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MONITORING OF THE OECD SPACE PROJECT RECOMMENDATIONS

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FOREWORD

This working paper is the result of an innovative monitoring exercise led by the Organisation for Economic Co-operation and Development (OECD)'s International Futures Programme (IFP), in the framework of the OECD Global Forum on Space Economics. The objective of this document is to briefly review some recent developments in the space sector (spring 2005 - spring 2007) through the prism of OECD IFP recommendations.

In 2005, the OECD International Futures Programme published the results of its research on the rising space sector in "*Space 2030: Tackling Society's Challenges*". In addition to extensive analysis of the space sector's potential contribution to economy and society, it contained a set of policy recommendations directed towards decision makers in the space community, in government departments and businesses using space-based applications, as well towards the public at large. These policy considerations were presented with a view to strengthening the space sector's growth and enhancing its contribution to addressing many of the world's social, economic and environmental challenges of the next decades. The recommendations focussed on (1) implementing a sustainable space infrastructure, (2) encouraging public use of space goods and services nationally and internationally, and (3) encouraging private sector participation through the creation of a supportive legal and regulatory environment for commercial activities, reinforcement of private provision of space goods and services, and the promotion of a more supportive international business and financial environment.

The OECD Global Forum on Space Economics, founded in 2006, was set up with a view to strengthening the role of economic analysis in the space sector. Participants in the Forum include as of spring 2007: the British National Space Centre (BNSC), Centre National d'Etudes Spatiales (CNES), Canadian Space Agency (CSA), European Space Agency (ESA), Italian Space Agency (ASI), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), Norwegian Space Centre (NRC), US Geological Survey (USGS). Other agencies and ministries from OECD countries are expected to join. A companion Working Group is open to other interested parties and representatives of the private sector.

Among the missions assigned by the Forum's Steering Group, there is the regular monitoring of the OECD policy recommendations concerning the future development of the space sector. This present document constitutes the first output of such a monitoring exercise. It attempts to identify progress within the public and private sectors towards the implementation of the recommendations, and especially with regard to policy and regulatory measures for the development of a sustainable and user-oriented space infrastructure. To this purpose, the document is organised in four chapters reviewing briefly: 1. Some enduring societal needs and challenges; 2. Efforts towards a sustainable space infrastructure; 3. Recent developments in terms of public use of space goods and services nationally and internationally; and 4. a final focus on the private sector participation. The results are based on a survey of various sources of governmental and non-governmental research and publications (e.g. annual reports of Ministries, Agencies, corporations), press releases and articles in specialised newspapers and journals, which became available between 2005 and early 2007. Given the vast amount of information released over the period, the survey is not exhaustive. Rather, it represents a selection of material that illustrates many of the key developments that have taken place.

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CHAPTER 1 – KEY SOCIETAL NEEDS AND CHALLENGES

In its 2002-2004 project on the space sector, the OECD explored five major challenges to which space assets might make a significant contribution. They include challenges related to the environment, use of natural resources, increasing mobility of people and goods, growing security threats, and, finally, the move towards the information society. The table below sets out how the OECD report described space's potential contribution. A brief review of the different challenges with recent developments is then provided in the following sections.

Table 1 – Enduring Societal Challenges and the Role of Space Infrastructure

Enduring challenges	The role of the space infrastructure
Environmental challenges	Space infrastructure – composed of Earth observation (EO), telecommunications and navigation systems – provides unique applications (links and data) that can be used for weather forecasts as well as for assessing greenhouse gas (GHG) emissions, monitoring air pollution, detecting potential anthropogenic change, validating climate models and predicting future change. These tools can be used to monitor changes in the natural environment, such as the evolution of fault lines, landslides, subsidence and volcanoes. Moreover, space-based systems also play a role in monitoring the application of the Kyoto Protocol commitments.
Challenges for managing natural resources and agriculture	Space-based data have a broad range of applications. With respect to energy, such data provide invaluable information on both the current and future state of energy systems and the state of natural habitats. They can also be used for controlling power and pipeline distribution systems, hydropower dam operation and wind power generation. Moreover, EO data facilitate the management of water resources through the better understanding of the water cycle, notably by providing information about atmospheric temperature, water vapour or sea surface temperatures. Space technology is also useful for managing forest resources more effectively and combating deforestation, wetlands mapping and for determining high and low water lines. Finally, space systems have important applications in agriculture when combined with other technologies. Global Navigation Space Systems (GNSS) and spaced-based augmentation systems (SBAS), geographic information systems, miniaturised computer components, automatic control and in-field and remote sensing can be used to appraise the state of crops, identify areas requiring attention and target treatment automatically.
Security challenges	The capacity of space-based systems to see, locate and communicate over broad areas finds a growing range of applications. For instance, space systems can provide useful input to disaster management information systems throughout the disaster management cycle. GNSS allow first responders to quickly pinpoint the scene of an accident, thereby reducing response time for emergency services, while space-based tele-medicine applications can enhance the ability of emergency personnel to treat victims quickly and effectively. GNSS can also be used for tracking and controlling the transport of illegal and hazardous goods. Moreover, space-based systems can be used for monitoring compliance with international treaties and for the surveillance of international borders.
Mobility challenges	Space-based systems can help exploit a broad range of traffic management applications, including route guidance (selection of optimum route in real time), the management of traffic flows (monitoring of traffic flows in real time, anticipation of traffic jams and implementation of remedial action in real time), fleet management, advanced driving assistance systems and road-charging schemes. Air traffic control represents another major area of application of space-based augmented systems.
Challenges related to the move to the knowledge society	The research and development (R&D) efforts of space agencies and other space actors create new knowledge that can be applied both in the space sector and in other sectors of the economy, while EO and deep space missions generate an unprecedented wealth of data and information on the state of our planet and of the universe. Moreover, space facilitates the distribution of knowledge: satellite communication is an essential element of the communications infrastructure (international coverage, broadcasting, flexibility and rapid deployment of service). They have been very successful in some market segments, such as direct broadcasting satellites (DBS) and help foster competition and innovation in these markets. They also provide the technical means for the delivery of certain public services (e.g. in rural and remote areas for emergency services, in developing countries, where, typically, the ground-based infrastructure is limited or inexistent.).

1.1 Environment

The environmental challenges identified in the 2004 OECD report remain prominent today. The sub-optimal management and distribution of farming lands and of food production, the rise of greenhouse gases and the consequential alterations in biodiversity, as well as the continual loss of glaciers remain daily concerns. In 2006 and early 2007, the world came together in many *fora* to discuss environmental challenges faced by our global society. Some of the issues of grave concern are those of the desertification of lands previously populated with diverse fauna and flora; energy-related pollution and climate change; crop production and marine and terrestrial biodiversity changes, as well as air and water pollution. Significant global gatherings have been, firstly, the UN 2006 World Summit, which released a platform of action on issues ranging from terrorism to poverty and environmental sustainability. Important commitments were made at the 11th Conference of Parties to the UN Framework Convention on Climate Change in 2005 and First Meeting of Parties to the Kyoto Protocol held in Montreal, Canada. World leaders met also at the annual United Nations Environmental Protection Agency (UNEP) Global Ministerial Environmental Forum in Johannesburg in 2006. While the latter focused on much of the wrong that has been done to the Earth's natural environment, there was also a demonstration that rising levels of research and development have made cleaner energy technologies more available than ever. At the same time, the adoption by organisations of the ISO 14001 standard as an indicator of their compliance with environmental managerial sensitivity provides a positive sign of growth in the awareness of such pre-eminent alarms. Concerning the economic costs of climate change, many reports have been published over the past year. The *Review on the Economics of Climate Change*, released in October 2006, by the economist Nicholas Stern for the British government, provided some stimulating findings that shook the policy and economic communities (i.e. 1% of global gross domestic product (GDP) per annum would be required to be invested in climate change mitigation, and that failure to do so could risk global GDP being up to 20% lower than its potential over the next decades). This was followed in April 2007 by the publication of the latest *Assessment Report of the Intergovernmental Panel on Climate Change,* providing results on the current international scientific understanding of the impacts of climate change on natural, managed and human systems, the capacity of these systems to adapt, and their vulnerability. Key environmental challenges are thus becoming more significant since 2004, with an even more growing need for monitoring the environment.

1.2 Natural Resources

Human consumption continues to create severe pressure on the Earth's ecosystems. Indeed, consumption harms the natural environment through the over-harvesting of animals, plants, mining of soil and oceans. These activities have continued to contribute to pollution through wastes from agriculture, industry and energy, as well as the development of merely short-term sustainable infrastructures such as roads and water-ways. According to the 2006 United Nations Human Development Report (UNHDR), the Millennium Development Goals (MDG) have not been met. In fact, some 1.1 billion people remain without access to clean water and 2.6 billion without access to sanitation. The report provides an arid description of how high-level international conferences and extraordinary targets were not met with actions to provide the tools and means to cut back on these figures. In short, on average 60 countries remain off track with respect to the MCG pertaining to issues of water and sanitation. Also, 55 countries are off track with respect to water targets, equalling a total of 800 million people, who still lack access to water. With regards to sanitation, about 74 countries, roughly 2.1 billion people, are without proper sanitation facilities.

1.3 Mobility of people and goods

The future of passenger transportation will depend on a broad range of factors, such as demographics, immigration, social equity, affluence, and urban development. By 2025, much of the western world's population will likely look different, especially as the baby boom generation ages and their personal and professional schedules change and their desires for travel increase. This will have to be met with an increased awareness and sensitivity to the importance of the environment and the close interaction between transportation activities and environmental impacts. To date, public transportation has not yet assumed its fullest capacity. People, energy and the environment influence transportation demand and each leads to changes in the markets of various transportation enterprises. Another possible source of travel growth is social equity, particularly growth in vehicle ownership. Further, the rates of motorized transport and its energy use have continued to grow over the last few years. The World Energy Council (WEC) has produced a series of scenario projections for future world transportation energy use. It predicts annual growth rates ranging from 0.9 per cent to 2.2 per cent implying 26 per cent and 92 per cent increases, respectively, in 2020 over 1990. This analysis also forecasts global passenger travel growing from 23 trillion passenger-kilometres in 1990 to 105 trillion in 2050. All of these forecasts foresee ever increasing demands for a more efficient global transportation arrangement. Conclusively, space technologies can contribute to the creation of a better adapted, well-organised and responsive transportation system that takes into account urban growth and development, newer means of transportation, as well social welfare and accident aversion.

1.4 Security Threats

Security threats are trans-national in nature and require cross-border cooperation in order to be dealt with effectively. Countries need to work together to prevent and overcome issues like the Asian financial crisis of 1997, trans-national terrorism (following the 11 September 2001 attacks in New York City) and SARS epidemic in 2003. Further, global leadership has had to confront and stay alert to the avian flu pandemic and the 2004 Tsunami disaster. Within Europe, the late 2005 bombing in Madrid, the July 2006 terrorist attacks in London, large forest-fires and floods in South and Central Europe demand the development of space applications that contribute to improving continental and regional security.

1.5 Information Society

Over the past decades, strong gains have been achieved in information technology. The International Telecommunication Union (ITU) has issued a report about digital opportunity around the world according to which the Asian economies, particularly those of the Republic of Korea and Japan continue to lead in digital opportunity, through their take-up of broadband and 3G mobile services. Also, systematic progress has been made by developing countries, however, and not surprisingly, India and China lead the opportunity by having almost doubled between 2001 and 2005 their digital infrastructure. While the above undoubtedly shows the maturity of the infrastructure, there still remain huge discrepancies in the production, distribution and use of information and knowledge in all non-occidental countries. Indeed, sophisticated technologies that solve grave societal challenges plaguing all citizens are disproportionately available. Europe, parts of the Americas and Asia all have higher density in telecommunications development. On average, their contribution to the information society as producers, distributors and users is higher than the world average of 0.37 out of 1; Africa’s role remains well below that of the rest of the world in new technologies. Africa’s gains have mainly been in the area of fixed line infrastructure. As such, the use and distribution and advantages of modern and mobile technologies such as telemedicine, global positioning systems and satellite-based telecommunication networks remain in the use of the most prosperous market economies.

As shown above, the societal challenges identified in 2005 remain important and space has an increasingly important role to play. Since the OECD report, some improvements to the overall space infrastructure and the underlying political and regulatory frameworks have been noted (e.g. increased efforts for coordinating earth observation satellites missions), however as described in the following sections, still much remains to be done to take full advantage of space assets.

CHAPTER 2 – IMPLEMENTING A SUSTAINABLE SPACE INFRASTRUCTURE

The existence of an efficient, robust and sustainable infrastructure is essential for the smooth operation of modern economies. Major failures clearly demonstrate our dependence on the discrete, but ubiquitous, presence of such infrastructures as communication or electricity networks, as well as on their seamless and almost invisible but essential operation. The same is true for space: without an efficient, robust and sustainable infrastructure, space actors will not be able to deliver, in an effective and efficient manner, space-based services that meet societal needs relating to major social challenges, such as those considered in this report. Hence, the development of a sustainable space infrastructure is viewed here as a major policy thrust that should be given particular attention by governments. This chapter gives some indication about how the furtherance of a sustainable space infrastructure has been met over the past couple of years. A first section covers developments of systems that have direct applications (Earth observation, navigation, and telecommunications). A second section presents recent developments in the key enabling infrastructure: the underlying space transport and servicing systems.

2.1 Towards a sustainable and diversified space infrastructure

This section focuses on recent initiatives that have contributed – or not – to developing a sustainable and diversified space infrastructure. As demonstrated throughout the OECD Space Project (2002-2004) and by the work of the OECD Global Forum on Space Economics (since 2006), a number of space assets and their applications can provide valuable support for several public policy issues. The following three sections review progress in a number of specific domains of applications: Earth observations, satellite navigation, and telecommunications.

2.1.1 Earth Observation Systems

Earth observation (EO) systems are likely to play an increasingly important role in a growing range of activities. They already provide a unique capability – in close association with ground-based systems – to generate the data and information that are needed to better understand, and better cope with, major problems to be faced in coming decades (ranging from problems raised by climate change and the management of natural resources to security challenges). A few recent developments tend to demonstrate that there is still much to be done to get to sustainable and user-oriented Earth observation systems.

As mentioned already during the OECD space project, the financial sustainability and replacement of space-based Earth observation systems, which provide key data for understanding the environment is important. Often scientific missions are operational for a short time (2 to 5 years in some cases), and can be discontinued for lack of budget, even if the systems are still functioning, or not replaced. This situation has been pinned down in late 2006 by the National Academy of Sciences in United States, which released a report on the state of Earth sciences from space. The report warned that the existing fleet of Earth science spacecrafts could degrade significantly in the next decade because of decreased funding for such programmes. Without a new generation of Earth science missions, the report warns, studies of climate change and other key Earth science topics will be adversely affected. This is true in the United States, but also in Europe, where successful scientific programmes might not all get sustained and replaced despite discussions on the Sentinels satellites between the European Space Agency and the European Commission.

Given the public good nature of many of the services provided by EO and given that the public sector is the main customer for many of these services, a cooperative public effort is needed at international level to ensure the sustainability and interoperability of the various systems as well as the quality of the services they provide.[1] The following recommendations are still relevant, and governments and their agencies are urged to continue:

- Identifying existing gaps and duplication, in close cooperation with users and in light of their data requirements.
- Establishing an overall plan in close cooperation with all stakeholders for the development of a sustainable system of systems.
- Estimating the potential benefits that might be achieved by upgrading the infrastructure as well as the costs involved.
- Establishing appropriate institutional, funding and monitoring mechanisms for the deployment of space-based and ground-based upgrades.
- Helping developing countries to participate fully in international efforts to establish a global Earth observation system, both regarding the use they can make of the system and the contribution they can make to the data collection effort.

2.1.2 Navigation Systems

Like time-keeping, the ability to locate one's position or the position of various objects accurately and reliably is a fundamental and universal need in a modern economy, with wide-ranging implications for traffic management, security, the environment, the management of natural resources and the provision of personal services (civil and commercial). Government action is needed because the substantial societal benefits to be derived from navigation systems will not be realised without public support. Moreover, governments have a clear interest in GNSS on strategic and security grounds. As an increasing number of activities come to depend on navigation systems, it is important that these meet standards that are as high in terms of the integrity, availability and accuracy of their services. They also need to be sustainable so as to offer the continuity of service demanded by users. Entrepreneurs seeking to develop applications are unlikely to invest substantial resources in such ventures unless the signal provider is in a position to guarantee a high degree of reliability and continuity of service.

Several recent developments in satellite navigation are highlighted below:

- ***Interoperability***: In terms of interoperability, the international situation has improved compared to the negotiation period which took place in the early 2000s between the United States and Europe. In Russia, presidential decisions initiated new efforts to make the national global navigation satellite system Glonass fully operational by 2008. In that context, Glonass, designed for both military and civilian purposes, continued being upgraded all through 2006 and spring 2007.[2] Throughout the year, Russia continued talks with the United States and the European Space Agency to prepare agreements on the use of their upgraded national system Glonass jointly with GPS and Galileo satellite navigation systems.[3]

- ***Galileo***: Discussions were ongoing in summer 2007 as to finalising the public financing and specific role of private actors in the global European system.

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[1] Some recent efforts concerning international coordination and the involvement of developing countries are reviewed in the next sections.

[2] In December 2006, with three new Glonass-M satellites just being launched (longer service life of seven years), the Glonass system had 13 satellites in orbit. "Russia Launches Three GLONASS Satellites", *Satnews Daily*, Dec.26, 2006

[3] In the United States, developments continue with the Global Positioning System (GPS) III programme. The U.S. Air Force is expected to award the multi-billion dollar GPS III contract in 2007. In the meantime, upgrades of the current GPS system are being done, and this includes Boeing's current production of 12 GPS Block IIF satellites under a contract from the Navstar GPS Wing at the U.S. Air Force Space and Missile Systems Center in Los Angeles. Boeing will deliver the first GPS IIF satellite in 2007.

- ***New regional systems***: Building on their existing capabilities and their respective bilateral technology transfers programmes, both India and China are developing their own systems. India is still in discussions with Europe concerning its potential role in the Galileo programme, and agreed formally to cooperate with Russia on its Glonass satellite navigation system.[4] This situation could bring at least six different satellite navigation systems (including possibly Japan), three of which are global (GPS, Galileo, Glonass), operating at the same time over the next decade.

In that context, the measures for concerted efforts that were recommended in 2005 seem to be quite relevant, taking into account recent developments:

- The pursuit of efforts to develop both civil and commercial applications that take advantage of the capabilities of new technologies. (Recommendation 1.2)
- The creation of a permanent mechanism, e.g. by means of an international agreement or convention, preferably at global level, to ensure that existing and future GNSS (e.g. European Galileo, GPS III and an upgraded version of GLONASS) are developed and operated in a coordinated manner, including appropriate legal and regulatory mechanisms. (Recommendation 1.2)
- The pursuit of the development of public space-based and ground-based signal augmentation systems and the support for the private development of such systems when appropriate, in order to meet particular regional and national demands. (Recommendation 1.2)
- The maintenance of an open regime for the production of navigation equipment and services worldwide. (Recommendation 1.2)
- The enactment of national and international legal regimes that outline commercial obligations and liability. (Recommendation 1.2)

2.1.3 Communications Systems

The regulatory regime developed in the context of the ITU for the international regulation of telecommunications services has encompassed satellite communications since the early 1960s, in particular technical issues such as frequencies, non-interference and orbital allocations. As the scope for wireless communications increases, efficient spectrum allocation and orbital allocation will become an increasingly important policy and economic issue. In October 2007, the ITU will hold its World Radiocommunications Conference. Key decisions will be made concerning the use of the C-Band frequency (3.4 - 4.2 GHz frequency range), previously reserved for satellites transmissions, which may be opened to new terrestrial mobile networks (e.g. WiMax), with a real risk of interference.

In the context of increased commercialisation, the regulatory process should progressively be improved so as to lead to a more efficient use of the spectrum and orbital slots. This should be done by encouraging the participation of private actors. The ITU regime is still essentially a state-oriented public one, even if non-governmental entities have greater opportunities to voice their interests and concerns, and by giving proper attention to the legitimate concerns of developing countries, while at the same time ensuring the efficient use of scarce spectrum. A final issue includes exploration of the feasibility of auctions for the allocation of orbital slots and spectrum. (Recommendation 7.3)

The ITU was still in 2006 and early 2007 tackling the paper satellite phenomenon, as it is faced by a large and growing backlog of coordination requests, which also slows the development of legitimate commercial systems. The ITU has done so through its regular Plenipotentiary with new due diligence administrative and financial procedures to discourage unwarranted filings.[5]

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[4] *Annual Report 2005-2006*, Indian Space Research Organisation, available at http://www.isro.org/rep2006/Index.htm.

[5] This process obliges all operators and national administrations that file requests for coordination of satellite systems to provide full details of system contractors, including manufacturers and launch companies, along with a planned schedule of system deployment.

Box 1. An example: Social Cohesion and the Digital Divide

Social cohesion can be defined as the capacity of a society to ensure the welfare of all its members, minimising disparities and avoiding extreme polarisation. Governments can use space infrastructure to help further social cohesion by encouraging satellite telecommunications deployment when it is the most cost-effective way to extend the delivery of e-government services to all citizens. This applies notably to the provision of such services in rural and remote areas so as to reduce the digital divide. Given the large economies of scale that prevail in the provision of satellite-based services, this may call in some cases for measures designed to facilitate the aggregation of demand across large geographical areas. (Recommendation 1.3)

As mentioned above, telemedicine is an important development in attaining greater social cohesion. Legally, there are several challenges and barriers to the development of telemedicine that have been more visible in 2005-2007. First, there is a lack of available information to the public and professional medical sector about this emerging industry. Second, there is fragmented demand for its services and few outlets for its practice. Third, resulting partially from the first two points, there is a distortion in the regulatory framework of the compensation schemes and reimbursement from private insurers and public health offices. Fourth, because of professional licensing boards and credentialing rules, doctors have a difficult time actually practicing telemedicine across jurisdictions: national or international lines. Finally, there are more specific legal concerns such as malpractice liability and doctor-patient privacy and confidentiality agreements.[6]

ESA's European Telemedicine Working Group is working on building telemedicine for a diversity of ends and users. These include telemedicine for elderly people, disaster relief, know-how and resources for hospitals in remote areas, as well as tele-consultation, medical tele-education, etc. The setup of regional healthcare networks of hospitals and health professionals enables access to medical expertise and health care regardless of people's location. International cooperation allows the dissemination of best and most appropriate medical practice. Satellite technology will be the most promising means for reaching underserved and isolated areas worldwide. In the future, Global Reference Telemedicine Centres will enable multilingual and multidisciplinary response. For this plan to materialise, satellite-based telemedicine services require strong, reliable and secure communication networks. The improvement of the quality of care by an access to medical specialists will lead to a reduction of the health care professional isolation especially in rural areas, to the possibility of local treatment and early return of the patient to the local community. Telemedicine via satellite is an application field that deserves tailored development taking care of medical and patient needs, standardization issues, technology development and legal and other regulatory aspects. Indeed, already developments in teledermatology across the western world have taken shape. For this type of telemedicine, voice is not the only important aspect of the communication system, but the accurate and precise transmission of images is elementary. Telemedicine via satellite is a key application for avoiding a digital divide of the world. ESA has three projects underway. These are the DELTASS (Disaster Emergency Logistic Telemedicine Advanced Satellites System), the MEDASHIP (Medical Assistance for Ships) and the EMISPHER (Euro-Mediterranean Internet-Satellite Platform for Health, medical Education and Research).[7]

2.2 Space transport and servicing infrastructure developments

It has been the experience of infrastructure developers in many fields that long-term R&D is generally needed to reduce the overall costs of some key enabling systems. This is true too of access to space technologies, launchers, satellites and ground-based segments. Often this is enabled by supporting space agencies programmes in basic R&D work. Another way to address this issue, proposed in the OECD *Space 2030* report, is to explore in-orbit servicing techniques by encouraging space agencies, in cooperation with satellite operators and manufacturers, to research and develop a new generation of serviceable satellites

[6] Gobins, Linda, "An Overview of State Laws and Approaches to Minimize Licensure Barriers", *Telemedicine Today Magazine*, Vol. 5, n.6 and Vol. 6, n.1, available at: http://www2.telemedtoday.com/statelawguide/index.shtml
[7] Graschew, G. *The European Space Agency Concept for Global Telemedicine*, Surgical Research Unit OP 2000 Robert-Roessle-Klinik at MDC Universitaetsklinikum Charite, Berlin.

and other platforms (e.g. platforms docking, plugging new fuel cell and hardware modules).[8] Finally, the space industry is the perfect forum to encourage and experience interagency work, between space and non-space organisations.

2.2.1 Access to space

The need for long term R&D has been exemplified since late 2005 by a number of measures to improve space launch systems in a few countries. The plethora of current and upcoming launch vehicles is increasing.

Both China and India have continued expanding their budgetary efforts to improve their respective fleets of launchers, including new plans. In the United States, some milestones in terms of technical requirements and industrial contracts awards have been reached, to replace the Space Shuttle (to be retired in 2010) and develop new launchers to send humans to the moon but not before 2014. In that context, combining new technologies and old concepts (e.g. capsules), the new Orion crew exploration vehicle and the Ares launchers are being developed. Concerning expendable launchers, the United Launch Alliance (ULA) joint venture was formed in late 2006 by Boeing and Lockheed Martin to combine the Atlas and Delta launch vehicle programmes and provide services to US government customers (i.e. Department of Defense, NASA). In Europe, the planned first flight of the large Automated Transfer Vehicle (ATV) atop an Ariane 5 in 2007,[9] and current developments for a small launcher dubbed Vega are the main ongoing activities, although cooperation with Russia is continuing. In December 2006, an upgraded Soyuz 2-1b version of the workhorse Russian-built launcher launched the CNES Corot satellite. The Soyuz 2-1b represents the latest step in the cooperative European / Russian programme to evolve Soyuz, which subsequently will be introduced by Arianespace in commercial operations from the Spaceport in French Guiana in 2008. With Soyuz' future service start-up at the Spaceport, it should become the reference European medium-class launch vehicle for governmental and commercial missions, joining the heavy-lift Ariane 5 and lightweight Vega.

[8] To run space infrastructure effectively and in a sustainable manner, operators should ideally be able to perform the servicing and maintenance of space platforms (e.g. satellite, space station) efficiently on a routine basis. This would involve, for example, the ability to replenish consumables and degradables (e.g. propellants, batteries, solar array); to replace failed functionality (e.g. payload and bus electronics, mechanical components); and to enhance the mission (e.g. software and hardware upgrades). Such servicing should also logically encompass the removal of debris and the orderly disposal of satellites at the end of their useful lives. Over the longer run, the demand for in-orbit servicing is likely to increase in a broad range of possible futures. Until now, in-orbit servicing has been limited to human missions (e.g. shuttle missions to repair the Hubble telescope) and software upgrades (e.g. scientific missions). The main limitation is cost and the fact that spacecraft typically are not designed with servicing in mind. At the same time, no progress has been made regarding the cleaning up of space debris. Indeed, as more and more assets have been put in orbit, the amount of man-made space debris has increased substantially, both in low Earth orbit and along the geostationary arc 36 000 kilometres above the equator.

[9] The first ATV dubbed "Jules Verne" will demonstrate a European capability to deliver cargo in orbit, to the International Space Station.

Box 2 – Reviewing regularly space transportation policies

The access to space policies adopted by most space-faring countries have typically three main elements: (i) the development of one or more launchers at national (or regional level) with strong R&D support by government to ensure independent access to space; (ii) preferential use of these launchers by institutional users; and (iii) efforts to offer the launcher on a commercial basis in order to recoup some of the development and fixed costs. The overarching sovereignty and security concerns that drive this policy approach take precedence over economic considerations; however the main policy challenge is to find ways to reduce the inefficiencies of the system,[10] while fully taking into account legitimate security and sovereignty constraints. One recommendation is therefore to have governments regularly review their "access to space" policy with a view to alleviating – if possible – the chronic excess supply conditions that prevail in the launching and launcher manufacturing segment of the industry. (Recommendation 2.3)

2.2.2 Pre-competitive R&D

Pre-competitive R&D refers to R&D that is distant from the market and focused on generic or enabling technologies rather than on technologies targeted at particular markets. Typically, the research effort is not expected to produce commercially usable technologies or products, but is aimed to reach the stage of demonstrating feasibility or providing research prototypes. Cooperation at the pre-competitive stage is often a good way to overcome basic technological hurdles. Such collaborative efforts have been undertaken extensively over the last decade in many OECD countries, often at national level. A *black box* approach can be used to deal with strategically sensitive items. (Recommendation 2.2) In terms of illustrating the pre-competitive approach in 2006, the European competitors SES Global and Eutelsat joined forces to finance a large S- band antenna to test the market for mobile television services in Europe.[11]

2.2.3 Entrepreneurship and R&D

Economic analysis strongly supports the view that innovation is a major contributor to economic growth. For instance, the 2003 OECD report, *The Sources of Economic Growth in OECD Countries*, points out that, when comparing economic performance across OECD countries, the development and diffusion of innovation and new technologies make an important difference for growth prospects. The report also finds that competition and innovation are closely linked and that, indeed, pro-competitive regulations help growth by promoting innovation. A related finding shows that the entry of new firms in a sector tends to boost productivity. In this overall context, SMEs play a major role. They constitute an important and dynamic element in all economies as they drive innovation, especially in knowledge-based industries.

From late 2005, the growth in space-related entrepreneurial activity in the space industry has been important, particularly in the United States. New investments include those made by wealthy individuals who are not solely driven by profit incentive, but also by personal interest and a desire to challenge the establishment and make a difference in the industry; and participation by multiple players, who are pursuing the sub-orbital tourism market. Both of these are occurring notwithstanding the high degree of uncertainty as to the number of passengers, the price point and the significant regulatory and legal hurdles to be overcome. Developments in Earth observation are also noteworthy, as new non-space actors are bringing data imagery in the public eye. With regards to telecommunications, the return to the stock market of two low-orbit satellite communications constellations in 2006 provided new opportunities for venture capitalists: the Globalstar satellite-telephone company and the Orbcomm data-massaging business.[12] These

[10] For example the current model for space transportation tends to prevent the exit of firms that would fail under normal business conditions, thereby preventing an efficiency-enhancing reallocation of resources. It also inhibits competition, since the firms' survival is achieved essentially by protecting their public market.

[11] The hardware could fly on the Eutelsat W2 satellite, to be launched in 2009.

[12] "Growing Satellite Sector Looks to 2007", Space News, 18 December 2006

companies raised their capital share on the US NASDAQ sufficiently to allow investment in second-generation satellite constellations. The table below summarises selected some recent entrepreneurial activities.

Table 2 –Recent entrepreneurial activities around the world

June 2007	During the Air and Space Show at le Bourget, in France, EADS announces plans to develop a suborbital launcher for space tourism.
April 2007	Workshop in Europe concerning the legal and regulatory aspects of space tourism, held at the European Space Agency.
October 2006	During the International Astronautical Congress in Valencia, Spain, the French-based ACE association (Astronaute Corps Européen) announces plans to encourage developments of suborbital launchers in Europe and while launching the European Student Aerospace Challenge.
September 2006	- In New York, Virgin Galactic shows for the first time a full scale model of its upcoming SpaceShip Two for commercial suborbital flights. The firm plans to operate a fleet of five of these crafts in passenger-carrying private spaceflight service starting in 2008. - In the meantime, Anousheh Ansari becomes the fourth paying customer to go into space, spending more than a week onboard the International Space Station. - The same month, the remote sensing firm GeoEye begins trading its share on the NASDAQ stock market, the first imaging satellite operator to earn a listing there.
August 2006	- NASA selects SpaceX and Rocketplane Kistler to conduct space station's resupply demonstration flights by 2010, under the Commercial Orbital Transportation Services Programme (COTS). - The consulting firm Futron Corporation predicts over 13 000 suborbital passengers in 2021, albeit at a higher cost than their original forecasts. - The Space Adventures firm, which already offers a week sojourn onboard the International Space Station for around USD 20 million, announces an agreement with Russia to allow customers to participate in a spacewalk for an extra USD 15 million.
July 2006	Bigelow Aerospace launches with success its first inflatable module in orbit. The objective is to build a private space station. Later in the year, discussions with Lockheed Martin to explore the use of a human-rated Atlas 5 for accessing the future station.
June 2006	The French national geographic institute (IGN) opens a website dubbed Géoportail, providing detailed imagery of France, as a response to the success of the Google Earth website.
May 2006	- NASA and the X PRIZE Foundation announce the launch of the USD 2.5 million Lunar Lander Challenge, which will require a vehicle to simulate a trip between the Moon's surface, to lunar orbit and back to the lunar surface. - The same month, Microsoft announces the acquisition of the remote sensing firm Vexcel to aid in its launch of a mapping programme Virtual Earth, competitor to Google Earth.
March 2006	- The keenly-awaited inaugural flight of SpaceX's Falcon 1 launch vehicle ended in disaster when the rocket tumbled out of control and slammed into the Pacific Ocean shortly after its liftoff in the Pacific Ocean's Marshall Islands. An investigation later revealed that a fuel leak triggered a fire around the top of Falcon 1's main engine leading to its destruction. Another launch is expected in the beginning 2007. - The same month, the two start-ups Kistler Aerospace and Rocketplane Limited merged to develop jointly a private reusable launcher.
February 2006	Space Adventures, Ltd., together with a Singapore-based consortium, announces that it plans to develop an integrated spaceport in Singapore that will offer suborbital spaceflights, as well as operate astronaut training facilities and a public education and interactive visitor centre in the country. The estimated cost of Spaceport Singapore is minimum USD 115 million and will be partially funded by the private sector.
November 2005	The firm Google launches a new free portal dubbed Google Earth, which includes remote sensing imagery.
October 2004	The USD 10 million Ansari X PRIZE for Private Spaceflight is won by Mojave Aerospace Ventures, a team led by aircraft designer Burt Rutan and Microsoft co-founder Paul Allen. Their winning entry, Spaceship One, is the prototype for a new class of sub-orbital spaceflight.

Despite those advances, the following recommendations presented in the publication "*Space 2030: Tackling Society's Challenges*", are still very much relevant today to encourage entrepreneurship in the space sector. The following measures are recommended:

- Encouraging industry to participate in R&D efforts, including in particular space entrepreneurs with no vested interest in the existing transport infrastructure. This includes the setting up of prizes (e.g. the X-Prize), tax reductions and liability-sharing regimes (e.g. maximum probable loss regime in US and Australian national space laws).
- Providing R&D support for the development of new innovative space-based communication technologies. The development of a new generation of telecommunication satellites calls for high-risk R&D investments that can generate significant externalities for society at large.
- Building national business environments that are conducive to innovation and entrepreneurship (e.g. a tax system that entails low compliance costs; the transparent and equitable application of rules and legislation; simple and transparent licence and permit systems; efficient bankruptcy laws and procedures; understandable and coherent product standards in world markets; clearly defined property rights; fair and reasonably priced dispute settlement procedures; and light, predictable administrative procedures).
- Supporting entrepreneurs who are attempting to develop innovative space commercial programmes and applications (e.g. space tourism).
- Encouraging SMEs to participate in large space programmes as contractors.

CHAPTER 3 – ENCOURAGING PUBLIC USE

Typically, governments are major users of infrastructure, whether they use public infrastructure to deliver their services to citizens or whether they use the services of private infrastructure as an input in their activities. In most cases, public services are financed by taxes levied on the population at large and are provided free of charge or on the basis of marginal costs. Space infrastructures offer in some cases attractive opportunities to pursue a broad range of public missions in a cost-effective manner. This chapter reviews first some mechanisms to further public use of the infrastructure, and then indicates recent experiences at international level in some specific domains (i.e. disaster management, treaty monitoring, and advantages for developing countries).

3.1 Mechanisms to Further Public Use

The utilisation of space assets can help address long-term societal needs such as those related to the environment, the management of natural resources, security, mobility and the move to a knowledge society, as seen previously. Unfortunately, such opportunities are not always fully exploited for a variety of reasons, ranging from lack of information to regulatory constraints or the existence of rigid bureaucratic rules that prevent the effective use of the infrastructures. Hence, a systematic approach that takes full account of all major impediments is needed to encourage the use of space infrastructure when it is cost-effective to do so.

3.1.1 Addressing Users' Needs with the Right Mechanisms

As mentioned in the publication "*Space 2030: Tackling Society's Challenges*", users will be able take advantage of space-based services only if these justly meet users' needs; show to be cost-effective; and are provided by an infrastructure that is robust, sustainable and fully integrated with ground-based facilities.

These characteristics are vital for making use of a particular service that generally requires at the outset substantial investment of time and resources, particularly for space-based or space-enabled services for which space components represent often only a very small, albeit essential, segment of the value chain. Entrepreneurs, who are considering taking advantage of space-based solutions to serve their clients, will be reluctant to undertake the necessary investment unless they have reasonable expectations that the space-based service they depend upon will continue to exist in a sustained, reliable and consistent manner in the future. In some instances, the value of a service is directly linked to its duration. An example is in the use of Earth observation data in climatology where the data is an initial input, but which serves for the understanding of long-term phenomena.

3.1.2 Linking Suppliers and Users

Space technology requires specialised expertise while its applications are wide-ranging. As an enabling technology, the space segment is often a relatively small – albeit essential – component of the value chain in many applications. In that context, potential users are often little inclined to learn how the information they need is actually produced. They are more concerned about the timeliness, accuracy and pertinence of the information and services. Links between suppliers and users of space systems can be achieved through four means.

- The establishment of formal cooperative mechanisms between users and producers. Such mechanisms (including internal regulations) facilitate the development of an ongoing dialogue between users and producers. This allows space agencies to become aware at an early stage of the needs of user departments, while user departments achieve a better understanding of what space can offer them. The sharing of experience between user department and space agencies presents opportunities for synergies and provides feedback that can be usefully applied to develop best practices. It also places users in a better position to take advantage of existing commercial space products and services. Space agencies also need to maintain regular contacts with associations of users, industry associations and industry actors. (Recommendation 3.2)

- The creation in each main user department of a marketer/promoter, who can increase the department's awareness of the benefits of the satellite services. (Recommendation 3.2)
- The active articulation of key user departments of their requirements and their engagement in the development of strategic space services. (Recommendation 3.2)
- The guarantee that appropriate financing mechanisms are in place to enable user departments to take full advantage of opportunities that space may offer for the effective delivery of public services. (Recommendation 3.2). This can be done by progressively aggregating the demand. As an example, adequate and sustainable sources of funding should be available for publicly generated Earth observation data in particular. In this regard, customer funding (i.e. by user departments) may be the best way to achieve sustainable funding and ensure that the data produced actually meet the requirements of users. (Recommendation 3.1).

In order to facilitate the relationship between remote sensing data institutional users and commercial data producers, some governments have started aggregating demand for such data. In the United States, the programme ClearView, which is run by the U.S. National Geospatial Intelligence Agency (NGA), replacing the National Imagery and Mapping Agency (NIMA) is still ongoing. ClearView was set up in January 2003 to help the Pentagon and other federal agencies procure commercial satellite imagery. It has a five-year contract with a base performance period of three years and two additional one-year options. The programme replaces a cumbersome licensing structure with a single licence that allows imagery to be shared with all the agency's potential partners. In 2006, two providers of commercial imagery participated in the programme: GeoEye, which resulted from Orbimage's acquisition of Space Imaging in January 2006, and Digital Globe.

On a different scale, a number of projects in Europe aimed throughout 2006 and early 2007 to create links between users and providers. As an example, the Geoland Project is carried out in the context of GMES, a joint initiative of EC and ESA, with the ultimate aim to build up a European capacity for GMES by the year 2008. Geoland is designed to support particular initiatives within the GMES, such as 'Land Cover Change in Europe,' 'Environmental Stress in Europe,' and 'Global Vegetation Monitoring.'[13] The structure of the service development and offering follows the needs of user organisations. There are some 50 user-organisations[14] ranging from international to local; participating under full-membership in the consortium. The services offered address environmentally relevant issues such as water quality, nature protection, and the Kyoto-process or food security issues. The project is structured into three regional and three global observatories, each of them supported by a core service that will be providing in time basic geo-information inputs.

3.2 Space assets' use at international level

Owing to advances in communications and transport, policy makers are sometimes required to respond to requests originating outside their borders. For instance, progress in communications means that people are better informed and made aware earlier of the occurrence of disasters in other parts of the world, while affected countries are in a better position to communicate their relief needs. As a result, the scope for dealing with disasters at the international level is increasing. At the same time, human action is causing externalities that are not confined to national borders. This includes, for instance, cross-border pollution, the generation of greenhouse gases, and the depletion of fish stocks. Such problems can only be dealt with effectively at the international level. Space systems can provide a modest but sometimes part of the

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[13] See *Geoland Project*, available at http://www.gmes-geoland.info/PROJ/index.php

[14] *Geoland* users include the Food and Agriculture Organisation of the United Nations (FAO), l'Institut francais de l'environnement, the Integrated Global Observing Strategy-Partnership, the Scottish Natural Heritage, The Network of European Metropolitan Regions and Areas, the Thüringer Landesanstalt für Wald, Jagd und Fischerei, and others. A complete list of user organisations is available at http://www.gmes-geoland.info/TEAM/user.php

solution to some of these problems because of their ubiquity, the non-intrusive nature of the services they offer and the fact that they can be rapidly deployed to theatres where their services are needed most, anywhere in the world. This section briefly reviews some developments in natural disasters prevention and emergency management, treaty monitoring, and social and economic development in low-income countries.

3.2.1 Natural Disasters Prevention and Emergency Management

The intensification of weather extremes, natural and technological hazards and the resulting increase in potential economic losses present new challenges for decisions makers, emergency agencies and the insurance sector. Where risk and disaster management at international level is becoming a main concern, space-based systems can provide specific capabilities for addressing those challenges, but some sustainability issues still need to be resolved.

There is scope for improvement, in particular for monitoring, in a continuous manner, areas where natural disasters occur frequently and for providing up-to-date information to the right local authorities. However, space-related agencies do not have the resources to sustain the overall architecture financially (including payment for value-added products needed by third parties, e.g. 3-D maps, from value-adding firms), and commercial data providers cannot be expected to provide their products and services at no charge on a continuous basis. Governments can encourage the use of space applications for global disaster prevention and emergency management purposes, by strengthening international co-ordination efforts already under way, building on existing international programmes that already provide operational assistance and extending the scope of their activities to the implementation of prevention measures. (*e.g.*, the International Charter for Space and Major Disasters). This increasingly needs putting the architecture on a sustainable financial footing. This could be done via the setting up of dedicated funds for disaster management. (Recommendation 4.1)

Some progress has been made in 2006. A report by the United Nations further explored those questions, in particular the feasibility of creating an international entity to provide for coordination and the means of optimising the effectiveness of space-based services for use in disaster management.[15] The UN Office reviewed the issues with different bodies, such as the Executive Secretariat of the International Charter "Space and Major Disasters" (which currently provides the main cooperative system for distributing imagery in times of disasters), the GEO Secretariat, and the International Strategy for Disaster Reduction (ISDR) Secretariat (which is charge of developing he implementation of the Hyogo Framework for Action 2005-2015: *Building the Resilience of Nations and Communities to Disasters* adopted by the UN General Assembly in December 2005).

Based on the ad-hoc support of a number of countries, the new DMISCO (Disaster Management International Space Coordination Organisation) could start in 2007 its operations, in coordination with existing UN bodies in particular, with the objective to "ensure that all countries have access to and use all types of space-based information to support the full disaster management cycle". The entity will be implemented as a programme of the Office for Outer Space Affairs under the supervision of the Director of the Office.

3.2.2 Treaty Monitoring

Many international treaties are not fully complied with because their implementation has not been effectively monitored and enforced. Space-based systems can contribute data for international treaty compliance and verification (e.g. environment treaties, negotiation of peace agreements, arms control and disarmament treaties), although external examination of a country's resources or activities from space may raise some delicate political questions relating to national sovereignty.

[15] United Nations Office for Outer Space Affairs (2006), *Study on the possibility of creating an international entity to provide for coordination and the means of realistically optimizing the effectiveness of space-based services for use in disaster management*, A/AC.105/873

Current observation systems already provide a unique ability for global observation (e.g. optical and radar systems) and this capability will increase in the future, as technology (e.g. number and diversity of sensors) improves further over the next decades. Governments can encourage space agencies to strengthen their partnerships with the secretariats of international treaties and conventions, notably those relating to the Earth's environment and sustainable development, to ascertain how space-based solutions might best be used for treaty monitoring and enforcement, and ensuring that future satellite missions take fully into account data needs related to monitoring of treaties. (Recommendation 4.2)

A recent joint report of the Convention on Biological Diversity (CBD) and the RAMSAR Convention provides guidelines to undertake, where necessary, rapid inventories, assessment and monitoring of the biological diversity of inland water, coastal and near-shore marine ecosystems, in the framework of RAMSAR and CBS treaties (RAMSAR, 2006). This report mentions in particular that space-based data can provide a cost-effective mean to realise a preliminary wetland assessment. A more extensive and expensive appropriate "ground-truth" survey can come afterwards.

Table 3 – Examples of treaties using space-based data for monitoring

Convention on Biological Diversity (CBD)	The Convention on Biological Diversity is one of the most broadly subscribed international environmental treaties in the world. Opened for signature at the Earth Summit in Rio de Janeiro in 1992, it currently has 189 Parties—188 States and the European Community—who have committed themselves to its three main goals: the conservation of biodiversity, sustainable use of its components and the equitable sharing of the benefits arising out of the utilisation of genetic resources. The Secretariat of the Convention is located in Montreal, Canada.
The RAMSAR Convention	The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 153 Contracting Parties to the Convention, with 1634 wetland sites, totalling 145.6 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance (http://www.ramsar.org).

3.2.3 Social and Economic Development in Low-income Countries

Many developing nations could use space applications in support of their national economic development programmes. Space applications can be at times useful tools for improving the quality of life of citizens in low-income countries and for contributing to the fight against poverty. But international co-operation is necessary to provide more equitable access to space technology, while taking into account the dual-use specificities of such assets.

By contributing to the training of new users of space applications in developing countries and sharing the experience acquired in the use of space solutions for the delivery of public services, by facilitating, for example, the use of existing systems in the developing world, e.g. by providing grants for the leasing of transponders from commercial operators and the acquisition of the necessary complementary ground equipment. (Recommendation 4.3)

In 2006 and early 2007, several United Nations initiatives have been pursued in particular to address information needs of developing countries (e.g. training courses, workshops). In the meantime, an increasing number of developing countries have publicized their ambitions in terms of indigenous space developments. Turkey, for instance, aims to create a space agency and develop its own satellite manufacturing capacity in telecommunications and Earth observation (an optical remote sensing satellite is to be contracted out in 2007). The telecommunications operator Turksat has seen its role expanded, with the addition in 2006 of the Center for Turkish National Applied Satellites and Space Technologies, which will cover diverse indigenous space developments. Other developing countries have shown increased interest in space systems, with Vietnam selecting Lockheed Martin to build the nation's first telecommunications satellite, and Algeria continuing to expand its remote sensing capabilities, by contracting out Astrium Satellites to build two optical satellites. As a last example, Malaysia entered into the space market in December 2006 with the beginning of the commercial operations of its Measat 3 telecommunications satellite manufactured by Boeing.[16]

[16] "ILS Proton M Rocket Launches Measat 3", *Space News*, 18 December 2006

CHAPTER 4 – ENCOURAGING PRIVATE SECTOR PARTICIPATION

While space activities were essentially public at the beginning of the space age, the role of private actors has expanded in recent decades. This chapter provides some information and developments on (1) supportive legal and regulatory environment for commercial activities, (2) private provision of space goods and services, and (3) on the general international business and finance environment.

4.1 Legislative and cooperative frameworks

The effective operation of our modern economies requires the existence of a legal and regulatory framework that is both stable and predictable. It should provide for clear rules, enforced in a consistent, fair and transparent manner. The framework should also help ensure that entrepreneurship and innovation are rewarded, that barriers to entry and the burden of regulations are minimised, that rent-seeking behaviour is discouraged and that property rights are protected nationally and internationally.

Given the liability implications under the international law regime of space activities, it is in the best interest of space-faring nations to implement national space laws in order to regulate the space activities that fall under their jurisdiction. Moreover, national space laws represent a major element of the legal and regulatory environment in which private space actors operate. They establish clearly for them how their national government interprets the international law regime. As legal and regulatory uncertainties are reduced in this way, actors are in a better position to make sound business decisions.

- National laws covering concerns of particular importance to the business community enables domestic administrative bodies to supervise of space activities, to register space objects, adopt indemnification regulations and additional regulations (e.g. those relating to insurance and liability, the environment, intellectual property rights, export controls, transport law, dispute settlement). (Recommendation 5.1)
- The coordination across nations of their space laws facilitates the operation of private space actors that engage in cross-border activities. A model law is currently under development by international legal experts, but has mostly received academic interest. (Recommendation 5.1)
- The timely review of existing international laws for purposes of assessing their parallel with the needs of the space-business community. (Recommendation 5.3)

There have been quite a few developments in space policies over the last year and a half. The table next page summarises for a few selected countries some recent developments in this area. One key aspect is that governments seem to become increasingly aware of the importance of a functioning space infrastructure. Societal challenges that were briefly identified in chapter 1, such as the growing environment and security challenges, are fuelling the demand for more information and secure telecommunications links, and the space sector should take advantage of this situation and argue more effectively the cost-effectiveness of some (if not all) of their solutions. Some recent space policy developments follow below:

- ***Updating / reviewing national space policies***: A number of countries have updated in 2006 their national space policies. This is the case of the United States, which reaffirmed its vision of the strategic dimension of space activities. China also updated in a white paper the chronology for its ongoing and future space developments, but still very much in line with its previous 2000 national space policy (*China's Space Activities in 2006*, 12 October 2006). Several countries have also launched in late 2005 and 2006 task forces to review their space policy for 2007. Internal reviews have been ongoing notably in France, the United Kingdom and Japan.

- ***European space policy in 2007***: The need to review policies has also reached the European Community. In May 2005, the European Commission released a draft report, in which it examined managerial responsibilities in sharing space activities between the European Union, ESA and their member States. It is thought that such cooperation might provide a more structured funding for European space programmes. In May 2007, European Ministers responsible for space activities met during a special Space Council (joint meeting of the European Union and ESA Councils), and adopted a Resolution on the European Space Policy. Through this resolution, the European Union, ESA and their Member States commit themselves to increasing coordination of their activities and programmes relating to space.

With regards to regulating space activities, the 2005 - early 2007 period has included some interesting developments:

- ***Preparing the ground for national space laws***: A number of countries have passed new laws and regulations pertaining to their space activities during the period (e.g. Belgium), while many others are in the process of doing so in 2007 (e.g. France).
- ***Regulating private spaceflight***: The Federal Aviation Administration (FAA) issued in 2006 new regulations requirements for crew and space flight passengers involved in private human space flight.[17] Among other requirements, the regulation requires launch vehicle operators to provide certain safety-related information and identify what operators must do to conduct a licensed launch with a human on board. Given the nature of the "space tourism" industry, the limited experience that society and administrative bodies have in general regarding this activity, the law governing this field is ever-emerging, changing and adaptive. As such, the standards developed by the FAA serve as a stepping stone for the industry in that, from an industry-wide research, it is the only body to have explicitly outlined rules covering "private" human spaceflight. These standards may serve as a guiding tool for other nations and for the industry in general, concerns for operators, insurers, travellers in terms of liability and cost-recovery can be seen as being generally well addressed by these requirements.

[17] *New Regulations Govern Private Human Space Flight Requirements for Crew and Space Flight Participants*, Department of Transportation, Federal Aviation Administration, No. FAA–2005–23449, effective as of 13 February 2007.

Table 4 – Selected countries: recent space policy and regulatory developments

Countries	Government body responsible for space activities	National Space Agency	Space policy framework	Regulatory framework
BELGIUM	Minister for Economy, Energy, Foreign Trade and Science Policy	Belgian Federal Science Policy Office	.	New *Law on the Activities of Launching, Flight Operations or Guidance of Space Objects* (June 2005)
CANADA	Ministry of Industry	Canadian Space Agency (CSA)	*National Space Plan 2003-2005* together with the *Nation Research Plan*, 3 February 2006.	New data access control legislation, with the *Remote Sensing Space Systems Regulations*, S.C. 2005, c. 45.
CHINA	State Council – Commission for Science, Technology & Industry for National Security	China National Space Administration (CNSA)	Update of development targets and major tasks for the next five years in the white paper *China's Space Activities in 2006*, a White Paper issued by the PRC	.
FRANCE	Ministry of Education, Research & Technology	Centre National d'Etudes Spatiales (CNES)	A report on the French space policy is underway at the French parliament, and should be published in 2007	Discussions are still ongoing on a first comprehensive French space law.
GERMANY	Ministry of Industry	German Space Agency (DLR)	The German space activities supervision has been moved in 2006 from the Ministry of Research to the Ministry of industry	.
INDIA	Department of Space	Indian Space Research Organisation (ISRO)	India announced official plans to conduct human spaceflight activities and develop its own navigation system.	.
ITALY	Ministry of University and Research (MUR)	Italian Space Agency	*National Aerospace Plan* (PASN 2006-2008), approved February 2006	.
JAPAN	Ministry of Education, Culture, Sports, Science & Technology	Japanese Aerospace Exploration Agency (JAXA)	A review of the Japanese space policy is underway since Feb. 2006, looking at institutional organisation and dual use activities.	A Japanese space law could be enacted in 2007.
NORWAY	Ministry of Trade and Industry	Norwegian Space Centre	Expansion of Norwegian involvement in the optional ESA programmes.	.
UNITED KINGDOM	Ministry of State Science and Innovation	British National Space Centre (BNSC)	Review underway for UK Civil Space Policy, to be released later in 2007	.
UNITED STATES OF AMERICA	Executive Office of the President: Office of Science & Technology Policy	National Aeronautics & Space Administration (NASA)	Enactment of an updated *U.S. National Space Policy*, on 31 August 2006.	Updated regulations for "spaceflight participants" in FAA's *Human Space Flight Requirements for Crew and Space Flight Participants: Final Rule*, (15 December 2006)

4.2 Private provision of space goods and services

Private actors have been able to exploit successfully, in some markets, technologies that were originally developed in co-operation with or for the public sector (e.g. telecommunication satellites). Moreover, the end of the cold war has created an environment more conducive to the commercial exploitation of space. In a more open world, space firms have been able to restructure and form new alliances, while the opening of markets has benefited important segments of the industry. These commercial developments have also led in many cases to the development of more cost-effective solutions for addressing important societal issues using space technologies (*e.g.* telecommunications networks in remote areas, Earth observation high-resolution data for disaster management). In spite of such progress, the development of commercial space remains fragile.

The role of public institutions is still key, in terms of the necessary investments in research and development (as seen in Chapter 2), as well as anchor customers of many space products and services. In appropriate circumstances, contracting out may offer public agencies a number of advantages. First, it may free up resources to focus on how the service or product may be best applied, rather than on the day-to-day production of the service. Second, it may provide access to the contractors' knowledge, network and research. In a competitive environment, it allows the agency to choose the product or service that best suits its needs. Contracting out may also be beneficial for the contractor as it helps to increase revenue base. Public procurement may also allow the firm to reap economies of scale and of specialisation. Finally, it can diversify a firm's stream of revenue, a particularly significant advantage when private demand tends to fluctuate significantly, as is the case for space. Public procurement can also be a way to stimulate the entry of new innovative private players into the industry, notably through procurement programmes specifically targeted to small and medium-sized enterprises (SMEs).

- The establishment of clear guidelines for public provision. In this regard, particular attention should be given to the costs and risks involved, notably: the complexity of the contractual arrangements that need to be established; the significant barriers to exit, once a long-term relationship has been forged with the contractor; and the high financial risks that are involved. These problems are particularly important when only a few companies are in a position to meet contractual requirements and the service or product required is very specialised.
- The creation of mechanisms that stimulate participation of innovative SMEs in the procurement process. This can be achieved by, for example, reducing the paperwork required for smaller contracts; request prime contractors to allocate a share of their contract to SMEs or make it a proposal evaluation criterion; setting aside a share of the procurement budget for SMEs.

Recent examples

- In Europe, the common ground in understanding the difficulties faced by SMEs is that the venture capital industry is too fragmented and access to capital in this high-risk/high-potential industry is difficult. Further, the EC Directorate-General for Enterprise and Industry noted that tax obstacles hamper cross-border investment within the EU.[18] In this regard, risk-sharing measures such as those through the Multi-annual Programme for Enterprise (MAP) have been implemented, including for the space sector. Through MAP, public-private funding (50/50) has been made available during the early-stage investment period of SMEs. MAP has been extended to stimulate further growth during the period of 2007-2013 by offering financial support of EUR 1 billion.
- Through the European AeroSpace and Defence Industries Association (ASD) programme, the AeroSME was developed with the aim of encouraging and supporting the participation of SMEs within the context of the EU Framework Programme of Research and Technological

[18] *Building Support for a Common Approach*, European Innovation: Confidence in Space, September 2005

Development.[19] The AeroSME aims to facilitate the generation of proposals directed towards certain thematic priorities as they arise in aeronautics and space. An example is the current bid for tender in the conception and development of a mathematical model of aerodynamic characteristics. The AeroSME programme facilitates cooperation among SMEs, between SMEs and large companies, and with other aeronautics related bodies. This engagement will have the side-effect of improving SMEs' position in the supply chain and enhance their networking opportunities. It will encourage multinational projects, which are a prerequisite for SMEs long-term competitiveness and will be a central point of contact and information for aeronautics SMEs.

To be noted is that all public procurement processes are very much determined by the prevailing legal framework under which they take place. For example, it is important to see under what context the procurement is to take place and, thus, whether the tender is subject to rules of regional, multilateral agreements or to a domestic procurement process. Further, it is crucial to keep in mind concerns of intellectual property rights, non-disclosure agreements and industry secrets when receiving the applications for bid. Lastly, the assessment of whether an oversight mechanism exists for eventual disputes is primordial for the transparency and good-governance growth of the industry. The latest ESA conference on *Developing Trends in Public Procurement and Auditing* held in The Netherlands in 2007 attempted to deal with these issues.[20]

4.3 Business and finance environment

The legal and regulatory framework determines the rules according to which space actors operate. Although a number of basic components of the legal framework are now in place, some gaps remain. As a result, existing regimes are currently not predictable, transparent and/or supportive of commercial space activities. Moreover, the regulatory framework is neither fair nor flexible and does not provide for a level playing field. This can stifle competition and discourage innovation and investment in the development of space systems. Indeed, while all space faring nations have legislation regarding the space endeavours under their national jurisdiction, these laws are not necessarily abided by or implemented properly and there is generally no oversight from an independent agency to guarantee the fairness of the commercial processes.

4.3.1 Matters of Competition

At international level, some relevant rules of trade agreements, as monitored by the World Trade Organisation (WTO), should be extended when possible to space-related activities of a commercial nature. Lack of clear rules can result in conflicts, notably regarding international trade in satellites and launch services. Moreover, as the importance of commercial activities increases, the cost imposed by trade restrictions (e.g. export controls) is likely to increase and become counter-productive from a strategic perspective.

Issues surrounding prices **–** As mentioned in the OECD publication "*Space 2030: Tackling Society's Challenges*", the level of institutional space activities differs widely among countries and regions, as do the specific situations for the growth of an indigenous space industry. Some countries were still seen in 2006 and early 2007 as providing "unfair competition" conditions for space assets development compared to Western space faring countries (e.g. India, China, which have relatively smaller space budgets in absolute terms are developing indigenously and commercialising entire portfolios of space assets). This is mainly due to local labour and of other inputs prices much lower than in the West, which in turn are reflected in significantly lower output prices. A noticeable change compared with the 2005 findings from the OECD report, concerns the new economic situation in Russia. A rapid rise in the costs of raw material for Russian

[19] AeroSME project, Website: http://www.asd-europe.org/content/default.asp?PageID=24
[20] *International Symposium: Developing Trends in Public Procurement and Auditing*, Conference held in The Netherlands, ESA, ESTEC, 14-16 May 2007.

space systems (e.g. metallic structures for rockets) had caused supply shortages repeatedly in 2006, and is forcing Russian space firms to raise their prices to adjust to Russia's new cost structure.

Export control regulations – One of the ongoing concerns of the space business community, particularly among entrepreneurs in the United States, regards the rules created by export control regulations, such as those of the International Traffic in Arms Regulations (ITAR). In late 2005, the possibility for the eventual overcoming of this hurdle was exemplified. The US Department of State issued a technical assistance agreement between the US-based Scaled Composites and the UK-based Virgin Galactic regarding the development of Spaceship Two, the suborbital spaceliner. This is an important step for the rules of future international business partnerships, for the adaptability of ITAR and the public-private dialogue within the industry.

Restrictions in telecommunications markets – Owing to the international commercialisation of space-related products and services, competition issues arise across many applications. One key issue relates to the need to maintain a level playing field between competing terrestrial and space-based solutions in a commercial market. In the case of communications, satellites have specific advantages in terms of international coverage, broadcasting, flexibility and rapid deployment of service. It is essentially the private sector that develops the civil satellite communications infrastructure. However, governments play an important supporting role to ensure that the communication infrastructure and all its main components evolve as needed to fully support economic and social development and the move to a knowledge society. Communications infrastructure should also provide an effective tool for delivering public services (such as health and education) to all in a cost-effective manner, including to households in rural and remote areas. In that context,

- Governments that are members of the WTO are encouraged in the case of the telecommunications sector to respect commitments undertaken in the Basic Telecommunications Agreement (Protocol 4) and open their markets for telecommunications, in a transparent manner. (Recommendation 7.1)
- Governments have a responsibility to ensure that technology-biased regulations do not bar telecommunications satellites from providing services in competition with terrestrial solutions by fostering a more level playing field for telecommunications' satellite operators. In a number of markets, satellite operators face significant barriers to entry, notably when entrenched incumbents – with significant sunk costs in their existing infrastructure – dominate such markets. (Recommendation 1.3)

As an example that open markets for satellite telecommunications are still an important issue in 2007 that arises in many different countries, India recently had negotiations about governmental restrictions with the Cable and Satellite Broadcasting Association of Asia (CASBAA).[21] In September 2006, the association called on the government of India to make a shift in its regulatory approach to the pay-TV industry. Founded in 1991, CASBAA represents some 120 Asia-based corporations, which in turn serve more than 3 billion people. While telecom markets, such as cellular services, have unleashed widespread competition, all too often Asia Pacific satellite markets remain constrained by the concept of protecting national incumbents or flagship monopolies. According to CASBAA, investment in high-quality content could quickly dry up as channel providers find they cannot make a return on their investment.

Issues of industry consolidation – Since 2004, substantial consolidation activities in the satellite and launcher industry occurred. Concerning telecommunications operators, Intelsat took over PanAmSat in August 2005, while the SES GLOBAL operator acquired New Skies Satellites (NSS) in December of that year, strengthening the two companies' already solid lead over the competition. Already more than half of the 260 satellites in geostationary orbits are owned by just five companies. On the manufacturing side, Alcatel and Finmeccanica merged in January 2005, and the process continued with Alcatel Space and

[21] "Asia Satellite Industry Association Urges Regulation Rethink for India", *Satnews Daily*, September 25, 2006

Alenia Spazio's fusion, forming *Alcatel Alenia Space* Europe's largest satellite manufacturer. In Russia, the long awaited consolidation of the satellite industry started in summer 2006, with the mergers of many builders of satellite components, including the satellite prime contractor NPO-PM, into a single entity to be called Information Satellite Systems. On the launch services sides, the US Federal trade Commission authorised in October 2006 Lockheed Martin and Boeing to merge their government launch businesses under the joint venture of United Launch Alliance (ULA), which formally began its operations in late 2006. All those recent examples show of a rationalisation of the space industry that may still continue in 2007 (e.g. consolidation of some telecommunication operators in Asia and the Middle East).

One problematic that will become of significance over the next few years will be the potential impacts of extreme consolidation in the industry (i.e. lack of competition, prices, less innovation). Those impacts will need to be carefully monitored by policy-makers. In the United States, the FCC found in spring 2007 that effective competition in the satellite markets addressed, based on a range of standard economic indicators commonly used to assess market concentration, conduct and performance.[22] As the initial review of the satellite services sector, the Report provides a brief outline of the history and structure of the industry, and identifies certain capacity and pricing aspects specific to the sector, and notes intermodal competition from terrestrial technologies. At Congress' direction, the Report also discusses the Commission's policies regarding foreign participants' entry into the U.S. market, and as well as U.S. companies' ability to access certain foreign markets.

Box 3 – A progressing space-related market: radio via satellite

The still small market for radio via satellite has been quite vibrant over the last year and a half. The market for digital radio receivers could grow from 5 million units in 2005, to almost 25 million unit shipments in 2010, according to high-tech market research firm In-Stat. The two current satellite radio companies, Sirius Satellite Radio and XM Satellite Radio Holdings, have been successful in late 2005 and 2006 in increasing their customer base, with huge related costs, but their envisaged merger in 2007 to save on costs may not be possible because of regulatory constraints.

- XM added more than 1.695 million new subscribers in 2006, ending the year with more than 7.625 million subscribers.
- Sirius ended 2006 with approximately 6,024,000 subscribers, an 82 percent increase over the company's 2005 ending subscriber base of 3,316,560. Sirius added a record 2.7 million net subscribers in 2006.

4.3.2 Financing and insurance

In most business activities, the ability to finance the acquisition of productive assets by borrowing from private lenders is essential. Typically, the productive asset is used as collateral so as to protect the lender against default by the borrower. In the case of the space sector, the range and volume of activities being conducted by private actors have dramatically increased over the last decade. However, commercial space systems are extremely capital-intensive to plan, design, construct, insure, launch and operate, and they can take years to complete. For this reason, work currently being carried out by the International Institute for the Unification of Private Law (UNIDROIT) to provide clear financing schemes for space companies will be very useful for the future of the commercial space sector.

There is as yet no established market for commercial financing of private space activities, as exists for most other industrial sectors. To fill this need, a dedicated space Protocol to the UNIDROIT *Convention on International Interests in Mobile Equipment* (opened for signature in 2001) is being drafted.[23] It would set a framework through which states can support a system of asset-based and receivables financing. By

[22] US Federal Communications Commission, *First Annual Report On State Of Competition In The Satellite Industry*, FCC 07-34, March 26, 2007

[23] This UNIDROIT Convention, opened for signature in 2001, already sets universally applicable general rules for the provision of default remedies, the international registration of security interests and the rules of priority regarding such security interests for mobile equipments. So far, 28 states have signed the Convention (October 2004) and its related dedicated Protocol on Matters Specific to Aircraft Equipment (Cape Town, 2001).

permitting secured financing for the space sector, the Protocol has considerable potential to enhance the availability of commercial financing for outer space activities and to further the provision of services from space to countries in all regions and at all levels of development. Hence, governments are advised to support UNIDROIT efforts to finalise the space assets Protocol to the UNIDROIT *Convention on International Interests in Mobile Equipment*, by signing and then ratifying the future Protocol promptly so as to make it applicable in national law. There is danger that the Protocol will not be effective if many states are reluctant to accept such a regime, or only want to accept it if there are sufficient opt-out possibilities. (Recommendation 7.4)

Advances in the Cape Town Convention regarding space assets have not been many. Indeed, inasmuch as aviation assets and their insurance have gained ground during the coming into force of the Convention, domestic legal reforms to bankruptcy and secured transactions laws, as well as, in the U.S.A., the 2005 civil aviation case of *United States v. J.A. Jones Construction Group, LLC*,[24] there remain a number of undecided factors that cause the retardation of the space community's adoption of these rules for space. These include:

- The delimitation of the term "space assets" is not clear. It is undecided whether it is to include all space-bound assets or only some that are of a specific nature or kind.
- The identification of space assets for registry purposes of security interests pose a conundrum: what kind of criteria are to be used for this task?
- There are standing rules in the aviation industry regarding the creation of security interests in the debtor's rights (payment and performance obligations owed to the debtor) and related rights (licenses, etc.). The question is whether these are relevant for space assets, which, generally, by the nature of the industry, might call for the rights of the creditors and debtors to be determined and determinable in ways yet unappreciated in the market of heavy equipment insurance.
- The concerns regarding national security and ITAR provisions on the import-export of space technologies and assets might infringe on the available remedies of creditors and debtors. How should these be remedied and can adequate parallels be drawn with other technology-sensitive industries?

Notwithstanding the challenges that the commercial space sector faces, there has been an increase of activity in the sector. According to Marsh Inc., underwriters' profit in the satellite and launch industry was up to USD 500 million in 2005.[25] This is due to the entrance of new players in the insurance market meaning that there was an increase in the available coverage, which could reach up to USD 475 million with interest rates hovering around 10 per cent. Drawing from the aviation section, insurers are now offering vertical placements that ensure identical terms among all insurers in a syndicated coverage deal.

4.3.3 Public-private partnerships

Space activities have been carried out in the public sector for a long time, and some of those activities will remain there for strategic reasons. Still, as commercial space expands, it is only natural that some activities become candidate for privatisation. This has a number of advantages. First, it brings a business discipline to production activities, as private firms have a strong incentive to keep costs down and to produce goods and services buyers are willing to purchase. Moreover, it allows private capital in production, capital that would not otherwise be attracted. Finally, it gives the privatised firm more flexibility to pursue

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[24] *United States v. J.A. Jones Constr. Group, LLC*, 333 B.R. 637 (E.D.N.Y. 2005).
The U.S. federal government filed a suit against some parties for delays in their performance of a construction contract. One of these defendants was LBL Skysystems (U.S.A.), Inc. (LBL), a subsidiary of a Canadian company. The former filed a bankruptcy proceeding in the Canadian province of Québec. The case revolves around the legal issue of international comity and relief.

[25] "Insurance Recovery", *Aviation Week & Space Technology*, 18 September 2006

international markets and seek international partnerships that enable it to focus its activities in areas in which it has a comparative advantage. In that context, to the extent possible, business-oriented activities in government agencies that serve private markets should be privatised. (Recommendation 6.2) Monopolies may also be privatised, but a regulatory system and public service obligations on privatised companies may be needed to serve the public interest. Consideration should also increasingly be given to public-private partnership (PPP) schemes when appropriate, especially for long-term projects in which the infrastructure to be developed jointly can serve both public and private needs. (Recommendation 6.2)

As an example of recent public-private partnership, the French procurement agency, DGA, through a public private partnership with Astrium Satellites, completed the operationalisation of the Lola project in 2006. The project is the Airborne Laser Optical Link, which had for purpose to use Lola, mounted on a Dassault Mystere 20 business jet, and the geostationary-orbiting Artemis satellite owned by ESA to link these two through optical laser beams and transfer, among other, telecommunications data from the airborne terminal to the satellite. The advantage of using this technology is that it minimises the signal's degradation as it passes through the atmosphere, especially during rough weather conditions. Because of the unequalled terminal's capacity of 50 megabytes per second, the resolution of this system is unmatched and highly competitive.[26]

[26] "France Uses Laser to Link Aircraft, GEO Satellite", *Space News*, 18 December 2006

CONCLUSION

Although not exhaustive, this report has used the prism of the OECD space project's recommendations to review some recent developments in the space sector, especially in terms of applications. The report constitutes a first step to a possible future formal assessment mechanism to track changes in the space activities' framework conditions. Some developments in 2006 and early 2007 are summarised below.

1) The space industry is recovering from the latest cyclical telecommunication crisis (since 2001), although overcapacity is still significant in satellite telecommunications.

2) In 2006 and early 2007, there was paradoxically:

   - An increasing number of actors in space activities:
     - Recent space faring countries, such as India and China, have raised their ambitions in terms of their respective space assets portfolios (e.g. developments of human-rated space systems for India).
     - Internationally, countries all over the world are increasingly developing their own capacities (e.g. Earth observation satellites, new telecommunications satellites). This trend brings new customers to the incumbent space industry, but will also contribute to the international overcapacity in some space assets (launchers, satellites transponders).
     - New entrepreneurs coming from space and non-space sectors (e.g. Google, Microsoft) are providing in early 2007 new funding and innovative ideas to the incumbent space industry and agencies.
   - An acceleration of the consolidation of large industrial actors in traditionally space faring countries (e.g. USA, Europe, Russia). Key big players have emerged, but although the rationalisation was needed in some aspects (e.g. Russian consolidation), the impacts in terms of prices for the end-customers (including public actors) will need to be monitored over the next few years.

3) The financial sustainability of operational space systems delivering public good services is still a key challenge in 2007:

   - In Earth observation, although the value-added of space-based data is proven in some specific applications, the political decision (with the adequate funding and operational mechanisms) to consider selected research satellites as precursors to operational systems is still debated in many countries. Efforts have been made nationally to develop new systems (e.g. Cosmos Skymed), as well as regionally (e.g. Eumetsat's increasing operational role in environment monitoring and not only meteorology). As concerns about the environment are becoming more pressing in public opinions, new budget mechanisms might be more adequately put in place over the next few years (e.g. Disaster Management International Space Coordination Organisation initiative).

4) Concerning the policy and regulatory framework conditions for space activities:

   - The usefulness of space law has become recognised by an increasingly number of countries, which have developed one or are in the process of doing so (e.g. Japan, France).
   - A trend detected in the 2004 report seems to be continuing in terms of supervision of space activities, with moves of space activities to Ministries of Economy or Industry (e.g. German space activities' supervision moved from the Ministry of Research to the Ministry of Industry).
   - A rather large number of actors have reviewed their national space policies in 2006 (e.g. United States, China) or are in the process of doing so (e.g. France, United Kingdom).

APPENDIX – LIST OF RECOMMENDATIONS

The recommendations presented below are intended to provide a long-term, future-oriented framework, i.e. an overall, consistent set of broad policy orientations that can offer a useful framework for policy formulation. The recommendations are made from a broadly societal non-space perspective and are therefore addressed to governments in general, rather than to the space community as such. More specifically, they are intended for ministries that have main responsibility for overall economic and social policies – including policies that may have a bearing on the performance of private space actors – as well as for user departments that can take advantage of space-based solutions for delivering their services to the general public. The recommendations focus on the "big picture" and take a long-term policy view. They aim to address what governments can do to strengthen the contribution that space can make to the solution of the major socio-economic challenges to be faced over the coming decades. Moreover, they extend beyond the traditional ambit of space policy per se to other policy areas that may have a bearing on the successful deployment and use of space applications, for meeting societal challenges, although the range of issues covered is by no means exhaustive.

BLOCK I - IMPLEMENT A SUSTAINABLE SPACE INFRASTRUCTURE

Pillar 1: Implement a sustainable user-oriented space infrastructure

Recommendation 1.1 – Foster the development of a more effective Earth Observation infrastructure that allows for greater participation by both public and private actors

Recommendation 1.2 – Foster the development of an effective and sustainable satellite navigation infrastructure, fully suitable for public and commercial applications

Recommendation 1.3 – Encourage the further development of communications satellite infrastructure, suitable for meeting effectively both public and private needs

Pillar 2: Develop and maintain cost-efficient space transport and servicing infrastructure

Recommendation 2.1 – Encourage long term R&D targeted to reducing the cost of access to space

Recommendation 2.2 – **Special Focus** Encourage international cooperation for conducting pre-competitive R&D work to reduce the cost of access to space

Recommendation 2.3 – Review 'access to space' policy to reduce redundancy

Recommendation 2.4 **Special Focus** – Encourage long-term efforts in developing a sustainable in-orbit servicing infrastructure

BLOCK II - ENCOURAGE PUBLIC USE

Pillar 3: Encourage public use at national level

Recommendation 3.1 – Create mechanisms for the effective generation and use of space-based data

Recommendation 3.2 **Special Focus** – Strengthen cooperation between user ministries and space agencies

Pillar 4: Encourage public use at international level

Recommendation 4.1 – Encourage the use of space applications for global disaster prevention and emergency management purposes

Recommendation 4.2 – Encourage the use of space applications for monitoring international treaties

Recommendation 4.3 **Special Focus** Encourage the use of space applications to foster social and economic development in low-income countries

BLOCK III - ENCOURAGE PRIVATE SECTOR PARTICIPATION

Pillar 5: Create a supportive legal and regulatory environment for commercial activities

Recommendation 5.1 – Develop national space laws when none exists, or complement existing ones

Recommendation 5.2 – Make existing domestic space laws and regulations more business-friendly

Recommendation 5.3 – Adapt international space laws to business needs

Recommendation 5.4 **Special Focus** – Review the application of general laws and their impacts on the development of space applications

Pillar 6: Strengthen private provision of space goods and services

Recommendation 6.1 – Foster public procurement from the private sector

Recommendation 6.2 – Privatise commercially viable business-oriented government activities

Recommendation 6.3 **Special Focus**– Encourage entrepreneurship and innovation

Pillar 7: Foster a more supportive international business and finance environment

Recommendation 7.1 – Extend free trade discipline to open up markets

Recommendation 7.2 – Encourage international standards

Recommendation 7.3 – Improve the allocation of spectrum and orbital positions

Recommendation 7.4 – Encourage the private financing of space activities