspectives and Options for Europe

EXECUTIVE SUMMARY

In developing its strategy for space exploration, Europe should take into account the aspirations and plans of other major space-faring countries and their impact on decision-taking. This study, "Space Exploration 2025: Global Perspectives and Options for Europe", is a reflection on the future position of Europe in space exploration contributing to strategic policy-making. It puts forth a strong plea for the debate on future space exploration strategies to be set in a broader geopolitical context, as well as in perspective with a more dynamic view of the future. The relationship between space activities and international politics is one of symbiosis, and therefore, any projections about the future of space exploration must take the global political environment into account.

Worldwide and national trends shaping the future

This study identifies and singles out five critical long-term meta-trends (economy, demography, energy, environment and science and technology) shaping the future. The main geopolitical drivers of the next 20 years are also described. The elements presented in this report introduce a reference system to derive a possible vision for the future. Since most of these trends and drivers differ considerably between the various parts of the world, the general analysis is completed by a more detailed examination of potential developments of the current actors in space exploration, as well as of potential newcomers in that domain.

Eleven countries are considered, with nine countries whose space agencies are part of the current Global Exploration Strategy (GES) initiative (Australia, Canada, China, India, Japan, Russia, South Korea, the Ukraine and the United States) as well as two countries with interesting economic potential and some significant space experience (Brazil and South Africa).

The overall geopolitical context is expected to evolve considerably in the years to come following the impacts of the five aforementioned meta-trends, and as a result, the world of 2025 will differ markedly from today. Several countries will witness major economic developments, while others could be plagued by major internal and external factors. Moreover, new alliances and partnerships might develop leading to a more diverse and complex international context. By anticipating and being responsive to a changing geopolitical context and the evolution of potential partners, Europe will be able to cope with those variations and strengthen its position in space exploration.

An evolving space exploration context

After a long hiatus, space exploration has returned in recent years to the top of the political agenda of a growing number of countries. Following the changing geopolitics of space activities, new actors are getting involved in space exploration principally for international prestige reasons. In order for Europe to anticipate the consequences of those changes, an overview of the evolution of the space context and of the trends in space exploration is provided.

An increasing number of space agencies are planning lunar and martian orbiter and lander missions often in the context of preparations for future human exploration. Complementing national endeavours, international cooperation has over the years become a central element of the strategy of most countries involved in space exploration. While Europe is in the process of setting the stage for future missions and plans, a better understanding of the capabilities, preferences and future strategies of selected non-European actors is therefore needed, especially before engaging in long-term international cooperation. The space background and space exploration plans of those eleven countries outside Europe are therefore presented providing relevant insights on existing relations with Europe, as well as the aspirations of those actors.

What is at stake?

Patterns of international relations have always been dynamic and foreign policy alliances have evolved over time. However, while S&T is increasingly shaping foreign policy and diplomacy, it may be expected that space activities, including space exploration, will also influence the future geopolitical context.

- At stake is thus Europe's ability to shape the priorities and timing of events, its capability to attract the best partners and reap the benefits that enable opportunities wherever it supports European space exploration objectives, but also the wider European policies goals.

Europe currently enjoys a leading position in the "space hierarchy", but this might not be everlasting. To maintain a leading role in space and to exercise "space power" to its fullest extent, besides increased "political will", a series of ambitious programmatic elements has to be put forward.

- Europe must demonstrate clear leadership across a wide range of space sectors, including space exploration, by having ambitious space plans and objectives of great appeal to its stakeholders, as well as to potential international partners.

The way forward

Up to now, Europe's space exploration programmes were based largely on scientific motives with limited political ambitions. Europe has a long-term vision (Aurora) and has demonstrated a solid set of capabilities, but in the evolving space context it is indispensable for Europe to take a long-term political decision on future exploration programmes to link space exploration with "high politics".

The evolution of the European space landscape foreseen with the European Space Policy and the Lisbon Treaty (or any alternative document) leading to a greater involvement of the European Union (EU) in space affairs could be of benefit for European space exploration plans. The ambitions of the EU in space affairs, if actually fulfilled, could provide new budgetary resources, but also political advantages to European space exploration plans due to the fact that it is a centre of gravity in international affairs and has the ability to shape its external policies into multi-dimensional comprehensive cooperation strategies.

Europe, drawing on both ESA-led and national programmes, but also on the EU, should thus engage in ambitious long-term commitments to support space exploration that could emerge as a new "flagship" programme following the footsteps of Galileo and GMES involving all European stakeholders.

The future vitality of Europe's space exploration programme is at a critical point as other space powers are developing or consolidating ambitious space exploration plans. Steering European exploration will mean facing some tough strategic decisions. Europe will need to make choices about which areas of exploration it wants to specialise in, but also decide on with whom to partner. Those decisions will set the direction, scope and size of the exploration programme for the next 5 to 20 years. They will also affect the competitiveness of Europe in many S&T domains, but also the attractiveness of its external policy.

Europe should therefore work towards developing a complete portfolio of space exploration activities to gain more equal footing in future cooperation endeavours with other space powers and have autonomy in cooperation. An optimal balance between robotic and human spaceflight activities, as well as between European missions within a global architecture and joint international missions, but also short and long-term goals has to be found. This study investigates therefore the possible options facing Europe in the next decades.

- The "status quo" option would consider a Europe that focuses on robotic exploration to the Moon, Mars and other planetary bodies, including Near Earth Objects (NEOs) and the sustained utilization of the International Space Station (ISS) and human activities in Low Earth Orbits (LEOs) in the post-ISS period.

- The "conservative" option would consider a Europe that focuses on robotic exploration to various destinations in the Solar system, the utilization of the ISS with the development of the capability to return the European cargo back to Earth (evolved-ATV) and human activities in LEOs in the post-ISS period, and involvement in human lunar exploration activities.

- The “pragmatic” option would consider a Europe with a robust robotic programme to various destinations in the Solar system, the continued utilization of the ISS and human activities in LEOs in the post-ISS period, autonomous human access to space and an involvement in human lunar exploration activities.

- The “ambitious” option would consider the above and a leading role in human exploration of Mars.

The proposed options were evaluated using three criteria (effectiveness of the option, projected cost and political feasibility of the option) for the period 2008-2025. Based on this assessment, in the foreseen conditions, the “pragmatic” option would have the highest score and would demonstrate a more assertive Europe with global ambitions, fostering its competitiveness and attractiveness vis-à-vis current and emerging partners.

Europe needs to ready itself for a world of global space exploration networks with constantly diversifying partners. It must therefore decide whether in the future competition or partnerships (or a mixture of both) is the best way to maintain its status and to help fulfilling its ambitions, but there should be a balance between autonomy, independence and cooperation.

Despite the concerns about the durability of the current international order, Europe should renew its commitment to it and help to find a way to accommodate rising space powers and involve newcomers. Major cooperation should continue with Europe’s traditional partners which are the United States, Russia, Canada and Japan. It should continue its constructive engagement with China and India, but also reach out to emerging strategic partners like Australia, Brazil, South Africa, Korea and the Ukraine. The European exploration strategy should, also be embedded in a worldwide context in order to exploit the synergies between programmes of different players and to take advantage of international platforms like the Global Exploration Strategy.

The timing of a decision to engage in any new large scale activities will be a key element to success as it takes many years to plan and prepare space exploration programmes and missions. To guarantee the optimal result, the first steps have to be taken immediately for a decision to be made at the 2011 ESA Council at Ministerial Level and in time to be considered in the next EU Financial Perspective. Furthermore, by looking at the political reality of potential partners, a limited “time-window” will open following the November 2008 U.S. Presidential election. This “window of opportunity” will last until 2011 and should therefore be used to engage and potentially conclude cooperative agreements.

The predictable evolution of the space context in the next 20 years will inevitably challenge Europe’s position in the “space hierarchy”. However, it would be extremely short-sighted to see these developments purely as a competitive threat. Demonstrating increased European assertiveness in space exploration by conducting an ambitious exploration programme and providing high-level political support will enhance European diplomatic, economic and scientific relationships through the strengthening of existing partnerships and the development of new relations. The objectives of Europe’s exploration strategy should therefore to have an ambitious exploration programme involving all European stakeholders to reinforce its space power status, but also to preserve its allies, while winning new partners.

Space Exploration 2025: Global Perspectives and Options for Europe

1. Introduction

1.1. Background

Space exploration[1] is an emblematic domain of space activities where traditionally only established space powers have been active. Following the changing geopolitics of space activities, new actors are increasingly becoming involved in space exploration for mainly international prestige reasons. 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.

1.2. Objectives of the study

While Europe is in the process of developing its rationale for space exploration, its long term exploration programmes cannot be decoupled from emerging worldwide meta-trends and the plans of other major space-faring countries as both will influence European future activities. The development of Europe into a fully-fledged actor in space exploration requires a common assessment of the future challenges, threats and opportunities it will be confronted with and an agreement on the best options for leading and anticipating rather than following and enduring change. This study takes into account the evolution of key structural factors affecting changes in the two decades to come and addresses some of the main political issues concerning the future of potential partners. Its intention is to enable Europe to anticipate the potential impacts of such developments on long-term space exploration plans and proposes some options for future European space exploration activities as well as international cooperation strategies.

The purpose of this study consists therefore in providing a better understanding of the variables influencing the evolution of the space context in which Europe will have to operate until 2025. This study is also intended to pave the way towards a profound reflection on the future position and role of Europe in space exploration and provides a contribution to strategic policy-making at the European level.

1.3. Purpose of the ESPI Report

This ESPI Report put forth a strong plea for the debate on future space exploration strategies to be placed into a broader geopolitical context, as well as into perspective with a more dynamic view of the future. By focusing on global developments across a broader spectrum of different trends and actors, it aims to provide new insights and seeks to pave the way for further reflection, thus providing a contribution to strategic policy-making on space exploration issues at the European level by laying out options and issues to be considered by decision makers.

In the space sector, there are relatively few attempts to undertake global forecasting across multiple issue areas that would provide an integrated image of the future. This ESPI Report does not aim at predicting what the world will look like until 2025 and is not an attempt to "forecast the future". However, it does tries to identify some of the

[1] Using ESA definition from the document entitled "European Objectives and Interests in Space Exploration. ESA 2007", space exploration is defined as to "extend access and a sustainable presence for humans in Earth-Moon-Mars space, including the Lagrangian Points and Near-Earth objects." In the context of this study it encompasses therefore both robotic and human exploration activities.

most relevant and robust trends shaping the global space environment in which Europe will evolve in about 20 years from now.

This study looks at the development of areas that will shape the wider context within which space exploration activities will have to interact. Therefore, it aims to shed a light on the environment in which Europe will operate, to identify emerging challenges and to foster adaptability to change and put into perspective the priorities and challenges of European space exploration strategies and choices. Policy options on how to act and react in relation to these issues are analyzed over time, with an appropriate balance of judgment and risk. The consequences of these decisions tend to endure for some time as programmes and missions, and various space systems can take a decade to be designed and acquired and many be retained in service for two or three decades. The timing of decisions is therefore critical since the decisions taken now affect the capabilities and industrial base that Europe will have at its disposal in 20 years time. A vision of the potential future nature and context of space exploration is therefore essential to support those decisions which will determine Europe's long-term space exploration capabilities and capacities, as well as its cooperation options.

Actions, even decisions not to act, will affect the future in some potentially very significant ways. The future cannot be predicted and Europe will still face the dilemma of needing to act in the face of uncertainty, but it must act as if it knows. This ESPI Report aspires to serve as a compass to help navigate in the direction that would be sensible to move forward in the domain of space exploration. Therefore, this analysis intends to help the European space community cope better with the challenges and uncertainties, but also opportunities that the future may bring.

1.4. Methodology

Any attempt to "forecast the future", that is, to assert with confidence what the world could look like in about 20 years time would be self-deluding. This study is therefore by no means a crystal ball reading exercise. The ESPI Report is based on reviews of numerous documents including specialized reports, in-depth sectoral studies and articles from international organizations, academia, think tanks, the private sector as well as other organizations.

The study uses exploratory methods, starting with the present and moving forward to the future by extrapolating past trends in order to establish a comprehensive baseline and a reference system to derive a possible vision for the future. However, the complexity of possible trends makes forecasting beyond 2025 difficult as the forecast risk obviously increases the longer the time horizon. The approach used in this study is the assessment of the most likely developments based on already existing data and assuming a constant development. Weight is therefore on steady variables. Many of the trends considered have substantial momentum behind them and will continue in the same direction. The pace of these developments shows no signs of abating over the next 20 years, and it appears that their effects will be ever more redoubtable. The assumption of continuity underlying the Report is thus deliberate.[2] However, the approach does not assume a strict linear development of certain factors in defined regions, but rather the mutual influences on the defined socio-economic and political factors are considered.

The decision was taken not to produce alternative scenarios, which are often included in prospective studies to draw attention to different possible futures and may leave the reader with a negative, neutral and positive image of the future. Therefore, while such scenarios might help one to break through conventional thinking and basic assumptions so that a boarder range of possibilities can be considered, they are biased because they lay preferred options over a general baseline. The focus of this study is however on the factors and actors that are likely to shape the future to provide a solid and comprehensive picture of the driving factors that will shape the world in the years ahead as well as of the positioning of the major countries and regions therein. Current space exploration plans of major space actors are also identified in order to provide relevant information to support future decision-making. This exercise is considered useful when thinking about the future in times of great uncertainty and this is true for the space sector in the next few years. ESPI hopes that this study will set a precedent and create an overall picture of the future space context with a particular focus on space exploration that will fill a vacuum and serve as a stimulating challenge to the readers.

[2] The potential for deviations from established forecasts on a series of issues is recognized, but the study nonetheless assumes a continuity of the developments.

1.5. Structure of the ESPI Report

The ESPI Report identifies and singles out the critical long-term meta-trends in five main areas that will shape the next 20 years: the economy, demography, energy, environment and science and technology. The main geopolitical drivers are also presented. Since most of these trends differ considerably across the various parts of the world, the general analysis is supplemented by a more detailed examination of the socio-economic and geopolitical developments of current actors in space exploration (i.e. countries outside Europe involved in the Global Exploration Strategy)[3] as well as potential newcomers to the domain (Chapter 2). On the basis of this work, the set of factors affecting the evolution of the space context are analyzed (Chapter 3). The resulting emerging trends in space exploration are described and an overview of the current and future space exploration plans and strategies of the major space-faring countries as well as of the potential newcomers is provided, including an analysis of their relations with Europe at the political and space level. European space exploration plans and activities are presented as well as the potential evolution of the European space context in the coming years. Finally, in order to adapt to the changing space exploration context, policy options for Europe, the timing issues to consider as well as partnerships opportunities are presented to give a preview of the possible evolution of space exploration (Chapter 4).

[3] As a result of the work between representatives of fourteen space agencies, which have met four times since August 2006, on 31 May 2007, at the third ESA/ASI workshop on “International Cooperation for Sustainable Space Exploration”, a 25-page report “Global Exploration Strategy - The Framework for Cooperation” was released as the first product of an international coordination process among those agencies. 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 17-country ESA.

2. Analysis of worldwide and national trends

The future is characterized by a number of unfolding trends and this chapter aims to present these by collating them into minimum of key sets. Five main meta-trends have been examined in the context of this study. These meta-trends relate to the economy, demography, energy, environment, and science and technology, which are not ephemeral trends, but long-lasting phenomena critical to future developments.[4] A section of this chapter is also devoted to the evolving geopolitical drivers in the next two decades. While there is reasonable, albeit not universal agreement on the shape and directions of the five meta-trends considered, the elicitation of trends is only part of this foresight exercise. A specific section will be devoted to country outlooks (i.e. countries outside Europe involved in the Global Exploration Strategy as well as potential newcomers to space exploration) that will provide a more detailed analysis of the evolution of the geopolitical context on the 2025 horizon.

2.1. Major trends shaping the global environment until 2025

This ESPI Report describes quantitative and qualitative trends that form a relatively robust and comprehensive base from which to generate a picture of the world until 2025 to inform on policy developments. It is expected that the overall geopolitical context will evolve dramatically in the years to come, and as a result, the world of 2025 will differ markedly from the world of 2008 just like 1991 was very different from today. This evolution needs thus to be taken into consideration by Europe when planning forward-looking long-term space exploration strategies, as its activities in space cannot be isolated from earthly issues, and in particular, from geopolitical developments.

[4] The key trends have not been listed in any preferential order due to their great interconnectedness.

2.1.1. Economy

In spite of periodic economic downturns, global economic growth is expected to remain strong until 2025. The whole world will, however, not benefit from this continued growth. The patterns of growth will be uneven and economic performance will vary enormously from country to country. Over time, we stand to see more dramatic growth in the Asia-Pacific region, while sub-Saharan Africa is likely to lag behind the other regions. In general, most forecasts for this period continue to show higher annual growth for developing countries than for developed countries (Figure 1).

The “new countries” are expected to become a stronger force in the world economy in the years to come and the list of the world’s largest economies may look quite different in 2025 than today (Figure 2). The current dominant triad, the United States, Europe and Japan will remain leaders, but with increasing competition from India, China and others. Consequently, a shift of the centre of the world economy to Asia is expected and the East will become an increasing pivotal centre of international economics. Trade flux and economic partnerships will therefore evolve dramatically in the years to come, with increasing “South-South” economic partnerships under among others, the leadership of China, India, Brazil and South Africa.[5]

[5] In this paper the use of the term “South” refers to all developing countries, as well as all Least Developed Countries (LDCs). It rests on the fact that all of the world’s industrially developed countries (with the exception of Australia and New Zealand) lie north of those developing countries. However, the diversity of countries in the South must be borne in mind. Some countries, such as Argentina, Brazil, China, India, Mexico, South Africa and South Korea, have enviable records of scientific achievement compared to the others. Yet, many countries from the South have not experienced significant development for some time.

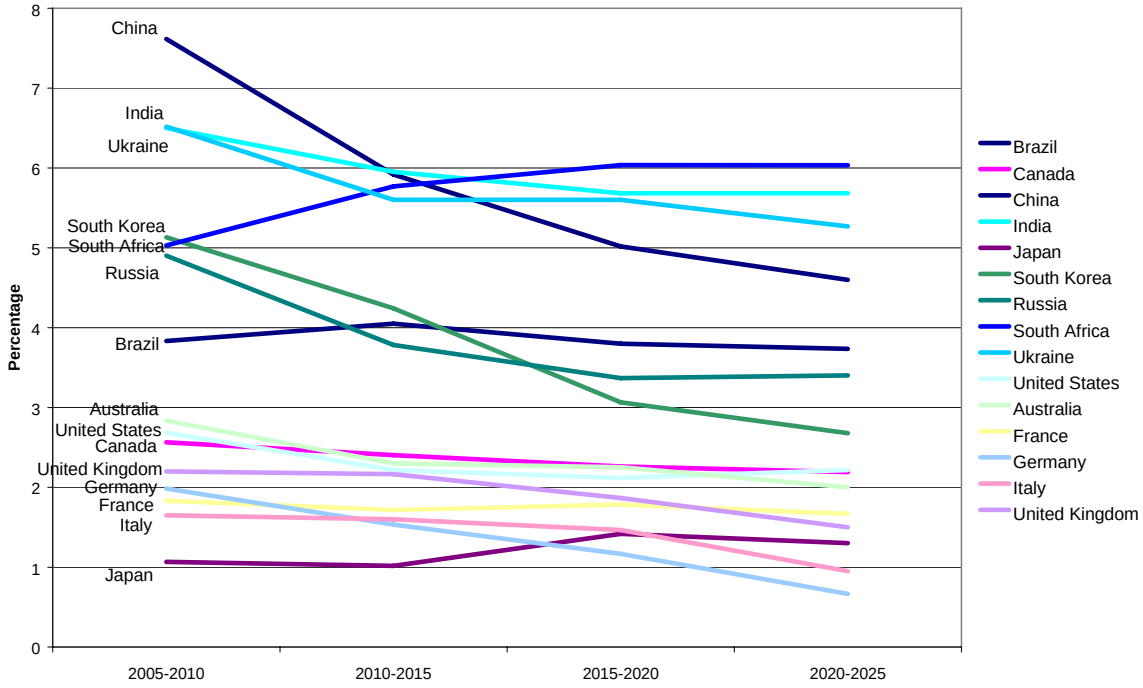

Figure 1. Forecast of GDP growth over the 2005-2025 timeframe for the major economies – average per five years period (Source: ESPI)

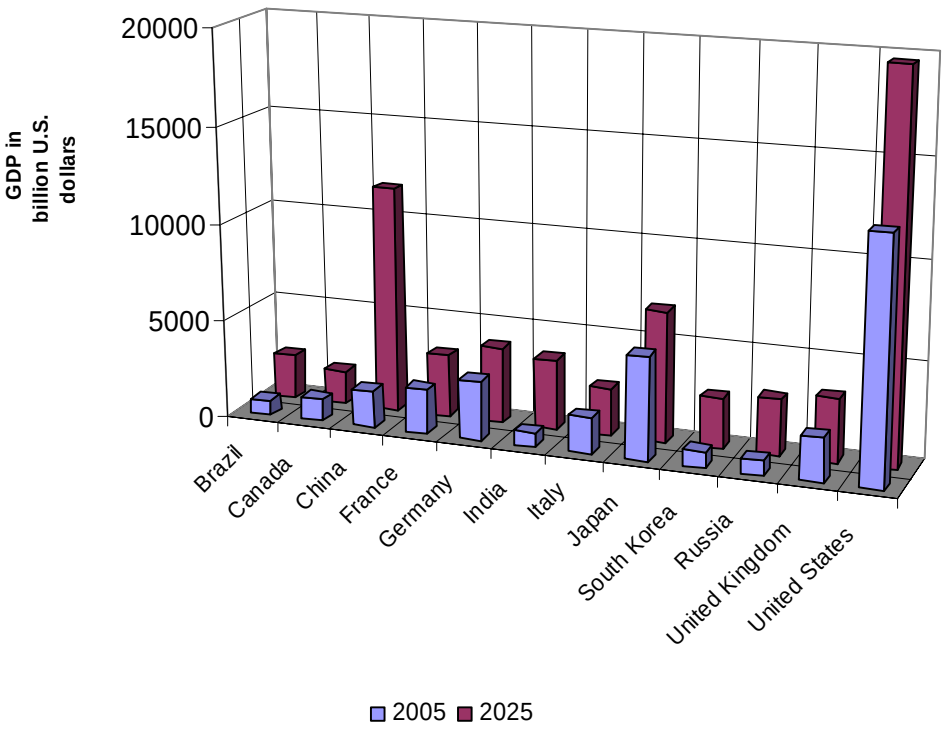

Figure 2. Estimation of GDP by major country in 2005 and 2025 (Source: Goldman Sachs 2005[6])

[6] O'Neill, Jim, Dominic Wilson, Roopa Purushothaman and Anna Stupnytska. "How Solid are the BRICs?" Global Economics Paper No:134. Goldman Sachs, 2005.

Over the next 20 years, the process of economic globalization is likely to continue, and it will remain a significant feature of the long-term economic context, with increasing foreign direct investment and international trade. While globalization will sustain world economic growth, it will also raise world living standards, but at the same time increase interdependencies. Provided there is no global economic crisis, international trade, investment and capital flows are expected to grow steadily worldwide leading to further economic integration. The next two decades will therefore be marked by an expanding and integrated global economy. However, because economic globalization will deepen and continue to drive economic growth, this will lead to greater competition to access new markets and to consolidate market shares. A key feature of this sustained globalization will be the continuing internationalization of the markets for goods, services and labour. New competitions will emerge on the world market and challenge developed economies across a broadening range of industries and services. In particular, service off-shoring will continue to expand and this will lead to new trade patterns and create new export opportunities for developed countries.

While the hierarchy of the world economy is expected to evolve as illustrated in Figure 2, when looking at gross domestic product (GDP) per capita, the picture will not be dramatically different from what we have today and significant per capita disparities will remain. Despite the rapid economic growth of some developing countries and while material conditions for most people are likely to improve over the next 20 years, the gap between the rich and the poor, or "haves" and "haves-not" will probably increase and absolute poverty will remain a global challenge. Poverty in certain parts of the world will therefore exert growing pressure on local governments, and will thus be a source of tension as well as motivation for many people to emigrate to regions and countries more well-off, particularly in the "North".

2.1.2. Energy

Energy-related issues are expected to remain an important subject of geopolitical affairs in the next decades due to increasing demand surpassing the available supply. Most of energy demand will come from developing countries, particularly from Asia, with sustained high demand from the fast-developing economies such as China and India. Developed countries are likely to maintain levels of consumptions consistent with sustaining their growth and will therefore, at best, stabilize their energy consumption (Figure 3).

While during the 20th century, the dominant sources of energy changed from wood and coal to oil and gas, those latter fossil fuels will remain the dominant resource for the next decades. Global oil consumption will rise from its current level of about 81.1 million barrels/day to about 114.6 million by 2025,

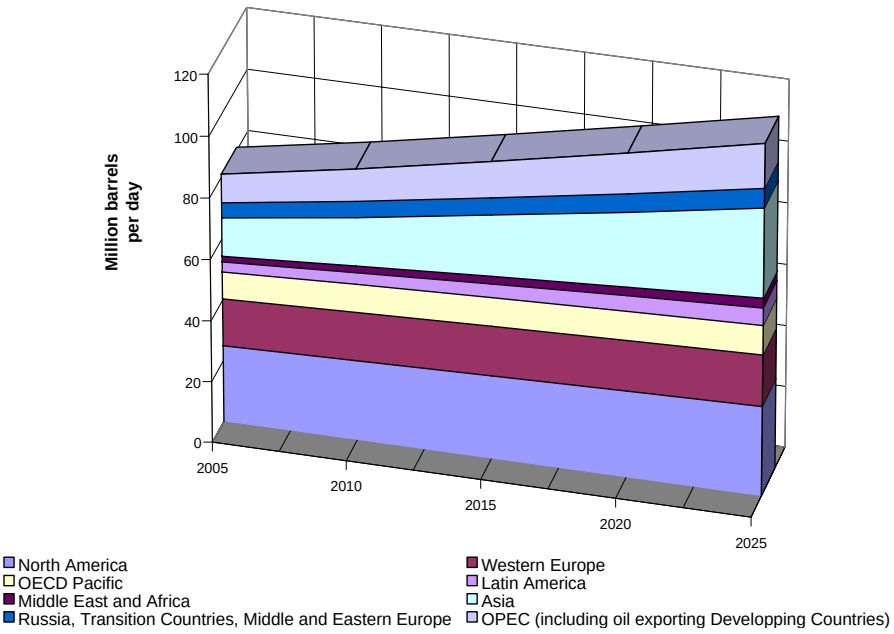

Figure 3. Projected oil demand for 2005 to 2025 per main region
(Source: OPEC "Oil Outlook to 2025" OPEC Review Paper 2004)

and developing countries are projected to account for half of energy demand in 2025 compared to one-third today.[7]

Other sources of energy besides fossil fuels (oil, gas and coal) are projected to increase (Figure 4). Nuclear power will become an important source of energy for electricity generation, particularly in developed and emerging countries. However, this will come with increased security concerns linked to the management of physical infrastructure as well as concerns about proliferation issues or even access to uranium. Renewable energy sources (solar energy, wind and hydrogen) will continue to be an alternative source of electricity production at the local and regional level, particularly in the developed countries, but will still represent only a small scale of overall energy generation. The transportation sector that is responsible for over half of world's oil consumption and about one-third of the world's total commercial energy consumption will continue to be the most rapidly growing sector in terms of oil consumption as the total stock of vehicles is growing worldwide particularly in the "South".[8] In this context, and in order to reduce the oil dependence of current transport systems, bio-fuels are expected to become an increasing source of fuel for transport, but this might consequently put greater pressure on agricultural resources and therefore food prices.

In this overall energetic context, maintaining safe and reliable access and containing instability risks to the access of key natural resources, especially to oil, gas and minerals of strategic importance (i.e. uranium) will become increasingly significant in the future. Competition will intensify with respect to access and control of energy resources. The major countries will increasingly seek political and economic partnerships to generate supply, particularly for the transport of gas resources, as delivery depends principally on pipelines. Moreover, since much of the world's hydrocarbon reserves are in regions vulnerable to the impacts of climate change and because many oil and gas producing States already face significant social economic and demographic challenges, instability is likely to increase. This has the potential to feed into even greater energy insecurity and competition for resources. A further dimension of competition for energy resources lies in the potential conflict over resources in polar regions, which will become exploitable as a consequence of global warming. The dependence on energy imports will increase substantially for all countries, and due to the potential political instability in many supplier countries as well as possible

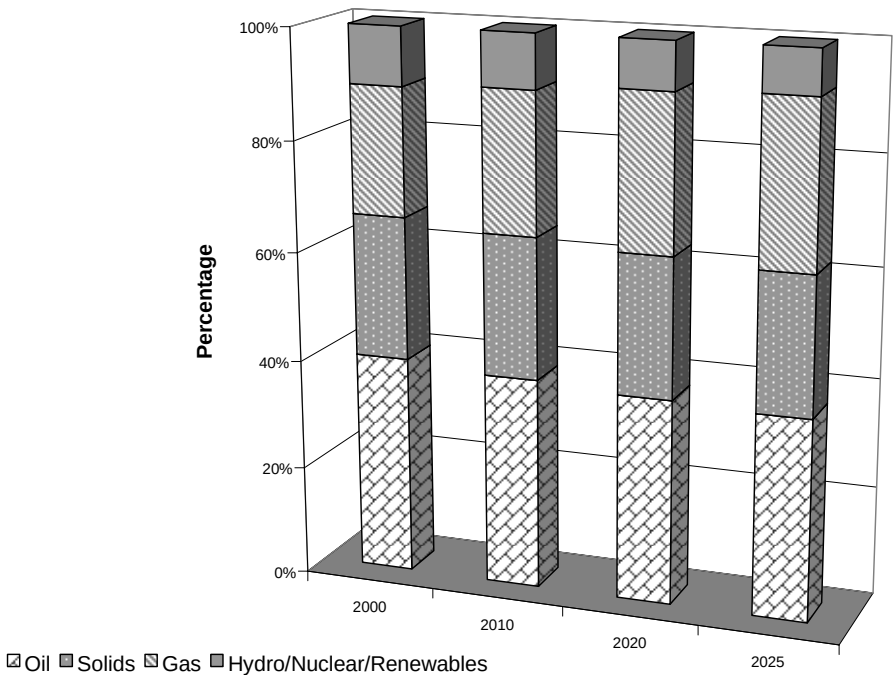

Figure 4. Share of world energy demand for fuel
(Source: OPEC "Oil Outlook to 2025" OPEC Review Paper 2004)

[7] OPEC "Oil Outlook to 2025" OPEC Review Paper,2004.
[8] OECD "Energy in the 21st Century: The Return of Geopolitics?" Highlights No. 17,, May 1999.

investment shortfalls, the prices of oil and gas are expected to break new records over that period. Energy security will therefore remain a high geopolitical concern in many countries in the 20 years to come and might lead to the creation of new political partnerships and consequently to a paradigm shift in the formation of geopolitical alliances.

2.1.3. Demography

Despite a century of major wars and conflicts, the last hundred years have been marked by unprecedented growth of the world population due to improved health care and living standards, and this trend is expected to continue over the next two decades at least. The global population is set to increase by about 1.5 billion inhabitants in the next 15 years up to around 8 billion in 2025. More important than this overall trend projection, though, is the evolution in population patterns and compositions. An evolution towards a general shift in demographic patterns and dynamics between the "North" and the "South" is expected (Figure 5). A decreasing percentage of the global population living in the developed world is foreseen while East Asia and Africa wil remain the most populous parts of the world. Furthermore, while the total population of developed countries will remain stable, there will be differences in the regional distribution with increases in the United States and Europe, and a decrease in population in Japan.

In the next 20 years it is expected that migration flux, and particularly, migration to developed countries will continue (the so-called "economic migration"). Nonetheless, no massive migration flows are projected. However, conflicts and crises, as well as the increasing effects of climate change and environmental issues will continue to trigger the displacement of a large number of people at the regional level. In addition, the trend of "reverse brain drain" is predicted to gain momentum in the years to come with professionals from the "South" trained in the "North" going back to their home country due to growing economic prospects.

Developed countries will also see a growing trend of "ageing" or "greying" populations over the next 20 years, while most of the developing countries will still be in the early stage of demographic transition with high birth and population growth rates driving the trend towards a "youthing" population. This will have major implications for the composition of the workforce. While the "North" will have a higher workforce-to-retired ratios and the working-age population will decrease leading to a loss of skills and qualified workforce, in the "South" the population will remain relatively young and the working-age population will expand. The healthcare problem in the "North" is consequently expected to worsen, and as a growing share of the population is likely to need special services, those economies will have an extra burden on public finances. In

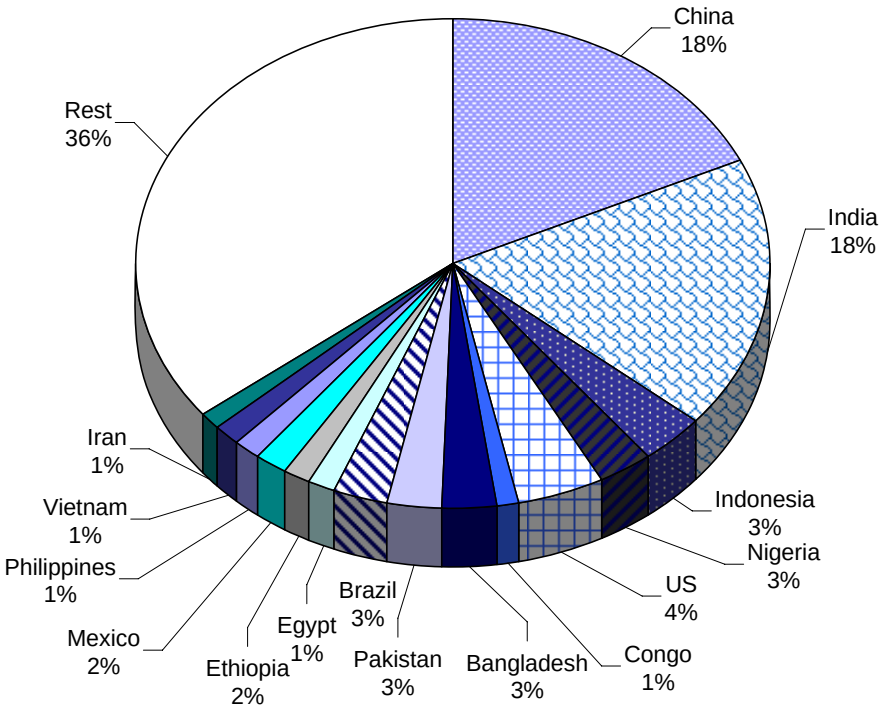

Figure 5. World population prospects in 2025
(Source: United Nations Department of Economic and Social Affairs "World Population Prospects: The 2006 Revision")

the "South", the increasing size of the young population combined with a lack of employment possibilities and social prospects as well as unfulfilled expectations may lead to a vulnerability to populist and other extreme political messages. Furthermore, gender imbalances in certain developing countries might lead to domestic tensions due to predominantly male societies.

In 2025, an estimated 57.5% of the world population will live in cities, compared to about 48.7% in 2005, with urbanization ratios being higher in developed countries than in developing countries. However, the "South" will see its "urbanization" increase dramatically. This means that there will be substantial growth in slums and favelas, and random urban settlement with poor living conditions in Asia, Latin America and Africa. All of these factors will increase pressure on infrastructure and governance. Infectious diseases will continue to have significant economic and social impacts across many regions of the world and HIV/AIDS in Africa and Asia will remain a major problem in highly populated urban areas.

2.1.4. Environment

Environmental trends are closely related to economic and demographic developments, and consequently, the expanding global economy and worldwide population growth will mean increasing environmental pressure in the future due to the more intensive exploitation of natural resources, particularly fossil fuels. Moreover, in the next two decades, environmental degradation caused by the intensification of agriculture and the reduction of arable land and the reduction of food and fish stocks are projected to trigger an increase in food prices that will consequently lead to tension in the affected countries and regions. Furthermore, due to population growth and the increasing agricultural consumption of water, water stress caused by excessive consumption as well as pollution is expected to increase considerably in several regions of the world. These growing disparities in water resources will contribute significantly to political and even possible military tensions in several affected regions.

Driven by industrialization and urbanization, pollution, not only of water sources, is expected to increase and to lead to more widespread and dangerous effects on human health. The potential reduction of pollution in developed countries due to greater "ecological consciousness" will be more than offset by the increase in pollution in the emerging economies because of the continuing massive reliance on fossil fuel energies. As a consequence, the global environment is expected to deteriorate in the coming decades. In particular, emissions of anthropogenic greenhouse gases, which are the main cause of the global rise in temperatures, are expected to continue to grow due mainly to the increase in growth in energy consumption. In turn, global warming is expected to continue leading to a dramatic climate change. There is compelling evidence that climate change will continue and that air temperature will continue to warm at an unprecedented rate throughout the 21st century. The findings of the Intergovernmental Panel on Climate Change (IPCC) demonstrate that even if emissions were to be reduced to below half of 1990 levels by 2050, a temperature rise of up to 2°C above pre-industrial levels will be difficult to avoid and might trigger a number of tipping points that would lead to further accelerated, irreversible and largely unpredictable climate changes (Figure 6). [9]

The rise in temperature induced by anthropogenic greenhouse gas emissions seems therefore inescapable in the long-term and will in turn lead to dramatic environmental changes. Uncertainties remain as to the precise rate and character of the expected changes over the next decades, as some changes may be sudden and uneven in their impacts. However, the major consequences are likely to include melting ice caps, thermal expansion of the oceans, and changes to oceans current and flows, while on land, some regions will experience flooding or desertification, and consequently change the patterns of agriculture. Moreover, an increase in the frequency and the intensity of extreme weather events is expected like heat waves, inundations or oceanic storms posing serious threats to the coastal zones that are heavily populated.

Climate change is therefore expected to become a threat multiplier that will exacerbate existing trends, tensions and instabilities. The core challenge is that climate change will result in humanitarian catastrophes which threaten to overburden States and regions, which are already fragile, since it will also affect food production. Moreover, several communicable diseases are expected to have a significant impact on the

[9] IPCC. "Climate Change 2007: Working Group I report: .The Physical Science Basis" Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Eds. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller. New York: Cambridge UP, 2007

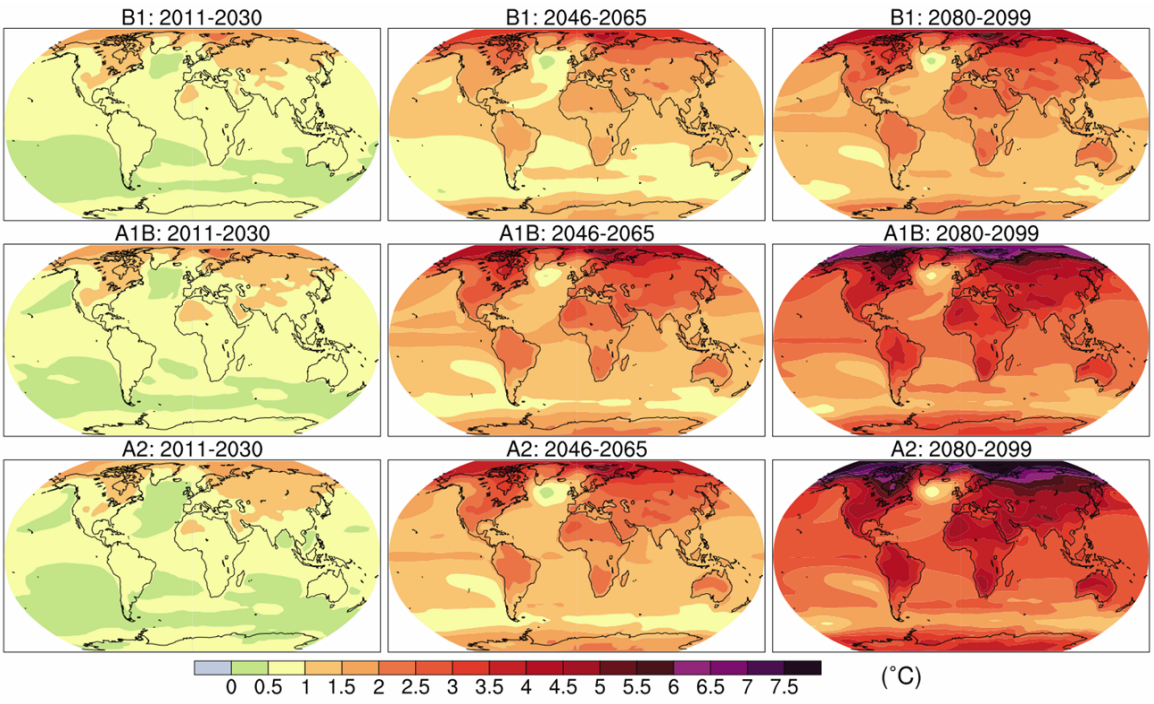

Figure 6. Multi-model mean of annual mean surface warming (surface air temperature change, °C) for the scenarios B1 (top), A1B (middle) and A2 (bottom), and three time periods, 2011 to 2030 (left), 2046 to 2065 (middle) and 2080 to 2099 (right) (Source: IPCC Working Group I).

population and development as environmental changes will likely allow some diseases like malaria to expand their geographic coverage and consequently move into currently temperate zones immune of such diseases.

2.1.5. Science and Technology (S&T)

Progress in S&T has revolutionized societies throughout the world in the last 20 years. However, the next two decades are expected to be even more challenging. S&T progress is expected to produce breakthroughs at an unprecedented rate and will increasingly originate from more international and globalized sources.

While it is impossible to make predictions about how novel and emerging technologies could be exploited and applied in the period up to 2025, it can, however, be stressed that the most rapid technological advances are likely to occur in the area of Information and Communications Technology (ICT), biotechnology, nanotechnology, energy, cognitive sciences as well as smart materials and artificial intelligence sectors, with most of the developments in these domains likely to be evolutionary, and even perhaps revolutionary. For instance, the greater access and increased reliance on ICT is expected to shape the world by creating a greater reliance on technology itself. Furthermore, what makes any predictions even more difficult is that future technology trends will be marked not only by accelerating advances in individual technologies, but also by a convergence of technologies that can lead to several societal paradigm shifts. In general, the new technology breakthroughs and new applications are expected to foster dramatic improvements in human knowledge and individual well-being.

Over the next 20 years, the trend towards rapid, global diffusion of technology and scientific achievements is, as aforementioned, expected to continue. However, the increase in volume of specialized and technical information and the proliferation of access to this information will lead to the unprecedented multiplication of sources of progress. Under these conditions, it is expected that knowledge and innovation will become more diffuse and internationalized. In the wider field of S&T developments, the United States and major current powerhouses like Europe and Japan will continue to be among the leading players by 2025. However, in certain cases new actors will be able to leapfrog technology developments due to the absence of existing infrastructure as well as increased resources devoted to S&T activities. New innovation centres and hubs are expected to appear in the rising powers and developing regions,

leading to a rapid catching-up of the "South" with countries like India and China even becoming leaders in several areas. This could consequently enable those countries to set the rules for designing standards and raise their status in the international S&T arena and therefore improve their economic competitiveness. Finally, while it is generally expected that until 2025 government and military-funded research will continue to drive investment, globalized demand and commercial logic are likely to grow in importance and thus increasingly drive the pace and direction of technological developments.

2.2. Geopolitical drivers

While it is predictable that States will remain the principle units of government until 2025, they will increasingly be challenged by the growing range and complexity of national and transnational threats. Transnational terrorism and especially faith-based terrorism as well as politically-driven terrorism will continue to proliferate particularly in failed States. Furthermore, as accessibility to technology that enables the production of chemical and biological weapons is likely to increase, the threats of large-scale terrorist attacks will remain high. International organized crime is also expected to grow in volume and to reach out to new markets, particularly in areas of increasing economic growth like Asia.

The next two decades will be characterized, as aforementioned, by the increasing interdependence of countries through a globalized economy, but the increasing competition for resources as well as border disputes and humanitarian catastrophe caused by climate change might lead to greater political instability. Several challenges to governance will also be posed in different parts of the world such as the loss of national identities due to multiethnic nation-States. The United Nations recognises approximately 500 nationalities, of which 140 live on the territory of a State governed by a different nationality with a large number of unresolved ethnic and territorial conflicts such as Arab-Israeli conflicts, the Kosovo, the Arab-African violence and genocide in Darfur and southern Sudan, conflicts between Ethiopia and Eritrea, Sunni and Shia conflicts, etc. [10] Furthermore, the current reversed democratization process in parts of the newly democratised world, especially in Eurasia, will pose a number of challenges to governance in those countries.

Barring an abrupt reversal of the process of globalization in the next decades, the combination of sustained high economic growth, expanding S&T capabilities, and large population will be at the root of the rapid rise in economic and political power for several countries, particularly from the "South". As indicated by the NIC 2020 report, "at no time since the formation of the Western alliance system in 1949 have the shape and nature of international alignments been in such a state of flux". [11] However, the likelihood of great power conflict escalating into total war in the next 20 years is lower than at any time in the past century due to an increasing interconnectedness and dependence on global financial and trade networks. The overall geopolitical context will thus evolve dramatically in the years to come and as a result, the world of 2025 will differ markedly from the world of 2008 and is likely to be more diverse and interdependent than today. In particular, the probable emergence of China and India as well as other powers from the "South" as new major global players will transform the geopolitical landscape. For instance, China's and India's growing global economic status will translate into a significant increase in their international political influence, diplomatic power, and possibly foreign commitments. This trend may lead to more strategic competition between them and existing powers, but it may also lead to a competition for allies and partners. The global balance of power and the nature of strategic alliances might therefore be dramatically different than today.

2.3. Trends in selected countries

This section looks into more detail at the socio-economic and geopolitical developments of current as well as potential space actors outside of Europe until 2025. This complements the information on the five meta-trends as well as overall political drivers presented in the previous section and helps to provide a sharper picture of what the world could look like in 2025.

[10] Naumann, Klaus, John Shalikashvili, Peter Inge, Jacques Lanxade and Henk van den Breemen, with Benjamin Bilski and Douglas Murray. "Towards a Grand Strategy for an Uncertain World – Renewing Transatlantic Partnership". Lunteren: Noaber Foundation: 2007.

[11] National Intelligence Council. "Mapping the Global Future: Report of the National Intelligence Council's 2020 Project". Pittsburgh: GPO, Dec. 2004.

Eleven countries are analyzed, with nine countries that are part of the current Global Exploration Strategy (GES) initiative (Australia, Canada, China, India, Japan, Russia, South Korea, Ukraine and the United States) as well as two countries presenting interesting economic potential and some significant space experience (Brazil and South Africa). For each of the countries, the analysis has been conducted using the same methodological framework in order to provide the reader with continuity and consistency in the information presented to asses the individual developments of those countries. A table synthesizes the main key indicators on the economy of a country (GDP (PPP) in current international dollar in 2006 and projection to 2025 as well as economic growth information), its population (size in 2005 and projection for 2025, current and projected working age population, as well as current and projected urban population for 2005 and 2025), some information on the main political milestones (election cycles at the presidential-level and the parliamentary-level, as well as the budget cycle) and finally, selected internal and external risks and threats. This approach permits taking into account to the fullest extent possible the emerging changing geopolitics and at the same time, providing European decision makers with a better understanding of the potential evolution of the priorities and the challenges that those eleven countries might face.

2.3.1. Australia

Economic growth is expected to continue in Australia in the next 20 years. In the 2008-2025 timeframe, gross domestic product (GDP) by purchasing power parity (PPP) is forecasted to almost double fuelled mainly by the sustained global demand for natural resources. [12] Australia is one of the few members of the Organisation for Economic Co-operation and Development (OECD) that is a significant energy exporter (Australia is currently the world's largest coal exporter and fifth largest exporter of liquefied natural gas (LNG)). Its energy exporter status presents some interesting opportunities and long-term economic potential due to increasing demand of energy hungry countries in the Asia-Pacific region.

Australia	
ECONOMY GDP (PPP) in current international dollars in 2006: 682.20 billion GDP (PPP) in current international dollars in 2025 (est.): 1056.9 billion GDP growth 2008 (est.): 3.1% Average GDP growth 2008-2025 (est.): 2.29%	**POPULATION** Population absolute number 2005: 20,310,000 Population absolute number 2025 (est.): 24,393,000 Working age population 2005: 62.7% Working age population 2025 (est.): 56.7% Urban population 2005: 882% Urban population 2025 (est.): 91.3%
ELECTION and BUDGET Election Cycle: President: no President; part of the Commonwealth with the Queen as head of state; head of the government is the Prime Minister, who is appointed from the parliamentary majority; Parliament: 2010, 2013, 2016, 2019, 2022, 2025, 2028 Budget Cycle: annual	**RISKS and THREATS** Internal • Demographic issues and particularly social disparities and ageing of the population • Immigration and ethnic differences • Water scarcity External • Growing economic competition on world market, especially in Asia • Increasing engagement in global events (i.e. humanitarian commitments) • Risk of terrorism

[12] Using GDP in U.S. dollars a Purchasing Power Parity (PPP) basis is more useful when comparing generalized differences in living standards on the whole between countries because PPP takes into account the relative cost of living and the inflation rates of the countries.

Australia will continue its transition from a virtually mono-cultural society to one of the most culturally diverse countries in the world. Its population has increased more than fivefold since the beginning of the 20th century and will reach more than 24 million by 2025. However, this population increase will be completed by an ageing of the population that will reduce the size of the active workforce. Urban concentration of the population is expected to reach an estimated 91.3% of the total population. In addition, Australia is already the driest continent but is also expected to be particularly impacted by global warming. Consequently, water scarcity is foreseen to become a major issue for the country, especially as population and agricultural activities are concentrated where water resources are the most limited.

Australia will continue to benefit from its proximity to Asia with strong economic ties with Japan, China, India, the 10 members of the Association of Southeast Asian Nations (ASEAN) and South Korea. Europe will also remain an important economic partner like the United States. However, its economic ties with China are foreseen to increase particularly as the Chinese demand for both coal and LNG rises. Finally, the United States and the United Kingdom are expected to remain Australia's major security partners.

2.3.2. Brazil

Brazil's economy that is already the tenth largest economy in the world, the second in the Americas and the first in Latin America, is expected to more than double in the next 17 years to reach a GDP (PPP) of about 3899 billion current international dollars in 2025. This will allow the country to climb in the hierarchy of the largest world economies. For instance, it is foreseen that Brazil will overtake Italy by size of the economy by 2025. [13] This economic expansion will be sustained by exports of natural resources (oil, gas, soybean etc.) particularly to emerging countries like China. Brazil will continue to be a bio-fuel superpower due among others to its ethanol fuel production from sugar cane, and it will benefit from an increase in world demand for alternative fuel sources for transportation.

Brazil will also see its population growing by about 42 million people by 2025 to reach about 229 million inhabitants. Its society, one of the most diverse societies in the world, will become increasingly urban putting a growing pressure on infrastructure, and accelerating the divide between the sparsely populated centre of the country and the populous coastal zones. Moreover, social inequalities, endemic corruption and organised crime

Brazil	
ECONOMY GDP (PPP) in current international dollars in 2006: 1881.3 billion GDP (PPP) in current international dollars in 2025 (est.): 3899.2 billion GDP growth 2008 (est.): 4.1% Average GDP growth 2008-2025 (est.): 3.9%	**POPULATION** Population absolute number 2005: 186,831,000 Population absolute number 2025 (est.): 228,833,000 Working age population 2005: 63.3% Working age population 2025 (est.): 62.4% Urban population 2005: 84.2% Urban population 2025 (est.): 90.4%
ELECTION and BUDGET Election Cycle: President: 2010, 2014, 2018, 2022, 2026 Parliament: 2010, 2014, 2018, 2022, 2026 Budget Cycle: annual * Brazil has apart from the yearly approved budget; a pluri-annual plan over four years (covers second, third and fourth year of a presidential term and the first year of the successor's term).	**RISKS and THREATS** Internal • Social inequality (gap between rich and poor) • Organised crime (i.e. drug trafficking) and endemic corruption • Environmental degradation External • Economic instabilities on the continent • Trans-national threats in the region (guerrilla warfare, esp. Columbia) • Border control issues

[13] O'Neill, Jim, Dominic Wilson, Roopa Purushothaman and Anna Stupnytska. "How Solid are the BRICs?" Global Economics Paper No:134. Goldman Sachs, 2005.

could be a threat to Brazil's foreseen economic growth but also a source of instability for the country.

Commensurate with its economic expansion, Brazil is expected to strengthen its status of regional power in Latin America by 2025 and to become more assertive on the global scene and more involved in world affairs. It is also expected that Brazil will increasingly seek partnerships with developed countries. It will however continue to reinforce its role as a promoter of "South-South" cooperation.

2.3.3. Canada

Canada's economy is expected to remain strong in the decades to come due to, among other things, important reserves of natural resources and particularly of fossil fuels.[14] Furthermore, due to global warming and the resulting melting of existing ice caps in the northern part of the country, new reserves of fossil fuels are expected to be discovered, accessible and exploitable guaranteeing sustained sources of revenues for the country. The Canadian economy is consequently expected to grow at an annual average of 2.29% over the 2008-2025 timeframe.

In conjunction with this economic expansion, Canada's population is expected to reach about 38 million in 2025 mostly concentrated in urban centres in the southern part of the country. However, this 5.7 million increase in population will not halt the projected ageing of the population, with the working age population shrinking to an estimated 56.6% of the overall Canadian population with strong disparities between the Canadian provinces.

Traditional Western partners are expected to remain the cornerstone of Canada's international cooperation strategy. However, an increase in Asian population, particularly in British Columbia, the already third most populous province of Canada, might lead the country to look more across the Pacific in the future rather than across the Atlantic for international partnerships. Furthermore, one of the challenges for the next 20 years will be for Canada to protect its interests in the Artic region, which will become an increasingly important area of geopolitical competition due to its untapped reserves of fossil fuels. This competition might lead in turn to several tensions and possible chilling of several existing partnerships.

Canada	
ECONOMY GDP (PPP) in current international dollars in 2006: 11571 billion GDP (PPP) in current international dollars in 2025 (est.): 1787.1 billion GDP growth 2008 (est.): 2.23% Average GDP growth 2008-2025 (est.): 2.29%	**POPULATION** Population absolute number 2005: 32,271,000 Population absolute number 2025 (est.): 37,912,000 Working age population 2005: 64.5% Working age population 2025 (est.): 56.6% Urban population 2005: 80.1% Urban population 2025 (est.): 83.3%
ELECTION and BUDGET Election Cycle: President: no president; part of the Commonwealth with the Queen as head of state; head of the government is the Prime Minister, who is appointed from the parliamentary majority; Parliament: 2011, 2016, 2021, 2026 Budget Cycle: annual	**RISKS and THREATS** Internal • Problems with illegal immigration and subsequent integration • Ageing of the population • Economic disparities among provinces External • Challenges of globalisation • Increasing engagement in global events (humanitarian commitments, etc.) • Access and control of the Arctic region

[14] Canada ranks first in the world in terms of bitumen resources and second in terms of total discovered recoverable resources of crude oil.

2.3.4. China

China has been the fastest growing major country for the past quarter of a century with an average annual GDP growth above 10%. In the next 17 years, its GDP growth is expected to be at an annual average of 5.39%. High investment rates and a large labour force will therefore contribute to China becoming the world's second largest economy by 2025.[15]

China's economic expansion is expected to continue at a very high pace in the next two decades even despite increasing internal challenges linked to socioeconomic and demographic issues (ageing population etc.), as well as environmental degradation (air and water pollution). In particular, while social and economic indicators have improved in recent years, rising inequalities that are evident between the more developed coastal provinces and the less developed and poor inland provinces are expected to increase. Furthermore, of particular concern is that China currently has only 8% of the world's fresh water to meet the needs of 22% of the world's population and this may even deteriorate in the next 17 years putting even more pressure on local governments.[16]

Along with economic growth, China will continue to increase its military capabilities particularly its force projection by improving its navy fleet. China is also expected to continue projecting its economic power into Africa and Latin America to guarantee stable and secure access of natural resources (especially fossil fuels) to support its economic growth. China's new posture on the geopolitical scene will push it to venture more and more into global affairs following its "peaceful rise" philosophy. In particular, it will increasingly seek peer status in international fora with other powers, and will also try to increasingly cooperate with the "South" by taking part in regional organizations (under its leadership) or more direct bilateral trade relations.

2.3.5. India

India's economic growth is expected to continue in the next two decades, making it the fifth largest world economy by 2025 after the United States, China, Japan and

China	
ECONOMY GDP (PPP) in current international dollars in 2006: 10147.3 billion GDP (PPP) in current international dollars in 2025 (est.): 27988.9 billion GDP growth 2008 (est.): 7,1% Average GDP growth 2008-2025 (est.): 5,39%	**POPULATION** Population absolute number 2005: 1.312.979.000 Population absolute number 2025 (est.): 1.445.782.000 Working age population 2005: 67.4% Working age population 2025 (est.): 62% Urban population 2005: 40.4% Urban population 2025 (est.): 56.9%
ELECTION and BUDGET Election Cycle: President: 2008, 2013, 2018, 2023, 2028 Parliament: 2008, 2013, 2018, 2023, 2028 * President elected by National People's Congress; National People's Congress members elected by municipal, regional, and provincial people's congresses; Budget Cycle: Five-Year-Plan * China's current Five-Year-Plan covers the period 2006-2010; the next will cover 2011-2015;	**RISKS and THREATS** Internal • Social inequalities (gap between rich and poor) and demographic transition issues • Organized crime (trafficking of drugs and human trafficking) • Environmental degradation and water scarcity External • Increasing engagement on the global political and economic stage • Regional tensions: Taiwan, Tibet • Energy dependence

[15] O'Neill, Jim, Dominic Wilson, Roopa Purushothaman and Anna Stupnytska. "How Solid are the BRICs?" Global Economics Paper No:134. Goldman Sachs, 2005.

[16] Glenn, Jerome C. and Theodore J. Gordon. "2007: State of the Future." The Millennium Project, World Federation of UN Associations, 2007.

Germany.[17] India is expected to have an economic growth of an estimated annual average of about 5.82% over the 2008-2025 period sustained principally by increasing internal demand from the developing middle class. This will lead to the rise of a mass consumption market, but also the continuing outsourcing of services from the developed world. However, energy dependence and access to natural resources particularly to water will become key issues for India's development in the next 20 years and will challenge its economic expansion. In particular, it is expected that primary energy demand in India will more than double by 2030, principally due to increasing transport energy demand as the vehicle stock expands rapidly with rising economic activity and household incomes.[18]

India is foreseen to become by 2025 the most populous country on Earth. In spite of declining fertility rates, falling infant mortality and increasing life expectancy will spur an increase of at least 313 million people to an estimated total of 1.447 billion people by 2025. However, this population increase and this economic development are expected to put a greater stress on infrastructure. Furthermore, due to the consequences of global warming, water scarcity could become a major problem for India. It currently possesses 16% of world's population, but just 4% of its water resources. In addition, total water consumption is expected to rise by 20% to 40% over the next 20 years.[19]

Following India's opening of its economy to globalisation and its aspirations of becoming a world power, India's foreign policy discourse has been shifting from the traditional non-aligned approach to a more pragmatic one with expanding economic relations with current world powers. This trend is expected to grow stronger in the future. India is, however, expected to build economic and political partnerships in the region and cultivate its role as one of the leaders of the "South", while it will seek at the same time partnerships with more developed countries. Furthermore, India's military modernisation is also proceeding at an accelerating pace that aims to provide India with all the attributes of a dominant world power.

India	
ECONOMY GDP (PPP) in current international dollars in 2006: 4231.6 billion GDP (PPP) in current international dollars in 2025 (est.): 12433.4 billion GDP growth 2008 (est.): 6,1% Average GDP growth 2008-2025 (est.): 5,82%	**POPULATION** Population absolute number 2005: 1.134.403.000 Population absolute number 2025 (est.): 1.447.499.000 Working age population 2005: 59,6% Working age population 2025 (est.): 63,7% Urban population 2005: 28,7% Urban population 2025 (est.): 37,3%
ELECTION and BUDGET Election Cycle: President: 2012, 2017, 2022, 2027 Parliament: 2009, 2014, 2019, 2024, 2029 * Note: Parliament has two chambers with different election cycle (5 and 6 years); in the statistics only the first chamber has been included; Budget Cycle: annual	**RISKS and THREATS** Internal • Social inequality (gap between rich and poor) • Providing adequate infrastructure for growing population • Environmental degradation and water scarcity External • Increasing engagement on the global political and economic stage • Continuing border issues (i.e. Kashmir) • Energy dependence

[17] O'Neill, Jim, Dominic Wilson, Roopa Purushothaman and Anna Stupnytska. "How Solid are the BRICs?" Global Economics Paper No:134. Goldman Sachs, 2005.

[18] International Energy Agency. "World Energy Outlook 2007: China and India Insights. Executive Summary." Paris: OECD/IEA, 2007.

[19] Government of India, Planning Commission. "India Vision 2020." New Delhi, December 2002. <http://planningcommission.nic.in/plans/planrel/pl_vsn2020.pdf>.

2.3.6. Japan

Japan's economy is expected to continue to grow at an estimated annual average GDP growth of 1.14% in the 2008-2025 timeframe confirming its position as a major world economy. In 2025, Japan is foreseen to be the third world economy by GDP behind the United States and China.[20] Japan like other Asian countries is dependent on imports to meet its energy needs and due to increasing competition at regional level this will present an even greater challenge for Japan to stay competitive and might be a threat to its economic expansion.

While Japan's economy will remain strong in the future, its population is forecasted to decrease by about 6.5 million over the next 17 years to a total of about 121.6 million in 2025. This will consequently lead to a decrease of the workforce that will exacerbate the ageing of the population. This change in the demographic structure will create a number of social issues, particularly with the continuing decline in the workforce population and increases in the cost of social security benefits that will put a greater pressure on public finances.

The rise of India and China as major global powers as well as the increasing competition to access foreign markets and natural resources, will lead to a buoyant regional context. Japan's status of regional power gained since its economic recovery after the Second World War will be considerably challenged and consequently, the country will increasingly have to focus its attention on the Asia-Pacific region to nurture new strategic partnerships while maintaining its relations with its traditional Western partners. Japan is nonetheless expected to preserve close economic and military relations with its key ally the United States, as well as with Europe.

2.3.7. Russia

Since the turn of the century, rising oil prices, increased foreign investment, as well as higher domestic consumption have bolstered economic growth in Russia. Russia is expected to continue its economic recovery witnessed in recent years with an average annual GDP growth of an estimated 3.63% over the period 2008-2025. This economic expansion will continue to be fuelled by sustained high prices of natural

Japan	
ECONOMY GDP (PPP) in current international dollars in 2006: 4155.5 billion GDP (PPP) in current international dollars in 2025 (est.): 5135.3 billion GDP growth 2008 (est.): 0.4% Average GDP growth 2008-2025 (est.): 1.14%	**POPULATION** Population absolute number 2005: 127.897.000 Population absolute number 2025 (est.): 121.614.000 Working age population 2005: 59.7% Working age population 2025 (est.): 53.1% Urban population 2005: 65.8% Urban population 2025 (est.): 71.7%
ELECTION and BUDGET Election Cycle: President: no; Japan is a hereditary Monarchy; head of the government is the Prime Minister, who is appointed by the parliamentary majority; Parliament: House of Representatives: 2009, 2013, 2017, 2021, 2025, 2029 House of Councillors: 2010, 2013, 2016, 2019, 2022, 2025, 2028 * Note: Parliament has two chambers with different election cycles (4 and 3/6 years [every three years, half of the delegates faces elections]) Budget Cycle: annual	**RISKS and THREATS** Internal • Demographic issues (greying of the population and reduction of the active workforce) • Natural threats (earthquakes, tsunamis, etc.) • Integration of immigrants into Japanese society External • Ascending economic powers in the region – challenge of staying competitive • Increasing engagement in global events (humanitarian commitments etc.) • Dependent on external resources for keeping the living and production standard (i.e. energy dependence)

[20] O'Neill, Jim, Dominic Wilson, Roopa Purushothaman and Anna Stupnytska. "How Solid are the BRICs?" Global Economics Paper No:134. Goldman Sachs, 2005.

commodities.[21] Thus, Russia's economy stands to become the world's eighth largest one by 2025.[22]

The size of the Russian population is forecasted to decrease by about 15 millions to total about 128 million in 2025. This demographic trend will be completed by a reduction of the working age population to 61.1%. However, this decrease of the overall Russian population combined with the aforementioned economic expansion will result in an increase of the individual living standard, which is likely to catch up in terms of income per capita with today's leading developed countries. Nonetheless, several internal issues such as environmental degradation as well as the impact of global warming or governance issues are threatening Russia's future. For instance, Russia is foreseen to face continuing questions over the next two decades related to the structure and distribution of power across the country.

In contrast to the prevailing centralism of its domestic politics, Russia will continue its openness to globalisation to ensure it reaps the benefits of its large reserve of natural resources. At the same time it will go on restoring the elements of its previous superpower status. Russia will continue its effort to revive its diplomacy channels and to maintain a strong voice in as many international organisations as possible (United Nations Security Council, Shanghai Cooperation Organisation, etc.). In overall terms, its foreign policy is likely to continue its movement away from the predominant Western and European focus pursued in the 1990s to look more East and towards the "South" and reach out to emerging powers like, in particular, India by using oil and gas as an instrument of international power.

2.3.8. South Africa

The economy of South Africa, which is currently the largest in Africa, is expected to grow over the next 17 years at an annual average pace of about 5.81%. This will consequently triple its GDP (PPP) by 2025 reinforcing its status of economic power of the continent.

Despite the continuous ravages of the HIV/AIDS virus, South Africa's population will grow by about 4.4 million citizens to reach

Russia	
ECONOMY GDP (PPP) in current international dollars in 2006: 1739.0 billion GDP (PPP) in current international dollars in 2025 (est.): 3460.8 billion GDP growth 2008 (est.): 4,5% Average GDP growth 2008-2025 (est.): 3,63%	**POPULATION** Population absolute number 2005: 143,953,000 Population absolute number 2025 (est.): 128,193,000 Working age population 2005: 67.8% Working age population 2025 (est.): 61.1% Urban population 2005: 73% Urban population 2025 (est.): 74.2%
ELECTION and BUDGET Election Cycle: President: 2008, 2012, 2016, 2020, 2024, 2028 Parliament: 2011,2015, 2019, 2023,2027 Budget Cycle: annual	**RISKS and THREATS** Internal • Demographic issues (decrease of the population size) • Re-emergence of nationalism • Organized crime (trafficking of drugs and human trafficking) and corruption External • Structure and distribution of power in the region • Increasing engagement in world affairs • Rise of political Islam in Central Asia and relations to the Balkans and the Caucasus

[21] Russia has the world's largest natural gas reserves, the second largest coal reserves and the eighth largest oil resources.
[22] O'Neill, Jim, Dominic Wilson, Roopa Purushothaman and Anna Stupnytska. "How Solid are the BRICs?" Global Economics Paper No:134. Goldman Sachs, 2005.

about 52.3 million in 2025. This population increase in conjunction with continuing rural exodus is expected to increase the trend of urbanization of the South African society, with urban centres concentrating almost 69% of the population by 2025. However, despite the strong economic expansion of South Africa in the years to come, large income gaps will persist, as well as daunting economic and social problems.

Having emerged from the international isolation of the Apartheid era, South Africa has become increasingly involved in international affairs. This is forecasted to increase. In this context, South Africa is foreseen to reinforce by 2025 its regional power status and its position as economic leader of the continent and will become a leading international actor confirming therefore its status of major emerging country. It is expected that South Africa will reach out an increasing number of international partners in the "South", but also developed countries.

2.3.9. South Korea

South Korea's rapid economic growth achieved through the exports of manufactured goods (automobiles, semiconductors, electronics, shipbuilding etc.) is expected to continue in the next 17 years confirming the increasing economic power of Korea in the globalized economy. This will anchor Korea as one of the world's high-tech and leading industrial powers of the future. This Asian Tiger is forecasted to double its GDP (PPP) by 2025 to reach about 2315.9 billion current international dollars. South Korea is thus expected to be the world's ninth largest economy by GDP (PPP) in 2025.[23]

The aforementioned economic expansion will continue to be based on human capital, and particularly on Korea's highly educated workforce, despite the reduction of the working age population to about 60.4% and the relative stabilization of its population growth. However, several challenges could threaten Korea's expansion. In particular, as the Korean Peninsula, especially in the South, is modestly endowed with natural resources most energy needs are met by imports and the regional competition to access natural resources will become fiercer and may divert Korea's efforts and resources.

As a rising economic power, in terms of foreign relations, Korea's main strategic interests are expected to remain in the neighbouring countries. It will tighten relations with the Asia-Pacific region and in particular with China, Japan and Russia. Korea is, however, expected to reinforce its partnership with its main ally the United States as well as with Europe.

South Africa	
ECONOMY GDP (PPP) in current international dollars in 2006: 618.1 billion GDP (PPP) in current international dollars in 2025 (est.): 1793.7 billion GDP growth 2008 (est.): 4.66% Average GDP growth 2008-2025 (est.): 5.81%	**POPULATION** Population absolute number 2005: 47.939.000 Population absolute number 2025 (est.): 52.300.000 Working age population 2005: 61.1% Working age population 2025 (est.): 62.2% Urban population 2005: 59.3% Urban population 2025 (est.): 69%
ELECTION and BUDGET Election Cycle: President: 2009, 2014, 2019, 2024, 2029 Parliament: 2009, 2014, 2019, 2024, 2029 Budget Cycle: Three-Year-Perspective * South Africa's three year perspective is subject to yearly adjustments.	**RISKS and THREATS** Internal • Ethnic violence and political instability • Climate change and implications for food security • Spread of HIV/AIDS External • Conflicts on the continent • Increasing engagement on the global political and economic stage • Border control issues

[23] Ibid.

South Korea	
ECONOMY GDP (PPP) in current international dollars in 2006: 1163.2 billion GDP (PPP) in current international dollars in 2025 (est.): 2315.9 billion GDP growth 2008 (est.): 5,53% Average GDP growth 2008-2025 (est.): 3,6%	**POPULATION** Population absolute number 2005: 47,870,000 Population absolute number 2025 (est.): 49,019,000 Working age population 2005: 67.6% Working age population 2025 (est.): 60.4% Urban population 2005: 80.8% Urban population 2025 (est.): 85.2%
ELECTION and BUDGET Election Cycle: President: 2012, 2017, 2022, 2027 Parliament: 2008, 2012, 2016, 2020, 2024, 2028 Budget Cycle: annual	**RISKS and THREATS** Internal • Demographic issues (greying of the population) • Natural threats (earthquakes, tsunamis, etc.) • Potential reunification with North Korea External • Stability in terms of strategic partnerships • Increasing engagement in global events (humanitarian commitments etc.) • Dependence on external natural resources (i.e. energy dependence)

2.3.10. Ukraine

The Ukraine's economy is forecasted to grow at a healthy 5.52% per year in the next 17 years with its GDP (PPP) reaching about 1030 billion current international dollars by 2025 confirming the recovery of Ukraine's economy from its near implosion in the early 1990s. However, in connection with Ukrainian's economic expansion, its energy dependence is foreseen to increase as energy consumption will grow considerably in the 2008-2025 timeframe.

Ukraine	
ECONOMY GDP (PPP) in current international dollars in 2006: 365.3 billion GDP (PPP) in current international dollars in 2025 (est.): 1029.5 billion GDP growth 2008 (est.): 6,1% Average GDP growth 2008-2025 (est.): 5,52%	**POPULATION** Population absolute number 2005: 46.918.000 Population absolute number 2025 (est.): 39.879.000 Working age population 2005: 64.7% Working age population 2025 (est.): 60.4% Urban population 2005: 67.8% Urban population 2025 (est.): 73.,4%
ELECTION and BUDGET Election Cycle: President: 2009, 2014, 2019, 2024, 2029 Parliament: 2012, 2017, 2022, 2027 Budget Cycle: annual	**RISKS and THREATS** Internal • Implementation of economic structural reforms • Demographic issues (aging of the population) • Tensions between pro-Western and pro-Russia populations External • Reversed democratization processes in parts of the region • Energy dependence • Rise of political Islam in Central Asia and parts of Russia

The Ukraine is currently in demographic crisis. In 2007 the country's population was declining at the fourth fastest rate in the world.[24] However, while the demographic trend is showing signs of improvement, Ukraine's population is forecasted to decrease dramatically by about 7 million to a total of about 40 million in 2025 that will consequently result in a decrease of the Ukrainian workforce. Other significant issues threatening Ukraine's economic expansion include undeveloped infrastructure, as well as corruption and heavy bureaucracy. Furthermore, environmental pressures and potential pollution will be an increasing issue for the Ukraine in the future.

In terms of foreign policy the Ukraine will continue to oscillate in the upcoming decades between a pro-Western future potentially becoming part of the European Union or an associated member, and strengthening relations with Russia.

2.3.11. United States of America

United States	
ECONOMY GDP (PPP) in current international dollars in 2006: 12954.7 billion GDP (PPP) in current international dollars in 2025 (est.): 19761.0 billion GDP growth 2008 (est.): 2.5% Average GDP growth 2008-2025 (est.): 2.23%	**POPULATION** Population absolute number 2005: 299,846,000 Population absolute number 2025 (est.): 354,930,000 Working age population 2005: 62,6% Working age population 2025 (est.): 57.3% Urban population 2005: 80.8% Urban population 2025 (est.): 86%
ELECTION- and BUDGET Election Cycle: President: 2008, 2012, 2016, 2020, 2024, 2028 Parliament: House of Representatives: 2008, 2010, 2012, 2014, 2016, 2018, 2020, 2022, 2024, 2026 Senate: 2008, 2010, 2012, 2014, 2016, 2018, 2020, 2022, 2024, 2026 * Note: Parliament has two chambers with different election cycles (2 and 2/6 years [every two years one-third of the delegates face elections]) Budget Cycle: annual	**RISKS and THREATS** Internal • Social inequality (gap between rich and poor) • Illegal immigration • Environmental degradation, especially water pollution External • Growing economic competition on the world market • Increasing engagement in global events (humanitarian commitments, NATO engagements, etc.) • International terrorism

The U.S. economy is expected to remain the world's economic centre of gravity until at least 2025, however, with increasing competition from Europe and Asia. It is expected that the economy will grow on average by about 2.23% per year in the next 17 years. In the mean time the U.S. population is foreseen to increase by 55.1 million to about 355 million inhabitants in 2025. However, according to the U.S. Bureau of Labour Statistics, the U.S. workforce will loose the skills and knowledge of about 46 million college-educated baby boomers who will retire over the next 20 years. This might consequently reduce the economic development potential of the country.[25] This trend is highlighted by the decrease of S&T-trained U.S. students. This will be compensated in part by increased immigration, but with the potential negative effect of encouraging the "clusterisation" of the U.S. society.

Besides the aforementioned reduction of its high-skills workforce, another threat to U.S. economic expansion is that the United States will become increasingly impacted by the consequences of climate change and particularly of global warming with prolonged drought and decreased rainfall in the central and southern parts of the country. Moreover, the warming of the Atlantic Ocean and its

[24] United-States, Central Intelligence Agency. "The World Factbook" 2008.

[25] Canton, James. Do You Know What Is Coming Next? The Extreme Future: The Top Trends That Will Reshape the World for the Next 5, 10, and 20 Years. New York: Dutton, 2006.

implications for storm energy put the Atlantic coast at greater risk and could therefore have dramatic economic consequences.

The United States is expected to continue it's the "global engagement" policy in the upcoming decades as well as its pragmatism in international relations with "à-la-carte" multilateralism consisting of using bilateral or coalition mechanisms with different perimeters depending on the issues. However, the changing demographics of the United States with an increase of the Hispanic and Asian minorities combined with the decrease in the American population of European descent might lead to a reorientation of the U.S. foreign policy towards the Americas as well as towards the Asia-Pacific region at the expense of Europe.

2.4. Summary

When assessing its future role in space exploration as well as its future international cooperation potential, Europe should take into account the socio-economic development of potential partners in conjunction with the evolution of the geopolitical context and the impact of the aforementioned five meta-trends. The developments and evolutions in the next 20 years underline that Europe needs to ready itself to a more diverse world by 2025. Several countries will witness major economic developments, while others could be plagued by major internal and external factors. Moreover, new alliances and partnerships might arise leading to a more diverse and complex international context. This chapter analyzes key structural factors affecting changes in the two decades to come and present a quite integrated image of the future that European decision-makers should take into account when planning long-term space exploration plans and considering engagements in international cooperation ventures.

3. Analysis of worldwide space strategies and plans

To help Europe anticipate and adapt to the possible changes foreseen in the domain of space exploration until 2025, this chapter presents an overview of the evolution of the space context and the trends in space exploration. The activities and plans of the current non-European countries that are part of the Global Exploration Strategy (GES) as well as two others countries with interesting economic potential and significant space aspirations are presented. European activities in space exploration and the potential evolution of the European space context are also discussed.

3.1. An evolving space context

Since the pioneering of space activities in the Cold War the geopolitical context of international relations has changed dramatically, and so has the space context. The Cold War and its East-West political environment has evolved from a bipolar space world dominated by the United States and the U.S.S.R. into a multipolar world characterized by the rise of many new actors with increasing technical capabilities, such as Europe through the European Space Agency (ESA) and European national space agencies, as well as other countries like Japan, China and India.[26] Moreover, since the 1990s, the involvement of non-traditional space actors has greatly increased and a growing number of countries are now entering the space arena. This is leading to an internationalization of space activities completed by an emerging globalization of the space actors, with space agencies now scattered all over the world.[27] Furthermore, because of the multiplication of space-faring countries and newcomers in space with increasing capabilities, there are a growing number of possibilities for cooperation. Major space-faring countries are now using space as a political tool to reach out to non-traditional partners through cooperation in order to build trusting relationships across political borders, illustrating that foreign policy and space are now once again increasingly overlapping, and therefore reinforcing the radical restructuring at the end of the Cold War.

In the current geopolitical context, the arguments in favour of cooperation have not changed fundamentally since the dawn of the "Space Age": they are still a combination of scientific, economic, political and security motives. But the nature and scope of international cooperation in space has fundamentally changed in recent years due to a set of factors, leading to a new paradigm in international space activities.[28] As aforementioned, the number of countries that could contribute to these cooperative endeavours has increased. The end of the Cold War removed the 50-year East–West barrier and opened new perspectives for cooperation. Cooperation in space is no longer restricted to short-term programmes, but has evolved to more strategic and long-term agreements, as illustrated by the multi-year science projects Cassini–Huygens and, in particular, the International Space Station (ISS) programme. Finally, the United States and Russia are no longer the only countries that can lead cooperative projects. There are now numerous players with varying degrees of capability allowing them to cooperate while providing a technological benefit. The number of potential partners with sophisticated government and industrial space technologies and capabilities has grown, and the majority of space-faring countries have much more experience in working together in their space programmes. Thus, the nature and patterns of international relations in space are changing fundamentally and the multiplication of space-faring countries with varying ranges of capabilities is leading to an increase in cooperative options that allow countries and space agencies to cooperate à-la-carte, rather than using the prior Cold-War

[26] Peter, Nicolas. "The Changing Geopolitics of Space Activities". Space Policy 22.2 (May 2006): 100-109.
[27] Ibid.
[28] Ibid.

era set of options. International cooperation is now an integral part of space policy and the strategy of the different space agencies around the world. States now rarely initiate and carry out a significant space programme without some element of foreign participation.[29]

While S&T (and space activities) is today becoming more and more significant in international relations, "space power" has also become an indispensable element of a portfolio of a country with global ambitions. Space activities have over the years become increasingly linked to national power, that is, the ability of a country to influence others through international diplomacy, economic incentives or pressure, cultural influence, or through the threat or application of military force. Exercising space power conveys a variety of benefits to space actors such as national and international prestige, economic competitiveness, military advantage, as well as scientific prowess and demonstrate the willingness of a country to ensure its non-dependence in space affairs.[30] Space power allows demonstrating leadership and projects national influence, but also its willingness and openness to cooperate at a regional or global level and therefore to garner greater prestige. Exercising space power is thus a means of impressing the world by the possession of elaborate space capabilities illustrating an assertive global position. Therefore, space exploration is a major and indispensable element of a country willing to exercise space power to its fullest extends.

3.2. Emerging trends in space exploration

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 come to the top of the political agenda of a growing number of countries around the world, and consequently, the overall space exploration environment has dramatically changed.[31] 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 the "worlds beyond."[32] The international interest in Solar system exploration can be illustrated by the development of the U.S. Vision for Space Exploration (renamed since the U.S. Space Exploration Policy), the ESA Aurora programme, as well as robotic exploration missions under development in China, India, Japan, Russia and others.

The overall exploration planning process is clearly led today by the United States which has identified space exploration as a national strategic goal and core mission of the major civilian space agency in the world, NASA. It is driven by the goal to return humans to the moon before 2020 and establish a human outpost before 2025. It is also leading the robotic exploration of Mars. China plans to demonstrate rendez-vous and docking operations in low Earth orbit (LEO) in the coming years, and launch a fleet of robotic missions to the moon (Table 2). Related activities in Russia focus currently on modernizing its crew and cargo space transportation capabilities, but Russia also works on robotic missions to the moon and Mars (Table 2). India is considering embarking on developing human access to space and is developing an ambitious lunar robotic exploration programme (Table 2). Japan is focusing its exploration efforts on human activities in LEO and robotic exploration of the moon and other planetary bodies (Table 2). Other countries are also eager to participate in this endeavour. Multiple robotic and human exploration missions are therefore foreseen in the coming decades.

[29] Ibid.

[30] Space power is defined as 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 in the presence of other actors in the world stage to affect the outcomes he wants if necessary to change the behaviour of others to make this happen by exploiting the space systems and associated infrastructure as well as political leverage it has garnered". Nicolas Peter "Space power and Europe in the need for a conceptual framework" 59th IAC Glasgow. Forthcoming.

[31] Peter, Nicolas "Towards a new inspiring era of collaborative space exploration" Humans in Outer Space–Interdisciplinary Odysseys. Ed. Luca Codignola, Kai-Uwe Schrogl with Agnieszka Lukaszczyk and Nicolas Peter. Vienna: Springer, Forthcoming 2008.

[32] However, even before the announcement of this new U.S. initiative, several space agencies around the world were developing plans for robotic and human exploration missions beyond Low Earth Orbits (LEOs).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Canada	Phoenix						ExoMars												
China	Chang'e-1	Shenzhou-7	Chang'e-2 Yinghuo-1	Shenzhou 8-9				Long March CZ5	Small Lunar Rover		Lunar Sample Return								
India	SRE-1	Chandrayaan-1, SRE-2		GSLV-Mk III	Chandraayan-2				*Manned Mission*, *Mars Orbiter*		*Asteroid Orbiter*		Chandrayaan-3	*Mission to Venus/ Mercury*					
Japan	SELENE 1		KIBO (JEM and ELM-ES), HTV 1	Venus Climate Orbiter mission (Planet-C), HTV 2	HTV 3	HTV 4	SELENE 2, HTV 5, *Mars Orbiter, Lander or Penetrator*		HTV 6		SELENE 3	*Marco Polo*							
South Korea														*Korean Lunar Orbiter*					*Korean Lunar Lander*
Russia	ISS 24P, ISS 14S, ISS 25P, ISS 26P, ISS 15S, ISS 27P	ISS 16S, ISS 29P, ISS 31P, ISS 30P ISS 28P, ISS 17S, ISS 32P	Phobos Grunt, ISS 33P, ISS 18S, ISS 34P, ISS 19S, ISS 35P, ISS 20S, ISS 36P, ISS 21S		Angara, Chandraayan-2	LUNA GLOB, OKA T	ExoMars	OKA T		Venera-D, Vozvrat MKA				*CSTS*, Angara manned version					
USA	Phoenix, DAWN, STS-117, STS-118, STS-120	LRO/LCROSS, STS-124, STS-125, STS-126,	Mars Science Laboratory, STS 119, STS-127, STS-128, STS-129, STS-130	COTS-1 (Dragon 3 – Cygnus-1), STS-131, STS-132, STS-133	GRAIL/LADEE, Juno, Bigelow Station, *Mars Scout/Mars : the great escape*		Mars Science and Telecommunications Orbiter (MSTO), ExoMars	Ares I, International Lunar Lander 1&2 (South- and Northpole)	*Robotic Lunar Mission, Altair*, Orion 5, Orion 6	*Astrobiological Field Laboratory, Mars Mid Rovers,* Orion 7, Orion 8	*Lunar lander 3&4,*Orion 9, Orion 10	Ares V		MSR (1), Manned Moon Mission / Lunar Outpost		MSR (2)			
Europe		Columbus, ATV	Node 3, Cupola, ATV 2		European Robotic Arm, ATV 3, Juno (I)	ATV 4, MoonLITE (UK)	ATV 5, *Don Quijote*, ExoMars, *Lunar Exploration Orbiter (Ger)*		Bepi Colombo	*Moon-NEXT*		*Marco Polo or other, Mars-NEXT*		MSR (1), *CSTS*		MSR (2)			

Table 2. List of international and European human spaceflight and space exploration missions by mid-2008
(In *italic* are potential missions)

Space exploration encompasses different types of missions and destinations. In this study a distinction is made between robotic missions (e.g. space probes, orbiters, landers and rovers)[33] and human-related activities in LEO and on the moon until 2025[34]. 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 (Table 2). All those plans could, of course, change in the future depending on various international and national reasons such as budgetary decisions. Nonetheless, this overview provides a clear indication on strategies and ambitions of the main space actors.

3.2.1. Robotic exploration missions

Space exploration has become a major element of the portfolio of any country with global aspirations, especially when looking at the current as well as the world's top 10 economies as projected for 2025. In this context, while the first two phases of space exploration concerned a limited number of countries with only the United States, Russia (ex-U.S.S.R), Europe (ESA and several of its member States) and Japan having dedicated robotic exploration missions,[35] the next two decades are expected to see a dramatic internationalization and globalization of space exploration with six countries and Europe (including ESA and several member states) having robotic missions to different destinations in the solar system (Table 2).

When looking at the different destinations, the moon is the centre of attention of most plans of robotic missions with 48% of all robotic missions launched and under development in the 2004-2025 timeframe targeting the Earth's natural satellite (Figure 7). Mars is the second target of choice for the countries involved in space exploration strategies with 27% of all robotic exploration missions targeting the Red Planet. Other planetary bodies, and particularly Venus, are destinations of choice, followed by near Earth objects (NEOs) (Figure 7).

While the moon is the destination of choice in terms of missions launched, it is also the target of the biggest number of countries involved in space exploration activities, irrespective of the type of activity be it orbiters, landers or sample return missions (Figure 8). For instance, following the footsteps of ESA's SMART-1 (Small Missions for Advanced Research in Technology-1) orbiter, a fleet of automated spacecraft are currently being dispatched to the moon by China, Japan the United States, and these States will soon be joined by India. Robotic missions to the moon, including orbiter missions, lander missions with mobility (i.e. rovers), as well as sample return missions are under development or planned by six countries plus Europe in the 2004-2025 timeframe (Table 2).

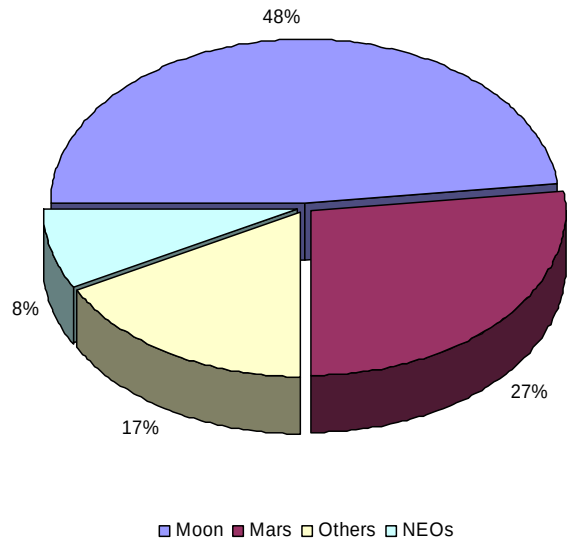

Figure 7. Estimate of the share of robotic missions per destination planned beyond LEO and scheduled for launch in the 2004-2025 timeframe

A new robotic International Lunar Network (ILN) that will aim to accelerate the first multinational operations on the surface of the moon is also under development. Nine partners (Canada, France, Germany, India, Italy, Japan, the Republic of Korea, the United Kingdom, and the United States) indicated in July 2008 that they are considering placing relatively standardized small, fixed robotic stations or simple rovers at several places across the moon as early as in 2013-2014.[36]

[33] A mission having different payloads is counted only once and the mission is only attributed to the lead country.
[34] Human exploration of Mars is excluded as no space agency has yet put forward a solid plan to launch a mission and land a human on Mars before 2025.
[35] Peter, Nicolas "Towards a new inspiring era of collaborative space exploration" Humans in Outer Space–Interdisciplinary Odysseys. Ed. Luca Codignola, Kai-Uwe Schrogl with Agnieszka Lukaszczyk and Nicolas Peter. Vienna: Springer, Forthcoming 2008.

[36] Covault, Craig "Lunar Robotic Network Revealed" Aviation Week & Space Technology. 17 Mar. 2008: 56

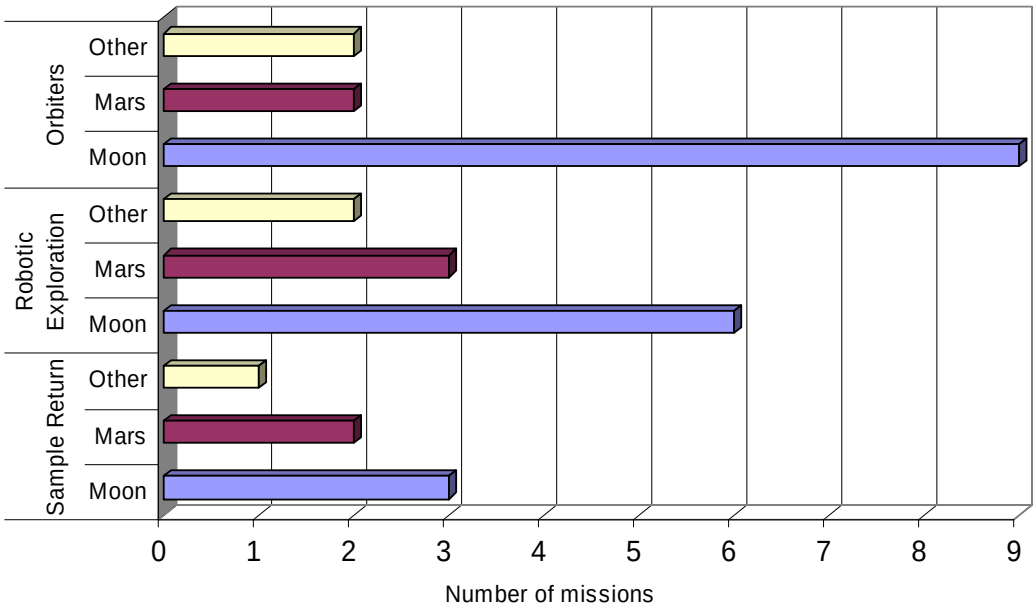

Figure 8. Estimate of the number of countries involved in robotic missions per destination scheduled for launch in the 2004-2025 timeframe

This robotic network is designed to gradually place 6-8 fixed or mobile science stations on the lunar surface that would form a seismic network keyed toward determining the nature of the moon's core and understand moonquakes and meteor impacts. It would also allow beginning lunar surface hardware cooperation with simple devices.[37] ILN will allow to build a coordinated network that none of the countries could afford to do independently and serve as a test-bed technology project for lunar telecommunications and navigation spacecraft, robot landers, and other significant infrastructure, such as ground segment elements or power supplies for surviving the lunar night. International participation in specific ILN activities will be established by appropriate international agreements. Additional participants may join in the future when they are programmatically and financially ready.

Several robotic spacecraft will also be sent to Mars and other planets in the Solar system (Table 2). There are, however, fewer

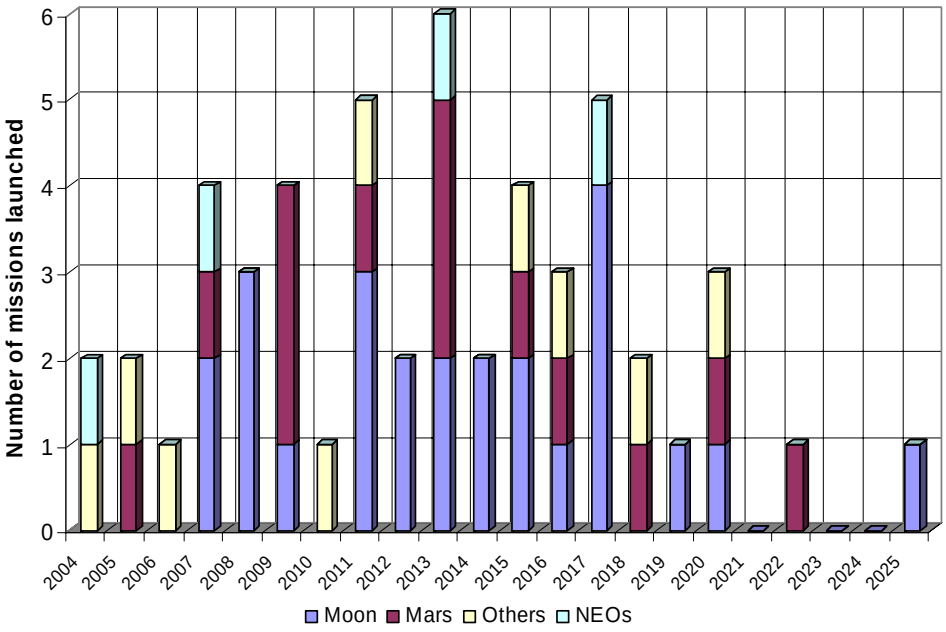

Figure 9. Robotic missions beyond LEO planned and scheduled for launch from 2004 until 2025 to the Moon, Mars, NEOs and others planetary bodies

[37] ibid

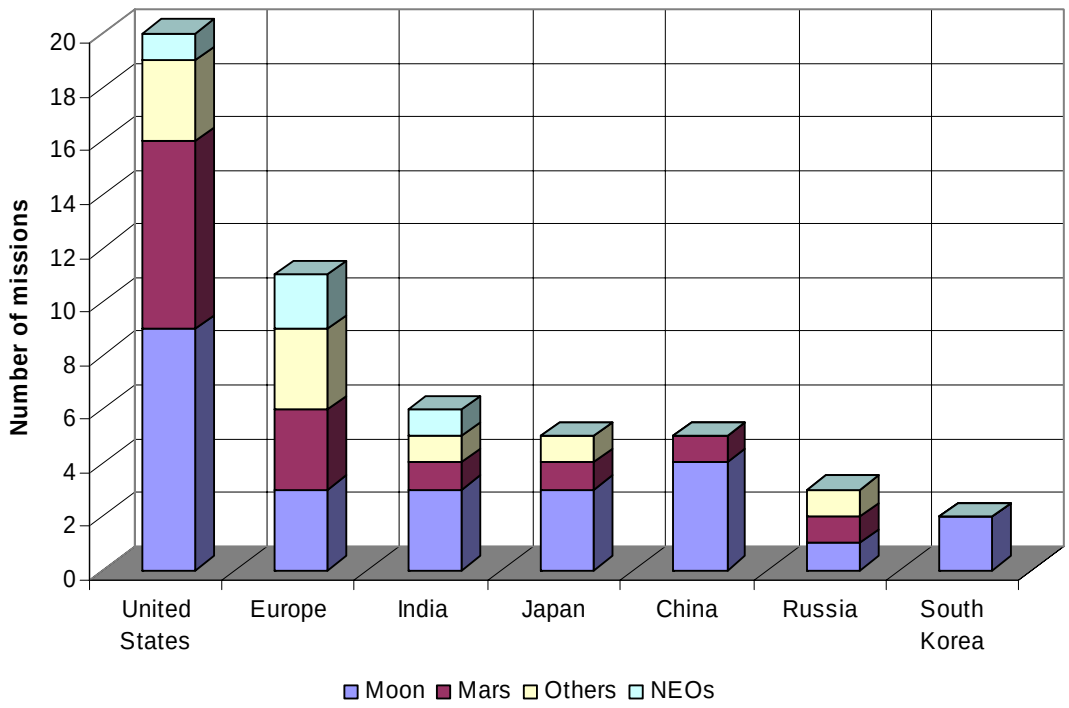

Figure 10. Robotic missions launched, planned and scheduled for launch from 2004 until 2025 per country and destinations

missions planned to Mars than to the moon (figure 3). Four countries plus Europe intend to send robotic missions to the Red Planet in the 2004-2025 timeframe (Figure 9).

When looking at the sequence and timing of those missions from 2004 until 2025, there is a steady increase in the number of missions scheduled to be launched until 2013; with that year seeing six missions to be launched (Figure 9).

It is estimated that 52 robotic missions having a launch date before 2025 are planned and scheduled (Figure 10). The United States is the clear leader in space exploration with 20 missions planned and under consideration, followed by Europe with 11 missions planned and under consideration (Figure 10). The on-going space rush in Asia is illustrated by the fact that India has six robotic missions planned and under consideration in the 2004-2025 timeframe, Japan and China 5, and South Korea 2 (Figure 10). Finally, Russia has three missions planned demonstrating its willingness to reenergize its lunar and planetary programmes.[38]

By looking at Figure 10, it appears that the United States, Europe and India are the most versatile actors in the field of robotic space exploration as they are the only countries that have plans to lead missions to the moon, Mars, NEOs, as well as to other planetary bodies. South Korea, by contrast, focus only on robotic missions to the moon (Figure 10).

3.2.2. Human spaceflight activities

When looking at human spaceflight activities, access to LEO is currently the main target, with various countries already having crew and cargo capabilities and new capabilities under development or consideration (Table 3). Countries involved in human spaceflight activities are less numerous than in the case of robotic missions beyond LEO due to the obvious technical and financial costs of human spaceflight programmes. However, several systems to go to the moon are also considered, particularly in the United States in the framework of the U.S. Space Exploration Policy (Cf. Ares V, the Altair landing module and the Earth Departure Stage).

In the domain of human spaceflight, the most emblematic and visible aspect of space exploration, but also the prerequisite for being a major player in space, the United States, Russia and China have already secured autonomous human access to LEO (Table 3).

[38] No Soviet lunar mission has been launched after 1976 and no planetary missions were flown after the Mars 96 launch failure.

Crew Vehicle			Cargo Vehicle		
In operation	Under development	Possible	In operation	Under development	Possible
United States	United States	Russia	United States	United States	India
Russia		Europe	Russia		
China		India	China		
		Japan	Europe		
			Japan		

Table 3. Crew and cargo launch vehicles in activity and under development until 2025

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
China								CZ-5						
India	SRE-1	SRE-2		GSLV-Mk III					Indian manned Vehicle					
Japan			HTV											
Russia					Angara									Angara manned version
USA				COTS-1 (Dragon and Cygnus)				Ares I	Orion Altair			Ares V		
Europe		ATV												

Table 4. Launch vehicles under development until 2025 for crew and cargo access to LEO and beyond

However, those three space powers are also upgrading their human transport systems by developing more capable launch vehicles (e.g. Ares I in the United States, Long March CZ-5 in China or Angara in Russia) or new crew vehicles (Orion in the United States) (Table 4). India has also started to conduct preliminary developments of a possible crew vehicle (SRE-1 and 2) that complements its improvements of its launch vehicle fleet (GSLV Mk-III) (Table 4).

It appears therefore, when looking at Table 4, that in the next two decades there will be an increasing number of capabilities for sending cargo into LEO (United States, Russia, China, Europe, Japan and India) and beyond (United States and possibly Europe and Russia), as well as humans into orbit (United States, Russia, China and maybe India and Europe).

3.2.3. International cooperation in space exploration

In the four years since the announcement of the U.S. Vision for Space Exploration, many countries have expressed an interest in collaborative exploration programme.[39] Formal discussions of the goals, capabilities, and timelines for future space exploration, particularly those focusing on the moon, have taken place among major space agencies.[40] This illustrates the paradigm shift in space exploration and indicates that international cooperation is now becoming central to any long-term space exploration strategy.[41]

In particular, the result of the work between representatives of fourteen space agencies, should be mentioned. On 31 May 2007, at the third ESA/ASI workshop on "International

[39] The new U.S. Space Exploration Policy seeks to "promote international and commercial participation in space exploration to further US scientific, security, and economic interests" and invites "other nations to share the challenge and opportunities of this new era of discovery."

[40] Other international working groups like the International Mars Exploration Working Group (IMEWG), the International Lunar Exploration Working Group (ILWEG) and the International Primitive Body Exploration Working Group (IPWEG) are platforms having representatives from all space agencies and major institutions used to exchange information on plans and strategies and promote international cooperation to maximize outcomes for each mission.

[41] Peter, Nicolas "Towards a new inspiring era of collaborative space exploration" Humans in Outer Space–Interdisciplinary Odysseys. Ed. Luca Codignola, Kai-Uwe Schrogl with Agnieszka Lukaszczyk and Nicolas Peter. SpringerWienNewYork, Forthcoming 2008.

Cooperation for Sustainable Space Exploration", 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.[42] From this document, the international definition of space exploration may be read as "a global, societal project driven by the goal to extend human presence in Earth-Moon-Mars space" [43] with the five exploration goals being:

- Human missions to near Earth orbits;
- Robotic and human exploration of the moon;
- Human missions to liberation points of the Earth-moon and Earth-sun systems;
- Robotic (and human) exploration of near-Earth objects (NEOs);
- Robotic and human exploration of Mars.

The document also discusses the rationale for society to explore space-based activities around five major themes: new knowledge in science and technology; sustained presence – extending human frontiers; economic expansion; a global partnership; inspiration and education. The May 2007 document illustrates therefore the awareness of the value of space exploration as a global, societal project.[44]

The "Global Exploration Strategy" (GES) also develops the case for globally coordinated space exploration and investigates, among other things, a framework for the future coordination of global space exploration. It recognizes that "Sustainable space exploration is a challenge that no one nation can do on its own. We are now entering a new wave of space exploration, one of historic significance. The United States has developed its Vision for Exploration, the European Space Agency has its Aurora space exploration programme. China, India, Japan and Russia have ambitious national projects to explore the moon or Mars, while future national missions are being discussed in Canada, Germany, Italy, Republic of Korea and the United Kingdom".[45] This strategy is designed to introduce minimum standards of interoperability to facilitate cooperation, while permitting individual countries to pursue their own national strategies. It also sets the stage for future discussions on ways to exchange information on national interests. A key finding of the Framework Document was the need to establish a voluntary, non-binding international coordination mechanism through which individual agencies may exchange information regarding interests, objectives and plans in space exploration with the goal of strengthening both, individual exploration programs as well as the collective effort. To support the implementation of the GES, the International Space Exploration Coordination Group (ISECG) has been created in November 2007 to facilitate the coordination of future space exploration plans towards achieving the goals of the GES and will soon be completed by an ISECG Secretariat.

3.3. Europe in space exploration

Europe (defined as ESA and its member States) has a long-standing tradition of space exploration and has participated with outstanding success in activities in many exploratory missions on its own and in partnership with other space-faring countries. However, the European space exploration context might evolve in the decades to come due to the increasing involvement of the EU in space affairs.

3.3.1. European programmes

Europe's long-term plans for exploration began in 2001 when the Aurora programme of robotic and human exploration of the Solar system was presented at the ESA Ministerial Council held in Edinburgh (Scotland). Aurora's primary objective was to develop a roadmap that would culminate with European astronauts reaching Mars within the first half of this century, preceded by a return to the moon. The Aurora programme aims to establish the ability of Europe to participate as a recognised partner in future robotic and human international space exploration endeavours. In December 2005, the importance of Aurora was re-affirmed at the ESA Ministerial Council in Berlin with the approved programme consisting of three major elements: the Aurora Core Programme, Aurora Robotic Exploration Missions and the Crew Space Transportation System (CSTS) Preparatory Programme. [46]

[42] 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 17-country ESA.

[43] "The Global Exploration Strategy Framework: Executive Summary". NASA. 31 May 2007 < www.nasa.gov/pdf/178109main_ges_framework.pdf >.

[44] Peter, Nicolas "Towards a new inspiring era of collaborative space exploration" Humans in Outer Space–Interdisciplinary Odysseys. Ed. Luca Codignola, Kai-Uwe Schrogl with Agnieszka Lukaszczyk and Nicolas Peter. SpringerWienNewYork, Forthcoming 2008.

[45] "The Global Exploration Strategy Framework: Executive Summary". NASA. 31 May 2007 < www.nasa.gov/pdf/178109main_ges_framework.pdf >.

[46] Several other solar system missions are also currently

The Aurora Core Programme is a preparatory programme for the development of European capabilities for enabling the long-term human exploration of the moon and Mars. The key objectives concern the development of an integrated long-term strategy for space exploration, General Technology Development for Exploration and Preparation for Lunar Exploration. A Mars Sample Return (MSR) mission has been identified as a key milestone in the scientific exploration of Mars and in the development of enabling capabilities for future exploration missions. An agreement with NASA on MSR cooperation is under discussion and activities have started on the International Mars Exploration Working Group on the definition of the MSR mission.

The Aurora Robotic Exploration Missions cover the development, launch and operation of selected exploration missions, the first of which is ExoMars to be launched in 2013. ExoMars is a robotic rover mission intended to perform exobiology and geology research. This will be the first ESA-led robotic mission to Mars. Cooperation agreements have been established between ESA and NASA, as well as between ESA and Roscosmos.[47] Canada is also participating in the mission through the ESA.

Completing the Aurora programme, ESA member States decided in 2006 the start of the Crew Space Transportation System (CSTS) Preparatory Programme together with the Russian Space Agency and other Russian organisations. The CSTS is intended for use in human exploration missions to the moon (both in orbit and on the surface) via LEO assembly, in addition to supporting missions to the ISS. ESA is also investigating other options that might provide European autonomy in human spaceflight activities (the so-called ECSTS)

ESA's Next Exploration Science and Technology Mission (NEXT) is also intended to fill a gap in ESA's exploration activities between ExoMars and MSR. NEXT must demonstrate key technologies for MSR and other future space exploration missions. Two NEXT missions concepts have been selected for Phase A Study: a Mars mission, Mars-NEXT, and a moon mission, Moon-NEXT. Based on the results of these studies, one mission will be selected. Mars-NEXT is a mission to be launched in 2018, after ExoMars and before MSR. The mission would include a spacecraft carrying three or four lander probes to establish a network of stations on the surface of Mars to investigate the internal geophysical aspects covering the structure and dynamics of the interior of Mars, the geology of each landing site and the atmospheric physics of Mars. The Moon-NEXT mission is a small rover foreseen to be launched in 2016 as part of the ILN effort targeted to land on the rim of the Shackleton crater near the lunar South Pole to study it as a potential human landing site. This mission would allow demonstrating precision soft-landing and hazard avoidance technologies, characterize the lunar surface environment, and perform various geophysical and geochemical investigations.

Europe has also been actively participating in human spaceflight since the flight of Vladimir Remek in 1978 (from at the 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 and the European human spaceflight programme is currently focused on assembly, operations and utilisation of ISS.[48] ESA is a major partner in the programme with the orbital laboratory Columbus launched in 2008, and the operational cargo system Automatic Transfer Vehicle (ATV), launched atop an Ariane 5 that is a key element of the ISS logistics system.[49] In addition, Europe provides the ISS with various hardware elements and services (i.e., the Microgravity Glovebox, the European Robot Arm ERA). ESA continues also to support the European programme for Life and Physical Sciences and applications (ELIPS) in the ISS. Finally, ESA possesses also a European Astronaut Corps. Europe is however fully dependent on international partners to access space.

envisaged in the context of the Cosmic Vision 2015-2025. The Cosmic Vision has its underlying vision the search for understanding of the Universe from the Big Bang, responding to question on the conditions of life and planetary formation, as well as on the formation and functioning of the Universe.

[47] The United States and Russia are major partners in this mission for the provision of among other data relay communication functions, the Pasteur Urey instrument and contribution to other Pasteur and Humboldt instruments, linkage to Phobos-Grunt mission, radio-isotope Heating Units (RHUs) etc.

[48] The nominal ISS programme ends in 2015 but discussion at international level have been initiated about possible extension of the programme until 2020.

[49] The ATV provides its own guidance, propulsion and docking systems and is capable of transporting more than 7 tons of scientific payload, general supplies, water, oxygen and propellant to the ISS.

3.3.2. National missions

Due to the high expenditures associated with space exploration, most of European involvement in this domain has been related to ESA missions. However, some countries have been involved independently in space exploration activities. 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 considering developing future robotic missions to the moon. For instance, the United Kingdom is developing a moon orbiter including penetrators (MoonLITE), Germany a Lunar Exploration Orbiter (LEO)[50], the Italian space agency ASI is considering a national lunar exploration programme (with orbiter/lander), while the French space agency CNES is investigating science oriented missions to Mars, possibly to near-Earth asteroids and to the moon. Various countries provided also instruments onboard of ESA-led missions such as Venus Express, etc. or for other planetary missions led by international space powers, such as Chaandrayan-1 from India.

Several European countries are also involved in the ISS programme particularly through scientific experiments, but some also provide specific infrastructure components to the station (the Multi-purpose Logistics Modules, and nodes 2 and 3 connecting the ISS modules, and the Cupola Earth observation platform).

3.3.3. Towards a new European space context

Contrary to the plans of the major space-faring countries and particularly the United States, Europe does not enjoy strong political backing or support for space exploration. This is due partially to the multi-level structure of European space activities between member States, ESA and since recently, the EU. However, the evolution of the European space landscape projected with the 2007 European Space Policy and the Lisbon Treaty and a greater involvement of the EU could be of benefit for European space exploration plans, and not only budgetary, but also politically, due to the fact that the EU is a centre of gravity in international affairs and in S&T.

The scope of the policies, responsibilities and expertise of the EU have broadened enormously since it came into existence in the 1950s, and it has now become involved in just about every sphere including S&T (and space affairs). The EU has also developed a proactive international policy in S&T to promote its goals, based on large and visible projects that aim to attract attention.[51] They have been an element of its relations with the rest of the world as S&T agreements have become a sort of umbrella policy over the years, where different distinct dimensions come together, including diplomacy. [52] European countries realized long ago that, in order to be able to compete internationally; they had not only to cooperate among themselves to unite their forces, but also to seek international partners.[53] Therefore, S&T cooperation for Europe is a long-established strategy and often a *sine qua non*.[54]

International cooperation in S&T has been growing steadily since World War II and may be considered the biggest contemporary axis of civilian governmental cooperation. The EU has consequently built a diverse and robust network of relations and cooperation with non-EU countries and organizations using S&T agreements and its Framework Programme (FP) [55] with the intention to become a centre of gravity in international S&T cooperation. The EU is thus increasingly using its "soft power" as a tool of foreign policy, both to reinforce existing relations and to establish new partnerships. Today, the EU tends to structure its most important foreign policies into broad dialogues or framework agreements, which involve, among other things, economic and political dimensions, as well as an S&T dimension. This capacity to "package" EU external policies into comprehensive multi-dimensional cooperation agreements has allowed the EU to augment

[50] LEO is currently in discussion for approval by the German Ministry of Finance.

[51] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy 23.2. (May 2007): 97-107.

[52] The signing of an international S&T agreement between governments or international organizations can indicate a willingness to improve relations among countries, leading in turn to broader cooperation.

[53] Peter, Nicolas. "The Changing Geopolitics of Space Activities". Space Policy 22.2 (May 2006): 100-109.

[54] Ibid.

[55] The EU's Framework programmes (FPs) are the primary tool for framing European research in the EU. FPs define the objectives, priorities and financial support from the EU over a few years in a limited set of topics. They are designed to complement and strengthen efforts at the national level by enabling effective medium- to long-term planning of research and are undertaken only when appropriate. FPs have grown since their creation in terms of resources allocated but also in terms of topics covered, allowing the EU to be more reactive and so to adapt quickly to a constantly evolving context of worldwide S&T research competition. They have been implemented since 1984 and cover a period of five-to-seven years with the last year of one FP and the first year of the following FP overlapping. The seventh FP was launched in January 2007 for 7 years.

its volume of activities over the years as well as to expand its influence in the world. This is particularly important today, since what was often considered "low politics" (i.e. S&T cooperation) has gained status and is now used as a tool to reach different countries as part of a broad foreign policy agenda.[56]

The increasing inter-linkages of EU's S&T and foreign policy are particularly important in space activities, as space has always been a domain of ''high S&T'' politics.[57] European openness to international cooperation with various actors through the establishment of strategic partnerships by ESA, national space agencies and the EU, provide a variety of possibilities for cooperation with the rest of the world, illustrating that European diversity is definitively a "multiplier factor" in international cooperation.[58] These different European space levels have started numerous scientific and technical cooperative programmes with a great variety of countries. However, the EU is establishing a new position in this changing geopolitics of space activities as illustrated by the strong international cooperation component of the Galileo programme. It is striking a balance between mutually beneficial cooperation and competitiveness combined with non-dependence. However, one of the distinctive features of the increasing involvement of the EU in space affairs is also that, while ESA was more responsive to the overall geopolitical context, the EU is more proactive on the international scene, since it can cooperate at various different levels with various other partners, with "high policy" as its objective.[59]

The EU does not have direct responsibility for space exploration yet. However, with the increasing role of the EU in space affairs, it is expected that it will encroach space exploration as it has demonstrated its ability to initiate and implement major supranational programmes such as Galileo and GMES. The fourth Space Council, a joint meeting of the Competitiveness Council and the Ministerial Council of the European Space Agency (ESA), made a major political commitment on 22 May 2007 when it adopted a Resolution concerning Europe's Space Policy. This followed the publication of a Communication drafted jointly by the Commission and the Director General of ESA and their member States, adopted on 26 April 2007 and entitled "European Space Policy". The European Space Policy outlines the strategic guidelines for Europe's future activities in space and highlights the strategic nature of the space sector contributing to the independence, security and economic development of Europe and recognizes the actual and potential contributions from space activities to support EU policies. The Resolution acknowledges also the rank of Europe as a leading space-faring actor and that Europe remains committed to maintain its position through closer intra-European and international cooperation. In overall terms, the Resolution clearly states the strategic importance of space for Europe in demonstrating its independence and its readiness to assume global responsibilities.[60] The Communication on the European Space Policy concerning space exploration states that "The international exploration endeavour has a significant political appeal in a vision of European identity, due to its potential to contribute to the creation of new knowledge, to foster innovation and to engage new companies and research organisations in space activities. The US, China and Russia have moved forward with ambitious space exploration plans. Now, Europe needs to urgently respond to these challenges". The Space Council Resolution states that "The Council emphasis the importance of a proactive ESA participation in the preparation of future international space exploration programmes, with the objective of ensuring a targeted and coordinated European role in this endeavour".[61]

While according to the current European Space Policy, ESA takes the lead with respect to Europe's overall representation in the area of space exploration after consultation with member States and the EU, as appropriate, and according to the decision of various member States, the role of the EU is expected to strengthen with the entry into force of the "Lisbon Treaty", or any alternative document.[62] The "Lisbon Treaty" aims to enhance the efficiency of the EU with a major focus on the reorganisation of the institutional and decision-making process of the EU, but it creates also legal bases for the

[56] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107.
[57] Since the successful launch of Sputnik I in 1957, space, like nuclear activities, has always been a prestigious S&T domain, in which governments have had strong interests.
[58] Peter, Nicolas. "The Changing Geopolitics of Space Activities". Space Policy 22.2 (May 2006): 100-109.
[59] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107.
[60] Council of the European Union "Resolution on the European Space Policy" DS 471/07 16 May 2007.
[61] Ibid.
[62] The consequences of the rejection of the referendum in Ireland vis-à-vis the adoption of the "Lisbon Treaty" on 12 June 2008 are still unclear, but the ratification process is expected to continue and no major modifications to the articles dealing with space affaires are foreseen if a new document would be drafted.

action of the EU in certain areas not previously explicitly covered, among which is "space". Using substantially the same wording as foreseen in the Treaty Establishing a Constitution for Europe of 2004 ("the Draft Constitutional Treaty") the Lisbon Treaty refers to "space" in two articles.

Article 4.3 states that

- "In the areas of research, technological development and space, the Union shall have competence to carry out activities, in particular to define and implement programmes; however, the exercise of that competence shall not result in Member States being prevented from exercising theirs."

Article 189, included in the Title XIX headed "Research and technological development and space": states:

- "To promote scientific and technical progress, industrial competitiveness and the implementation of its policies, the Union shall draw up a European space policy. To this end, it may promote joint initiatives, support research and technological development and coordinate the efforts needed for the exploration and exploitation of space.
- To contribute to attaining the objectives referred to in paragraph 1, the European Parliament and the Council, acting in accordance with the ordinary legislative procedure, shall establish the necessary measures, which may take the form of a European space programme, excluding any harmonisation of the laws and regulations of the Member States.
- The Union shall establish any appropriate relations with the European Space Agency.
- This Article shall be without prejudice to the other provisions of this Title."

The provisions of the Lisbon Treaty make a clear attribution of competences to the EU in the space field as a "support competence". Consequently the EU is foreseen in the future to take a larger role in space policy including eventually space exploration. EU's involvement would allow the emergence of an exploration strategy based on ambitious political goals and would reinforce existing plans such as the Aurora programme.

Up-to-now, the EU and the European Commission (EC) has been reluctant to get involved in space exploration but this is evolving. As indicated in April 2008 by Vice-President of the European Commission Günter Verheugen, Commissioner for Industry and Enterprise in charge of space policy in the EC, while acknowledging that relatively little resources are allocated for space exploration from the EC budget, indicated that this needs to change. For him, in the context of the international situation, it is perceived that space exploration done in cooperation could be a way to ensure the competitiveness of the industrial and scientific sector in Europe. This echoes the space policy speech given by French President Nicolas Sarkozy on 11 February 2008 that encourages the EU's involvement in space and underlines that France considers the EU as the right vector for large projects with ambitions that go beyond the reach of any member State, but also to strengthen Europe's assets in space exploration. Space exploration could therefore become a new Community initiative. As underlined by Vice-President Günter Verheugen, space exploration (to Mars) should be done in the context of international cooperation with Europe's main partners. President Nicolas Sarkozy indicated also that a stand alone European exploration programme should not be considered insofar as it should only be elaborated in collaboration with the United States and other space-faring countries, since space exploration can be only a global endeavour.

At the first informal Space Council meeting, held on 20-22 July 2008 in Kourou (French Guiana) in the context of the French Presidency of the Council of the European Union (also called the French Presidency) the European ministers for space affairs while dealing with major space issues considered among others the role of the EU in space exploration. While acknowledging that the European exploration programme must be conducted as part of a global programme that is open to all countries. They concluded that "it is essential to carry out an audit of the existing skills that are crucial in determining the European Union's involvement in such a programme" and that "a conference should be launched to decide in more detail what the European Union may contribute to such a programme"[63]. This does therefore illustrate the paradigm shift whereby the EU is increasingly being considered as a future stakeholder in space exploration.

Finally, while strong European institutions are likely to foster strong space programmes through enhanced political visibility and

[63] Outcome of the meeting of ministers for space affairs, Kourou (French Guiana). PFUE-22 July 2008. < http://www.ue2008.fr/impressionPDF.do?url=%2FPFUE%2Flang%2Fen%2Faccueil%2FPFUE-07_2008%2FPFUE-22.07.2008%2Fresultats_de_la_reunion_des_ministres_en_charge_de_l_espace_a_kourou_guyane%3Bjsessionid%3DF6F57EEA5C03BE8BB71D4ED68A223E9D>.

budgets, successful and ambitious space exploration programmes can help to reinforce the building of a European identity. Space exploration may therefore be seen as a brick in the process of the European construction and as a building block of a European identity. As stated on 9 May 1950 by Robert Schuman, the French Foreign Affairs Minister, ''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.'' [64] Space exploration can be one of those achievements. It can help to promote the awareness of a common European identity among citizens and demonstrate increased confidence in the future capabilities.

3.4. Country outlook

Space exploration, an issue that used to be of marginal political interest in recent years is now at the top of the space agenda in many countries. While Europe is in the process of setting the stage for future missions and plans, a better understanding of the future plans of selected non-European actors is needed especially before engaging in long-term space exploration and consider international cooperation. Future space exploration cooperative ventures will fail if expectations are unrealistic, rules unclear, commitments unreliable or capabilities insufficient. They require thus a thorough understanding of the capabilities, preferences and plans of potential partners. The space background and space exploration plans of the eleven countries already analyzed (Cf. Chapter 2), as well as their relations with others, but also with Europe are therefore presented to provide the relevant insights needed to assess the existing relations and future aspirations.

3.4.1. Australia

Australia joined the European Launch Development Organisation (ELDO) as an associate member in 1961, and while it was the fourth country to launch a satellite (WRESAT) from its territory on November 1967 its activities in space have been modest since the United States and ELDO stopped using the Woomera launch site in the 1970s. The Australian Government is, however, currently engaged in rather limited space-related activities in support of national strategic, economic and social outcomes and reassessing its ambitions and aspirations in space. [65] The country's space engagement is user and market-driven, with a key objective being to obtain secure and economic access to the benefits of using space. A range of organizations undertake space-related activities in Australia, but Australia's national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), is the one most involved in space affairs. It manages operations of the Canberra Deep Space Communication Complex (CDSCC) and the new Australian Tracking Facility (ATF) in Western Australia.

Australia	
Space Agency: Office of Space Science and Applications part of the Commonwealth Scientific and Industrial Research Organisation (CSIRO)	**National Space Budget:** 10 million USD (est) Foreseen Budget Trend: Stable
Priorities in Space: • Earth observation and environment monitoring • Space science (radio-astronomy) • Space-related engineering (small scientific satellites)	**Selected Space Exploration Prospects:** • Host of ground infrastructure for radio communication and tracking to support future robotic and lunar exploration activities • Potential instruments for on-board robotic missions

Australia has up-to-now played a small, but significant, role in space exploration with the management of Australian-based ground stations in support of NASA programmes ranging from Earth orbiting, human space flight programmes (including Gemini, Mercury and Apollo programmes) to solar system exploration. Australia has had two of its citizens fly in space for a total of five flights.[66] Despite its limited activities in space exploration in recent years, the country is increasingly interested in taking part in international exploration ventures as illustrated by its participation in the Global Exploration Strategy. Australia's contribution to international cooperative arrangements is primarily foreseen for areas where it has competitive advantages such as in the ground-segment aspects of space

[64] Schuman R. Declaration of 9 May 1950, </http://www.robert-schuman.org/robert-schuman/declaration2.htmS>.

[65] Australia. Department of Industry, Tourism and Resources. "Australian Government Space Engagement. Policy Framework and Overview"– Nov. 2006

[66] Paul Desmond Scully-Power flew once (1984) and Andrew Thomas flew four time (1996, 1998, 2001, 2005). Both flew as NASA astronauts.

infrastructure with ground station facilities to support international endeavours in space. And, while no national exploration missions are currently planned, Australia is potentially interested in providing instruments and subsystems for future robotic missions.

In terms of international cooperation besides historical space cooperation with the United States and Europe, Australia is increasingly anchoring itself in the Asia-Pacific region and is reaching out to regional actors like Japan, China or South Korea. Nonetheless, Europe remains a partner of choice for Australia.

Australia has over the years developed strong relationships with Europe through its member States and particularly with the United Kingdom. Europe is the major economic partner of Australia while Europe benefits from Australia's mineral and energy commodities. EU-Australia bilateral relations are based on the Joint Declaration on relations between Australia and the European Union, signed on 26 June 1997. The Joint Declaration was followed by a document entitled "Australia and the European Union: an Agenda for Cooperation", which was adopted in 2003 and which will be revised in 2008. Active cooperation in a broad range of sectors including science and technology (S&T) is a regular practise. As part of the 1997 Joint Declaration on relations between Australia and the EU, a specific section is devoted to "Scientific and cultural cooperation, education and training". Australia may also participate in the framework programme. Furthermore, to promote the interaction between the EU and Australian research communities, the Forum for European-Australian Science and Technology (FEAST) has been set up as a key vehicle in this process.

Australia has had a series of cooperative ventures in space with Europe. In particular it was, as aforementioned, an associate member of the ELDO. However, since the 1970s cooperation with Europe in the space sector has been limited. Today, Australia hosts one of ESA's ground stations in New Norcia and the EU has included in May 2007 the Australia Square Kilometre Array Pathfinder (ASKAP) radio telescope in a priority list of 35 large-scale research projects. Australia is also increasing its involvement with the EU in space affairs, since it expressed interest in participating in the Galileo project.

3.4.2. Brazil

Brazil	
Space Agency: Agência Espacial Brasileira (AEB)	**National Space Budget:** 151 million USD Foreseen Budget Trend: Rising
Priorities in Space: • Satellite activity concentrating on Earth observation applications, telecommunications and scientific missions • Access to space via the development of indigenous launch capabilities	**Selected Space Exploration Prospects:** • Potential contributions to ISS (hardware of experiments) • Potential access to space • Potential instruments for on-board robotic missions • Ground infrastructure (tracking and telemetry)

Brazil undertakes by far the largest space programme in South America. Its space activities started in the 1960s with a launcher development programme and scientific and application satellites. Brazil's space activities emphasised also the development of space technology applications, particularly Earth observation and telecommunications. The first Brazilian satellite was launched (by the United States) in 1993 (SCD-1). In the early years of Brazil's space programme, the military sector controlled a large portion of its activities and budget. However, in 1994, most of these operations were transferred to civilian authorities. The Brazilian Space Agency (AEB) was created to manage Brazil's space policy and the national programme. Its main operational arm the Instituto Nacional de Pesquisas Espaciais (INPE) was created in 1971. Over the last several years, Brazil's space programme has oscillated between technical successes and major setbacks particularly in the development of its indigenous launcher family to access space from its Alcantara launch centre. In 2003, the explosion of a VLS (Veiculo Lancador de Satelites) rocket on the launch pad killed 21 engineers and technicians. However, a year later the first Brazilian sounding rocket VSB-30 was successfully launched.

Since the inception of its space activities, Brazil has oriented its initiatives towards applications that meet its society's needs and demands. However, in 1997, the AEB and NASA signed an agreement where Brazil agreed to provide scientific equipment for the International Space Station with in particular the "Express" Pallet (ExPS) in return for utilization rights and astronaut flight opportunity. But, due to economic turmoil in

the region, and particularly in Brazil, allocations to the space programme were significantly cut at the beginning of the century with the contribution to ISS largely affected. Brazil had to renegotiate its participation in the ISS programme and cancelled the Express pallet project. Nonetheless, in 2006 Brazil entered the exclusive club of countries having astronauts with the first Brazilian astronaut, Marcus Pontes, sent in space in March 2006 aboard the Soyuz TMA-8/12S mission for a 9-day trip to ISS based on a Russian-Brazilian agreement. Thus, while Brazil is not part of the GES it was however a partner of the ISS carrying a number of experiments and it has ground stations that can be used for exploration missions.

International cooperation has been from the inception of the Brazilian space programme a vital component in the planning and implementation of its space activities. Brazil puts consequently a great emphasis on international cooperation and has developed many activities with several countries. The AEB pursues a policy of cooperative technological developments, which includes strong relationships with the United States and agreements with Argentina, China, India, Israel, Russia, the Ukraine, etc. In particular, Brazilian space activities have benefited from active bilateral cooperation with China, notably on the China-Brazil Earth Resources Satellite (CBERS) programme. Furthermore, Brazil is also increasingly cooperating with India in a similar fashion it cooperated with China in the 1990s to foster "South-South" cooperation. Brazil has also entered into a partnership with the Ukraine and in discussions with Russia to receive help and support for the development of its launch sector and the exploitation of the Alcantara Launch Centre.

Europe and Brazil have close historical, cultural, economic and political ties, particularly through EU's member States, and specifically Portugal. The EU and Brazil established diplomatic relations in 1960. The present relationship is governed by the EC-Brazil framework co-operation agreement (1992), the EU-Mercosul Framework Co-operation Agreement (1995) and an EU-Brazil S&T Cooperation Agreement (2004). The S&T Cooperation Agreement opened the way for Brazil to participate in the EU's Framework Programme. In addition, a series of "Specific International Co-operation Actions" (SICA) will be dedicated to international cooperation with Brazil to jointly address, on the basis of mutual benefit, issues of shared concern. In May 2007, the EU recommended to launch a strategic partnership to further deepen its ties with Brazil. Consequently, the first ever EU-Brazil Summit was held in Lisbon in July 2007.

Space is also an area of increasing cooperation. Member States and ESA have been the traditional driver of this partnership. For instance, Brazil signed a cooperation framework agreement in February 2002 with ESA and, in 2004, an extension agreement for the setting up and use of tracking and telemetry facilities on Brazilian territory was signed. Brazil is also cooperating on the CNES-led COROT mission. However, with the development of the Galileo programme a greater EU-Brazil dialogue on space is developing. The creation of GEONSAT (interministerial group headed by the Brazilian Space Agency, with the task of preparing the decision on Brazil's participation in the Galileo programme) demonstrates that the matter is being taken seriously. However, despite expressions of interest on various occasions at different levels, and a number of specific EC-Brazil dialogues on Galileo, no official position has been communicated thus far to the European Commission.

3.4.3. Canada

Canada	
Space Agency: Canadian Space Agency (CSA)/Agence Spatiale Canadienne (ASC)	**National Space Budget:** 384 million USD Foreseen Budget Trend: Stable
Priorities in Space: • Space technology applications Earth observation and telecommunications • Space robotics (ISS) • Space science • Human space flight and space exploration	**Selected Space Exploration Prospects:** • Support technologies for robotic and human space flights exploration activities • Contribution to ISS • Strong interest in Mars and lunar exploration • Potential instruments for on-board robotic missions • Utilization of Mars Analogue Station in Nova Scotia

Canada has been involved in space science research since the early 1950s. It was the third country to conceive and build its own satellite, the Alouette-1 satellite that was launched in 1962. Canada has since then been actively involved in a wide variety of space efforts. Since the inception of its space programme, it has developed a niche strategy that focuses on Earth observation

and telecommunication systems as well as on robotic activities with a specific decision not to develop a domestic launcher. Canada strives to maximize its return on investment by concentrating on technologies where it can provide specific systems or expertise that can allow Canadian space industry to develop a strong stance on the export market. The Canadian Space Agency (CSA) was established in 1989 to manage the Canadian space programme. However, it has been stalled somewhat due to leadership change over the past few years and stagnant budgets.

Canada's ambitions are to position itself in large international programmes with specific targeted inputs. In particular, Canada is intending to take an active role in space exploration to boost its robotic industry and enhance its industrial competitiveness. Canada is thus committed to space exploration activities through robotic missions, but also to human spaceflight. The country has been involved with the space shuttle programme since the early 1980s. The first flight of the Remote Manipulator System known as "Canadarm" aboard the Shuttle took place in 1983 (it was the first non-U.S. equipment on a NASA-manned vehicle). Canada was also the first foreign partner to reach an agreement with NASA and State Department officials on the text of agreements covering participation in the ISS. Canada is providing the dextrous manipulators (Canadarm-2, Dextre), collectively known as the Mobile Servicing System (MSS) that play a critical role in the assembly process, as well as in the maintenance and servicing of ISS. Moreover, Canada is committed to continue its human spaceflight activities as demonstrated by the recent opening of a new call to recruit astronauts. There is also a strong interest in NASA's robotic Mars exploration programme. For instance, Canadian scientists are participating in NASA's Phoenix mission launched in August 2007 that landed on Mars on 25 May 2008. Through the CSA, Canada participated in the development of the Global Exploration Strategy and in the creation of the International Space Exploration Coordination Group (ISECG). In parallel, it has established an internal Exploration Steering Committee to review various options for Canadian contributions to the international space exploration effort. Canada hopes to be a frequent, reliable and visible partner in future international exploration missions. Canada intends to contribute to exploration missions by supplying key technologies along the following lines: it wants to be an early partner; it wants to be involved in surface mobility activities, as well as scalable and transferable activities.

International cooperation is a cornerstone of Canada's space activities. Canada participates in several NASA programmes like the ISS, JWST (James Webb Space Telescope), Phoenix, to name a few. Besides the cooperation with its neighbour, the United States, Canada has also general agreements with Japan, Russia and India. For instance, the CSA will provide the ultraviolet detectors for the telescope UVIT to ISRO for the ASTROSAT mission.

Canada is one of Europe's oldest and closest partners, particularly of France and the United Kingdom. Moreover, what started out in the late 1950s as a purely economic relationship with the EU has evolved over the years into a close strategic alliance. In 1976, the European Economic Community (EEC) and Canada signed a Framework Agreement on Economic Co-operation, the first formal agreement of its kind between the EEC and an industrialised third country. Since then, the EU and Canada have concluded several agreements covering a wide range of economic activities. In 1990, European and Canadian leaders adopted a Declaration on Transatlantic Relations, extending the scope of their contacts and establishing regular meetings at Heads of State and Government and Ministerial level. In 1996, a new Political Declaration on EU-Canada Relations was made at the Ottawa Summit, adopting a joint Action Plan, identifying additional specific areas for co-operation. At the Ottawa Summit on 18 March 2004, the EU and Canada adopted a Partnership Agenda which specifies ways of working together and to move forward on issues of mutual interest. Apart from the economic dimension, education and science play a major role in the EU-Canada relations. In the 2004 Partnership Agenda, S&T were recognised as being critically important to economic prosperity and thus needed to intensify bilateral cooperation. First steps were made by organising thematic workshops to examine areas of collaboration and intensifying partnerships under the EU's Framework Programme, by raising awareness of collaborative opportunities and by developing approaches to aid in the creation of partnerships. Space was one of those topics.

Canada's space activities are founded on civilian ties to both Europe and the United States. Europe is therefore a partner of choice for Canada. Cooperation with Europe is almost 30 years old. Canada has been a Cooperating State of ESA since 1979. The current cooperation with Europe is based on terms and conditions of the Cooperation

Agreement that entered into force in June 2000. Moreover, in December 2002, the declaration signed at the Canada-EU summit in Ottawa listed six areas of research priority where efforts would be made to intensify research collaboration including space and particularly Earth observation, telecommunications, and navigation. This was further underlined in the 2004 Partnership Agenda. Canada and ESA are also cooperating on ISS science experiments and astronaut training, and Canada participates in the Aurora programme and is interested by the ExoMars Rover project and the planned Mars Sample Return missions. Canada is thus increasingly involved in the EU's space affairs especially through Galileo and the Global Monitoring of the Environment and Security (GMES) programmes.

3.4.4. China

China	
Space Agency: China National Space Administration (CNSA)	**National Space Budget:** 2 billion USD (est) Foreseen Budget Trend: Rising
Priorities in Space: • Launch vehicle development • Space applications (Earth observation, telecommunications and navigation satellites) • Human spaceflight • Space science including materials science, astrobiology, microgravity experimentation, astronomy and space physics	**Selected Space Exploration Prospects:** • Potential plans for an orbital space station • Strong interest in lunar space exploration • Interest in Mars exploration • Long March CZ5 launch vehicle to be completed in 2014 • Potential instruments for on-board robotic missions • Recoverable capsule for microgravity experiments

China has in recent years emerged as a major space power with ambitious goals backed by heavy investments and strong political support. China launched its first satellite in April 1970 using a Long March 1 rocket, making China the fifth country with an indigenous launcher. Since then, China has launched remote sensing, telecommunications, weather satellites as well as science and navigation satellites. While China's space programme remains relatively opaque, its achievements are numerous. China has developed a reliable family of launch vehicles, as well as competitive Earth observation and telecommunication satellites. The Chinese government is moving ahead to build its own global satellite navigation system named Compass/Beidou. The country is consequently moving rapidly to acquire a comprehensive range of capabilities. China National Space Administration (CNSA) that was established in 1993 is responsible for China's civil space policy as well as the country's space-related intergovernmental agreements and relationships. Over the years, China has established steady and consistent progress in its space efforts with the pace of its development picking up in the 1990s. Overall, space activities are regarded by the government as an integral part of the State's comprehensive development strategy as underlined in its 2006 White Paper entitled "China's Space Activities". The paper drives the country's use of space for the next five years and is completed by the February 2007 "Eleventh Five Years Space Development Plan" issued by the Commission of Science Technology and Industry for National Defense (COSTIND). In this context, Chinese space activities focus on programmes serving the country's economic development such as Earth observation, satellite communications, access to space as well as activities allowing it to garner prestige, like human spaceflight and space exploration.

China's human spaceflight and space exploration activities are part of a long-term programme to expand China's space technology capabilities. With the success of its manned Shenzhou 5 mission in October 2003, China has become the third country to successfully accomplish an independent manned space mission after Russia and the United States. The third Shenzhou mission that had been originally scheduled to take place in late 2007, will carry three astronauts in late 2008, one of whom is to do extravehicular activity (EVA). Officials also mentioned plans to build a space station in low Earth orbit (LEO). The development and operation of China's human spaceflight programme is run by the People's Liberation Army (PLA) and to date, all the participants have been selected from members of the PLA Air Force. China is also getting more and more involved in robotic space exploration activities. In 2007, it launched its first lunar probe, Chang'e-1 as part of the first phase of the China Lunar Exploration Program (CLEP). China aims to land a rover on the moon and eventually safely return lunar soil samples back to Earth. China has also expressed plans to land a human on the moon in the 2025 timeframe.[67] Finally, China is also developing

[67] CNSA briefings on China's civil space activities in April 2006 at CSIS and later at National Space Symposium in Colorado Springs.

a new launch vehicle; the Long March CZ-5 intended to go into service in 2014.

Chinese space activities are planned to ensure self-reliance, but the country remains open to international cooperation. For China, gaining prestige through space activities is an important motivation, particularly through cooperation with space powers to demonstrate its status, but also with less competent space actors to use space as a tool of international diplomacy. China is thus seeking cooperation with the "North", while it is at the same time entering in cooperative activities with countries from the "South" like Brazil in the context of the CBERS programme or the Asia-Pacific Cooperation Organization (APSCO). In particular, space science and exploration have been embraced as a key area for expanding the Chinese space programme to demonstrate both its autonomy and to build international cooperation. For instance, China is developing the Chang'e programme on lunar exploration independently, but it is also involved in Mars exploration in cooperation with Russia. China signed a dedicated agreement with Russia in March 2007 to contribute a small satellite (Yinghuo-1) to be launched along the Russian sample return mission "Phobos Explorer" to the Martian moon Phobos in October 2009. China is also a member of the GES demonstrating its interest in becoming involved in future long-term cooperative space exploration activities.

While the United States is divided on its China policy between proponents of containment and their opponents who favour engagement, European countries have followed a policy of "constructive engagement" towards China. [68] The EEC established formal relations with China in 1975 and since then its goals have been overwhelmingly oriented towards trade and investment relations. The 1985 "EC-China Trade and Co-operation Agreement" still constitutes the main legal framework of EU-China relations. This agreement, which replaced an earlier version of 1978, covers economic and trade relations, as well as the EU-China cooperation programme. It was complemented in 1994 and 2002 by exchanges of letters establishing a broad EU-China political dialogue. Negotiations on a much more comprehensive Partnership and Cooperation Agreement (PCA) started in January 2007. [69] These will also include an updating of the 1985 agreement. Current EU policy towards the country is based on the Commission's policy entitled "EU–China: closer partners, growing responsibilities", released in October 2006, which sets the new agenda for EU–China relations for the coming years. The EU's fundamental approach to China is one of engagement and partnerships and includes strengthening bilateral cooperation in S&T. A dedicated S&T agreement was therefore signed in 1998 and entered into force in 2000; it was then reviewed in 2004. In addition, 2007 was "China–EU S&T year". China is now one of the most important third countries participating in EU's framework programme and is also an important partner on the International Thermonuclear Experimental Reactor (ITER) project.[70]

Through ESA, Europe and China thus already have a long record of cooperation going back for almost 30 years. ESA has been the traditional European partner, with scientific collaboration beginning in 1980 with the signing of a document facilitating the exchange of information between ESA and China's State Science and Technology Commission (SSTC).[71] In 1992, the Chinese Academy of Science signed an agreement with ESA to collaborate on the Cluster mission, and in July 2001, a collaborative agreement on the Double Star programme was signed. [72] The first Chinese scientific mission was thus done in collaboration with ESA. The two Double Star satellites were launched from China in December 2003 and July 2004. During ESA's SMART-1 mission, ESA provided the Chinese with details of the spacecraft's position and transmission frequencies to help to test their tracking stations and ground operations by following it as part of their preparation for Chang'e-1. ESA is also collaborating with China on the Chang'e-1 Moon mission by providing spacecraft and ground operations support services to CNSA (utilization of the ESTRACK

[68] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107.

[69] A PCA is a legal framework setting out the political, economic and trade relationship between the EU and its partner countries. It is a 10-year bilateral treaty signed and ratified by the EU and the individual state.

[70] ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power. The partners in the project - the ITER Parties - are the European Union (represented by EURATOM), Japan, China, India, South Korea, Russia and the United States. ITER will be constructed in Europe, at Cadarache in the South of France.

[71] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107.

[72] Double Star aims to study the effects of the Sun on the Earth's environment following the steps of ESA's Cluster mission. The Double Star spacecraft were launched in December 2003 and July 2004.

network).[73] In 2005, an ESA-China Framework Agreement was also signed. Consequently, a Steering Committee was set up with one of its five working groups focused on space exploration. Over the years, the relations between China and the EU in space have grown.[74] In October 2003, an agreement on cooperation in EU's Galileo programme was signed. And, in April 2004, a high-level steering group on China–EU Space Cooperation was set up to reinforce the dialogue between the EU and China, and to support the development of long-term perspectives for cooperation in space.[75] The steering group includes representatives of government administrations, agencies and manufacturers, as well as operators and service providers. A Joint Statement launching the Space Dialogue between the EC and China was endorsed in September 2005, and since then, a series of high-level meetings has taken place. However, the cooperation on Galileo remains unclear.

3.4.5. India

India	
Space Agency: Indian Space Research Organisation (ISRO)	**National Space Budget:** 964 million USD Foreseen Budget Trend: Rising
Priorities in Space: • Commitment to space technology applications: Earth observation, telecommunications and navigation • Autonomy in launch systems • Heading towards human spaceflight • Develop space science activities	**Selected Space Exploration Prospects:** • New launch vehicle GSLV-Mk III to be ready in 2012 • Strong lunar exploration interest • Development of human spaceflight capabilities • Interests in Mars and other planetary bodies exploration • Potential instruments for on-board robotic missions • Develop a Deep Space Network

From humble beginnings in the 1960s, India is poised to become a major space actor in the near future. In 1962, India embarked on a programme to develop its own satellites and launch capability and in 1963, its first rocket was launched. Then, the Indian space agency, Indian Space Research Organisation (ISRO), was set up in 1969 and placed under the direct supervision of the Prime Minister with the primary objective of developing space technology and its applications to fulfil various national tasks. Since its inception, the Indian space programme has been dominated by a pragmatic approach consisting of space activities being dominantly used to support the development of the country. Space applications have therefore been the main priorities of the Indian space programme as well as autonomy in access to space. It has since advanced to the front rank of the world's space countries. For instance, India was the seventh country to achieve orbit capability in July 1980. Indian leadership has continually politically and financially supported its space programme and in recent years, the growth in India's space budget has been unparalleled by any other country. The increasing level of funding illustrates the priority status awarded by the Indian government to the national space programme, and the country's ambition in space. Consequently, the Indian space programme underwent an impressive expansion in the 1990s and India is now considered as an important space-faring country.

While India has well-developed space capabilities in the field of Earth observation and telecommunications and long ago demonstrated the ability to build sophisticated launch vehicles, its space agency, in a buoyant regional context, is eager to start a human spaceflight programme. Space science and exploration have long been a minor activity at ISRO which has given more priority to applications. India has had up to now only one astronaut, Maj Rakesh Sharma, flying with Russia under the Soviet Intercosmos programme in April 1984 for a seven-day mission. A manned spaceflight programme would therefore mark a very big step for India. In spring 2008, ISRO submitted to the Indian government its project proposing a first manned space mission in the 2014-2015 timeframe with a decision expected by the end of 2008. ISRO has carried out studies for about 4 years examining the technological challenges of a manned space mission and the Indian capability to undertake it. ISRO estimated that the project leading to a first manned flight will cost 2.5 billion U.S. dollars[76]. With a growing economy and a high-tech workforce, India appears to have the means and the

[73] ESA has also been cooperating with China's National Remote Sensing Centre (NRSCC) in the development of Earth observation (EO) applications over the past decade.
[74] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107.
[75] Ibid.
[76] Jayaraman K.S. "ISRO Seeks Government Approval For Manned Spaceflight Program" Space News. 13 Nov. 2006: 6

resources it needs to fulfil its aspiration of developing a manned spaceflight programme. The decision to develop a man-rated GSLV has been taken and actions have been initiated. ISRO already validated its re-entry technology in January 2007 with the successful recovery of its space capsule, the Space-capsule Recovery Experiment (SRE-1). ISRO has also started working on pre-project, long-lead items for human missions such as spacesuits, and simulation facilities under a 23 million U.S. dollars preliminary funding by the government.[77] In the mean time, India is also considering sending one of its citizens into space on-board a Russian spacecraft to acquire the skills necessary for future manned space missions with a potential trip to ISS onboard a Soyuz by 2012.[78] ISRO is also showing greater interest to space science and exploration as illustrated by the development of new programmes and particularly Chandrayaan-1, the first Indian planetary mission, foreseen to orbit the moon in the second half of 2008. India is also working towards the establishment of a Deep Space Network (DSN) required for communication with the spacecraft. ISRO is also beginning to define its first Mars orbiter for launch as early as 2015. Finally, India is also part of the GES illustrating its interest in taking a greater role in international space exploration endeavours.

International cooperation is important for India and ISRO has been involved in international cooperation since its inception. Agreements now exists with countries from the “South” like Brazil, Egypt, Indonesia, Mauritius, Mongolia, Syria, Thailand as well as with countries from the “North” like the United States, Canada, Russia and various European actors. India is cooperating with Russia on updating Russia's Global Navigation Satellite System (Glonass) as part of a broad space cooperation plan. The Russo-Indian cooperation has also been extended to space sciences and exploration, with an Indian instrument set to fly onboard the Russian Coronas-Photon satellite and a cooperation agreement signed for the Chandrayaan-2 mission for a joint lunar lander mission.

EU-India relations go back to the early 1960s. India was among the first countries to set up foreign relations with EEC and bilateral agreements were signed in 1973 and 1981. The current 1994 cooperation agreement is a wide-ranging third-generation agreement going well beyond trade and economic cooperation. The institutional basis for EU-India political dialogue is a Joint Political Statement signed simultaneously with the third Cooperation Agreement. Several Communications by the Commission such as the 1996 "EU-India Enhanced Partnership" have been put forward. The Commission Communication of 16 June 2004 was another milestone, as it sets out concrete proposals to up-grade the relationship to a strategic partnership. In the 1994 Cooperation Agreement, S&T was a major item and since then, cooperation has expanded in many different domains. This was further reinforced by the 2005 Joint Action Plan. India also cooperates with Europe within the framework of the international research project aiming to demonstrate the feasibility of fusion power, ITER.

Europe and India have a long and deep heritage of cooperation. India’s most consistent international partner has been Europe. Following initial relations in 1971, a framework agreement between ISRO and ESA on the peaceful use of outer space was signed in April 1978. India is developing its cooperation with Europe, including European participation in Chandrayaan-1. Apart from the indigenous payloads onboard Chandrayaan-1, ISRO solicited proposals through an Announcement of Opportunity (AO) for international and Indian scientific community for participating in mission by providing suitable scientific payloads complementing the overall Chandrayaan-1 scientific objectives: Four European payloads were selected out of the 6 international payloads carried on Chandrayaan-1 mission (2 others payloads are from the United States). India has agreed to include an atmospheric sounder called Rosa from the Italian Space Agency (ASI) on board its Oceansat-2 satellite. Two Indo-French joint satellite missions, Megha-Tropiques, to study the atmosphere water circulation in the tropical belt and SARAL (Satellite for Argos & Altika Mission) providing altimetric measurements to study ocean circulation and sea surface elevation have made further progress. ISRO is also cooperating with the German Aerospace Centre (DLR) with the MOS instrument onboard the IRS-P3 satellite and the Italian Space Agency (ASI) with the ROSA instrument onboard the OCEANTSAT-2 spacecraft. In the 2005, Joint Action Plan dialogues between ISRO, the Department of Space (DOS) and ESA and the EC in various domains including space exploration were initiated. India has also indicated its willingness in participating in the European flagship programme Galileo.

[77] Mathews, Neelam. “Decision Near: India Takes another Step Toward Human Spaceflight” Aviation Week and Space Technology. 5 May 2008: 31-32
[78] Ibid.

3.4.6. Japan

Japan	
Space Agency: Japan Aerospace Exploration Agency (JAXA)	**National Space Budget:** 2210 million USD (est) Foreseen Budget Trend: Stable
Priorities in Space: • Space technology applications including Earth observation and telecommunications • Launch systems development • Human spaceflight activities • Space science and planetary research • Improvement of its industrial base	**Selected Space Exploration Prospects:** • Contribution to ISS • Strong interest in lunar exploration and other planetary bodies • Potential instruments for on-board robotic missions

Japan is one of the largest civilian space powers. It embarked into space activities as early as in the 1960s with the creation of the Institute of Space and Astronautical Science (ISAS) and the National Space Development Center in 1964. Japan was the fourth country after the U.S.S.R., the United States and France to achieve national satellite launcher capability with the first Engineering Test Satellite being launched by an N-1 rocket in 1975. The space programme has grown considerably since then. Japan is now involved in all domains of space activities. However, following a series of setback and organizational malaise since the 1990s with in-orbit and launch failures, Japan's top priorities were to restore programme efficiency and reliability. In 2003, ISAS, the National Aerospace Laboratory of Japan (NAL) and the National Space Development Agency of Japan (NASDA) merged into the Japan Aerospace Exploration Agency (JAXA). JAXA was created to improve the management efficiency and flexibility of its national activities and it has since reinvigorated the country's space programme. Japan's overall space policy is currently in transition as a new bill for the establishment of a "Basic Law for Space Activities" was adopted in May 2008. It aims to update Japan's strategic goals with regard to space activities.

Japan has overcome recent difficulties and continues to be an important player focused on human spaceflight and space exploration. Human spaceflight is one of JAXA's largest budget lines outside the general budget. Japan's participation to the ISS focuses on the development and exploitation of the Japanese Experiment Module (JEM), Kibo (hope), along with the H-II Transfer Vehicle (HTV). Japan is also studying the option to develop a recoverable HTV. In 2008, a new call for recruiting astronauts was also released. Japan has also developed a pallet to carry instruments intended to be transported by the shuttle. Furthermore, JAXA has expressed some interests to participate in the future Advanced Crew Transportation System (ACTS) with Europe and Russia, but no dedicated funds have been earmarked. New technology development and strategic studies for the next human space activities such as human lunar exploration are also underway. In the document "JAXA Vision 2025" released in March 2005, the Japanese space agency underlined its aspiration for lunar and Martian exploration as well as of NEOs and primitive bodies. Deep space missions are historically the core of the space exploration programme of Japan. The country has been actively pursuing robotic scientific exploration including missions to the moon, Mars and Venus as well as asteroids. In particular, in 2007 Japan outpaced its Asian rivals by launching its lunar probe more than a month before China deployed its lunar mission and several months before India's upcoming lunar mission. The Selenological and Engineering Explorer (SELENE) also known as "Kaguya" was launched on an H-IIA launch vehicle flight on 14 September 2007. Kaguya is JAXA's first large lunar explorer. Japan had previously launched Hiten in 1990, delivering the small lunar orbiter Hagomoro. Illustrating its commitment to space exploration on 1 April 2007, JAXA established a new branch for space exploration activities which is called JAXA's Space Exploration Center (JSPEC). The core tasks of the JSPEC are both robotics and human lunar and other planetary exploration activities. Japan is also a partner in the Global Exploration Strategy.

Japan continues to focus its cooperation efforts in Research and Development (R&D) activities as well as scientific activities with established space powers like the United States and Europe. However, following the creation of the Asia-Pacific Space Cooperation Organization (APSCO) a regional space organization under Chinese leadership, Japan re-launched the Asia-Pacific Regional Space Agency Forum (APRSAF) that started in 1993. In particular, Japan is aiming at supporting Asian countries in various applications programmes and in Earth observation and education programmes as a tool of foreign relations in the region through the APRSAF

that holds yearly meetings under the auspices of Japan.

Europe and Japan have a long history of cooperation. The scope of the overall relationship has broadened in recent years and now goes far beyond the earlier trade-related focus of the 1970s and 1980s. Japan-Europe bilateral relations are anchored in two key documents: the Joint Declaration of 1991 and the Action Plan for EU-Japan Cooperation of 2001. The Joint Declaration on relations between the European Community and its member States, and Japan established common principles and shared objectives in political and economic cooperation as well as in cultural areas. It also established a consultation framework for annual meetings between Japan and the EU. The Action Plan of 2001 "Shaping our Common Future" is the key instrument establishing a strong and results-oriented partnership over a ten-year period. It has four basic objectives: promoting peace and security; strengthening economic and trade partnership; coping with global and societal challenges; and bringing people and cultures together. In addition, the aforementioned documents engage in a host of other sectoral dialogues, including S&T. Japan has become a major partner of the EU's framework programme, as well as of the ITER project.

While Japan has important space cooperation with the United States it is also increasingly looking to strengthen cooperation with Europe. Already in 1972, an agreement between the Japanese Science and Technology Agency and the European Space Research Organization (ESRO) on scientific data exchange, information of respective space programmes and regular specialist meetings was reached. Since then, cooperation has developed and now covers various fields including space exploration. For instance, Hinode (Solar-B) and Akari missions are Japanese-led missions with ESA participation. BepiColombo that will explore Mercury is scheduled for launch in August 2013 consisting of two orbiters is Japan's first mission in cooperation with ESA. Moreover, new mission prospects like Marco Polo are currently being considered. In addition, ESA's SMART-1 team has helped the Kaguya team test their ground segment. This was done by testing reception of the signal of SMART-1 while in orbit around the moon. Over the years, Japan and Europe have established a mutual relation of trust resulting in a constant increase of cooperation between Europe and Japan.

3.4.7. Russia

Russia	
Space Agency: Federal Space Agency (FSA)/Roskomos	**National Space Budget:** 1836 million USD (est) Foreseen Budget Trend: Rising
Priorities in Space: • Refurbishment of the satellite navigation constellation (Glonass) • Human spaceflight activities • Development of a new launch vehicle Angara and associated ground infrastructure • Modernisation and streamlining of its industry	**Selected Space Exploration Prospects:** • Human spaceflight activities • Contribution to ISS • Completion of Angara vehicle by 2011 • Crew Space Transportation System to succeed Soyuz spacecraft • Strong interests in lunar and Mars exploration • Interests in other planetary bodies • Potential instruments for on-board robotic missions • Recoverable capsule for microgravity experiments

Russia, formerly part of the Soviet Union (U.S.S.R.), has made a number of space achievements including the first artificial Earth satellite (Sputnik), the first human in space (Yuri Gagarin) and the world's first space station (Salyut), but also the first unmanned lunar landing (as part of the Luna programme) and has acquired an extensive experience in space activities. Russian "space power" is currently resurgent, ending its decline following the fall of the Soviet Union. Recent years have been marked by an impressive recovery of the Russian space programme as high oil and other natural resources prices have made it possible to balance and grow the Russian institutional budget. As part of a broad reorganization of the government in 2004, the Russian Space Agency (Rosaviakosmos) was restructured in the Federal Space Agency (Roskosmos). Furthermore, in October 2005, the Russian government adopted a new Federal Space Programme (2006-2015) that comprises a space spending plan to attempt to halt the decline of the country's industrial base and ending years of under-funding. This budget increase and new political drive are leading to new ambitions in space. Recent main issues for Russia's space programme have been to reaffirm its role on the global scene as a supplier of launch vehicles, and to be recognized as a major partner in the ISS programme and the GNSS field.

Russia's historic emphasis on human spaceflight has left a legacy of technical and operational competence. Russia has remained a definitive leader in the field of space exploration in spite of troubled economic and political times in the 1990s. And, following its involvement in the ISS project in 1993, it has since provided essential building blocks (modules) as well as logistic infrastructure (crew and cargo). Moreover, with the grounding of the Shuttle programme following the loss of the Columbia orbiter on 1 February 2003, Russia has been providing the only mean of access to the ISS. Following the decision of the U.S. to terminate Shuttle operations in 2010, and the existence of a gap before the entry into operation of the next U.S. human space flight vehicle, Russia will play an unforeseen role at the outset in providing support to the ISS. It will be the only country capable to deliver crew to the ISS. This elevates Russian importance in providing logistical and supply flights, but particularly human access to the station. The development of a new generation of crew vehicles for missions to LEO and potentially the moon to replace the existing Soyuz vehicle has been initiated (the so-called CSTS). This development might be undertaken in cooperation with international partners (Europe and Japan). Russia is also developing a new family of launchers, called Angara. It is developing a new spaceport, the Vostochny launch centre as an alternative to Baikonur for, among others, manned missions. Russia is also considering an extension of ISS until 2025. Along with increasing funding, Russia is also re-energizing its lunar and planetary programmes. Russia, which pioneered and then abandoned robotic exploration of the moon, is starting the development of its first lunar mission in more than 30 years. [79] Following the loss of costly, high profile probes to Mars in 1989, 1990 and 1996 Russian activities in exploration are on the rise. Russia is planning to launch a sample return mission to the Martian moon Phobos in October 2009. Russia is also part of the GES illustrating its commitments for long-term space exploration activities.

The renewed space interest at the highest-political level in Russia combined with the budgetary increase devoted to space activities has led to the reinforcement of several cooperation and partnerships and Russia has successfully positioned itself as a partner of choice in international space fora. Russia is cooperating with Europe and the United States on human spaceflight and space transportation activities. It is also aiming to increase its cooperative activities with emerging space powers. In particular, it is looking at closer partnership with China in lunar exploration to evolve beyond the traditional sales of Russian equipment to the Chinese government. A dedicated cooperation agreement was signed in March 2007 according to which a Chinese small satellite will be launched on the Russian sample return mission "Phobos Explorer". China and Russia are also cooperating in space astronomy. China will participate to the "Radioastron" programme scheduled to start in 2008 and it will also launch the Russian Ultraviolet Observatory in 2010. While Russia is cooperating with China, it is also collaborating with India on updating Russia's Global Navigation Satellite System (Glonass) as part of a broad space cooperation plan that also encompasses space sciences. In particular, an Indian instrument for solar physics and solar-terrestrial sciences will be place on the Russian Coronas-Photon satellite. A cooperation agreement has been signed for the Chandrayaan-2 mission for a joint lunar lander mission, and Russia might train and send an Indian astronaut into space. Russia's revitalization of its space programme has led also to an increasing number of space cooperation agreements with non-space-faring countries as a tool of international diplomacy. On 5 September 2006, a 10-year agreement between Russia and South Africa was signed that covered the development of launch vehicles and other peaceful uses of space activities. Russia will also help Brazil on its VLS-1 launch vehicle (Veículo Lançador de Satélite). Furthermore, the astronaut Marcus Pontes became the first Brazilian in space and went onboard the Soyuz TMA-8/12S mission to the ISS. Russia has also been reported considering the possibility to cooperate with Venezuela especially regarding the training of a Venezuelan astronaut. Iran as well as Thailand would like also to send their first astronaut into space with the help of Russia.

In the context of the Cold War, Euro–Russian relations were limited in scope and trade relations were based on bilateral agreements with individual member States.[80] The EU had no official relationships with the U.S.S.R. until the late 1980s. However, since 1989 a cooperation agreement between the U.S.S.R.

[79] Major Soviet achievements included the first lunar flyby in 1959; the first lunar far-side photos in 1960; the first semi-soft lander to return images from the surface in 1966; a series of successful lunar orbiters starting in 1966; three robotic sample returns in 1970, 1972 and 1976; and two Lunokhod rovers in 1970 and 1973.

[80] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107.

and the EC normalizing trading relations has been in place. Most importantly, since 1 December 1997, Russia and Europe have in effect had a Partnership and Cooperation Agreement (PCA) for political and economic relations, confirming that the EU and Russia have become "strategic partners".[81] This agreement establishes the institutional framework for bilateral relations, sets the principal common objectives and calls for activities and dialogue in a number of policy areas including S&T. Discussions about a new PCA are about to be initiated. Russia can take part in EC's framework programme and is also party to the ITER project.

Cooperation in space between Europe and Russia has over time involved different actors, but also evolved in scope, allowing the building of a comprehensive common experience in working together.[82] Individual countries, notably France dominated the first phase of Euro–Russian (then Soviet) cooperation at the end of the 1960s and in the 1970s.[83] The second phase that started in the 1980s is characterized by the development of a more coherent European approach by ESA through, for instance, the creation of the Interagency Consultative Group (IACG), which held its first meeting in 1982 to coordinate its members' respective missions to Halley's Comet.[84] However, the first ESA–Russia Framework Agreement on Cooperation was only signed in 1991 and focused on human spaceflight. In 1993, ESA signed an agreement for two ESA missions to the Mir space station (the so-called Euromir missions).[85] This cooperation continued with the training of ESA astronauts as flight engineers for the Soyuz capsule and a number of short-duration flights to the ISS. A bilateral "Space Dialogue" between the EU and Russia was launched in 1998 and, since then, both sides have expressed a mutual interest in multiplying their cooperative projects in space.[86] A tripartite (EC–ESA–Rosaviakosmos) Joint Memorandum signed in December 2001 on "New opportunities for a Euro–Russian Space Partnership" provided a political framework for future work. On 19 January 2005, ESA Director General, Jean-Jacques Dordain and the Head of the Russian Federal Space Agency, Anatoly Perminov, signed an agreement in Moscow on long-term cooperation and partnership in the development, implementation and use of launchers. This partnership is based on two main pillars: the exploitation of the Russian Soyuz launcher from Kourou, Europe's spaceport in French Guiana and cooperation without exchange of funds on R&D in preparation for future launchers.[87] Moreover, at the 15th EU–Russia Summit in Moscow in May 2005, leaders of the EU and Russia adopted a "Roadmap for the Common Economic Space" to reinforce their cooperation, which included a specific paragraph dedicated to "space activities". Its objectives are to build an effective system of cooperation and partnership between the two in various space fields. Then, at the 16th EU–Russia Summit held in October of the same year, the technical and economic potential of working closer together on space transportation systems and satellite navigation was underlined. Russia and the EU (and ESA) also signed a cooperation agreement on space technologies and activities on 10 March 2006. The areas of specific interest include, among others, space exploration and the ISS and space technology development. A rich history of cooperation in exploration missions exists also. For instance, the Russian Academy of Science will provide an instrument for the BepiColombo mission and Russia will also be a partner of ExoMars.

3.4.8. South Africa

South Africa	
Space Agency: Council for Space Affairs; and a Space Agency currently under development	**National Space Budget:** 10 million USD (est) Foreseen Budget Trend: Rising
Priorities in Space: • Earth observation and environmental monitoring • Space science (Gamma-ray and radio astronomy) • Space-related engineering (small scientific satellites)	**Selected Space Exploration Prospects:** • Host of ground infrastructure for radio communication and tracking to support future 933robotic and lunar exploration activities • Potential instruments for on-board robotic missions • Potential for analogue planetary research

[81] This PCA is extended beyond 2007 on an annual basis
[82] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107.
[83] Ibid.
[84] Composed of IKI (Space Research Institute in Moscow), ESA, the National Aeronautics and Space Administration and the Institute of Space and Astronautical Science of Japan.
[85] Until this agreement, all the European visiting mission to Russian stations were organized on a national basis between Russia and the country concerned.
[86] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107.
[87] Ibid.

While up to now the involvement of South Africa in space affairs has been modest, it has the most significant space programme on the continent. In the late 1980s, South Africa commenced a military programme to develop and launch a reconnaissance satellite, but this was discontinued in 1994. South Africa's main achievement has been the launch in 1999 of the first South African satellite, Sunsat, a low-resolution Earth observation satellite. Up to now South Africa has been primarily a consumer of space technology, but this is evolving. While spending on space programmes remains low until now, more recently the national space programme is receiving greater support from the government. In 2005, South Africa embarked on a 3-year capacity building and satellite development programme. As a result, a new satellite named SumbandilaSat is currently being prepared to be launched in LEO. South Africa has solid capabilities in many facets of space science and technology as illustrated by the South Africa Large Telescope (SALT) and its competition to host the Square Kilometer Array (SKA) project. A national space agency is also under development. On 5 December 2007, the Cabinet approved the establishment of a national space agency. This agency will be tasked with coordinating the use of space technology and local science research. However the Bill entitled "South African National Space Agency Bill" is still being debated in the South African Parliament as of the end of June 2008. A draft of the first South African policy is also currently under development by the Department of Trade and Industry (DTI). Furthermore, the recently approved "Department of Science and Technology (DST) 10 Year Innovation Plan" includes space science and technology as one of the five grand challenges and consequently a "National Space Science and Technology Strategy" has been drafted. It has been developed with a vision calling "for South Africa to be among the leading nations in the innovation utilization of space science and technology that enhances economic growth and sustainable development in order to improve the quality of life for all". [88] And, according to the Space Strategy, in 10 years, South Africa should be an important contributor to global space science and technology.

South Africa has a variety of institutions and programmes that can support space exploration programmes and has a rich heritage of supporting such missions. South Africa has been an active participant in space exploration since the dawn of the Space Age. From the 1950s to the 1970s, lunar and interplanetary missions were supported by a tracking station in South Africa. For instance, this station received the first images of the planet Mars (taken by the Mariner IV spacecraft). More recently, Mark Shuttleworth, a South African entrepreneur was the second self-funded space tourist, and first African in space. On 25 April 2002, Shuttleworth went into space onboard the Russian Soyuz TM-34 mission, paying approximately 20 million U.S. dollars for the trip. Space science and exploration are also listed as key focus areas of the "National Space Science and Technology Strategy" to raise interest in space affairs and educate the broad public about space. Furthermore, space science and exploration are also one of the four thematic areas identified in the document that will make meaningful contributions to the realization of a viable space programme.

South Africa is currently developing its international partnerships. South Africa is eager to cooperate with established and developing space-faring countries as an avenue for its capacity development. The country has, after years of isolation due to the Apartheid regime, been increasingly seeking partnership with space powers like Russia. But Europe is also a partner of choice. More broadly, South Africa strives to contribute to the development of Africa including using space activities as a key instrument. South Africa has also been at the forefront of pan-African discussions about the coordination of continental activities particularly in the field of Earth observation.

Europe-South African relations have flourished since 1994, and both sides entered into a Strategic Partnership in May 2007 that aims at moving from political dialogue to active political cooperation on a regional, continental and global level and at enhancing cooperation in a wide range of areas. The partnership establishes an overarching structure for existing cooperation fora. South Africa and the EU signed a Trade, Development and Cooperation Agreement (TDCA) in October 1999 which entered fully into force on 1 May 2004. The TDCA covers political dialogue, trade and cooperation in the development of the economic and other sectors. Cooperation in research and development is the subject of a specific S&T agreement signed in 1996. South Africa has since been cooperating in EC's framework

[88] Department of Science and Technology Republic of South Africa "National Space Science and Technology Strategy" version 1.3. <http://www.dst.gov.za/Draft%20National%20Space%20Science%20and%20Technology%20Strategy.pdf>.

programme, particularly, in aeronautics and air transport, as well as in nuclear energy thematic of the FP6 with the South African participants ranking fourth, behind the United States, China, Russia, in terms of successful FP6 participation by non-EU countries.

Bilateral cooperation in space activities has been limited up to now, but this is evolving. South Africa and the EU will cooperate closely in supporting the implementation of the Science, Information Society and Space Partnership of the Joint Africa-EU Strategy adopted at the Africa – EU Summit held in Lisbon, Portugal, in December 2007 that includes space as a cooperation item, paving the way for new cooperative ventures.

3.4.9. South Korea

South Korea	
Space Agency: Korean Aerospace Research Institute (KARI)	**National Space Budget:** 338 million USD Foreseen Budget Trend: Rising
Priorities in Space: • Acquisition of independent core space technology (rocket technology and commercial satellite production) • Development of a space launch vehicle (KSLV-1) and associated infrastructure (launching pad) • Human spaceflight activities and lunar exploration	**Selected Space Exploration Prospects:** • Heading towards independent access to space • Strong interest in lunar exploration • Potential instruments for on-board robotic missions

Even though it started later than its Asian counterparts, Korea is making notable investment and progress in its indigenous space capability. It has significantly ramped up its space programme in recent years. Korea currently is not yet a significant space actor, but the country has a long-term space-investment plan that includes a domestic line of Earth observation satellites and launch vehicles. Based on the strength of its information and telecommunications technologies, it is aiming to become a global leader in space technology by 2015. [89] In October 1989, the Korean Aerospace Research Institute (KARI) was created to serve as the national space agency. The first Korean satellite KITSAT-1 (KAISTSat) was only launched in 1992, but since then, Korea has started numerous initiatives with thus far a remarkable success. KARI launched the first indigenous sounding rocket (KSR-1) on 4 June 1993. In 2006, Korea became the newest member of the club of countries with their own high-resolution optical reconnaissance satellite with the successful launch of Kompsat-2 satellite aboard a Rockot vehicle from Russia's Plesetsk Cosmodrome on 28 July 2006. Seoul's ambition to become a space power was further confirmed with the launch of the Koreasat-5 civil/military telecommunications satellite aboard a Sea Launch vehicle in late August 2006. The Korean government is also overseeing launch related projects. One such project is the construction of the Naro Space Centre. The construction project started in 2002 and is scheduled for completion in late 2008. The space centre will serve to launch the Korea Space Launch Vehicle 1 (KSLV-1) currently under development which is being built with technical cooperation from Russia and scheduled for its first launch in 2008. Korea's ambitions are to become the tenth country able to independently place a satellite into orbit. A longer-term initiative is also the development of the KSLV-2, which is planned for completion by 2017. In line with Korea's hope of becoming a major space-faring country, its programme has received increasing funding in recent years. Korea has one of the fastest-growing space programmes in the world and it is expected that this budget increase will continue as its economy expands in the next two decades. Korea has also laid out a long-term plan for its space programme and in 2007 released its "Long-Term Plan for National Space Development Promotion" according to the Space Development Promotion Act of 2005. The long-term plan provides a vision and direction for national space policy through 2016. Korea's strategic plan is to transform the country into a regional space leader. The plan, in particular, changes the focus from a programmatic-oriented approach to the acquisition of an independent core space technology and establishes milestones and strategies for the independent development of satellites and launch vehicles based on implemented space programmes.

While Earth observation and acquiring autonomous launch capabilities are the centrepieces of the national space programme, space science and exploration activities have been so far limited. However, this is evolving and in recent months, ambitious exploration aspirations have been put forth. The objectives of the next decade as laid out in the long-term plan include the development of a reliable indigenous launch

[89] He-suk, Choi. "Science Ministry vows to turn Korea into a global space leader by 2015" Korea Herald on the web 15 January 2007

vehicle, more capable Earth observation systems as well as exploration activities, particularly lunar robotic exploration activities to demonstrate world class capabilities commensurate with its economic growth. Korea is part of the Global Exploration Strategy, but it also plans to send several spacecraft to the moon including a lunar lander. Korea's first astronaut, Yi So-yeon also went to the ISS aboard a Russian Soyuz in April 2008. This astronaut project that started on 16 November 2005 has very important technical and social significance for Korea and more great advances are expected in the years to come.

Since the 1990s, Korea has pursued autonomy in space in a gradual manner through progressively advanced programmes, as well as by constant efforts to acquire foreign technology under cooperation projects or by direct purchases from foreign companies or governments. Korea has been cooperating widely with major space actors like the United States, Russia, but also with Asian powers like Japan, China and India, as well as with other emergent powers like Malaysia and Israel.

Today's relationship between Korea and Europe is founded on increasingly strong economic links reflecting large bilateral trade and investment flows. Furthermore, Europe reiterated support for Korea's policy of engagement with North Korea. Following the formal end of military rule (1987) and the election of the country's first President with a civilian background (1992), the EU decided to negotiate a Framework Agreement on Trade and Cooperation with Korea in 1995. The Framework Agreement and its attached Political declaration were signed in October 1996. It is a mixed agreement with both the participation of the European Commission and the member States on the side of the EU. The Agreement commits the parties to work towards fostering growth of two-way trade and investment and is encouraging broad-based cooperation initiatives including in the fields of justice and home affairs, culture and S&T. Since the Framework Agreement entered into force, bilateral trade and investment relations have flourished. Much progress has been made in recent years to stimulate S&T exchanges with Korea. Negotiations for a Science and Technology Agreement were launched in 2005, and the country also participates in EC's Framework Programme. Korea is also party to the ITER research project.

Institutional cooperation in space with Europe is less developed than its industrial relations. European companies have a long and rich cooperation history. They have been providing various hardware and services, including access to space to Korea. KARI has thus far enhanced international collaboration with the United Kingdom, France, and Germany. Institutional cooperation is nonetheless foreseen to increase, particularly with the EU, as Korean authorities signed an agreement to participate in Europe's Galileo programme.

3.4.10. Ukraine

Ukraine	
Space Agency: National Space Agency of Ukraine (NSAU)	**National Space Budget:** 45 million USD (est) Foreseen Budget Trend: Stable
Priorities in Space: • Sustain a reliable access to space (Zenit and Tsyklon launcher systems) • Establishment of a National Satellite Communication System • Development of Earth observation capabilities	**Selected Space Exploration Prospects:** • Zenit launcher system • Space research experiments on-board the ISS • Potential instruments for on-board robotic missions

The Ukraine is the largest space actor in Central and Eastern Europe. It gained tremendous expertise during the Soviet era and after the dissolution of the U.S.S.R. it inherited a significant share of the Soviet capabilities, particularly the Zenit and Cyclone launch vehicle families. The National Space Agency of Ukraine (NSAU) was established in February 1992 to oversee the Ukraine's space activities. While the funding for space activities has been scarce since Ukrainian's independence in 1991, the first Ukrainian satellite, Sich-1, an oceanographic weather satellite, was launched in 1995. The Ukraine spends much of its budget on launch vehicles and related hardware as part of its market-oriented strategy. Despite budgetary issues the Ukraine managed to keep its standing among major space countries by creating joint ventures with foreign partners, especially Russia and the United States, to commercialise the launch vehicles it produces (Sea Launch, Land Launch, or ISC Kosmotras).[90]

[90] Mathieu, Charlotte. "Space in Central and Eastern Europe. Opportunities and Challenges for the European Space Endeavour" ESPI Report 5. September 2007.

The Ukraine is not an official partner of the ISS programme, but has formed direct cooperation agreements with Russia and the United States. As part of those agreements, the Ukraine has performed scientific and technological experiments onboard ISS in the field of life science and material sciences. Moreover, the Ukraine already expressed its interest in participating in exploration programmes. NSAU was invited to participate in the space exploration strategy workshop organised by ESA in Edinburgh in January 2007.[91] The Ukraine is also part of the Global Exploration Strategy.

Russia is the traditional Ukrainian partner and they have a long and deep cooperation history. The Ukraine is still very dependent on Russia from an economic standpoint and this relationship is also particularly reflected in the space sector. For instance, Ukrainian systems include many Russian components and subsystems.[92] The Ukraine is, however, looking for other partners in order to diversify its partnerships and limit its dependence on Russia. Ukraine cooperates with Argentina, Egypt, Israel, South Korea, and Turkey. As aforementioned, it is also cooperates with the United States. Brazil has been an important partner of the Ukraine as well in recent years. In particular, a Ukrainian-Brazilian company "Alcantara Cyclone Space" was created in 2007 for the establishment of a ground-based complex for the Cyclone-4 rocket at the Alcantara Launch Center with a first launch scheduled for 2010. China is also a key technological partner for the Ukraine and 29 joint projects in four areas including launch vehicles, satellites, space hardware and space science and electronics are being carried out as part of a plan for strengthening Ukrainian-Chinese cooperation in space for the period 2006-2010 under an agreement signed in June 2006.

Europe is also a close partner for the Ukraine. Since Ukraine's independence, the EU has been the main actor fostering bilateral ties. The political framework for the cooperation between EU and the Ukraine is the European Neighbourhood Policy. EU relations with the Ukraine are based on the Partnership and Cooperation Agreement (PCA), which entered into force in 1998 and provides a comprehensive and ambitious framework for joint work with the Ukraine in all key areas of reform. Negotiations on a new enhanced agreement with the Ukraine started in Brussels on 5 March 2007. A number of specific agreements, in particular, policy areas such as trade, justice and home affairs, environment, transport, S&T and nuclear energy are also in place. The EU is seeking an increasingly close relationship with the Ukraine, going beyond cooperation, to gradual economic integration and a deepening of political cooperation. The Ukraine is therefore considered a priority partner country within the European Neighbourhood Policy (ENP). A joint EU-Ukraine Action Plan was endorsed by the EU-Ukraine Cooperation Council on 21 February 2005. A revised Action Plan on Justice, Freedom and Security (JFS) was endorsed by the Cooperation Council on 18 June 2007. The EU and its members also support Ukrainian scientists and engineers and their integration into international projects through different channels and the Ukraine is also participating in EC's Framework Programme.

The Ukraine is also looking to become a greater space partner with Europe. A framework agreement between the Cabinet of Ministers of the Ukraine and ESA is under preparation and might be signed in 2008. The EU is also increasing its cooperation with the Ukraine in the space field. In the PCA, a dedicated article focuses on space and calls for "long term co-operation in the areas of civil space research, development and commercial applications." In the 2005 Action Plan, there is also a joint space working group under the PCA Science and technology, research and development heading. An agreement between the EU and the Ukraine on Galileo and EGNOS was signed in December 2005. The Ukraine was the third non-EU country after China and Israel to sign such an agreement. On 10 January 2007, the Cooperation Agreement on a civil GNSS with the European Community and its member States was signed. The Ukraine is also interested in developing capabilities that are GMES-compatible and complement it. Moreover, the official opening meeting of the EU-funded Twinning project in the filed of space took place on 22 April 2008.[93] The two-year Twinning project "Boosting Ukrainian Space Cooperation with the European Union" is conceived with the objective of closing the gap between the Ukraine and the EU in the space sector, and deepening cooperation and development in matters of legislation, science and industry.

[91] Ibid.
[92] Ibid.

[93] This project is the first one related to the space sector in the history of the Twinning European programme, an EU institution-building initiative originally aimed at candidate countries but now extended to Ukraine. The European Commission selected a Franco-German consortium made of the French Space Agency (CNES) and the German Space Agency (DLR), as partner to NSAU in the Twinning project. The project is funded by the European Commission and is worth 1.5 million euros. The contract concerning the Twinning project was signed and endorsed on 6 November 2007.

3.4.11. United States of America

United States of America	
Space Agency: National Aeronautics and Space Administration (NASA)	**National Space Budget:** 53.411 million USD (est) Foreseen Budget Trend: Stable
Priorities in Space: • Development of the Crew Exploration Vehicle (CEV) and the Crew Launch Vehicle (CLV), • Human spaceflight activities • Solar and Earth systems research • Atmospheric aeronautics transportations	**Selected Space Exploration Prospects:** • Human spaceflight activities • Contribution to ISS • Development of a new space transportation architecture • Strong interests in lunar and Mars exploration • Interests in other planetary bodies • Potential instruments for on-board robotic missions

Since the collapse of the Soviet Union, the United States has been the clear leader in space affairs in terms of budget and capabilities both in military and civilian space affairs.[94] It is the country with the broadest set of space activities. NASA is the biggest civilian space agency in the world with an annual budget of 17.3 billion U.S. dollars for Fiscal Year 2008. The United States has been the only country to send humans to the surface of the moon and initiated the project that would later evolve into the ISS. However, the Space Shuttle Columbia accident of 1 February 2003 led to a complete reassessment of the U.S. civilian space policy. The result was a decision to place an overriding focus on exploration issues. While NASA was long criticized for its lack of guiding vision, space exploration has become its new focus. This new direction was spelt out on 14 January 2004 in the U.S. Vision for Space Exploration, renamed U.S. Space Exploration Policy (USSEP) put forth by President George W. Bush. The USSEP provides specific targets, defines human and robotic objectives and sets timetables. It states four overarching objectives[95]:

- Develop and realize a viable, budget-conscious human and robotic space exploration programme;
- Expand human presence across the solar system, sending astronauts to the moon by 2020 and to Mars thereafter;
- Develop space-related technology and infrastructure to accomplish the first two goals;
- Foster international and commercial space exploration cooperation in order to advance U.S. science, security and economic interests.

The Vision charged NASA with ISS completion by 2010, safe shuttle operation and retirement by 2010, development and full operation of new Crew Exploration vehicle (CEV) and the Crew Launch Vehicle (CLV) by 2014, delivery of astronauts to the moon by 2020, development and implementation of a plan to carry astronauts to Mars following a moon mission, and continuing execution of other advanced science and planetary missions to help develop and support human spaceflight and exploration goals and aspirations. The U.S. Congress ratified that position with an overwhelming bi-partisan majority making the Vision a law. As stated in the NASA Authorization Act of 2005 "The Administration shall establish a program to develop a sustained human presence on the moon, including a robust precursor program to promote exploration, science, commerce and US pre-eminence in space as a stepping stone to future exploration of Mars and other destinations." The U.S. plan is a step-by-step approach to exploration and NASA expects to implement its exploration activities in a go-as-you-pay approach. Yet NASA's exploration initiative has suffered chronic under-funding from the beginning and future adjustment might be needed that could impact the pace of U.S. exploration activities.

NASA is now focusing its efforts on developing a new family of launch vehicles (Ares 1) to implement its space policy. The development of a new launch architecture following the shuttle retirement around 2010 has been initiated with no foreigner in the critical path. The programme "Project Constellation" is composed of the CEV, now renamed Orion, an exploration vehicle for the transportation of crew, the CLV, renamed Ares I, a two-stage launcher carrying the Orion vehicle, the Cargo Launch Vehicle (CaLV), named Ares V, a two-stage heavy-lift launch vehicle carrying an Earth Departure Stage together with the Altair vehicle, and the "Altair" lunar lander. This lander will eventually be capable of landing four astronauts on the moon, providing life support and a base for week-long initial surface exploration missions and returning the crew to the Orion spacecraft that will bring them home to Earth.[96] However,

[94] Peter, Nicolas "Space Policy, Issues and Trends in 2006/2007" ESPI Report 6 Sept. 2007.
[95] NASA. "The Vision for Space Exploration".. Feb. 2004 < www.nasa.gov/pdf/55583main_vision_space_exploration2.pdf >.

[96] The work on Altair and Ares V is only performed at conceptual level with a decision to proceed with the

because the Shuttle is set to retire in 2010, a gap of several years is expected before the United States will have its new human spaceflight capabilities operational (most likely in March 2015). As the current exemption of the Iran, North Korea, and Syria Non-proliferation Act (INKSNA) is set to expire in 2011, NASA is currently seeking the acceptance by the U.S. Congress of its request to amend the INKSNA, that would permit NASA to keep paying Russia to transport U.S. astronauts to and from the ISS beyond 2011, as well as other ISS-related goods and services.[97] Consequently, while the United States remains ISS's largest contributor, it will be dependent on other countries for transporting crew and cargo to the ISS in the 2010-2015 timeframe. NASA has declared that it wants to shift ISS funding to lunar exploration after 2015 without, however, stopping its commitment to ISS. Besides the development, of a new space transportation infrastructure the development of a lunar architecture and associated technology to support the establishment of a human outpost on the moon, most likely in the South Polar Region, is the main emphasis of NASA.[98] The first mission would begin by 2020. The base would be built in incremental steps, starting with four-person crews making several weeklong visits. The moon base would eventually support 180-day lunar stays, a stretch of time seen as the best avenue to establish a permanent presence there as well as preparation for future human exploration of Mars. NASA's lunar plan also encourages participation by other countries as well as non-governmental organizations and commercial groups. A series of missions are planned to prepare the human return to the Moon such as the Lunar Reconnaissance Orbiter (LRO) mission, the Lunar Crater Observation and Sensing Satellite (LCROSS) mission, the Lunar Atmosphere and Dust Environment Explorer (LADEE) mission etc. NASA is at the same time pursing a vigorous Mars robotic exploration programme with various missions planned. The Red Planet is a target of choice for the United States in addition to the Spirit and Opportunity rovers and the Phoenix lander, other probes and participation in ExoMars and other national missions, (Mars Science Laboratory (MSL) etc.) as well as an ambitious Mars Sample Return mission possibly in cooperation with Europe are planned. NASA is also planning missions to other destinations in the Solar system. The United States is involved in the GES that it initiated.

The United States has been cooperating with many actors since the beginning of its civilian space programme often using space as a tool of international diplomacy allowing it to reach out to new partners and demonstrating goodwill. Since 1958, NASA has concluded over 4000 agreements with over 100 countries and international organizations. NASA has established cooperation with every region in the world, and all of its Mission Directorate has international partnerships. Currently, it has cooperative missions with Argentina, Australia, Canada, India, Japan, South Korea, Russia as well as may European stakeholders. However, within the framework of the USSEP, it is planning to cooperate mainly with ISS partners as well as GES partners, particularly in Europe, India, Japan and Russia.

Europe and the United States have a long and rich history of cooperation. The relations evolved rapidly beyond trade issues. To assess and develop trans-Atlantic cooperation, the European Union and the United States hold regular summits. They came into being as a result of the November 1990 trans-Atlantic declaration. However, it was deemed necessary to go beyond the regular consultations introduced by the trans-Atlantic declaration. Thus, on 3 December 1995, at the EU–US summit in Madrid, the New Transatlantic Agenda (NTA), which provided for joint action in four major fields (promoting peace and stability, responding to global challenges, contributing to the expansion of world trade and closer economic relations, and building bridges across the Atlantic) was signed. More recently, the June 2005 EU–US economic summit launched the "EU–US initiative to enhance transatlantic economic integration and growth", covering cooperation in a broad spectrum of areas with a view to promoting further economic integration across the Atlantic and maximising the potential for economic growth. The EU and the U.S. have also a long history of cooperation in research, science, and technology at many levels.[99] In the context of increasing trans-Atlantic relationships, an S&T cooperation agreement between the EU and the U.S. was signed on 5 December 1997. This agreement stems from the launch of the New Transatlantic Agenda (NTA) in 1995, and is part of the chapter on "Building bridges across the Atlantic". It is a multi-dimensional agreement in scope (acting

development to be taken in 2011.

[97] Portions of that law (INKSA) adopted in 2005, prohibit "extraordinary payments" both "in cash" and "in kind" from the U.S. Government to the Russian Government, Roscosmos, and entities under Roskosmos' authority for the ISS.

[98] The preliminary location is on the rim of the Shackleton Crater on the South Pole.

[99] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107

as umbrella for numerous activities), covering cooperation in many scientific domains and may take the form of coordinated research projects, joint research projects, task forces or studies, seminars and conferences, training, visits and exchange of personnel, exchange and sharing of information, materials and equipment. The United States is also a major partner in EC's Framework Programme, as well as the ITER project.

The United States and Europe have been cooperating in space activities for more than four decades, making the trans-Atlantic partnership the oldest alliance in space.[100] During this period, more than a hundred missions have involved various forms of U.S.-European cooperation. The cooperative aspects of these missions have varied greatly in scope, complexity, and success.[101] The history of European-U.S. cooperation in civilian space affairs has continued despite significant geopolitical, economic and technological changes such as the end of the Cold War, the pressure of budget reductions on both sides of the Atlantic, political differences in several areas, in addition to the difficulties of cooperation in several projects such as the International Solar Polar Mission (ISPM), the ISS, and the difficult GPS-Galileo negotiations. Human spaceflight has been a particularly visible example of trans-Atlantic partnership, beginning with the 1969 U.S. invitation to Europe to participate in its post-Apollo spaceflight efforts.[102] This ultimately resulted in Europe contributing the Spacelab module to the Space Shuttle programme. Many European astronauts have also flown aboard the shuttle. Europe has developed its contributions to the ISS (the Columbus orbital module and the re-supply cargo vehicle, the ATV).[103] A long history of cooperation exists between NASA, ESA and individual European countries, but the U.S.-EU cooperation in space has been increasing in recent years, not only in the framework of GPS-Galileo negotiations. During the 2005 EU–US Summit, both sides agreed to initiate a dialogue on civil space cooperation as part of the "European Union and United States initiative to enhance transatlantic economic integration and growth".[104] On 24 March 2006, European and American officials met to discuss trans-Atlantic cooperation in space. This was the first meeting of the "EU–US dialogue on Civil Space Cooperation" announced at the June 2005 US–EU Summit. A broad range of activities and policy issues were on the agenda including space science and exploration. The last EU-US meeting took place on 28 May 2008 with space exploration being an agenda item again. It was further acknowledged the good cooperation in this domain and that it should remain a cornerstone of EU-US space cooperation in the future.

3.5. Summary

The space exploration context is in transition due to the internationalization and globalization of space affairs. This is leading to new programmes and missions being developed by an increasing number of actors and the fact that the major actors are in the process of improving their respective space activities in selected areas of national concern. However, when developing future European plans and strategies a through understanding of the future plans and aspirations of the main non-European space actors and existing relations with Europe are needed when considering international cooperation in space exploration.

[100] Ibid.
[101] European Space Policy Institute and Space Policy Institute. "Reinvigorating Transatlantic Space Relations: The Joint ESPI-SPI Memorandum" Space Policy 24.3 (Aug. 2008): 119-123
[102] Ibid.
[103] Ibid.
[104] Peter, Nicolas. "The EU's emergent space diplomacy". Space Policy. 23.2. (May 2007): 97-107

4. The way forward

As stated in September 1962 by U.S. President John F. Kennedy "The exploration of space will go ahead whether we join in it or not, and it is one of the great adventures of all time, and no nation which expects to be the leader of the nations can expect to stay behind in the race for space".[105] Forty-six years later this is still true for the United States, but also for major countries and it will remain the same in the next 20 years.[106] Space exploration will be one of the challenges of the century where all actors involved will principally do it for prestige and other national interests as space exploration is not a destination, but a process driven by political and socio-economic motives. However, world politics have changed greatly since President Kennedy's speech and will continue to evolve in the future as underlined in Chapter 2. Over the next 20 years, the geopolitical context might change considerably. This could prove very disruptive for the current space exploration strategy with the entry of new actors onto the space exploration arena, as the space domain is no longer the exclusive province of a handful number of countries. The eleven countries this study focuses on are joined by other countries that have some degree of space involvement and Europe needs to anticipate these changes.

The next 20 years will be a period of fast change with new opportunities, but also challenges (Cf. Chapter 2). This implies that Europe should not breed complacency, but it must do more to prepare itself for an evolution of the overall geopolitical system, as well as increasing competition. Europe needs to anticipate and adapt to those changes and evolve if it wants to sustain its record of technological innovation, but also scientific excellence as the expected socio-economic impacts of space exploration will spread to many sectors and provide Earthly benefits.[107] The decision to take vis-à-vis the future space exploration come in a special context with the unanimous support of the European Space Policy by 29 European member States, but also because Europe though ESA has confirmed its position as a leading global player in space exploration with the launches of Columbus and ATV. Europe should however not rest on this achievements and on the opposite in an evolving space exploration context as underlined in Chapter 3, new programmes have to be put forward to assert Europe as an indispensable and major actor in space exploration in the two decades to come.

While Europe has invested enormous volumes in the last 50 years to become a leader in space, the plans of other countries are threatening Europe's position in the future "space hierarchy" (Cf. Chapter 3). Space exploration is a global undertaking that will receive increased visibility in the decades to come. In an evolving multipolar space context, Europe 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, Europe needs to be actively involved in space affairs including 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 in order to benefit from enabling opportunities wherever it supports European space exploration objectives, but also wider European policies goals.

Following the evolution of the European space context with the adoption of the European Space Policy, the eventual entry into force of the Treaty of Lisbon, the EU will be able to increase its involvement in space activities (Cf. Chapter 3). The growing role of the EU in space exploration could ensure a higher

[105] Kennedy, John F. Address at Rice University on the Nation's Space Effort. Houston, Texas. 12 Sept. 1962. <http://www.jfklibrary.org/Historical+Resources/Archives/Reference+Desk/Speeches/JFK/003POF03SpaceEffort09121962.htm.>.

[106] The notion of race for space could however be downplayed for the next 20 years.

[107] Space exploration could allow consolidating European identity around an objective which offers a high profile to Europe and pride to its citizens. It could also inspire more students to pursue S&T studies. An ambitious space exploration programme could thus allow the development of a high-tech workforce and a dynamic industrial base that are both critical for Europe's economic competitiveness on the world stage.

degree of political visibility in Europe and the rest of the world. Europe and the EU, in particular, should thus engage in an ambitious long-term commitment to support space exploration in cooperation with ESA and national actors that could emerge as a new "flagship" programme following the footsteps of Galileo and GMES. This would imply in particular that the appropriate EU financial instruments in the framework of the multi-annual Financial Perspective and appropriate long-term Community investment are developed, because a "go-as-you-pay" approach should be avoided. Existing mechanisms such as the Framework Programme (FP) could be used to provide new institutional funding opportunities to European exploration activities in the context of the next FPs (post-2013). As a complement to the FPs, some Trans-European Networks funds as well as the Competitiveness and Innovation Framework Programme (CIP) and other Community mechanisms could be used. The FP could also help to reach out to new partners to join this endeavour as it has considerably supported the involvement of non-European countries in European S&T activities as illustrated in Chapter 3.

Europe can play a significant role in future space exploration if there is a "political will" to invest resources commensurate with the challenge. The amount of funding invested during the time period 2008-2025 will ultimately determine the content of the European exploration programme and pace of its implementation. To pull its weight, Europe (the EU, ESA and their member States) needs therefore to make the most of their combined resources at both the European and national level. 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. The attractiveness of Europe as a major partner for international cooperation can also help reduce the uncertainty linked to the amount of funding allocated in the future. It is therefore important that Europe remains the number one option for international cooperation (so-called "partner of choice").[108] However, a lack of ambitions and inaction could lead Europe to become a follower, but also isolated, or only able to cooperate with less capable actors which will be a regression for Europe compared to its present status.

4.1. Policy options

Europe currently enjoys a strong position in the global "space hierarchy", but this might not be everlasting. To maintain a leading space role what is needed besides "political will" is a series of ambitious programmatic elements. 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 potential international partners. However, if Europe wants to play a significant role in the worldwide exploration context, a commonly agreed European exploration strategic plan, and above all, a comprehensive programme with well defined development projects, is indispensable and needs to be established and agreed in the near future.

Europe has a long-term Vision (Aurora) and has demonstrated a solid set of 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 R&D. 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.

Europe has to focus on selected strategic priorities and initiatives. However, the definition of the European role in space exploration is ultimately a political decision made all current and future stakeholders. 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. 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

[108] The impact assessment done by the European Commission (COM (2007) 506) for the European Space Policy concluded that cooperation with key international partners is indispensable to contribute to the international exploration endeavour.

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.

Space exploration is an indispensable element of Europe's portfolio contributing to maintain and perhaps improve its standing on the global scene. This document proposes some options to be considered in Europe in the timeframe 2008-2025 beyond currently approved programmes and missions in order to provide European decision makers with potential elements and perspectives to consider if Europe wants to be a major space exploration actor in the next decades. Those options need to be forward looking and attainable and should build a consensus by involving as much as possible all European stakeholders behind them. Europe needs to develop strategic capabilities which will not only build on European industrial competences, but also acquire new one to make Europe an influential actor and partner of choice. A non-linearity of the European space context is assumed with a potential greater involvement of the EU in ESA-led space exploration activities (and national activities) following the adoption of the 2007 European Space Policy and the Treaty of Lisbon (or any alternative document), and therefore a potential subsequent budgetary increase.

In order to prioritize European initiatives to ensure that Europe remains a leading space power in the field of space exploration and adapts to an evolving space context key options for the next 20 years are explored. Those policy options based on internal ESPI reflection that take into account an evolution of the European space context with the increasing interest of the EU in space exploration activities. These options provide directions in which Europe could move forward in the next two decades. The specific technology capabilities needed are not listed as it is perceived that political decision has to be secured first. However, the options put forward would allow drawing on initial roadmap for future space exploration activities.

- The first option would consider a Europe focusing on robotic exploration to the moon, Mars and other planetary bodies, including NEOs and the sustained utilization of the ISS ("status quo" option).
- The second option would consider a Europe focusing on robotic exploration to various destinations in the solar system, the utilization of the ISS with the development of the capability to return the European cargo back to Earth, and an involvement in human lunar exploration activities ("conservative" option).
- The third option would consider a Europe with a robust robotic programme to various destinations, the continued utilization of the ISS, autonomous human access to space and an involvement in human lunar exploration activities ("pragmatic" option).
- The fourth option would consider a Europe with a robust robotic programme to various destinations in the solar system, the sustained utilization of the ISS, human autonomous access to space, human lunar exploration activities and leadership role in preparing activities linked with human exploration of Mars ("ambitious" option).

4.1.1. "Status quo" option

In this option, Europe would continue its specialization in robotic exploration, particularly to Mars within the framework of the Aurora programme as well as to the moon and other planetary bodies for scientific and technological objectives. The leadership in ambitious robotic missions (ExoMars) or co-leadership (Mars Sample Return - MSR - missions) would show the excellence of European space project management and technologies and allow Europe to develop unique capabilities (entry descent and landing technologies, surface mobility, etc.) that would serve as building block for an eventual long-term human mission to Mars. Those robotic missions could be very well adapted to a large-scale cooperation scheme. The main partners in those activities would be the United States especially for Mars missions of large size, such as MSR missions, and other traditional space actors like Russia and Canada for robotic surface activities like landers, and Japan for missions to other planetary bodies. This type of activity would also allow Europe to continue its "constructive engagement" in space activities by cooperating with China and India in hosting payloads on European robotic missions or providing sensors to other missions and by sharing data and services.

Renouncing to human spaceflight activities in LEO and access to the ISS is not politically acceptable as regards the technological progress and investments made over the years. Therefore, Europe should continue to use ISS for research in life and physical sciences, particularly as a test-bed and platform for developing enabling capabilities for space exploration, as well as to favour long-duration flights by European astronauts. Europe should also open cooperation for

potential science missions onboard Columbus to other partners including emerging and future space powers. Over the last years, the uncertainty over the future of the ISS programme has been significantly reduced. The United States is likely to continue to use the ISS beyond 2016 even as it focuses on lunar and Mars exploration projects. In particular, the U.S. Congress has designated in 2005, the U.S. segment of the ISS as a "national laboratory" and directed NASA to develop a plan to increase the utilization of the ISS by other federal entities and the private sector. However, while the ISS will remain the dominant human spaceflight activity for the years to come, Europe should also consider the future of European human spaceflight beyond the ISS programme to secure continued research in space. It should seek continued commitment to the operations of ISS with current partners as well as with newcomers to maximize both, scientific and technologic return on investment in the ISS programme. Europe should therefore aim to continue to be involved with a wide range of partners. This option would allow it to maintain a minimum of human spaceflight capabilities in Europe by exploiting its orbital laboratory module and accessing the ISS as passenger onboard human spaceflight vehicles of Russia and the United States.

This "status quo" option focuses on robotic exploration to various destinations in the solar system addressing high scientific priorities of the European science community, particularly Mars, and guarantees a similar level of human spaceflight activities until 2025 as today, concentrated on the ISS operation and utilization, including operation of the orbital infrastructure beyond 2016 and possible follow-up infrastructure. However, this option would represent a relative stagnation for Europe as no new ambitious programmes in human spaceflight would be put forth, and consequently, Europe will loose its place in the current and future "space hierarchy" in a context were all others powers to pursue ambitious agenda.

4.1.2. "Conservative" option

This option envisages that the ISS would remain the cornerstone of Europe's space exploration activities. In this context, while Europe has developed the Automatic Transfer Vehicle (ATV) to transport supplies to the ISS, it should consider the need to develop independently the ability to recover the ATV back on Earth so it can return cargo to Earth after delivering capabilities to the ISS. Developing such capability would provide a significant download capability guaranteeing the maximization of utilization of the ISS as the current Soyuz capsule is insufficient and Orion will have limited down-mass capability.[109] This development could also support the extension of the ISS utilization beyond 2016 and enable Europe to anticipate the post ISS-era while committing it to continue human activities in LEO. Modifying the ATV to permit a cargo-return function would be the first step in a gradual evolution allowing Europe to transport crews to, in and from space and will demonstrate to others partners Europe's willingness to take responsibility, but also that it is a reliable partner. While this cargo infrastructure has to be developed independently to demonstrate European capabilities in deep space automatic transportation, it could to be made interoperable with other systems to add redundancy and robustness to the global human transport infrastructure including traditional partners like the United States, Russia and Japan, but also emerging powers like India and China.

After the Apollo programme, human spaceflight has concentrated for more than 35 years exclusively on missions to Earth orbits with the development of transportation systems and orbital infrastructure. However, as new plans for human exploration of the moon are spreading, Europe should consider joining this endeavour. The moon could be used by Europe as a test bed for human exploration by capitalizing on its assets such as Ariane 5, the ATV and Columbus as capability building blocks. By focusing on a few sustainable technology niches that can be transferable, Europe could develop key strategic technology and capabilities for human lunar exploration of relevance for future Mars missions. It could envisage providing on-the ground technologies, such as lunar habitat or surface transport elements and service contributions. The option of an ATV capable of bringing back elements would allow Europe to provide a vital contribution to the transport infrastructure as a soft and precise landing in any lunar location would be extremely useful for future robotic and human missions. It will also provide barter capabilities for other endeavours and may provide the possibility to have European astronauts on the moon. Human lunar activities should be pursued in cooperation with the United States to develop the foundations for a sustainable future human spaceflight exploration programme.[110]

[109] In the 2010-2015 timeframe Russia will have with the Soyuz spacecraft the only spacecraft capable to transport materials back to Earth.

[110] For more information see the NASA-ESA Comparative Architecture Assessment released in July 2008.

However, Europe will still remain a "junior partner" compared to the United States in such endeavour. Robotic lunar exploration cooperative activities could be done with other partners under European leadership by hosting foreign payloads or by involving Deep Space Network infrastructure and scientists of other countries, including emerging space powers.

This "Conservative" option would envisage that Europe continues its development in robotic exploration missions to the moon, Mars and other planetary bodies in European scientific priority areas and open them to international cooperation with various partners. It would also allow Europe to develop new capabilities (evolved ATV) to continue to maintain its commitment in on-going human spaceflight activities, as well as develop enabling capabilities and embrace new challenges such as lunar human exploration. This option would thus allow Europe to maintain its position as a major space power, but it will not preclude a loss of competitiveness and attractiveness in the long-run.

4.1.3. "Pragmatic" option

Access to space has always been a priority for Europe. However, there are different levels of access to space, and Europe currently lacks human spaceflight capabilities, the most emblematic of all means to access space. While Europe has been developing significant capabilities and experience in human spaceflight during the past three decades, it has been dependent on its international partners for human spaceflight core functions (i.e. access to space) and this dependence has led to many delays and even programmes cancellation. The impacts of such dependence have been reflected in the light of the Columbia accident and the subsequent grounding of the space shuttle fleet. Against this backdrop, it appears now critical and timely to review Europe's ambitions in human spaceflight activities. Thus far, only the United States, Russia and China have mastered human transport into near-Earth orbits, but India is also considering following this path. For Europe, the major question is therefore whether or not it wants to enter into this field. This clearly determines if Europe can play a leading role in the future or continue to be a "junior partner" in future human space exploration with lower costs and risks, but fully dependent on others. Human spaceflight is often considered a necessary prerequisite for being a major player in space, in this context Europe should recognize human spaceflight as a strategic activity and develop the necessary capabilities and infrastructure for a safe and secure human access to space that create another way of reaching the ISS. Thus, while ESA is currently recruiting a new generation of astronauts, Europe should strongly consider developing its own access to space to ensure its strategic non-dependence in the next decades. Europe could either cooperate with Russia to develop the Crew Transport System (CSTS) or develop a European Crew Transport System (ECSTS) independently. In any case, European access to space should be part of an international transport architecture enabling human mission to cis-lunar space to provide redundancy in crew transportation. It would increase the visibility of Europe's role in ISS through increased flights and astronauts to the ISS and enhance the robustness of ISS logistics beyond 2016. It would also ensure the utilisation of the orbital infrastructure for the preparation of European space exploration interests and provide more research opportunities for Europe and the international user community. It would also anchor ISS and human spaceflight activities beyond the nominal ISS programme duration and prepare for the post-ISS era. This capability should be available by the time the U.S.'s attention will be focused almost exclusively on the moon to guarantee future ISS full utilisation. Moreover, if Europe develops its own capability it could open access to space (to LEO and beyond) to non-European countries as a tool of foreign policy and could make barter agreements with various partners that could provide tangible benefits to Europe.

Having astronauts on the moon would be a clear message of assertiveness for a country. European astronauts on the moon would therefore be a very visible expression of European ambitions in space and in the world. An intensive contribution to the U.S.-led lunar outpost with the development of independent and complementary capabilities to other partners would allow Europe to acquire the technologies it feels are of interest, such as deep space communication and navigation. It would also allow it learning how to transport and to utilize local resources and how to sustain human adaptation to reduced gravity conditions and prevailing radiation environment. This would also prepare Europe to become a major player in future human Mars missions. Europe should also establish itself as a co-leader in future Mars space exploration sample return activities.

In this "Pragmatic" option, Europe would develop a comprehensive long-term exploration strategy, comprising autonomous human access to space and independent activities in cis-lunar space, as well as a robust robotic space exploration programme to various destinations in the Solar system and ambitious human lunar activities. This option would allow facing the emerging competition resulting from the evolving space context and will increase Europe's status and standing in world affairs.

4.1.4. "Ambitious" option

The future of European human spaceflight is focused in the short and medium term on operations and full utilization of the ISS. In this context, Europe should ensure access for European astronauts to space and for the European user community to research infrastructure in space. Europe should also maintain its international commitment and fulfil its responsibilities through the provision of operational, logistical support, etc. and reflect on post-ISS options to maintain a sustained European presence in LEO. However, Europe should take a leading role in the development of future architecture for human spaceflight missions to the Red Planet and develop the first elements of a man mission to Mars to be implemented in the 2030s. Both, the "European Objectives and Interests in Space Exploration" and the "ESA Strategy for Human Spaceflight, Microgravity and Exploration Programmes" documents identify Mars as the ultimate objective for potential European human space exploration. While the United States are focusing on the return to the moon, Europe could step into the vacuum left by the United States to pursue its own interests. It is widely admitted that Mars human missions are going to be the most visible and ambitious space activities of the forthcoming decades. Consequently, as the United States took the lead for human exploration of Earth's closest neighbour, Europe could take a leading role in the exploration of Mars, especially as on the U.S.-side, the work on an updated Mars Design Reference Mission has been halted as a result of the language in the U.S. Appropriation Act of 2008 prohibiting funding of any research, development, or demonstration activities related exclusively to the human exploration of Mars. Stating firmly that Europe will play a leading role in this long-term undertaking and that it will engage early in technological developments would be a clear way to express European ambitions in space in the 21st century. Europe cannot do it alone, so it needs to join others or assemble an ad hoc coalition, but this should be done under its leadership. This long-term initiative would allow Europe to attract all space powers as well as emerging space actors to back humankind's next grand challenge. There will be a large portfolio of cooperation opportunities with established, emerging and future space powers, but also with other strategic partners as sending humans to Mars would require substantially new technologies in almost all areas of space activities, in particular, in automatic and human space transport for long-duration missions. However, the success of most of these cooperative efforts will depend to a large extent on pre-existing alliance structures and S&T cooperation heritage.

While Mars is a destination of choice, it is undesirable for Europe to be completely absent from lunar exploration efforts. Being involved in the U.S.-led endeavour would allow developing technological capabilities in the area of strategic importance for Europe. It would permit building relevant planetary surface infrastructure and acquire advanced technologies, including habitation and life support, mobility surface activities, resources management, demonstration of life support systems, etc. Participating in lunar exploration would be a stepping stone opening the door to future Mars exploration activities, making it possible to achieve both objectives on a technological and political standpoint. Europe should also consider accessing and utilizing Lagrangian points (i.e. L4 and L5 points in the earth-moon system) for strategic reasons.

This "Ambitious" option focuses on robotic exploration to various destinations and particularly pathfinder missions to Mars, but also human missions to the moon to develop the necessary enabling capabilities to take a leading role in a Mars mission. This option would demonstrate Europe's ambition on the global scene and would have tremendous societal benefits by fostering a forward-looking Europe to its citizens.

4.1.5. Method of assessment and evaluation

In order to evaluate the proposed four options addressing the issue of the future role of Europe in long-term space exploration, a series of empirical methods have been considered. The analysis has been preformed in particular by using political and socio-economical criteria and factors. Three measures of the options were considered as important. These include the likely effectiveness of the option, the projected cost of the option, and the political feasibility of

the option. Those criteria are not comprehensive but represent the major elements to be taken into account by decision makers and allow gaining insight into those priorities and lay a foundation for subsequent detailed analysis and evaluation.

An option is considered effective if it increases the place of Europe in the "space hierarchy" by either presenting ambitious plans targeting interesting destinations independently or by inviting partners to be involved. A successful alternative would meet some or all of the following objectives:

- It demonstrates Europe's ambitions as a dominant space actor.
- It opens new alternatives for partners to engage in cooperation with Europe.

The cost of each option is also assessed. This is particularly important as Europe's overall budget devoted to space activities is limited. To judge options under this criterion, each option's cost has been be examined as the amount of funding needed by Europe to implement the option individually or in cooperation over the period 2008-2025 considering the evolution of the European space context laid out in Chapter 3.

The final criterion is political feasibility, which is a judgment of whether or not the option is politically feasible for Europe in terms of expanded funding and implementation. It includes an assessment of the likely acceptance of the option by the various European stakeholders.

4.1.6. Evaluation of options

Each option has been evaluated using the aforementioned criteria in order to have a qualitative assessment of those options. The options were given a score on each criterion on a scale of 1 to 5 (1 represents a low score or low success on the criterion, and 5 represents a high-score or great success on the criterion) based on internal assessment and ESPI's best knowledge providing therefore a general appraisal of the four options put forward. The options were subsequently ranked using a scorecard method to provide a general overview of their performance.

4.1.6.1. "Status quo" option

Effectiveness
The ambitions of this option are rather limited as it provides few possibilities for Europe to project influence on the world scene and to attract foreign partners in European led-space activities, except in the field of robotic missions. This option would mean an inadequate role for Europe in the upcoming global space exploration context. The effectiveness of this option would therefore be very low.

Cost
Relative to the other alternatives, the cost for this option is quite low for Europe as no new major human spaceflight programme would be developed and only a number of new robotic missions would be initiated.

Political feasibility
This option would not allow maintaining the industrial capability of Europe nor attract the best partners for future endeavours. Furthermore, several European stakeholders want to promote a more assertive and ambitious Europe in space exploration. The political feasibility of this option is therefore moderate.

4.1.6.2. "Conservative" option

Effectiveness
The effectiveness of this alternative would likely be high as it would allow Europe to increase its position in the ISS infrastructure system and engage into human lunar exploration activities, while having a robust robotic exploration programme. This option would permit leading several international cooperation ventures reinforcing therefore Europe's attractiveness.

Cost
The cost of this alternative, relative to the other options, is moderate and is within the financial projection of Europe for the period 2008-2025.

Political feasibility
Several European actors would be favourable to such an initiative since it might provide new resources for the European space industry and demonstrate a more forward-looking Europe. However, Europe would remain dependent on third parties to access space for European astronauts and therefore to reap the benefits of its long-term investments in the ISS programme.

4.1.6.3. "Pragmatic" option

Effectiveness
The effectiveness of this alternative is likely to be high, as Europe would enter the exclusive club of space powers having autonomous manned access to space. It would also allow developing new international cooperation ventures under European leadership in the field of robotic missions and potentially offer crewed access to space to other countries.

Cost
This option is affordable within European space budgets if all European stakeholders unite behind the goal of having an assertive and ambitious Europe for the decades to come.

Political feasibility
The political feasibility of this alternative would be high, because it would allow Europe to develop new enabling technologies and capabilities paving the way for future space exploration activities and eventually improve the innovation potential of European space activities, by engaging in a broad set of new activities. This option would also allow consolidating European identity around an objective of great appeal, which offers a high profile to inspire European citizens.

4.1.6.4. "Ambitious" option

Effectiveness
The effectiveness of this option would likely be very high. It would develop the image and identity of Europe as a dominant world player attracting the best partners to participate in its projects. This option would enable Europe to be a visible actor in all exploration activities and influence future space exploration programmes.

Cost
The cost of this option relative to the other four options is very high, as it requires high capital investment devoted to research and development in unproven technologies and concepts that will span over decades. The affordability of such a programme is beyond the current capabilities of Europe, and even international cooperation would not make it possible (referring to projected economic conditions of the potential partners analysed in Chapter 2).

Political feasibility
This option has the highest political appeal due to its ground-breaking nature. However, although it is by far the most innovative and ambitious option in this analysis, it is also the most controversial. The political feasibility of this option is consequently very low due to the absence of strong commitments of current space activities for a human mission to Mars with a leading role of Europe.

4.1.7. Summary

This section highlights the key findings arising form the evaluation of the four policy options. This appraisal provides an indication of the choices that Europe can take. In Table 5, each option is ranked based on the three evaluation criteria.

The assessment of the four policy options for space exploration proposed for the next 20 years provides a reference system upon which to base future reflection at political level in Europe. As illustrated in Table 5, the "pragmatic" option (autonomous human access to space and lunar exploration) would have the higher score. This option would demonstrate a more assertive Europe with global ambitions, fostering its competitiveness and attractiveness vis-à-vis current and emerging partners. The "conservative" option (evolved ATV and lunar exploration) would allow Europe to maintain its current position in the global "space hierarchy" and would guarantee its human activities in LEO, however dependent on other partners. Another option, the "status quo" option presents some interesting potential due to the moderate cost associated of the option, but implies a regression of Europe in the future "space hierarchy". Finally, the "ambitious" option (human missions to Mars) might be too premature due to the high cost associated with the effort despite its very high effectiveness.

4.2. Timing of the decision

As with any major space endeavour, it takes many years to plan and prepare the next steps in space exploration. However, to guarantee the best and optimal decision for the option selected to be implemented in a timely manner, the first steps have to be taken immediately. Activities need to be prepared and initiated to have results ready by the end of 2010 to allow for the preparation and presentation for the respective programme proposals of the option selected at the 2011 ESA Council at Ministerial level and in time to be considered in the next EU Financial Perspective and in

Option	Effectiveness	Cost	Political feasibility	Total
"Status quo" option	1	5	2	8
"Conservative" option	3	4	3	10
"Pragmatic" option	4	3	4	11
"Ambitious" option	5	1	1	7

Table 5. Analysis matrix of options

the preparatory activities of the next FP. There is also a clear need for a global orientation in order to enter into discussions with potential partners, as time is needed to identify common objectives and enter into discussions.

Short and long-term objectives and options cannot be determined in isolation from the economic, social, scientific and political context in which Europe will operate in the future. As indicated in Chapter 3, the scope of space exploration activities that will be pursued by the respective actors will undoubtedly differ; Europe should nonetheless try to shape the perception and definition of space exploration worldwide in the directions of its own performance. Despite all benefits, international cooperation does not happen by accident. International cooperation must be initiated at least by one actor and Europe should play this role according to its ambitions. As potential partners are defining their plans and programmes, it would be an opportunity to offer attractive solutions in time for them to be considered in the various options put forward and take part in future programmes and missions. Europe needs however to act now, when those capacities are still developing, and not in ten years' time when the stage has already been set (by others). Early consultation and mapping of potential partnerships would make effective cooperation easier by identifying early-on all the necessary steps of specific projects.

By looking at the political reality of potential extra-European partners, a limited "time-window" will open following the 2008 November U.S. Presidential election to engage in long-term space exploration programmes and missions (Table 6). This "window of opportunity" will last until 2011, as the leadership of most countries is expected to remain in place for a few years ensuring a greater political stability, but also the possibility to reach and conclude a cooperative agreement in this period (Table 6). Europe should therefore consider the various national political cycles and try to maximize this "window of opportunity" to engage with potential partners to take part in its long-term space exploration activities.

4.3. International cooperation in European space exploration plans

Recent (and future) geopolitical developments, combined with the funding constraints of the various space-faring countries, have made it clear that greater international cooperation will be important for future space exploration activities. Sustained human missions beyond low Earth orbits will not be possible with the resources of a single country. Although space exploration during the second half of the 20th century was dominated by the former Soviet Union and the United States, the fairly exclusive space club has been joined by Europe, Japan, China, India and soon others will join. Unlike the earlier period, the post-Cold War context is as aforementioned undergoing a rapid evolution with a growing number of new actors considering and engaging in space exploration activities. Space agencies around the world are now looking to a variety of partners as they plan their future endeavours. There will thus inevitably be opportunities for many countries to make major contributions to a global programme, as cooperation can occur at different stages of a space project (mission planning, mission design, or mission operations, etc.) and can cover different types of activities such as the exchange of scientific and technical information, training activities, etc. Future space exploration endeavours will therefore involve significant cooperation between space-faring countries, but also with newcomers.

The benefits of cooperation are numerous and well documented. Among others, they include improving capability, sharing costs, building common interests and increasing the total level of available resources, eliminating the duplication of efforts, and improving international relationships. [111] It potentially makes the implementation of a space project more affordable to each individual partner involved, while enriching the pool of scientific and technological expertise. In addition, international cooperation offers robustness and redundancy through added mission options and access to alternative transportation systems. It also enhances domestic legitimacy of space projects and gives them international credibility and consequently it makes them less vulnerable

[111] Correll, Randall R., and Nicolas Peter. "Odyssey: Principles for Enduring Space Exploration". Space Policy 21.4 (Nov. 2005): 251-258.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Brazil			Pr./Pa.				Pr./Pa.				Pr./Pa.				Pr./Pa.			
Canada				Pa.					Pa.					Pa.				
China	Pr./Pa.					Pr./Pa.					Pr./Pa.					Pr./Pa.		
India		Pa.			Pr.		Pa.			Pr.		Pa.			Pr.		Pa.	
Japan		Pa.1	Pa.2			Pa.1/Pa.2			Pa.2	Pa.1		Pa.2		Pa.1	Pa.2			Pa1./Pa.2
Korea	Pa.				Pr./Pa.				Pa.	Pr.			Pa.		Pr.		Pa.	
Russia	Pr.			Pa.	Pr.			Pa.	Pr.			Pa.	Pr.			Pa.	Pr.	
South Africa		Pr./Pa.					Pr./Pa.					Pr./Pa.					Pr./Pa.	
Ukraine		Pr.			Pa.		Pr.			Pa.		Pr.			Pa.		Pr.	
USA	Pr./Pa.		Pa.		Pr./Pa.		Pa.		Pr./Pa.		Pa.		Pr./Pa.		Pa.		Pr./Pa.	
Australia			Pa.1/Pa.2			Pa.1/Pa.2			Pa.1/Pa.2			Pa.1/Pa.2			Pa.1/Pa.2			Pa.1/Pa.2

Pr.	Presidential elections
Pa.	Elections to the Parliament; Pa.1 and Pa. 2 stands for two separately elected chambers
Pr./Pa.	Presidential elections and elections to the Parliament take place in the same year

Table 6. Foreseen political milestones of major space actors until 2025

to cancellation due to domestic political or financial problems.[112] However, while cooperation is seen as an important complement to each country's capabilities, it also carries risks and explains why cooperation does not always take place.[113]

The advantages of international cooperation are usually more marked under certain conditions. Successful cooperation requires the satisfaction of a significant amount of the core interests and needs of all partners as the benefits to each partner from cooperation are often also neither simultaneous nor of the same nature. Moreover, States generally cooperate when it benefits their self-interests and therefore, partners may be pursuing common programmatic goals, but for different reasons, as each partner's space programme exists within its own political environment.[114] International cooperation in space is also an outgrowth of good political relations. Furthermore, not all countries regard international cooperation equally; several counties actively solicit, establish and work to maintain partnerships, while others have a more nationalistic and individual approach.[115]

International cooperation is not static, but highly dynamic, and has an intrinsic reverberating character in which partners adapt to the other, which implies an adaptation to this new situation by other stakeholders. Reciprocity is therefore an important source of interaction.[116] Cooperation projects and partners can thus be determined based on the previous behaviour of others. Patterns of international relations have always been dynamic and foreign policy alliances have evolved over time. However, while S&T activities are increasingly shaping foreign policy and diplomacy, it may be expected that space activities, including space exploration, will also influence the future geopolitical context, as governments initiate or participate in cooperative projects for a number of scientific reasons, but also for broader foreign and domestic policy motives. New axes of cooperation will therefore arise, some will deepen, while others will weaken, indicating consequently that the upcoming years will undoubtedly see new partnerships that will reflect the emerging geopolitical and economic context as the contours of the geopolitical map of the 21st century are still evolving.

Depending on the option pursued, Europe can remain a major space actor until at least 2025, but engaging with other partners should be an element of Europe's plans. Developing all capabilities independently is too expensive and difficult to be politically feasible in the time frame considered. International cooperation is therefore important to ensure the robustness and sustainability of European exploration activities. Europe should thus leverage other national efforts through international coordination and cooperation to foster its space exploration programme to avoid more and unwanted duplication and overlaps, but also to fill existing gaps and enhance critical path redundancies. International cooperation is therefore mandatory and Europe's partnerships with other actors are of vital importance. As Europe plans its exploration activities, it should therefore lay the foundations and establish precedents that invite a host of participants and followers to participate in its endeavours. Europe's attractiveness on the world stage must be earned - not by resting on past achievements or by unilaterally establishing the architecture, but by putting into place a programme and architecture that allows for partners to participate in significant ways.

Europe should however identify what interests and activities it wants to pursue autonomously, independently or in partnership. Europe must decide in the future whether competition or partnerships (or a mixture of both) offer the best path towards maintaining its status and help to fulfil its ambitions. Europe's activities should not only evolve within the framework of cooperative international programmes, but there should be a balance between autonomy, independence and cooperation. The future European space exploration programme should provide certain level of autonomy, and even independence is essential as it will allow having freedom in the choice of its objectives and consequently its partnerships. The decision to embark on cooperation or to rely on own efforts will however have to be done on a case-by-case basis and depends on political considerations (e.g. technological independence) and attractive cooperation opportunities. Europe's resources are limited; it can not cooperate with all interested parties. It therefore needs to set priorities

[112] Peter, Nicolas. "The Changing Geopolitics of Space Activities". Space Policy 22.2 (May 2006): 100-109.
[113] International cooperation adds layers of complexity to the specification and management of the programmes and introduces additional elements of dependence and risk that can undermine successful performance within budget and the planned schedule.
[114] Peter, Nicolas. "The Changing Geopolitics of Space Activities". Space Policy 22.2 (May 2006): 100-109.
[115] Correll, Randall R., and Nicolas Peter. "Odyssey: Principles for Enduring Space Exploration". Space Policy 21.4 (Nov. 2005): 251-258
[116] Ibid.

not only vis-à-vis potential partners, but also in the areas of cooperation.

International cooperation is a tool necessary to implement an ambitious European space exploration endeavour. However, while looking to the future, Europe should also be learning from past experience and as such, Europe should avoid a situation in which it is critically dependent on its partners (unless there is reciprocity). The risk of cooperation/failure should remain manageable for Europe within available resources and schedules. European space exploration activities should be based on the engagement of both current space-faring and non-space-faring countries, as Europe needs to ready itself for a world of global space exploration networks with partners coming from many more places. European exploration strategy should be thus embedded in a worldwide context in order to exploit the synergies between the programmes of different players and to take advantage of international collaboration like the Global Exploration Strategy to reinforce the European space exploration programme.

Several different approaches to organizing cooperative space activities have already been tried and it is very likely that new approaches will emerge as long-term space exploration will differ fundamentally from previous large space ventures. [117] Europe should therefore remain flexible in terms of the structure and the mechanisms it will use to structure its partnerships. However, any cooperation should be based on "no-exchange of funds" principles taking into account the availability of the resources of all parties involved. Partners would thus be expected to fund their own capabilities.

The value of international cooperation cannot be challenged. Inviting meaningful international participation is a necessity and international cooperation will therefore be an essential element of Europe's exploration strategy. Without international cooperation European plans might be moot and scaled down or stretched out in time. In this context, Europe should promote cooperation with all space-faring countries and newcomers so as to minimize total dependence on other stakeholders for particular aspects of the programme. However, there are different objectives depending of the stakeholders involved, be it European space agencies or pan-European institutions.

[117] Ibid.

Cooperation in the interest of space agencies consists of:

- Europe should engage in large, complex and costly programmes which are beyond individual financial capability, but are nevertheless considered essential to Europe's role at global level.
- International cooperation lessens costs and can optimize resources, but also gives access either directly or indirectly to new technologies.
- International cooperation gives access to non-European spacecraft enabling results and observation time to be shared.
- Support for Europe's programmes which requires a network of ground stations such as Tracking Telemetry and Command (TT&C), uplink stations and sensor stations.

Cooperation in the interest of pan-European institutions consists of:

- Contribution to the implementation of EU policies.
- Support for EU's external policy.
- Cooperation as a market-opener for the promotion of European technology and services in the space field.
- Promotion of European values.

Despite these different motivations, Europe's policies vis-à-vis international cooperation in space exploration should be guided by the following core principles:

- Compliance with international obligations with respect to space activities.
- Fulfilment of the priorities of EU policies, including external policy.
- Support the implementation of the European space programme.
- Strengthening the positioning of the European space sector in the global market for space technologies and services.

Europe needs to prioritize its cooperation objectives in line with its overall long-term objectives. Therefore, it should engage in space cooperation when it is the interest of its member states, ESA and the EU. International cooperation needs to be coherent and support the implementation of the European policy objectives including EU external policy. European space exploration plans should also support the European project and policy objectives and position Europe as a visible strategic partner. The European space exploration programme should thus consist of European-led missions with limited dependence on possible partners as well as contributions to international space exploration endeavours according to Europe's aspirations and core competences. Europe's

	Australia	Brazil	Canada	China	India	Japan	South Korea	Russia	South Africa	Ukraine	United States
Launch System	NE	UD	NE	D	D	D	UD	D	NE	D	D
Human Spaceflight Capabilities	NE	NE	NE	D	UD	NE	NE	D	NE	NE	D
Astronaut Corps	NE	NE	D	D	UD	D	UD	D	NE	NE	D
Satellite Manufacturing Capabilities	UD	UD	D	D	D	D	UD	D	UD	D	D
Deep Space Network	D	NE	NE	UD	UD	D	NE	D	D	NE	D
Moon Missions	NE	NE	UD	D	D	D	UD	D	NE	NE	D
Mars Missions	NE	NE	D	UD	UD	D	NE	D	NE	NE	D
Other Planetary and NEOs Missions	NE	NE	D	NE	UD	D	NE	D	NE	NE	D
ISS Participation	NE	NE	D	NE	NE	D	NE	D	NE	NE	D
GES Participation	D	NE	D	D	D	D	D	D	NE	D	D

D	**Developed**
UD	**Under Development**
NE	**Non-existent**

Table 7. Overview of space exploration capabilities and global partnerships of major space actors outside Europe

cooperation in space exploration should therefore be driven by political, programmatic and budgetary considerations.

An important element in the implementation of the European long-term plan for space exploration is the development of a strategic framework for international cooperation. Moreover, Europe's plan must be flexible enough to be able to adapt to changes in priorities and budgets over several election cycles, it must also be able to adapt to changes in international participation and changes to their priorities. There is therefore the need for new cooperation strategies that allow addressing this evolving context as the geography of space activities develops new peaks around the world. Europe should also identify relevant partners for each building block of its exploration programmes. However, when engaging in future cooperation, Europe should take into account individual preferences and the plans of potential partners (Cf. Chapter 3), but also other existing political partnerships when seeking international cooperation for its long-term space exploration plans (Table 7).

The relationships between space activities and international politics is one of symbiosis and projections about the future of space exploration must therefore take the global political environment into account, because in future endeavours one may expect to see political developments on Earth reflected in orbits. As indicated in the second chapter of the Report, there is no guarantee that the prosperous and technologically advanced countries of 2008 will retain their lead in 2025. A change in the balance of power would lead numerous countries to realign not only their commercial and diplomatic relationships, but also space partnerships. Nonetheless, as seen in the Chapter 3 Europe should build on its long space cooperation heritage, but also broader S&T activities as well as political dialogue between the EU and other countries to structure its future space exploration dialogues and cooperative ventures.

While the current leadership of space activities is rather obvious, various countries around the world are making significant progress in space. These countries may very soon in the future be in a position to offer alternative leadership and partnership opportunities (Table 7). Europe must therefore be able to anticipate this situation to remain a partner of choice in space exploration endeavours. In this changing space context Europe should give priority to strengthening alliances and partnerships. Despite the concerns about the durability of the current international order, it should renew its commitment to the current order, but also help find a way to accommodate rising space powers. Besides continuing to be a major actor in the ISS programme, the Global Exploration Strategy (GES) and other related global partnerships linked specifically to space exploration major cooperation should continue with Europe's traditional partners, which are the United States, Russia, Canada and Japan and continue to reach out to emerging space powers like China and India. However, too often, countries such as Australia, Brazil, South Korea, South Africa or Ukraine are left aside in analysing Europe's choices for international

cooperation in space activities, and particularly, for space exploration activities. One could wonder why Europe should engage with them and put an effort into strengthening the ties with them. However, when looking forward and trying to anticipate future developments, it is imperative to take into account political and economical considerations rather than only prevalent current space capabilities. Countries such as Australia, Brazil and South Africa are important emerging strategic partners as they are regional leaders and thus can serve Europe as a hub or relay in various areas and public policy domains. The Ukraine is very important for strengthening the neighbourhood policy and creating a secure environment on the continent. South Korea, Brazil and South Africa are countries that are witnessing impressive economic development and their economic growth is expected to accelerate in the future (Cf. Chapter 2). Consequently, sooner or later their capacities in the space field will probably be of benefit for European exploration efforts. Therefore, it is of strategic importance for Europe to secure early on the potential of these countries. The degree of involvement and type of partnerships will differ among those clusters and countries. It is however important for Europe to consider reaching out to all of those actors to keep future options open. The objectives of Europe's exploration strategy should be therefore to maintain allies while winning new partners for scientific and technical reasons, as well as political motives to take part in its exploration activities.

4.4. Summary

Europe (ESA, the EU and their member States) should anticipate the evolution of the space exploration context to maintain its position in the "space hierarchy", but also to remain a centre of gravity and a partner of choice in space activities. Up to now European space exploration was largely driven by scientific motives with limited political concern, but this might be evolving in the years to come with the increasing involvement of the EU in space affairs. The ambitions of the EU in space affairs, if actually fulfilled, could prove beneficial for European space exploration activities by providing new resources but also increased political visibility to Europe's plans.

Demonstrating increased European assertiveness in space exploration by conducting an ambitious exploration programme and providing high-level political support will enhance European diplomatic, economic and scientific potential. Europe 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. It will confer some benefits in the form of international prestige and overall power. Europe should thus work towards developing a complete portfolio of space exploration activities to gain more equal footing in future cooperation endeavours with other space powers.

An optimal balance between robotic and human spaceflight activities as well as between European missions within a global architecture and joint international missions, and between short and long-term goals has to be found. Europe should consider pursuing a robust robotic programme to various destinations, the continued utilization of the ISS and human activities in LEO in the post-ISS period, autonomous human access to space and human lunar exploration activities. Europe as a visible space exploration actor would allow it to cooperate with traditional space partners, continue its constructive engagement with emerging space powers, but also reach out to new strategic partners. However, in the context of appraising Europe's future activities in space exploration and particularly its international partnerships it should take into account individual preferences and plan of potential partners (but also existing partnerships). Having a flexible and robust plan that anticipates potential developments as much as possible, but also being responsive to a changing geopolitical context and aspirations of potential partners will allow Europe to cope with those variations and strengthen its position. Furthermore, the timing of a decision to engage in any new large scale activities will be critical. Using the "political window" that will open from the U.S. presidential election in November 2008 until 2011 to reach out to potential partners is recommended in order to exploit potential cooperative synergies in the decades to come.

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