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REPORT

on

THE PRINCIPAL PROGRAMMATIC AREAS OF FUTURE SPACE POLICY

SPACE POLICY: DARING OR DECLINE

HOW TO MAKE EUROPE WORLD LEADER IN THE SPACE DOMAIN

Christian Cabal, Member of Parliament, and Henri Revol, Senator

Tabled in the Bureau of the National Assembly by Mr Claude Birraux First Vice-President of the Office

Tabled in the Bureau of the Senate by Mr Henri Revol President of the Office

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Principal programmatic areas of future space policy
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SPACE POLICY: DARING OR DECLINE

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HOW TO MAKE EUROPE WORLD LEADER IN THE SPACE DOMAIN

CONTENTS

FOREWORD

*The Parliamentary Office for Scientific and Technological Assessment (OPECST) was requested to undertake a study concerning the "*Principal programmatic areas of future space policy*", by the President of the Senate Economic Affairs and Plan Committee, Jean-Paul Emorine, on May 3, 2005.*

This space policy analysis and recommendation mission is the third of its kind.

The 1991 report by Senator Paul Loridant addressed the orientations of French and European space policy.

*The 2001 report by Senator Henri Revol contained a review of all space activities under the title "*Space: a political and strategic ambition for Europe*". The majority of the recommendations contained in this report were subsequently implemented by the public authorities*[1].

*The committee responsible for this latest study set out the analytical field targeted in the following terms: "*access to space; applications concerning the general public, and telecommunications in particular; sustainable development and prospects for more efficient monitoring of the planet for the purpose of predicting and detecting disasters; security and defense, and scientific research in all areas involving space*".*

Henri Revol, Senator and President of the Office, and author of the 2001 report, and Christian Cabal, Member of Parliament, were designated by the Office at its meeting of May 10, 2005.

As part of the feasibility study preceding preparation of the report, a conference was organized in the Senate on November 2, 2005, on "European space policy for a 2015 horizon". *This conference brought together the rapporteurs and European decision-makers from the space sector. The feasibility study for the report was adopted on May 3, 2006.*

An advisory board was then set up to assist the rapporteurs with the task of establishing contacts and dialogue with the relevant specialists, and interpreting the information collected.

The members of this committee, representing the full range of skills and expertise in the areas of research and industry, the European Space Agency and the astronaut community, namely Jean-François Clervoy, ESA astronaut, Alain Gaubert, Secretary General of Eurospace, Stéphane Janichewski, Associate Director General of CNES and Yves Langevin, Research Director with the Orsay Institute of Astrophysics, should be warmly thanked for their extremely valuable contributions, and may in no way be held responsible for opinions expressed and recommendations made, political responsibility for the report being carried by the rapporteurs alone.

In line with the methods generally employed by the Office, a number of private hearings were organized, which the leading French and European authorities from the space community, together with representatives from the public authorities and industry, were good enough to attend.

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[1] *See Annex 3.*

A number of missions to countries outside Europe were also undertaken, to Russia (twice, in July and October 2006), the USA (early November 2006), China (end November 2006) and India (December 2006).

The French Embassies concerned, and first and foremost their scientific departments and economic missions, provided essential and noteworthy assistance to the rapporteurs in connection with all these field missions.

All persons met and heard, whether in Paris or outside France, together with the General Secretary of the Parliamentary Group for Space, Emmanuel de Lipkowski, who provided us with constant assistance, deserve our warmest thanks for their invaluable contributions to the mission undertaken by your rapporteurs, this mission being defined as follows: ***"Diagnosis of the current situation in the French and European space domain, identification of prospects for a 2020-2030 horizon, and presentation of recommendations in line with the achievement of a major ambition".***

ABSTRACT

Since the 2004 announcement by the USA of its return to the Moon, planned for 2020, there has been a spate of major events in the space sector, whether this is a coincidence or not. China made its second human spaceflight in 2005, and has initiated a lunar program for 2020. In the military domain, China neutralized an American spy satellite by dazzling it with a laser beam in 2006, and less than six months later, destroyed one of its own older satellites in orbit with a ballistic missile. Also in 2006, India announced a human spaceflight program for 2014, and early in 2007 retrieved one of its satellites intact from orbit, thus taking another step towards landing an Indian astronaut crew on the Moon in 2020.

Compared with the situation at the beginning of the decade, future prospects for the space sector have taken a sharp upward turn and its vitality has been restored.

While the future of the space sector appeared to lie essentially in the merchant services domain – telecommunications, TV broadcasting, positioning, etc. – *and although these missions are still there, others are now coming to the fore, missions vital for mankind, with the study of climate change and the search for ways and means of combating the greenhouse effect. The space sector constitutes a mandatory tool for all of these.*

After the initial orbital probe missions to the Moon, Mars and Venus, and the giant planets Jupiter and Saturn, the period of major discoveries concerning the solar system appeared to have come to an end.

But now the search for life on Mars is regarded as essential for understanding our origins, and solar probe missions as a prelude to solar meteorology as equally essential for more efficient management of Earth.

Was the Star Wars program no more than an aberration, spawned by confrontation between the two power blocks? *The rush for military satellites, for observation, transmission, listening watch and early warning is now bringing with it the creation of the means to destroy satellites in orbit.*

Considered to have reached a state of maturity, should the space sector now become a market activity? *Public investment is being stepped up by the leading powers, whether based on a market economy such those of the USA and India, or a state-controlled economy as is the case with Russia and China.*

The dynamics of the space sector development in general are not only merely on the move. We are now witnessing a race even more frenzied than that of the 1960s, but in this case involving a number of individual players rather than just the Eastern and Western blocks.

While the NASA budget of around $ 17 billion is not increasing faster than prices, the USA is currently allocating a budget of $ 20 to 25 billion to the military space sector, with an anticipated increase of 30% between now and 2012.

At the same time, and as a result of its oil and gas revenues, Russia has multiplied its civil space agency budget tenfold in eight years, reaching a level close to that of the European Space Agency (ESA) on an equal purchasing power basis.

Japan is also accelerating its investments and has announced a lunar program for 2022.

With sharply rising budgets, of the order of one billion dollars, but in fact substantially greater if we take account of military budget and cost differentials, China and India are demonstrating their growing technical expertise year by year, as also their ambitions which now embrace human spaceflight and lunar programs. Another capital phenomenon is that space technologies – launchers and satellites – can increasingly be regarded as *'proliferating technologies'*, with more and more powers possessing long-range missiles capable of both launching and indeed destroying satellites.

It is to these radical changes that France and Europe must respond. The stagnation of their investment in the space sector has left them unprepared for this situation. However their history and expertise put them in a position to take up the challenge.

France is still the leading European space power. But the budget restrictions imposed on the French Space Agency, CNES, the public subsidy for which is increasing more slowly than inflation, is obliging the Agency to mark time. In contrast, Germany and the United Kingdom are stepping up their investment programs. The increase in the mandatory ESA budget does not exceed the rise in prices, and the European Union takes the space sector inadequately into account in its common policies.

Taking national and mutualized investment together, Europe is investing one-quarter as much as the USA in the civil space sector, and one-twentieth as much in the military space sector.

The European space industry has been experiencing a period of very pronounced austerity since 2001, with a drop of 20% in its consolidated sales between 2001 and 2005, and a 16% fall in payroll numbers. The collapse of the commercial telecommunications satellite market, which formed the platform for the activities of the French and European industries, has unfortunately not been offset by an increase in public sector procurement. This contrasts sharply with the USA, where the public sector accounts for 90% of space business.

In real terms, to avoid finding themselves completely out of their depth in world competition in the space sector, France and Europe need firstly to analyze their present misapprehensions, and then declare a clear vision of the role of the space sector for the decades ahead.

The first misapprehension faced by France and Europe is the currently widespread opinion that space sector growth can be induced first and foremost by the ***market***. No space power, with the exception of Europe, is making this mistake. Space sector investments are capital-intensive and long-term, and generate externalities which the markets do not take into account and can only fund with difficulty.

Competition in this market is distorted by dumping by generally public sector industries, more interested in geopolitical influence than profit. In the absence of adequate public support, the European space industries are seeing their long-term future compromised by insufficient R&D capabilities and profitability. Institutional support for the space sector must consequently be amplified on an urgent basis, both at national and European levels.

Another misapprehension is that the space sector is ***invisible*** at the present time. Public opinion ignores the fact that a single day without satellites would produce twenty-four hours of economic and social chaos. Experiencing an unprecedented period of austerity, the space agencies and industries are concentrating their resources on their very survival. Reduced to their very simplest expression, human spaceflight missions lack the dimension required to stimulate imagination, meet the technological challenges of performance, dependability and complexity, irrigate industry and the economy, devise wise management for the planet Earth and move outward towards new frontiers in the Universe.

A new policy is thus essential for France and Europe. This policy must be reconstructed from its very foundations, and be based on a long-term vision of the French and European space sectors.

France must return to fundamentals – to a dual, strategic and scientific dimension, with absolute priority for autonomous and competitive launchers, support for national defense from the space sector, and world leadership in space science – and at the same time advance towards human spaceflight.

For its part, Europe must use the space tool to pursue its secular role in the domains of discovery and exploration, stiffen up its cohesion and federate worldwide investment in human spaceflight.

Space must win back its ***priority*** position in the French and European institutional mechanisms. A ten-year space program, to be reviewed in mid-term, must be prepared at the highest political level and approved by Parliament, in France as in Europe. The institutional organization of the European space sector must be simplified, based on what functions efficiently – ESA (European Space Agency), and Eumetsat (European Organization for the Exploitation of Meteorological Satellites). Public support for space research, whether fundamental or technological, must be included in French and European priorities, at the risk of the overall technological disengagement of the European Union. Without waiting for an unpredictable institutional future, the European space sector must move forward on the basis of concrete projects.

The truth of the matter is that France and Europe already possess technical skills of the first order, and a world leader position in a number of segments such as launchers and telecommunications and observation satellites. With a political ambition to match these scientific and industrial trump cards, Europe can set its sights on the position of leading space power in the world.

Like all the other space powers, France and Europe must use the space sector to confirm both their expertise and respective identities. Their investments in this sector must be stepped up considerably, and this for the additional reason of the resultant technological drive and economic benefits generated.

Europe is world leader in the ***launcher*** domain with Ariane-5. To retain this position, Europe must continue development of its flagship launcher, increasing payload capacity with the addition of a reignitable third stage and acquiring qualification for human spaceflight missions. Commissioning of Soyuz at the CSG and development of the VEGA launcher must be completed without delay.

France and Europe must take the fullest advantage of their exceptional expertise in the space science domain.

Astronomical observation satellites, automatic probes and robot explorers will provide terrestrial observation activities with the additional data increasingly important for our comprehension of the Universe, only 5% of which is currently observed and identified, and the formulation, still largely incomplete, of the fundamental laws of physics.

With their expanding capabilities, ***telecommunications*** and TV broadcasting satellites can take over the HR Internet, HD digital TV, television for mobiles and digital radio, and participate in widespread distribution of the new digital audiovisual technologies. It rests with Europe to devise major projects and remove political and bureaucratic obstacles, all of which are clearly trivial in the light of the issues at stake.

Satellite ***positioning*** and navigation services are becoming essential for both heavy and service industries, and also for the public at large, at a speed vastly greater than that observed in the past for other technologies including mobile telephony.

Observation satellites represent the ideal instrument for monitoring and controlling the implementation of sustainable development and measures for combating climate change. The Galileo and GMES (Global Monitoring of Environment and Security) projects clearly merit absolute European budget priority, in the same way as the major new project concerning " *space for collective security and digital equality in Europe*", designed to generate concrete and immediate benefits for the citizens of Europe.

As the space sector is recognized as an **irreplaceable military tool** for observation, communication with the armed forces and listening watch and early warning functions, to the point where military satellites themselves must be protected by new space-based systems, the leading European states involved in the space sector, and first and foremost France, Germany and Italy, must set up select multilateral cooperation agreements to move forward in all these domains.

Finally, the question of ***human spaceflight*** missions can no longer be sidestepped. A very minor partner in the International Space Station, Europe cannot continue to tag along behind the USA and Russia when it comes to transportation of its astronauts.

When the USA, China and India all have their permanent bases on the Moon, would the Europeans pardon their leaders for having missed out on this major step forward, one which will strengthen confidence in the future and lead to new technological progress and other major scientific discoveries?

Europe already possesses the technical means and financial resources to build an autonomous space transportation system compatible with other American and Russian systems. Europe's duty is to develop its expertise and place it, independently, at the service of mankind whose destiny it is to explore the Universe, with or without Europe.

The 50 recommendations (see below) put forward proposals, in as precise terms as possible, for a new audacious space policy, one truly worthy of France and Europe.

INTRODUCTION:

THE EXISTENTIAL CRISIS IN THE EUROPEAN SPACE SECTOR

"What's it like in space?"

"What would we feel if we went into space?"

These are two of the questions most frequently heard by astronauts, including Jean-François Clervoy and Jean-Pierre Haigneré[1] in particular.

Space applications are many in number, and essential for our daily life despite the fact that they are generally invisible. Their importance lies in the scientific, industrial, economic, political, cultural and identity-related domains. In the space sector, discussions, and indeed conflicting influences, are permanent aspects of the struggle to obtain precedence for this or that project in a context of financial penury, to the point where all sight of the essential targets is lost.

For real enthusiasts, or the merely curious, it is natural to imagine oneself in space to assess one's own conditions and that of planet Earth in the Universe.

"What strikes astronauts most forcibly when in orbit round the Earth, apart from their pride in the technical exploit in which they are engaged, is the beauty of the planet and the fragility of life thereon.

From space, one can see hurricanes eight hundred kilometers wide, and volcanoes spewing out their gas and ash: Earth has its own life independent from that of Man, the planet is strong and will survive. Overflying the Himalayas, it is clear to see that no force created by man will ever equal the forces which pushed the Indian tectonic plate under the Tibetan plate, to produce this majestic mountain chain.

In Earth orbit, the astronaut sees darkness and emptiness in every direction through the thin layer of our atmosphere. This demands respect for our planet, and its fragility and exception lead one to think that the human species will one day no longer be there.

Nevertheless, we can but hope to push back the day of reckoning."[2]

The views expressed by Jean-François Clervoy are shared by all astronauts, professional and amateur alike.

Fifty years after man sent the first artificial satellite, Sputnik, into space, space and space-related activities have developed at a rate unique in the history of technologies. Space applications contribute to all sectors of activity, and technological progress is very considerable and equally astonishing. Space also

[1] *Jean-François Clervoy, astronaut, and Jean-Pierre Haigneré, cosmonaut, hearing of December 21, 2006.*
[2] *Jean-François Clervoy, astronaut, hearing of December 21, 2006.*

provides Earth with an irreplaceable observatory for correcting errors in our utilization of the planet.

Despite all this, the space sector is currently experiencing a many-facetted existential crisis in Europe.

Combining the investment of the various Member States and those, still modest, of the European Union, Europe is indeed the second world space power.

However, Europe is dragging its heels while the USA is revigorating its programs, Russia is turning again to its ambitions of the Soviet era, Japan has declared a lunar objective following restructuring of its space sector, and China and India are preparing for exploration of the Moon.

This acceleration of the space race is something in which Europe and France are incapable of participating at the present time. Europe has no priorities despite the many possibilities for space development. As for France, with its stagnating budget, its leadership is paying the price and is deprived of any ambition to match the issues at stake.

Between now and 2008, the French and European space sectors will reach a turning point in their history. A multitude of decisions have to be taken unless the slow dilapidation we are currently witnessing, leading inevitably to the decline of Europe as a whole, is to be avoided.

The technical and financial capacities are there. The projects are also there, and programs can be finalized and implemented rapidly.

One preliminary action remains to be accomplished. A specifically French and European vision of space must be defined, shared and popularized.

Such a **vision** is shared by definition. This report sets out to suggest the component elements of a French and European vision of space for the coming years, which it will be the role of the public and space authorities to ignore, criticize or improve.

Simple **principles** for a new space policy, the ambitions of which will be on a par with the position of Europe in the world, namely a major power which ignores the fact, and which could be held in greater esteem than is currently the case, stem from this vision.

Based on this vision, simple **technical proposals** can be defined. It will then be up to industry and the space agencies to react in one direction or another.

The European space sector is on the decline, and on the point of disengagement.

We must pardon the parliamentary members of the Office for the scientific and technological options they have chosen, and their intrusion in a sector in many respects too regalian, too technical and too remote for the general public.

But what the space sector most needs in France and Europe is a bold approach. The Office will have failed to meet its remit defined by the Senate

Economic Affairs Committee, if it does not adopt a truly audacious attitude to space.

"How to make the Europe the world leader in the space domain?"

The purpose of this report is to answer this question.

PART 1:

COMPETITION IN SPACE – A POLITICAL CHALLENGE FOR FRANCE AND EUROPE

The space community will celebrate its fiftieth anniversary in October 2007, taking its starting point as October 4, 1957, when Sputnik 1, the first artificial satellite ever launched was placed into orbit.

Whether by coincidence or not, the space sector in France and Europe finds itself at a turning point in its history exactly fifty years later.

While its competitors in the past were essentially the USA and the Soviet Union, the French space sector is now faced with increasingly dynamic performance in Italy and Germany, while Europe as a whole is encountering revitalized investment by its original competitors.

At the same time, the major emerging countries, China, India and also Brazil, are not only demonstrating their proficiency in the major space technologies, but are also plunging into the launcher, civil commercial application and space transportation markets.

The explosion of competition in the area of civil space applications should be sufficient, in its own right, to demonstrate that a new era has begun, and one for which we must prepare.

At the same time, the role of the space sector is amplifying in the defense and security sectors. Furthermore, the future of Europe in the space technology race has not been prepared as it was in the past, due to the absence of the investment required to do no more than renew expertise and infrastructures.

The globalization challenge for France and Europe is particularly evident in the space domain.

Given its security, economic and environmental implications, the long-term future of the European space sector represents a major political challenge, to which the flaccid current consensus regarding minimum national or European space development provides no response at all.

I – GENERALIZED COMPETITION FOR ACCESS TO SPACE

In budget-related terms, Europe is currently the second world space power, taking national investment implemented on an individual basis, mutualized investment within the framework of European Space Agency (ESA) and the – still too infrequent – incitement of the European Union.

In scientific and technical terms, Europe is proficient in practically all space technologies. While European industry cannot lay claim to mastery of human spaceflight technologies, either as regards launchers or dedicated capsules for such missions, it excels in space applications at the service of the general public, and in the area of space sciences associated with knowledge of the Universe, with the assistance of the space agencies and research organizations.

The situation of the European space community in late 2006, compared with that of other world players, does not consequently give rise to any particular degree of concern.

On the other hand, changes which have occurred over the last few years, and in particular, direct observations made by your rapporteurs *in situ*, in the USA, Russia, China and India, unambiguously demonstrate a dynamic approach highly unfavorable to the old continent in general and France in particular.

Indeed, it could be said that the evolution of the European space community does no more than reflect the situation with European industry as a whole.

However, the problem would remain whole, and appear even in a particularly critical light, were it not for the fact that the space sector, however invisible it may be – except for the enthusiast – now plays a critical part in contemporary economies, and will doubtless increase in importance over the coming decades.

1. Austerity for the French and European space sectors

By comparison with the rest of the world, the degree of motivation in the space sector, taken as whole, is favorable neither in France nor in Europe. Unhappily, this is the case as much for public investment as for industry[1].

▪ *French public space investment running out of steam*

The 2006 State subsidy for CNES amounted to € 1.376 billion. If we add the French share in Eumetsat, calculated on the basis of its GNP, total public investment in the civil space domain amounts to € 1.41 billion, or 34.2% of the

[1] *Alain Gaubert, Secretary General of Eurospace, hearing of November 16, 2006.*

European total. By comparison, civil public investment is € 0.822 billion for Italy (20% of the total), € 0.766 billion for Germany (18.6%), € 0.337 billion for the United Kingdom (8.2%) and € 0.206 billion for Spain (5%)[1].

Thus, France maintains its leader position in Europe in terms of public investment in 2006, but the trend is not in its favor.

France has indeed decelerated its efforts in the space domain since 2000, in contrast to its European partners which are also its rivals. French public expenditure on space has dropped on average by 1.6% per year, whereas public investment in space increased by 1.1% per year in Germany, 4.1% per year in Italy and 6.1% in the United Kingdom[2].

The only favorable note is that the CNES subsidy should increase at an average annual rate of 0.7% up to 2010, with an annual increase of 1.5% in the subsidy contributing to the national part of the CNES budget. However, neither of these increases exceeds the rise in prices. This means that investment, expressed in constant euros, will continue to decrease.

▪ *Crisis in the space industry in France and Europe*

The trend in France is no better in industrial terms. Following a 1996-2000 period marked by growth in the sector, a sharp down-turn occurred in 2001, leading to a major retraction phase for business.

Space industry sales in France increased by over 60% between 1996 and 2000, but this was followed by a 28% drop from 2000 to 2005.

While the rationalization program conducted between 1996 and 2000 led to a 0.1% drop in employment during this period while the level of business increased sharply, payroll numbers in the space industry in France fell by 19% between 2000 and 2005.

When the Internet bubble burst, numerous telecommunications satellite orders were cancelled from 2000 onwards. Further amplifying the disastrous consequences of this phenomenon independently from the sector itself, Earth observation satellite orders also dropped sharply from 2000.

Representing 60% of total sales by European industry, institutional contracts have stagnated in recent years. Commercial contracts, representing 40% of the total, have dropped substantially although a slight tremor was observed in 2006. While European industry has held onto its market share for commercial applications in global terms, many thousand employees have been laid off.

The crisis in the space industry has been an undeniable reality in France and Europe since 2000, and its consequences are alarming when we look ahead.

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[1] *Source: CNES memorandum to the rapporteurs, based on Euroconsult estimates and Eumetsat data, December 26, 2006.*

[2] *Rachel Villain, Euroconsult, I-Space–Prospace seminar, September 27, 2006.*

▪ *Insufficiency of European institutional support*

One could have expected the French and European public institutions to increase their orders to attenuate the impact of the crisis on the commercial market. This has not happened.

ESA orders placed with European industry have tended to drop substantially, were down 31% for the period 1996-2005[1].

Out of an annual total of € 300 million, orders placed by the European Union with European industry in 2005 amounted to only € 14 million.

On the basis of an ESA budget of € 2.9 billion in 2006, the growth rate anticipated between now and 2010 is an average of only 2.5% per year for the mandatory program (science and general budget), representing no more than 20% of the total.

The public authorities have consequently failed to play a counteractive role, such as could have attenuated the crisis and prepared for the future.

▪ *Rising strength of Italy and Germany*

The major event in the European space sector in recent years has been the steady increase in the strength of Italy, second European space power, with Germany third and the United Kingdom in fourth position, since 2000.

This is confirmed both in terms of public investment and the national space industries[2].

Italian public investment was € 0.822 billion in 2006, representing 20% of the total for the European Union and a strong second place after France. Following the mergers of Italian companies under the Finmeccanica banner, the Italian space industry boosted its sales by 17% between 1996 and 2005. Sales by the Italian space industry represented 13.8% of the European total in 1996. This share increased to 15.5% in 2000 and 16.6% in 2005. It is as though Italy has taken advantage of the crisis to gain in strength.

Germany achieved public investment amounting to € 0.766 billion in 2006, representing 18.6% of the European total. The German space industry made sales worth € 0.614 billion in 2005, or 14% of the European total. Payroll, numbers totaled 4,429, or 16% of the European total. The German space sector is progressing at a rate which could accelerate substantially under the impetus of the new Chancellor, Angela Merkel, who has expressed her interest in space matters on numerous occasions.

Public support for the space sector in the United Kingdom amounted to € 0.337 billion in 2006, or 8% of the European total. British space industry sales

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[1] *Source: Pierre Lionnet, Eurospace Facts & Figures, 2006 issue.*

[2] *Sources: CNES memorandum to the rapporteurs, based on Euroconsult estimates and Eumetsat data, December26, 2006, and Pierre Lionnet, Eurospace Facts & Figures, 2006 issue.*

were € 0.501 billion in 2005, or 11% of the European total, with a payroll of 3,382.

Spain has also improved its position, although public investment in 2006 was only € 0.206 billion, less than 5% of the European total, with space industry sales of no more than € 0.180 billion in 2005, or 4.1% of the European total.

2. Original competitors boosting their space investment strongly

While strict austerity continues in the French and European space sectors, all the longest-established space powers – USA, Russia and Japan – are stepping up their investment programs vigorously.

▪ *A new upsurge in American space activity, likely to increase the US lead*

With the Constellation return to the Moon civil program, and increased military investment, the US space industry is enjoying a new golden age in a position of already massive world supremacy.

In budget terms, civil space activities are experiencing growth although this is only moderate. The NASA (National Aeronautical and Space Administration) budget was $ 16.5 billion for the 2006 financial year, up 2.4% on 2005. The other principal civil space agency, NOAA (National Oceanic and Atmospheric Administration) has a budget of $ 964 billion for its space activities[1], with an annual growth rate of 6%.

Apart from these regular budget increases, the "Moon, Mars and Beyond" project announced by President Bush on January 14, 2004, has committed the American nation to the long-term Constellation program, involving automatic probes, robots and human spaceflight missions aimed at exploration of the solar system, commencing with a return to the Moon followed by the exploration of Mars and other destinations. For the time being, this program is to be conducted on the basis of a constant budget, such that NASA will be obliged to redefine the majority of its human spaceflight infrastructures. However, American industry has received another kick-start in the shape of new development contracts, in some cases of an innovative nature such as the COTS (Commercial Orbital Transportation Services) program.

The American military space sector has enjoyed budget appropriations exceeding those for the civil space sector since 1982[2]. These appropriations amount to between $ 20 and 25 billion, half of which are for secret "black programs". Taking account of the necessary replacement of equipment currently in operational service, and the incorporation of technological progress, it is anticipated that the US military space budget is likely to rise by 30% between now and 2012[3].

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[1] *Activities grouped in its NESDIS (National Environmental Satellite, Data and Information Service) division.*
[2] *Apart from the period 1996 to1998.*
[3] *ICA Hervé Bouaziz, Military Attaché's Department, French Embassy in Washington, November 6, 2006.*

The total US federal space budget is close to $ 40 billion per year, and has increased sharply since 2004. This trend should continue over the next few years, whether imposed (lunar program) or sought (military program).

▪ *Reflation of Russian space activities*

As a result of the development of its oil and gas resources[1] and the recovery of its economy, Russia is now experiencing strong economic growth, Its GNP has risen by an average of 6% per year since 2001. At the same time, its substantial export revenues have enabled Russia to accumulate the fourth largest exchange and gold reserves in the world ($ 247 billion), and to set up a stabilization fund amounting to $ 60 billion, accompanied by total convertibility of the ruble since mid-2006. The recovery of its economy is reflected in a new industrial policy, pursued by the State in collaboration with private companies. Leading-edge technologies have become the second national priority in Russia, in just behind energy which plays the clearly identified strategic role of provider of foreign currency and generator of geopolitical influence. It is consequently not surprising that the Russian space sector is experiencing massive resurgence.

Following the collapse of the Soviet Union, Russian investment in the space sector was reduced by a factor of 5 during the 1990s compared with the average level during the last years of the USSR. With available resources redirected at the essential sectors, namely launchers and certain satellites, in particular those with a military vocation, it has been possible to preserve technical skills, expertise and resources. A recovery program was initiated in 1998. The Russian civil space agency, Roscosmos, has seen its budget multiplied by 10 in the space of eight years, reaching $ 1 billion in 2006[2]. Given the differential between local costs and those of the western nations, the actual Roscosmos space budget should be multiplied by a factor of between 2 and 4. Taking the latter assumption, the Roscosmos budget equates to that of ESA (European Space Agency). Furthermore, Russia has on no occasion made fewer than 20 launches per year since 1998, taking the world leader position in this segment. Once the aeronautical sector had been put in order, Roscosmos turned its attention to rationalizing the space sector, which has retained highly efficient structures such as the Keldish Institute, a high-level engineering design entity, and the manufacturers Energomash and CADB-KBKhA which produced high quality rocket engines.

Another tangible indication of this resurgence, a federal space program was recently adopted for the period 2006-2015, on the basis in particular, of a dedicated budget amounting to $ 225 million for the period, for the development of space technologies.

Currently experiencing very substantial economic growth, Russia is using all peaceful resources at its disposal to establish its position in the concert of

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[1] *Russia is the second world oil producer and the first world natural gas producer. Its proven oil reserves are in seventh position in the world, and its natural gas reserves in first position.*

[2] *Alain Fournier-Sicre, ESA, Moscow, July 6, 2006.*

nations in Europe. It is to be anticipated that space will play a special part, and that Russia will, at the very least, become a formidable competitor, not only in the launcher but also in the satellite fields.

▪ *Confirmed Japanese space ambitions*

The third space player in the world after the USA (NASA, NOAA and others) and ESA[1], Japan's public budget appropriations for its civil activities amounted to $ 2.2 billion in 2006.

Japan has been developing its own launchers since the 1950s, placing its first satellite into orbit in 1970 and participating (12.8%) in the International Space Station (ISS).

Japan engaged in extensive revamping of its space organization in 2003, the aim being to accelerate and enhance the efficiency of its investment program. The Japanese space agency, JAXA (Japan Aerospace Exploration Agency), resulting from the merger between its three predecessor bodies[2], has established a "long-term vision" 20-year development plan.

The build-up of its launcher production program was interrupted by the explosion of the H-IIA launcher in 2003. Since then, MHI (Mitsubishi Heavy Industries) has been assigned responsibility for development of the H-2B launcher, designed to carry the HTV cargo vehicle for ISS missions.

Japan has set a number of exploration-related objectives to ensure the visibility of its space investments. Firstly, human spaceflight missions are scheduled for a 2020 horizon, followed by the creation of a permanent lunar polar base with a 2025 horizon, this being the ultimate target of the SELENE program.

The growth in space investments observed between 1996 and 2002, and interrupted since then, should pick up over the next few years under the impact of a number of factors.

With its military reconnaissance IGS (Information Gathering Satellites) spacecraft, Japan has demonstrated its awareness of the value of possessing its own autonomous resources for monitoring high-risk States such as North Korea, in its immediate vicinity. As a result of acquiring observation resources to meet its needs, Japan has acquired a particular status in Asia[3].

There is every reason to believe that Japanese space development will accelerate in the coming years.

Space activities represent a recognized vehicle for technological progress and an efficient export trade vector. Furthermore, Japan is in competition with China, very active in the space sector, and South Korea which has got off to a vigorous start. Furthermore, the North Korean threat argues strongly in favor of accelerated development of Japanese military space sector investment.

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[1] *Rachel Villain, Euroconsult, I-Space–Prospace seminar, September 27, 2006.*
[2] *These were NASDA, NAL, and ISAS.*
[3] *Xavier Pasco, Master of Research, Foundation for Strategic Research, October 25, 2006.*

3. Multiplicity of new players

▪ China, a future dominant space power

China launched its first satellite in 1970. Since then, the Chinese Long March launcher has flown 91 times, placing 78 satellites into orbit, 27 of which were for foreign operators.

In 2006, China launched and recovered 22 retrievable satellites, placed 22 telecommunications satellites of all types into orbit, and had 7 operational meteorological satellites of national design in service. The crowning achievement of its space program, China placed its first taikonaut into orbit in October 2003, followed by a team of two taikonauts[1] in October 2005.

The Chinese space program is the fruit of centralized organization. The three launch bases and facilities associated with human spaceflight, belong to the People's Liberation Army. A key component of the Chinese space program, COSTIND (Commission of Science, Technology and Industry for National Defense), is headed by a minister reporting directly to the Council of State. This minister holds powers of decision, and the key to the budget appropriations, and is trustee for the essential public entities in the high tech sector[2].

The mailed fist of the Chinese State for the execution of space programs is CASC (China Aerospace Corporation), responsible for all design and production tasks for all space equipment, including launchers, via a number of entities dedicated to a greater or lesser degree[3].

Three other authorities play important parts alongside the military-industrial space complex. These are the Ministry of Science and Technology (MOST), the Chinese National Space Agency (CNAS) and the Chinese Academy of Sciences (CAS).

The power of the State, and at the very core, the Communist Party, consequently has the means for direct control of the space sector.

Chinese space development was initially based on Russian technology. Cooperative arrangements have since been extended to include Ukraine, Brazil, Venezuela and France. However, technological autonomy is more than ever the final objective.

At all events, the space sector is identified as one of the five priority sectors for Chinese technological development over the next fifteen years,

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[1] The crew who fly in vehicles designed for human spaceflight are called cosmonauts in Russia, astronauts in the USA and Europe, and taikonauts in China (from the word taikongren or "man of the great void").

[2] In particular, NORINCO (terrestrial armaments), CSSC (naval constructions), CNNC (nuclear), AVIC (aeronautical) and CASC (China Aerospace Corporation).

3 Academies belonging to the CASC, CALT and CAST are responsible for the design and production of launchers and satellites respectively.

involving new materials, biotechnologies, information technologies and the energy and environmental sciences[1].

For the Chinese authorities[2], innovations of major social and economic dimensions will indeed stem from mastery of space technologies. Space budgets are consequently experiencing significant increases. CAST alone, responsible for the design and production of satellites, has recorded growth rates of 30% for its budget over the last two years, making a figure of € 700 million in 2006. According to estimates, this budget should be multiplied by a factor of between 4 and 6 to obtain its western equivalent on an equal purchasing power basis.

The Chinese military space applications budget is not made public. However, by reference to other countries such as India, it can be estimated as at least half the civil budget.

The future Chinese highway in the space context is clearly marked out.

China has set out a civil space plan 5-year program, the latest plan dating from 2006. Detailed objectives are set for each principal domain: development of new generation launchers, application of human spaceflight missions, development of a national positioning system, high resolution observation and exploration of the Moon.

With the CAST center near Beijing, the Chinese space industry possesses some of the best construction and test facilities in the world. These include the third largest vacuum chamber in the world, used for testing equipment and the Chang'E spacecraft[3] in particular, electrical compatibility and noise and vibration resistance test systems, simultaneous assembly facilities for 10 satellites, and the largest anechoic chamber in the world for testing HF antennas.

A noteworthy fact is that Chinese international policy now draws strength from its space sector. Two Earth observation satellites have been built jointly with Brazil. The Chinese Beidu positioning and navigation system, currently consisting of only 3 satellites, should ultimately have 12, with access being offered to its APSO (Asia Pacific Space Cooperation)[4] partners. Responding to a demand for energy partnerships with the oil and natural gas producers, China will supply a telecommunications satellite to Nigeria and another to Venezuela under the terms of closed contracts.

China was already quoting for medium power telecommunications satellites at competitive prices in the international marketplaces in 2006, within the framework of tenders accompanied by aggressive financing and insurance terms. The technological lead of European or American manufacturers over the Chinese space community appears to be no more than five years according to the experts.

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[1] *Josselin Kalifa, Economic Councilor, French Embassy in China, Beijing, November 27, 2006.*
[2] *Dr Sun Laiyan, Administrator, China National Space Agency, Beijing, November 27, 2006.*
[3] *The spacecraft has the following dimensions: height 22.4 meters, diameter 12 meters.*
[4] *APSO has 9 Member States: China, Bangladesh, Indonesia, Iran, Mongolia, Peru, Thailand, Pakistan and Turkey.*

Chinese progress in the military space domain is even more spectacular. Having successfully "dazzled", in other words neutralized, an American military observation satellite for several minutes using a ground laser in 2006, China has more recently destroyed one of its own meteorological satellites in orbit, using one of its ballistic missiles.

This feat places China in the still exclusive club (USA and Russia) of space powers capable of neutralizing satellite systems.

▪ *India, a stringent and determined space power*

India first became interested in space applications back in 1962, following the decision taken by Pandit Nehru to launch a space research and development program at the suggestion of Vikram Sarabhai, since regarded as the father of the Indian space program.

The first Indian satellite flew in 1975 on a soviet launcher. In 1981, India used its own SLV-3 launcher to place a new payload of Indian design and manufacture into low Earth orbit (LEO). Since then, India has moved steadily forward in the acquisition of modern space facilities.

As regards launchers, India continues to concentrate on low and polar orbit missions, with a progressive increase in payload capacity (ASLV in 1987, PSLV in 1997), later obtaining access to geostationary orbits (GSLV in 2001 and GSLV-MkIII in 2007). The Sriharikota launch base, near Chennay (Madras) now has three pads, the most recently constructed of which is intended for the future GSLV-MkIII launcher, and is equal in size and technicality to the Kourou[1] facilities.

India has developed two main systems in the satellite domain: these are the INSAT (Indian National Satellite) system for telecommunications, broadcasting, meteorology, disaster management, tele-education and telemedicine, and IRS (Indian Remote Sensing Satellite) for observation and remote sensing. India has a total of 9 telecommunications satellites and 7 observation satellites in operational service.

It should also be noted that India is planning to create its own satellite positioning-navigation system using a 7-satellite constellation.

Space sciences of the Universe are not absent, but take a back seat compared with services for the Indian population, the number one priority in India.

The Minister for Space, reporting directly to the Prime Minister[2], is responsible for Indian space development. A "space" committee, comprising all ministers concerned with space activities serves to involve the various administrations. ISRO (Indian Space Research Organisation) is the operational

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[1] *Visit of December 13, 2006.*
[2] *Dr. Rajeev Lochan, Director, INSES and Assistant Scientific Secretary, ISRO, Bangalore, December 14, 2006.*

space agency, and is responsible, assisted by a number of specialist laboratories, for designing, building and deploying all Indian space systems. The ISRO budget for 2006 amounted to $ 820 million, up 17% on the previous year[1].

Military space activities are totally disconnected from civil space activities, according to the Indian authorities. The DRDO (Defence Research and Development Organisation) has a global study and commissioning assignment for military equipment, and is also responsible for defense-related space applications, for which the annual budget is estimated at $ 500 million[2]. There is no doubt however that India, faced with recurrent regional tensions with Pakistan and China, is allocating substantial resources to space telecommunications and observation, not to mention the development of ballistic missiles.

Industrial development in India has been based on planned economy principles from the outset. While take-off of the aeronautical sector has been backed by both public and private investment, development of the space sector is based entirely on public investment. Cooperation is marginal and on an equal footing, so intense is the Indian desire for autonomy. In an effort to obtain a satisfactory return on investment, ISRO has set up the Antrix space application marketing structure. Antrix has an exemplary cooperation arrangement with EADS Astrium in the mid-range telecommunications satellite field (see Part 2).

Now applied to mid-range satellites and launch services, Indian competitiveness in the space domain is based on comparatively low costs, excellent reactivity in regard to market requirements resulting from a centralized decision-making process, and a very satisfactory level of technicality. This is destined to move forward rapidly, due to the very substantial share (64%) of budget resources allocated in favor of space technologies.

The Chandrayaan-1 program, involving injection of an automatic probe into lunar orbit in 2008, will provide India with strong international visibility, and the stimulus required to set up the ambitious human spaceflight program in course of final discussion at the end of 2006[3].

India took the first step towards mastery of the necessary technologies early in 2007, with the retrieval of a capsule placed into orbit by one of its launchers.

Definition of a lunar human spaceflight program is in process, and the support of the Indian scientific community has already been acquired. The Indian Parliament is expected to examine the project in the near future, and provide the resources for it to move forward.

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[1] *Total Indian civil space investments so far is estimated at $ 7 billion. Source: K. Kusturirangan, Director, National Institute of Advanced Studies and Member of Parliament, Bangalore, December 15, 2006.*

[2] *The margin of error for this assessment is substantial, given the shortage of information in this domain.*

[3] *Dr Lochan, ISRO, Bangalore, December 14, 2006.*

▪ *Israel, an unrecognized but dynamic space power*

Israel is a member of the club, initially limited but expanding steadily over the years, of nations possessing autonomous space launch and national satellite development capabilities.

The Israel Space Agency (ISA) set up in 1983, initially under the aegis of the Ministry for Science and Technologies, is now linked directly to the Prime Minister's office. Israeli military space activities come under the Ministry of Defense[1].

The Shavit launcher, derived from military missiles, entered service in 1988. The latest version can now place loads of about 300 kg into low orbit from Israeli territory. A development program is scheduled with the aim of increasing payload injection capacity to 1.55 metric tons[2].

Israel has been active in the observation sector since 1988 for obvious military reasons. The most recent of its OFEQ series satellites now provide performance among the best in the world for sub-metric observation and consequently reconnaissance.

In the telecommunications domain, Israel is also at the leading edge of progress, in particular with its Techsat microsatellites. With a mass of less than 100 kg and costing only $ 3.5 million, these spacecraft have remarkable performance. Israel placed its first AMOS (Afro Mediterranean Orbital System) geostationary telecommunications satellite into orbit in 1996, with the assistance of Arianespace.

As a supplier of high quality space technologies, Israel is involved in cooperation agreements with ESA, Germany, the USA, Taiwan, Turkey and Ukraine.

▪ *Brazil, a potential new player*

Positive commitment of Brazil in regard to the space sector dates back to 1994, which saw creation of the Brazilian space agency (AEB), supported in particular by the Brazilian National Space Research Institute.

The initial phase of Brazilian progress in the space domain was marked by development of microsatellites launched in 1993 and 1998, and the construction and launch of two CBERS observation satellites in cooperation with China. Three successive failures of the Brazilian national VLS-1 (Veiculo Lancador de Satelites) solid propellant launcher led to a comprehensive rethink of Brazilian projects, and increased commitment by the public authorities[3].

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[1] *Source: CNES, memorandum to the rapporteurs, December 26, 2006.*

[2] *In contrast to customary practice, launches from Israeli territory are made in a westerly direction to avoid overflight of neighboring countries, with a consequent reduction in payload capacity.*

[3] *The first two failures occurred in flight in 1997 and 1999. The third failure occurred on the launch pad in 2003, causing 21 casualties.*

A governmental space activity program (PNAE - Programa nacional de atividades espaciais) has been set up for the period 2005-2014. Annual budget appropriation for 2006 amounted to $ 100 million, the target being to reach an annual figure of $ 200 million by the end of the program[1].

The space program principally covers enhancement of space infrastructures, and intensified R&D in all strategic domains[2]. Regarding launchers, the VLS program has been recommenced with Russian support, and the Alcantara launch base has been opened for operation of the Ukrainian Cyclone-4 launcher. An initial flight is scheduled for 2007.

Brazil has cooperation agreements with various space powers including Ukraine and Russia. Cooperation with China continues with the CBERS 3 and 4 satellites. Germany is providing assistance via the DLR in the radar observation domain. ESA signed a framework cooperation agreement with Brazil in 2002.

Brazil is not yet a battle-hardened competitor in the world space market. However, it could enter the market in about 2035, provided the public authorities continue to invest over a period of at least thirty years, this being regarded as the minimum to achieve autonomous space power status.

▪ *Ukraine, a far from negligible player*

Following the collapse of the Soviet Union and the acquisition of its independence in 1991, Ukraine has naturally held onto and retrieved for its own purposes, the Yusnoye and Yuzmash intercontinental ballistic missile design and production centers. These facilities have since been reassigned to the production of the Cyclone and Zenit launchers, and shortly the Mayak launcher.

Public support for the Ukrainian space sector is estimated at a figure of $ 60 million for 2006. The Ukraine still requires assistance from Russia for the implementation of these programs, but is seeking its autonomy. Having created the National Space Agency of Ukraine (NKAU) back in 1992, Ukraine set up its first national space program for the period 2002-2006.

Given the potential military applications for its expertise in the space domain, Ukraine quickly became involved in international cooperation partnerships, under the auspices of the USA, India and Australia in particular. ESA is also one of its partners.

Ukraine does not have its own launch base, and its launchers fly from Plessetsk in Russia, Baikonur in Kazakhstan and the Sea Launch platform. Launch services provided by Sea Launch are based on a launcher the first two stages of which are built by Zenit, with a Russian third stage built by Energia. Countries including Brazil and Malaysia are interested in its technical expertise, and have plans for launcher cooperation agreements with Ukraine.

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[1] *CNES memorandum to the rapporteurs, December 26, 2006.*

[2] *In particular: liquid propulsion, altitude control, sensors, high resolution optical imagers, synthetic aperture radar (SAR) systems and nanotechnologies.*

Ukraine also possesses expertise in the observation satellite domain and has supplied a number of satellites to Russia. Egypt has placed an order for one satellite. Telecommunications satellites and advanced propulsion systems for automatic probes are currently at the design stage.

Ukraine could see its position strengthen considerably in the future, in the context of cooperation with States possessing substantial financial resources and wishing to acquire space capabilities.

▪ *South Korea poised to acquire access to space*

South Korea recently decided to accelerate development of its space sector for military reasons, in the light of its complex relations with its dangerous neighbor, North Korea. Public support for the space sector rose to € 209 million in 2006 for this purpose. South Korea's aim is to be one of the ten leading world space powers by 2015.

Having failed to build its own two-stage launcher, South Korea acquired the technologies of the first stage of the Russian Angara launcher at the end of 2006, with a second stage built in South Korea itself. Cooperation with Russia appears likely to increase, as Russia has made proposals to South Korea to fly a South Korean astronaut in one of its Soyuz spacecraft.

South Korea possesses observation satellite technologies. The Kompsat-2 satellite was launched successfully on Eurockot from Plessetsk in July 2006. South Korea is still at the apprenticeship stage in the telecommunications field, with startup based on microsatellites built by Surrey Technology Ltd.

Applying a self-initiated policy, South Korea has demonstrated its ability to move fast with development in numerous sectors, including shipbuilding, the automobile industry and consumer electronics.

While it is extremely difficult to construct a space sector, there is no doubt that South Korea will become a strong player between now and 2020.

3. An upcoming change in space leadership?

The process of change in recent years, where we have seen an increasing number of players invest in the space domain, is not about to dry up. The same forces which induced the space powers to become involved in this sector are still at work. This is something worth remembering.

While the launcher technologies developed by Nazi Germany were picked up and developed by the USA and the Soviet Union for strategic purposes, space research quickly emerged in its turn, to such an extent that the World Committee on Space Research was set up as far back as 1958.

For its part, France has had a dual objective, both strategic and scientific, since the creation of the French space agency (CNES) in 1961[1]. This made France the third world space power. The French Diamant A launcher successfully flown in November 1965, stemmed from a military program, with a civil version, of which Ariane-5 is a distant heir, appearing in 1970. Scientific applications and space services were developed simultaneously, leading to the launch of the first French telecommunications satellite, Telecom-1A in 1984.

Sovereignty and international prestige always play a major part in the development of the national space sector for any State. Accumulated experience shows that both these notions have an increasingly important technological and economic dimension, above and beyond any political factors, making the space sector even more essential in an economic development context.

If the number of players involved in the space sector continues to increase, and their individual expertise to amplify, what will the world space stage be like in the decades to come?

Will the USA be able to hold on to its space leadership during the next twenty years? Given the cost of the lunar adventure, combined with American budget difficulties, will its alliance with a partner possessing adequate financial strength be indispensable?

Will Russia have the means to pick up the thread of its brilliant space history on its own, and in the contrary case, with which other power will it seek an alliance?

Will China become the space workshop of the world or will it continue its space sector growth program, placing the emphasis on its domestic market ?

Will India continue its self-centered development or, to accelerate its power buildup, will it seek a partnership in Asia or, on the contrary, with the western powers?

Will we see international cooperation intensify in a growing number of space segments, or will each of the leading players, whether established or new, concentrate on preserving its autonomy in each domain?

While technological and industrial time accelerates, making predictions ever more difficult, it will always be preferable to negotiate from a position of strength, on the basis of solid national or European expertise and achievements.

France and Europe cannot continue at their present pace for all these reasons, the more so as a full-scale space applications boom is in process, accompanied by a plethora of human spaceflight projects centered on the Moon, which will have the effect, in particular, of boosting space technologies.

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[1] *The creation of the European Space Agency (ESA) in 1973 led to the grouping of European forces in the domains of launcher construction and space research.*

II – THE INVISIBLE SPACE BOOM AND HUMAN SPACEFLIGHT

The image of Earth seen from space with which we are all familiar, is that of a blue planet, irised with white, unique in the Universe as we know it today. Above the atmosphere surrounding the planet like a skin, numerous satellites launched by man, some in service, others declassified, but all invisible to the inhabitants of Earth, form a new animated lattice.

The number of objects of significant size and of all kinds in Earth orbit is estimated at 5,500[1], of which 2,500 are satellites.

No fewer than 1,001 satellites were placed into orbit worldwide, including military satellites, over the ten-year period from 1997 to 2006[2].

An outward extension into space of tools developed by Man to enhance his condition, this satellite lattice provides new services, and also new instruments for the observation and protection of the planet itself.

A day without the space segment would result in shutdown of a major part of international telecommunications and worldwide television broadcasts, audiovisual blackout in many parts of the world, stammering defense and security systems, return of weather forecasting to that of times gone by, the disappearance of GPS signals and associated services, a return to Earth observation plot by plot, the disappearance of tele-education and telemedicine in India and China, and abrupt stoppage of an essential part of the flow of scientific data concerning our solar system, our galaxy and beyond.

If access to space is the target of world competition, it is because space technologies offer a range of direct and indirect services, in addition to the premium of sovereignty and international prestige, the importance of which will increase in the coming decades.

Space is also exploration by means of human spaceflight. It is also the International Space Station (ISS), the current platform for human spaceflight. Criticized and little known in many countries, the ISS must nevertheless be completed and its service life extended over the coming years.

In addition to the ISS, numerous exploration-related human spaceflight projects have recently been announced, picking up where the Apollo lunar exploration program left off

As much as in the case of the ISS, discussions have long persisted as to the value of human spaceflight for space exploration, compared with automatic probes

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[1] *Source: CNSA, Beijing, November 27, 2006.*

[2] *Breakdown by type of application is as follows: radiocommunications including navigation: 470, Earth observation: 87, science: 226, military including GPS: 218. Source: Euroconsult, quoted by CNES, memorandum to the rapporteurs dated December 21, 2006.*

and robots which can be used to a certain extent in its place - at substantially lower cost.

The matter now appears to have been settled with the emergence of the projects of numerous space powers, all of which are resolutely including human spaceflight exploration in their space programs in association with unmanned missions.

1. The current and future proliferation of space services

Recognizing only the final service it obtains, the public frequently disregards the fact that space constitutes an essential link in many services relating to our daily lives, and on a larger scale, the main economic functions and public services. The position which the space sector has acquired over the last fifty years as a basic infrastructure is however quite clear, nothing compared with what it will become in the next few decades.

Space is an incomparable provider of scientific data concerning the Universe and Earth itself, and a fundamental infrastructure for a multitude of services the importance of which is already paramount and will further increase in the future.

▪ *An essential instrument for the sciences of the Universe*

The possibility of getting outside the terrestrial atmosphere which impedes observation, and sending automatic probes into the solar system, and perhaps one day further still, is a scientific dream which has come true in fifty years of space exploration.

As regards the ***sciences of the Universe***, it would be incorrect to say that we cannot move forward in our knowledge of the origins and evolution of the Universe from here on Earth. On the contrary, the leading observatories play a substantial part in the collection of data from increasingly detailed observation of space.

However, very substantial data is now acquired by space telescopes and probes, and their contribution should increase rapidly in the years to come.

For example, the Hubble space telescope has provided input which has been decisive in the discovery of phenomena such as the expansion of the Universe and its acceleration, gamma-ray burst sources, black holes or extra-solar planets[1]. The COBE satellite has made it possible to identify fossil radiation, and the heterogeneity of energy density during the early ages of the Universe, leading to formation of the galaxies. The COROT satellite, launched in December 2006, will no doubt exceed, in terms of discoveries, the number of two hundred exoplanets already catalogued. The new generation space telescope (NGST) will

[1] *Roger-Maurice Bonnet, Executive Director, International Space Science Institute, hearing of December 21, 2006.*

make it possible to gain a further two orders of magnitude in terms of the power delivered to the human eye, compared with Hubble.

Observation of the remote Universe enables us to backtrack the fourteen billion years separating us from the Big Bang (t=0), its origin according to the most robust theory at the present time. However, observations cannot be made at a point earlier than the 300,000-year barrier (t=300,000 years). The space sector will doubtless make a major contribution to our knowledge of the earlier stages, these remaining opaque for the observer at the present time. Once the means to detect neutrinos and gravitons have been developed, we can well imagine that space observation will play an important part.

Regarding exploration of the Universe, the best and most important progress for our comprehension of the Universe is doubtless still to come.

Luminous matter, namely the stars, only represents 0.5% of critical density, and normal dark matter comprising protons, neutrons and electrons, about 5%[1]. Exotic dark matter represents 25%, and we do not know what it is. As for dark energy, responsible for the acceleration and expansion of the Universe, this represents 70% of the cosmos, but here again its nature is unknown. A map of a small portion of dark matter has recently been made, and this is again the result of Hubble observations. The next generation of space telescopes will doubtless enable us to make a breakthrough with identification of the greater part of the Universe.

In-depth understanding of physical forces is another area in which space will doubtless make an essential contribution. Thus, the mechanism of weak force, which serves to convert neutrinos into electrons and vice versa, remains to be explained. As for gravitational force, its messenger, the graviton, which nevertheless functions over distances of several million kilometers, as witnessed by the Sun's attraction acting on Pluto, has yet to be demonstrated.

Our knowledge of the ***solar system*** has increased exponentially with the ambitious automatic probe programs[2].

Europe, which was scarcely present in this domain up to the end of the 1990s, is now the second world player behind the USA, and has scored some remarkable successes such as the Huygens probe which penetrated the atmosphere of Titan[3], and the probes placed into orbit round Mars (Mars Express), the Moon (Smart-1) and Venus (Venus Express) in 2004 and 2005.

This dynamic program will continue between 2010 and 2020, with the operational phase of the Rosetta comet mission and the Bepicolombo mission to Mercury, in collaboration with Japan. French teams have played an important part in this adventure, with responsibility for 30% of the onboard instruments for the European missions, and CNES jointly responsible for the Rosetta mission lander module.

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[1] *Hubert Reeves, Latest news from the cosmos, October 2002, Editions du Seuil.*
[2] *Yves Langevin, Research Director, Orsay Institute of Space Astrophysics, hearing of January 24, 2007.*
[3] *Titan is the largest of Saturn's satellites.*

Planetary space missions will continue to play a decisive role in the future for our comprehension of the formation of the solar system, to obtain information concerning the appearance of life, and to explore environments where life could have developed independently from life on Earth.

A major scientific issue of today, exobiology, has led the French scientific community to assign priority to the exploration of Mars[1].

Furthermore, space missions allow continuous observation of the Sun for all wavelengths, whereas many are blocked by the terrestrial atmosphere.

The joint European-NASA Soho mission has this as its primary objective. More comprehensive knowledge of the Sun is essential to enable us to understand climatic cycles in the longer term, and thus perfect short-term evolution models. Likewise, only space missions make it possible to characterize solar radiation and particle flux phenomena, and their complex interaction with the magnetic field of our planet. The "space meteorology" domain has progressed considerably since 2001, with the Cluster multi-satellite mission, another result of European initiative.

Space science indeed looks to have a rosy future. The coming decades will see research programs deployed in the four areas for which the approach path has already been cleared. These are determination of the laws of physics, formation of the planets and the appearance of life, and interactions between the Sun and its planetary system.

▪ *A promising infrastructure for telecommunications, radio and TV broadcasting*

Although facing competition in certain areas from terrestrial networks, the satellite has considerable advantages for the telecommunications, radio and TV broadcasting of the future.

Coverage of large countries, mountainous areas and regions neglected by the main terrestrial networks, belongs to the satellite. While a certain degree of skepticism exists in the industrialized countries regarding the ability of the satellite to reduce the digital gap, whole continents only have access to high-rate Internet services via the satellite, relayed in certain cases by local networks[2].

High-definition digital TV also represents a demonstrated current growth market for the satellite, the most efficient carrier in this domain.

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[1] Some satellites of the giant planet (Europa, satellite of Jupiter, and Titan and Encelade, satellites of Saturn) would also be of interest from this point of view.

[2] The YLAS satellite, built by the EADS Astrium-Antrix Euro-Indian partnership, was indeed designed for bidirectional coverage of isolated areas in Spain, the United Kingdom and the Far Eastern countries, to provide HR Internet access.

If doubts persist regarding TV broadcasting for cell phones, this will appear as evident and essential in ten years time for the upcoming generations, as the cell phone itself is today.

The digital radio sector is also destined for substantial growth in the coming years. Already broadcast by Internet and terrestrial networks, digital ratio will ensure continuity of reception over large areas as a result of the power and wide geographical coverage of the satellite, accompanied by the multiplication of programs at negligible unit cost. Business radio programs, and programs aimed at a limited public, for example enthusiasts of a dedicated cultural or leisure activity, are spreading in the USA to an extent which augurs well for an identical process for dedicated TV programs[1].

▪ *A fabulous tool for management of Earth*

The space sector has been responsible for the enhanced accuracy of weather forecasting, with probabilities of close to 95% for three-day predictions, 85% at five days, 70% at seven days and 40% at 10 days now being achieved[2].

Space enables us to obtain precise measurement of the size of volcanoes, the rise in water levels and temperatures, and man-induced pollution such as CO2.

The potential of the space tool is considerable, and has a synergetic impact due to the emerging of sensors and the information collected[3].

In the case of disaster management for example, space will provide a unique service resulting from the combination of meteorology, imaging, telecommunications, positioning and navigation.

Space will likewise make a decisive contribution to sweeping changes in precision farming. The multispectral satellite will identify plots and crop yields. With the combination of climatic, weather forecasting and agronomic data, it will be possible to achieve maximum yield while saving both water and fertilizers. Naturally, a farmer who logs onto Internet to determine optimum fertilizer quantities per acre, will be unaware of the contribution made by the space segment although this will be decisive.

Among the vast number of new services which the merging of different potentials will create, we can also mention institutional services, such as urban management for building, flood management for which space observation has proved vastly more efficient than aerial observation, and civil security.

Satellite tele-education and telemedicine are also flagship applications for the new major space powers, China and India. These public services are supplied to the most remote regions at minimum infrastructure investment cost.

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[1] *Stéphane Vesval, EADS Astrium, Bangalore, December 15, 2006.*
[2] *Roger-Maurice Bonnet, Executive Director, International Space Science Institute, hearing of December 21, 2006.*
[3] *Yannick d'Escatha, President, CNES, hearing of November 16, 2006.*

Furthermore, by combining *in situ* surveys with weather forecast data, epidemiological monitoring can be conducted and preventive measures set up with maximum efficiency.

▪ *Technological progress induced by space activities*

It is also fashionable in certain circles to deprecate the role of space applications as a technological driving force, simply because these applications are always costly.

However, it is for the very purpose of setting up new space applications that a number of technologies have been developed, before using them in other sectors. Furthermore, certain countries such as Japan have made no mistake in defining major technological development objectives based on a long-term space-related approach, such as the Vision 2025 program of the Japanese space agency, JAXA.

Space applications have required considerable progress in the areas of miniaturization and hardening of electronic components, radio communications, electromagnetic sensors, observation sensors, signal processing, engineering, software and propulsion systems.

Satellites are greedy energy consumers. Solar cells and panels and associated batteries provide the greater part of energy consumed in flight. Space applications have made a powerful contribution to technological progress in these domains and the efficiency of fuel cells has been enhanced for the space segment.

Composite materials have found special outlets in the space sector, given the mass and mechanical performance gains to which they contribute. Remote manipulation and automatic control system technologies will also make a permanent contribution in the space context.

Given the cost and complexity of satellite launches and the satellites themselves, not to mention the particular constraints of human spaceflight, the space sector has opened the door to progress with dependability enhancement and management methods for both industrial production and services.

It is not surprising that the view of space adopted by the Bush administration is justified in the following terms: "*The fundamental purpose of the American vision of space is to promote the scientific, security-related and economic interests of the nation, through a robust space exploration program*"[1].

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[1] *The Vision for Space Exploration, National Aeronautics and Space Administration, February 2004.*

2. The international space station, a success despite its critics

A permanent space station in orbit round the Earth has been a science fiction writer's dream for nearly two centuries.

The Soviet Union was the first to make this dream come true with the Salyut-1 spacecraft placed into orbit in 1971. The USA followed with Skylab in 1973, and the USSR later assembled the renowned MIR space station from 1986 onwards.

After these early efforts, conducted in an atmosphere of competition between the two blocks, an international station project (the International Space Station or ISS) finally saw the light of day a few years after the end of the cold war. The first two elements of the ISS were assembled in 1998, and the first international crews took up residence in 2000.

An international space cooperation flagship project, the ISS has achieved its initial objective of enabling different space communities to learn how to work together, and obtaining the convergence of different technological approaches.

Retrospectively, it appears that the ISS was doubtless not the best way of achieving progress with human spaceflight technologies.

Furthermore, the ISS has not come up to expectations as a facility for the production of medicaments or complex materials for commercial purposes in a weightless environment. The responsibility for this lies not with the setbacks experienced in building the station and its equipment, but rather in the failure, perhaps only temporary, of a research path.

But, the ISS has the advantage of federating the efforts of a number of space powers, and must be completed and operated to the end of its service life.

The ISS is indeed an essential study facility for space exploration, and a model for international cooperation which must play its part up to about 2020, even if the number and nature of the partners change between now and then.

▪ *A disavowed commercial purpose*

Announced to the public as a commercial production facility, the station was intended, among other objectives, to take advantage of its weightless environment to manufacture new drugs or new materials profitably.

This has not been the case, and was predictable in regard to new materials. It was less predictable for molecules for therapeutic purposes, and this was a great disappointment. However, not all technological bets will ever be winning bets.

The commercial return from the ISS is very paltry, apart from paid in-orbit visits to the station. But, it offers numerous possibilities for scientific experiments, and constitutes a powerful no consumption of energy, the station generates its own electricity with its vast solar panels, backed up by batteries during the sixteen daily shadow transit periods.

Impressive in its size, with a length of about 40 meters which will stretch to around 100 meters, the ISS provides its various component modules, each with headroom of about 1.8 meters, with an acceptable level of quality of life over an extended period, and satisfactory conditions for numerous scientific experiments.

Many scientific experiments are already in process in the Russian and American modules, and their number will increase with the arrival of the European Columbus space laboratory and the Japanese laboratory. For Columbus, the experiments will be selected progressively and funding released as appropriate. Léopold Eyharts is scheduled to participate in the mission to install the Columbus laboratory in the ISS in the autumn of 2007. This mission will inaugurate a particular busy sequence. The second part of the Canadian robot arm, and the first module of the Japanese part will arrive next, and a third mission will be devoted to completing construction of the Japanese module.

▪ *ISS, a life science laboratory in space*

The station is first and foremost a select facility for conducting exploration studies. This explains the considerable number of ISS life sciences experiments planned.

Regarding the effects of microgravity on human physiology, a number of potential effects make it necessary to study and set up countermeasures. This has demonstrated that the cardiovascular system adapts quickly and efficiently to a microgravity environment. However, over a long period, the volume of blood fluid and cardiac muscle decreases slightly, generating hypotension on return to the Earth and requiring a three-day readaptation period for short flights and one month for long flights[1]. Hence the need for pressure suits after a flight. Furthermore, microgravity triggers osteoporosis phenomena which must be studied in depth.

The second domain in which the ISS will make an essential contribution is the study of space radiation. This must be blocked by means of dedicated devices[2].

The third study area concerns the physiological effects of isolation, confinement and promiscuity, the results of which will be essential in regard to deep space human spaceflight missions, in particular to Mars.

▪ *An investment already made*

Some French scientists describe the cost of the International Space Station as being unacceptable to such an extent that our financial participation will have absorbed all resources available in France for major scientific facilities.

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[1] *Visit to Biomedical Laboratories, Johnson Space Center, Houston, November 3, 2006.*
[2] *Vincent Sabathier, CSIS, Washington, November 9, 2006.*

Europe will have provided less than 10% of ISS funding. The French share, less than a quarter of the European share, consequently represents less than 2.5%. Ninety percent of this expenditure has already been made. This investment gives France the possibility of accessing all resources offered by the station.

By comparison, Japan has contributed 13%.

To accuse the USA of having offloaded the financial burden of the ISS onto its partners consequently does not make sense, the USA carrying 80% of the cost. On the contrary, it is fair to observe that Europe has negotiated efficiently, to obtain access to this scientific laboratory and test bed, unique in regard to life in space, at lowest cost.

Funding conditions for the ISS will nevertheless change once the station has been completed. It is planned for the European contribution to be covered to a major extent by contribution in kind, namely by the transport of freight on board the ATV (Automated Transfer Vehicle). Hence the importance for ESA of a first successful launch of the ATV in 2007.

▪ *Formidable international cooperation for construction and operation*

A wager of capital political importance has been won with the ISS: the ability to conduct a joint project, based on different technical and managerial cultures, with success has been demonstrated. The technical challenge was to achieve compatibility between the technological disparities of the various parties involved.

A remarkable international cooperative, ISS is so far the most important international technico-scientific project ever undertaken with success.

The first module Zarya (dawn) was launched by the Soviet Union. The second, the Unity module, built by the USA, was then connected to Zarya, an unfortunately disregarded political symbol. The two-module station was however not yet habitable. Developed from the MIR station, the Russian Zvezda service module was then docked with the station, providing onboard living quarters. The Zvezda module is still used by the crew to take their meals, and also contains the only toilets on board and the only motors of the station. Life would not be possible in the ISS without this module. However, Russia could detach this autonomous module from the ISS and continue its mission alone, although with limited electrical resources and increased fuel consumption for station-keeping. In this case, all other parts of the station would be unusable.

Russia launches its modules on the Proton vehicle while its cosmonauts fly on Soyuz. The USA uses Shuttle to take up the contributions of the industrialized countries, including the European Columbus laboratory scheduled for launch in 2007, followed by the Japanese modules.

Docked with the station for a period of six months, a Soyuz vehicle acts as evacuation module, ensuring the safety of the astronauts and ready at all times to bring a crew of three back to the Earth. The station has a total of three Soyuz docking ports.

The Canadian robot arm extracts cargo from the Shuttle hold. When its second part is added, this arm will be able to undertake delicate operations, thereby reducing the frequency of extra-vehicular activity (EVA). The building bricks of the enormous "Lego" structure in space include the MPLM (Mini-Pressurized Logistics/Laboratory Module), the enormous Italian space container used to carry freight on board Shuttle, which remains docked only for the time required to offload, then returning to Earth with the same container.

The ATV (Automated Transfer Vehicle), built by ten European countries under French prime contractorship, will soon make its first trip to the station, using a highly innovative automatic, pilotless rendezvous procedure.

Three nations are providing a solution to the problems of ISS station-keeping and avoiding space debris which could damage the station.

Russia is providing the services of the Progress cargo capsule, which, once docked, can act as a tug, and the motors for the Zvezda service module.

The European ATV will provide the same service as from 2007.

The USA is providing the propulsion capability of Shuttle when docked with the ISS.

Likewise, to maximize its electricity production capability, the ISS must be maintained in the best possible position in regard to the Sun. The gyrodynes incorporated in the American part, or the Russian motors installed in the service module are used for this purpose[1].

The majority of ISS control operations are conducted from the ground[2]. Three American satellites and a set of Russian ground stations provide telecommunication links with the station.

An international space cooperative, the ISS is also the stage for cooperation between the astronauts of all countries. This does not just concern a few dozen hand-picked astronauts. On the contrary, several hundred people are involved in training of the astronaut, in each country supplying the main station modules, and in Houston for training on integration of the different parts of the station and emergency situation management. Several thousand international engineers and technicians have worked in close collaboration on the design of each module, and its integration with the other modules.

After the end of the cold war, is this an achievement which can only be regarded as of secondary importance?

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[1] *When the gyrodynes are saturated, the motors must be used for this adjustment task and to desaturate this equipment.*

[2] *ISS experience leads to the conclusion that future spacecraft will need greater autonomy, as signal transmission time, already far from negligible for the ISS, will make the real-time control potential in the event of a problem, impossible in the case of deep space missions.*

▪ *Maintaining the ISS in service for as long as possible*

Termination of activities on board the ISS is theoretically scheduled for 2016. But can we imagine abandoning an investment of $ 100 billion, and the corresponding equipment and the possibilities which it offers?

Assembly of the ISS will be completed by the end of 2010, provided all Shuttle flights are completed normally. NASA has decided to withdraw Shuttle from service, the cost of its operation being incompatible with its current budget restrictions.

When he took over as head of NASA, administrator Michael Griffin was highly critical of the ISS. The attachment of the other partner countries to its construction and complete operation convinced him however not to reconsider the American commitments. ISS is a priority for NASA[1]. Not only must everything be done, according to cross-checked and concordant information, to complete the study, but in all probability its utilization by NASA will be extended.

After discontinuation of Shuttle flights in 2010, the USA does not believe it will be deprived of the means to access the ISS, unless the COTS (Commercial Orbital Transport Services) launcher development program conducted by new commercial sector companies fails to produce rapid results[2].

Should the COTS program not produce a new solution as from 2010, launch opportunities on Soyuz flights have been purchased from Russia, to ensure the transfer and presence of American astronauts on board the ISS for the period 2010-2014.

As from 2014, Ares-1 and the Orion capsule will reestablish a direct link. NASA estimates that the ISS constitutes a "sound basis" for international cooperation which will develop in the context of future exploration missions[3].

While the question of crew transfer appears to have been settled, this is not the case with large items of non-pressurized equipment, such as are currently carried in the cargo hold of Shuttle, and in particular and above all for the return of these items to Earth[4].

For its part, Russia has maintained a human presence in space throughout the difficulties of the perestroika period and the collapse of the Soviet regime. There can be no doubt that Russia will contribute to the long-term survival of the ISS. The question is at what cost.

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[1] *Robert Cabana, Deputy Director, Johnson Space Center, NASA, Houston, November 3, 2006.*
[2] *See Part 3, I. Autonomous access to space.*
[3] *Mr Robert Cabana, op. cit.*
[4] *For example, scientific experiment racks cannot pass through the internal airlocks of the Russian modules due to their size. Other solutions will have to be found, such as stowing heavy and cumbersome objects on the ATV.*

3. Human spaceflight, a strongly resurgent human adventure

▪ *The deafening silence of Europe on the subject of lunar exploration*

ESA priorities in 2006 in the field of planetary exploration concerned the study of Mars and the use of automatic probes and robots. However, a four-year delay with the ExoMars robot mission has already been conceded. Initially programmed for 2009, it has been put back to 2013.

Although Europe notched up a major success in the lunar exploration domain with the Smart-1 automatic probe launch in September 2006, the ESA solar system exploration program is silent, or practically so, on the subject of eventual human spaceflight missions to the Moon.

This is astonishing on more than one count.

ESA has not accumulated up a substantial store of knowledge concerning our satellite.

All the leading space powers have been planning lunar missions since 2004, this being regarded as part of an essential technological validation process.

Consequently, lunar missions, relatively easier to implement than Martian missions, will trigger a dynamic exploration impulse which it will be extremely difficult to latch onto a later date.

▪ *The US lunar and Martian program*

NASA's Apollo program, over the period 1963 to 1972, involved six lunar landing and return to Earth missions. A large section of American opinion currently fails to understand why this program was interrupted, and over 60% approve the new program announced by President Bush on January 14, 2004.

The Constellation lunar program is founded on the design and construction of a brand new set of launchers, capsules and lunar modules, based on proven technologies. For reasons of technical prudence and budget control, current NASA plans are limited to a return to the Moon. Neither a long-term presence on the Moon nor flights to Mars are included in identified budgets at the present time.

NASA has again adopted the concept of a multipurpose capsule of the Apollo type, which will serve both for orbital flights, transfers to the ISS and lunar missions.

The Orion capsule, the volume of which is two and a half times greater than that of the Apollo capsule, could carry between 4 and 6 astronauts. Its first, unmanned flight should take place in 2012, and its first crewed flight in 2014. The first manned lunar mission is programmed for 2020.

The Orion capsule will fly on the Ares-1 two-stage launcher, which has a low Earth orbit payload capacity of 20 to 25 metric tons.

The Constellation program also includes construction of the new Ares-5 heavy launcher, designed to place payloads of 130 metric tons into low orbit. This launcher will have two main parts, the second of which, designated "*Earth Departure Stage*", will carry the lunar module with which the Orion capsule will dock following in-orbit rendezvous.

Speculations concerning the long-term future of this program, following an eventual political change in 2008, are pointless as the program has been accepted in full by both the Democrats and Republicans.

The interest of the American people in space has its roots in the history of the nation. The myth of the frontier, the way the West was won, and now the conquest of space, constitutes a durable part of its imaginative and economic driving forces. Emblem of the ability of the American people to meet any challenge, the national space program, with the lunar program at the fore, also has the task of demonstrating a unique store of know-how[1].

As for doubts concerning the ability of NASA to implement the program within its budget objectives, these appear also to be groundless[2]. Retirement of Shuttle in 2010 will release a margin of at least $ 5 billion per year. The US contribution to ISS should also stop in or around 2015. At this date, the annual $ 8 billion human spaceflight budget will be free for allocation to the Constellation program.

▪ *The Russian lunar program*

Russia has a number of ambitious projects aimed at increasing its already substantial knowledge of the Moon.

As regards automatic probes and robots, Russia has scheduled the Luna-Globe lander for 2012, and the Lunar-Rover, the Lunar-Grunt sample return and the Lunar-Polygon lunar surface station for 2020 at latest. The presence of Russian cosmonauts on the surface of the Moon is also planned for 2020, followed by the construction of a lunar orbital station in 2025, and a permanent lunar base in 2030.

These lunar projects are completed by the Phobos-Grunt mission covering the return of samples from the Martian satellite Phobos. The return of Martian samples is planned for between 2020 and 2025, with the further objective of the presence of Russian cosmonauts on Mars in around 2033.

▪ *The Chinese lunar program*

Following the success of its two human spaceflights in 2003 and 2005, China's new target is the Moon, based on a process involving a number of intermediate steps.

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[1] *Jean-Pierre Haigneré, astronaut, December 21, 2006.*

[2] *NASA budget envelopes are as follows: $ 16.45 billion (2006), $ 16.96 billion (2007), $ 17.3 billion (2008), $ 17.61 billion (2009) and $ 18.03 billion (2010).*

China's first objective is to improve its knowledge of human spaceflight techniques. Its aim is to carry out EVA operations and docking of capsules with cargo vehicle before 2011. The next step will be to set up a permanent, autonomous space laboratory, maintained by taikonaut missions[1]. This laboratory will apparently have characteristics similar to those of the Soviet Salyut spacecraft of the 1970s and 1980s[2].

A major five-year launcher program is in process. The objective is to be able to place payloads of 10 metric tons into lunar orbit, compared with the current maximum of 3 metric tons.

China's plans for lunar exploration identify three stages, each corresponding to unmanned missions: firstly, injection of the Chang'E-1 satellite into lunar orbit, with launch scheduled for April 2007[3], followed by a lunar Rover landing with Chang'E-2 programmed for 2012, and finally automatic return of lunar samples with Chang'E-3 in 2020.

As indicated by China Space Agency management, China is seeking partnerships to reduce the cost of its programs, collaboration with France being one of its objectives.

A program covering human spaceflights to the Moon and lunar landing by a team of taikonauts is currently under study.

China should have achieved the same technical level as Russia by 2020[4].

▪ *The Japanese lunar program*

Japan is a major partner in the International Space Station, with a 13% financial share in funding of the station, and an investment envelope of about € 8 billion over the period of the program[5]. The Japanese JEM-KIBO module will be launched in three separate segments in 2007 and 2008.

Its secular strategic rivalry with China will probably induce Japan to accelerate its complete space program.

Indeed, a task force was set up in 2006 to prepare a lunar program. The main dates put forward are 2020 for robot exploration, followed by creation of a lunar outpost in 2022 and a lunar polar base in 2025.

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[1] Dr Wang Keran, Deputy Director General, China National Space Agency (CNSA), Beijing, November 27, 2006.

[2] Philippe Berthe, EADS Astrium Space Transportation, hearing of December 20, 2006.

[3] This CAST satellite, with a mass of 2.3 metric tons, will be placed into lunar polar orbit at an altitude of 200 km. Its mission covers mapping of the lunar surface, analyzing the composition and measuring the density of the lunar soil, and studying the lunar environment. Source: Roger-Maurice Bonnet, Executive Director, International Space Science Institute, hearing of December 21, 2006.

[4] Philippe Berthe, EADS Astrium Space Transportation, hearing of December 20, 2006.

[5] Mathieu Grialou, CNES, I-Space–Prospace seminar, May 17, 2006.

▪ *The Indian lunar program*

As we have already seen, India is engaged in an ambitious space program, and regards lunar missions as part of a natural technological progression.

An $ 80 million budget has already been appropriated. The current priority is automatic probes and robots. The Chandrayaan-1 satellite will be placed into lunar polar orbit in 2008, its task being to map the lunar surface and identify its chemical composition. The subsequent step will be a lunar landing by a robot delivered by Chandrayaan-2 in 2010[1].

Intensive analyses were conducted in 2006, aimed at a rapid and in all probability positive decision regarding human spaceflights. The Indian scientific community is favorably disposed towards this prospect, also supported enthusiastically by Indian public opinion[2].

Subject to a final decision, India is targeting an initial human spaceflight in 2014, and the presence of Indian astronauts on the lunar surface in 2020.

Implementation of the Indian program is all the more likely as the $ 2 billion budget for the first five years has not induced any negative reaction on the part of the public authorities.

4. The purpose of human spaceflight

Human spaceflight is of interest for many reasons, both political and media-related, but also technical, technological, industrial and therefore economic.

In the ***political*** context, the American people identified themselves, at the time, with the Apollo program which demonstrated the technological leadership of the USA while, in political terms, offsetting the human and moral disaster of the Vietnam war.

For the new space powers, human spaceflight has the same objective of affirming national identity, demonstrating the technological capabilities of the country and uniting the nation behind a major project.

In the ***technical*** context, automatic probes are useful for achieving clearly defined objectives. However, being assigned to a predetermined task and one dimensioned for a given application, the lessons to be learnt from corresponding programs are necessarily limited[3].

Furthermore, automatic probes and robots are not suitable for executing delicate or unscheduled tasks such as complex ***repairs***. For example, it was astronauts flying on board Shuttle who were able to repair the Hubble space telescope *in situ*, and who have since conducted regular upgrading of the

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[1] *Dr Lochan, ISRO, Bangalore, December 14, 2006.*
[2] *Dr C V S Prakash, Director, International Marketing, Antrix, Bangalore, December 15, 2006.*
[3] *Igor Petrovitch Volk, hearing of the Parliamentary Group for Space, Moscow, July 6, 2006.*

telescope[1]. Satellite maintenance and repair missions, despite the technical difficulties and dangers involved, are carried out more efficiently by astronauts than by robots. This is the case, for example, with the assembly of large structures in space or the management of complex platforms, the outright replacement of which by automatic resources cannot be considered.

Manned flight also constitutes a powerful ***technological lever***.

The dimensions and functions of spacecraft – launchers and capsules – must be increased and extended by comparison with automatic probes, making it necessary to develop a set of new technologies.

Decisive progress must be made in regard to the reliability of infrastructures, equipment and procedures.

Human spaceflight also means projects of extreme complexity, requiring know-how difficult to develop, but which can be transferred easily to other activities which, on their own, would not necessarily address the solution of their own complex problems.

Finally, the ***visibility*** of space activities is multiplied tenfold by the presence of astronaut crews. Technical exploits such as the Huygens landing on Saturn's satellite Titan, principally attracted the interest of specialists and a knowledgeable public only.

The feeling for and conceptualization of a crew have appeared to be particular important for providing an additional and incomparably stronger dimension, of which public identification is by no means the least. The Apollo program aroused the enthusiasm of young Americans in particular and students most of all, and an increase in registrations for scientific courses and PhD programs.

For all space powers, the presence of Man in space ultimately appears inevitable and indispensable, as being necessary for the achievement of a strong, sustainable space ambition, and in that way, substantial identity-related pride.

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[1] Roger-Maurice Bonnet, Executive Director, International Space Science Institute, hearing of December 21, 2006.

III – REVIGORATION OF THE FRENCH AND EUROPEAN SPACE SECTORS, A MAJOR POLITICAL CHALLENGE

Increasing competition from new players, and the emergence of new space applications of major importance, are becoming apparent at a time when the French and European space industries are in a considerably weakened state, and the national and European space agencies do not currently possess significant freedom of action.

This situation is challenge to the strategic autonomy, political influence and economic competitiveness of France and Europe.

1. France and Europe wrong-footed

The French and European space sector has indeed been wrong-footed.

Following a period of strong growth during the 1990s, during which space industry sales increased by almost 60%, a sharp reversal of the trend occurred between 2000 and 2005, with a 22% slump in the telecommunications market, and figures of 53% for Earth observation, 35% for launches, 86% for space infrastructures and human spaceflight programs, and 17% even for scientific applications.

The European space industry has consequently had to lay off staff and restructure its facilities.

While a recovery appears to have occurred in 2006, with a return to a level of 20 new telecommunications satellite orders per year worldwide, the volume of business in this sector is still less than one-third of the highest levels for the previous decade.

The Earth observation markets are not, for the moment, in a position to induce a decisive increase in activity, even though an annual rate of ten satellite orders or more is probable for the next few years.

It is in this context of weak market growth that new competitors are appearing on the international stage, competitors which are all the more to be feared as the notion of profitability is of secondary importance insofar as their tenders are concerned, due to their public structure.

The consequences of the crisis are still present, and the European space industry finds itself brutally confronted with unbalanced competition, in a situation where it does not possess the financial resources to reestablish a decisive competitive advantage.

2. The dangers of the market-driven European space growth model

In France and in Europe, it is as though space policy has adopted the assumption that the space sector is mature and functioning in a competitive world market.

Consequently, to balance public finances or release subsidies for other sectors, the view is taken that these industries should be increasingly self-reliant, and that governmental support could consequently be reduced progressively.

Any such analysis is flawed, and endangers the French and European space sector.

▪ *The paucity of public procurement*

The commercial or institutional structure of space markets has a substantial impact on the health of their industries according to the countries concerned.

France is the only European country where the institutional and commercial markets are at the same level. The institutional market in Germany is about one-third greater than the commercial market. The institutional market in Italy is five times the commercial market, and eight times the commercial market in the United Kingdom[1].

The institutional markets – whether civil or military – in the USA accounted for 95% of sales by the American space industry in 2005[2].

The extent of commercial market procurement is indeed a reassuring pointer to the present competitiveness of the industry benefiting from this business. However, this situation creates a dangerous degree of dependence on markets which are essentially of a cyclic nature.

It should be remembered that global sales for the European space industry dropped by 20%, and 16% of its payroll were laid off between 2000 and 2005.

Any other industry would have obtained massive support from the public authorities.

We have already seen what happened. The European space industry had to adapt on its own. Productivity gains were achieved, and internal restructuring programs made it possible to eliminate team duplication in the countries concerned.

Nevertheless, the difficulties encountered led to reduced margins. Internal R&D is essential for the future, and is situated *de facto* at an insufficient level most of the time. Furthermore, the financial attraction of space projects has lost its shine, with profitability dropping to levels inducing doubts as to the long-term survival of said projects.

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[1] *Pascale Sourisse, President, Eurospace, ESTEC, May 29, 2006.*
[2] *Jean-Jacques Tortora, The American Space Program, CNES, I-Space-Prospace, 2006.*

The increasing strength of France's European partners would not be the subject of concern in its own right if France were itself pursuing a dynamic policy. But this is not the case, as we have already seen.

The absence of commitment on the part of the public authorities has already had its consequences, and will continue to do so in the longer term, both in regard to R&D on which the future is based, and profitability, the inadequacy of which can lead to pure and simple shutdown of the national or European tool.

▪ *Inadequate R&T*

The ESA appropriation for research and technology in 2005 amounted to € 85 million. The combined investments of the European space agencies for the same year can be estimated at € 240 million.

Total public investment in R&T was therefore close on € 325 million, very substantially less than in the USA.

The US Department of Defense appropriates almost half its space budget for research, technology, test programs and appraisals, or close on $ 10 billion per year. NASA also appropriates about $ 1.2 billion for research and technology in the exploration and human spaceflight domains.

Under these conditions, we could have hoped that industry would have filled the gap by conducting its own ambitious research and technology programs. This is unfortunately not the case as a result of its financial constraints.

That part of European space industry revenue allocated to research and technology (R&T) is of the order of 6%[1]. European industrial investment can be estimated at € 300 million per year for all European Union companies.

The scientific space programs indeed make a contribution to technological development, but this does not remove the need for massive, targeted investment.

▪ *Insufficient profitability of space activities*

Space activities involve very substantial, long-term investments, subject what is more to far from negligible risks.

Profitability is frequently low compared with the short-term projects sought by many investors. This has two consequences.

Firstly, funding is difficult to obtain, as demonstrated by the obstacles encountered with the European Galileo satellite navigation and positioning project.

Secondly, for the large groups the space sector can be regarded as a deadweight compromising their overall profitability. While space activities fortunately do not generate substantial financial losses in Europe, the profitability

[1] *Pascale Sourisse, President, Eurospace, hearing of November 16, 2006.*

objectives of large groups such as EADS, Alcatel, Thalès and Finmeccanica substantially exceed those of the space domain[1].

Hence the risk, which should not be underestimated, of seeing these groups offload this activity.

Furthermore, medium-sized companies operating as sub-contractors of the space sector, acquired by investment funds seeking rapid return on investment and capital gains, can also be led to shed their space activities[2].

3. Changing the pattern to revigorate the French and European space sector

Faced with the current difficulties of the space sector, it is French and European political organization which is under challenge to react.

Throughout the world outside Europe, the space powers accord decisive institutional support – whether civil or military –to their space sectors.

Space activities do not achieve total financial balance anywhere in the world.

Only Europe, and France, confronted with its budget margin reductions, still wish to believe that commercial market outlets can offset the stagnation of public financial support for the space sector. This is not so.

At all events, intervention by the public authorities is essential in a strategic domain such as the space sector where development requires substantial long-term investment, one which produces positive externalities of all types for the community, and the funding of which exceeds the capabilities of the private sector.

It is fruitless to believe that market dogma can monopolize space activities.

It would be a dramatic decision to limit space sector development to those activities which could be handled by the market.

Europe and France cannot afford the luxury of this perspective error, and on the contrary, must go back to the aggressive policies which have led them to major successes in the past.

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[1] *Pascale Sourisse, President, Eurospace, hearing of November 16, 2006.*
[2] *Stéphane Albernhe, Senior Partner, Roland Berger Strategy Consultants, CEPS (Strategic Prospective and Study Center), October 25, 2005.*

PART 2:

A FRENCH AND EUROPEAN VISION FOR AN AUDACIOUS SPACE POLICY

A long-term space policy must be set up in France and Europe to counter the emergence of new space powers, and define the means, not only to cope with this situation but also to bounce back.

France and Europe cannot miss out on definition of their own vision of space.

What needs should space meet over the coming decades? What resources should be allocated to the space sector and what will its development priorities be? What organization principles should be adopted in Europe and France? What international cooperation will Europe be ready to set up?

A clear vision is necessary to find one's way through the multitude of issues and techniques involved.

A clear vision is also necessary to make the public understand what space is and what its role will be in the coming years.

Once this long-term vision of space has been defined, an equally long-term policy can be unrolled, combining a transverse policy the key elements of which are addressed below, and a sectoral policy relating to the different space segments which is addressed in the third part.

I – A FRENCH VISION OF SPACE

France cannot justify its lack of ambition in the space context by the shilly-shallying of Europe.

The European space sector would not have existed without the pioneering work of France. The Member States of the European Union are quick to recognize this fact. But the countries which are now entering the space sector are seeking to increase their influence and the part they play. France cannot dispute their right to do so.

France must consequently increase its investment in order to retain its position. The horizon for space activities is a distant one, and France must take a long-term vision of its national space sector in a European context.

The multi-annual 2005-2010 contract between the French Government and CNES provides an initial component of this vision. But it is limited and cannot therefore suffice.

French space policy must not be constrained in a situation where budgets increase more slowly than prices, nor which is frozen for six long years without the freedom of action essential to achieve a minimum degree of reactivity. Nor again must French space policy fail to set long-term objectives and corresponding resources for its industry and research laboratories.

The French space sector which we know today is the fruit of the vision of the pioneers of the 1950s and 1960s.

The current leaders of the space sector are responsible for the presence of French industry in the four quarters of the globe. They achieve commercial triumphs in the face of fierce competition but ignored by the general public, and they possess a vision.

The following pages constitute a proposal, the purpose of which is to initiate the process which, ***driven by CNES, industry, the specialist press and Parliament,*** should lead to adoption by the Government before the end of 2007 of a ***French view of space for the period 2008-2030***.

Proposal for a French vision of space

1. French genius at the service of Europe

From the outset, the French space adventure associated strategic and scientific objectives. This was its specific characteristic, both original and remarkable, as compared with other countries, the majority of which privileged one or other of these two aspects.

Another specificity of the French approach was that its space development program was based, again from the outset, on public institutions and industrial companies, thus drawing the fullest benefit of a mixed economy.

France played a pioneer role in the European space adventure in the launcher domain, with the "pierres précieuses" launcher series (Agate, Topaze, Rubis, Emeraude, Saphir and Diamant), followed by the Ariane 1 to 5 launcher family. France's expertise in the satellite sector is unique, as witnessed by the successes chalked up by the French manufacturers in this field.

It is the roll of successive generations to enhance and continue the progress achieved in the space sector by the earlier generations of researchers and engineers, which were responsible for providing France with the advantages it possesses today.

It is also the task of successive generations to place French achievements in the space sector at the service of Europe in line with national interests.

2. Serving national sovereignty

Space is indeed a matter of sovereignty for France. The credibility of our nuclear deterrent policy, the technological skills and expertise of our companies and their place in the international marketplace depend on this.

In addition to its direct sovereignty over its own territory, air space and maritime space, France also possesses a shared sovereignty over extra-atmospheric space.

This shared sovereignty entitles France, in line with the interests of other nations, to use space for its security and defense, the implementation of new services supplied to the public authorities, companies and citizens, and for extending our knowledge of the origins and evolution of the Universe.

▪ *Space at the service of national defense*

Space constitutes the fourth dimension of national defense, alongside the terrestrial, air and maritime dimensions.

As a force multiplier factor, space ensures the effectiveness of our nuclear deterrent, enriches strategic vision, and increases the efficiency and protection of armed forces in action.

In this connection, it is the task of the armed forces themselves to examine and apply a systematic development policy for the space tool as defined by the Government and Parliament.

▪ *Utilization of dual technologies wherever necessary*

To reduce the costs of each tool and make it possible to increase the number of space infrastructures, dual - civil and military - technologies are applied systematically wherever they are compatible with the demands of safety and efficiency.

▪ *Protection of the space tool*

Space infrastructures have their own vulnerability, and this must be reduced by appropriate technical means.

Space defense policy takes this essential need into account at each level. The best technologies are used or developed for this purpose.

3. French space research in a world leader position

As a projection of its scientific history, France accords pride of place to research on the creation and evolution of the Universe with the aim of enriching the common patrimony of mankind.

In this context, space tools have their deserved place among the panoply of very large thematic scientific facilities[1].

Development of scientific instruments used for automatic probes, robot explorers and human spaceflight is a national research priority.

4. An essential driving force for the economy of the future

Space activities contribute to the competitiveness of the national economy, and consequently to economic development and enhancement of the living standards of the French population.

To obtain fullest benefit from investments in launchers, satellites, automatic probes and manned spacecraft, the highest degree of importance is accorded to maximizing the corresponding economic benefits, whether direct or indirect, and in particular through technology transfers to other sectors.

Specific attention is also paid not only to the ground segment, but also to data processing, data enhancement by means of numerical models, and the utilization and consequent distribution of these data.

Public and private investment in the complete space system is encouraged by all means compatible with France's European Community and international commitments.

In particular, public data users contribute to funding the infrastructures, and their operation and long-term future.

The services associated with space data are the subject of an accelerated national and local development policy.

5. The indispensable presence of man in space through human spaceflight missions

Exploration of the Universe and the creation of permanent manned facilities in space form part of the vocation of mankind. Human access to circumterrestrial space, the Moon and the planets of our solar system, and in a more distance future the rest of the galaxy, is consequently encouraged.

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[1] *The role of very large scientific facilities in public or private research in France and Europe, Christian Cuvilliez, Member of Parliament, and René Trégouët, Senator, report issued by OPECST, Assemblée nationale No. 2821, Senate No. 154, December 2000.*

The benefits anticipated from this exploration correspond to advances in the accumulation of knowledge and technologies.

To take the next step in its space development, France has instituted a long-term solar system exploration program. The public authorities are responsible for implementation of this program within the framework of European and international cooperation agreements, which it is their task to encourage and institute effectively.

Automatic probes and robots will be used in a parallel with human spaceflight missions.

II – A EUROPEAN VISION OF SPACE

Europe has need of an identity: ***"where there is no vision, the people perish"***[1], and the European space sector requires a vision which gives meaning to all the considerable progress achieved by Europe, although the significance of this escapes the majority of Europeans due to defective communication, and not deficient meaning.

The following proposal is aimed at initiating a shared process for the essential definition of a European vision of space, to be conducted in European industrial and/or institutional circles.

Proposals for a European vision of space

1. Peaceful space at the service of all

▪ *Europe at the forefront of discovery of the Universe*

Knowledge of the Universe and discovery of its physical laws, origins and future, represent a challenge which all mankind has taken up since its very origins. The space sciences offer a decisive opportunity for accelerating this quest in the coming years.

Discoveries made with space tools having achieved advances with sciences and the living conditions of mankind, Europe has set itself the target of contributing at the forefront of research on the sciences of the Universe. European efforts are directed at the origin and evolution of the Universe, the study of fundamental laws of physics, the formation of stars and planets, the appearance of life in space and comprehension of how the solar system functions.

The distribution of fundamental knowledge acquired in space is a pressing and permanent obligation which Europe has adopted in regard to all other States engaged in space activities.

In order to maximize efforts on a worldwide scale, Europe has taken on the mission of federating the efforts of the different space powers in regard to the sciences of the Universe.

▪ *Europe in favor of the utilization of space at the service of all*

Any national appropriation of space, the solar system, or indeed the galaxy, must be prohibited.

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[1] "Where there is no vision, the people perish"*: this quotation from the Bible is written in capital letters above the rostrum of the Committee on Economic Affairs of the US Congress.*

Europe will ensure ratification of the 1979 international agreement covering the activities of States on the Moon and other celestial bodies, by all its members[1], and will contribute to its ratification by all space powers also.

In the current state of technologies, economic exploitation of planets and their satellites, and the Moon in particular, is very unlikely. This contrasts with decisions taken in haste and totally unrelated to current technical realities.

If this is nevertheless proven possible, exploitation of the resources of the solar system, galaxy and elsewhere, could only be undertaken after in-depth examination of its consequences, both for the planet concerned itself and for Earth and its populations, and should benefit all mankind.

▪ *Space for the collective security of Europe and the world*

Space contributes to security through the provision of observation, early warning alert and countermeasures capabilities.

The European Union places particular emphasis on setting up space security tools for its own needs and making these available to its Member States and allies, for the purpose of contributing to peace in the world.

2. Space, a federating and identity-related project for Europe

The possibilities offered by space are of a kind to move forward with the establishment of a European identity by leaps and bounds. Exploration of the Moon, and later Mars by European teams will inculcate a European pride, a pride long in its acquisition, in the European countries. These space applications will contribute in decisive terms to European security and cohesion. Europe must embark resolutely on a major project to this end.

▪ *Safety, a vector for development of a European identity*

Europe is currently focusing on security, the links of which with space technologies are evident[2]. Of major political importance, the GMES program is aimed at contributing to environmental security, and in particular to combating the greenhouse effect, and the prevention of natural disasters.

Satellites also offer possibilities in domains concerned with security in the broadest sense, such as monitoring of frontiers and combating clandestine immigration ample.

A European space sector dedicated to the cause of security, could establish its own identity in this context, and make an effective contribution to the European political project.

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[1] *At January 1, 2006, only 12 States had ratified this agreement and only 4 had signed it. Of the Member States of the European Union, only Belgium and the Netherlands had ratified it, and only France and Rumania had signed it.*

[2] *Xavier Pasco, Master of Research, Strategic Research Foundation, hearing of October 25, 2006.*

▪ *Contribution to the balanced, dynamic development of the European Union*

Balanced development of the Member States is a priority objective of the European Union.

With their favorable technical characteristics, space technologies can make a substantial contribution to setting up an efficient, sustainable agricultural activity, reducing the audiovisual and digital gaps, encouraging the creation and operation of research networks and boosting education and public health.

▪ *A major "Space for collective European security and digital equality" as a contribution to European identity*

The European Union will celebrating the fiftieth anniversary of the Treaty of Rome in 2007, but is still seeking to establish a European identity. With each year that passes, Europe continues to appear to its citizens as being incapable of protecting the Member States against the effects of globalization. The deep-rooted reason for this is that Europe behaves as if on the defensive, and severely buffeted by the winds of change. The dynamic capacities of Europe must consequently be strengthened. This is an urgent need.

We know what happens to general strategies accompanied by costed objectives, such as the Lisbon strategy and its 3% of GNP devoted to research. Such strategies are not only difficult for the citizen to decipher, but are also frequently and regularly contradicted by the realities of the situation, with no sanction for those responsible as they are difficult to identify.

The application to the European population as a whole including the new Member States, of a major project for development, on the one hand of security in the broadest sense and the security of the environment, and on the other of generalized HR Internet telecommunications throughout Europe, taking advantage of all space resources and boosting a set of new services, will clearly declare Europe's vocation to protect its citizens while providing them with an opening to the world.

Such a "*Space for European security and digital equality*" project will involve all the space industries and the services sector, and will target the immediate creation of jobs in all domains and at all levels.

3. Autonomy, compatibility and transversality of the European space sector

▪ *Autonomy and compatibility*

Europe must aim at an autonomous position for its space systems providing strategic functions for its security and economic development.

This autonomy must not equate either to isolation or refusal to cooperate. Europe must contribute to the standardization of space systems, and strive for the compatibility of its own systems with the largest possible number of systems in other parts of the world.

▪ *Generalization of a "system of systems" approach*

European space sector development must be designed on the basis of the "system of systems" approach.

The traditional approach to the development of space activities is program-oriented, involving the application of dedicated resources to achieve a precise objective. The resources allocated can serve for other applications in certain cases, without complementarity being either sought or amplified. Once the objective has been achieved, the organization set up is disbanded and its component elements reassigned for other purposes.

In contrast, a system of systems consists of a set of variable geometry infrastructures, these being adapted to technological changes and serving for different missions, as a result of the intelligent processing of information and the use of standardized interfaces. A system of systems not only links a set of resources, but employs them in a network configuration applying the open architecture principle[1].

Thus, the GEOSS (Global Earth Observation System of Systems) will combine the European contribution to Earth observation, namely GMES, with that of other partners, including the USA in particular. This will make it necessary to set up coherent satellite platforms, exchanging and downloading data with and to the ground stations and processing the data in a coordinated manner.

A considerable advantage is the fact that a system of systems ensures the technological lead of the country which sets it up. A system of systems ensures maximum exploitation of all information available, thus putting in perspective the importance of a breakthrough made by one particular country in a given domain. This concept also has the advantage of increasing the ruggedness of system architecture in the longer term.

▪ *The transversality of the European space sector*

The already irreplaceable contribution of space is multiplied by a very substantial factor in terms of its efficiency when associated with other technologies.

A powerful and dedicated tool, space is a core element of modern technological systems, also contributing to missions of general interest.

The space sector applies new approaches, following the principle of transversality, and proposes new applications such as space for public health, space for security, space for mobility and space for development[2].

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[1] *With a system approach, launchers are guided by GPS satellites. Positioning and navigation systems such as Galileo or GPS are interoperable, contributing numerous advantages in terms of backup, ruggedness and add-on services.*

[2] *Claudie Haigneré, advisor to the Director General of ESA, former minister, hearing of January 25, 2007.*

4. The essential participation of Europe in cooperative programs on the solar system and beyond

Europe must make itself heard in the concert of lunar and Martian project announcements, and set up its own project based on harmonious combination of the forces of ESA and the national space agencies. It will then be its task to work on the compatibility if the not the coordination of world projects.

At all events, it is inconceivable that Europe should not participate in lunar and Martian exploration, for which the combination of complementary resources in the shape of automatic probes, robots and human spaceflight will be required.

▪ *The presence of Europeans in exploration projects*

Europe is participating in orbital missions through the inclusion of ESA astronauts in the ISS crews. This contribution to operation of the ISS will also increase significantly in 2007 and 2008, when the ATV cargo vehicle and Columbus laboratory are in service. Nevertheless, Europe relies on the Russian Soyuz spacecraft and Shuttle for access to the ISS for its astronauts and, in the case of Shuttle, for installation of Columbus also.

Without denying the value of this cooperation, very much to the contrary, Europe cannot continue on this path, one which is contrary to its own space development plans and those of the whole world deprived of its first level capabilities.

By updating and going beyond the European Space Agency Aurora program, Europe will consequently define its own vision of the space sector, enabling it to be present in space with its own transportation system and crews.

▪ *Europe as a federating force for world exploration projects*

With their exploration programs, the large developing countries, China and India, are declaring their national identity, demonstrating the high level of their technological development and their strong position on the international stage.

The longest established space powers are accelerating their development or returning to their former ambitions.

In regard to exploration of the Universe, as in other fields, the task of mankind is to unite to maximize its forces and accelerate its progress in the acquisition of knowledge.

Confronted with its various exploration projects and human spaceflight missions to the Moon and later Mars, Europe will set itself the task of promoting and achieving compatibility between specific systems, so as to reduce the cost of each system, increase overall performance and succeed in raising the global level of security for near or deep space exploration of the Universe.The exploration, and indeed exploitation of space, cannot be based, in valid terms, on independent programs or, worse still, programs competing with each other. Because of the vastness of the challenges to be met, the future will be devoted to setting up a system of complementary and interdependent systems. Europe will concentrate on promoting the technological compatibility of individual national initiatives.

III – NEW GOVERNANCE FOR THE SPACE SECTOR IN FRANCE

The recent history of the space sector in regard to French political institutions depict a descent into the cold darkness of anonymity, and a total disregard of its key importance for the future of the country.

The economic and military challenges of the space sector worldwide makes its return to favor essential in terms of national priorities.

1. Relocation of decisions concerning space at the highest level of State authority

Once a clear priority has been accorded to space, the governmental structures will place it at the highest level. This was the case in France in the past, but is no longer so.

While world competition races ahead in the space markets and the exploration field, a strong reaction by France is essential, both for its own future and that of Europe, of which it has always been the driving force in the space domain.

▪ *Space at the core of the decision-making systems of the major space powers*

Insofar as the new space powers are concerned, space is naturally a central element of power simply because its progress is a political project coordinated by the public structures.

In ***China***, the space sector is placed under the aegis of the People's Liberation Army and COSTIND, the Science, Technology and Industry Commission for National Defense, directed by a plenipotentiary minister who is a member of the Council of State. In addition, the research structures and all industrial companies involved in space are fully State owned.

In ***India***, the space sector is controlled by a plenipotentiary ministry having direct control over the Indian space agency (ISRO), the latter heading a group of public research and production structures.

The longer established space powers such as Russia and the USA also accord a level of ministerial responsibility to space.

In ***Russia***, space activities have been controlled by Roscosmos, a specialist national agency, since the separation of Rosaviakosmos, now a purely aerospace agency. The Director General of Roscosmos, appointed by the President of the Russian Federation, holds ministerial rank.

In the ***USA***, the President is assisted by the Office of Science and Technology Policy, the constant attention of which regarding space matters is reflected by the publication of numerous reports on which American space policy is based[1], and the PCAST (President's Council of Advisors on Science and Technology), the members of which comprise university heads and representatives of all high tech industries including the aerospace sector in particular[2]. Thus, the President of the USA has the means to conceptualize changes in space techniques, and reflect these in a coherent, dynamic policy.

In the civil space domain, the American space agency, NASA (National Aeronautics and Space Administration), set up by Congress in 1958, is directed by an administrator appointed by the President of the USA on the advice and with the consent of the Senate.

The Department of Defense (DoD) has placed space at the center of its defense strategy, ensuring an excellent level of visibility and investment for the sector. Each of the armed forces has a Space Command. The Space High Command (US Space Command) has also been integrated in the strategic high command (USSTRATCOM – US Strategic Command), in order to establish and amplify still further the role of space in American military strategy.

Furthermore, the Ministry for Commerce has set up an internal department responsible for meteorology and oceanography (NOAA – National Oceanic and Atmospheric Administration) specialized in processing data, and space data in particular (NESDIS – National Environmental Satellite, Data and Information Service). The Department of Transportation maintains close control over the space sector via the Federal Aviation Administration (FAA), and control of space research aids dispensed by the National Science Foundation (NSF).

Finally, **Japan**, while it does not have a dedicated ministry for space, has seen the Council for Scientific and Technological Policy (CSTP), chaired by the Prime Minister, publish a basic strategy for the development and utilization of space in 2004. The supervisory ministry for the Japanese space agency (JAXA) previously published its own long-term plan for space development in 2003, and JAXA had itself prepared its own long-term vision of the space sector. A total of seven Japanese ministries participate in funding space development[3,4].

When we look at foreign examples, a correlation between the dynamic process of space development and the decision-making level in the governmental mechanism appears clear and logical. This also applies to France.

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[1] April 2003: US Commercial Remote Sensing Policy. January 2004: US Space Exploration Policy. December 2004: US Space-Based Positioning, Navigation and Timing Policy. January 2005: US Space Transportation Policy.

[2] PCAST members include Norman R. Augustine, former President and CEO of Lockheed Martin, the leading American space sector company, in particular.

[3] The seven ministries are: MEXT (Ministry of Culture, Education and Sport, Science and Technology), supervisory ministry for JAXA and principal player, MLIT (Ministry of Land, Infrastructures and Transport), METI (Ministry of Economy, Trade and Industry), supporting the Japanese space industry, MIC (Ministry of International Affairs and Communication), MoE (Ministry of the Environment) and MAFF (Ministry of Agriculture, Forestry and Fisheries).

[4] Mathieu Grialou, CNES Tokyo office: the Japanese space sector, I-Space-Prospace seminar, May 17, 2006.

▪ *Relocating space at Ministerial level*

The last minister to include the word Space in their title in France was the deputy minister to the Minister for Industry, Post and Telecommunications, responsible for post, telecommunications and space (1995-1997). Since then, any reference to space has not only disappeared from the ministerial titles, but also, since May 2006, from the central administration of the deputy minister for research, which now has the new title of General Directorate for Research and Innovation (DGRI). Furthermore, it is just one attribution of a sectoral department of the DGRI, also in charge of sciences of the Earth and the Universe, the geo-environment, aviation and transportation.

The difference compared with the situation between 1992 and 1993, with a Ministry for Research and Space, is striking.

Furthermore, the High Council for Science and Technology was set up under the terms of the research program law of 2006[1]. This High Council is responsible for "*advising the President of the Republic and the Government, on all matters relating to the principal directions for the nation in regard to scientific research, technology transfer and innovation policy*".

It is only to be regretted that no historical personality from the space sector nor any leading witnesses or specialists from the sector were appointed to the High Council for a four-year term of office in September 2006.

Furthermore, the French Space Agency, CNES, a public enterprise of an industrial and commercial nature, is placed under the aegis of the Minister of Defense, and of the Minister for Space and the Minister for Research who in fact are currently one in the same person. The supervisory role of the Minister for Industry disappeared in 1996.

A ***Space Council*** should be set up to ensure that all ministries concerned with the space sector are involved.

Under the authority of the President of the Republic, the *Space Council* will be responsible for preparing major decisions concerning French space policy, drafting a space planning law and monitoring application of decisions taken[2].

Revitalization of the space sector, vital for the future of France, will also be dependent on the creation of a ***Minister for Space*** member of the Cabinet, having a supervisory position as regards CNES, and responsible for preparing, driving and controlling French space policy.

On the military side, a ***space command*** should also be created within the High Command of the armed forces.

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[1] *Program law No. 2006-450 of April 18, 2006 concerning research.*
[2] *A reference example of efficiency, the Atomic Energy Committee (CEA), under the authority of the Prime Minister and with the participation of the various ministries concerned, defines the main decisions for French nuclear policy and verifies their application.*

2. Introduction of a space planning law

For the medium term, the French space sector is covered by negotiation of the multi-annual Government-CNES contract, the latest version of which relates to the period 2005-2010.

This is the positive result of a method which must nevertheless be established in greater depth and extended

Space has a marked impact on the daily life of the French population, employment in the large French regions, and the vigor of the national economic fabric.

Parliament must consequently take an even greater part in defining French space policy.

Debates on space policy should be organized at regular intervals in both chambers.

A space planning law should be set up for the space sector, detailing space policy for the next ten year, and reviewed if necessary after five years.

The space planning law will cover the following themes in particular: development of launchers, defense and security, research and technology, science of the Universe, sustainable development, exploration and manned spaceflight and contribution to ESA.

3. Law on legal responsibility relating to space

In order to provide all space activities with a stable legal character, the President of the Republic called on the Government to prepare a space law in March 2006, the Council of State having already published a report on this subject. The aim is to formalize, structure and indeed extend existing measures, so as to put an end to the current state of legal insecurity of the State in regard to space activities.

▪ *Issues for the future law on space law*

The law in course of preparation must secure space activities, and not sterilize initiatives and new applications, with particular reference to sub-orbital flight.

Its content must naturally be based on examples of the space laws promulgated in other countries. A conference on this subject has been organized by the Council of State for 2007[1].

A draft law should be submitted to Parliament early in 2007.

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[1] *A legal policy for space activities, Council of State studies, La Documentation française, 2006.*

The role of the Federal Aviation Administration (FAA) in the USA throws an interesting light on the legal issues involved.

The role of the law is first and foremost to protect populations from the possible fall-back of a private launcher or spacecraft. In the case of any such accident, the law relating to public safety applies.

The FAA has developed safety procedures in collaboration with the United States Air Force (USAF). The FAA is also responsible for safety as relating to launches, atmospheric reentry of objects and federal and private launch pads. Inspectors are appointed for each launch. Regarding COTS the private space transportation program, it is the FAA which will issue airworthiness certificates for launch vehicles developed by the contractors Space-X and RPK. The FAA will not supervise construction in detail, but will nevertheless issue safety licenses for certain components.

It will be the task of CNES to play an equivalent part in France.

Europe could adopt the bottom-up type approach in regard to safety and responsibility in the space domain, whereby the Member States would be encouraged to exchange details of their best practices. A directive issued by the European Union would then endorse the main principles.

▪ *A special case: US statutory approach to the sub-orbital flight domain*

The example of the USA in regard to private space transportation is interesting in this respect[1].

In the USA, this sector will have the benefit of a learning and test period in a statutory environment encouraging initiative and based on the responsibility of the players involved.

The aim of US regulations is indeed to enable the space industry to develop in an unfettered manner.

A passenger on a sub-orbital flight will have the guarantee of a minimum level of safety, but also knowledge of the existing risks. This will be checked by the FAA. The passenger will sign a responsibility release document in exchange for provision of information relating to flight safety. If this principle is complied with, the FAA could issue a certificate of airworthiness. The principle is that the promoters of these flights will attach major importance to safety themselves, if only for the reason that an accident would mean the demise of the operator and a major setback for the sector.

The FAA authorized Blue Aerospace to commence the pre-certification process in October 2006, on the occasion of the 2006 X Prize award event held in New Mexico. The FAA will also be involved in certification of "Space Port America", also located in New Mexico and developed by Virgin Galactic.

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[1] *Patricia Grace Smith, Associate Administrator for Commercial Space Transportation, Federal Aviation Administration, Washington, November 7, 2006.*

The FAA does not maintain regular relations with its counterparts. Furthermore, there are no international standardization specifications in this area. However, information is exchanged with foreign counterpart authorities, including those in Japan and Australia for example, in connection with space tourism projects.

4. Restoration of room to maneuver for CNES

CNES is currently restricted in its actions by a subsidy which, according to the terms of the Government-CNES contract for the period 2005-2010, will only increase by an average rate of 0.7% per year.

Following the reorganization phase, conducted with great success by its President, Yannick d'Escatha, CNES must now endow itself with a new impetus to meet the challenges of the space sector over the coming decades.

▪ *Successful reorganization*

With seven successful launches since its initial qualification flight in 2005, the Ariane-5 ECA heavy launcher is now fully qualified with a maximum payload capacity of 9 metric tons (GTO). During these seven flights, the physical parameters of the launchers were held to scheduled values without the intervention of any redundancy, and orbit injection was extremely precise.

Transition from a prototype production phase to a scaled-up industrial production phase is in process. Furthermore, CNES has introduced a skill and expertise preservation mechanism with the Ariane industrial partners, so as to ensure that transition to the Ariane-5 scaled-up phase is not reflected in any loss of know-how in the development domain.

Another success to the credit of CNES has been the restructuring of the Kourou launch base. This can now operate satisfactorily at a rate of one launch per month. In addition, all contracts relating to operation of the Soyuz launcher at the CSG have been signed with the governments, industrial partners and the French Guiana regional authority. The competitiveness of the launch base has improved as a result of more open competition between suppliers, and agreements with all trade unions involved concerning the CSG site convention. Construction work on the Soyuz pad is proceeding satisfactorily, and this was celebrated in late February 2007 in the presence of Russian and European management.

On the financial side, 2005 saw extinction of the € 35 million deficit of 2002. CNES finances returned to a healthy state with a positive bottom line at € 5 for the year.

The fact that CNES has been able to achieve this financial recovery is due to the involvement of its staff, the expertise of which is recognized in Europe and worldwide, including the USA and Russia.

▪ *For CNES, imagination and application, for the Government and Parliament, the choice of a bold space sector*

With a Minister for space, member of the cabinet, and a position reestablished in a dynamic national growth environment, CNES will be able to devote itself fearlessly to its fundamental task, that of submitting a scientific, technical and industrial strategy for space to the public authorities which is both ambitious and innovative, and implement the decisions taken by the political authorities.

It is essential for CNES to be able once again to provide input for Governmental and Parliamentary thinking, proposing bold, imaginative and progressive paths for the nation to follow, without self-criticism or limits set by outside authorities.

CNES should be authorized to propose a range of ambitious projects, capable of making France the top-ranking world player.

CNES must also be empowered to assess, not in terms of opportunity within the limits which it has been set, but in technical and financial terms and in a totally transparent context, proposals emanating from other circles of French society – Parliament, industry and the associations – before passing these on to the public authorities.

Once the national options have been decided by the Government with the approval of Parliament, CNES will use its best endeavors, as is already the case, to ensure application of the decisions taken.

▪ *A new, essential budgetary dynamism*

The space sector has is roots in the scientific and industrial history of France.

It is totally contrary to the vocation and future of France to limit CNES to management of the budget short-fall.

What do the budget figures of today and the next three years show? ***That France has decided to increase the CNES budget at a slower rate than that of the European Space Agency (ESA)***. This policy is unacceptable.

The French space agency must now return to a state of forward movement based on its acknowledged successes of the past.

To prepare a future which will doubtless be space-related, France has need of CNES, an essential contributory element for the implementation of the strategy decided at the highest political and parliamentary level. France also needs CNES to support its industry, which is short of resources following its restructuring programs, and to assist with the formation of young companies in increasing numbers, to provide new space-based services.

Europe also needs a strong and dynamic CNES. While other Member States, such as Italy and Germany, are developing their space industries, Europe as a whole needs CNES, its experience in the launcher and orbital systems domains, its support with the coordination of programs as prime contractor, and its capabilities in terms of system studies and technological innovation.

Expansion of the world space sector also has need of a strong CNES, which is in a position to increase the number of multilateral partnerships with the USA, Japan, Russia, China and India, all of which are seeking CNES involvement in many of their programs.

This is why it is essential to review the Government-CNES multi-annual contract in 2007.

It is essential to dissociate the "*space sciences*" segment from the "*preparation for the future*" segment in the CNES budget.

The second segment, now renamed "*future technologies*" must receive an additional, recurrent subsidy amounting to 15% of the total CNES budget, as from 2008.

The space law in course of preparation will also assign new areas of expertise to CNES, for *regulating* space activities, as also for the *certification*, namely monitoring the security of these activities, and even in due course a quality control function for data distribution, for example for positioning-navigation data supplied by Galileo, and later still in regard to environmental security data delivered by the GMES program.

CNES must consequently have the benefit of an additional subsidy, drawn from the State budget[1], for these entirely new missions.

Finally, to enable CNES to amplify its multilateral cooperation agreements with its traditional partners – USA and Russia – and to hold out a more confident hand to the new space powers, the increase in the "*national part*" of the CNES budget[2] should be increased to at least 8% per year as from 2008, in place of the current, inadequate figure of 1.5%. In terms of the total CNES budget, including the ESA subsidy, this increase should make it possible to achieve an annual growth rate of 5%, constituting a minimum increase for France in view of the priority to be accorded to the space sector.

5. Involvement of the research and innovation support agencies and regional authorities

France acquired new research simulation and aid instruments in 2005, and should now use these in support of its trump cards in the space sector.

The National Research Agency allocates subsidies of the order of several hundred thousand euros per project, based on upstream research proposals submitted by public and private research teams in response to calls for proposals.

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[1] *And not from the industrial companies, whether well established or at the start-up phase in the services market.*

[2] *National part, in reality reserved for multilateral cooperation programs directed by CNES.*

The Industrial Innovation Agency handles larger sums, of the order of several tens of million euros, for pre-competitive industrial projects. The regional authorities invest more and more frequently in support for research and industry.

All these instruments must be placed at the service of development of the space sector, given its economic and strategic importance.

▪ *National Research Agency*

The National Research Agency (ANR), set up under the terms of the research program law of April 18, 2006, is a public and administrative establishment the vocation of which is to finance research projects.

ANR funding of upstream research relating to space, can be implemented via the various programs for which project calls are issued, or via "*blank*" programs for which no specific theme is imposed.

Programs possessing a space dimension are the "Interactive and Robotic Systems", "Software technologies" and "Telecommunications" programs.

Both public and private researchers should be made more fully aware of outlets in the space sector.

▪ *Industrial Innovation Agency*

Set up in July 2005, the Industrial Innovation Agency (AII) has the task of supporting large industrial structuring programs, with the aim of creating high qualification jobs and supporting exports[1]. Aid is provided in the form of a reimbursable downpayment and subsidy, up to a maximum of 50% of the expenditure committed by the companies, and is accorded to Industrial Innovation Initiator Programs (PMII).

Of the projects receiving aid in 2006, only one, TVMSL (unlimited mobile TV) submitted by Alcatel, relates to a domain concerning space although limited to the ground infrastructure. This project covers development of a new standard for the telecommunication S band between a satellite and terrestrial network[2]. Scheduled aid is limited to a subsidy of € 17 million, and a € 21 million downpayment reimbursable in the event of success, making a total of € 38 million to be shared between eight industrial partners and three public laboratories.

One cannot but be astonished at the very limited attention paid to the space sector.

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[1] *Expenditure eligible for AII aid covers the following: personnel expenses, research equipment expenses, cost of purchasing consultancy or sub-contracting services and other operating costs associated with research.*

[2] *Other projects are as follows: BioHub for the enhancement of agricultural resources via biotechnologies; HOMES for energy-economical building; NeoVal for automatic modular tired transport; Quaero for the search and recognition of digital contents; NanoSmart for innovative substrates for opto- and micro-electronics; HDI hybrid vehicle; ADNA for diagnostic progress and new therapeutic approaches; ISEULT for future medical imaging; OSIRIS, for new biotechnologies for the enhancement of agro-resources; MINimage for microcameras and MaXSSIM for mobile multimedia services.*

AII must avoid the trap of scattering its aid, and capitalize on the industrial advantages of France, of which the space industry is a primordial component.

▪ *Involvement of the regional authorities*

At territorial level, the centers of excellent represent a new and fundamental tool for accelerating development in the space sector.

It is the vocation of the territorial authorities to contribute to the funding of large scientific facility projects. The Île-de-France region has done so for the Soleil synchrotron, providing funding for the 2002-2009 period for an amount of € 149 million, alongside the Essonne department for an amount of € 34 million.

In its turn, Bavaria has invested € 180 million in support for service companies associated with the Galileo project, with Latium in Italy contributing € 50 million[1], to encourage the creation and implementation of new positioning- and navigation-related services.

The regional authorities must not only listen more attentively to the companies, laboratories and CNES, but also be quicker to respond to their requests.

Less bureaucracy and more, rapid commitment are essential.

The spatial identity of the Toulouse urban complex could be developed further by assisting start-up service providers for the future European Galileo and GMES systems.

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[1] *Marc François, Industrial Director, Telespazio, hearing of October 26, 2006.*

IV – NEW GOVERNANCE FOR THE EUROPEAN SPACE SECTOR

1. Reformed ESA governance

With seventeen Member States, namely the fifteen EU States plus Norway and Switzerland[1], the European Space Agency (ESA) is an international organization, structurally independent from the European Union. Its 2006 budget was € 2.6 billion.

With the decisive assistance of the national space agencies, ESA has enabled the European space sector to progress substantially. Nevertheless, the Agency has reached a turning point in its history in 2007.

▪ *Major successes but a clear loss of momentum*

The recent changes at ESA led one to question its real possibilities of inducing a dynamism matching the future challenges of the space sector.

The mandatory activities of ESA – space science and general budget – which represent 25% of total expenditure, are funded by the contributions of each Member State, calculated in proportion to their GNP. ESA conducts operational programs accounting for 70% of total expenditure, in which the Member States can participate or not. ESA also works in support of developing countries, for which corresponding expenditure amounts to 5% of the ESA budget.

Orders placed by ESA are in line with the principle of geographical return, according to which ESA invests in each Member State in the form of contracts signed with its industry for the execution of space-related activities, or an amount approximately equivalent to the contribution of the State concerned.

The areas of excellence of ESA are the definition of space missions and the development of technology and space systems, and in-orbit operations.

ESA has made specialist structures responsible for exploiting operational systems, such as Eumetsat for example, or operating specialist facilities such as the European Southern Observatory (ESO).

At its Ministerial level meeting of December 6, 2005, ESA Council adopted the principle of a long-term plan covering the period 2006-2015, the measures of which consequently acquired key importance in the current context of competition and decelerating space-related investment in Europe.

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[1] *The seventeen ESA Member States are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. In addition, Canada, Hungary and the Czech Republic participate in a number of ESA projects under the terms of cooperation agreements.*

As regards the mandatory budget, during the Ministerial session of the December 2005 meeting, ESA Council adopted the principle of a 2.5% increase per year for the scientific program only, with a stable general budget for the period 2006-2010.

Commitments relating to optional activities, which should be defined during the next few months, could offset, and more, this prudence, which does not auger favorably for making up the European lag.

▪ *Reform of the ESA decision-making process prior to its revitalization*

The increase in the number of ESA members raises the question of Agency governance. Five countries are candidates[1] and with the three Baltic countries[2], the total number of ESA members could rapidly rise to 25.

Already having induced marked consequences, this additional enlargement could lead to a state of paralysis for the Agency.

By reason of the two-thirds vote rule applicable for the voting of budgets, the small countries, representing less than 15% of total contributions, could force the hand of the larger countries which provide over 85% of the budget. Thus, the large countries have already been forced to put back budgets from year n to year n+1 against their will.

In future, it will therefore be essential to withdraw from the current system where each country has one vote, irrespective of its financial involvement. Other criteria must be taken into account. A qualified majority system must be considered, on the basis of a minimum percentage of aggregate public budgets or GNPs.

The new decision-making process should reconcile the interests of the various types of country and ensure their continued solidarity. Those States which are essentially users should not feel themselves excluded either. However, the space sector user States must acquire room to maneuver, and must see their industrial interests taken into account.

▪ *Geographical return based on new criteria*

Geographical return is one of the foundation stones of ESA. The principle ensures that a State contributing to the ESA budget will obtain economic benefits in return for its investment.

Geographical return has always had a major drawback, in that it contributes to the geographical dispersion and duplication of expertise. This problem, one which also impacts the mandatory programs, is more acute as far as the optional programs are concerned. The leader country in a given program usually demands that the corresponding skills are located inside its frontiers.

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[1] *The five candidate countries for membership of ESA are: the Czech Republic, Hungary, Poland, Rumania and Slovenia.*

[2] *Estonia, Latvia and Lithuania.*

The total cost of duplication can reach very high levels. Apart from duplication of investment we can see the infernal sequence of creation – discontinuation – recreation, again resulting in duplicated investment plus costs connected with the redundancy plan for termination of the activity[1].

This is why it appears necessary to redefine criteria for geographical return, coherently with European rules on competition. A number of methods can be considered.

Selection of the most favorable tender, irrespective of the nationality of the tenderer, would have the effect of increasing the heterogeneity of the European space industry. However, gains in terms of efficiency would make it possible to increase the total volume of investment.

A less extreme solution would be to measure in global terms rather than program by program.

Furthermore, apart from the amount of contracts signed with local companies, new criteria could be introduced such as the service provided for partners in the program concerned.

It is necessary to review procedures for application of the geographical return rule to maximize ESA action.

The ESA geographical return rule should apply to a set of programs, and not "program by program" and include services as well as industrial production.

The aim must be to submit this question, together with that on the decision-making process, at the next ESA Council meeting at Ministerial level to be held in the Netherlands in 2008[2].

▪ *Convincing Europe to adopt the notion of European preference*

Following lengthy discussions, the ESA Council meeting at Ministerial level of December 2005 decided to set up a policy of European preference regarding launchers.

This involves an evident principle of common sense, that of European solidarity.

However, two limits to this principle have been set.

Firstly, it is a question of preference and not obligation.

Secondly, European preference is mandatory for ESA but not for the Member States.

This cannot but have an impact on geographical return.

As it applies to participants in ESA programs, the geographical return principle has no meaning unless it is reciprocal.

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[1] *François Auque, President, EADS Astrium, hearing of November 15, 2006.*

[2] *The last ESA Council meeting at Ministerial level was held in Berlin in December 2005. Ministerial level meetings are held at 3-year intervals.*

Each Member State participating in whatsoever way in the production of ESA launchers, should be required to use these launchers, unless it wishes to see its workload redistributed between its partners.

▪ *Amplified ESA ambition*

Once reformed, ESA will be in a position to increase the number of its projects, and extend the ambitions of these projects. Strengthened cooperation agreements could be set up by variable geometry country groups.

It is inconceivable that ESA should not take part, with its own initiatives, in the concert of lunar and Martian projects, and not have a major ambition in terms of manned spaceflight missions.

2. The European Union, an essential space sector player

The involvement of the European Union in development of the European space sector is clearly disappointing at all levels.

This deficiency thrusts the current European political project into a position of illegibility if not insubstantiality.

In the absence of any global common defense and security project, or any clearly identified economic and industrial project, and in the absence of any soundly based financial commitments, it is not surprising that the European Union is but a weak player in the European space community. It should also be noted that the space industry preceded the European integration approach by many years.

However, the seeds of increased involvement of the European Union in the space adventure do exist.

The space sector can contribute to the "construction of Europe". The various instruments which Europe possesses in its present state can also serve to increase the power of Europe while contributing to European unity.

▪ *The FPRTD, an instrument requiring greater flexibility*

The Framework Program for Research and Technological Development (FPRTD or FP) is not sufficient to stimulate European research, and space research in particular, as it should. However, little is required to make the FP genuinely useful.

Adopted on December 18, 2006, the 7th FP (FP7) covering the period 2007-2013, scheduled an amount of € 1.43 billion for the space sector, corresponding to € 204 million per year and representing 2.6% of the total FP budget.

One can be surprised at the very small percentage for space research. Nevertheless, the annual amount of aid provided by FP6 (2002-2006) can be estimated at € 80 million.

This means that FP7, constructed on clear operational thematic bases, represents an unquestionable step forward and should continue to attach increasing importance to space activities in the future.

At all events, the operating rules for the FP must be adapted on a permanent basis, to reduce the complexity of procedures and put an end to the obligation for the industrial partners to provide 50% co-funding, two reasons which have led in the past to the non-distribution of all subsidies budgeted.

In addition, European funding extending beyond the scope of the FP must be sought.

▪ *Galileo, a first funding package extending beyond traditional boundaries*

The European Union has provided substantial funding for the research and definition phase of the Galileo positioning and navigation system project.

The sum of € 100 million was provided under the terms of FP5, and the same amount for FP6.

In addition, the project received € 550 million in connection with the TransEuropean Network program.

The EU has proved in this way that the European budget can support major structuring projects and should continue to do so.

▪ *Eligibility of the space sector for inclusion in Common Agricultural Policy and rural development budgets*

European Union budget commitments in favor of agriculture amount to € 42.7 billion for 2007, or 34% of the total EU budget.

Utilization of the space tool for monitoring crops and forests is expanding rapidly, in particular by the new large space powers such as China and India.

While the dimension of their territory accords space superiority over all other techniques in these countries, the successive inclusion of new countries in the European Union makes *in situ* control of the correct application of the Common Agricultural Policy increasingly complex, costly and ineffective.

The Common Agricultural Policy budget should consequently include funding of a space infrastructure for monitoring and inspecting crops and forests. This funding would be reimbursed, on the one hand by a reduction in the level of fraud, and on the other by crop enhancement and more efficient forestry management.

Space can also contribute to rural development, to which the EU allocated commitments of € 12.4 billion for 2007, or 9.8% of the total EU budget, in addition to € 0.2 billion for protection of the environment in 2007 (0.2% of total budget).

The introduction of an advanced space tool of this type is essential, the more so as the effects of climate change must be identified and their consequences anticipated.

▪ *Regional cohesion reinforced by the space sector*

Regional cohesion is a priority objective of the European Union. It will allocate € 45.5 billion, or 36% of its total expenditure in 2007 for this purpose, via the European Regional Development Fund (ERDF) and Cohesion Fund subsidies. Corresponding aid is aimed at raising the level of local infrastructures in the regions to harmonize development conditions.

Space technologies make decisive contributions to assist the least favored regions of the Member States in closing the gap, as for example for telecommunications, TV broadcasting and HR Internet access.

▪ *The essential contribution of the European Commission as space user*

Participation by the European Union in funding space infrastructures via regular contributions made by the space data user General Directorates of the European Commission, is essential.

Thus, the Directorate General Energy and Transport should contribute permanently to funding the CSG in Kourou, the Directorate General for Research to scientific applications of space, the Directorate General Environment to funding of the GMES system, and the Directorate General for Health and Consumer Protection to funding of remote sensing and the monitoring of epidemics.

▪ *A new approach to space by the European Commission*

Space affairs essentially come under the aegis of the EC Directorate General Enterprise and Industry. The Directorate General Research is also involved in space affairs, but on a marginal basis via the FP. Finally, the Directorate General Energy and Transport is only involved in the space sector via the Galileo project.

In real terms, integration of the space sector by the European Commission is both fragmented and undersized.

Space applications concern all the Directorates General, and a transverse approach must be introduced.

At Commission level, a Space task force grouping the commissioners concerned should be created, in the same way as the Space Council to be set up in France.[1].

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[1] *Claudie Haigneré, advisor to the Director General of ESA, former minister, cosmonaut, hearing of January 27, 2007.*

Furthermore, the President of the Commission, anxious to establish ambitious projects for Europe in concrete form, should be better informed of the large space programs which ESA, the national space agencies and European industry are capable of pushing forward.

▪ *For the European Union, establishment of objectives, for ESA, control of their implementation*

In its Article III-254, the draft European Constitution introduces the notion of a remit shared by the Union and the Member States, in regard to the definition of a European space policy. Furthermore, the Union is encouraged to develop its links with the European Space Agency in the same article.[1]

Despite the fact that the Constitution has been rejected, cooperation can still be continued through the Space Council. A framework agreement between the European Union and the European Space Agency, established in May 2004, effectively formalized their cooperation for the joint development of a European space policy. This agreement established the Space Council, which brings the EU Council and ESA Council together at Ministerial level[2].

The resultant collaboration is good. But, it should not lead to a confusion of functions, nor set aside the intergovernmental nature of ESA.

In this respect, it is essential to clarify, in advance and on a definitive basis, the respective functions of the European Union and ESA in regard to the desirable prospect of increased involvement of the European Union in the space sector.

The European Union and the Council of Ministers, if not the European Council, could provide the framework for the drafting of an EU space policy. However, the Commission possesses no technical know-how in the space domain.

It would be counterproductive for it to seek to acquire such know-how, which ESA already possesses at the highest level, as a result of feedback acquired over more than thirty years[3]. It would also be extremely dangerous to imagine ESA as a European Community agency, as the space sector will continue to exist largely on the basis of optional programs, making it possible to progress with cooperation between the most highly motivated Member States.

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[1] *The text of Article III-254 states: " I. The Union prepares a European space policy to encourage scientific and technical progress and industrial competitiveness. For this purpose, it can promote joint initiatives, support research and technological development, and coordinate the aid required for the exploration and utilization of space.*

II. To contribute to implementation of the objectives set out in paragraph I, the European law or framework law establishes the measures necessary. These can take the form of a European space program.

III. The Union establishes all useful links with the European Space Agency."

[2] *For example, the Space Council meeting of November 28 and 29, 2005 recommended that the Space Council and European Parliament should examine the introduction of an EU budget contribution to funding the operating costs of the GMES services.*

[3] *ESA replaced ESRO (European Space Research Organization) and ELDO (European Launcher Development Organization) in 1973.*

It is consequently essential for ESA to retain its specific nature. ESA must be the principal agency implementing European space policy, by developing its capacity for coordinating the programmatic efforts of EU itself and its Member States.

▪ *German and French presidency of the European Union, the opportunity to revitalize the European space sector*

Two leading space countries will hold the presidency of the European Union in 2007 and 2008[1]: Germany for the first half of 2007 and France for the second half of 2008.

For the future, not only of the European space sector but also the global destiny of Europe, the two countries, together with Italy, must sweep aside national differences and move forward boldly with a new policy.

Audacious projects must be adopted, both in regard to space applications and human spaceflight missions.

The European Interparliamentary Conference on Space (EICS)[2] has frequently expressed the wish to see European space policy amplified rapidly, to meet the technological and political challenges of the coming decades.

At national level, the Parliamentary Group for Space is making every effort to submit proposals along these lines to the decision-making authorities.

As things are, to wait for reform of the Europe institutions to give the European space sector its chance would be suicidal in view of the extent to which the competition is making the matter urgent.

With the European Union in its present state, ESA, the national space agencies, specialist organizations such as Eumetsat and major institutions already exist. Very substantial progress is possible without awaiting the hypothetical European constitution.

Progress must be made modestly step by step without delay, reducing the numerous obstacles in the path of a dynamic approach, many of which are identified in this report, and also reducing all other obstacles which may exist.

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[1] *European Council presidency: 2006: Austria (1st half), Finland (2nd half). 2007: Germany (1st half), Portugal (2nd half). 2008: Slovenia (1st half), France (2nd half). 2009: Czech Republic (1st half), Sweden (2nd half).*

[2] *The European Interparliamentary Conference for Space (EICS), set up in 1999, brings together each year members of Parliament of founder members (France, Belgium, Germany, Italy, Spain and the United Kingdom), permanent members (other Member States of both the EU and ESA), associate countries (Member States of the EU or ESA), countries with special status (Russia) and observer States (China, USA and Brazil). The 8th Meeting of the EICS was held in Brussels in May 2006.*

3. Existing European institutions, a relevant platform for the future

"For governance in the years after 2015, there is doubtless nothing more important than convincing the European Union to lean heavily on the existing constellation of existing European intergovernmental structures."[1]. Such is the view, founded on experience and with the aim of efficiency, of Professor André Lebeau, former President of CNES and Eumetsat.

▪ *GMES, an ambitious program complex in its implementation*

The GMES (Global Monitoring of Environment and Security) program is the future European Earth observation instrument network program (global surveillance of the environment and security) set up in 2001 by joint agreement between the European Union and ESA, the two entities sharing the initial total funding requirement of € 2.4 billion on a 50/50 basis[2].

The challenges presented by the GMES program are numerous, one of the most critical being its general organization.

Three problems remain to be cleared on the technical side.

Satellites currently in orbit already delivery relevant quantities of data for monitoring the environment. The priority task is consequently to ensure that they are replaced so as to ensure continuity of information.

The second problem, which is indeed the core of the GMES program, concerns data processing, development of numerical interpretation models and data distribution. GMES is doubtless more a data enhancement program rather than one concerned with information gathering. This is why FP 7provides for an envelope of € 800 million for the space segment and € 400 million for associated services.

The third problem requiring a solution is the development and funding of the three families of Sentinel satellites, which will enrich the available data panel.

As regards organization, the question is to determine what type of organization should be set up to make GMES work.

It is estimated that Eumetsat satellites will supply 70% of GMES program data for a 2008 horizon, with the remaining 30% delivered by the Sentinel satellites.

▪ *Eumetsat, an efficient international organization*

Eumetsat is an intergovernmental organization funded by the national meteorological departments, the initial mission of which is to create, maintain and operate a system of operational meteorological satellites[3].

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[1] *Professor André Lebeau, hearing of October 5, 2006.*
[2] *This European initiative has prospered, as it was rapidly followed by the international GEOSS (Global Earth Observation Systems of Systems) program initiated in 2003.*

[3] *Dr Lars Prahm, Director General, Eumetsat, hearing of December 20, 2006.*

Eumetsat is now (2007) operating nine Meteosat geostationary satellites for this purpose, and is preparing to place the Metop non-geostationary satellite, launched into low polar orbit at the end of 2006, into operational service, and to launch the Jason-2 oceanic altimetry satellite in 2008.

Preliminary R&D for the satellites was conducted by ESA, and Eumetsat is responsible for operating the satellites and distributing the data gathered to the meteorological departments of the Member States.

Eumetsat is also an example of the successful mutualization of a set of space resources employed to monitor the environment.

▪ *Eumetsat, an institution capable of taking in hand the GMES program*

The Eumetsat convention has been modified to enable it to decide new programs without first having to revise the text of the convention under the terms of which the organization was set up. Instead of the initial unanimity requirement, the two-thirds rule has been adopted. This prevents a State from blocking decisions, and provides for optional programs introduced in parallel. As a result of this essential modification, the mission assigned to Eumetsat was extended in 2000 to include climate monitoring and the detection of climate changes.

Eumetsat has also rejected the geographical return rule, with Member States contributing in proportion to their national GNPs.

The structures of the Eumetsat organization are consequently suitable to take in hand the GMES program.

The organization has had lengthy experience in dialoguing with ESA concerning the design and building of satellites, and also, a fundamental point, the distribution of data, this function having been conducted for the benefit of the meteorological departments for the last 20 years.

As regards data processing, and numerical modeling of data supplied by the Sentinel1 and 2 satellites, it is a matter of identifying the laboratories capable of executing the work required.

Possessing precise information concerning the fabric of European research, the European Union, which is also familiar with invitation to tender methods via the FP, could be assigned the task of selecting research teams.

Both the Eumetsat member countries and ESA are in favor of a project of this type.

Decisions must consequently be taken quickly by the European Union to validate the proposed scheme which, using an existing efficient structure, namely Eumetsat, avoids the cost and delays involved in the creation of a new entity, is clearly the best of the solutions which can be considered.

V – REVIGORATION OF THE EUROPEAN SPACE INDUSTRY IN ITS PRESENT CONFIGURATION

A merger of the European space industries to create a "*Satellite Airbus*" is a scarecrow waved at regular intervals by certain observers.

A fundamental argument to torpedo this "ungood idea" once and for all is that neither of the companies concerned are in favor. It should be said that the European space industry has lost a lot of blood in terms of sales and payroll since 2000, and this could only develop into a veritable bloodbath in the event of a merger.

Furthermore, the disappearance of competition between European companies following any such merger would have the inevitable result of opening the public markets to extra-European contenders.

1. EADS Astrium in favor of the continued two European player situation

As indicated by its President[1], given the institutional and political changes occurring in Europe, EADS Astrium takes the view that intelligent cooperation between the two major European companies in the space sector is more realistic than an abrupt consolidation.

The bursting of the Internet bubble and social problems in the sector tended, for a while, to indicate an opportunity for its consolidation, supported by the public authorities, with funding for restructuring measures and the political choice of a major European player.

Other changes have since occurred.

Firstly, there is no chance of obtaining sustained acceptance at the present time, of the notion of a single major European player, even if a political turnaround in favor of a stronger Europe were to see the light of day in the four major countries.

Secondly, there is no mechanism preventing competition with the USA within the European Union. Like the United Kingdom for example, where EADS was competing with Lockheed Martin for Paradigm, one could not exclude the possibility of the single European champion being placed in competition with an American rival by the EU authorities for European invitations to tender, but also by space sector supplier countries for their national markets.

[1] *François Auque, President, EADS Astrium, hearing of October 26, 2006.*

2. Alcatel Alenia Space, the other essential leading European player

Alcatel Alenia Space, the other leading player in the European space sector that emerged from Alcatel has been further strengthened by the arrival of Thalès.

Its long-term survival is also essential.

▪ *The Alcatel Alenia Space Franco-Italian structure and the new part played by Thalès*

Alcatel space activities have been grouped in two structures in which Finmeccanica has equity interests.

The first is Alcatel Alenia Space, with Alcatel holding a 67% interest and Finmeccanica 33%. The second structure is Telespazio, specializing in the service sector, with Alcatel holding 33% and Finmeccanica 67%.

As part of its merger arrangement with Lucent and acquisition of the 3G mobile activities of Nortel, which will make Alcatel the world number one in the telecommunications infrastructure field, Alcatel has decided to hive off its space sector activities.

Alcatel interests in Alcatel Alenia Space and Telespazio have consequently been sold to Thalès, together with its transportation division which manufactures signaling systems, and part of its system integration division. In exchange, the Alcatel interest in Thalès will rise to 22%, enabling it to play the part of reference shareholder.

Strengthening of links with Thalès represents an opportunity for defense activities, but also for satellite communications and security programs[1]. Following this operation, Alcatel Alenia Space will retain its links with Alcatel in the form of a cooperation agreement. Its links with Finmeccanica will also be preserved, as the cooperation arrangement is entirely satisfactory, and the convergence and optimization program is running in line with expectations.

▪ *The dangers of increased concentration of the European space industry*

Alcatel Alenia Space takes the same view as EADS Astrium[2].

If the space market was solely commercial, consolidation of the European Space Industry would have some meaning. However, this market is in fact primarily institutional. Any eventual consolidation would result in a transition from two companies to only one.

To comply with European competition rules, a single European manufacturer would have to be placed in competition with American or Asiatic

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[1] *Pascale Sourisse, President, Alcatel Alenia Space, hearing of October 25, 2006.*
[2] *Pascale Sourisse, ibid.*

companies, leading to the inevitable award of certain contracts to American or Asiatic companies unless the competition was purely formal.

This would equate to opening the European market a little more to American companies, although this market is much smaller than its transatlantic counterpart, not to mention the future Chinese and Indian markets.

Alcatel Alenia Space and EADS Astrium have chosen to cooperate in a number of essential institutional programs such as Galileo, GMES and other scientific programs. This cooperation is advantageous for both companies, and also extends into a number of commercial markets. Competition persists to the benefit of future customers in the other markets.

At all events, analysis of the two leading European companies can only be confirmed in its conclusions.

It is not the time to lay off staff or reduce investments.

The essential revitalization of the European space sector must be based on growing, and not diminishing capabilities.

3. Amplification of space sector activities from the downstream end and in the service domain

On the basis of surveys of the European space industry conducted by Eurospace, it is estimated that the manufacture of launchers and the supply of launch services represents 3% of space sector revenue, building satellites 11%, the construction and marketing of ground facilities 24% and the satellite operational segment and the sale of associated services 62%, in the space business value chain.

According to other estimates, investment in the space sector apparently generates additional sales in the services domain ten times greater than direct investment.

The space industry must consequently aim to extend its services downstream.

A number of companies in the space sector are now proposing an increasingly complete package, incorporating downstream services previously only available from other players.

This is already the case with EADS Astrium, which will supply an integrated satellite telecommunications service to the British armed forces under the terms of a fifteen year contract, in collaboration with its subsidiary Paradigm Secure Communications. By constructing and operating the infrastructures, the manufacturer can harvest the total value added, and obtain maximum return from its activity under optimum conditions.

The path opened up by EADS Astrium is unquestionably a path of the future. The space industry must concentrate more on utilization and enhancement of the value of space data in the future. In doing so, it will find new markets capable of increasing its earning performance.

VI – ESSENTIAL BUT CONDITIONAL COOPERATION WITH THE DEVELOPING COUNTRIES

The scientific and technological lead of a developed country such as France is doubtless its greatest, if not only advantage in the international competition arena in the face of the new space powers.

On this basis, ***how far should international cooperation go?***

Should one adopt a defensive attitude, and close the door to any possibility of cooperation? On the contrary, should any invitation to cooperate, in whatsoever form, be given a warm welcome? Should different levels of cooperation be defined according to the domain concerned – fundamental research, applied research, engineering, or production?

Without due precautions, an open attitude is no more possible than the creation of defensive, fearful barriers round existing technological achievements.

At all events, a distinction must be made between the fundamental research, industrial and training levels.

1. Unreserved cooperation in the fundamental research domain

If it is considered necessary to adopt a purely defensive position, all scientific exchanges must be discontinued. In this case, other countries more confident in their abilities and their future will occupy the ground. World scientific competition is obliging an increasing number of western laboratories to establish contacts with Chinese or Indian laboratories to set up cooperation arrangements.

In real terms, fundamental research must be the subject of unreserved cooperation with the new leading space powers such as India and China.

The USA is obtaining substantial benefits from the presence of tens of thousands of foreign students, mainly European and Asian, in the laboratories of the American universities This situation is invigorating US fundamental research, partly explaining the number of Nobel Prizes awarded to American researchers. Scientific and industrial links with the countries of origin of students working for master's' degrees, doctorates or post-doctorate qualifications are thereby strengthened.

We should consequently have no fear of scientific competition in the fundamental research field in a substantially internationalized scientific world.

The essential task is to continue to ***lead the field*** with the support of the public authorities and industry.

▪ *An end to scientific tourism*

If our aim is profitable cooperation for France, there are two possible policies: inaction and organization. The case of China is eloquent.

Inaction and a traditional policy of exchanges and study grants are the solutions currently adopted. Six hundred French researchers go to China every year, and 41% remain in the country for less than a week. We can place the emphasis on individual meetings to identify large-scale projects, but this policy is not sufficient to lead the field.

If we take the view that we must get alongside China now in order to be in the same position as one of its leading partners in the future, we need to set up long-term multilateral cooperation arrangements between France and Europe in a number of key domains.

This obviously assumes that research and development are strong in France and Europe, both in order to maintain our lead in regard to China, but also to be credible partners.

Cooperation projects with a good level of R&T must be proposed in this context, accompanied by appropriate funding over two or three years, projects in which the Industrial Innovation Agency and National Research Agency can participate. Priority programs will concentrate resources on common research domains, identified as the most promising in view of the respective strengths of the two parties[1,2].

▪ *The laboratories have the floor*

In the case of priority programs, the research teams should have the benefit of the highest degree of freedom of action, adopting a bottom-up approach[3].

For many laboratory managers, the essential degrees of flexibility and reactivity demand retrospective as opposed to prospective control.

Once the priorities have been defined and the participating research teams selected, the greatest possible freedom of action must be accorded for the selection, by the laboratory managers, of students taking master's degrees, doctorates and post-doctorate courses. The practice of three-months internships for foreign students in France, for the purpose of testing candidates, should be encouraged.

Long-term courses – master's, doctorate and post-doctorate – should be offered to the most promising students.

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[1] *Professor Bernard Belloc, Counselor for science and technology, French Embassy in Beijing, November29, 2006.*

[2] *A project agreement was signed at the end of 2006, on the genomics of intestinal flora. Two other projects, on energy and traditional pharmacology, are currently under examination.*

[3] *Professor Alain Aspect, Bangalore, December 15, 2006.*

2. Export and industrial cooperation

Confronted with the strength of Chinese and Indian competition at the present time, and more so in the future, the French and European space industries, far from being tetanized, have already adopted and implemented an elastic cooperation strategy involving different levels of sophistication.

Meetings held by your rapporteurs in China and India, during their preparatory missions for this report with a number of French leaders of industry, won their admiration for the inventiveness, skill and determination which French companies applied for the benefit of the national community.

▪ *Uneven export restrictions in Europe*

Export restrictions in "sensitive" high tech domains, namely involving direct or indirect military application, are not constant within the European Union.

While France is particularly strict in regard to the control and authorization of exports, other countries are much more accommodating. Lost markets can be substantial in various sectors, such as helicopters for China or combat aircraft for India, and with no gain whatsoever for Europe in terms of global security.

Harmonization of European practices is all the more essential as extra-European competitors can be led to sidestep ITAR rules (International Traffic in Arms Regulations) for which they nevertheless impose application to the rest of the world.

▪ *Local workshops, a possible path subject to certain conditions*

The Safran Group is making substantial sales to China with the CFM56 engines[1] installed in 50% of the Chinese civil commercial aviation fleet, and Turbomeca engines installed in 50% of helicopters in service in China. The Group is also present in the Chinese marketplace with landing gear, navigation and safety equipment and mobile telephony.

Safran has set up a number of 50/50 joint venture production units with two aims: firstly to provide China with return for the contracts awarded, and secondly to take advantage of local production conditions.

In particular, Safran sub-contracts the manufacture of components to joint-venture companies within a carefully predefined framework. Sub-contracting arrangements concern the machining of specific engine and landing gear parts. These are individual parts and are not critical technical assemblies. The materials used are supplied from France. Machined parts are treated and assembled in France[2].

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[1] *CFM56 engines are built by CFMI, a joint subsidiary of SNECMA (50%) and General Electric (50%).*
[2] *Kening Liu, Chief Representative, Safran, Beijing, November 29, 2006.*

The purpose is consequently to transfer various technologies, as requested by the Chinese contacts, while retaining control of overall production and the design of parts manufactured locally.

This industrial cooperation model operates to the satisfaction of both parties. The market shares won by Safran in China are substantial as we have seen.

▪ *All-round cooperation*

In the satellite domain, labor costs for assembly of a platform or payload only represent a small part of the total cost. For a European manufacturer, the essential advantage of cooperation with the new space powers is the opportunity to penetrate markets which would otherwise be closed. For the foreign partner, the advantage is to be able to acquire the benefit of leading edge technologies, in particular as regards payloads.

Alcatel Alenia Space has been cooperating with the Russian company NPO-PM since 1993 in the telecommunications satellite domain, essentially for the Russian market.

Alcatel Alenia Space has also developed long-established cooperation arrangements with various players in the Chinese space sector[1]. The aims here are not only to cover local needs, but also to obtain access, alongside China, to over-the-counter markets closed by reason of their political implications, such as Nigeria and Venezuela, situated in a "satellite for oil" context.

▪ *Long-term cooperation between peers*

The strategy adopted by EADS Astrium in India takes another form, that of a long-term partnership between peers in a market of interest to both parties.

In the telecommunications satellite domain, EADS Astrium concentrates on the top of the range to meet the requirements of its traditional customers, although a stable market for less powerful satellites exists. As a general rule[2], the leading players have withdrawn from this market, due to a shortage of investment capacity and the difficulty of reducing their production costs.

The Antrix marketing subsidiary of the Indian Space Agency, ISRO, contacted EADS Astrium in 2005, its aim being to set up a common medium range telecommunications satellite[3] distribution and marketing approach Antrix capital is closed, and EADS Astrium could not acquire an equity interest. The solution adopted was to create a joint venture for programs, with each partner contributing know-how and capacities, and without injection of capital.

A few months after signature of the partnership agreement, an initial contract for the W2M satellite – to be launched on Ariane-5 – was obtained from

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[1] *CASC, CAST, SINOSAT, APT and Chinasat in particular.*
[2] *The only western player in this market is Orbital Sciences Corporation.*
[3] *Less than 4.5 kW.*

Eutelsat, a traditional customer of EADS Astrium. This was followed a few months later by a contract for the Hylas satellite, signed with the British company Aventi[1].

The expediency of this Franco-Indian alliance has been confirmed by the successes achieved. The two entities have complementary product portfolios. EADS Astrium is in a position to offer a complete range of satellites[2], and Antrix has identified outlets for its production via the commercial and technical know-how of its partner.

A number of cooperation models are thus employed in the aerospace sector. The space sector does not fear globalization but takes dynamic advantage of it.

3. Training in France rather than creating outposts in other countries

Space sector competition is a core element of technological competition worldwide, and requires global responses. These include the provision of training at university level.

▪ *Training of engineers, a critical aspect of international competition*

Is it in the interests of France to export the efficient advanced training model represented by its universities?

Emerging countries such as China and India today appear on the planisphere of the leading universities competing to select the best students in the world. Under these conditions, any cooperation would be of a nature to reinforce the competitiveness of their products in the world higher education marketplace. It should be noted that the leading American universities have not set up subsidiary establishments in the large emerging countries.

Furthermore, the following simple principle should be borne in mind: ***the closer one gets to the act of producing, the lesser the extent to which cooperation can be developed. Production know-how, design and engineering are all trump cards in the commercial competition arena. Their export should be barred.***

Consequently, the training of engineers can be regarded as a highly sensitive question, one which can be summarized as follows: ***should we encourage a leading French university specialized in the aerospace construction sector to hive off establishments in China or India ?***

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[1] *Yves Guillaume and Stéphane Vesval, EADS Astrium, Bangalore, December 15, 2006.*

[2] *Due to a shortage of production capacity, EADS Astrium was apparently unable to manufacture the platforms for the W2M and Hylas satellites.*

▪ *Training of foreign engineers in France*

In connection with construction of its A 320 assembly line in China, Airbus will be required to train specialist workers and technicians *in situ*. This will also apply for maintenance centers to be set up in India, to ensure follow-up for massive sales in this rapidly expanding market.

Should we go further and train engineers as well as technicians?

Two models already exist for French university cooperation at engineer level: creation of a replica of a leading French university *in situ*, or training of large numbers of foreign students in a French university.

The group of the five French "Écoles Centrales" (Paris, Lyon, Nantes, Lille and Marseille) has decided to create a sixth member of the group in Beijing, within the framework of Beihang University, going so far as to export the integrated preparatory class model *in situ*[1]. A degree of self-limitation in this development is indeed scheduled, insofar as two classes of one hundred and ten students have already been recruited, and the ceiling has been set at one hundred and fifty students per class. It is nevertheless to be feared that once training know-how has been acquired, the structures and methods set up and introduced in Beijing will be duplicated across China. In this case, Chinese companies will be able to recruit the majority of young graduates for their own needs. Thus, the original and fertile principles of the intellectual training of "École Centrale" students, on which numerous French export successes have been based, would be duplicated in one of France's leading industrial competitor countries for the coming decades.

The second model is that of the Écoles Nationales Supérieures des Arts and Métiers (ENSAM) or the Institut d'Optique. Selected *in situ*, foreign students take their full course on the French campuses of these university establishments, acquiring in-depth familiarization with French culture and thinking, joining student and former student associations and consequently representing select recruits for the Chinese or Indian subsidiaries of French companies. Another advantage of this model is that the presence of these foreign students swells the numbers attending the French universities.

The training of foreign engineers must consequently remain the prerogative of the leading French universities on their home campuses. Training in design and production must remain French on French soil.

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[1] *Visit to the Ecole Centrale de Beijing, University Beihang University of Aeronautic and Astronautic Science and Techology, November, 30, 2006.*

VII – NEW RELEVANT BUT NOT GENERALIZABLE FUNDING MECHANISMS

To offset the inadequacy of orders and public funding, whether national or European, the space industry has had recourse to new funding mechanisms, ranging from exclusively private funding to various types of partnership with the public authorities.

Just how far can we go with this type of arrangement? Can the public authorities really withdraw from funding the space sector?

1. Limits of the new financial packages – the example of Galileo

To offset the lack of commitment by the public authorities, the space sector has been obliged to turn to different, innovative funding methods. This concerns financial plans which cannot be limitless, and which could well run dry overnight should a flagship program fail.

▪ *Value and limits of public-private partnerships*

The aim of a public-private partnership is to combine public and private funding for start-up, or indeed implementation of a project, while obtaining the benefit, where possible, of the respective advantages of two types of structure in terms of management –integration of the longer term by the public sphere, and short-term management efficiency of the private sphere.

The public-private partnership solution has always been a mechanism commonly employed, whether explicitly or not, in the space sector. This structure continues to be efficient in the case of controlled applications involving a limited number of participants, each with clearly established responsibilities.

A recent example is provided by an innovative project for satellite coverage of zones unable to access HD Internet services. The Astrium-Antrix Hylas project mentioned above covers regional deficient coverage zones in Spain, the United Kingdom and the eastern countries for HD Internet services via a new generation 2.3-metric ton satellite rated at 2 kW and costing € 50 to 75 million, scheduled for launch on Soyuz for a 15-year mission[1].

The key element in this project is the private company Aventi, specialized in the distribution of targeted advertising in shopping malls and hypermarkets. To enhance its financial muscle, Aventi has opened its capital to a number of venture capital companies. As the project provides for building a demonstrator, ESA is supplying its technologies developed in-house, EADS Astrium is developing the

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[1] *Stéphane Vesval, EADS Astrium, Bangalore, December 15, 2006.*

payload, and the Indian company Antrix is supplying the platform. A number of banks have completed the pool. This type of public-private partnership proves flexible, efficient and appropriate for a targeted project.

Conversely, a public-private partnership can prove extremely cumbersome where the project is complex, involves a large number of partners and attempts to reconcile different points of view.

Galileo represents an extreme example of the difficulties which can be encountered in a PPP context.

The Galileo satellite positioning and navigation project is a European Union initiative, for which the decision in principle dates back to 2001, and setting up of the financial package to 2002. The European Commission is responsible for policy management of the project and its agenda. The European Space Agency (ESA) is a partner in the project, and is directing development of its technical infrastructures, namely the satellites and ground segment.

Serving to officialize the partnership between the European Union and ESA, the Galileo Joint Undertaking (GJU) structure set up by the European Commission and ESA, is responsible for creating the PPP, development of the program and validation of the system in particular, and relations with the concession companies.

Finally, the European Union has set up an EC agency, the Global Navigation Satellite System Supervisory Authority (GNSS), responsible for managing public interests relating to European programs, and serving as regulating authority[1].

Compared with the American GPS system, managed by the DoD with the support of a simple coordination department, the Galileo administrative structure is highly complex.

As regards funding, the European Union has provided aid initially for research connected with definition of the Galileo project[2], via FP 5 (1999-2002) for an estimated amount of € 100 million. The EU then contributed to funding of the development and validation phase via the TransEuropean Network for € 550 million, and FP 6 (2002-2006) for € 100 million. ESA has also co-funded development and validation of Galileo for € 550 million. Total public funding for research and development consequently amounts to € 1.3 billion.

Initially estimated at a cost of € 2.1 billion, the Galileo deployment phase must be covered by the private sector for at least two-thirds of the total, namely €

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[1] *The principal missions of the European Regulating Authority are as follows: negotiation and conclusion of the concession contract, management of European funds allocated to the program, coordination of frequencies, technical support for the European Commission in its relations with the European Parliament and Council, certification of Galileo components, handling of questions relating to safety and security, and responsibilities for upgrading of the system and new generations.*

[2] *Definition studies are as follows: GALA definition of global architecture; GEMINUS definition of services; INTEG for integration of EGNOS (European Geostationary Overlay Service); SAGA standardization; Galileosat space segment architecture; GUST receiver specification and certification; SARGAL Search and Rescue (SAR) service.*

1.4 billion of the initial figure, and a maximum of one-third by the EC budget, namely € 700 million. Applying the new financial prospects of the European Union, and taking account of the special difficulties of the satellite services and their marketing, the EU contribution could be increased from € 700 million to € 1 billion.

In real terms, sharing of funding between the EU and the concession company has proved so delicate a matter that the two consortia competing for award of the Galileo concession, EADS Thalès on the one hand and Alcatel-Finmeccanica on the other, were invited to merge their tenders. This finally led to signature of the concession contract on June 27, 2005.

Negotiation of that part assigned for public funding has proved a complex matter, due to the thorny question of the risk associated with development of the market and that linked to the responsibility of the concession company. Furthermore, the existence of the governmental utilization PRS is still challenged by a number of countries.

The delay in implementation of the project has led to an increase in the total cost. The concession company investment is now estimated at € 1.8 billion, compared with € 1.4 billion in 2004.

This delay could also lead to additional difficulties for Galileo in asserting its position now that it is faced with an upgraded GPS.

The public-private partnership solution is thus proving, at European level, to be extremely cumbersome in terms of organization, the sharing of funding and responsibilities being particularly difficult to establish.

The question consequently arises as to whether an alternative structural form would not have been preferable for a project of such large dimensions, mingling the diplomatic objectives of the European Union with frequently divergent objectives at national level.

In all events, the organization set up for Galileo could not conceivably be duplicated for GMES.

▪ *Private funding of public services*

Another particular form of partnership between the public and private sectors is that of the Private Finance Initiative (PFI) for funding a public service. The public authorities procure a complete service, developed by an industrial entity, which in turn obtains revenues guaranteed for the long term on the basis of a long-term supply contract, but also carries the technical risks involved.

The PFI solution has been adopted by EADS Astrium for the Paradigm program[1].

With its Skynet 5 system entirely under its own aegis within the framework of the Paradigm program, EADS Astrium is the only company in the

[1] *François AUQUE, President, EADS Astrium, hearing of November 15, 2006.*

world to act as operator of military telecommunications satellites, and is also the only supplier of protected services in the world. EADS owns military satellites which it operates on behalf of the British Government, which, in contrast to customary arrangements in this domain, neither buys, integrates or operates the facilities, but merely purchases telecommunications units.

A major advantage of this financial package is that the British Government is not purchasing the full capacity of the system, but only pays for the capacity used at any time. The purchase of a minimum number of units ensures a balanced financial position for EADS Astrium. If actual needs exceed the minimum, the Government will then purchase additional units. For its part, EADS Astrium is authorized to sell excess capacity to France, Germany, Portugal and the Netherlands, for example.

Given the success of the project, the British Government has called on EADS Astrium to study the possibility of also supplying civil institutional capacity, operating on the "one stop shop" principle.

Representing a particularly simple and efficient system in this way, the Private Finance Initiative solution could acquire other applications in the future, the public authorities avoiding funding and operation of complex systems in this way, with the industrial partner enjoying guaranteed revenues over an extended period[1].

We can however consider that actual contract funding capacities for this type of project are limited in terms of volume.

2. Essential public support for the space sector

Satellite telecommunications are regarded as a profitable sector, not requiring public funding. Supporters of a liberal space development model quote this sector as an example, and propose its generalization to all other applications – positioning, navigation and Earth observation.

Any such position is flawed in two ways, firstly because space telecommunications also have the benefit of public support on start-up, and also because space applications generate positive externalities which cannot be taken into account by the market.

[1] *The types of contract traditionally used for institutional contracts are as follows: Firm fixed price (FFP) contract, including all costs with no ceiling, in favor of the industrial partner which carries all the risks; Fixed Price with Escalation, similar to the FFP contract, but in this case the public authorities carry the exchange and price increase risks; Cost plus Fixed or Incentive Fee contract, with cost hedging and fixed or variable profit; and Cofinancing, requiring investment by the public authorities and by the industrial partner from its capital resources.*

▪ *Profitable telecommunications and TV broadcasting due to initial governmental support*

Satellite telecommunications and TV broadcasting services are only profitable, as in the case of Eutelsat for example, as a result of initial support from the public authorities.

It is only when the technology has been acquired, the risks overcome, the markets stabilized and long-term profitability ensured, that the structure can then be privatized, where appropriate.

The initial setbacks of mobile telephony satellite projects – Iridium, Teledesic and Globalstar – demonstrate that failure is assured in the absence of public support during the deployment phase. These projects were indeed set up in a totally private context, with apparently sufficient funding amounting to $ 9 billion. However, unexpected delays occurred with setting up the satellite infrastructures. The terminal costs have remained inflexibly high in the absence of a mass market, for which the means to create this market would have been required. Consequently, GSM technology has had time to get started and preempt the mobile telephony market.

An economic model for commercial applications developed without prior support of the public authorities is consequently not viable.

▪ *Non-commercial revenue for other space applications*

While space telecommunications and TV broadcasting are solvent applications, other flagship applications of the space sector are not or in any case not sufficiently solvent to cover all their costs.

The meteorological departments cover only part of their costs and are not profitable. The national meteorological authorities have their own resources, but these are inadequate.

For its SPOT program, CNES stated that it would cover its costs. However this has proved beyond its means, insofar as SPOT Image revenue, although it has increased, is also insufficient.

The truth of the matter is that the main sources of revenue for current space applications are non-commercial[1].

Space-based meteorology and monitoring of the environment are not measured by the market in tune with the externalities which they generate. How can you measure the value of a factually proven weather forecast? How can you measure the value of monitoring of rising water levels or erosion? The price for these services cannot consequently reflect their true value.

[1] *Professor André Lebeau, hearing of October 5, 2006.*

▪ *An economic model for navigation or observation space data, a challenge for Europe*

So as not to depend on the GPS signal, controlled as to its availability and precision by the USA, Europe has decided, as we know, to set up Galileo, its own satellite positioning system, with a restricted access signal associated with governmental utilization, namely the Public Regulated Service (PRS). The complete program represents a cost of € 3.6 billion. The economic issues relating to Galileo are presented as being substantial. The world market for satellite positioning is estimated at € 250 billion for a 2010 horizon, and the number of jobs created for the associated services at 150,000.

The basic assumption for the complex financial package for Galileo, as officially presented, is that utilization of the positioning and navigation signal will identify a market, and could be billed on the user by reason of its dedicated services which are superior to those of the GPS signal. For example, air navigation should constitute a solvent market which will contribute to the profitability of Galileo.

On this basis, certain Galileo signals[1] will be sold on the basis of their specific properties, whereas the GPS signals are free.

Having developed GPS for its military applications, the USA has opened the service for civil utilization at no charge. Indeed, the USA considers the general provision of this signal as a public service due to the tax payer. Thus, rather than setting up a necessarily complex system for payment of user fees to recover the cost of GPS, the USA decided to develop associated services which generate fiscal revenues[2].

Another essential aspect is that GPS is subject to permanent upgrading to improve its military performance. It is consequently illusory to believe that the Galileo signal, when marketed, would necessarily replace the quality of the GPS signal, and that the quality differential would justify payment for accessing the signal.

A similar problem will appear for GEOSS (Global Earth Observation System of Systems) environmental data.

American policy for meteorological data is a no-charge policy as far as possible[3]. What will be the policy for access to data delivered by the GMES

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[1] *Galileo is required to deliver five types of service: an Open Service which is free; a commercial service procuring two additional signals, enhancing the updating and precision of the signal (Commercial Service); a safety service advising the user of a drop in signal precision (Safety of Life Service); a Search and Rescue Service (SAR) providing for collection of alert signals for rescue purposes, enhancement of the existing COSPAS-SARSAT service and a Public Regulated Service.*

[2] *Mike Shaw, Director, National Space-Based Positioning, Navigation and Timing Coordination Office, Washington, November 7, 2006.*

[3] *Conrad C. Lautenbacher, Vice Admiral, US Navy, Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator, US Department of Commerce, Washington, November 8, 2006.*

satellites, bearing in mind that the USA will probably opt for a free service, following the same principle as that adopted for the GPS?

Obviously, these questions, although of decisive importance, cannot be answered for the moment. The economic model for these future services is consequently still unknown.

On the other hand, construction of the Galileo and GMES systems must commence at the earliest possible moment.

Support from the public authorities, in excess of current commitments, is consequently absolutely essential.

VIII – DEVELOPMENT OF EXPERTISE AND APPROPRIATION OF THE SPACE SECTOR BY THE GENERAL PUBLIC

1. More muscle for space sector R&T

The competitiveness of the European space industry is weakening. The effects of this long-term process are not yet discernible, insofar as the competitiveness of 2006 is the result of efforts made in 2000 and decisions taken earlier still. However, the inadequacy of current investment is compromising future competitiveness at a five-year horizon. Thus, instead of assisting the development of competitiveness, research credits have had to be used to support the recovery of Ariane-5, or for utilization of the International Space Station[1].

The European space industry is the most fragile in the world and its survival is, for the moment, dependent on its competitive position as it has a vital need of commercial markets to obtain an adequate volume of business.

▪ *The space sciences, a vector for technological development*

For both CNES and ESA, technological progress stems largely from scientific programs concerned with observation of the Universe. The space sciences require leading edge equipment and instruments which in turn necessitate major technical progress.

This is why CNES has grouped the space sciences and preparation for the future, namely research and technology, in a single segment. CNES had funds amounting to € 118 million for these two vectors in 2005, corresponding to 6% of its total budget, and 17% of its national budget excluding its subsidy contribution to ESA.

However, this is no more than a substitute for a genuine R&T support policy, which is necessary by comparison with the offensive approach adopted in the USA.

At all events, the space industry is able to develop new technologies in the USA as a result of military procurement.

If we compare the European and US program budgets one by one, the differences are considerable. GPS budgets are substantially greater than those for Galileo. American budgets in the telecommunications domain are three times those in Europe.

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[1] *Jean-Jacques Dordain, Director General, ESA, hearing of June 27, 2006.*

The USA funds its space R&D activities from its defense budget. A military telecommunications satellite is billed at € 200 million in France, and € 1 billion in the USA, a ratio of 1 to 5[1].

Additional investment in Europe is therefore essential in view of the new applications to be developed over the coming decades, in particular for monitoring the environment and human spaceflight exploration.

▪ *Development of basic technologies, a priority*

To avoid the European space community being left behind in technological terms by the USA, and overtaken by the new space powers, investment is required both in regard to development of basic technologies, and the manufacture of demonstrators for in-flight testing.

Investment in basic space technologies is an absolute priority. CNES is paying particular attention to this need, in particular by assisting industry with the execution of research programs. A detailed analysis of the critical skills and teams to be maintained at all cost, have been conducted jointly by industry and CNES. CNES subsequently issued contracts to the manufacturers for this purpose. For example, the aid provided for Alcatel Alenia Space in this context for the development of telecommunications technologies, represents a total amount of € 33 million for the period 2006-2010. Apart from that, the problem also arises for sectors other than telecommunications, and in particular in the observation field, where the markets associated with monitoring of the environment are expanding rapidly.

With the single objective of maintaining skills, the action undertaken will not suffice in the medium term, and would not provide for the technological development essential for preserving the current lead of about five years over the new space powers.

Another technological challenge must also be met, that of dependence on the USA for certain components. It is essential for Europe to acquire full technological independence in order to avoid being barred from export outlets. US regulations relating to exports prohibit the export of satellites of European manufacture which contain components of US origin to certain countries, in application of the International Traffic in Arms Regulations (ITAR). It would be appropriate to follow the example of Alcatel Alenia Space, which has developed its own components to eliminate the need for US export licenses[2].

▪ *The urgent need to stop the brain drain*

Since 1984, the launcher sector has experienced a continuous fall in its staff numbers. This dual sector, namely one employing adjacent technologies for civil and military applications, had a total payroll exceeding 4,500 in 1984. By

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[1] *Pascale Sourisse, President, Alcatel Alenia Space, hearing of October 5, 2006.*
[2] *ANAE (National Academy of Aeronautics and Space) report of June 2006.*

2006, this figure had dropped to 2,600 (60% loss). It was cancellation of the ground deterrent, Hades mobile ballistic missile and Hermes European shuttle programs which triggered this drain.

Industry is expecting to lose a further eight hundred jobs in view of the current drop in its workload. The last three major programs are reaching their conclusion at the same time, the M51 strategic missile, Ariane-5 and the ATV (Automated Transfer Vehicle). The critical threshold for skills has already been reached. It should be remembered that these skills, in particular in the systems domain, are unique in Europe.

To continue the continuous upgrading which is essential for the M51 deterrent force vector, the DGA (Armed Forces Ordnance Department) has commenced preparation for the M51-2, involving the manufacture of two technological demonstrators for the upper part of the ballistic missile.

A parallel approach should be implemented by CNES and ESA. It is essential to initiate study programs in the systems domain, and for development of the Vinci-2 engine, the reignitable version of the Ariane-5 upper stage engine, to develop new skills, meet commercial or institutional requirements and face up to the competition.

2. Development of skills in the space sector, a critical question

In common with other major industrial sectors, the space sector is impacted by the aging of its staff.

▪ *Investigations in the USA and solutions envisaged*

The US Congress recently emphasized that the greatest area of fragility in the space sector is the shortage of expertise.

The new national space policy defined by the Bush Administration on August 31, 2006, sets out the principles, targets and guidelines for the measures to be taken.

Among these, the first and foremost priority is the development of human skills[1].

▪ *NASA at the leading edge of information and education*

NASA considers that the accomplishment of its missions rests on the shoulders of well-trained, fully motivated professionals. The interest expressed by the general public in images distributed by NASA is not regarded as adequate to

[1] *"Develop Space Professionals. Sustained excellence in space-related science, engineering, acquisition and operational disciplines is vital to the future of U.S. space capabilities. Departments and agencies that conduct space-related activities shall establish standards and implement activities to develop and maintain highly skilled, experienced and motivated space professionals within their workforce." US National Space Policy, Presidential Executive Order, August 31, 2006.*

arouse a sense of vocation. Consequently, NASA is implementing a set of programs, placing its discoveries and achievements at the core, with the aim of stimulating the interest of students and the educational community.

NASA will devote nearly 1% of its total budget for the 2007 financial year to education[1]. While a figure of 1% can appear relatively modest, it nevertheless corresponds to a substantial working margin of $ 153 million for 2007 alone.

Various actions are aimed at elementary and secondary education (31% of the total), university education (35%), distance learning via Internet (6%), general information (2%) and support for research and educational programs for minority populations (26%).

Despite these efforts, already vast by comparison with Europe, NASA reviewed its educational support mechanism in mid-2006 as a preliminary step towards increasing its investment in this domain[2].

▪ *Reinforcement of the leading aerospace sector universities*

Europe possesses a leading space training authority, the International Space University (ISU), based in Strasbourg. This university is currently funded essentially by industry, following a reduction in the support received from the American and European space agencies. The ISU runs master's degree and technical courses, and management courses for space sector activities. ISU graduates, drawn from many different countries, are extremely positive in their judgment of the training received.

Apart from the ISU, the question arises as to whether it is time for France to set up its own university specializing in space activities. Higher education in space techniques currently equates toy specialization within the framework of the aeronautical universities.

Space technologies are increasingly sophisticated and specific. This trend will be further accentuated with development in the areas of space data processing, digital models and space services of all types. We can consequently anticipate a need for specialized courses.

3. More efficient information of the public

The question of public interest in the space sector is both difficult and important. Apart from Shuttle and Ariane-5 launches, pictures of the astronauts on board the International Space Station, and a few shots of deep space were went back by automatic probes, day-to-day space activities are currently invisible for the public at large.

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[1] 2007 budget called for by the President of the USA for NASA: $ 16.792 billion. Education line: $ 153.3 million.

[2] Shane Dale, Deputy Administrator, NASA, Washington, November 7, 2006.

The space agencies are consequently paying considerable attention to information and communication, with the aim of enhancing public perception of the space sector. Additional investment is regarded as necessary, investment which should combine augmented resources in the traditional media fields, with, it is clear, utilization of new dedicated media.

▪ *CNES and ESA actions*

Insofar as CNES is concerned, there is no special difficulty in communicating with educators and the specialist media. Anyone interested in space knows where to find relevant information. CNES has also set up numerous interfaces with the educational world.

Communication between the space sector and the general public is not as successful as it should be.

CNES is operating an external communication plan. This is being developed by stages and progress is being achieved. However, CNES has not yet succeeded in making itself visible to sixty million French people. The objective is consequently for CNES to be present in the leading TV newscasts, and in films, newspapers and magazines aimed at the general public[1].

To reach the general public, CNES plans to move outside the restricted domain of the space sector in the future, and cooperate with other research authorities in the field of communication[2].

ESA has a central communication service, forming part of the Directorate of External Relations. The ESA regional centers also have the task of informing the public on the activities in which they are engaged, and distributing images and written documents on major programs. ESA recently set up a department specialized in education and support for the teaching fraternity.

▪ *Media silence on space matters*

The specialist French press has only one magazine devoted exclusively to space[3]. Space activities are regularly reported in reviews concerned primarily with astronomy or aeronautics[4]. The scientific magazines also address space matters, but not on a regular basis.

General press attention devoted to space is no more than episodic, and limited to particularly noteworthy events and only when other items leave the door open. This is due in most cases to the absence of a regular science page in the majority of written press publications.

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[1] *Yannick d'Escatha, President, CNES, hearing of November 16, 2006.*

[2] *Pierre Trefouret, Director for external communication, education and public affairs, CNES, hearing of November 16, 2006.*

[3] *Espace Magazine, bimonthly review.*

[4] *Air & Cosmos and Ciel et Espace in particular..*

The audiovisual public service offers no regular specialist TV or radio programs on space. In more general terms, this is also the case for science, unacceptably absent from general public TV programs.

The contest to win increased TV viewer public ratings, and the constraints of economic survival for the written press, are obvious reasons for this shortage of information on space activities, and contribute to limiting the size of the supposedly interested public still further.

On the basis of published figures, that section of the public regularly purchasing magazines addressing space activities can be estimated at between ten and twenty thousand in France.

Can we consider that measurement of this kind provides a true picture of public interest in space matters? From the evidence, the answer is no. We need no better proof than the phenomenal success of events such as the "Nuit des Étoiles", which has attracted hundreds of thousands of persons annually since 1991[1].

In truth, space activities are invisible to the French. Nevertheless, anyone who comes into contact with this domain quickly becomes intensely interested in the problems of space exploration and conquest.

The central requirement is consequently to invigorate the processes of information and communication concerning space.

▪ *Inventing new media and new contents for the space sector*

In its report of June 2006, under the heading "*Europe in Space: issues and prospects*", the National Air and Space Academy[2] called for the creation of a European think tank to address the subject of "vision-strategy-education". Its two tasks would be to make the different players – agencies and industry – aware of the need to engage in a new communication process, and to achieve a consensus and coordination leading to proposals for joint actions.

While a European approach is relevant, France should be the most enterprising in this matter, if only by reason of its rich space history and to retain its leader position.

Regarding contents and media, modern technologies provide technical resources in the existence of which no-one would have believed ten years ago.

Twenty million surfers in France possess cable or wideband HR Internet links.

These links mean that a complete media package – radio and TV – can be delivered to the general public at very low investment cost.

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[1] *The "Nuit des Étoiles", an event created by the French Astronomy Association in 1991, comprised 400 individual events in France, Italy, Switzerland, Belgium and Tunisia, organized by over 3,000 volunteer coordinators, between August 3 and 5, 2006.*

[2] *Europe in Space: issues and prospects, File No. 27, National Air and Space Academy, June 2006.*

Internet often makes it possible to generate mode or "buzz" phenomena very rapidly, hence the exceptionally fast increase in audience numbers, provided the content offered is creative.

If the 2006 Roland Garros tennis tournament can be broadcast to France Télévisions broadband subscribers in HD, it is difficult to imagine that it is impossible to do the same for a substantial number of events concerning the space sector, for example Ariane-5 or Soyuz launches.

Likewise, it would be extremely easy to multiply the number of blogs on new editorial vectors.

Digital radio by satellite or telephone also makes it possible to reach the growing number of community radio stations, the cost of setting up and operating each channel being limited, or to create a radio station devoted exclusively to space.

Webcams also bring the event closer, and it is a simple matter to take advantage of this.

As for content, space history and news provide a multitude of subjects.

The Institute of Space History, which is doing extremely useful work in collating private archives, could set up a series of interviews with leading personalities and players from the space community, whose deeds and actions have provided the material to write our space saga[1].

In particular, it would be essential to collect and present the accounts of their experiences by French cosmonauts and astronauts.

The Foundation for Space Research and Aeronautics (FRAE), a State-approved entity, could have its statutory purpose extended to embrace the prospective space domain, on the basis of calls for contributions, and the implementation of projects illustrated with cartoon films.

CNES and industry should design and distribute regular, or even continuous programs on their activities and achievements. Archive data should be used to make films on the exploration of the solar system. These would astonish the public.

By creating its own contents and media, the space sector will reawaken the interest of the mass media, which will not stay away from a promising area of interest.

As a result of technical progress in the media domain, the space sector has a historical opportunity for opening the eyes of the French public to its achievements, its projects and the men and women concerned.

The involvement of all players is essential, the national space agency, CNES, and also industry, which must learn to communicate, not only with its customers, but with the general public in the broadest terms.

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[1] *Christian Lardier, Air & Cosmos, January 23, 2007.*

▪ *Invention of new dialogue and meeting points on space activities*

To go out and meet the public, there is now no more important assignment for Jean-Pierre Haigneré. His "Space Cafe" project will enable him to demonstrate the importance of space is in daily life and for the future of Earth[1].

A noteworthy initiative, the Toulouse Space City is welcoming large numbers of visitors, demonstrating the genuine appetite of the general public for space. The same concept could well be developed on other sites, in particular in the Île-de-France region.

4. Sub-orbital flight, a unique opportunity for increasing access and reference to space

Sub-orbital flight represents a new frontier for the space sector, one which can be accessed by new companies, and discovered by a number of passengers incomparably greater than that of professional astronauts, cosmonauts and taikonauts.

▪ *A new frontier and new markets*

A suborbital flight involves taking a small number of paying passengers up to an altitude of 100 km for a few minutes, and involving simultaneous testing of a weightlessness situation, having a quick look at the interstellar void and obtaining an overview of Earth over a radius of 1,000 km, before landing under conditions acceptable for untrained passengers.

Compared with the $ 20 million charged for a flight on Soyuz, the price for a sub-orbital flight should be of the order of $ 200,000.

Concordant studies demonstrate that a market does exist for a project of this type. According to the FUTRON study of 2006, over 70,000 passengers would be ready to pay the asking sum for such an experience between now and 2016.

Once stabilized, the suborbital flight market should be worth between $ 2 and 4 billion annually.

▪ *Multiple initiatives*

The prospects of suborbital flight are instigating a flurry of industrial initiatives in the USA, frequently funded by new players, a considerable number of which emanate from the new IT and telecommunications technology sector[2]. This is resulting in widely differing, and at first sight innovative, technical solutions.

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[1] *Jean-Pierre Haigneré, hearing of December 21, 2006.*
[2] *Jean-Pierre Haigneré, Director of the Soyuz at the CSG project in Kourou, ESA, cosmonaut, hearing of December 21, 2006.*

One of the best known players in the sector is the Scaled Composites company, which won the famed X Prize[1] with its Spaceship-1 project, funded by the cofounder of Microsoft. The latest Scaled Composites project is Spaceship-2, funded by Richard Branson[2]. This should enable two pilots and six passengers to reach an altitude of 100 km in 2009.

Another player is Rocketplane Kistler, involved in the COTS program, which plans to equip a LearJet type business aircraft with a rocket motor. For its part, Space-X, the other company chosen by NASA for its COTS program and backed by a successful Internet contractor, plans to develop a capsule carried on a Falcon rocket. The Blue Origin company, belonging to the owner of Amazon.com, is proposing a vertical takeoff capsule which reached an altitude of about 100 m at the end of 2006.

Thanks to the initiative of Jean-Pierre Haigneré in promoting sub-orbital flight, and the exploratory work of EADS Astrium and Dassault, Europe does not intend to be absent from this new sector.

Apart from strictly commercial prospects, we can expect that the development of sub-orbital flights will constitute a prime mover for new technological development for civil or military uses, and stimulate fresh interest in space applications, as new experiences, accompanied by images and first-hand accounts will be proposed to the traditional media or Internet.

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[1] *The Ansari X Prize, worth $ 10 million, was awarded to the team capable of building and launching an aircraft capable of taking three persons up to an altitude of 100 km, and repeating the exercise twice in two weeks.*

[2] *Richard Branson's company Virgin Galactic plans to commission the first commercial space line.*

PART 3:

HOW TO MAKE EUROPE THE NEXT WORLD LEADER IN THE SPACE DOMAIN

Experience acquired by the now mature space powers demonstrates that it takes about thirty years to create an efficient space sector. Conversely, the consequences of a slow-down in space investment can rapidly prove extremely costly.

Current space achievements are the fruit of a dynamic space development project, and thirty years' resolute decisions and major investment in both R&D and production.

An absence of decisions at the present time would compromise the next thirty years.

The dimension of space investments is wildly overestimated by the general public.

At the present time, Europe is investing € 1.5 per citizen and per year in the space sector. This is sixteen times less than in the USA. By comparison, the amount spent by Europeans in the betting arena is no less than € 140 per citizen and per year[1].

Europe would have no excuse for not meeting the challenge of the new space powers.

On the other hand, clear and firm decisions would make it possible to continue the European space adventure, and indeed increase its beneficial impact on the European economy and population.

Given its capacities, and the importance of the space sector in regard to the identity, coherence and competitiveness of Europe, an ambitious target must be set, that of ***making Europe the next world leader in the space domain.***

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[1] *Jean-François Clervoy, hearing of June 21, 2006.*

I – AUTONOMOUS ACCESS TO SPACE, A CRITICAL CAPABILITY REQUIRING CONTINUOUS DEVELOPMENT

Past history and present experience in the space sector demonstrate that the keystone of a space policy is its launchers. Without an autonomous launch capability, a country has no control over its satellite applications, and can take no material part in the exploration of the Universe. Furthermore, launcher control is decisive in regard to any space defense sector worthy of the name, up to and including protection of the national territory against external ballistic missile aggression.

Right from the start, France and Europe rightly accorded top priority to the deployment of a range of launchers designed and manufactured under totally autonomous conditions.

This approach has been validated more than ever by the very substantial investment made in this domain by all space powers, old and new. This is reflected in a constantly expanding launch service supply situation.

This trend bears the seed of increasingly intense competition, insofar as a growing number of operators are quoting launch service prices totally devoid of any economic basis, their aim being to use dumping prices to sweep aside the solidarity, in truth not sufficiently strong, which represents the only means of ensuring the long-term future of the European launcher system at acceptable cost levels.

1. The expanding world launcher supply situation

A. COMPREHENSIVE REORGANIZATION OF US LAUNCH SOLUTIONS

The USA has an extensive range of national launchers of all types, including the only existing reusable launcher – Shuttle – and also controls two international launch service providers.

Despite previous attempts to rationalize this industry, reorganization of the civil launch facility is again required.

1. The upcoming dilemma of the USA regarding its existing launch services

▪ *Retirement of Shuttle in 2010*

NASA currently uses Shuttle for human spaceflight in terrestrial orbit, and for handling the heaviest payloads. Shuttle can place payloads of 20 metric tons, such as ISS structures, into LEO.

Three Shuttle flights were made in 2006, two with Discovery in July and December, and one with Atlantis[1]. Operation of Shuttle is returning to normal, after grounding for two and a half years following the Columbia accident in February 2003, and return to flight status with the Discovery launch of July 2005.

Five missions are scheduled for 2007, one of which will be devoted to node No. 2 of the International Space Stations, and another in November, which will orbit the European Columbus ISS laboratory. Four flights are planned in 2008 and 2009, and two or three in 2010, making a total of fifteen or sixteen missions.

Final termination of Shuttle missions is programmed for 2010 for two essential reasons.

Shuttle must be requalified and recertified at this time, under the terms of its return to flight authorization obtained subsequently to the Columbia accident. The cost of overhauling the three Shuttles to comply with current safety standards would be prohibitive.

Furthermore, the cost of operating Shuttle has proved extremely high, of the order of one billion dollars per mission[2], with a NASA budget of $ 5 billion per year for Shuttle for an average of five flights[3]. The high cost of each Shuttle flight is explained by the need to recondition the retrievable boosters and Shuttle engines, replacement of the central fuel tank which cannot be reused, and the cost of a complete overhaul of Shuttle on its return to the ground.

Shutdown of Shuttle operations will make it possible to reallocate the corresponding sums to the Constellation program, and therefore construction of the Orion capsule and the new Ares-1 and Ares-5 launchers.

▪ *Atlas-5 and Delta-4 specialized in institutional launches*

The USA uses Lockheed Martin Atlas-5 launchers and the Boeing Delta launcher family for launching civil and military satellites. These two launchers

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[1] Of the five Shuttles built for NASA, two were destroyed following accidents: Challenger on lift-off on January 28, 1986 (explosion resulting from non-conformance of one of the solid propellant boosters), and Columbia on February 1, 2003 on atmospheric reentry (fracture of the thermal shield as a result of damage to the central fuel tank on lift-off). The three surviving Shuttles are Atlantis, Discovery and Endeavour.

[2] Shuttle operating costs + investment cost of payloads carried, Jean-François Clervoy, hearing of December 22, 2006.

[3] Jean-Jacques Tortora, Space attaché, French Embassy in Washington, November 6, 2006.

have taken over from Titan-2, in service up to 2004, and Titan-4 which continued in service up to 2005.

Two Atlas-5 launches and nine Delta launches (six Delta-2 and three Delta-4[1]) were made in 2006.

The Delta-4 launcher is not competitive, and is not consequently in demand from the competitive market. Atlas-5 is following the same trend[2].

The USA also has other launchers for flying military satellites, such as Pegasus, Taurus and Minotaur, used on a marginal basis.

2. THE EELV PROGRAM AND ITS DIFFICULTIES

The principal heavy launchers currently used by the USA, Atlas-5 and Delta-4, originated from the EELV (Evolved Expendable Launch Vehicle) program initiated in 1995. The objectives of this program are far from having been achieved.

▪ *The EELV program*

After the collapse of the Soviet Union, the US Congress called on the Department of Defense to set up a launcher cost saving plan, which was nevertheless required to guarantee US access to space for both military and civil space applications.

Of the various solutions put forward in 1994, the EELV program was finally chosen in 1995.

The objective of this program was to develop a family of launchers, services and support structures, for which the life cycle cost would be significantly less than for the previous generation, this being achieved by modular launcher design, standardization of launcher components and competition between manufacturers.

The fruits of the EELV program, namely Atlas-5 and Delta-4, are indeed operational, but their cost has not been reduced to any material degree.

This one of the reasons why American space transportation policy was redefined by a Presidential directive dated January 6, 2005.

▪ *The new American space transportation policy*

The Presidential directive on space transportation confirmed the central role assigned to the two launcher families. However, NASA and the Department of Defense (DoD) are required to participate in development of new capabilities.

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[1] *Christian Lardier, Air & Cosmos, January 12, 2007.*
[2] *Jean-Jacques Tortora, ibid.*

Non-US participation in the EELV program is not encouraged, with certain exceptions. In particular, the Administration wishes to remove dependence on Russia for the RD-180 engine for Atlas-5.

However, another problem exists, that of utilization of the same engine, the RL-10, for both launchers. Procurement problems with this engine could consequently ground both Atlas-5 and Delta-4, simultaneously blocking an extended range of missions, the two launchers not having the same application spectrum.

To provide an answer to these critical problems, Lockheed Martin and Boeing finally decided to join forces in a 50/50 interest joint subsidiary designated ULA (United Launch Alliance). This was authorized in 2006.

The question still arises however, as to whether the USA could be interested in international cooperation, based on a fully balanced situation both in terms of knowledge and technological know-how, the objective of which would be to reduce the cost of launchers.

3. THE COTS PROGRAM OR THE IDENTIFICATION OF TECHNOLOGICAL AND INDUSTRIAL GAPS

The primary purpose of the COTS (Commercial Orbital Transport Services) program is to provide an ISS cargo service capability, with the possible addition of a crewed version, to overcome the American lack of ISS mission launch resources over the period between the unavoidable retirement of Shuttle in 2010 and commissioning of the Orion capsule and Ares-1 launcher, scheduled for 2014. This situation comes at the worst possible time, operations with the ISS being at their most intensive precisely during the period 2010-2014.

Apart from this medium-term objective, NASA hopes to induce veritable technological gaps resulting in a reduction of launch costs by a factor of ten. The leading manufacturers already operating in the space sector for many years – Boeing and Lockheed Martin – appear to be incapable of achieving this, and NASA has decided to bring in other manufacturers which they expect to be innovative.

▪ *Two new players on the launcher stage?*

NASA has allocated a budget worth half a billion dollars to contribute to the development of demonstrators.

NASA issued an invitation to tender which led to the selection of two manufacturers, Space-X which has received $ 278 million, and Rocket Plane Kistler (RPK) $ 207 million, both of which will also receive technical assistance from NASA and have access to its facilities[1] in addition to this financial aid. Four other tenders were accepted, but will only receive technical support[2].

The demonstrators to be developed by Space-X and RPK will be required to provide the following four functions: non-pressurized external transportation of freight to the ISS, the vehicle then being disintegrated in the upper layers of the atmosphere[3]; pressurized internal transportation of freight and disintegration of the vehicle; internal transportation of freight and return to Earth and optional crewed missions.

Three flights will be required before the end of 2008. If the demonstrators are successful, NASA will purchase corresponding transportation services[4].

▪ *The COTS program, a new step forward for the space sector?*

The COTS program has aroused the enthusiasm of many specialists, who see in this approach the means of revolutionizing the traditional launcher manufacturers, still dozing on the ultra-comfortable mattress of DoD subsidies.

With the new technologies, and above all the new management methods which only start-ups can implement to transfer the efficient methods on which the success of Silicon Valley has been based to the space sector, it should be possible to reduce the cost of launchers by several orders of magnitude[5].

In this regard, one wonders whether the procedures for creating computer programs do not have something in common with metallurgy, propellants, flight control systems and other hardware devices constituting the core of launch vehicles.

At all events, the hazards encountered by the COTS program are considerable. Space-X had a failure with the Falcon-1 launcher which only flew for a few seconds. After ten years of development studies on testing mock-ups and atmospheric reentry, RPK has apparently only studied one small two-stage launcher, the K-1, in detail. Furthermore, neither of these companies have any experience in the orbital rendezvous domain.

This pessimism must be tempered by the fact that the two new players will have the benefit of NASA expertise, as also partnerships with the leading manufacturers including Boeing[6]. Thus, the essential target of NASA is to introduce a new management structure which is more dynamic than that of the traditional industrial giants, rather than new technologies requiring much time to develop and test.

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[1] *Referred to as "anchor tenancy" in American parlance.*
[2] *Paul Eckert, Boeing, November 7, 2006.*
[3] *"Trash disposal".*
[4] *Jean-Jacques Tortora, Space attaché, French Embassy in Washington, November 6, 2006.*
[5] *Alain Dupas, Collège de Polytechnique, hearing of January 24, 2007.*
[6] *Paul Eckert, ibid.*

At all events, should the COTS program fail, this will prove that the efficiency of the large traditional launcher suppliers is not open to criticism, and that launcher development conducted on a commercial basis is not valid.

▪ *The COTS program, an alibi for premature discontinuation of American contributions to the ISS?*

Should the COTS program not succeed, can it be inferred that the USA would use this failure to terminate all contribution to the ISS, following shutdown of Shuttle in 2010?

Certainly not. President Bush himself has clearly stated that completion of the ISS, and its utilization represent an essential part of the Constellation program of human spaceflight missions to the Moon and later to Mars. The Deputy Administrator of NASA has clearly and publicly reaffirmed the commitment of NASA to complete the ISS[1].

Other launch services would have to be used. The only current option is recourse to services of Russia with the Progress capsule, and the Soyuz capsule and launcher.

However, robust operation of the ISS demands development of a second, alternative transportation system.

It must be Europe's task to meet this need.

4. THE NEW ARES-1 AND ARES-5 LUNAR PROGRAM LAUNCHERS

The Constellation program includes the creation of a complete new transportation system, comprising two new launchers and the Orion capsule, previously designated CEV (Crew Exploration Vehicle).

This program is based on the architecture of the Apollo program. It is planned to use proven technologies.

It should be remembered in this regard that the primary quality required of a launcher is its dependability. This is why it is essential to capitalize on experience acquired with earlier, traditional launchers.

Despite this reasonable approach adopted by NASA, it is by no means certain that the number of difficulties to be overcome is only modest, on the one hand as a result of possible loss of expertise since the end of the Apollo program, and on the other, the intensification of safety requirements since the end of the 1960s.

[1] "We reaffirm our commitment to achieve the ISS", *Shane Dale, Deputy Administrator, NASA, Washington, November 7, 2006.*

▪ *The issues attaching to the Ares-1 launcher*

The first stage of Ares-1 is a five-segment solid propellant booster, derived from the Shuttle boosters. The four-segment Shuttle booster will not therefore be used as such, and this means development of a new first stage.

The second, or upper stage of Ares-1 is powered by a Pratt & Whitney-Rocketdyne J-2X cryogenic engine burning LOX and LH2[1]. This is a development of the J-2 engine used for the Saturn-1B and Saturn-5 launchers of the Apollo epoch, and the J-2S, a simplified version of the J-2, which has been tested but never flown.

We consequently observe that development of Ares-1 is in turn dependent on development of a new solid propellant booster and a new second stage engine.

This represents two costly and hazardous technological challenges, insofar as the mass of the Orion capsule is not yet known with certainty.

▪ *A projected new heavy launcher*

In the architecture adopted by NASA, the Constellation program includes the construction of a heavy launcher, following the same philosophy as for the Saturn-5 launcher on which the success of the Apollo program was founded. Ares-5 has been designed with a liftoff mass of 3,300 metric tons and a payload capacity of 130 metric tons.

The lower composite of the Ares-5 comprises a central core stage and two twin boosters. Derived from the external tank of Shuttle, the central core stage has five RS-68 LOX/LH2 engines as already used in the Delta-4 launcher, and preferred to the costly SSME Shuttle engine. The two solid propellant boosters flanking the central core stage are similar to the first stage of Ares-1.

The upper composite of Ares-5, designated "Earth Departure Stage", is a transportation module powered by the Pratt & Whitney Rocketdyne J-2X cryogenic engine (LOX/LH2) also used for Ares-1.

For lunar exploration missions, the Earth Departure Stage module will carry the LSAM (Lunar Surface Access Module) lander module, akin to the LEM used for the Apollo program. After orbital rendezvous, the LSAM will dock with the Orion Crew Vehicle for departure of the Earth Departure Stage/ LSAM/Orion composite for the Moon.

As in the case of Ares-1, the technological challenges to be met are difficult. Funding injected into the builder companies will doubtless enable them to achieve technological breakthroughs in this domain or elsewhere. However, the need for a heavy launcher has been lessened as a result of progress in the orbital rendezvous domain, providing for in-orbit assembly of modules with a mass compatible with the launchers of today.

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[1] *Liquid hydrogen (LOX) and liquid hydrogen (LH2).*

▪ *Formidable support for the American space industry*

Development of the Ares-1 and Ares-5 launchers is creating a substantial workload for American industry. The design and manufacture of a new solid propellant stage will ensure that the corresponding family is maintained. Furthermore, new cryogenic engines will have to be built, using new technologies taking due account of dedicated service constraints[1]. Finally, return to a heavy launcher in the shape of Ares-5, comparable with Saturn-5, represents a very substantial technical challenge in that the performance of its second stage engine will have to be of the same order as that of the Ariane-5 cryogenic main stage.

Among its various purposes, the Constellation program can thus be regarded as a powerful driving force for revitalization of the American launcher industry.

It is clear that the technologies developed for Ares-1 and Ares-5 will subsequently find other applications in the defense space sector domain, and indeed for civil space applications.

This represents an additional future threat for European industry.

B. RUSSIA AND UKRAINE IN A SEARCH FOR PROGRESS IN THE LAUNCHER DOMAIN

1. PROTON WITH ILS, AN INCREASINGLY COSTLY LAUNCHER

The Russian Proton launcher is marketed by Lockheed Martin via the Russo-American joint venture ILS (International Launching Services), created in 1995.

The Proton launcher, long established and well proven, can place payloads of 6 metric tons into geostationary orbit from Baikonur. Proton is a potential competitor for Ariane-5.

The ILS order book is substantial on paper. Officially, over one hundred launches have been ordered since startup of the company, representing sales worth $ 8 billion. Six launches were made in 2006, including a failure in February.

Lockheed Martin announced the sale of its shares in ILS in September 2006. This withdrawal is explained firstly by the downturn in the return on its investment in this Russo-American joint venture, Russia having decided to increase the price for Proton launchers.

It is also explained by the decline in launcher production quality which led to the February 2006 accident.

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[1] In particular, the lunar lander equipped with a cryogenic engine, can spend several months in orbit round the Moon. This will require development of a dedicated thermal dynamic machine or long-term storage of cryogenic propellants. Source: Philippe Berthe, EADS Astrium Space Transportation, hearing of December 20, 2006.

The threat for Arianespace represented by Proton appears to be diminishing in view of the increase in prices for this launcher[1].

2. ZENIT WITH SEA LAUNCH AND LAND LAUNCH, ANOTHER THREAT

Another family, based on the aim of assisting and coordinating the Soviet launcher family, following the collapse of the USSR, the two commercial structures, Sea Launch and Land Launch, offer services using launchers of Soviet origin.

A partnership between the USA, Russia, Ukraine and Norway, with Boeing acting as prime contractor, Sea Launch provides geostationary launch services for payloads with a mass of between 4 and 6 metric tons, flying the Zenit launcher from an offshore platform positioned on the Equator.

The first two stages of Zenit are of Ukrainian origin, and the third stage is Russian (RSC Energya). The payload structure is provided by Boeing.

Insofar as Arianespace is concerned, the competitiveness of Zenit as proposed by Sea Launch is appearing to weaken as a result of the increasing cost of the launcher and the complexity of its logistics.

In addition, the explosion of the Zenit launcher which should have placed the NSS-8 telecommunications satellite into orbit for SES New Skies on January 30, 2007, appears to have seriously damaged the launch platform which will be out of service for several months[2].

In contrast, Zenit launch services proposed by Land Launch, operating from Baikonur for satellites with mass values up to 3.5 metric tons at relatively low cost, represents a serious threat for Arianespace[3].

3. SOYUZ, A LAUNCHER OF THE FUTURE

No fewer than twelve Soyuz launches were made in 2006, bringing the total number of launches for this vehicle to 1,717. Soyuz is by far the most fully proven launcher in the history of aerospace activities.

Soyuz will continue as a relevant basic launcher over the coming years, appreciated for its dependability and multipurpose characteristics, both for launching satellites and human spaceflight.

The share of the international market held by Soyuz should increase in the future with the development of Starsem operations at the Guiana Space Center.

▪ *Soyuz and Starsem*

Starsem is a joint company, the shareholders of which are EADS, Arianespace, Roskosmos and TsSKB-Progress (Samara Space Center). It made its first launch in 1999.

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[1] *Jean-Yves Le Gall, CEO of Arianespace, hearing of the Parliamentary Group for Space, May 3, 2006.*
[2] *Christian Lardier, Air & Cosmos, February 2, 2007.*
[3] *Jean-Yves Le Gall, ibid.*

Recommended by the Parliamentary Office for Scientific and Technological Assessment in 1994[1], formation of the Starsem company responded to a dual objective for Europe, that of extending the Arianespace range with a complementary launcher, and for Russia, for obtaining access to the commercial know-how of a major European group.

Starsem currently uses the Soyuz launcher flown from Baikonur. The two launches made in 2006 were of particular importance in this context. On October 19, 2006, a Soyuz 2-1a, an upgraded version of the standard Soyuz, placed Metop-A, the first European meteorological and climate monitoring satellite into polar orbit, to gather atmospheric temperature and humidity profiles. On December 27, 2006, the first Soyuz 2-1b launcher placed the Corot star mapping and exoplanet research satellite also into polar orbit.

Extension of the Soyuz range is thus being achieved with no loss of dependability.

As from 2008, the potential of this launcher will be further extended with commencement of launch operations from the Guiana Space Center, using the further upgraded Soyuz-ST version capable of placing even heavier payloads into orbit.

▪ *Soyuz, a competitor for Ariane-5 in certain markets?*

One of the major advantages of Soyuz is its dependability, inseparable from its record of one thousand seven hundred and seventeen flights at end 2006.

The Soyuz launcher has substantial capacity for evolution, and the process has already commenced.

Does this mean that further competition for Ariane-5 is to be feared, while the technical characteristics of the initial version represent a complement for the European launcher?

Within a relatively short time, the payload capacity of Soyuz could be boosted by increasing the present propellant load. On this basis, Soyuz could achieve a geostationary transfer orbit injection capacity of 4 metric tons.

To go further, the launcher would have to be redimensioned and the engines replaced. The time required to develop new engines is of the order of ten years. In the short-term therefore, Soyuz does not appear to be in a position to attack the single launch market for payloads of 5 metric tons.

If development of new engines was found to require less time, or if the increase in satellite mass values was not an intangible factor in the marketplace,

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[1] The issues of cooperation and technological exchange agreements with the countries of Central and Eastern Europe, Henri Revol, Parliamentary Office for Scientific and Technological Assessment, Assemblée Nationale No. 1818, Senate No. 155, December 1994.

competition between Soyuz and Ariane-5 could no longer be negligible, even if the mechanism is governed by the ESA-Arianespace convention.

C. CHINA AND INDIA, BOTH PROGRESSING RAPIDLY IN THE LAUNCHER DOMAIN

China and India are moving forward rapidly in the launcher domain. Having initiated their respective programs using Soviet, and later Russian technologies, both countries are steadily acquiring technological proficiency enabling them, or which will enable them, to offer launch services at prices all the more competitive as the notions of cost are secondary by comparison with the aim of establishing themselves in the international marketplace.

It is not irrelevant to note that China and India are both setting themselves the target of achieving the performance levels currently demonstrated by Ariane-5.

1. Successful incremental development of the Chinese Long March launchers

China has made thirty-eight launches since 1999, of which four in 2004 and five in 2005.

With six launches in 2006, China achieved a level of activity exceeding that of the Guiana Space Center.

China has modernized its Long March launcher progressively since the commencement of its space program, applying a modular development strategy. The initial Russian technologies have been replaced by more modern technologies, for which it is difficult to determine the national or external origin.

At all events, we are observing an increase in launcher and booster diameters[1], an increase in the number of boosters and replacement of LOX/kerosene engines by LOX/LH2 engines[2].

The boosters employed at the present time are of the LOX/kerosene type of which there are two types, with diameters of 2.25 m, and 3.35 m for the most recent version.

The basic Long March launcher can place payloads of 6 metric tons into low orbit, or 4 metric tons into geostationary orbit, using a 3.35-m diameter first stage, and two 2.25-m boosters, all burning a LOX/kerosene mixture.

With four 2.25-m boosters and a core stage burning a LOX/LH2 mixture, the Long March launcher can place 10 metric tons into low orbit, 6 metric tons into geostationary orbit, or 5 metric tons into heliosynchronous orbit.

The ultimate target of China, as part of its lunar program, is to be able to place 25 metric tons into low orbit and 14 metric tons into geostationary orbit.

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[1] *The progression pattern is 2.25 m, 3.35 m and then 5 m.*
[2] *Presentation by the CNSA (China National Space Administration), Beijing, November 27, 2006.*

2. *INDIA, A NEW LAUNCH SERVICE PROVIDER*

Compared with China, India is still in its start-up phase, with nine successful launches since 1999, compared with thirty-eight for China. India makes an average of two launches per year, compared with five per year for China.

India has taken ten years to progress from its first ASLV launcher, which flew for the first time in 1987, to the PSLV launcher still in active service.

Launched for the first time in 1997, the PSLV (Polar Satellite Launch Vehicle) launcher can place 1 metric ton into geostationary orbit, and 1.3 metric ton into heliosynchronous low orbit. PSLV has flown nine times since 1997, most recently in January 2007.

The GSLV (Geostationary Satellite Launch Vehicle), the second launcher in the ISRO (Indian Space Research Organisation) program, was placed in service in 2001. With a geostationary orbit capacity of 2 metric tons, the GSLV has only flown three times, including a failure in July 2006. Return to flight status is scheduled for 2007.

With the GSLV-MkIII launcher, India should double up its geostationary orbit capacity by comparison with the GSLV. The new launcher, scheduled to fly for the first time in 2008, will be able to place 4 metric tons into geostationary orbit and 10 metric tons into low orbit.

The success of the GLSV-MkIII is an essential component of the Indian lunar program.

The determined nature of the progressive approach adopted by India is quite clear, and is beginning to convince foreign customers such as Indonesia, Argentina and Italy[1].

2. Ariane-5, a success to be amplified

The career of Ariane-5 is a remarkable success, as one of the most powerful launchers in the world with Boeing's Delta-4, and a leader in the launch service market.

While the Ariane-5 ECA heavy version has been qualified in generic terms by ESA since December 2006, further evolution of Ariane-5 is essential to extend its applicational field still further.

[1] *Christian Lardier, Air & Cosmos, January 12, 2007.*

A. ARIANE-5, A WORLD LEADER AFTER A REMARKABLE RECOVERY

In common with many launcher programs, the Ariane-5 program had to face up to a number of teething difficulties, with the failure of qualification flight 501 on June 4, 1996, and later the failure of the qualification flight for the more powerful Ariane-5 ECA version[1] in December 2002. This was quickly followed by return to flight status on February 12, 2005[2].

▪ *Ariane-5 recovery*

In 2003, the expenditure induced by the return of Ariane-5 to flight status led to adaptation of the Arianespace business plan. Another factor having a similar effect, the bursting of the Internet bubble, led to the collapse of the telecommunications satellite market as from 2003. This was accompanied by accentuated dumping in the launcher market[3].

At its Council meeting at Ministerial level of May 2003, ESA consequently set up a number of programs for the return of Ariane-5 to flight status, and to ensure its financial viability (EGAS program). The principle of incorporating the Soyuz launcher in the European launcher range flying from the Guiana Space Center (CSG) was adopted at the same meeting.

The EGAS program was set at approximately € 200 million per year, on the basis of an exchange rate of € 1 = $ 1. As a result of the EGAS program and the satisfactory technical performance of Ariane-5, Arianespace was able to balance its books, achieving a profit of between € 8 and 10 million in 2003, 2004 and 2005. The result for 2006 should be balanced. In addition, its substantial order book ensures a positive cash position for Arianespace.

In technical terms, the Ariane-5 ECA launcher was qualified by ESA on December 12, 2006, following its five successful launches.

▪ *Arianespace, world leader in the launch services domain*

A remarkable statistic, demonstrating its penetration of and position as leader in the launch service market, nearly two-thirds of all commercial satellites currently in operational service worldwide were launched by Arianespace.

Arianespace flew the Ariane-5 ECA five times in 2006 alone, placing ten telecommunications satellites and a technological demonstrator into geostationary transfer orbit.

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[1] *Ariane-5 ECA uses the Vulcain-2 first stage engine.*
[2] *Some observers take the view that Ariane-4 was retired too early, given the fact that this launcher had achieved a very high degree of dependability, and with all development phase investments recovered, its cost was very low.*
[3] *At this date, the price of a launch quoted by Russia was $ 50 million and € 80 million for Europe. The arrival of China and India in the launch market then further accentuated the phenomenon.*

The performance of Ariane-5 is now regarded as a launch service reference. With thirty successful launches behind it, Ariane-5 is the only launcher capable of placing two payloads into geostationary transfer orbit at the same time, offering its customers performance, flexibility and attractive prices.

Arianespace booked twelve new satellite launch contracts in 2006, corresponding to seven launchers, and had an order book totaling thirty-eight satellites at the beginning of 2007.

B. HOW TO CONSOLIDATE AND AMPLIFY THE SUCCESS OF ARIANE-5

Europe must capitalize on the Ariane-5 launcher to strengthen its operational capacity.

As the construction of a new launcher induces the loss of market shares due to the inevitable set-backs and delays, the only relevant objective is a progressive performance enhancement process.

▪ *Continuation of the EGAS program*

Arianespace is faced, more than ever, with the consequences of the drop in the dollar rate, with an average parity for 2006 of € 1 = $ 1.28. Arianespace purchases its supplies and pays its staff in euros, but bills its customers in dollars. Since the EGAS program was set up, the drop in the value of the dollar has induced a 20% short-fall in Arianespace revenues.

Launch prices have increased since the failure of the Russian Proton launcher, in part offsetting the weak dollar. With its first quality service, and in particular the preparation of satellites in Kourou, Arianespace can obtain prices slightly higher than those of the competition. Prices are consequently between 10 and 12% up on those for 2003.

However, this evolution does not compensate the fall in the dollar rate, which continues to constitute a major handicap for the company. Prolongation of the EGAS program is consequently essential.

▪ *Rationalization of functions and the industrial tool on the right track*

Clarification of their respective functions firstly between ESA and CNES, then EADS Astrium and finally Arianespace, essential following the failure of the ECA heavy version, was initiated in 2003. Industrial expertise is now the responsibility of CNES and ESA. EADS Astrium builds and delivers the launcher to Arianespace, and Arianespace handles the payload[1].

The resultant, clarified organization has borne fruit, as demonstrated by the run of five successful Ariane-5 ECA launches.

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[1] *Alain Charmeau, CEO, EADS Astrium Space Transportation, hearing of December 20, 2006.*

While further progress is still required, this essentially concerns upgrading of the industrial tool, already operating for more than fifteen years. An increase in capacity is necessary in view of the increased Ariane-5 market share. Production lead times must be reduced. All these industrial challenges call for investment, on the one hand in R&T to design new facilities, on the other in acquisitions to place the facilities in service.

▪ *Industrial cooperation to reduce the cost of a new Vulcain-3 engine?*

As we have already seen, NASA is having the J-2X engine developed by Pratt & Whitney-Rocketdyne for the upper stage of the new Ares-1 launcher, and the *"Earth Departure Stage"* lunar transportation module, to be placed in orbit by the Ares-5 heavy launcher. According to its specification, the J2-X should have characteristics similar to those of the Ariane-5 Vulcain-2 first stage engine produced by Safran.

From both the French and European points of view, even though the Vulcain-2 engine is entirely satisfactory, it is considered advantageous for its evolution to continue. In particular, a more powerful version could be developed.

It would be of obvious interest to develop a Vulcain-3 engine capable of meeting the reliability and versatility constraints of human spaceflight missions.

The USA plans to develop an autonomous space transportation system. The idea of evenly balanced cooperation between France and the USA for a Vulcain-3 engine project could nevertheless be seen by the Americans as of major economic interest, with the specifications defined to meet the needs of both Arianespace and NASA.

For the USA, this cooperation would indeed make it possible to obtain an engine to replace the J-2X at reduced cost, should the need for this be felt. For France and Europe, the development costs for a Vulcain-3 version adapted to meet their future needs would be reduced.

An industrial cooperation arrangement of the 50/50 type set up by Safran with General Electric for the CFM56 engine, would enable each partner to build the engine for its own account, in its own national plant at suitably lower cost.

Of major interest to all players in the space sector, and indeed for the future of this sector, reduced launch costs are a priority. A transatlantic cooperation arrangement such as mentioned above could contribute to this end, subject to in-depth appraisal work.

Should the technical feasibility and economic interest of a project of this type be confirmed, the project should be finalized at the highest political level.

▪ *Development of the Ariane-5 ES-ATV version*

The most powerful Ariane-5 ECA version will not be required to launch the ATV (Automated Transfer Vehicle) cargo vehicle for supply missions to the International Space Station (ISS).

A dedicated Ariane-5 version will be used, designated Ariane-5 ES-ATV (ES for Evolution Storable upper stage). This version will use the most powerful Vulcain-2 first stage engine, but the upper stage will be the storable propellant EPS stage with the reignitable Aestus engine.

Other modifications will be required to ensure correct injection of the ATV with a full payload into the ISS orbit.

▪ *A powerful reignitable cryogenic third stage engine for Ariane-5*

At the time of its design, Ariane-5 was to have had a reignitable cryogenic third stage engine. For reasons of economy, the non-reignitable Ariane-4 engine was finally used[1].

The dedicated ECA stage using the Vinci engine is not reignitable, and ignition cannot even be delayed for a few seconds, insofar as pressure must be maintained in the engines to avoid icing.

Manufacture of a reignitable engine Vinci-2 and its installation in place of the current engine would enable Ariane-5 to extent its application range considerably.

It would be possible to use the geostationary transfer orbit, with reignition of the engine at perigee. The full potential of the launcher would then be available, extending from missions assigned to small launchers to those specific to heavy launchers, by definition inaccessible to small launchers. Ariane-5 could then launch six Galileo satellites at a time, the different orbits required being reached by successive reignitions.

The ECB stage using the Safran Vinci-2 engine will not only contribute the essential reignition function, but also the 30% increase in power, these enhancements being required to launch an ATV with a full payload. Upgraded in this way, the performance of the Ariane-5 ECB version will be 12 metric tons in geostationary transfer orbit.

The corresponding investment is reasonable, earning performance will be considerable. Ariane-5 could then remain in service for more than 20 years.

▪ *Human spaceflight qualification for Ariane-5*

Another major prospective evolution, Ariane-5 could also be used for human spaceflight, at the price of fairly costly enhancements by comparison with development of an entirely new heavy launcher.

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[1] *The maximum geostationary transfer orbit payload mass for Ariane-4 was 5-6 metric tons.*

Ariane-5 is the only launcher with redundant electrical systems, which have also been tested and checked in detail. To increase dependability still further, it would now be necessary to introduce additional redundancies and review certain software programs, in particular for booster separation.

An ejection device (abort system) should also be added at the top of the launcher as a crew safety measure.

The total cost of all these improvements however would not exceed an initial estimate of one billion euros, equivalent to the Ariane-5 return to flight status EGAS program.

3. A complete European launcher range with Soyuz and Vega

As the Parliamentary Office recommended in its 2001 report, the public authorities have taken measures to extend the range of services proposed by Arianespace to include medium and small payloads. The Starsem joint company was set up by EADS, Arianespace, the Russian federal space agency, Roskosmos, and the Russian company TsSKB-Progress, responsible for the design and production of the Soyuz launcher family.

Starsem provides a complete launch service with Soyuz, currently flying from Baikonur and shortly from the Guiana Space Center.

A. SOYUZ AT THE GUIANA SPACE CENTER

The enhanced 2-1-A/B versions of Soyuz will play an important part. Soyuz is an extremely efficient launcher, also capable of executing human spaceflight missions.

The first Soyuz launch from the Guiana Space Center is scheduled for 2008.

The construction of facilities for Soyuz at the Guiana Space Center has been funded, since February 2004, to a total amount of € 344 million, of which € 223 million by the ESA Member States and the European Union. The absence of a dedicated line in the EU budget is nevertheless creating difficulties with payment of the € 22 million announced.

It will be legitimate for the European Union, and the Directorate General for Transportation in particular, to contribute to the cost of completing and operating the Soyuz pad, as also construction of the facilities required for human spaceflight missions, both for Soyuz and the future human spaceflight version of Ariane-5.

B. THE VEGA LAUNCHER WELL ON THE WAY

The solid propellant Vega launcher is designed to place a payload of 1.5 metric ton[1] into low orbit.

Developed by ESA under Italian leadership, the Vega program also enjoys the backing and support of CNES and EADS Astrium[2]. Astrium is ready to assist Italy in developing this small launcher, which will enable Europe to use Vega for its own requirements, and propose a complete launcher range.

The Vega P-80 first stage engine was tested successfully at the Guiana Space Center in November 2006. The maiden flight of the Vega launcher is scheduled for September 2008. Five other flights should follow between then and 2010.

4. New generation launchers

The world is at the dawn of the effective utilization of space. The future of the space sector must consequently be prepared on a permanent basis, and in particular in regard to the launchers of the future.

▪ *A strategy for preparation for the 2020 date-line*

Progressive upgrading of Ariane-5 must be the main vector of our strategy for preparing for the future.

The main quality of a launcher is its reliability, as it is appropriate to capitalize on the demonstrated technologies of Ariane-5, and in more general terms, on experience acquired in all domains.

Consequently, the horizon for commissioning the new generation of launchers is situated around 2020. But, steps can also be taken to obtain new launchers at an earlier date should the need be identified.

In line with the strategy decided by CNES, two pitfalls must be avoided, firstly a premature choice of technologies which would make it impossible to benefit from further progress, and secondly, non-compliance with the time scale.

Technical innovations are already available, and Vega should consequently be innovative in regard to Ariane-5.

In global terms, future launchers will have a marked resemblance to the launchers of today, but will integrate experience accumulated over the years. The principal quality of a launcher will continue to be its dependability.

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[1] *Vega characteristics are close to the French deterrent force M51 strategic missile.*

[2] *French involvement amounts to € 150 million. CNES is employer for the P80 first stage. Europropulsion and Safran are working on the P80 stage and nozzles, and EADS Astrium on OB software.*

▪ *Concrete initiatives*

ESA set up a program designated FLPP (Future Launcher Preparatory Program) in 2004 for this very purpose. ESA defined corresponding study areas, and signed a number of contracts with the manufacturers, CNES and potential foreign partners.

In particular, a cooperation agreement was signed between ESA and Russia in January 2005, concerning the development of advanced technologies for future launch systems (FLPP).

The URAL program for bilateral cooperation between CNES and Roskosmos is aimed at the identification of innovative technologies for propulsion systems, and association of the technical cultures of Russian and European companies achieved by the construction of ground and flight demonstrators[1].

The work to be undertaken is defined and allocated to the manufacturers on a joint basis by CNES and Roskosmos. CNES is funding the work executed by French and European manufacturers, with Roskosmos funding that conducted by Russian companies. This is the first program not involving transfer of funds between the two countries, since the collapse of the USSR. Progress with the URAL program in 2006 was satisfactory. The program for 2007 is in process[2].

Extension of this cooperation arrangement could be considered necessary.

Furthermore, EADS Astrium has set up a joint company with Finmeccanica under the name NGL (New Generation Launchers)[3] to participate with Italy in the development of new generation launchers on a partnership basis.

In its capacity as coordinator of French and Italian investment, NGL is already involved in the FLPP (Future Launcher Preparation Program).

5. Nuclear propulsion for deep space missions

The time required for interplanetary travel using existing propulsion technologies compromises the feasibility of any such project. While it only takes three days to orbit the Moon starting from a terrestrial orbit, at least six months are required to reach Mars.

The travel time involved increases the logistic problems of human spaceflight, the psychological discomfort of the astronauts, and the physiological impact of micro-gravity and radiation on their health.

New propulsion systems are therefore required, capable of accelerating and braking a spacecraft over longer periods than for the engines existing today. Nuclear propulsion appears to be the best potential technology at the present

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[1] Parliamentary Group for Space and ESA working meeting, Moscow, July 6, 2006.
[2] Parliamentary Group for Space and ESA working meeting, Moscow, July 6, 2006.
[3] Capital interests are as follows: EADS Astrium 70% and Finmeccanica 30%.

time[1], and is the only solution able to diminish the risks of interplanetary travel by reducing transit times[2].

The use of nuclear reactors in space is currently limited to small reactors for generating heat and electric power on board automatic deep space probe explorers.

The example of a nuclear propulsion system reactor developed by the USSR and the Keldish Institute during the 1970s gives an idea of the performance obtained[3]. This motor was based on a simple principle, but was complex to operate from the technological point of view.

The nuclear reactor supplies heat to sublimate hydrogen, which acts as a cooling fluid. Hydrogen raised to a very high temperature is ejected without combustion to provide the propulsive force.

This reactor has thirty-seven fuel assemblies with a uranium carbide base, placed in a core with a diameter of one meter, and fifty-five centimeters high. Hydrogen temperatures are - 250°C at input, and 3,000°C at output[4].

Delivering a thrust of 3.6 tonnes, the engine performed very efficiently for spy satellites, in particular for observation of US submarines. Forty spacecrafts of all types were placed in orbit with this engine. It was abandoned as a result of the political decision to place no further nuclear reactors in Earth orbit.

The USA has also studied nuclear propulsion for deep space missions. The energy density of nuclear reactions makes it possible to obtain very high specific impulse values for propulsion systems, hence the possibility of reaching the periphery of the solar system rapidly and overcoming the weakness of solar radiation. As in the Russian case, the nuclear technology studied is based on the use of heat generated by a small nuclear reactor, to raise hydrogen to a high temperature and eject it via a nozzle.

Work performed in the USA from 1961 onwards, in connection with a program designated NERVA (Nuclear Engine for Rocket Vehicle Application) was aimed at developing a propulsion system for human spaceflight missions to Mars. While the corresponding engines were never launched into space, they were in fact built and tested successfully on the ground[5].

Alongside nuclear propulsion, apparently now shelved, other technologies are being studied at the present time, including ionic and electric plasma motors. Electromagnetic ionic motors and HALL type plasma motors already function satisfactorily, but lack power.

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[1] *Léopold Eyharts, ESA astronaut, Houston, November 3, 2006.*

[2] *Vincent Sabathier, CSIS consultant, Washington, November 9, 2006.*

[3] *Visit to the Keldish Institute, Moscow, October 19, 2006.*

[4] *The thrust/mass ratio of this reactor was seven times greater than that of a liquid propellant engine. Its specific impulse reached 900, compared with an average figure of 600 for existing engines. According to the Keldish Institute, the comparable American engine delivered a specific impulse of only 750.*

[5] *Emmanuel de Lipkowski, Secretary General, Parliamentary Group for Space, Washington, November 8, 2006.*

CNES has not yet initiated an R&D program for onboard nuclear reactors for space applications but should do so in cooperation with the CEA. France and the USA could have privileged cooperation links in this domain, although propulsion itself must always be handled at European level.

Given its incomparable attraction for deep space missions, R&T programs on nuclear propulsion should be initiated as rapidly as possible at European level.

II – SPACE AT THE HEART OF DEFENSE AND SECURITY, WITH OR WITHOUT EUROPE

1. The security-defense and military space sectors

▪ *Interconnected domains*

To define the various components of the space sector in terms of defense and security, as also in military terms, with precision, the UNO vision is a useful reference.

The broadest concept is that of security, this being concerned with the global stability of a society, including the protection of persons and property, environmental security, civil security and also defense. Numerous security functions in France are militarized, such as maritime security and the gendarmerie (national guard).

Apart from combating external aggression and protecting national interests in metropolitan France and overseas, defense has a number of dimensions including the fight against terrorism, all types of trafficking and uncontrolled immigration.

The military context is limited to action by the armed forces against external threats.

We have here a Russian doll notional situation, with security containing defense, and defense containing military action[1].

For security, as for defense and military action, the space sector can provide a substantial value added contribution.

▪ *The military space sector*

The military space sector includes a number of types of program, ranging from telecommunications, armed forces management systems, and also the acquisition of information concerning potential threats, to systems for attacking terrestrial or space objectives from space.

Implementation of these four types of program is unequal, but moving forward rapidly in time[2].

At the first level, the military space sector is first and foremost concerned with the use of ***space-based solutions*** by the armed forces for

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[1] *General Bernard Molard, Vice-President Defense and Security, EADS Astrium, CEPS (Strategic Prospective and Study Center) debate, October 25, 2006.*

[2] *Pascale Sourisse, President of Alcatel Alenia Space, CEPS (Strategic Prospective and Study Center) debate, October 25, 2006.*

telecommunications, observation, navigation and all types of electromagnetic signal listening watch. These non-aggressive resources are used widely by the USA, and on a much smaller scale by various European countries, by Russia and at different levels by the new space powers.

Military operations involve space to a greater and greater extent, with space becoming a key to operations by increasing the capabilities of the armed forces[1]. The NWC/NCO (Net Centric Warfare/Net Centric Operations) concept adopted in the USA, has led to multiplication of the bandwidth per individual involved in the conflict by one hundred between 1990 (first Iraq war) and 2004. By means of massive investment, the USA has succeeded in reducing the time between acquisition and redistribution of, and access to information to one minute.

At the second level, the military sector is also concerned with ***defense against threats*** from space, using early warning and ballistic or tactical missile interception measures. The initial components of this second level are already operational in the USA, and doubtless in Russia too. Nevertheless, considerable progress is still required before all types of threat can be covered.

At the third level, the military space sector includes not only the protection of national ***space systems***, but also neutralization or destruction of enemy systems[2]. Secrecy regarding this domain is quasi-total. However, there can be no doubt that "killer" satellites have already been tried out, and that the major powers possess this tool.

At the fourth level, the military space sector is concerned with ***attack***, using in-orbit systems to treat air, marine or terrestrial targets. This domain is also opaque, although implementation is still coming up against major technical difficulties which do not yet appear to have been overcome.

▪ *International treaties*

Contrary to what one may think, international treaties have a place for the military space sector. The 1967 space treaty, now signed by a total of 102 countries, cannot be described as being particularly coercive.

The non-aggressive use of military satellites is authorized. The signatory States are free to set up space systems, including military systems. Antimissile weapons are not illegal. The only genuine limitation concerns nuclear weapons which are banned from space.

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[1] Sensor networks are used to collect information which is then collated and analyzed before being redistributed. Thus, each player sees everything that all the other players see, in the same way as maritime warfare systems, where all the ships see what the radar systems of all the other ships see. The infantry man in the field sees aerial views taken by satellites or drones, and reprocessed information enabling him to know the state of the enemy forces on a nearby hill.

[2] Introducing the new American space policy in July 2006, Donald Rumsfeld, Defense Secretary, indicated that his number 1 objective was to avoid a "space Pearl Harbor". In this situation, the Defense Secretary considers it vital to strengthen the protection of US space-based capabilities.

2. Massive US investment in the military space sector

The Department of Defense space budget for 2006 is estimated at between $ 20 and 25 billion, with uncertainty concerning secret programs, by definition difficult to quantify in detail.

The American investment budget in favor of the military space sector has exceeded the NASA budget since 1999. This was already the case between 1982 and 1994, following the strategic defense initiative introduced by President Reagan.

The ambition of programs set up since 1999, and the extent of the strategic changes initiated following the first Gulf war, make it likely that the anticipated 30% increase in the American military space budget between now and 2012, will be substantiated.

A. THE MILITARY SPACE SECTOR AT THE HEART OF THE AMERICAN ARMED FORCES

▪ *The unwavering direction of American policy*

Far from being innovative, the new American national space policy (NSP) resulting from a Presidential directive published in July 2006, merely puts into words the space dominance policy initiated in 1997.

This policy is based, as regards defense, on four pillars: recourse to the space sector as a multiplying factor for the armed forces by means of space-based information, monitoring of the adversary and optimized application of national forces, partnership with civil applications, and control of space for the purpose of guaranteeing or prohibiting access.

American national space policy is unilateral. The USA claims total freedom of action and the right to prevent access to space, for example for "maverick States", access to space being as important as air or sea power. On this basis, the USA withdrew from the ABM (Anti Ballistic Missile) treaty in 2002 so as to have total freedom of action.

In the theaters of operations in Kosovo, Afghanistan and Iraq, space forms part of the panoply of the American combatant. The deterrent approach has been rethought, and the objective is domination of battlefield information.

In more general terms, the development of space-based weapons has been integrated in American strategy.

▪ *The all-purpose military space sector*

Current American doctrine is the result of two post-cold war reviews.

The conclusion that the cold-war arsenal was inappropriate for localized wars and their new tactical functions, was reached at the time of the first Gulf war.

New resources were consequently developed. The second Gulf war placed the space sector at the heart of military operations, and strengthening of the preceding directions adopted was then decided.

This involved developing hardening telecommunications capabilities. Furthermore, emphasis was also placed on the deployment of acquisition systems.

A consequence of the decisive importance of the space sector, dependence on this sector had to be corrected by protection of space infrastructures. There is no doubt that if protection systems can be operational, they will be set up.

B. A PERMANENT SEARCH FOR A TECHNOLOGICAL LEAD

The development strategy adopted for the American military space sector involves developing innovative technologies, irrespective of the risks taken, cost-related considerations being of secondary importance despite becoming more and more evident. Following this approach, major technological risks can have an extremely beneficial consequence, namely a lead of a one generation in technological terms.

▪ *Civil and military meteorological activities merged in NPOESS*

The civil (POES) and military (DMSP) program meteorological satellites will reach the end of their service life in 2009. This is why the US Congress has called for their replacement with the emphasis on reducing corresponding expenditure.

The NPOESS (National Polar-orbiting Operational Environmental Satellite System) program is designed to obtain convergence between the civil and military Earth observation space programs in the broadest sense, in a unified national program[1].

The NPOESS program covers the atmosphere, the oceans, dry land and the space environment. NASA is responsible for development, while NOAA (National Oceanic and Atmospheric Administration) is the operational agency, the function of which is close to that of Eumetsat.

The NPOESS system will comprise four satellites, compared with six initially, and will be assisted by the European satellite Metop for the morning and afternoon orbits.

The use of non-American capacities is a direction adopted by NOAA which has come under criticism from Congress.

Launch of the first satellite is scheduled for 2012, and the system should reach its initial operational capacity in 2014 and full capacity by 2016.

[1] *Jean-Jacques Tortora, the American Space Program, Governmental Strategy and Industrial Prospects, CNES, I-Space–Prospace, 2006.*

The total cost of the NPOESS system is currently estimated at $ 11.5 billion.

▪ *The revolution in military space telecommunications*

The American armed forces use two telecommunications systems, one protected and the other not[1].

The unprotected DSCS program was launched in the 1969s, and has undergone three successive upgrading phases.

There have been various versions of the protected systems, namely AFSAT followed by FLTSAT and UFO, and finally MILSTAR.

Their successor, designated AEHF (Advanced Extremely High Frequency), will use three to four satellites to provide high security links at transmission rates more than ten times greater for ground-satellite links, and six times greater for satellite-satellite links. The first AEHF satellite should be launched in 2008, the second in 2009 and the third in 2010, with a total investment cost of $ 2.1 billion.

An intermediate program, designated WGS (Wideband Gapfiller Satellites) with three satellites operating in the X and Ka bands, has had to be set up to cover the transition phase between MILSTAR and AEHF.

However, further progress is in preparation with the TSAT (Transformational SATellite) program, designed to serve as the pivot for the new network warfare approach (Network Centric Warfare).

TSAT will comprise a space-based Internet network using laser links between the ground and satellites, and between satellites, based on a constellation of six satellites with one backup. Delays have been experienced in development of the TSAT program since its initiation in 2003. The cost of this program is estimated at $ 16 billion. Production should be decided in 2008, with an initial satellite launch in 2015.

▪ *The GPS system, subject to constant upgrading*

The GPS system is of key importance for the American armed forces, satellite guided munitions and weapons being omnipresent in their arsenal.

This is why GPS, operational since 1994, is constantly being upgraded with replacement of the twenty-four satellites by successive blocks.

The eight launches of the GPS IIR-M block since 2005 have led to an increase in signal power and resistance to jamming, and also the introduction of new military codes and a second civil signal.

The sixteen launches of the GPS IIF block as from 2008 will introduce a third civil signal, accompanied by further improvement in resistance to jamming.

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[1] *Hervé Bouaziz, ICA, Department of the Military Attaché, French Embassy in Washington, November 6, 2006.*

The Department of Defense plans to launch the GPS III block satellites as from 2013, to enhance the dependability, availability, precision and hardening of the signal, and make GPS compatible with Galileo.

Block IIF of the GPS program is currently being supplied by Boeing, with sixteen satellites with a lifetime of twelve years scheduled for launch between 2008 and 2014.

▪ *Listening watch and early warning functions*

Listening watch programs, managed by the National Security Agency (NSA), as also reconnaissance programs, are under the seal of secrecy[1].

Monitoring is provided by the DSP system, which will be replaced by the SBIRS system (Space Based Infrared System) for early detection of missiles.

Initially planned with five geostationary satellites and two sensors in elliptical orbit, the system has since been reduced to two or three satellites. The two elliptical orbit sensors were delivered in 2004 and 2005. The first geostationary satellite will be launched, following a substantial delay, in 2008.

Preempting the wishes of the Pentagon, the US Congress has demanded immediate preparation of a new program based on new technologies, to take over from SBIRS.

Another flagship program of the years to come, Space Radar is an all-weather radar observation and mobile monitoring system. Its purpose is real-time guidance of missiles to mobile targets.

The Space Radar system was initially planned with twenty-one satellites in low orbit, plus a number of satellites in MEO, but was finally reduced to nine satellites in 2005. The cost of the program is currently estimated at $ 34 billion. Development commenced in 2004 and demonstrators should fly in 2008-2009. The first satellite should be launched in 2015, and operational capacity achieved in 2025.

Thus, the US Department of Defense has established a permanent, unrestricted technological surge forward, to enhance the contribution of the space sector to the actions of the land and naval forces, and also, logically, to protect these same systems against hostile activities. The various programs are ambitious and consequently costly. Cost drift recorded for the majority of the programs has led to the inclusion of enhancement of the management process for military programs and commands, in the objectives of the new national space policy.

[1] *Hervé Bouaziz, ICA, Department of the Military Attaché, French Embassy in Washington, November 6, 2006.*

3. Russian, Chinese and Indian investment

▪ *The Russian military space sector, a worthy heir to its Soviet predecessor*

Revitalization of the Russian space sector over several years, while benefiting the civil space sector, has the same effect on the military space sector which monopolized the greater part of Russian space-related expenditure during the dark years following the collapse of the Soviet Union. Launches for military purposes still represent half the number of launches made annually by Russia to meet its own needs.

It is estimated that of the total of seven Soviet space systems, six have been maintained in service[1].

Only the early warning terrestrial radar calibration and space monitoring system appears to have been abandoned.

Optical observation is thus provided by at least three military observation satellites, with one satellite monitoring the oceans.

Military telecommunications are based on four medium-power satellites and seven small satellites.

The electronic listening watch function is provided by a number of satellites of relatively antiquated design.

The Russian military satellite navigation system comprises two components, the Parus constellation and, in due time, the Glonass constellation. The latter comprised seventeen satellites at the end of 2006, and will have a total of twenty-four when the system is commissioned in 2009.

Two satellites in low orbit, and one geostationary satellite form the early warning system[2].

▪ *Chinese presence in the military space sector*

China is investing heavily and making rapid progress in the launcher, satellite and human spaceflight domains.

China also possesses its own military telecommunications and electronic listening watch satellites. Its Beidu positioning system also has a primarily military vocation.

The search for offensive space capabilities has already produced results. China successfully "dazzled" an American spy satellite in 2006, indicating the likelihood of efficient location capabilities and efficient utilization of a powerful laser.

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[1] *Christian Lardier, Air & Cosmos, January 12, 2007*
[2] *Christian Lardier, ibid.*

China stunned military and political circles when it confirmed the in-orbit destruction of one of its meteorological satellites in 2007, using a ballistic missile fired from Chinese territory.

This event was decisive in numerous ways. Until then, only the USA and Russia were reputed to be capable of achieving a technical exploit of this nature.

Whether China achieved this success with technologies acquired outside its frontiers, or using its own resources, is equally disturbing.

If technologies of non-Chinese origin were used, this signifies that they are accessible in the international marketplace and, why not, by other powers.

If it is a matter of national technologies, then China has progressed even further than one could have supposed.

Interception of a satellite in orbit requires particularly sophisticated skills in terms of locating the satellite, as also the velocity and guidance of the missile, with particularly rapid and efficient actuation of the missile's flight parameters.

The method used to destroy the satellite also gives rise to two other causes for concern.

If the satellite was destroyed by exploding a charge in the close vicinity of the satellite, then a large number of debris would have been disseminated in space, constituting a danger for the satellites of other countries.

If the satellite was destroyed by the mechanical impact of a "killer vehicle", then control of the terminal approach phase must have been extraordinarily precise. In this case, Chinese mastery of the corresponding technologies is an enormous surprise, and will motivate accelerated efforts on the part of the other space powers.

4. Other countries in the process of acquiring military space resources

We know that India, South Korea and Israel have been investing in the military space sector for many years.

The dissemination of military space technologies to many other countries is in process.

North Korea has developed its own launchers, and is supplying these to its foreign partners. Its failures in the intercontinental missile domain are only temporary.

Iran will rapidly be in a position to place satellites into orbit, for which the applications will be numerous although primarily military, using its own resources with the aid of imported technologies.

Faced with these developments, France must accelerate its investment, also acting as a motive force for the hard core Member States of the European Union.

5. Inadequate and threatened development of the French military space sector

A. THE ABSENCE OF EUROPE CANNOT JUSTIFY IMMOBILITY AT NATIONAL LEVEL

While France is European leader in the military space sector, with the largest defense space budget in Europe at the present time, national military planning does not appear to regard the military space sector as a priority domain, in contradiction of the repeated declarations by the Minister of Defense.

New operational capabilities must be provided for the forces in the field, in particular in the context of offshore operations.

France must enhance its national capabilities, while participating at the forefront of European projects, as discussed below.

B. MANDATORY DEVELOPMENTS

The most important element is not the satellite but operational information[1]. This is dependent on observation sufficiently precise to make reconnaissance possible.

A very strong increase in telecommunications needs has emerged in theaters of operations. Fifty percent of the capacity of Syracuse 3 B has already been taken up.

▪ *Syracuse-3C for rapidly increasing military telecommunications needs*

Military satellite communications (SATCOM) demand is exploding. Despite the existence of the Syracuse-3A and 3B telecommunications satellites, coverage needs and supplementary capacities will make an additional satellite (Syracuse-3C) essential as from 2010-2011[2]. France must order this satellite without delay.

Hardening of Syracuse-3C and its ability to resist jamming from the ground or space, must be further enhanced by comparison with its predecessors.

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[1] *Rear-Admiral Guy Poulain, CEPS (Strategic Prospective and Study Center) debate, October 25, 2006*

[2] *The first satellite covers a zone from the Atlantic to India, and the second the Pacific zone. The third Syracuse satellite will cover the rest of the world, and serve also a backup resource to ensure that two satellites are in service at all times.*

▪ *Helios-3 for continuity of and progress with optical observation*

France possesses long-standing and first class expertise in the HR observation domain, including essential military applications.

The Helios-2A satellite is already in orbit and Helios-2B will be launched in 2008-2009.

It is already time to prepare for the successor to Helios-2B, aiming at a resolution of at least 20 cm per pixel with a generous swath width. Studies for Helios-2 have now been completed.

Studies for Helios-3 must consequently be initiated without delay as from 2007, reproducing the Helios-2 virtuous project, studies for which were commenced immediately after the Helios-1 launch.

6. Europe and space for security

A. EUROPE'S MILITARY SPACE SECTOR GAP

Europe is engaged in various programs for the non-aggressive military utilization of space, in particular in the areas of telecommunications and Earth observation. Listening watch and early warning projects also exist.

The limits of European commitment are frequently numerous. There is no European program, but rather a juxtaposition of national, bilateral or at most trilateral programs. Five European countries have military space telecommunications systems, but all five systems are different from the others. The three observation programs were decided separately.

Nevertheless, there are signs of positive change. The joint tender submitted by France, the United Kingdom and Italy for the new NATO telecommunications system won the contract. Data exchanges are planned in the Earth observation domain. While there is no European defense policy, there can be no European military space policy. Nevertheless, the European Defense Agency (EDA) is taking an interest, although its resources are limited to fewer than one hundred staff and a budget of only € 5 million.

In global terms, the European gap is consequently considerable.

As a whole, European military space sector expenditure represents 1/20th of comparable American expenditure.

This difference naturally stems from the weakness of overall European military spending which, for all European countries together, represents only one-third of American military expenditure, but also and above all the weakness of the role assigned to the space tool in the context of national military outlay. Taken separately or together, the Member States of the EU are just not aware of the strategic value of space.

B. METHODS TO BE ADOPTED

▪ *Mutualization*

The proliferation of European systems is favorable as regards sales in the short term, but is penalizing in the longer term as regards profitability and prospects for development. Furthermore, as in the case of any industrial activity, there is a critical size in the space sector for obtaining the benefit of scale effects. The dispersion of existing systems makes this impossible to achieve.

Furthermore, the mutualization of systems induces an enhanced quality of service. Satellite fleets secure the services provided, both in the event of a launch failure or the failure of a given satellite.

Mutualization also induces a reduction in service prices. This in turn stimulates growing demand.

▪ *Duality*

Typically military space activities exist, such as heavily protected telecommunications for example. However, the majority of space applications are of a dual nature[1].

These include Earth observation, as civil applications also exist for very high resolution images. Navigation is dual by definition, insofar as the American GPS was first of all a military application before being open to civil users, and where Galileo, designed for civil purposes, should also meet military application needs.

Space science is developing technologies which are subsequently used by both sectors.

In the telecommunications domain, a civil payload and a military payload having neighboring missions can coexist on the same satellite platform[2]. Segregation on board the satellite is justified by the dedicated functions involved, for example protection against jamming for a military payload. Priority for military applications must be ensured in a time of crisis, and their coexistence on the same platform with institutional applications is preferable to that with commercial applications.

Civil applications can serve military applications and vice versa, and it is appropriate to avoid total separation between civil and military. Priority should be accorded to civil applications having a security function in order to increase new capacities.

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[1] *Joël Chenet, Senior Vice President, Alcatel Alenia Space, hearing of October 5, 2006.*

[2] *This was the case with the French Telecom-1 and 2 satellites, and is the case at the present time with the Koreasat-5 satellite launched in 2006.*

▪ *System ownership, an obsolete concept?*

The question of the ownership of European space tools should be regarded as obsolete. In this respect, it is to be applauded that Galileo is a mutualized system. Likewise, Paradigm opens a new domain, that of capacities and services guaranteed for a given entity, the British Government, while excess capacity can be sold to allied governments[1].

C. THREE CONTEXTS FOR EUROPEAN DEFENSE SPACE SECTOR COOPERATION

The security and defense space sector should be developed at various levels, adopting a segmented approach.

The first context is that of NATO which, frequently forgotten, is nevertheless the natural and effective framework for military cooperation between the European armed forces.

The second context is that of the European Union taken as a whole. However, this level of cooperation is limited in two ways, by the lack of interest in the space sector by a number of Member States, and the fact that at least eight Member States are required to enter the reinforced EU cooperation dimension.

A third context is therefore required, that of multilateral cooperation outside the European Union.

▪ *The position of NATO*

Whether one likes it or not, Europe has a defense tool in the shape of NATO, which is indeed the only one of its kind.

NATO does not possess autonomous space-based assessment and action resources. Many countries consider it pointless to provide NATO with these, as they are already provided by the USA.

Numerous exchanges of information in the space domain already exist between NATO members. For example, in the area of monitoring, the French Navy and US 6th fleet are cooperating in the monitoring of the flow of immigrants via the Canary Islands.

It is necessary for the EU Member States to take an initial step forward, namely to achieve the interoperability of their military telecommunications systems, and first and foremost between the French Syracuse, British Skynet and Italian Skymed systems.

Following the success of the Franco-Italo-British consortium in the face of an American rival, in winning the contract for the supply of satellite capacities to NATO, a second appropriate project for the European defense space sector could

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[1] *Gilles Maquet, Senior VP, Institutional Relations, EADS Astrium, CEPS (Strategic Prospective and Study Center) debate, October 25, 2006.*

be the creation of a dedicated security and defense telecommunication space segment, to be made available to NATO and UNO[1].

▪ *Security, a sphere of action for the European Union space sector*

At European Union level, it is clear that not all Member States are examining the question of European defense to the same degree, and even fewer the role of the space sector in this domain.

Europe can consequently have no other ambition than that of security at the present time.

On the other hand, the demand for security is very strong in Europe. There are consequently prospects for major development in this area, the more so as the European administrations and national civil agencies possess their own investment potential. It is encouraging to note that France will have the necessary means to exploit space-based security tools, as the French military are familiar with security operations.

Another objective, one which could be easily shared between the EU Member States, namely autonomy in terms of military space technologies, could be set as a priority objective.

▪ *Multilateral cooperation in the space sector monitoring and listening watch domains*

Initiatives in the military space sector in Europe are fragmented. However, this situation is not inevitable. It will be possible to federate investment based on new satellite generation.

Space monitoring and listening watch applications could be handled at the second level of military space sector development in Europe, namely multilateral cooperation.

Thus, listening watch satellites could be he subject of strengthened multilateral cooperation, given the community of global interests and the particular determination of certain Member States to acquire independent resources in this domain.

Space monitoring, namely the identification of threats against one's own space-based infrastructures, is also a domain where a number of European countries could initiate multilateral cooperation arrangements.

As civil space services develop, a new form of vulnerability is appearing which endangers national security[2]. Interruption of meteorological or bank transfer services for example, constitutes a particularly serious threat which could come from any direction. The initiatives of the various space powers must

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[1] *Professor André Lebeau, hearing of October 5, 2006.*

[2] *Admiral Benoît Montanie, Defense and Security Adviser to the President of Alcatel Alenia Space, CEPS (Strategic Prospective Study Center) debate, October 25, 2006.*

consequently be monitored, and controlled where appropriate[1]. The objective is to be able to go to the point of denying freedom of action to the adversary.

In the words of Clausewitz: *"Who holds the high ground also holds the low ground"*. Autonomous access to space must be guaranteed. Furthermore, space monitoring must ultimately include advance warning, a vital necessity for protecting European capabilities.

D. A REALISTIC EUROPEAN MILITARY SPACE SECTOR DEVELOPMENT PLAN

Closing the gap between Europe and the USA is not something which can be achieved rapidly. One can even ask the question as to whether it is desirable, given the differences in terms of worldwide engagement of the EU Member State forces and those of the USA.

Nevertheless, the motivating effect of military space sector investment is substantial, both on the technologies themselves, specialized industries and industry in general.

It is consequently appropriate to initiate buildup of European military space sector investment which is both realistic and determined.

▪ *Rapid reduction of the gap between Europe and the USA*

Annual investment in the military space sector in Europe is of the order of € 950 million.

The figure for France in 2005 was € 416 million, with € 285 million for the United Kingdom, € 129 million for Germany, € 87 million for Italy and € 22 million for Spain[2].

Thus, European defense space sector investment corresponds to 1/20th of the official US annual military space budget of $ 20 to 25 billion.

Multiplication of European investment is essential. This would make it possible to cover a substantial range of space segments, as a result of the efficiency of European industry, less accustomed to budget overruns than its transatlantic counterpart.

European industry has conducted a positioning and costing exercise which has the advantage of proposing objectives which are attainable.

The first task is to stiffen up the traditional observation and telecommunications programs.

But it is also a matter of investing, in navigation, SIGINT (SIGnals INTelligence) listening watch and early warning facilities from now on.

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[1] *Admiral Benoît Montanie, Defense and Security Adviser to the President of Alcatel Alenia Space, CEPS (Strategic Prospective Study Center) debate, October 25, 2006.*
[2] *Antoine Bouvier, President, EADS Astrium Satellites, hearing of November 15, 2006.*

▪ *Preparing the new generation of observation satellites*

Europe is in a relatively optimized position in the military observation domain. In view of existing specialization in Europe, France, as European leader in the optical observation field with SPOT, Helios and shortly Pleiades, does not wish to recreate domestic radar expertise, whereas Germany and Italy have clearly decided to invest in this domain.

Europe is proficient in post-Helios very high resolution technologies, with performance close to that of the USA, the next step being situated in the drones and aerial reconnaissance domain.

Specialization by country is a sound solution in strategic terms. To balance specialization in optics in France for the next fifteen to twenty years, a joint approach to the architecture and definition of forthcoming space missions, and the merging of ground segments and procedures for utilization of the data gathered, is essential.

The immediate task should be to study architecture, missions and post-Helios, post-Sarlupe and even post–Terrasar-X[1]systems.

▪ *The challenge of interoperability and mobility for military telecommunications*

The only European military telecommunications program is that supplied to NATO.

However, the most efficient procedure would be to pool telecommunications capabilities via a single operator. Thus, the pooling of satellite fleets which would make their optimization possible, and the need for a common interface for all operators, would prepare convergence of the requirements of the various countries, and the subsequent merging of different programs in one.

The savings in resources resulting from non-duplication of conventional satellites could be used for highly protected applications for small HR receivers.

A European project similar to Lockheed Martin's MUOS (Mobile User Objective User) project concerning HR communication for mobile forces in an extended theater of operations, could be envisaged..

Progress is consequently necessary both in regard to joint programs and mobiles.

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[1] *The aim of Terrasar-X is to supply radar images of Earth with resolution down to 1 m. The Terrarsar-X satellite is scheduled for launch from Baikonur at the end of February 2007.*

▪ *ELINT and COMINT listening watch systems, a new field for development*

The ELINT (ELectromagnetic signals INTelligence) systems are designed for detection, designation and location functions for fire-control and search radars, for the purpose of monitoring, preparing actions and radar mapping.

ESSAIM is a listening watch demonstrator, the purpose of which is to meet the requirements of the armed forces which have made an ELINT system their number 2 priority for the post-Helios era, which will be subject, as we have already seen, to a capability gap. The ELISA demonstration program for an ELINT listening watch system is being co-funded by the DGA and CNES.

Low orbit and high orbit telecommunications listening watch, in line with the COMINT (COMmunication Intelligence) system, is an additional objective.

▪ *PRS*

The second priority in terms of new security applications will be the effective utilization of the Galileo PRS signal.

▪ *Early warning*

Early warning is the first technological brick in an antimissile defense system. A system of this type is relevant, on the one hand for monitoring non-proliferation agreements in regard to missile test firings, and on the other, for strengthening deterrent measures.

The potential aggressor during the cold war was known. With the proliferation of weapons of mass destruction and ballistic missile capabilities, the potential aggressor can no longer be identified. Deterrent measures only work if the potential aggressor knows it will be identified.

Placing security in the front line of its priorities, Europe must invest in early warning space technologies.

▪ *The vulnerability of the space sector*

The vulnerability of the military space sector is less than that of the other forces, but does exist. The space sector is indeed only vulnerable in regard to other space powers, each of which has its own degree of vulnerability.

Protection against threats is situated at a number of different levels.

The first level is diplomatic, in particular with ratification of treaties prohibiting weapon systems in space. The second level corresponds to detection of the aggressor, and the third to its identification. The fourth level is the ruggedness of the defense against threats, and the fifth is the ability to retaliate.

Once the development priorities have been covered, it will then be necessary to invest in protection of space-based resources old and new.

▪ *Transition from € 1 billion to € 2 billion to begin to close the gap with the American military space sector*

If we total the sum of European military space sector ***requirements***, the investment necessary to meet them is an annual € 2 billion.

It should be remembered that current investment, slightly below € 1 billion covers less than half these requirements, and that the USA invests over $ 20 billion annually in its military space sector.

An annual investment of € 2 billion would provide Europe with a minimum platform ensuring strategic autonomy, and strengthening its operational effectiveness.

Taking due account of current budget constraints, this amount, validated by industry, would make it possible to maintain space technologies at a sound level. The choice of ruggedness and simplicity, and reduction of the mass of instruments and satellites alike, would generate savings and make it possible to build technological demonstrators and achieve satisfactory performance for each operational program.

A program of this type is essential to provide a workload for teams currently tending to disperse towards other sectors, such as the aeronautical sector, so inadequate are prospects at the present time.

III – REVITALIZATION OF SPACE SERVICES TO AVOID TECHNOLOGICAL DISENGAGEMENT

Space is an incomparable source of information and services. An ambitious space policy should cover all domains: science, telecommunications, radio and TV broadcasting, navigation and monitoring of the environment.

No type of application must be sacrificed. There is no place for a leading space power which chooses to restrict space to the service of science. Nor is there any place for a leading space power which focuses solely on service applications.

A space policy must target all these interdependent objectives with an equally dynamic approach, at the risk of rapid technological disengagement.

1. Space science

One of the priorities of CNES is to participate in the most effective way in the mandatory scientific program of the European Space Agency, in particular through the supply of instruments. This is a priority shared by all partners.

CNES is also engaged in bilateral or multilateral scientific programs, as also a number of national programs. All partners in these programs seek their optimization.

▪ *The incomparable contribution of space to our knowledge of the Universe*

Space science is of capital importance in regard to knowledge of the Universe. The supporters of the Hubble project have gone so far as to affirm, with scarcely exaggerated enthusiasm, that this telescope has delivered more knowledge of the cosmos than all other instruments together.

Space investigation tools supply information which cannot be obtained on Earth. However, their integration with terrestrial observatories, such as the VLT, is obviously narrow, with the development of astronomy and astrophysics, and other observation resources such as balloons which continue to be relevant.

Study of the planet Mars is of critical importance in the context of space science programs. If we are to believe that life once existed on Mars, then the study of its appearance and disappearance is a capital subject.

In the same way, fresh progress will be possible with the COROT satellite, the mission of which is to identify telluric exoplanets differing from the gas giants which we already know so well.

Space science and its research targets which are of such great importance, thus contribute to the fundamental quest of the scientific approach. The Mars Express and Venus Express, and Huygens and Smart programs conceal extraordinary potentialities.

▪ *The capital role of international cooperation*

The majority of CNES scientific space activities are part of the ESA mandatory program.

The CNES 2005-2010 multiannual contract cannot be implemented without international cooperation.

For example, CNES coordinates the technical construction of the Altika new generation oceanographic altimeter, but cannot take on responsibility for the platform. Altika will consequently be integrated in a satellite launched by India.

The French space sector cannot do without international cooperation, in particular for exploration.

2. Investment in new generation space telecommunications

▪ *Growing needs*

The upturn in satellite sales in 2006 was a fact, but did not reach the high levels of 2000 and the next few years (25 to 30 satellites annually). The real problem of the moment is that of prices, pushed down by international competition and unfavorable exchange rates. The USA manufactures and works in dollars, whereas Europe pays its costs in euros and bills in dollars. This has a serious consequence in that the satellite activity generates no profit with a resultant R&D funding problem.

Nevertheless, satellite telecommunications are destined to develop rapidly, given their essential role in a range of different applications.

The GMES program will involve substantial telecommunications capacities for data collection, processing and transmission. The GMES systems will consequently, in all probability, require relay satellites.

Space-based monitoring is necessary for efficient operation of the defense tool and civil security, and will require increased telecommunications capacities.

Space telecommunications are the only factor capable of reducing the digital gap in many regions. In this regard, the satellite + WIMAX solution, operating with local networks connected to the satellite via a head end, is destined for a flourishing future.

▪ *Space frequencies in danger*

New perils for the satellite telecommunications frequencies are emerging[1].

The terrestrial systems – 4G mobile telephony, WIMAX/BLR (Internet wireless High Rate technology), UWB (Ultra-Wideband) for computer connections and UAV (Unmanned Aerial Vehicles) – generate considerable

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[1] *Marc Pircher, Chief Technical Officer, Alcatel Alenia Space, hearing of October 4, 2006.*

frequency demand. This covers satellite bands for scientific applications, telecommunications and even radionavigation.

France must take care to hold onto the frequencies already assigned, and encourage the allocation of new frequencies for future satellite telecommunications systems.

Frequency bands are generally allocated for the lifetime of the satellite concerned, and are well protected once assigned. This is why it was so important to launch the GIOVE-A satellite before the end of 2005, to maintain the allocation of frequencies to Galileo. But it is difficult to extend the bands already allocated at their limits. The French space sector must take steps to position the satellite in 4G mobile telephony insofar as frequencies are concerned.

The World Radiocommunications Conference (WRC) of the International Telecommunications Union (ITU) must take major decisions in this respect at the end of 2007[1]. To counter pressure from the terrestrial systems, it will be necessary to switch from a strictly defensive position as at the present time, to an offensive position based on new technologies and services. In the long run, it is governments which must defend national positions.

3. Support for the development of new radio and TV broadcasting markets

Europe has not yet come to terms with the phenomenon of community digital radio and TV, as is developing in the USA.

These markets are destined to expand, insofar as fragmented modern societies, where the individual is increasingly isolated, must establish social links.

The European Union has a part to play in the infrastructures which could be made available to groups or associations sharing a common cultural or leisure project.

Likewise, mobile TV continues to encounter pronounced skepticism on the part of many authorities, whereas it has already come to stay in countries open to new technologies such as Japan.

Here again, it is up to the European authorities to invigorate these applications, promoting programs which induce genuine value added for the European population.

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[1] *The WRC meets every four years, with an intermediate session every two years. The decision-making process involves special groups which examine frequency spectrum capacities and possible sharing arrangements between operators and systems, and arbitrate any disputes.*

4. Accelerated commissioning of the Galileo navigation system

A. AN EXPLODING NUMBER OF NAVIGATION SYSTEMS IN THE WORLD

Based on the example of the American GPS system, other navigation systems are about to appear in considerable numbers throughout the world. Following Russia which is developing the Glonass system, China has commenced the construction of its Beidu system and India is also planning to launch its national system.

▪ *The Russian Glonass system in course of completion*

Following a one-third increase in allocated budgets, the Russian Glonass System should be fully operational by the end of 2007 with 18 satellites, when the last 5 have been launched to complete the constellation. According to certain sources, Glonass will only operate at full capacity with 24 satellites, a configuration called for by President Putin and which should be reached in 2011.

▪ *The Chinese Beidu system*

Officially, the Chinese Beidu (Great Bear) three satellite positioning-navigation system has no military vocation.

In truth, the creation of a national navigation system meets the objective of autonomy with respect to the GPS system, operation of which, as we know, can be degraded or interrupted by the USA in a given region.

In the event of a generalized conflict, it is to be feared that one of the priority actions of an aggressor would lead to the destruction of the positioning system of its adversary. In contrast, in the case of a regional conflict, a national system provides guaranteed autonomy.

The Chinese Beidu positioning system already appears destined for military applications, despite its limited resolution (30 m). Apparently, receivers have already been distributed to the Chinese Army as equipment for units of about ten soldiers.

▪ *The Indian system project*

India is planning to set up its own navigation system based on seven satellites. However, this does not prevent it from proposing its services for Galileo, pointing out that it could reduce the global cost by supplying certain components at competitive costs.

India is in a hurry to acquire an efficient system and has doubts concerning the availability of Galileo. It plans to cooperate with Russia for the latter's Glonass system.

B. ESSENTIAL ACCELERATION OF THE GALILEO PROGRAM

The Galileo program involves a number of steps which, following the creation of the EGNOS system and the GIOVE-A launch essential for the reservation of frequencies, are encountering successive delays.

The first European step in the direction of positioning-navigation systems, the EGNOS (European Geostationary Navigation Overlay Service) system enhances the availability and precision of the GPS signal, and gives warning of any eventual degradation of this signal. EGNOS was commissioned on schedule in 2005.

The GIOVE-A[1] satellite was launched at end 2005, at the deadline date for reserving frequencies for Galileo.

Still to launch are GIOVE-B, and above all the 26 satellites of the operational constellation.

▪ *Delays with Galileo*

Initially scheduled for 2008-2010, commissioning of the Galileo system will now probably take place in 2011-2012[2]. The first phase, involving four satellites, will make it possible to acquire partial validation of the Galileo concept and the actual Galileo system[3]. The order for the four initial satellites will be followed by one for a further 20 to 26 satellites.

Delays are accumulating dangerously for a number of reasons. The first appears to be of a technical nature, resulting from difficulties encountered with the satellites themselves. The second stems from the complexity of the structures set up to initiate and manage the project.

However, this delay is also due to two key questions, the subject of arduous negotiations, namely responsibility and the PRS (Public Regulated Service).

▪ *Shared responsibility*

As regards the risks to be hedged and responsibility, the task is to establish the respective responsibilities of the EU and the concession company, for example in the event of an air crash due to a system failure.

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[1] *GIOVE-A, built by Surrey Satellite Technology Ltd UK, was placed into medium Earth orbit (MEO).*

[2] *Report of the National Academy of Aeronautics and Space (ANAE), presentation by Gérard Brachet, June 19, 2006..*

[3] *Complete validation of the system requires ten satellites.*

▪ *The key to the PRS, a strategic question*

The PRS (Public Regulated Service) which could be supplied by Galileo with a substantial degree of protection against jamming or degraded performance, at the exclusive service of the European Union Member States, is the subject of animated discussions concerning its financial and strategic implications.

Introduction of the PRS would justify increased public participation in funding of the project, on which subject agreement has not yet been reached.

Furthermore, a number of Member States are opposed to the very principle of the PRS, reflecting concern expressed by the Americans. Indeed, as Galileo is destined to include a large number of members, the USA fear that Europe would not control distribution of the PRS signal, which could be used for military purposes, with a sufficient degree of firmness and reactivity[1]. Indeed, we are well aware of the importance of GPS-guided weapon systems in the conflicts of today.

The essential question raised by the PRS is its undesirable utilization by hostile countries or groups.

Consequently, a waiting game is being played on this subject not only between the Member States themselves, but also between the latter and the European Commission.

A solution must be found at the highest political level of the Member States. The opposition of some States can only be overcome by means of a cooperation agreement between Europe and the USA[2].

Among the possibilities which can be considered, the Galileo PRS could have a double key, one held by the European Supervisory Authority (GNSS – Global Navigation Satellite System Supervisory Authority) and the other by NATO.

5. New approaches for monitoring of the environment

Europe has played a pioneer role in devising the GMES project, one quickly copied by the USA and the rest of the world.

The European Council, meeting in Gothenburg in June 2001, expressed the need for a global system for monitoring the environment and security. Under the terms of its resolution of November 13, 2001, the Council launched the initial phase of GMES (Global Monitoring for Environment and Security), the aim of which was to set up an operational, autonomous European capability for a 2008 horizon.

At all events, Europe has the opportunity to establish itself as world leader in the resources and public health management service domain with GMES.

In the wake of this innovative move, the Johannesburg Earth Summit of September 2002 emphasized the importance of coordinating observation

[1] Mike Shaw, Washington, November 7, 2006.
[2] Pascale Sourisse, President, Alcatel Alenia Space, hearing of October 25, 2006.

conducted worldwide. The first summit on Earth Observation, which followed in Washington in July 2003 at the instigation of the USA, set up an intergovernmental Earth Observation group (Ad hoc Intergovernmental Group on Earth Observation).

In order to avoid marginalization of the GMES European initiative, the European Commission emphasized the strategic function of the GMES system to establish the role of the European Union in the world, in February 2004. Furthermore, the European Union succeeded in obtaining support, within the GEO, for creation of a global Earth observation system of systems (GEOSS), rather than a single world system. In this configuration, the European GMES system appears as part, indeed an important part, but only a part of the GEOSS global system, the governance of which is the subject of discussion between the space powers.

As at the beginning of June 2006, the GEO group membership totaled 65 countries and 43 organizations.

The deployment process for Galileo will continue up to 2020. This will also apply for GMES, and will include major development work, the creation of new infrastructures and operational commissioning of the system.

Many decisions will have to be taken in 2008. The contribution of France will be essential.

Cooperation between ESA and the European Union will be extremely important in the case of GMES in the same way as Galileo.

The contribution of France to the ESA mandatory programs is proportional to its GNP. As regards the optional programs, the level of its contribution must be determined. The French contribution is insufficient at the present time, and does not make it possible to apply all national skills as it does not generate sufficient benefits, in application of the fair return rule.

For the moment, a French contribution to the GMES program of 25% is planned. To retain its leadership in Europe, France must be more ambitious in regard to the ESA optional programs.

A. APPLICATIONS PRINCIPALLY FOR THE PUBLIC AUTHORITIES

The increase in the demand for security applies to all domains: public health, food supply, and the forecasting and prevention of natural disasters. This demand will probably increase still further in the future, obliging the public authorities to introduce new instruments. In this context, it is to be wondered whether the public will not demand the introduction of forecasting or detection instruments to provide more efficient management of crisis situations such as severe heat waves or bird flu epidemics. Canada has set up a ministry for public security with transverse jurisdiction for this purpose.

We can also take the view that the public will take an interest in new services tailored directly for its use, though no such services exist for the moment.

At all events, priority markets respond to the needs of the public authorities. For example, the three "fast track" priority programs adopted for GMES are crisis management, land usage and monitoring of the oceans. The nine services adopted on a priority basis for GEO concern crises, public health, energy, the climate, water, meteorology, ecosystems, agriculture and biodiversity[1].

B. SPACE FOR PUBLIC HEALTH SECURITY, A MAJOR PROJECT FOR EUROPE

Space tools can be combined with conventional technologies to make a decisive contribution to public health security, a key mission for the European population.

A space tool such as the positioning service provided by Galileo is the only tool capable of providing a traceability function for animals and foodstuffs. Its value in terms of public health security increases in step with expansion of the European Union.

Climate change will probably result in the resurgence of old diseases or the appearance of new ones. Linked with ground observations, space-based meteorological data will make it possible to forecast the propagation of an epidemic and set up optimum preventive measures. With Galileo, emergency aid resources will be located in optimum positions. Telemedicine will also be a valuable tool, providing efficient means for diagnosis and treatment, irrespective of the region under threat however remote it may be[2].

Space for public health security is a major project which France should promote for its rapid implementation.

C. COMPLEX SERVICE MARKETS[3]

The GMES systems are service markets, and not data/image markets.

The satellite Earth observation market has currently peaked at € 300 million per year in Europe. Making only small profits, the companies in this sector have no capacity for investment.

GMES will be of an entirely different dimension.

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[1] *José Achache, GEO (Group on Earth Observation) Secretariat Director, CEPS (Strategic Prospective and Study Center) debate, June 6, 2006.*

[2] *Claudie Haigneré, advisor to the Director General of ESA, former minister, cosmonaut, hearing of January 25, 2007.*

[3] *José Achache, GEO (Group on Earth Observation) Secretariat Director, CEPS (Strategic Prospective and Study Center) debate, June 6, 2006.*

▪ *The essential mutualization of data*

The future will see the mutualization of observation systems for comprehensive information of service activities.

Meteorology requires geostationary and non-geostationary satellites, but also aircraft and balloons for *in situ* measurement. A vast quantity of data and a large number of processing systems are required for forecasting.

Water resource management requires imaging with efficient ground and water table coverage, but also in situ and water level information.

This is why the GEOSS system of systems concept is the only one which is operational.

▪ *Space and in situ data*

Apart from military intelligence, no GMES service supplied solely with space data can exist.

We can estimate that 80% of GMES products and services will combined space data and data collected *in situ*.

Investments in GMES must take account not only of space infrastructures, but also *in situ* measurement systems for substantial amounts.

▪ *Three-stage services*

The GMES services will consequently have three stages.

The first will be the infrastructure stage, and the second the operator stage, in particular with regard to data broadcasting. Broadcasting sales should be ten times greater than those of the infrastructure producers. We can expect data to be broadcast via the Web, following installation of the Web 2.0 system.

The third stage will be the associated services stage, sales for which should exceed those of the infrastructure industries by a factor of 100. Associated services will consequently constitute the true market and the true motive force for economic development. A typical example of these services concerns meteorological models developed with public funds.

▪ *International competition*[1]

While Europe is well placed for the first, infrastructure stage of GMES services, it appears largely absent for the second, data broadcasting stage, and almost totally absent for the third, services stage.

Europe is weak in the services economic sector, and is paying a high price in terms of employment.

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[1] *José Achache, GEO (Group on Earth Observation) Secretariat Director, CEPS (Strategic Prospective and Study Center) debate, June 6, 2006.*

Among the few companies which could penetrate this market, only SAP and Dassault Systèmes are realistic contenders.

International competition will be very strong. It is estimated that India will soon be capable of implementing the three GMES service stages on an extra-market basis, and that China will be able to do the same.

As for the USA, its space investments will doubtless have a stimulating or facilitating effect for this new business sector. The NASA annual budget of $ 17 billion alone represents 66% of the total budget for the three GMES stages for their first ten years in service.

In this respect, control of Internet, which will be a GMES service access vector, will be of capital importance, in particular with the introduction of the Web 2.0 system. It is essential for Europe to develop its expertise and strengthen its integrators in this context.

With an adequate degree of political drive, Europe has the chance to acquire genuine world leadership in the environment and public health monitoring service domain.

D. THE STATE OF PROGRESS WITH GMES: PRIORITY FOR CONTINUITY OF OPERATIONAL SERVICES AND BROADCASTING

ESA had proposed to develop GMES between 2005 and 2012, to place the system in operational service as from 2013, and to integrate GMES in GEOSS as from 2015. The total cost of the space segment and ground segment over ten years would be € 2.3 billion, of which two-thirds would be funded by the European Union and one-third by ESA.

However, some of the observation signals required by the GMES system are already delivered by existing satellites, approximately fifty in number.

The existing observation capability would make it possible to commence operation with the GMES system here and now.

"Sentinel" satellites[1] so named by ESA, will indeed be built and launched during the next few years in connection with the GMES project. Most of these satellites will do no more than ensure operational continuity for existing measurement resources. Only a few of these satellites will generate new measurement data.

Far from being an accessory factor, consolidation of existing resources is of vital importance for the future of GMES. Commercial services could only be

[1] *The Sentinel-1 satellite series is intended to ensure continuity of SAR (Synthetic Aperture Radar) measurements, and first and foremost in the C band. The Sentinel-2 series will ensure continuity for data currently delivered by the SPOT-5 and Landsat satellites, which are reaching the end of their life. The Sentinel-3 series satellites will be concerned with observation of the oceans as the successors to ERS, Envisat and Jason. The Sentinel-4 series of geostationary satellites and the Sentinel-5 LEO satellites will monitor the chemical composition of the atmosphere.*

developed provided long-term guarantees of measurement continuity are given. This is particularly true in the meteorological domain.

▪ *Commitment by the public authorities, a basic condition*

GMES services can only be developed subject to a commitment by the public authorities to acquire them in due course, over a period of at least five years.

The amount of investment required for their development cannot be underestimated. GMES needs about 150 different scientific observations, and this will require 150 different applications.

The development of GMES is an interministerial matter, which must be addressed with the objective of making all user ministries (agriculture, defense, transport, environment and industry) contribute to funding the system.

Commitment by the States is also justified by the fact that the scientific communities will have free access to open GMES data, which they will subsequently reprocess. At all events, involvement of the scientists is essential, in the capacity of co-developers, for development of numerical models.

▪ *Eumetsat, GMES space infrastructure operator*

Satellite services have been developed on the basis of three main economic models.

The first model corresponds to satellite telecommunications services, which were initially marketed at high prices, these prices since being maintained by virtue of continuously enhanced technical transmission performance.

The second model is that of Galileo, which, moving on from the no-charge GPS reference, will offer high value added fee-paying services.

The third model corresponds to satellite-based meteorological departments, which have been set up as a result of action by the public authorities, and the mutualization of national resources within the framework of Eumetsat.

Successful implementation of GMES demands application of the third model, with Eumetsat as GMES space infrastructure operator.

IV – EXPLORATION AND HUMAN SPACEFLIGHT MISSIONS, INSEPARABLE AND UNTHINKABLE WITHOUT EUROPE

Return to the Moon and the Martian project for the USA, probable resurgence of Russian initiatives, human spaceflight projects for India and Japan, an orbital space station for China as a starting point for lunar missions – what can and should Europe do when confronted with this flurry of announcements and projects, but also concrete programs?

Current European thinking and incipient programs fall far short of the powerful space-oriented bandwagon onto which a growing number of major powers are jumping.

If Europe did not possess the skills or resources to compete, it would need to indulge in massive investment to close the gap with its international competition.

But Europe already possesses the skills required to be the world leader in the exploration of space. It is the responsibility of the generations at the controls of the public authorities and industry to provide the European space sector with the resources to acquire and hold the leader position.

1. Current European thinking on exploration and human spaceflight

▪ *The French scientific community in favor of Mars*

The CNES Scientific Programs Committee has accorded top scientific priority to the *in situ* exploration of the surface of Mars, while not excluding the attraction of seizing opportunities to set up scientific experiments on the Moon, provided that their cost is acceptable. The ESA study is required to supply key elements concerning possible participation in the lunar program, and the Agency has been requested to accelerate its conclusions.

▪ *Current thinking of the national space agencies*

Discussions are also in process between the space agencies of fourteen countries, concerning the new landscape resulting from the American initiative, and the means of response.

What can the French and European positions be? What should be the framework for possible cooperation? To answer these questions, we must assume that the initiative of President Bush is bipartisan, which would represent a durable constraint for the future of NASA.

Discussions between the fourteen national space agencies also concern articulation of the American vision with long-term international cooperation on the broadest scale, where Europe could retain its autonomy in a cooperative context.

The way forward could be that of systems of systems, where basic bricks developed within the framework of national strategies could be consolidated in a global architecture. In any such context, the contribution of the USA would be just one brick among others.

▪ *ESA's Aurora program under review*

European exploration strategy is still principally defined by the Aurora program, prepared in 2001 and which sketches the prospect of a human spaceflight mission to Mars.

The first mission of this program, the Martian vehicle Exomars, was approved in ESA Council meeting at Ministerial level in Berlin at the end of 2005, for launch in 2011. Finalization of technical planning and budget maturities subsequently led the launch date to be put back to 2013.

The return of a Martian sample, initially planned for 2011, is now scheduled for a later stage although essential for the prospect of a human spaceflight mission to the red planet.

The American, Chinese and Indian lunar projects are clearly reshuffling the pack.

It is indeed inconceivable that Europe should leave the other leading powers to explore, study and set up permanent bases on the Moon, without participating in such an ambitious international program.

ESA is consequently working at the present time, at the request of numerous Member States including France, on the definition of a number of scenarios for exploration, including robot exploration and, in the longer term, human spaceflight, with the prospect of a European program in synergy with the American Constellation program, and those of other space agencies.

The aim of this approach is to define technical scenarios and the requisite budgets, so that the ESA Council meeting at Ministerial level of 2008 can decide the first phase of eventual European participation in an international lunar exploration program.

At the request of CNES, ESA has consequently put its exploration plan back on the stocks, without yet having officially abandoned Aurora.

Review of the Aurora program is necessary in the light of the lunar exploration plans mentioned above.

At the request of CNES, ESA is currently examining all possible exploration scenarios with a view to a European contribution to the Constellation program of the USA. Possible contributions include the manufacture of rovers, lunar bases and navigation and telecommunications infrastructures. The objective set by ESA is to develop these scenarios, so that the agencies and ministers can decide eventual European participation at the ESA Council meeting at Ministerial level in 2008. Any such decisions will obviously require prior financial assessment.

In the absence of these scenarios, it is difficult to answer questions concerning the legitimacy, soundness and relevance of human spaceflight missions.

2. Interest and limits of a presence on the Moon

The permanent presence of astronauts on the Moon will constitute the basic difference between the Apollo program and all future lunar programs, irrespective of the country concerned.

A lunar base will make it possible to test and apply, under actual scale conditions, technologies essential for exploration of the Universe, and in particular provide a test bed for Martian exploration.

A major project for mankind, an obvious extension of exploration of the Earth, installation of permanent lunar colonies will also respond to the continual quest for knowledge of human societies, and the technological progress which makes this possible.

▪ *A lunar base for progress with the sciences of the Universe*

A permanent base on the Moon will make it possible to push forward with the acquisition of knowledge of our satellite itself, and consequently of the formation of our solar system.

Facilities could be set up and maintained for study of the Sun and the Universe, the hidden face of the Moon being of particular interest in this respect.

▪ *Problematic exploitation of the Moon*

The conquest of the Moon for purposes of direct economic exploitation is proposed by some experts. In conflict with the international approach which prevailed for Antarctica for example, the continent reserved for scientific research and deployment of new technologies, this new approach appears to create more problems than it solves.

According to some experts, the Moon would constitute an energy reserve for the long-term future of mankind. The lunar soil apparently contains helium 3, a fuel which could be used for future fusion reactors. According to calculations made by Roger-Maurice Bonnet[1], to meet Earth's requirements, it would be necessary to excavate twenty thousand square kilometers of the lunar surface to isolate the one hundred metric tons of helium 3, supposedly enough to meet total terrestrial energy requirements for one year, and send them down to Earth.

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[1] *Roger-Maurice Bonnet, Executive Director, International Space Science Institute, hearing of December 21, 2006.*

Furthermore, replacement of the deuterium + tritium mixture used for the ITER reactor project by a mixture of deuterium + helium 3 would have the nullifying consequence of requiring a temperature five times higher, and a plasma containment pressure ten times greater.

Illusory in technical terms for several decades to come, this approach would not be without posing a number of insoluble environmental problems. In the current state of techniques, mining activities on the Moon would raise such quantities of dust that any other activity, and astronomic observation in particular, would be impossible.

Finally, in symbolic terms, it is difficult to see Man, who has always had the greatest difficulty in managing his own planet, laying waste the natural satellite which bears witness to the mystery and singularity of Earth in the Universe.

▪ *Conditions for French and European participation in the American lunar program*

The best American friends of France repeat emulously that the USA promises to fly its allies to the Moon using their own, autonomously developed transportation system, and fail to understand, in good faith, that this commitment is not sufficient to wipe out all European fears regarding dependence[1].

Jean-François Clervoy takes the view that European participation in the American lunar program can only be considered under three conditions, drawn from experience with the ISS[2]. Firstly, this participation should be **visible**, so that industry can draw benefit and the public feel pride. Secondly, this participation should be **imperative**, so that the American lunar program cannot be implemented without the European contribution. Finally, European participation should be **independent**, namely in a position to produce substantial results, even in the event of abandonment of the American program.

Finally, if it were confirmed that the USA did not wish to, or could not assign a critical part of its space transportation program to Europe, then the solution most compatible with the interests of all parties concerned would be for Europe to develop its own program, under conditions of total autonomy and full visibility, as a specific system of compatible national systems, or which were complementary with each other.

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[1] *Dr J. Donald Miller, NASA representative for Europe, December 22, 2006.*
[2] *Jean-François Clervoy, astronaut, December 21, 2006.*

3. Human spaceflight within the reach of France and Europe – Three scenarios

The American Constellation program, which involves the development of two new launchers – Ares-1 and Ares-5 – in particular, is based on the new Orion capsule which will be able to transport four astronauts and six metric tons of freight to the Moon.

Other scenarios can be constructed based on or derived from existing resources[1].

Apart from its basic function in terms of international cooperation and the bringing together of different technical and managerial cultures, the ISS was initially presented as a potential infrastructure for the production of very high value added drugs or materials, as experience has shown not to be the case, and a laboratory for scientific experiments corresponding to its current utilization.

The ISS also plays another essential part in future space conquest. It must first serve for the study of extended period living conditions in space. We can also see it providing an essential low orbit relay function on the way to the solar system.

As regards exploration, the essential problem is to cut loose from terrestrial attraction. At the present time, we have a number of proven launchers such as Delta-4H[2] and Proton, which have no difficulty in placing payloads of 20 to 25 metric tons into low Earth orbit (LEO). Once in LEO, these limited payloads can be assembled without difficulty. The resultant structure can then be transferred to a lunar orbit using an ATV type tug. A transfer of the same type to a Martian orbit is also possible.

This proven and operational procedure avoids the need to develop a semi-heavy launcher such as Ares-5, a costly operation the implementation of which in quick time is doubtful.

For its part, Ariane-5 can be boosted to place 25 metric tons into low orbit. Its qualification for human spaceflight missions must be obtained soon after its qualification for ATV missions.

Europe would thus acquire an autonomous human spaceflight capability.

Three scenarios are then presented, aimed at ensuring European participation in lunar exploration.

Corresponding to a growing ambition, the first scenario involves a massive call on international cooperation. In the second, Europe acts as an independent service provider for the American Constellation program. The third scenario requires Europe to play a solo part in the concert of an international system of systems.

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[1] *Michel Tognini, cosmonaut, Director of the European Astronaut Center, Moscow, October 18, 2006.*
[2] *Delta-4H: H for heavy.*

A. EUROPE IN PARTNERSHIP WITH RUSSIA AND INDIA

▪ *Space transportation options examined by Russia*

According to ESA, three options are currently being considered under the generic program name of ACTS (Advanced Crew Transportation System), by the design and engineering departments for the next generation of Russian human spaceflight vehicles[1].

The first option corresponds to a modernized Soyuz-TMA capsule, and the second concerns the TKS capsule built by Krunichev during the Soviet era.

The third option is derived from the Clipper vehicle, a stretched capsule to which wings can be added where appropriate. A winged vehicle has the advantage of being able to land comfortably and at a variety of sites. In contrast, a capsule requires splashdown or landing in a desert region.

A winged vehicle would provide advantages in terms of transportation capacity, maneuverability, reduced landing gear dimensions and precision for the return flight.

Conversely, the presence of wings introduces additional constraints in terms of aerodynamics and systems for emergency evacuation of crews if a problem is encountered during the launch, as also for emergency landings and thermal protection of the leading edges of the wings during high-speed atmospheric reentry.

An evolutionary solution could indeed be studied, with upgrading of existing capsules, followed by the design of lifting bodies and finally a winged vehicle.

▪ *A possible cooperation plan*

Cooperation could relate to the new vehicle once its type has been decided.

At all events, the ATV (Automated Transfer Vehicle), scheduled for launch in late 2007, could serve as a tug for the trip to the Moon, after modification.

Taking this assumption, the ATV would be launched from Kourou, and the ACTS from Baikonur on a Proton launcher, and the two docked vehicles would then transit to a low lunar orbit.

Russia is anxious for Europe to participate in the ACTS program.

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[1] *Mr Alain Fournier-Sicre, Head of the ESA permanent mission in Russia, GPE-ESA working meeting, Moscow, July 6, 2006.*

ESA is also interested in this cooperation and has appropriated an envelope of € 20 million for system studies to be conducted as from early 2007. The Russian party seeks a stronger commitment.

The European Parliamentary Group for Space supports the ACTS program, and would like this program to be Euro-Russian.

Satisfied with its space sector cooperation with France, and emphasizing French expertise and loyalty, India for its part is seeking further cooperation with France for the design of a human spaceflight program, the first step in which would naturally be the Moon[1].

▪ *The dangers of dependence through cooperation*

Two dangers inherent in this scenario should be emphasized and avoided.

The first danger is that of **minimizing the workload** for French industry.

There is a real danger insofar as production costs in India are attractive, and could lead to transfer of equipment manufacture.

As regards Russia, costs are rising, as we can observe for the ILS Proton and Land Launch Zenit launchers, for which launch service prices are now less attractive. However, its long-standing mastery of Soyuz and Progress technologies could enable Russia to preempt the construction of new transportation modules.

The second danger is that of **technological dependence**. There are numerous examples of cooperation arrangements which do not result in genuine sharing of technologies despite license agreements, and make it necessary purely and simply to purchase complete sets of equipment from the partner.

Technological dependence can also lead to an increase in program costs, if one of the partners is working above all to its own ends and not for the partnership.

B. EUROPE, AN INDEPENDENT FREIGHT TRANSPORTER FOR THE AMERICAN LUNAR PROGRAM

The budgets currently allocated to NASA for its Constellation program are no more than sufficient, provided operation of Shuttle is terminated in 2010, and the International Space Station is no longer used after 2015, to provide for one two-way trip to the Moon, and under no circumstances to establish a permanent lunar base.

However, the USA does not accept the idea, for the moment, of international cooperation for the creation of its transportation system.

Furthermore, NASA has been assigned the mission of establishing a permanent US presence on the Moon, a task for which it does not possess the

[1] *Dr Kasturirangan, President, National Institute of Advanced Science, Bangalore, December 15, 2006.*

financial means. Hence, the search for international cooperation in the areas of telecommunications infrastructures, scientific equipment and the permanent lunar base, complete with its energy, atmospheric and food supply logistics.

With the USA undertaking to provide transportation for the personnel and equipment of its partners to the Moon, there is clearly no reason to doubt the possibility of Europe having access to the facilities to the construction of which it would have contributed[1].

For all that, for reasons of long-term costs, it does not appear satisfactory for Europe not to have control of the transportation of its contribution to the lunar space infrastructures. This is all the more true as Europe possesses its own resources for the transportation task.

According to studies conducted by EADS Astrium Space Transportation[2], it will be possible deliver a net useful payload of two metric tons close to one of the lunar poles using an Ariane-5 launcher, or even three metric tons by combining two payloads.

Thus, Europe could deliver scientific instruments, small vehicles, bulk fluids and all types of stores to the Moon using its own resources.

Any such contribution would be of strategic importance in that it would provide an essential complement to traffic handled by Ares-5. The capacity of the American heavy launcher should be six metric tons of freight, or three times that than Ariane-5. At a rate of two flights per year, Ares-5 could take twelve metric tons of freight to the Moon. With two Ariane-5 launchers, Europe could deliver four metric tons of freight. This contribution, amounting to one-third of the total, could prove to be a strategic asset for Europe in the eyes of the promoters of the project.

Furthermore, the European system could constitute an alternative, strengthening the security and ruggedness of the lunar facilities.

With its own lunar cargo system – *independent from, but compatible with the American system* – Europe could obtain free transportation of its astronauts from the USA.

To proceed with this program, an automatic lunar landing cargo vehicle, designated ALL (Automated Luna Lander) would be designed and built, using some of the technologies developed for the ATV.

Above and beyond this lunar project, Europe could federate other space powers such as India, Russia, Japan and China, for building a launcher with a liftoff mass of 3,000 metric tons and a payload capacity of 100 metric tons for the Martian vehicle. This would be an alternative to Ares-5.

The International Space Station has demonstrated that international cooperation in ambitious space projects is possible.

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[1] Dr. Donald Miller, NASA European representative, meeting of the Parliamentary Group for Space, Paris, December 22, 2006.

[2] Philippe Berthe, EADS Astrium Space Transportation, hearing of December 20, 2006.

C. EUROPE OPERATING SOLO FOR MOON MISSIONS AS PART OF AN INTERNATIONAL SYSTEM OF SYSTEMS

Another scenario can also be considered, that of Europe operating on a solo basis for lunar missions, given its accumulated know-how which makes European autonomy possible, as also its integration in an international system of systems.

1. ARIANE-5 QUALIFIABLE FOR HUMAN SPACEFLIGHT WITHIN TEN YEARS

The Ariane-5 launcher has been developed with an approach and applying specifications derived from those of NASA. Had this direction not equated to a constant political choice, it would have imposed itself in view of the total blackout existing in regard to the specifications of Russian launchers, demonstrated by the difficulties encountered in drafting the Soyuz at the CSG safety convention.

▪ *Ariane-5, the core element of the future launcher range*

At all events, Ariane-5 possesses a suitable architecture for human spaceflight, combining solid propellant and cryogenic LOX/LH2 engines. NASA's Ares 1 launcher, also referred to as the CLV (Crew Launch Vehicle) has a solid propellant stage and a cryogenic stage. Selected for ballistic launchers, solid propellant engines offer substantially demonstrated dependability, despite being based on a concept and production processes which differ widely from those of liquid propellant engines.

In terms of power, Ariane-5 is also situated in a core target position among launchers already developed.

For its Constellation Vision Ares-1 launcher, NASA has an LEO payload capacity target of 23 to 25 metric tons, largely similar to Ariane-5 performance. The Chinese Long March 5 is also aiming at 25 metric tons in LEO by 2015 and India has set an identical target.

A standard is thus emerging, namely an LEO injection payload mass of 25 metric tons.

▪ *Ariane-5 power enhancement*

The increase in Ariane-5 power is being achieved with enhanced dependability demonstrated on each successful launch, and in the ECA configuration. The process can be continued with further improvements.

The core element of the Ariane-5 first stage is the cryogenic Vulcain-2 engine burning LOX and LH2. Upgrading of this engine into Vulcain-3 can be performed. Comparable as it is with the J-2X engine which NASA is beginning to develop from the J-2 engine of the Saturn 5 launcher, the Vulcain-3 could constitute, as is, a French contribution to the western space exploration system of systems, in the event of a genuine get-together with the USA.

The Vinci cryogenic engine, the principal third stage component of the Ariane-5 ECB version, requires also development. The Vinci-2 engine could be available by 2015. A possible increase in the load of the solid propellant boosters (MPS2) could also be studied.

In all events, Russia does not possess and will not possess a launcher of comparable capacity. The maximum geostationary orbit capacity of the Proton heavy launcher is only six metric tons. Furthermore, it is the absence of a high specific impulse engine which has obliged Russia to increase the number of engines for each launcher.

Consequently, in 2015, Europe could have a launcher at least comparable with or superior to that of its principal competitors in terms of performance, as also in terms of experience and competitiveness.

▪ *An Ariane-5 launcher at the highest level of dependability*

A gain in dependability of one or several orders of magnitude for Ariane-5 can be achieved in two complementary ways.

An increase in the dependability of each component of each launcher system, item by item, would make it possible to further reduce the probability of an incident or accident.

The inclusion of an ejection device (abort system) in the crew vehicle would reduce the gravity of an accident, the probability of which would have been further reduced by the above measures. This device could be activated at any time during the flight phases. In its ESAS lunar architecture study, NASA recently stated that a vehicle incorporating an abort system and assembled on the commercial version of Ariane-5, would provide this system with a degree of safety five times greater than that of Shuttle.

▪ *An investment within the reach of Europe*

In addition to the enhancement of its dependability, and the additional development described above and already initiated, further investment should make it possible to use Ariane-5 for human spaceflight missions. Should studies indicate the need for same, the structure of Ariane-5 should be reinforced, as appropriate, to cater for the payload mass increase to 25 metric tons. The Guiana Space Center (CSG) pad should also be completed to cater for human spaceflight missions.

The total amount of investments to be made before 2015 would be of the order of € 1 billion, or less than € 120 million per year, compared with the € 200 million currently committed for the EGAS program.

2. HERMES, THE ARD AND ATV, TECHNOLOGICAL BRICKS OF A EUROPEAN TRANSPORTATION SYSTEM

Europe has designed and developed two space vehicles. These will be demonstrated in flight in the near future, and can constitute pivot elements for human spaceflight.

▪ The ARD, a European capsule

The ARD (Atmospheric Reentry Demonstrator) is a retrievable capsule. An unmanned demonstrator flew with success in 1998.

The ARD could be enlarged to constitute a manned capsule.

This evolution would make it possible to bounce back after the abandonment of the Hermes program. The Hermes winged vehicle came up against the technical difficulty of powering a lifting body placed on top of a launcher. Attitude control for a configuration of this type is naturally extremely delicate. Furthermore, separation of a winged vehicle is difficult if not impossible. Likewise, hypersonic reentry of a winged body is considerably more complex than that of a capsule.

Although this project was abandoned, the studies conducted for Hermes have led to a number of technological breakthroughs, such as composite thermal protection materials which have given Europe a ten-year lead over the USA.

▪ The ATV, a soon to be demonstrated trump card for Europe

Flight tested after launching on Ariane-5 in 2007, the ATV (Automated Transfer Vehicle), with a mass of 19 metric tons, should be able to dock with and supply the ISS, using a fully automated rendezvous procedure. The corresponding technologies can achieve a degree of precision of 2 cm during the final approach, and this will give Europe an incomparable lead in the orbital rendezvous domain, an essential factor for future missions involving the assembly of large structures in space or the return of samples.

The first ATV flight will consequently represent an enormous success for Europe.

Apart from its ability to rendezvous in orbit, an essential technology for any lunar exploration architecture, the ATV will later be able to act as a service module for the future European capsule derived from the ARD. The combined ARD-ATV composite could then dock with the ISS to transfer crew members and thus participate in lunar exploration.

3. OPERATION OF THE ISS AND EUROPE'S CONTRIBUTION TO AN EXPLORATION SYSTEM OF SYSTEMS

With twenty years' investment behind it, Europe now possesses the essential technologies for a manned exploration system. The ARD and ATV vehicles could be finalized and combined in a system of systems, the investment required for which would be limited.

This system would constitute the European contribution to a western space exploration system of systems.

The intrinsic compatibility of the ATV with the ISS could be extended in two directions, for the ARD and in regard to the future American system.

▪ *ISS and after*

Another advantage is that the ARD-ATV composite would provide autonomous access to the ISS after 2016, at which date the USA could decide to discontinue its utilization.

Operation of the ISS could in fact continue after this date, at least for several years, without an explosion of its maintenance costs. At all events, the Columbus laboratory which is due to be coupled up to the ISS at the end of 2007, could doubtless operate for at least ten years. This would lead to continued operation of the ISS up to 2018.

The experience acquired with the ISS would make it possible to built a spaceport in an optimized LEO, differing from that of the ISS by its lower angle of inclination (51°).

Missions could be deployed to the Moon from this new spaceport.

▪ *A space transportation system which could be financed by the European space sector in its present state*

The greater part of investments in a European space transportation system has already been made.

As we have already seen, the ARD retrievable capsule flew in 1998. The task now is to build a larger manned version.

The ATV will make its first flight in 2007, with a cylindrical transportation container module loaded on the propulsion and service platform. This same platform could receive the upgraded ARD.

Fundamental studies and tests for the ATV-ARD composite have already been conducted.

As an initial approximation, definitive development of a manned version would represent an investment of the order of € 1 billion.

D. THE MANDATORY AMBITION OF THE EUROPEAN SPACE SECTOR

Europe has the possibility to compete with the USA at much lower levels of investment, by capitalizing on its earlier investments and adopting a system of systems approach.

The essential technological bricks are available.

Ariane-5 can be qualified for human spaceflight missions. There is no need to develop a heavy launcher, as the orbital rendezvous technique makes it possible to assemble large structures in space. The ATV transportation vehicle, initially developed for supplying the international space station, can also serve as a propulsion and service module for the manned capsules which can be derived from the ARD.

The investment required for finalization are estimated at a total of € 2 billion. Economic studies for the production and operation of the various components of the global system remain to be conducted. However, by reference to the competitiveness of Ariane-5, we can already state that the European transportation system will, by construction, be less costly than the American Orion/ Ares-1/Ares-5 system.

In the light of these prospects, it is quite clear that Europe should display and assume a maximum degree of ambition, develop the skills acquired over several decades, integrate, in a fully autonomous position, in the world system of systems for the ***cooperative exploration*** of the Universe which it falls to Europe to promote.

CONCLUSION

If left without satellites for a single day, our contemporary world would be plunged into chaos. Situated at the core of major infrastructures, satellites relay information and serve to locate, predict and manage both economic activities and the environment. Space-based services already proliferate. Technical progress is driving the space sector, which in turn is propelling economic activity towards new horizons.

One notion is omnipresent in the politico-media language of today, that of sustainable development, according to which the interests of future generations must not be compromised by our contemporary actions.

It is certainly not in the long-term interest of Europe for our generations to stand back and watch other countries catch up, and the technological gap with the USA widen, ultimately abandoning the space task initiated fifty years ago by exceptionally talented visionaries.

The long-term interest of Europe is to lead the world in setting up techniques for monitoring and controlling our environment and our security.

However, the space adventure is also, alongside the journey of biology towards the infinitely small, the greatest human adventure ever undertaken, one which examines the origins and destiny of each one of us in the greatest possible depth.

Leaving aside all considerations of language, culture, and political or religious inclination, the first steps taken by Armstrong on the Moon constituted, without any doubt, among all pacific events having so far occurred in our environment, the event which struck all mankind most forcibly.

The Earth has a natural satellite, the Moon.

It is a fact that Man does not wish to be absent from the Moon. In stories, poetry and images, our satellite is part of every culture.

The Moon will soon be visited once more by teams of astronauts, cosmonauts or taikonauts. This time, they will stay there longer and set up a permanent base.

Could Europe accept the idea of not taking part? Could Europe allow representatives of other major regions of the world to observe our planet from the Moon and bear witness to Europe's decline?

It is in the long-term interest of Europe that its peoples grasp their space project firmly and take it forward in their turn. The best of scientific knowledge is yet to come. We are still largely unaware of the benefits of the space adventure.

The interest of Europe, sight of which is lost in the state of impotence prevailing at the present time, is for a vision of space to finally gel on our continent, and that the challenge of being world leader in the space context is accepted, triggering a dynamic movement of which each of us feels part and contributing to the emergence of a strong European identity.

However, nothing will be possible without clearer visibility of the space sector, and a greater awareness of its contribution to the issues of the future.

Budget constraints are considerable in all Member States, and limitation of the European budget is a reality in the present state of affairs.

The real task is consequently to enlist public opinion to transcend these budget constraints. Space is not sufficiently visible either for the citizens of Europe or the media.

"Where there is no vision, the people perish".

France and Europe have borne a vision of space for many decades, a vision which they have not dared to formalize.

It is time to identify, in the clearest terms, the European space project as being one essential for our continent.

It is time to declare, in equally clear terms, the ambition of Europe to be world leader in the space sector. There are no prizes for finishing second in any competition, and in this case, Europe has the capabilities to finish first.

RECOMMENDATIONS

I – BASES FOR A NEW SPACE POLICY

A. - Governance of the space sector in France

1. A ***French space vision*** is defined jointly by the Government, Parliament, CNES and industry.

2. The ***principles of the French vision of space*** are: autonomous access to space for Europe must be ensured; the space sector is the keystone of defense; France is world leader in space science; human spaceflight missions are an essential dimension for exploration of the Universe.

3. The Minister for space is a ***member of the Cabinet*** whose responsibilities are restricted exclusively to space.

4. To ensure the motive force behind, decisions concerning and monitoring of space policy at the highest level, ***a Space Council*** is set up with the President of the Republic.

5. The ***High Council of Advisers for science and technology*** is approached as rapidly as possible concerning "space technologies of the future", and two leading observers from the space sector are appointed immediately following the next rotation of High Council membership.

6. A ***space planning law*** covering a period of 10 years, and reviewed and revised if necessary after 5 years, is voted by Parliament.

7. The ***CNES multiannual contract*** is ***revised*** in 2007, with effect as from 2008.

8. The ***national segment*** of the CNES budget is increased by ***8% per year*** as from 2008.

9. An ***additional subsidy***, outside the framework of the multiannual contract, is allocated to CNES to enable it to take on the new regulation and certification functions assigned under the terms of the law relating to space law.

10. The CNES multiannual contract includes an ***additional unallocated budget line*** making it possible to respond to ***new projects*** set up by ESA or other partners in multilateral cooperation contexts.

11. CNES sets up a dedicated program concerning ***technological research and demonstrators***, on a cooperative basis with industry and funded by a dedicated "technological research and demonstrators" budget line as distinct from the "space sciences" line, without delay.

12. The ***Industrial Innovation Agency*** and ***National Research Agency*** contribute to funding of future space programs.

13. CNES sets up ***partnership*** arrangements with the ***regional*** **and** ***departmental authorities*,** for the development of new space projects**.**

14. CNES develops ***new information and communication resources*** to meet its own needs and those of its partners, including industrial partners in particular, based on digital technologies, Internet and digital audiovisual satellite broadcasting, for more efficient information of the general public concerning current space achievement news.

B. - Governance of the space sector in Europe

15. ***Decisions*** by ***ESA Council,*** meeting at Ministerial or ordinary level, are taken on the basis of a ***qualified majority*,** defined by a minimum percentage of budget contributions.

16. The ESA ***geographical return*** rule applies to a set of programs, and not "program by program", and includes services as well as industrial production.

17. A ***European space vision*** is defined by an authority including the President of the European Commission, the Director General of ESA, the presidents of the national space agencies and the heads of space sector companies.

18. The ***European vision*** of space takes account of the ***following principles*:** the European space sector contributes to collective security, protection of the citizen, and the cohesion and balanced development of the EU; the European space sector adopts a transverse approach, and sets up systems of systems with the rest of the world; combining automatic probes and human spaceflight missions, Europe participates in Universe exploration projects, and its aim is to federate these projects.

19. The European vision of space is ***adopted*** by the ***European Council*** of Heads of State and governments.

20. A ***Spac*e *Council*** is set up within the ***European Commission,*** comprising the commissioners in charge of enterprise and industry, transport, the environment, health and consumer protection and agriculture.

21. A ***Space Commission*** is set up within the ***European Parliament.***

22. European space policy is formulated on the basis of concrete projects within the framework of a ***European ten-year space development plan,*** reappraised and revised where appropriate after five years.

23. Space applications are eligible for funding by the ***CAP*** and ***ERDF.***

24. A major project designated *"**space for collective security and digital equality in Europe**"* is launched by the European Council in 2008.

25. The ***European Union*** contributes to the definition and funding of ***European space policy.*** The ***prime contractors*** for the corresponding programs are ***ESA*** and ***Eumetsat,*** also authorized to develop their own add-on programs.

II.- NEW FRENCH AND EUROPEAN SPACE PROGRAMS AND MISSIONS

A.- Launchers

26. The ***EGAS program*** is extended to offset the impact of the weakness of the US dollar on the Ariane-5 program. European funding is set up to complete the Soyuz launch pad, and install Soyuz and Vega at the CSG.

27. Research, development and test work on a more powerful new version of the EPS-AESTUS engine is initiated for the ***ATV with a full load.***

28. Development of the ***reignitable Vinci cryogenic engine*** for the Ariane-5 third stage is initiated without delay, with the assistance of national and European public authorities.

29. A task force is set up for application of the Franco-American cooperation CFM model to the production of the new generation ***Vulcain-3*** launcher engine**.**

30. ***Qualification*** of Ariane-5 for ***human spaceflight missions*** is obtained within five years.

31. Sanctions are introduced for non-compliance with ***European preference*** for launching European civil or military institutional satellites.

32. Development of ***sub-orbital flight*** technologies is supported by the public authorities.

33. An ***upstream research*** program on engines for future launchers is set up by Europe in cooperation with ***Russia***.

34. Studies and tests for ***nuclear propulsion systems for deep space exploration*** are reactivated by the Atomic Energy Authority (CEA) in liaison with industry.

B.- The defense space sector

35. ***European defense space sector budgets are doubled every five years*** up to 2020, within a select multilateral framework.

36. ***The military telecommunications*** space systems of European NATO member states are made ***interoperable*** within two years.

37. Investment in the ***Syracuse-***3C and ***Helios-3*** satellites is committed in 2007.

38. Development of a protected ***satellite HR Internet system*** for mobile military units is initiated in 2007.

39. A European ***integrated military telecommunications*** system is supplied to NATO by the European Union member states.

40. A European ***electromagnetic listening watch*** system is set up within the framework of a select multilateral cooperation agreement.

41. Studies for a ballistic missile ***European early warning*** system are initiated in 2007, with the aim of commissioning the system within ten years.

C.- Space services

42. A ***European 20-year plan,*** ratified by the European Union and placed under the aegis of ***ESA,*** is initiated for the ***observation and exploration of the Universe*** by satellites and automatic probes, and integrated in the European 10-year space action program.

43. ***EUMETSAT*** is the operator for GMES space segment infrastructures**.**

44. Implementation of the ***Galileo*** **program** is accelerated so as to achieve ***commissioning of the system in 2010***.

45. The role and access rights of the ***Galileo international partners*** are defined before the end of 2007, with coordination of the system reserved for ESA members.

46. Problems raised by the ***PRS*** (Public Regulated Service) are cleared in liaison with the NATO authorities.

D.- Human spaceflight missions

47. The conditions for operation of the ***ISS International Space Station after 2015*** are examined as from 2007, in cooperation with all partners.

48. The ESA ***Aurora exploration program*** is revised before the end of 2008, with a view to including the lunar project as a test bed for Martian technologies.

49. Development of the ***European ATV-ARD space transportation system,*** autonomous but compatible with the NASA and other transportation systems, including Russian systems in particular, is implemented as from 2007, with a view to experimentation in 2012.

50. ***Moon landing*** by a first ***European crew***, and their return to Earth using the European space transportation system, are programmed for ***2018.***

* * *

MINUTES OF THE MEETING TO EXAMINE THE REPORT BY THE OFFICE OF FEBRUARY 6, 2007

The Office examined the report prepared by Christian Cabal, Member of Parliament, and Henri Revol, Senator and President of the Office, on the "*principal programmatic areas of future space policy*" at its meeting of February 6, 2007.

Henri Revol, Senator and rapporteur, stated that the referral to the Economic Affairs Committee was for the purpose of establishing a prospective appraisal of the space sector for the next twenty years.

Christian Cabal, Member of Parliament and rapporteur, stated that the previous report by the Office, published in 2001 and the recommendations of which had been implemented by successive governments, had naturally served as a reference and point of departure for responding to the new referral.

One of the main aspects of changes in the space sector since 2001 had been the substantial upturn in worldwide competition in this sector. The USA is investing $ 17 billion in the civil space sector, or four times more than Europe, and had allocated a budget of $ 20 to 25 billion to the military space sector, or twenty times the figure for Europe. A substantial increase is also planned for the coming years. After its black period of the early 1990s, Russia is increasing its space investments very substantially, which are now on an even keel with Europe and will increase in the future. China is proclaiming great ambitions, both in the military and civil space sectors, as demonstrated recently by its ability to destroy a satellite in orbit, and its progress in the positioning and navigation domains. Moving forward even faster, India is developing its own technologies while cooperating with new partner countries, including those of the European Union. New space powers such as Israel, Brazil and Iran are also emerging. It is reasonable to fear that European investment will be overtaken by a considerable distance.

Henri Revol then emphasized the increasing number of lunar mission projects. The American Constellation program for a return to the Moon in 2020, decided by President Bush in 2004 and already in process with the commencement of studies for new launchers and a new spacecraft, is irreversible as a possible upcoming Democrat administration will continue with the program. Russia is planning a lunar base for 2025, and Japan, China and India has also decided to go ahead with various programs which will ultimately lead to human spaceflight missions to the Moon.

To react to this strong competition, France has to prepare its long-term space vision, and induce Europe to do the same.

Christian Cabal described the basic components of a French and European vision of space, then pointing out that decisions in the space domain in other countries are taken at the highest political level, and emphasized the need to increase the budget allocated to the French space agency (CNES). Henri Revol addressed the question of European governance of the space sector. Possessing an internal decision-making process now based on the qualified majority principle, the European Space Agency (ESA) should have its responsibility for implementation of European space policy duly recognized. Finally, space programs should have the benefit of all European Union funding sources by reason of their contribution to common policies.

Christian Cabal explained the situation with the European Galileo positioning-navigation system. The complexity of the legal structure, difficulties encountered with the public-private partnership and the technological ambition of the project has induced delays. These have to be made up in view of competition from the upgraded GPS system, the Russian Glonass system and in the near future, the Chinese Beidu system. The GMES (Global Monitoring of Environment and Security) program, of vital importance in connection with the problems of climate change and sustainable development, which made Europe the leader of worldwide federation of programs of this type, has to be accelerated within the framework of structures simpler than those of Galileo, where Eumetsat (European organization for operation of meteorological satellites) should take on a space infrastructure operator function.

Henri Revol then described the current situation in the launcher sector. The irrevocable termination of operation of the American Shuttle in 2010, combined with the impaired competitiveness of the Atlas-5 and Delta-4 launchers, is leading the USA to review its entire policy. At the same time, the costs of the Russian and Ukrainian launchers are increasing and their dependability declining. The world leader position of Ariane-5 is consequently reinforced, at least for the moment. However, in the USA, the call on new private initiatives, together with the Constellation return to the Moon program, represents powerful support for US industry. It is consequently essential to continue with the Soyuz at the CSG (Guiana Space Center) program, complete development of the Vega launcher and continue development of Ariane-5, including in particular the development of a reignitable third stage engine and qualification of the launcher for human spaceflight missions.

Proving a pivotal function for the armed forces of today, as a result of its essential contribution in the areas of telecommunications, observation, electromagnetic listening watch and early warning, the defense space sector has to be strengthened in France, with immediate orders for Syracuse-3C and Helios-3 in particular. European investment, which totals less than € 1 billion for all national investments taken together, compared with a figure of $ 20 billion for the USA, has to be doubled to cover at the very least its most immediate needs in the security domain.

Christian Cabal emphasized that with the return to, or inexorable arrival on the Moon of American, Chinese and Indian astronauts, Europe could afford even less to be absent from the human spaceflight scene as it already possessed the essential technological bricks for this purpose, in the shape of Ariane-5, the ATV (Automated Transfer Vehicle) cargo vehicle and the retrievable ARD (Atmospheric Reentry Demonstrator) capsule.

Henri Revol then presented the fifty recommendations included in the report, all of which are aimed at creating a revigorated approach to space, this being the only way of recruiting the young engineers essential for the survival of the space sector.

Claude Birraux, Member of Parliament and Senior Vice-President of the Office, congratulated the rapporteurs for their in-depth investigation of the projects of the space powers, both old and new, and for having formalized a new vision as a sequel to that formulated by the Office in 2001. He also raised the question of the coordination of European investment in space research.

Henri Revol explained that European investment in space science is coordinated by ESA.

Pierre Cohen, Member of Parliament, expressed his regret at not having participated in preparation of the report, while approving the majority of the analyses and recommendations which it contained. Reactivation of public funding is essential in France, both in regard to national space strategy and to give the lead to Europe. Given its importance in regard to combating climate change, the GMES program has to become an absolute priority, and consequently be a permanent subject of political discussion for this purpose. The role of the space sector in combating the natural and industrial risks threatening our planet, and promoting a new notion of citizenship through the multimedia and telecommunications system should be emphasized. As regarding human spaceflight, the importance of which is heavily underscored in the report, the financial cost of such missions should not be underestimated, any more than the issues involved in projects concerning exploration of the planet Mars. Europe has to be accorded competence in regard to the space sector, as provided for in the draft European constitution.

Pierre Laffitte, Senator, congratulated the rapporteurs on the quality of their report and the interest of the prospective vision which they proposed. The funding requirements of the European space sector further justify the proposal for a major European loan of € 150 billion for innovation which is arousing increasing interest in Europe, in particular on the part of the European Investment Bank (EIB). After all, the Europeans have to be made more fully aware of issues relating to space, not only in regard to human spaceflight but also, as a result of ever more numerous applications, to our daily life.

Christian Cabal emphasized that Europe could not afford to be absent from the human spaceflight scene, and that the defense space sector requires rapid development.

Claude Saunier, Senator, congratulated the rapporteurs, expressed his agreement with the recommendations, and wished to see them structured, with development of space at the service of sustainable development accorded number one priority.

Marie-Christine Blandin, Senator, emphasized her preference for the space sector at the service of security, in a wider sense than that of defense alone and, following clarification by the rapporteurs, expressed her agreement with their proposals.

Claude Birraux proposed approval of the report which was then adopted by the unanimous vote of those present, with Pierre Cohen abstaining.

ANNEX 1

ADVISORY BOARD

- Jean-François Clervoy, ESA astronaut
- Alain Gaubert, Secretary General of Eurospace
- Stéphane Janichewski, Associate Director General of CNES
- Yves Langevin, Research Director with the Orsay Institute of Astrophysics

ANNEX 2

LIST OF PERSONS MET DURING MISSIONS OR ON THE OCCASION OF PRIVATE HEARINGS

- Ministry of Higher Education and Research
  - François Goulard, Deputy Minister for Higher Education and Research

- CNES
  - Yannick d'Escatha, President
  - Michel Eymard, Director of Launchers
  - Laurent Germain, Financial Director
  - Pierre Trefouret, Director of External Communication, Education and Public Affairs
  - Geneviève Debouzy, Deputy Director, Programs Directorate
  - Jean-Jacques Favier, Deputy Director, Programs Directorate
  - Elisabeth Moussine-Pouchkine, Communication and Institutional Relations Directorate
  - Pierre Frisch, International Relations Directorate, Counselor for Russia, Central and Eastern European Countries
  - Michel Pons, Launcher R&T Project Manager
  - Francis Fiszleiber, Head of Public Affairs Office, Communication, Education and Public Affairs, CNES - HQ

- ESA
  - Jean-Jacques Dordain, Director General
  - Claudie Haigneré, astronaut, former Minister, Counselor to the Director General of ESA
  - Jean-Pierre Haigneré, astronaut, head of Soyuz at the CSG project

- EUMETSAT
  - Lars Prahm, Director General
  - Paul Counet, Director of Strategy and International Relations
- André Lebeau, former President of CNES, former Director General of ESA, former President of Eumetsat
- EUROSPACE
  - Pascale Sourisse, President
  - Alain Gaubert, Secretary General

- ACADEMY OF SCIENCES
    - Jean-Loup Puget, Member of the Academy of Sciences, Institute of Space Astrophysics, Paris-Sud Orsay University

- ALCATEL ALENIA SPACE
    - Pascale Sourisse, President
    - Marc Pircher, Technical Director
    - Joël Chenet, Director of Strategy and Business Development
    - Marc François, Industrial Director, Telespazio – space services
    - Michel Austruy, Sales, Strategy & Development Director, Telespazio France
    - Cécile Ha Minh Tu, institutional relations

- ARIANESPACE
    - Jean-Yves Le Gall, CEO
    - Antonio Accettura, Business Operations Manager

- CNRS
    - Dominique Le Quéau, Director of the National Institute of Sciences of the Universe, CNRS
    - Arnaud Benedetti, Director of Communication

- Collège de Polytechnique
    - Alain Dupas, Director of Strategic Studies

- EADS ASTRIUM
    - François Auque, Executive President, EADS Astrium
    - Robert Laine, Technical Director, EADS
    - Eric Beranger, President, EADS Astrium Services
    - Antoine Bouvier, President, EADS Astrium Satellites
    - Patrick Eymar, Vice-President, EADS Astrium
    - Dominique Darricau, Institutional Relations, EADS Astrium
    - Gilles Maquet Senior VP, Institutional Relations, EADS Astrium
    - Alain Charmeau, CEO, EADS Astrium Space Transportation
    - Philippe Berthe, Human Spaceflight Systems Engineer, EADS Astrium Space Transportation

- FOUNDATION FOR STRATEGIC RESEARCH (FRS)
    - Xavier Pasco, Master of Research

- INTERNATIONAL SPACE SCIENCE INSTITUTE
    - Roger-Maurice Bonnet, Executive Director

- I-SPACE–PROSPACE
    - Norbert Paluch, Director

- BELGIUM
  - Alain Chappe, CNES representative, European institutions
  - Mathieu J. Weiss, Counselor for space affairs, permanent French representative to the European Union
  - Eric Beka, Ambassador, Senior Representative for matters of space policy

- CHINA

  - Prof. Bernard Belloc, Counselor for science and technology, French Embassy
  - Yannick Lannes, Representative, Science and Technology Department, French Embassy
  - Bruno Gensburger, Counselor, Head of Communication, Interpretation and Translation Department, French Embassy
  - Guillaume Agostini, Sectoral attaché – aeronautics and space, Economic Mission, French Embassy
  - Josselin Kalifa, Economic Counselor – High technologies, Economic Mission, French Embassy
  - Nicolas Chapuis, Ministerial Counselor, French Embassy
  - Nathalie Broadhurst, Counselor, French Ambassy
  - Erkki Maillard, Counselor, French Embassy
  - Laurence Mezin, Counselor, French Embassy

  - Dr Sun Laiyan, Administrator, China National Space Administration CNSA
  - Yao Jianting, Deputy Division Director, Department of Foreign Affairs, China National Space Administration CNSA
  - Wang Keran, Deputy Director General, Department of Foreign Affairs, China National Space Administration CNSA
  - Hu Hao, Director General, Lunar Exploration Program Center of CNSA

  - Dr Ye Peijian, Member, Chinese Academy of Sciences, CASC
  - Zhang Xiaodong, Deputy Director General, International Market and Relationship, Department of Business & Development, CASC
  - Mingzhu Zhang, Deputy Director, International Market and Cooperation Div., CASC
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- Marc Zolver, Deputy Director, Engineering cycle & Research coordinator, Beijing Ecole Centrale
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- Jean-Jacques Liu, Chief Operating Officer, Alcatel China Investment Co. Ltd.
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- Jean-Luc Valerio, China Representative, EADS Astrium
- Francesco Emma, Galileo Program representative in China, Navigation Department, Directorate of EU and Industry Programs, European Space Agency (ESA)

  - Kening Liu, Chef representative, Safran, China Representative Office
  - Hugues Pavie, General Manager, Spot Image, Beijing Spot Image Co., Ltd.
  - Eric Imbert, Corporate Chief Representative, China, Thales China Office

- USA

  - Jean-David Levitte, French Ambassador
  - Francis Jouanjean, Military attaché, Ordnance Engineer General, French Embassy
  - Hervé Bouaziz, Colonel, Assistant Defense Cooperation Attaché for Aerospace, Missile Defense, Test & Evaluation and export control, French Embassy, DGA
  - Jean-Jacques Tortora, CNES representative, attaché for space, French Embassy
  - Jacques A. Figuet, Counselor for Nuclear Energy, French Embassy
  - Jérôme Fabre, Economic and Industrial Counselor, French Embassy, Economic Mission
  - Patrick Berron, Consul, Commercial Counselor, Houston

  - Shane Dale, Deputy Administrator, National Aeronautics and Space Administration NASA
  - Michael Coats, Director, Johnson Space Center
  - Robert D. Cabana, Deputy Director, Johnson Space Center, NASA
  - Brian Smith, Lead Flight Director for Automated Transfer Vehicle, Johnson Space Center, NASA
  - Leopold Eyharts, ESA Astronaut, Johnson Space Center, NASA
  - Dr Steven Platts, Johnson Space Center, NASA
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  - General Henry A. Trey Obering III, Director, Missile Defense Agency, US Department of Defense
  - D. Mark Jenkins, Division Chief, Europe / NATO, International Program Support, Missile Defense Agency, U.S. Department of Defense
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  - Joseph D. Rouge, Senior Executive Service, Associate Director, National Security Space Office, Department of Defense

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- Dr William J. Brennan, Deputy Assistant Secretary for International Affairs, NOAA

- Michael E. Shaw, Director, National Space-Based Positioning, Navigation and Timing Coordination Office
- Raymond E. Clore, Senior Counselor, GPS-Galileo Issues, U.S. Department of State

- Philip L. Ritcheson, Ph.D., Director for Space Policy, Defense Policy and Strategy, National Security Council, The White House
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- Johannes Loschnigg, Staff Director, Committee on Science, US House of Representatives
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- Frederic Nordlund, Head, Washington Office, ESA
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- INDIA

    - Dominique Girard, French Ambassador,
    - Prof. Bernard Heulin, Counselor for science and technology, French Embassy
    - Sandie Favier, Attaché for Science and Technology, French Embassy
    - Jean-Louis Poli, Economic and Commercial Counselor, French Embassy
    - Natacha Monnet, Economic attaché, Building and Public Works, Environment, Transport and Industry, New Delhi Economic Mission, French Embassy
    - Bruno Rouot, Ph.D, Attaché for Science and Technology, French Embassy

    - Dr. K. Kasturirangan, Member of Parliament, Director, National Institute of Advanced Studies

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- Manod Jinnuri, Vice President, Business Development, Thalès
- Filippo Corvara, Installation & commissioning manager, Angelantoni Industrie
- Hervé Beaudet, CEO, SCE India PVT. Ltd. Group

- RUSSIA

    - Jean Cadet, French Ambassador,
    - Bertrand Fleutiaux, Counselor for Science and Technology, French Embassy
    - Catherine Ivanov-Trottignon, Attaché for space, French Embassy
    - Denis Flory, Nuclear Counselor, French Embassy
    - Jean-François Tardy, Lieutenant Colonel de Gendarmerie, Assistant attaché for internal security, French Embassy

    - Michel Tognini, Head of European Astronaut Centre, Directorate of Human Spaceflight, Microgravity and Exploration, European Space Agency (ESA)
    - Alain Fournier-Sicre, Head of the ESA Permanent Mission in the Russian Federation, European Space Agency (ESA) - Permanent Mission
    - Pierre-Henri Pisani, Senior Research Fellow, Earth Observation European Space Policy Institute (ESPI)

- Viacheslav G. Tsvetkov, President of the Executive Committee, The Federal Assembly of the Russian Federation the State Duma, Intergroup Union of the Deputies, "Aviation and astronautics of Russia"

- Anatoli Perminov, Director, Roskosmos, Federal Space Agency
- Sergey Troshchenkov, Deputy chief of rocket engines department Ph.D, Federal Space Agency

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ANNEX 3

RECOMMANDATIONS SUBMITTED IN THE 2001 REPORT BY HENRI REVOL

Space: A political and strategic goal for Europe
by Henri Revol, Senator (2001)

If Europe is to maintain its strategic independence, it must master space technology. Moving towards such a situation should be the unifying principle of space policy.

The services made available by space technology in telecommunications, television, navigation, meteorology and earth observation have penetrated all the major sectors of human activities. Their presence in daily life is now entirely routine.

As a result, developed countries are in a situation of profound, diverse and absolute dependency on space services. Their availability is regarded as a matter of fact despite being the product of enormous efforts.

A situation of this kind is dangerous in that it conceals, behind the daily routine, the political and global strategic issues involved in the control of space. It leads to mistaken analyses that hide, behind sectoral considerations that have now become necessary, the global nature of the issue and the responsibility of the public authorities. This way we tend to lose sight of a fact which must be resolutely affirmed: the mastery of space is one of the bases of the information society and the decisions that affect it are political. Such decisions concern the future of Europe, its economic, cultural and political power and, ultimately, its place in the world.

Ariane has given us independent access to space which must be made permanent. European independence is to be built in the field of satellite navigation with the Galileo programme. The institutional structures of European space are to be consolidated. Should we agree to or refuse to open the Kourou base to foreign launchers? These are some of the major strategic decisions where space challenges the political authorities and that should be clarified by taking a global view of the issues.

An energetic space policy must be formulated and the relevant political decisions must be submitted for parliamentary discussion, for these choices are important to the national interest in the medium and long term.

PROGRAMME AND STRUCTURAL RECOMMENDATIONS

I.- PROGRAMME ASPECTS

▪*Launchers and access to space: keeping European independence*

European capacity is based mainly on two components of equal importance: the Ariane launcher and the equatorial launchpad. Neither should be of lesser importance than the other.

The strategy in this field should be based on six main elements, and of course the French approach should be devised to preserve and promote European solidarity, which the magnitude of the French leadership may weaken:

- Conducting an Ariane 5 improvement programme with the twin aim of following market evolution and significantly reducing production costs;

- Improving the competitiveness of the Guyana launch centre by perfecting the launch facilities and improving the user reception area; harmonising tariffs with American practice;

- Broadening the range of Europe's launchers, both by European developments and by broadening cooperation with Russia;

- Exploring the opening of the Guyana centre to foreign launchers and particularly to Soyuz;

- Strengthening the structure of Arianespace;

- Pursuing a programme of technological developments to prepare the launchers of the future.

▪ *Satellites: mastering technological evolution*

For Europe to act effectively in the satellites field, two main lines of action are required:

- The possibilities of miniaturisation and the reduction in costs resulting from technological evolution are to be taken into account. This approach has already begun but must be greatly stepped up. Except for the University of Surrey, space agencies, in particular the CNES, have been slow to explore this approach. The catch-up effort started with Proteus and the microsatellites programme must be energetically pursued in close cooperation with industry;

- An effort to upgrade industrial capacity in the commercial geostationary satellites field continuing the Stentor programme. The aim is to very rapidly supply this industry with the necessary aid to allow it to have the necessary technologies to answer invitations to tender concerning heavy platforms (7 T) and the corresponding payloads.

▪ ***Research: splendid success***

The success of the CNES and ESA scientific programmes has allowed the European scientific community to reach a world-class level of excellence in a number of fields: astronomy, Earth sciences, geodesy, etc... The goal is therefore to maintain and broaden this success. The means available to this community must not be reduced, especially the funding of the mandatory European scientific programme.

Also, the relations of the CNES with the scientific community, which the space agency has always cleverly nurtured, must continue to receive special attention, bearing in mind the broadening of the disciplinary field concerned and the growing intervention of industrial know-how in the execution of onboard experiments.

▪ ***Telecommunications: essential support from the public authorities***

This field of paramount importance apparently has a purely commercial logic; in fact its mastery governs all the sectors of strategic independence, from the military to the cultural without forgetting economic and social aspects. As far as France's and Europe's place are concerned, there can be no question of leaving the matter to market forces alone, especially as these forces are completely biased by the subsidies of military origin pumped into American industry.

Yet in this sector, even more than in all others, space industry is the essential instrument of European presence. In all their actions, the public authorities must therefore be guided by the concern to strengthen industrial competitiveness. The presence of the public authorities and of Europe as such in international regulatory bodies is an aspect of these actions which must not be neglected.

The at least temporary failure of constellations has brought to the forefront, for the foreseeable future, heavy geostationary satellites, which are the main objective of industrial competitiveness.

The use of tele-medicine and of distance education, which can notably improve equality of access to health and to culture, should be developed.

Special attention should be paid to the evenness of territorial coverage for emerging informational services, especially for those necessary for the development of local economic activity.

▪ ***Earth observation: essential convergence of European efforts***

The European approach is characterised by an abundance of quality projects along with a dispersion of initiatives. The Pleiades and GMES initiatives must therefore lead to a convergence and harmonisation of European efforts in this sector. The primordial issues of this sector affect the environment, action by the public authorities as regards their socio-economic responsibilities, and defence.

The aim is to consolidate the structure of space Europe and its ties with political Europe in this field.

▪ ***Navigation: a primordial goal of European independence***

The primordial importance of this field has now been largely recognised.

The implementation of the Galileo programme is of course the structuring element of space policy.

The potential of the Doris system must not however be neglected owing in particular to the independence potential it embodies for the design of European satellites.

For European space policy overall, Galileo appears as a structuring element, both because it expresses a goal of stategic independence and because it forces harmonisation of the structures of space Europe and political Europe.

II.- STRUCTURAL ASPECTS

▪ ***The future of space agencies: towards a European network***

Leaving aside the evolution of their relation with the space industry, bearing in mind the degree of maturity reached by this industry, its capacity of initiative and its relation with the market; space agencies are faced with two main and difficult questions, which must find a solution:

- Harmonisation of relations between their technical centres, so as to transform what is a juxtaposition of centres of national or European expertise into a coherent network;

- Establishment (this concerns more specifically the ESA but also the CNES insofar as it is France's representative on the ESA Board) of organised and formalised relations between the ESA and the European Union, in other words between space Europe and political Europe.

▪ ***Industrial structures: between State and market***

No more in Europe than in the United States or elsewhere in the world, the space industry cannot keep its level and develop without resolute help from the public authorities.

Nor is it admissible that this help should be left to the sectoral initiative of users. The unity of space technology requires a global approach like moreover the global nature of the issues at stake.

- Referring to launchers, the main goal should be a strengthening of the structure of Arianespace and the assertion of its role as the single operator for all launches from the Guyana site.

- Turning to satellites, the completion and consolidation of the grouping process should be accompanied by the public authorities.

Use of these major industries as stepping stones for public authority action with regard to the fabric of small and medium enterprises is an approach worth being explored.

▪ ***International cooperation: space inevitably transcends borders***

International activity is highly present in space activity for various specific reasons: volume of cross-border flows of information brought about by the implementation of space telecommunications systems, worldwide structuring of environmental observation, global dimension of fundamental research, etc... All this makes space technology both player and subject of the globalisation process; international cooperation therefore has an especially important place here. Such cooperation concerns foremost:

- The United States with which traditional ties are to be strengthened insofar as this is allowed by their determination to use space as an instrument of hegemony while bridling European independence;
- Russia, with which it is advisable to seek the bases of cooperation founded on mutual interest and a uniting of industrial expertise;
- Other space nations, foremost among which Japan, with which common interests greatly prevail over possible rivalries.

▪ ***Defence: the need for a specific effort***

In the general context created by the delay incurred by the defence Europe with respect to the other dimensions of European construction, it is absolutely necessary to remedy two shortcomings:

- At national level, the lack of a doctrine on the place of space regarding the armed forces as a whole; this doctrinal weakness seems to be even more pronounced than the weakness of the means and explains that, despite the initial insufficiency of financial resources available to the space component of armament, these resources have also undergone successive and unjustified reductions.
- At European level, the degree of concertation between national players and of coherence between national programmes are entirely insufficient and very much lower than what exists in the civil field. This leads to a mediocre use of already insufficient resources. Resolute efforts must quite clearly be pursued or undertaken to improve this situation. Complete interoperability of European means appears to be a minimum goal that absolutely must be reached.

III - SPACE: A MAJOR POLITICAL CHOICE

At the end of the necessarily brief analyses of this report, several general ideas compel attention:

- Technical unity and the unity of the industrial substratum, which would tend to be hidden by the diversity of space applications, require a global approach mobilising State means and based on an overall vision, in other words a space policy;
- The formulation of this policy is a matter for the government which must involve most ministerial departments, whatever specific responsibilities are entrusted to some of them;

- The variety of users of space technology and their penetration in the socio-economic fabric are causing a general phenomenon of strategic dependence, control over which supplies the unifying principle of space policy.

The awareness of the existence of a global challenge remains very insufficient, no doubt because its emergence is recent and as it remains hidden by the spectacular dimension of space. Political choices in this field should be submitted in the future, in an appropriate form, to parliamentary debate as is normal practice for choices which, in the medium and long term, commit national interest substantially.

Quite clearly the annual debate on budgetary amounts is, in this respect, entirely insufficient. The implementation of a space policy evidently requires continuity which transcends budget annuality and which must not be challenged in its principles by short term economic contingencies. It therefore requires a multiannual formulation. It is also necessary for this policy to be based on a broad consensus which democratic debate alone can establish. In this debate, parliamentary representation must play its role and occupy the place it deserves.

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