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Introduction

When reading this issue of Space Policy, Issues and Trends it should be kept in mind that there are remarkable variations and lack of consistency in the publicly available figures on space activity. This is attributable to differing methodologies used by data providers, currency conversion issues, and time period variances. The lack of consistency starts at the very top, where there can be differences of tens of billions of Euros between estimates of the overall size of the global space economy; and it continues down to company-to-company comparisons, where different accounting practices produce different sums. But it is, of course, commonplace that differences in purchasing power in different economies, and differences in wage and infrastructure cost make one-to-one comparisons very difficult. Also, some countries are very restrictive in providing institutional data, for instance on defence spending.

Notwithstanding the many data uncertainties, this issue of Space Policy, Issues and Trends identifies important trends and developments. As Winston Churchill noted, statistics must be taken with a grain of salt, yet purely by looking at relativities much can be learned.

This is not a reason to be complacent about the precision of figures. Space has great societal importance and the space community owes it to political decision makers to be able to provide standardised, accurate figures. In this aspect, the United States is clearly ahead of the game, and Europe must perhaps consider whether institutions such as Eurostat should not become more involved in data collection and processing for the space field.

1. Global Political and Economic Trends

1.1 Global Economic Outlook

The United Nations Annual Report "World Economic Situation and Prospects" noted a slight improvement in global growth in 2014, which was expected to continue at only a moderate level across most regions and major economic groups.[1]

In 2014, the growth of World Gross Product (WGP) was estimated to be 2.6%, thus marginally better than the growth of 2.5% in 2013, but less than the 2.9% that had been anticipated mid-year. This was due partially to a number of unexpected shocks such as heightened geopolitical conflicts in different parts of the world, in addition to unfinished post-crisis adjustments in the process of recovery from the global financial crisis.[2]

In the Euro zone, while monetary policy measures led to a significant improvement in the sovereign debt crisis, the economic situation remained fragile. Western Europe continued to struggle with GDP growth estimated to be only 1.2% in 2014, as growth in the region had yet to reach pre-recession levels. However, Germany, Spain, Portugal, Ireland, and the UK returned to positive growth. Also, Eastern Europe gained further ground, due partially to recovering domestic demand, the gradual abandonment of fiscal austerity, and a turnaround in the inventory cycle. And while labour markets continued to improve, progress was uneven across the member states.[3]

The economy of the United States of America had some fluctuations in 2014 with GDP growth estimated at 2.3%; however that growth was expected to increase to 2.8% in 2015. While the fiscal drag on growth was diminishing, there was concern that volatility in financial markets in response to the normalization of monetary policy could lead to adverse effects on the real economy. And with an overall decline in employment rates in developed economies since the beginning of the financial crisis in the United States, the labour force participation rate was near its lowest level in the past 10 years due to population ageing, an increase in skill requirements, and a higher number of discouraged workers.[4]

In Japan, the momentum generated by the fiscal stimulus package and monetary easing introduced in 2013 receded due to a rise in inflation expectations and the further increase of the consumption tax by the central bank in late-2014. Exports were expected to eventually benefit from the depreciation of the Japanese yen triggered by the monetary easing, while the planned cut in corporate taxes would support fixed investment. And while GDP grew by 0.4% in 2014, it was expected to increase to 1.2% for 2015.[5]

While the global economy struggled to gain momentum in grappling with the legacy of the global financial crisis, developed economies were expected to see growth in the oncoming years, thanks to gradually recovering labour markets, ebbing fiscal consolidation, and low financing costs. While GDP growth was estimated at 1.8% in 2014, it was expected to grow to 2.2% in 2015. In developing countries growth was projected to gradually accelerate, rising from 4.4% in 2014 to 4.8% in 2015.[6]

Overall, WGP was forecast to grow at a pace of 3.1% and 3.3% in 2015 and 2016, respectively. Unemployment figures remained elevated in several developed countries, particularly in the euro zone, and to some extent, wage stagnation eroded the benefits of salaried employment. However, in developing economies, from 2013unemployment rates remained relatively stable, partly owing to lower labour force growth. Nevertheless, high unemployment levels continued to persist in South-Eastern Europe, Northern Africa, and Western Asia.[7]

[1] "World Economic Situation and Prospects 2015." 10 Dec. 2015. United Nations 7 Mar. 2015 <http://www.un.org/en/development/desa/policy/wesp/wesp_archive/2015wesp_full_en.pdf>.
[2] Ibid. at 1.
[3] Ibid. at 8.
[4] Ibid. at 11.
[5] Ibid. at 8.
[6] "Global Economic Prospects | Having Fiscal Space and Using It." 13 Jan. 2015. The World Bank 7 Mar. 2015: 21 <http://www.worldbank.org/content/dam/Worldbank/GEP/GEP2015a/pdfs/GEP15a_web_full.pdf>.
[7] "World Economic Situation and Prospects 2015." 10 Dec. 2015. United Nations 7 Mar. 2015

1.2 Political Developments

1.2.1 Geopolitics

Many significant world events remained unresolved by year's end. In the Middle East Abdel Fattah el-Sisi's success in the May 2014 Egyptian presidential elections ushered in increased military and political relations with Russia and deteriorating relations with the United States; in Syria and Iraq the emergence of the 'Islamic State' (IS or ISIS) brought renewed concern to the region. In contrast to the Arab Spring that arose through political demonstrations and unrest within the Arab world, ISIS had already existed as 'al-Qaeda in Iraq' and gained notoriety when it began to send forces to fight in Syria's civil war. Denounced even by al-Qaeda for its brutality toward its enemies, its scale as an international threat remains uncertain. While the U.S. has sent troops to Iraq to advise its army on how to regain territory, and the U.S. and Iran have launched airstrikes on IS territory to slow the growth of the group, the IS continues to draw in foreign jihadists (including some Europeans and Americans), and pledges of allegiance from other jihadi groups.[8]

In Iran, President Hassan Rouhani was unable to rally the country to scale back its nuclear ambitions in exchange for the roll-back of Western sanctions. In January 2014 a six-month joint plan of action between Iran and the U.S., UK, France, Germany, Russia, and China, was launched in an attempt to conclude the negotiations process, yet an agreement was not reached by July – nor was one reached in November, following a four month extension in talks. A new deadline was set for 1 July 2015.[9]

Russia's annexation of Crimea significantly impacted EU-Russia relations, especially following the downing of Malaysia Airlines passenger Flight 17 over rebel-held territory in Ukraine. Tensions began at the end of 2013, when the pro-Russia former Ukrainian President Viktor Yanukovich decided not to sign a much anticipated trade deal with the EU. Protests continued into February 2014, when Yanukovich resigned from office and fled the country, and pro-Russian militants seized the Crimean capital in return. Following a questionable referendum, wherein 95% of Crimeans voted in favour of rejoining Russia, in May pro-Russian separatists in other regions of eastern Ukraine declared independence, and held their own elections; while the rest of the country elected Petro Poroshenko as the pro-Western Ukrainian president. Following the downing of the Malaysia Airlines flight on 17 July 2014, the EU and United States responded by increasing sanctions against Russia, which contributed to continuing tensions throughout the rest of the year.[10]

In West Africa, Ebola outbreaks in Liberia, Guinea, and Sierra Leone resulted in a death toll of over 6,000 people by the end of 2014. While several outbreaks had occurred since the virus' discovery in 1976, those deaths ranged between several dozen to hundreds, having emerged in less densely populated areas. The opposite was the case this time; and with the inadequate, slow and uneven international response, some isolated cases reached the U.S. and Europe. With economic growth rapidly decreasing, and food shortages becoming common, there was concern that the economic costs of the Ebola outbreak in West Africa would have long-term effects.[11]

In Europe, austerity measures accompanying the financial crisis drove a wedge between Euro zone members in the north and south. And while there was some sign of growth, its impact on the high unemployment rates in the countries of the 'periphery' was minimal – youth unemployment rates in particular remained very high, more than 50% in Greece and Spain.[12]

1.2.2 Environment

Space applications have an important role in the monitoring and protection of the environment. Space assets are uniquely positioned to offer a global perspective on climate change. They help to better manage disaster situations around the world, and are often a common multinational platform for collecting relevant meteorological and environmental data. These characteristics make them ideal promoters of international understanding and cooperation in this field. Satellite based systems are used to gather information on climate change indicators e.g. the melting of the ice-caps, changes in the global sea level, and to gather data on the regions most affected by global warming. Remote sensing

<http://www.un.org/en/development/desa/policy/wesp/wesp_archive/2015wesp_full_en.pdf>.

[8] Lindsay, James M. "Top Ten Most Significant World Events in 2014." 15 Dec. 2014. Council on Foreign Relations 10 Mar. 2015 <http://blogs.cfr.org/lindsay/2014/12/15/top-ten-most-significant-world-events-in-2014/>.

[9] Ibid.

[10] Ibid.

[11] Ibid.

[12] "Youth Unemployment Could Prolong Eurozone Crisis, Christine Lagarde Says." 10 Dec. 2013. The Guardian 19 May 2014 <http://www.theguardian.com/business/2013/dec/10/youth-unemployment-eurozone-crisis-christine-lagarde-imf>.

technologies can also be used to monitor deforestation and land use, and are important for better utilization of fresh water sources. There is no doubt that space technologies will play an important role in human and environmental security in the future, hence technical development of their capabilities is necessary.

Climate change remains one of the major agenda topics within the global political debate. In the days leading up to the 20th UN Framework Convention on Climate Change Conference of Parties (UN FCCC/COP) which took place in Lima, Peru, from 1 to 12 December 2014, the EU had pushed for the legally binding mitigation target of a 40% reduction in emissions by 2030; whereas the U.S. preferred a more buffet-like approach that included some binding elements, but allowed countries to determine the scale and pace of their emissions reductions even if it this could mean that the goal of keeping global temperature rises below 2°C would not be met.[13] However, rather than establishing a new global agreement on climate change, the Lima meeting provided a set of procedural steps, which consisted of loose arrangements for parties to bring forward their intended nationally determined contributions (INDCs); these INDCs and the remaining issues and options put forward by the parties will be included in the elements for a draft negotiating text that will be produced mid-2015. Containing the raw material for the next meeting, the elements paper covered such issues as mitigation, adaptation, finance, technology transfer, transparency, the legal nature of parties' commitments, the use of market mechanisms, and procedures to periodically update commitments. However, amid the compromises being made by industrialized and emerging nations, unresolved major issues remained by the end of the conference, such as whether INDC's should focus only on mitigation, or also on adaptation and finance, and whether quantifiable information was expected on a voluntary or mandatory basis. Moreover, the method for assessing the aggregate effect of the INDCs, and whether the responsibilities and financing from industrialized and emerging nations should remain differentiated, remained points of discussion.[14]

The Lima conference featured the first "multilateral assessment" of mitigation efforts by 17 industrialized countries, as part of the transparency procedures established under the Cancun Agreements of 2010; showing their progress toward achieving the 2020 emission pledges as agreed on in the "Copenhagen Accord" of 2009. Moreover, by the end of the Lima conference, the Green Climate Fund (GCF) established under the Cancun Agreements of 2010 surpassed an informal initial goal of $10 billion in pledges; at the Cancun conference, industrialized nations committed to mobilize $100 billion per year in public and private finance by 2020, to assist developing countries in handling the effects of global warming and climate change. And in terms of aid to developing countries for "loss and damage" resulting from climate change, the meeting decided on the composition of the executive committee for the Warsaw International Mechanism for Loss and Damage, established at the Warsaw conference of 2013, and adopted an initial two-year work plan to mitigate climate impact and risks.

Aside from increased transparency through the development of an online Information Hub on the UN FCCC website, not much progress was made regarding the UN Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN REDD), where governments had previously agreed on a set of measures to reduce emissions from deforestation and forest degradation.

The new global agreement on climate change is expected to be concluded in at the 21st UN FCCC/COP in Paris, France running from 30 November to 11 December 2015.[15]

On 20 November 2013 the European Parliament and European Council adopted a decision to establish the EU's 7th Environmental Action Programme (EAP) (running until 2020) "living well, within the limits of our planet", which entered into force in January 2014. It identifies three key objectives: i.e. protection, conservation and enhancement of the EU's natural capital; turning the EU into a resource-efficient, green, and competitive low-carbon economy; and safeguarding the Union's citizens from environment-related pressures and risks to health and wellbeing. It also lists four 'enablers' that will facilitate these goals: better implementation of legislation; better information by improving the knowledge base; increased and wiser investment for environment and climate policy; and full integration of environmental requirements and considerations into other

[13] Nelsen, Arthur. "UN climate change deal must have legally binding targets, says EU." 27 Nov. 2014. The Guardian 31 Mar. 2015 <http://www.theguardian.com/environment/2014/nov/27/un-climate-change-deal-must-have-legally-binding-targets-says-eu>.

[14] "Outcomes of the U.N. Climate Change Conference in Lima." Dec. 2014. C2ES.org 31 Mar. 2015 <http://www.c2es.org/docUploads/cop-20-summary.pdf>.

[15] Ibid.

policies. Its two overarching horizontal priority objectives are to make the Union's cities more sustainable, and to help the Union address international environmental and climate challenges more effectively.[16]

1.2.3 Energy

Instability in parts of the Middle East, the major source of low-cost oil, and tension between Russia and Ukraine, sparked concerns over natural gas security, demonstrating that the energy system may be in danger of falling short of meeting global energy needs in the coming decades. While global energy demand should grow by 37% by 2040, the change in the distribution of that demand will be more dramatic, with consumption increasing substantially in China and the rest of Asia (60% of the global total), along with other emerging regions in Africa, the Middle East, and South America. On the other hand, energy demand will remain flat at current rates in Europe, Japan, South Korea, and North America.[17]

China is expected to become the largest oil-consuming country by the 2030s, surpassing the United States whose own oil production and consumption will start to fall back in the 2020s. As oil demand will increase in emerging countries, the turmoil in the Middle East is a major concern given the increasing reliance on this region for oil production growth. Additionally, the long-term supply of natural gas is another concern, with the key uncertainty being whether it can be produced at an attractive price to consumers across Asia and Europe, while still providing an incentive to invest in gas exploration and exploitation. An investment of around $900 billion per year in upstream oil and gas production is needed by the 2030s to meet the projected demand.[18]

Coal production will remain abundant, constrained mainly by measures to tackle pollution and reduce CO2 emissions. India is expected to surpass the United States as the world's second biggest coal importer before 2020, and will overtake China shortly thereafter. Relieving pressure on energy supplies and mitigating the impact of price disparities between regions will require a focus on energy efficiency. In 2013, fossil-fuel subsidies totalled $550 billion, whereas subsidies for renewable energy were nearly a quarter of that amount, i.e. $120 billion. According to the United Nations Environment Programme report 'Global Trends in Renewable Energy Investment 2015', investment in developing countries rose by 36% to $131.3 billion in 2014, with China investing $83.3 billion (up 39% from 2013), while Brazil ($7.6 billion), India ($7.4 billion), and South Africa ($5.5 billion) were also among the top 10 investing countries. Additionally, more than $1 billion was invested in Indonesia, Chile, Mexico, Kenya and Turkey. Yet in industrialized countries, the U.S. invested $38.3 billion (up 7% from 2013), while European investment rose by less than 1% to $57.5 billion, and Japan rose by 10% to $35.7 billion.[19] It is expected that by 2040, the world energy supply mix will be split almost evenly between oil, gas, coal, and renewable/low-carbon sources.[20]

1.2.4 Resources

Space applications and Earth monitoring technologies play an important role in the area of resource management, as they can provide better control of and support for the utilisation of scarce natural resources. Likewise, satellite based technologies can perform indispensable tasks for international trade, e.g. by streamlining global business transactions and payments. Global navigation satellite systems (GNSS) are already relied on as an integral part of transportation and utilisation of natural, agricultural and industrial resources. And the use of meteorological and imaging satellites is making agricultural output larger and more reliable, allowing greater precision. For many developing countries the rationale for investment in space is improvement of the management of their agricultural and natural resources.

The growth of international trade continued at a rate of 2.2% in 2013, remaining subdued from the 13.8% growth experienced in 2010, and was expected to remain between 2.5% and 3% during 2014.[21] Moreover, the volume of trade in nearly all regions appeared to have decelerated, excluding some developing countries in Asia, and Sub-Saharan Africa, with varying impact on developed, developing and transitioning economies. Developed economies experienced the greatest slowdown, with a 0.4% reduction of imports in 2013, primarily the result of weak intra-EU

[16] European Union. Decision of the European Parliament and of the Council on a General Union Environment Action Programmes to 2020 "Living Well, Within The Limits Of Our Planet". 20 Nov. 2013, European Parliament and Council Decision PE-CONS 64/1/13 REV 1 of 20 November 2013. Strasbourg: European Union <http://ec.europa.eu/environment/newprg/pdf/PE00064_en.pdf>.
[17] International Energy Agency. World Energy Outlook 2014 – Executive Summary. IAE: Paris, 2014.
[18] Ibid.
[19] "Global Trends in Renewable Energy Investment 2015." 31 Mar. 2015. FS-UNEP 26 Aug. 2015 <http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2015>.
[20] International Energy Agency. World Energy Outlook 2014 – Executive Summary. IAE: Paris, 2014.
[21] According to the latest data available from UNCTAD.

trade, along with continued contractions in Japan and the U.S. However, EU exports to countries outside the region grew by 1.4%, whereas growth in U.S. exports shrank to 2.6%, while Japan's exports further contracted by 1.8%. Another concern was the situation in the economies in transition, where a slowdown was even more noticeable, due mainly to weak European demand for their exports, and a slump in their own GDP growth, resulting in the halving of the growth rate of imports. Growth in exports in transition economies slowed even further from 1.3% in 2012 to 1.0% in 2013, while imports dropped from 5.0% in 2012 to 2.7% in 2013. Developing economies also experienced further weakened growth in exports for 2013, dropping to 3.4% from 4.6% in 2012, mainly due to weak external demand from developed countries. However, growth in developing countries' imports remained resilient in 2013, increasing to 5.5% from 5.3% in 2012, due to increased demand from some of the larger economies.[22]

In mid-2014, crude oil prices remained similar to previous years.[23] According to the United Nations Conference on Trade and Development (UNCTAD), crude oil market prices remained high between the second half of 2013 and the first half of 2014, with prices fluctuating in a $102.3-$108.8 band, and averaging $105.5 per barrel for the 12-month period. However, there were signs of increased volatility in oil prices in the second quarter of 2014 as geopolitical tensions between Ukraine and Russia continued to escalate, raising risk perceptions in energy markets. However, as there was no significant disruption in production associated with those rising tensions by mid-2014, the volatility can be attributed more to market sentiment than to real production effects. In fact, the oil market was well supplied in this period mainly due to increased production by the U.S. linked to its shale oil and gas boom, and other large non-OPEC country supplies that had helped to buffer oil supply disruptions that had occurred in other oil producing countries such as Iran, Libya, Nigeria, and South Sudan. And while growth in the oil trade decreased by roughly 1% in 2013, it marginally increased again by 1% in the first half of 2014.[24]

Yet crude oil prices dropped radically in the second half of 2014, reaching the nadir of $63.72 (Brent) and $67.53 (West Texas Intermediate) on 1 December 2014.[25] Oil prices were clearly dampened by the November 2014 decision of the Organization of the Petroleum Exporting Countries (OPEC) to keep the market oversupplied, in order to protect market share against that of shale oil producers. By the end of the 2014, the price of oil had thus dropped by nearly 40 per cent compared to mid-2014.[26]

As in previous years there continued to be a high degree of volatility in non-oil commodity prices, which were strongly dependent on variable weather conditions that caused stagnation in production of certain commodities. In general, there was continued growth in demand for commodities, at even step with the sluggish growth of the world economy. Moreover demand coming from rapidly growing developing countries such as China continued to increase, due partly to government stimulus measures. Nevertheless, the percentage change of non-oil commodity prices appeared to be bottoming out, following an 8.3% reduction in 2012, and a 6.7% reduction in 2013, it showed a 3.9% reduction in 2014.[27] Non-oil commodities prices were forecast to begin increasing in 2016.[28] As in previous years, uncertainty and instability were the major distinguishing features of commodity markets, which were also reflected in the greater volatility of commodity prices. However, from 2012 to 2014, most commodity prices stayed at substantially higher levels than the average levels between 2003 to 2008, and many commodity prices were still at levels close to their peaks prior to the financial crisis. Nevertheless, in line with previous years, vegetable oil seeds and oils, agricultural raw materials, minerals and metals and crude petroleum all showed higher levels of volatility.[29] Whereas overall, metals and minerals prices decreased by 6.8% in the reporting period, nickel and zinc were the exception with growth of 10.2% and

[22] United Nations Conference on Trade and Development. Trade and Development Report, 2014. Geneva: UNCTAD, 2014. 1-14. 2014 data not yet available.
[23] Based on the United Nations Conference on Trade and Development (UNCTAD) mid-year reporting period.
[24] United Nations Conference on Trade and Development. Trade and Development Report, 2014. Geneva: UNCTAD, 2014. 8-10.
[25] "Oil prices fall to near five-year low again." 5 Dec. 2014. The Financial Times 26 Aug. 2015 <http://www.ft.com/intl/fastft/246631/oil-prices-fall-near-five-year-low-again>.
[26] Tully, Andy. "OPEC Fires First Shot In Global Oil Price War." 30 Nov. 2014. OilPrice.com 26 Aug. 2015 <http://oilprice.com/Energy/Oil-Prices/OPEC-Fires-First-Shot-In-Global-Oil-Price-War.html>.
[27] United Nations Conference on Trade and Development. Trade and Development Report, 2014. Geneva: UNCTAD, 2014. 10.
[28] The World Bank. Global Economic Prospects – Coping with policy normalization in high-income countries. Volume 8 / January 2014. Washington DC: World Bank, 2014.
[29] United Nations Conference on Trade and Development. Trade and Development Report, 2014. Geneva: UNCTAD, 2014. 10.

7.4% respectively.[30] The indexes for gold, silver, and platinum declined for a second year, by 10.3%, 19.7%, and 6.9% respectively in 2014.[31]

1.2.5 Knowledge

There is no doubt that sustained education and knowledge improvement is one of the necessary conditions for successful space activities, as well as for the full exploitation of their societal benefits. In general, space technology and development, drawing on multiple scientific disciplines, is one of the most difficult and challenging fields in scientific and technical research. Therefore, coherent and sustainable strategies aimed at improving higher education and supporting technical and scientific activities are particularly relevant and necessary for space sector activities.

For Europe, the expansion of its pool of highly skilled and specialised scientists and professionals should be a constant priority if it is to remain a leading actor in the field of space-related scientific and technological R&D. With other developed and emerging economies increasing investment in R&D in response to the financial crisis, for Europe to remain a leader in the global race for knowledge and excellence in space R&D, current levels of financial spending and political commitment in this area will have to be increased, and not only simply maintained. For example, in 2014 30% of the European working age population (not including Bulgaria, Cyprus, Malta, Latvia, Lithuania, Romania, and Croatia) held a higher education degree compared to 43% in the U.S., 47% in Japan and 53% in Canada.[32] While OECD figures tend to show that many European states can expect a significant increase in the proportion of their population that attains a higher education degree, countries including Spain, France, and Germany, and to a lesser extent Portugal, Austria, Slovakia, Hungary, Czech Republic, and Italy, are at risk of falling further behind the OECD average of 33% of the working age population (between 25-to-64 years of age) with a higher education degree.[33]

Typically, employment rates are highest among people with high qualifications, while people with the lowest educational qualifications are at greater risk of being unemployed.[34] According to the European Centre for the Development of Vocational Training, while employment is projected to grow by 2% over the period 2013-2020, the European skills forecast indicates that the EU will miss its target of reaching 75% employment by 2020, reaching instead 68.5% due to weak demand for labour following the financial crisis and the modest recovery and average GDP growth rate. Prior to the financial crisis, between 2000 and 2008, the employment rate increased by 3.7%. Between 2013 and 2020, the number of high qualification job openings should exceed 55 million (combining replacement needs and expansion demand), whereas medium qualification openings will be over 40 million (coming mainly from replacement needs), and low qualification jobs will be lower than 10 million (due to shrinking demand offsetting replacement needs). In fact, the overall share of the labour force with low qualifications is forecast to fall from 22% in 2013 to 16.8% in 2020. And while the EU is on course to surpass its education goal of 40% of 30-34 year-olds having completed higher education by 2020, possibly reaching 45% by that time, weak high-skilled labour demand could mean that there will be an increased risk of skill mismatch due to the over-qualification of highly skilled labour that has no alternative than to accept lower skilled employment.[35]

Encouragingly, the population of university and higher education students in Europe has been constantly increasing in recent years. There are around 4,000 universities and other kinds of higher education institutions in Europe, with over 20 million students in 2011.[36] Unfortunately, this quantitative increase has not been accompanied by qualitative improvements in governance structures and proposed academic curricula, or by increases in funding. Although increasing in size, Europe's higher education system has not yet achieved an academic curricula distribution that will train scientists and professionals with the right kinds of skills to support economic growth and scientific excellence in new technologies. This is especially true for the space sector, which has a relatively lim-

[30] Ibid.
[31] World Bank Group. Commodity Markets Outlook. January 2015. Washington, DC: World Bank, 2015: 23.
[32] OECD. Education at a Glance 2014: OECD Indicators, OECD Publishing, 2014: 44 <http://www.oecd.org/edu/Education-at-a-Glance-2014.pdf>.
[33] Ibid. at 46.
[34] Ibid. at 102.
[35] "Cedefop's latest skill supply and demand forecasts highlight Europe's employment challenge." 1 Apr. 2014. CEDEFOP 7 May 2015 <http://www.cedefop.europa.eu/node/12684>.
[36] "Tertiary education statistics | Data from September 2013." Eurostat Statistics Explained 8 May 2015 <http://ec.europa.eu/eurostat/statistics-explained/index.php/Tertiary_education_statistics>.

ited human resources supply and demand chain.[37]

According to a report to the European Commission on new modes of learning and teaching in higher education, there remains a culture of conservatism within European higher education that impedes its potential to fulfil its role in society and contribute to Europe's prosperity. While an uncoordinated bottom-up approach has been used to a large degree to spur a broad range of good practices across Europe, there is a need for governments and institutions to develop comprehensive strategies at both the national and institutional level for the adoption of new modes of learning and teaching within higher education. New models of provision, such as open online courses, provide the opportunity for lifelong learning, continuing professional development and internationalisation, and also the ability to collect and analyse learner data that could allow for personalised learning and enhanced retention by students.[38] Another form of learning beyond the traditional lecture hall that is being utilized in the European space sector comes in the form of industry school labs, such as the DLR's School Lab programme in several universities throughout Germany, which has helped in the long-term furtherance of interest in the natural sciences.[39]

The EU budget dedicated to funding programmes for education, training, youth, and sport was about €14.774 billion for the period 2014-2020, which means an increase of 67.9% compared to the 2007-2013 period.[40] These programmes feature three key actions which address: 1) the learning mobility of individuals; 2) cooperation for innovation and the exchange of good practices; and 3) support for policy reform. The main activity of the first key action will involve youth exchanges, and European voluntary services. The second key action will focus on strategic partnerships for the purpose of implementing innovative practices that lead to high quality teaching, training, learning and youth work, institutional modernisation and societal innovation, and capacity building to foster cooperation and exchanges in the field of youth between participating countries. The third key action will be in the form of a structured dialogue in various meetings between young people and decision-makers in the field of youth.[41] The European Commission has also proposed a 46% rise in research funding under the planned Horizon 2020 strategy that will bring funding up to €80 billion.[42]

1.2.6 Mobility

Maritime commerce accounts for the bulk of global trade, whereas air traffic carries most of the world's passenger traffic. Space assets are indispensable to both, as they provide meteorological, navigation and communication services that make sea and air transport safer and cheaper. Maritime navigation and mobile communications are two of the upcoming sectors with significant financial interests in the development of new generations of satellite-based applications.

Maritime transport is the most commonly used form of transport for international trade, representing about 80% of global merchandise trade. While prospects for the world economy, along with trade and shipping, indicate possible slowly improvement, there are still risks in the fragile recovery of developed economies, especially in the event that geopolitical tensions escalate. By 2013, vessel orders had stopped their downward trend, marking a tentative end to the significant order decline that had followed the financial crisis and ending one of the longest uninterrupted growth periods in recorded maritime history. In early 2014, order books showed slight increases in terms of bulk carriers, tankers, and container vessels; however the general cargo ship category continued to diminish. Even with the small uptick in orders, there was still a high number of ship demolitions (29,052) – yet, total demolitions in 2013 were 20.0% lower than in the previous year (36,293). In 2013, dry-bulk carriers retained the greatest share of the total quantity of tonnage sold for demolition at 44%,

[37] Europe 2020 Target: Tertiary Education Attainment. Europa.eu 11 May 2014 <http://ec.europa.eu/europe2020/pdf/themes/28_tertiary_education.pdf>.
[38] High Level Group on the Modernisation of Higher Education. "REPORT TO THE EUROPEAN COMMISSION ON New modes of learning and teaching in higher education." Oct. 2014. Europa.eu 8 May 2015 <http://ec.europa.eu/education/library/reports/modernisation-universities_en.pdf>.
[39] "Study confirms long-term furtherance of the interest in the natural sciences." 4 Oct. 2010. DLR 8 May 2015 <http://www.dlr.de/schoollab/en/desktopdefault.aspx/tabid-1708/13696_read-34709/>.
[40] "Erasmus+ | The new EU programme for Education, Training, Youth, and Sport for 2014-2020." Europa 8 May 2015 <http://ec.europa.eu/programmes/erasmus-plus/discover/index_en.htm>.
[41] "Erasmus+ | The new EU programme for Education, Training, Youth, and Sport for 2014-2020." 24 July 2014. SALTO-YOUTH EASTERN EUROPE AND CAUCASUS RESOURCE CENTRE 8 May 2015 <http://msy.gov.ge/files/EaP%20Conference%20Tbilisi%202014/July%202/SALTO_presentation.pdf>.
[42] "An EU Strategy for Modernising Higher Education – Questions and Answers." 20 Sept. 2011. European Commission – Press Release. 1 Mar. 2012 <http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/11/615&format=HTML&aged=0&language=EN&guiLanguage=fr>.

followed by oil tankers at 20%, and container ships at 18%.[43] However, while new ship orders were made in 2014, it will take several years before the maritime industry enters a new shipbuilding cycle.

Another challenge for the maritime industry is the heightened exposure and vulnerability of international shipping to piracy, armed robbery, and other crimes. Between 2003 and 2012, around 3,436 acts of piracy were reported worldwide.[44] And in that period, piracy incidents in East Africa, particularly off the Somalia coast, the Gulf of Aden and the Indian Ocean were particularly alarming, especially since they exceeded those in some of the traditional regions for piracy such as Indonesia, Malaysia, Singapore, and the Philippines. Indeed, between 2005 and 2012, piracy off the coast of Somalia accounted for nearly 50% of all recorded hijackings. This spurred an increased international military presence in this region, and preventative measures by merchant ships that privately contracted armed personnel, reducing Africa's share of piracy incidents from 50% in 2008 to 17.3% in 2012.[45] This downward trend has continued, with the number of reported piracy incidents in 2013 having decreased by 11.1% to 264, followed by another reduction of 7.2% to 245 in 2014. Thus, the number of Somalia-based piracy incidents has fallen from 49 in 2012 to 3 in 2014, although it continued to increase in East Asian waters.[46] In its heyday, the surge in piracy in the Gulf of Aden generated considerable costs especially for Europe as 80% of shipments that pass through the area come from or are going to this continent. Re-routing shipments around the Cape of Good Hope alone is estimated to have created over $7.5 billion of additional shipping costs annually with associated increased energy consumption.

[43] United Nations Conference on Trade and Development. Review of Maritime Transport 2014. Geneva: UNCTD, 2014. 46.
[44] United Nations Conference on Trade and Development. Maritime Piracy | Part 1: An Overview of Trends, Costs and Trade-related Implications. Geneva: UNCTAD, 2014. 3.
[45] Ibid.
[46] ICC International Maritime Bureau. Piracy and Armed Robbery Against Ships: Report for the Period 1January – 31 December 2014. Jan. 2015. ICC-CSS 11 May 2015 <http://www.hellenicshippingnews.com/wp-content/uploads/2015/01/2014-Annual-IMB-Piracy-Report-ABRIDGED.pdf>.

2. Global Space Economy

Chapter 2 covers the 2014 public budgets and commercial revenue related to space activity. There will be a brief discussion of space related public budgets and commercial revenue with a quantitative assessment of the overall market value and financial performance of space activities in the last 12 months.

In the absence of internationally uniform standards, developing an accurate estimate of financial and market figures of global space activities is a complicated task, especially when considering that most countries and space research institutions adopt their own distinct methods of categorising and distributing funding for space activity. Likewise, the lack of transparency in certain government space programmes, e.g. military space projects, further complicates calculations. And an additional degree of distortion is introduced by floating currency exchange rates, as all numbers are reflected in terms of U.S. dollars. Moreover, commercial companies publish their financial figures regularly, but not in a uniform and synchronised way that would allow direct horizontal industry comparisons.

2.1 Global Space Budgets and Revenue

Total government space expenditure in 2014 increased substantially, reaching $79.17 billion from $74.10 billion in 2013.[47] Of this, total government expenditure for civil space programs amounted to $43.84 billion in 2014. In 2014, the compound annual growth rate (CAGR) of the entire space industry, including commercial revenues and government expenditure, was 9.1%, increasing significantly from the 5.9% growth experienced in 2013.[48] The following section provides a more detailed analysis of institutional budgets.

The 2015 Space Report indicates that the 2014 total revenue from commercial satellite services grew slightly, by 0.5%, reaching $123.18 billion including telecommunications, Earth observation and positioning services. However, revenue from space-related commercial infrastructure including manufacturing of spacecraft and in-space platforms, launch services as well as ground equipment, is estimated to have grown by 8.6% reaching $127.65 billion. And overall, total commercial space revenue reached $250.83 billion in 2014.[49]

2.2 Overview of Institutional Space Budgets

According to the Space Report 2015, total institutional spending on space programs in 2014, including that of intergovernmental organisations, increased by 6.8% to $79.17 billion, with a notable increase of 12.9% by non-U.S. government space actors which are investing in new capabilities or expanding existing ones.[50] Global 2014 space spending was comprised of $43.84 billion in civil expenditure (55.4% of the total share), and $35.33 billion in defence expenditure (44.6%), showing a slight shift toward increased defence space spending from 2013.[51] In contrast, Euroconsult listed 2014 civil space expenditure to be $42.03 billion and government expenditure for defence space programmes to be $24.45 billion; changing the civil-to-defence ratio in the opposite direction, i.e. 63.2% civil expenditure, 36.8% defence.[52]

In defence spending, the Space Report 2015 estimates that worldwide defence related expenditure reached $35.33 billion in 2014, with 63.6% of this amount ($22.483 billion) spent by the United States for space security programmes under its Department of Defence (DoD). The U.S. DoD's space budget funds its military space programmes, in addition to organisations such as the National Reconnaissance Office (NRO) and the Na-

[47] The Space Report 2015. Colorado Springs: The Space Foundation, 2015: 14.
[48] Ibid. at 1.
[49] Ibid.
[50] Ibid. at 2.
[51] Ibid. at 23 - 24.
[52] Euroconsult 2015. Profiles of Government Space Programs: 16.

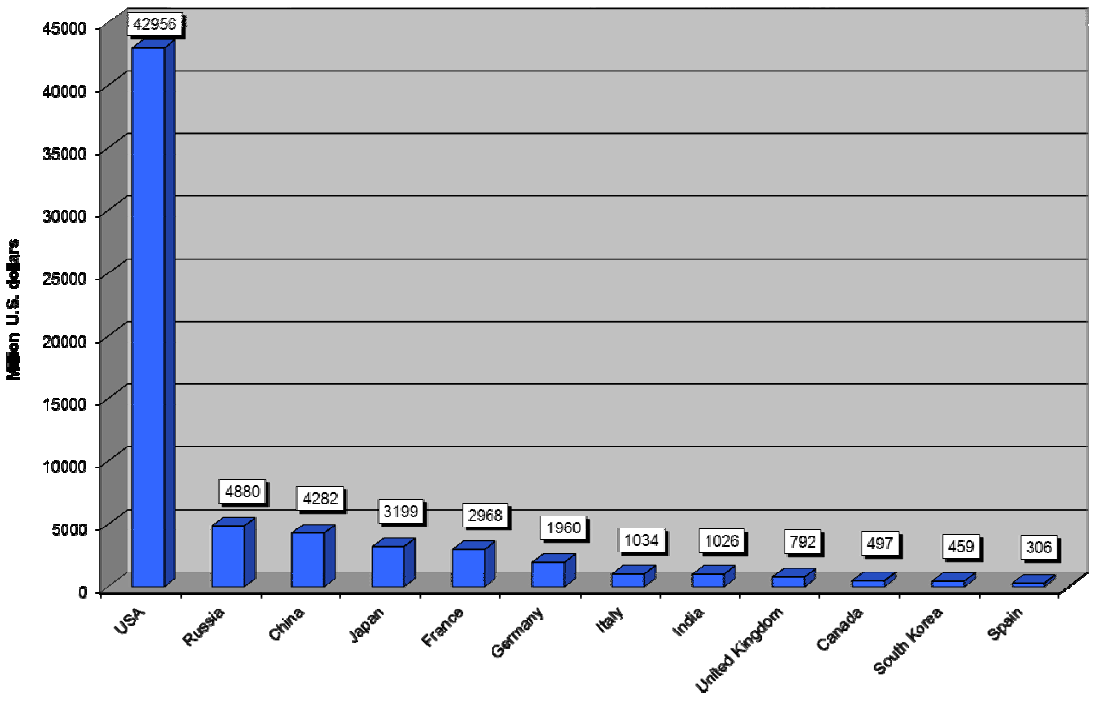

Figure 2.1: Public space budgets of major space powers in 2014 (Based on Euroconsult and the Space Report 2015 data).

tional Geospatial-Intelligence Agency (NGA).

Moreover, total defence spending by non-U.S. government space actors continued to increase, reaching a 36.4% share ($12.84 billion), from 31.7% ($10.33 billion) in 2013.[53] However, it should be noted that a degree of uncertainty exists regarding expenditures on defence space activities as not all relevant funding is made public.

The expenditure ranking saw some significant changes among European space actors in 2014 (Figure 2.1).[54] The United States had the largest space budget, placing $20.473 billion toward civil purposes, and $22.483 billion toward defence.[55] Next, prior to the reorganisation of Russia's space industry, Roscosmos space budget for 2014 amounted to approximately 165.814 billion roubles ($4.88 billion).[56] China remained in third position, spending an *estimated* 26.564 billion Yuan ($4.282 billion) in space activity.[57] Japan remained in fourth position spending ¥324.0 billion ($3.199 billion), while France followed close behind in fifth position. French space spending reached €2.153 billion ($2.968 billion) in 2014, an increase of 5% from the €2.04 billion ($2.65 billion) spent in 2013.[58] Germany came next, followed by Italy, which barely overtook India in space spending. While Canada's budget decreased by 26%, it was followed closely by South Korea, which also overtook Spain, with a 46.6% increase in its space spending for 2014.

The 2014 budget of the European Space Agency decreased by 4.2% to €4.102 billion ($5.65 billion) from €4.282 billion ($5.65 billion) in 2013, due to decreased spending by the EU. ESA member state spending proper grew by 7.4%, amounting to €3.339 billion ($4.60 billion) from €3.110 billion ($4.11 billion) in 2013.[59] In 2014, as in 2013, the five biggest contributors were Germany 18.7%, France 18.4%, Italy 8.5%, the UK 6.6%, and Belgium 4.6%. Belgium had overtaken Spain for fifth position in 2013, contributing 6.0% of the 2013 budget.[60] Among the countries assessed within this section, 13.9% of the world concentration of space expenditure was generated by Asian space

[53] The Space Report 2015. Colorado Springs: The Space Foundation, 2015: 39.
[54] N.B.: Figures in this section are based on the Space Report 2015 data (U.S.A, Russia, Japan, China, and France), while all other values in figure 1.1 comes from the Euroconsult Report 2015 - Profiles of Government Space Programs.
[55] The Space Report 2015. Colorado Springs: The Space Foundation, 2015: 23.
[56] Ibid. at 36.
[57] Ibid. at 27.
[58] Ibid. at 29-34.
[59] "ESA Budget for 2014." ESA 26 June 2015 <http://www.esa.int/For_Media/Highlights/ESA_budget_2014>.
[60] "ESA Budget 2013." 24 Jan. 2013. ESA 2 Feb. 2014 <http://www.esa.int/About_Us/Welcome_to_ESA/Budget_as_presented_during_DG_press_conference_24_January_2013>.

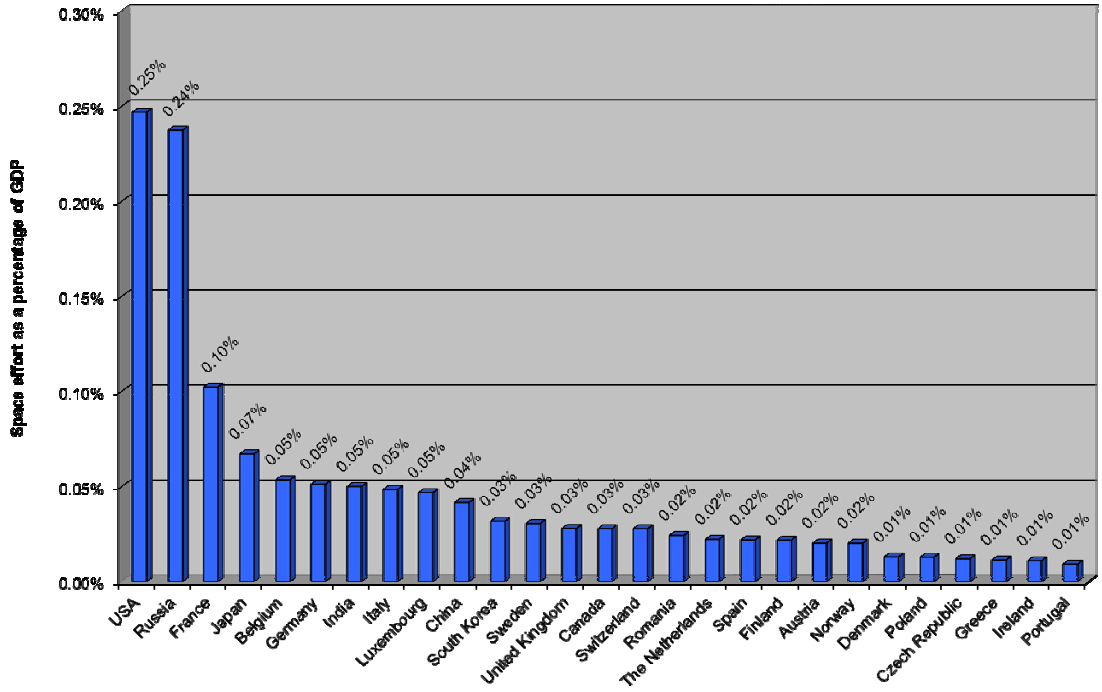

Figure 2.2: Public space budgets (selection) as a share of nom. GDP in 2014 (source: Euroconsult/Space Report/ European Space Directory 2014/IMF)

powers, China, Japan, India, and South Korea, whereas the remaining 86.1% came from the U.S., Europe (including ESA contributions), and Russia in 2014.

When measuring the investment of countries in the space sector, additional perspective can be gained by viewing these figures in regard to GDP and per capita spending[61] (Figures 2.2 and 2.3). Yet these figures paint only a partial picture since comparisons between countries with different economic conditions (e.g. purchase power parities or wage levels) do not provide a complete picture.

US space spending as a percentage of GDP tapered off in 2014, remaining at 0.247% for a second year. Nevertheless, that value underscores the U.S.'s strong engagement in the space field, placing it ahead of Russia that had been in the first position in 2013. Russia's space effort decreased to 0.237% in 2014. France was in 3rd position with 0.102% space spending as a proportion of its GDP, followed by Japan with 0.067%. And Belgium leaped to the 5th position with 0.054%, while Germany overtook India, with spending ratios at 0.051% and 0.050% respectively. The remaining leading space countries in Europe invested less than 0.05% of their GDP in space activity.

U.S. per capita space expenditure increased by 3.6% in 2014, reaching $135.21; this followed a substantial reduction of 14.5% to $130.48 in 2013. France's per capita expenditure grew by 11.7% from $41.47 in 2013 to $46.30 in 2014, surpassing Russia's expenditure of $33.96. Next, Germany's per capita expenditure decreased by 7.2% to $24.23; as did Japan's expenditure which reduced by 1.4% to $25.17. Luxembourg's per capita space budget maintained its second position with a continued $50.00 spending per capita in 2014; while Belgium's per capita expenditure increased by 2.2%, amounting to $25.27 for the year. In 2014, the per capita space budgets of 9 European states increased (presented in descending order: Poland, Romania, Switzerland, the Netherlands, France, Sweden, Austria, Denmark, and Belgium); the most substantial increases came from Poland which increased by 39.2%, followed by Romania which increased by 33.8% - growth by the other listed states did not exceed 17%. 10 European states experienced a reduction in per capita space funding, (presented on a sliding scale the United Kingdom, Ireland, Spain, Germany, Italy, Norway, Finland, the Czech Republic, Portugal, and Greece); Greece experienced the most substantial reduction by 25.6%, followed by Portugal, which had a 21.5% reduction.

[61] The data used is the nominal GDP converted to current U.S. dollars using the official exchange rates as indicated by the International Monetary Fund.

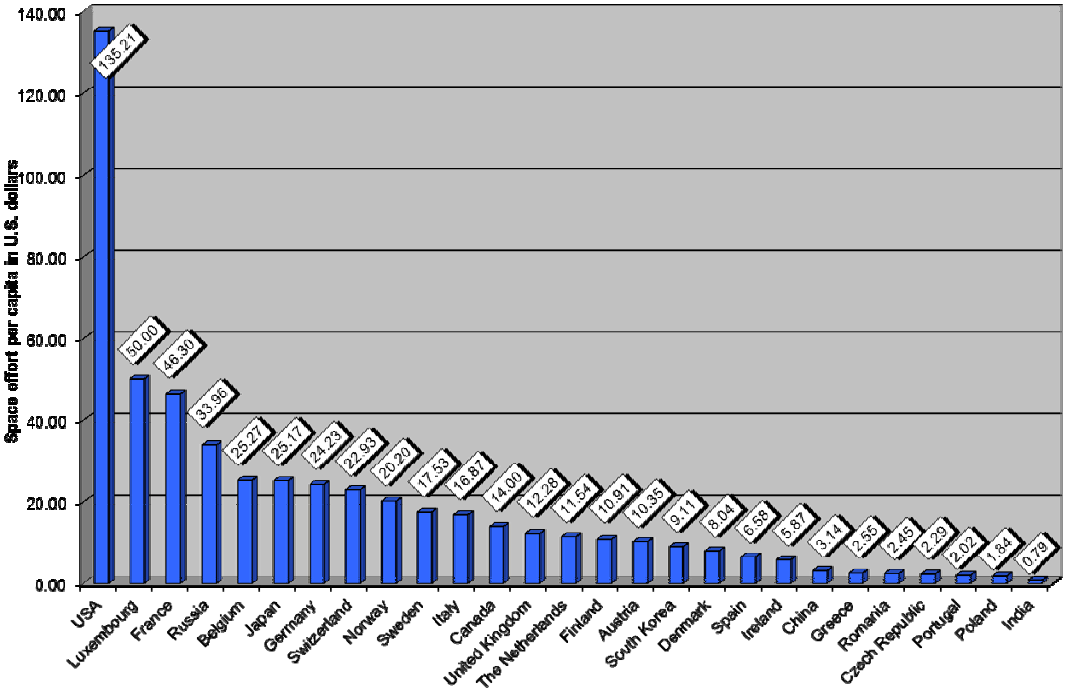

Figure 2.3: Public space budgets per capita (selection) in 2014 (source: Euroconsult/Space Report/European Space Directory 2014/PRB)

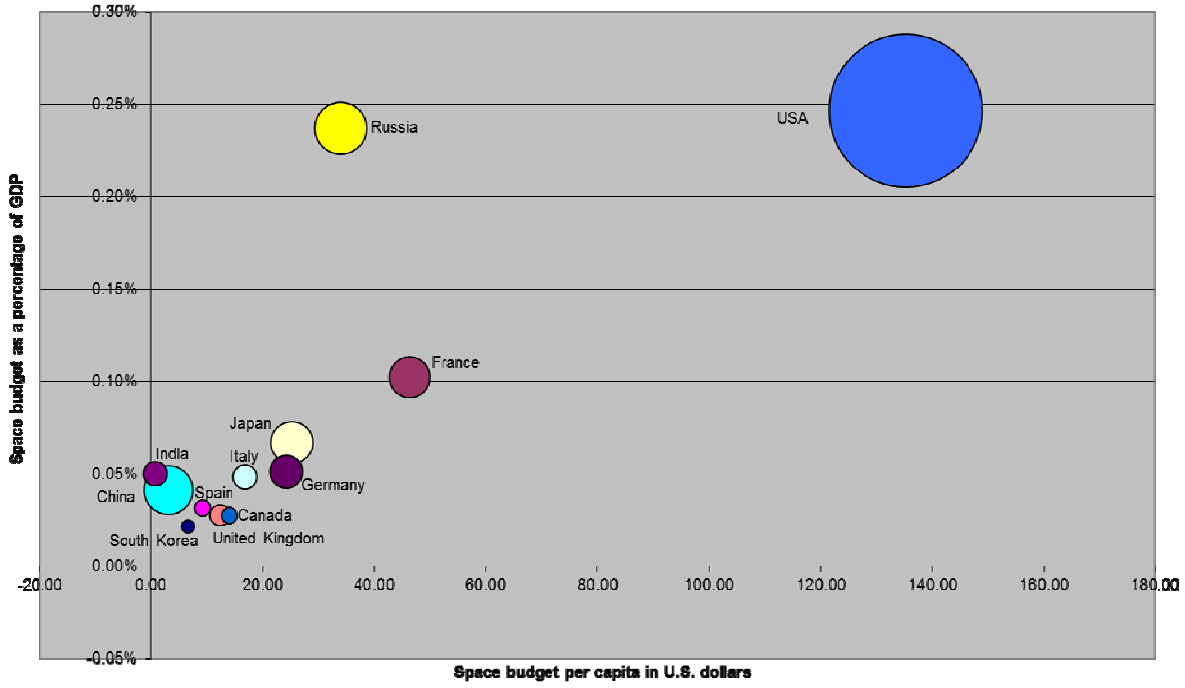

Figure 2.4: Public space budgets as share of GDP mapped against space budgets per capita in 2014. The bubble size indicates the absolute space budget (Based on Euroconsult, the Space Report 2014, and publicly available data)

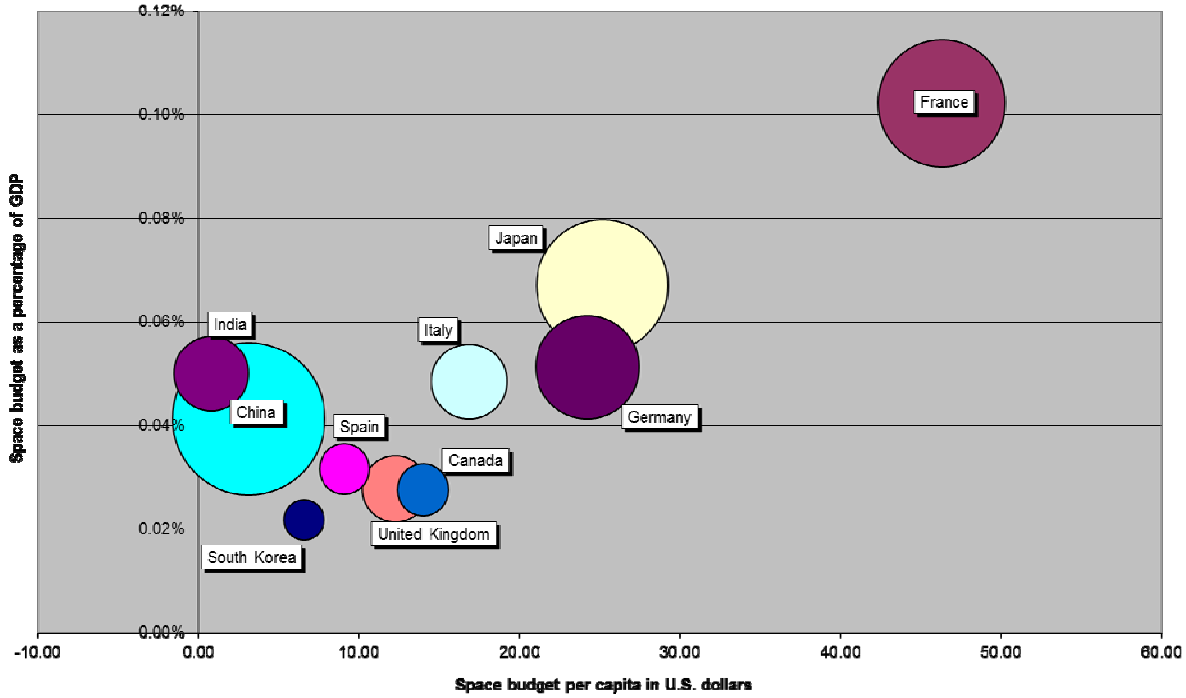

Figure 2.5: Public space budgets as a share of GDP mapped against space budgets per capita in 2014, not including the U.S. and Russia. The bubble size indicates the absolute space budget (Based on Euroconsult, the Space Report 2014, and publicly available data)

2.3 Overview of Commercial Space Markets

Global industry revenues from satellite services, satellite manufacturing, launch industry, and ground equipment continued to grow in 2014, as shown in both Satellite Industry Association (SIA) and Space Report 2015 assessments. The SIA reported that global revenues amounted to $203.0 billion in 2014, up from $195.2 billion in 2013.[62] And from the Space Report 2015, the combined revenue from commercial space products and services, and from commercial infrastructure and support industries, grew to $250.83 billion in 2014, up from $240.07 billion in 2013.[63] It should be noted that these authorities use different methodologies in reaching their assessments, and there is an increasing discrepancy in the findings of SIA and the Space Report, resulting in a difference of $47.83 billion in the figures for 2014, $44.87 billion in 2013, and $36.37 billion in 2012.

The following section presents key figures and data on commercial space activities divided by field of activity, based primarily on available SIA figures generated by the Tauri Group, in addition to previous Futron reports.

2.3.1 Satellite Services

A sustained expansion of satellite capacity and corporate revenue was fuelled by continued demand from emerging economies and developing regions. In 2014, the revenue earned from satellite services increased by 3.6%, reaching $122.9 billion, from the $118.6 billion earned in 2013.[64] However, the rate of revenue growth in satellite services appears to be nearing a plateau, as the growth rate has continued to decline from 8.6% in 2011, to 5.2% in 2012, and 4.5% in 2013. The bulk of revenue comes from the consumer services subgroup (consisting of satellite television, satellite radio, and satellite broadband services), which accounted for 82.1% of the revenue earned by satellite services. According to SIA, consumer services alone accounted for 49.7% of the total reve-

[62] "2015 State of the Satellite Industry Report." 24 May 2015. Satellite Industry Association and The Tauri Group 27 Sept. 2015 <http://www.space.taurigroup.com/reports/SIA_SSIR_2015.pdf>.

[63] C.f. The Space Report 2015. Colorado Springs: The Space Foundation, 2015: 14, and The Space Report 2014. Colorado Springs: The Space Foundation, 2014, 24.

[64] "2015 State of the Satellite Industry Report." 24 May 2015. Satellite Industry Association and The Tauri Group 27 Sept. 2015: 11 <http://www.space.taurigroup.com/reports/SIA_SSIR_2015.pdf>.

nue earned by the global satellite industry in 2014.[65]

Additional subgroups of satellite services include fixed satellite services (e.g. transponder agreements, and managed network services), as well as mobile services (voice and data), and Earth observation services. The following is a breakdown of the industry's key developments and trends, according to the nature of the services provided.

Consumer Services

As mentioned above, consumer services are made up of satellite television, radio, and broadband services. While the $100.9 billion in revenue generated by consumer services revenue was greater than the combined revenues of upstream satellite industry segments (i.e. manufacturing, launch services, and ground equipment) in 2014, 94.1% of that consumer revenue came from satellite television services (DBS/DTH). With about 230 million satellite television subscribers worldwide, it is a key driver in consumer services revenue, with increasing growth in emerging markets. The U.S. accounted for just 42% of global revenues from satellite television services in 2014. Moreover, the rate of growth has continued to slip in recent years, with 2.6% in 2014, from 4.8% in 2013.

In 2014 satellite radio revenue grew by 10.5% to $4.2 billion from $3.8 billion in 2013 and satellite broadband had 5.9% revenue growth, reaching $1.8 billion from $1.7 billion in 2013.[66] Satellite radio and broadband services amount to 5.9% of the consumer services segment, with 27.3 million and 1.6 million subscribers respectively, most customers being in the U.S.[67]

Fixed Satellite Services

Fixed Satellite Services (FSS) refers to the use of spacecraft that utilise land terminals in fixed positions to broadcast. Whereas Consumer Services covers satellite broadband Internet, communications and network television and radio broadcasts, FSS relates to commercial signal agreements, such as transponder agreements and managed network services (which include spaceflight management services). The FSS segment also saw growth in 2014, with revenue increasing by about 4.2% for both transponder agreements and managed services. In 2014, FSS revenue increased to $17.1 billion, whereof transponder agreements generated $12.3 billion while managed services earned $4.8 billion - compared to no growth for either subgroup in 2013. The growth is explained by the continued demand for video and broadband, mainly from the Americas, but with additional growth in Europe and Asia. In 2014, the revenue ranking order of the top FSS operators maintained their position; however, the sharp rise of the U.S. dollar against most major currencies at the end of the year had the effect of showing revenue declines, whereas actual revenue growth was reported in local currencies.[68]

Mobile Satellite Services

Mobile satellite services (MSS) offer both mobile data service and mobile voice service (including satellite phones). In 2014, MSS revenue grew by 26.9%, earning $3.3 billion from $2.6 billion in 2013. After experiencing very little growth in the years following the financial crisis, mobile voice services have recently experienced incremental increases, amounting to around $900 million in 2014, from $800 million in 2013, and a string of earlier years where revenue remained at about $700 million. In contrast to voice services, mobile data service experienced a significant jump in revenue in 2014 to $2.3 billion, and has consistently experienced revenue growth in previous years, as these data services are used heavily in the aviation sector. In 2014, this latter segment comprised 69.7% of all mobile satellite services revenue.[69]

Earth Observation Services

Earth observation services refers to commercial companies that provide optical and radar images to the open market; however, demand for such services is mostly driven by government entities. Nevertheless, new entrants such as Skybox Imaging and Planet Labs have continued to raise capital, and have begun to deploy initial constellations. In 2014, Earth observation service revenue grew by 6.7% reaching $1.6 billion from $1.5 billion in 2013.[70]

[65] Ibid. at 4.
[66] Ibid. at 11.
[67] Ibid. at 12.
[68] De Selding, Peter B. "The List | Top Fixed Satellite Service Operators." 13 July 2015. Space News 18 Aug. 2015 <http://spacenews.com/the-list-2014-top-fixed-satellite-service-operators/>.
[69] "2015 State of the Satellite Industry Report." 24 May 2015. Satellite Industry Association and The Tauri Group 27 Sept. 2015: 11 <http://www.space.taurigroup.com/reports/SIA_SSIR_2015.pdf>.
[70] Ibid. at 13.

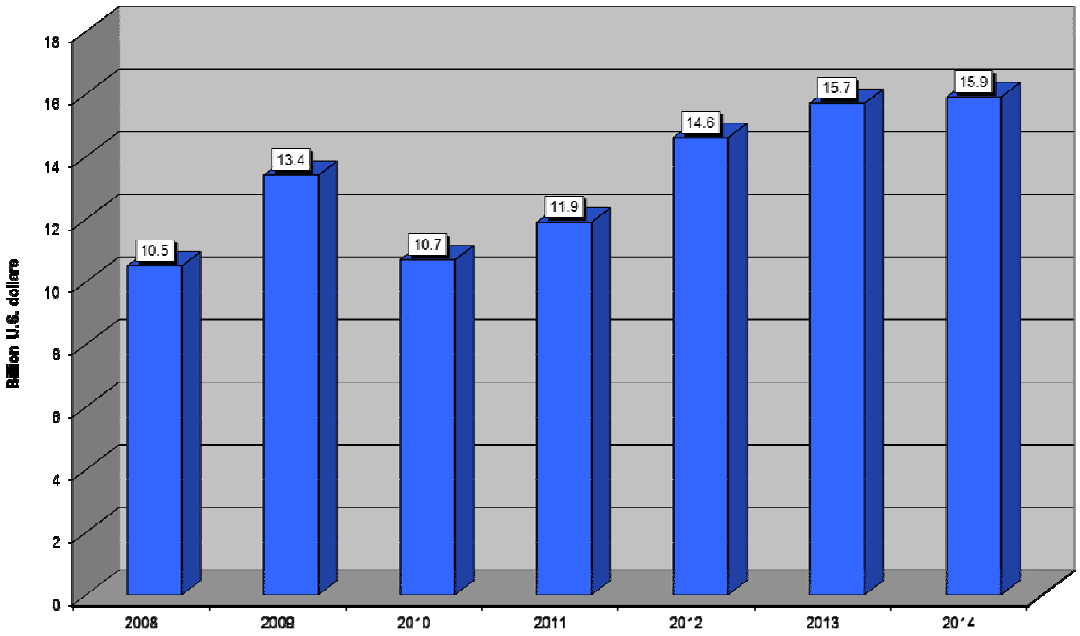

Figure 2.6: World satellite manufacturing revenue (Source: SIA)

2.3.2 Satellite Manufacturing

In 2014, the total revenue of satellite manufacturers that built satellites both for governmental and commercial customers amounted to $15.9 billion, an increase of 1.3% from the $15.7 billion generated in 2013. Yet, it is notable that in 2014 U.S. generated revenue decreased substantially, whereas the opposite occurred for non-U.S. manufacturers. In 2014, U.S. satellite manufacturers earned combined revenue of about $10 billion, an 8.3% decrease from the $10.9 billion earned in 2013. In comparison, non-U.S. manufacturers earned combined revenue of $5.9 billion in 2014, a 22.9% increase from the $4.8 billion earned in 2013. For 2014, the share of non-U.S. revenue thus increased to 37.1%, from 30.6% in 2013. The SIA reports that 33% of the total revenues generated in satellite manufacturing came from communications satellites (i.e. 25% from commercial communications, while 8% were for civil/military communications). Next, military surveillance satellites represented 38% of the revenue for the year, while navigation satellites were 15% and Earth Observation satellites were 9%. Meteorology satellites represented 2% of the 2014 revenue, as did scientific satellites and satellites developed for R&D purposes which amounted to 1%. It should be mentioned that despite the large number of cubesats that were launched in 2014, they represent less than 1% of the total revenue generated for the year.[71]

2.3.3 Launch Sector

A total of 23 commercial launches were conducted in 2014, with one launch failure of the Antares 120 cargo capsule, which carried 29 cube satellites intended to be released from the ISS. The 22 successful commercial launches carried 53 commercial services payloads into orbit (in addition to 56 commercial cube satellites released from the ISS). Commercial launches in 2014 accounted for 25% of the total 92 launches conducted for the year and for 36% of the 295 payloads launched. Of the 295 payloads that were launched in 2014, 69 were cube satellites launched directly into orbit while another 96 cube satellites were intended to be released into orbit from the ISS (with 29 cube satellites mentioned earlier having been destroyed, and 6 cube satellites returned back to Earth from the ISS). When not considering cube satellites, the percentage of commercial payloads launched amounted to 30.7%, or 39 commercial payloads out of a total of 127 non-cube satellite payloads.

In 2014, U.S. launch providers conducted 11 commercial launches, while an additional 12 were non-commercial; their commercial launches amounted to 47.8% of the total commercial launches for the year. Russia had the most launches for 2014, although only 4 of its 28 launches were conducted for com-

[71] Ibid. at 17-18.

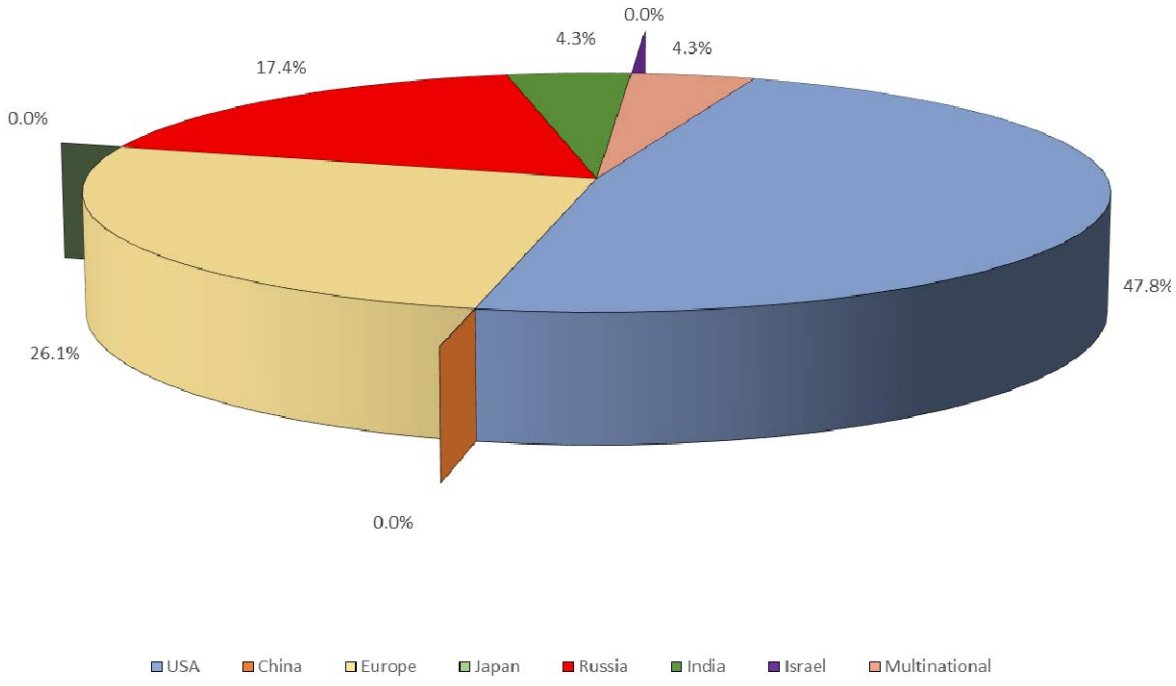

Figure 2.7: Commercial Launch Activity by Country in 2014 (Source: FAA)

mercial purposes; those launches held a 17.4% share of total commercial launches for the year – substantially lower than its 52.2% share in 2013. China did not have any commercial launches for the year, but did conduct 16 non-commercial launches. In contrast to China, 6 of the 11 European launches in 2014 were commercial; representing a 26.1% share of total commercial launches in 2014, up from 17.4% in 2013 (not counting the actual number of payloads launched). And finally, the single commercial launch of India and the multinational Sea Launch AG each had a 4.3% share of the 23 commercial launches in 2014.

The revenue from the 23 launches amounted to an estimated $2.36 billion in 2014, an increase of 23.6% from $1.91 billion earned in 2013. In 2014, the U.S. earned its highest amount of commercial launch revenue since 1998, amounting to $1.107 billion - more than three times the amount it earned in 2013. Europe was a close second, earning $920 million for the year - an increase of 29.6% from the $710 million earned in 2013). Russia followed in third position, earning $218 million (a 71.3% reduction from the $759 million earned in the previous year). Next, multinational revenue took in $95 million – similar to its $100 million earned in 2013. And India earned $15 million in its single commercial launch for 2014, highlighting its competitive advantage as a low-cost launch provider.[72]

In 2014, Ariane 5 had four commercial and two non-commercial launches, which lifted 7 commercial telecommunications satellites, 1 military communications satellite, two civil government communications satellites into GEO orbit, and the final ATV-5 to the ISS. The Europeanized Soyuz had two commercial launches, which placed 8 O3b commercial communications satellites into medium Earth orbit (MEO); and two non-commercial launches that lifted the Sentinel 1A for ESA and two Galileo navigation satellites for the European Commission. The Vega launcher had one launch from French Guiana.

2.3.4 Ground Equipment

Ground equipment revenue includes infrastructure elements, such as mobile terminals, gateways and control stations, and consumer equipment, such as very small aperture terminals (VSAT), ultra-small aperture terminals (USAT), DTH broadcast dishes, satellite phones and digital audio radio satellite (DARS) equipment. Portable Navigation Devices (PND) form one of the sub-segments of end-user electronics that incorporate GPS chip sets.

[72] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2014. Washington DC: FAA, Feb. 2015: 12.

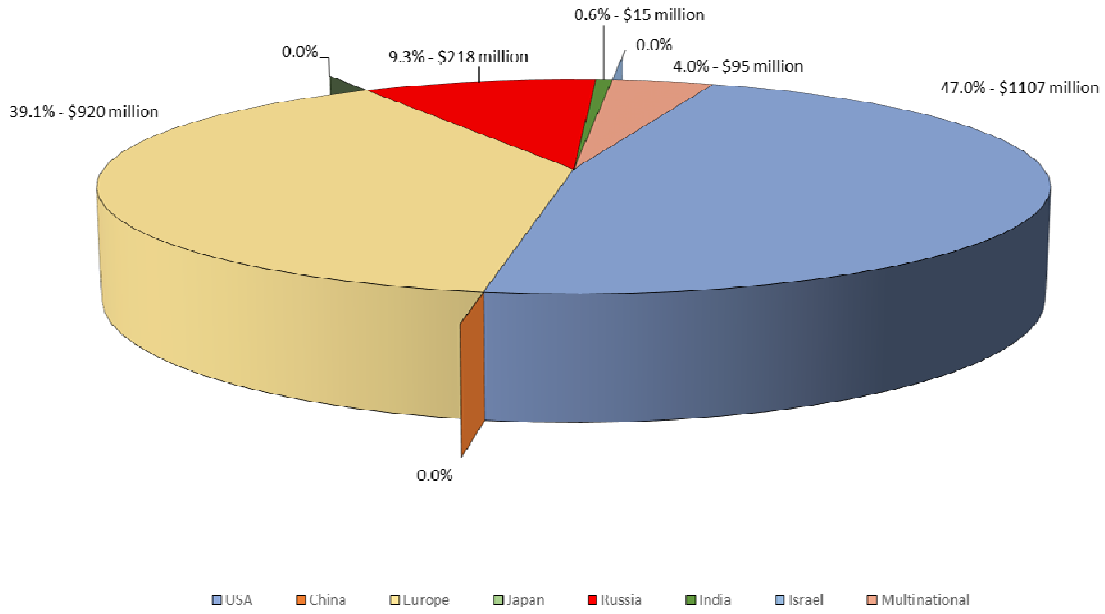

Figure 2.8: Commercial Launch Revenues by Country in 2014 (Source: FAA)

	Total Revenue	2013	2014
TomTom		€963.454 million ($1.326 billion)	€950.292 million ($1.155 billion)
Garmin		$2.632 billion	$2.871 billion
	Geographical Sales		
TomTom	Europe	€710.101 million ($977.525 million)	€718.767 million ($873.647 million)
	North America	€177.725 million ($244.656 million)	€163.461 million ($198.684 million)
	Rest of World	€75.628 million ($104.110 million)	€68.064 million ($82.730 million)
Garmin	Europe/Middle East/Africa	$955.900 million	$1.054 billion
	Americas	$1.433 billion	$1.538 billion
	Asia Pacific region	$243.056 million	$278.092 million

Table 2.1 Understanding TomTom & Garmin variables

In 2014, flat revenue from consumer equipment for satellite navigation reflected a further migration from standalone devices to embedded chipsets for devices such as smartphones.[73] Staying at $31.1 billion for 2014, consumer equipment represented about 53% of overall ground equipment revenue, down from 57% in 2013. In contrast, network equipment and consumer broadband equipment revenue grew by 5.7% and 14.7% in 2014, reaching $9.3 billion and $17.9 billion respectively. Overall ground equipment revenues grew by 5.0% to $58.3 billion in 2014, constituting a 28.7% share of the $203.0 billion in world satellite industry revenue in 2014.

The revenue profiles for Garmin and TomTom, the two companies leading the PND market, diverged in 2014, with Garmin's revenue showing signs of growth, while TomTom's revenue continued to decrease. Following three years of reductions in revenue, in 2014 Garmin's total revenue increased by

[73] "2015 State of the Satellite Industry Report." 24 May 2015. Satellite Industry Association and The Tauri Group 27 Sept. 2015: 27 <http://www.space.taurigroup.com/reports/SIA_SSIR_2015.pdf>.

9.1% to $2.871 billion, following a drop to $2.632 billion in 2013.[74] Its growth came from increased revenue in aviation, marine, fitness and outdoor products. TomTom's total revenue from consumer, automotive, licensing, and telematics segments amounted to €950.292 million ($1.155 billion) in 2014, a continued decrease of 1.3% from the €963.454 million ($1.326 billion) earned in 2013.[75]

2.3.5 Insurance Sector

While in previous years insurance rates were in decline as the space industry continued to demonstrate increased hardware reliability, low accident rates and promising growth, 2013 was the first money losing year since 2007, with more than $800 million in expected claims.[76] The year 2014 was not any better for insurance providers, with claims made by Orbital Sciences, ABS, Hispasat, the Russian Satellite Communications Company, and others, appearing likely to result in another losing year, which is expected to mean that insurance premiums will increase in coming years. Following the failure of the Orbital Sciences Antares 120 Commercial Resupply Services (CRS) launch on 28 October, which succeeded in attaining the milestone goal of ignition and lift-off (but not the milestone goal of launch success), Orbital Sciences was entitled to partial payment from NASA. However, Orbital Sciences had taken out a $48 million insurance policy for the 'mission success' milestone, which will be paid by insurance providers and is expected to cover the entire final milestone payment.[77]

Following the launch of its ABS-2 satellite on 6 February 2014, the Asia Broadcast Satellite (ABS) commercial satellite operator experienced an anomaly of a key Russia-directed beam by mid-summer, which has resulted in an insurance claim of $214 million.[78] Another claim is expected for Hispasat's Amazonas 4A, launched on 22 March 2014, which had a problem with a power subsystem that could halve its broadcasting capability; the Amazonas 4A is insured for €145 million ($199 million).[79] And the insurance claim for Russia's Express-AM4R satellite that failed due to the launch failure of the Proton M is expected to be 7.8 billion rubles ($225.4 million).[80] The failure of the Europeanized-Soyuz to place the two Galileo satellites into orbit on 22 August 2014 did not lead to insurance claims, as the European Commission had chosen to self-insure, in line with common governmental practices.

Even with the launch and in-orbit failures in 2014, governments seem eager to stimulate the space sector by reducing the cost and associated red tape in launching a satellite. On 30 April 2014, the UK government agreed to adopt industry recommendations to reduce satellite insurance requirements for third party damage by 25%, from £80 million to £60 million with the UK government covering the possible remaining losses beyond that figure, thus easing the way for satellite companies to obtain licenses for satellites (particularly small satellites) and to increase economic activity in the UK space sector.[81]

2.4 Sectoral Overview

2.4.1 Launch Sector

The launch sector is seen as an enabler rather than as a primary economic activity. Yet, with the growth of low-cost launch services, the revenue it will generate in the coming years is bound to attract greater attention.

The year 2014 experienced increased activity for the launch sector, with a total of 92 launches conducted by launch providers from Russia, the United States, Europe, China, Japan, India, Israel, and the multinational

[74] "Garmin Ltd. Form 10-K for Period Ending December 27, 2014." Garmin 2 Apr. 2015: 41 <http://www8.garmin.com/aboutGarmin/invRelations/reports/10-K_2014.pdf>.
[75] "TomTom Annual Report 2014." 21 Feb. 2015. TomTom 2 Apr. 2015: 47 <http://annualreport2014.tomtom.com/xmlpages/resources/TXP/tomtom_ar_2014/pdf/TomTom_Annual_Report_2014.pdf>.
[76] SpaceNews Staff. "SpaceNews 2014 Year in Review." 26 Dec. 2014. SpaceNews 13 July 2015 <http://spacenews.com/spacenews-2014-year-in-review/>.
[77] De Selding, Peter B. "Orbital Sciences Entitled To Partial NASA Payment for Antares Failure." 25 Nov. 2014. SpaceNews 13 July 2015 <http://spacenews.com/42658orbital-sciences-entitled-to-partial-nasa-payment-for-antares-failure/>.
[78] De Selding, Peter B. "ABS Files $214 Million Insurance Claim for Bad Satellite Beam." 17 Oct. 2014. SpaceNews 13 July 2015 <http://spacenews.com/42218abs-files-214-million-insurance-claim-for-bad-satellite-beam/>.
[79] Forrester, Chris. "Hispasat's $100m claim on Amazonas 4A." 25 Apr. 2014. Advanced Television 13 July 2015 <http://advanced-television.com/2014/04/25/hispasats-100m-claim-on-amazonas-4a/>.
[80] "Russia: Express-AM4R's failed launch covered by insurance." 20 May 2014. Business Insurance 13 July 2015 <http://www.businessinsurance.com/article/20140520/NEWS09/140529999>.
[81] De Selding, Peter B. "Britain To Reduce Space Insurance Requirements, May Ease Smallsat Licensing Rules." 30 Apr. 2014. SpaceNews 25 June 2015 <http://spacenews.com/40417britain-to-reduce-space-insurance-requirements-may-ease-smallsat-licensing/>.

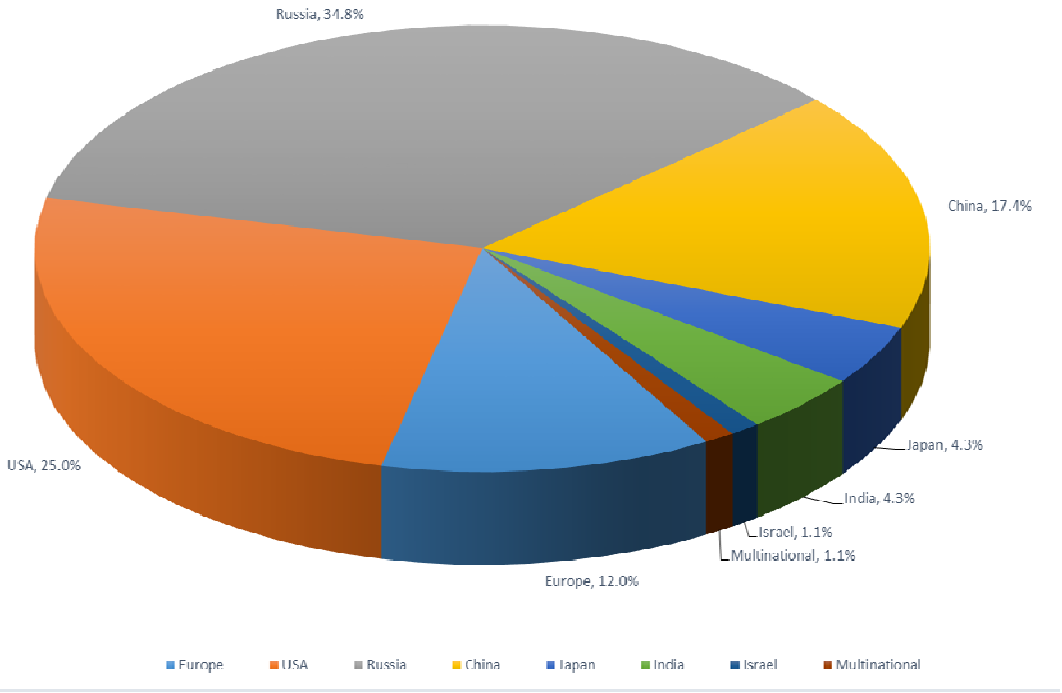

Figure 2.9: Worldwide launches by country in 2014 (Source: FAA)

Sea Launch AG. There were some important events in 2014, such as the 2 non-commercial launch failures: a Proton M launch from Baikonur, Kazakhstan, carrying Russia's Express AM4R satellite in May; and a Europeanized Soyuz 2.1b launch from Kourou, French Guiana carrying the first two fully operational satellite models of Europe's Galileo navigation system in August – the failure of the launcher's upper stage and premature release of the satellites compromising the mission. There was also the commercial launch failure of the Antares-120 launcher, carrying a Cygnus commercial cargo capsule including 29 cube satellites to be released from the ISS, in October.

When looking into the launches of specific countries (Table 2.2), Russia continued as the world leader in the number of launches for 2014, accounting for 34.8% of total launches. The United States had the second largest share, accounting for 25% of the total. China was in third position in 2014, with a 22.2% share, while Europe followed in fourth position with a 12.0% share. Both Japan and India each had a 4.3% share, while Israel and the Multinational Sea Launch AG each provided 1.1% of the total launch figure (see Figure 2.9).[82]

Russia launched 32 vehicles using nine different launch system configurations[83]. The U.S. used nine different launch system configurations[84] for a total of 23 launches, while seven different launch configurations[85] were used by China for its 16 launches. Europe used its Ariane 5 ECA and ES-ATV launchers, the Soyuz 2.1 launcher, and its Vega launcher for its 11 launches (5 Ariane 5 ECA, 1 Ariane 5 ES-ATV, 1 Soyuz 2.1a, 3 Soyuz 2.1b, and 1 Vega). Japan had 4 launches using the H-11A 202 launch configuration while India used three launcher configurations (i.e. PSLV CA, PSLV XL, and GSLV MK2) for its 4 launches. Israel used the Shavit launcher for its single launch, while Sea Launch AG used its Zenit 3SL for its launch.

Launch system utilization diminished in this period, moving from 40 active launch systems in 2013 to the use of 36 in 2014. While four actors i.e. Russia, the U.S., China, and Europe conducted most launch activity, Japan and India saw increased activity. It should be recalled that certain launchers have dual-launch capabilities, e.g. Europe's Ariane 5 launcher is able to lift two standard-size payloads to orbit. Hence the number of launches

[82] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2014. Washington DC: FAA, Feb. 2015: 10.

[83] i.e. Angara A5, Dnepr, Proton M, Rockot, Soyuz 2.1a, Soyuz 2.1b, Soyuz FG, Soyuz U, and Strela.

[84] i.e. Antares-120, Antares-130, Atlas 5 401, Atlas 5 541, Delta 2 7320-10, Delta 4 Heavy, Delta 4 Medium +(4,2), Falcon 9, and Falcon 9 v1.1

[85] i.e. Kuaizhou, Long March 2C, Long March 2D, Long March 3A, Long March 3C, Long March 4B, and Long March 4C.

does not reflect the number of payloads brought to orbit.

Launchers	Number of launch systems active in 2014	Total number of launches	Commercial launches	Non-commercial launches
Russia	9	32	4	28
United States	9	23	11	12
China	7	16	0	16
Europe	5	11	6	5
Japan	1	4	0	4
India	3	4	1	3
Israel	1	1	0	1
Multinational	1	1	1	0
Total	**36**	**92**	**23**	**69**

Table 2.2: Worldwide launches in 2014 per country, number of launched systems, and commercial status (Source: FAA)

The U.S. led in the number of commercial launches in 2014. The Ariane 5 dual payload capability paved the way for Europe to earn the second highest amount of commercial launch revenue. And while Russia had the same number of launches as the previous year, its four commercial launches placed it at a distant third position in terms of commercial revenue. When considering non-commercial launches, Russia had a substantial lead, conducting 40.6% of launches, China was in second position with 23.2%, followed by the U.S. with a 17.4% share. Europe, Japan, India, and Israel split the remaining 18.8% share of non-commercial launches.

Whereas in the two previous years, it appeared that the number of commercial launches was increasing relative to non-commercial payload launches, the ratio returned to the 1-to-3 equilibrium experienced earlier; yet the number of payloads launched increased significantly in 2014, due mainly to the exponentially increasing number of cube satellites and microsatellites that were launched.

In terms of the global share of payloads launched in 2014 (Figure 2.10), the U.S. surpassed Russia, lifting 131 payloads, which represents 44.4% of the total. Russia was in second place, launching 88 payloads (on par with the previous year) resulting in a 29.8% share. In third position, China's 24 payloads amounted to a 8.1% share, followed closely by Europe with 23 payloads (7.8%), and Japan with 18 payloads (6.1%). India launched 9 payloads (3.1%), while Israel and Multinational each had 1 payload (0.3%). However, when excluding all 168 cubesat payloads from the assessment, the U.S. drops to second position with a 23.6% share, while Russia's share increases to 34.6%. Moreover, Europe's share increases to 18.1%, while China drops to fourth position with 15.7%, with little change to the remaining launch country shares.

Some notable changes in the distribution of payload sizes occurred in the 2014 reporting year (Figure 2.11). With 168 payloads, "Micro" sized payloads accounted for 56.9% of total payloads launched, which is not surprising considering this increasing trend was visible when it reached 46.2% in 2013. The average mass of these cube satellite payloads was around 10.2 kg, with the sum of their mass reaching 1721.3 kg. While 96 cube satellites were to be released from the ISS, 27 were destroyed in the 28 October Antares 120 launch failure, in addition to the return of 6 cube satellites from the ISS. "Small" satellites were in second position with 41 payloads launched, accounting for 13.9% (decreasing by 6.9% from 2013). "Medium" sized payloads were in third position with 33 payloads at 11.2% (up 0.8%), 26 "Large" payloads at 8.8% (down 5.8%), 25 "Intermediate" payloads at 8.5% (up 1.9%), and 2 "Heavy" payloads at 0.7% (down 0.7%).[86]

[86] Micro payloads have a mass of 91 kg or less, and are mainly science satellites, technological demonstrators or small communications satellites. Small payloads weigh between 92 and 907 kg and are very often Earth Observation satellites, similar to the Jason or the RapidEye series. Medium payloads weigh between 908 and 2,268 kg, and feature the most diverse set of satellites, including small satcoms in geostationary orbit, Earth Observation satellites, and most of the Russian military satellites from the Kosmos series. Intermediate payloads, weighing between 2,269 and 4,536 kg, comprise medium satcoms and big scientific satellites. Large payloads, between 4537 and 9,072 kg refer to big satcoms, as well as to the Soyuz and Progress spacecraft flying to the ISS. Finally, Heavy payloads, exceeding 9,072 kg, are linked to ISS activity, such as the cargo spacecraft, ATV, HTV, etc. *See* Commercial Space Transportation: 2011 Year in Review, 32.

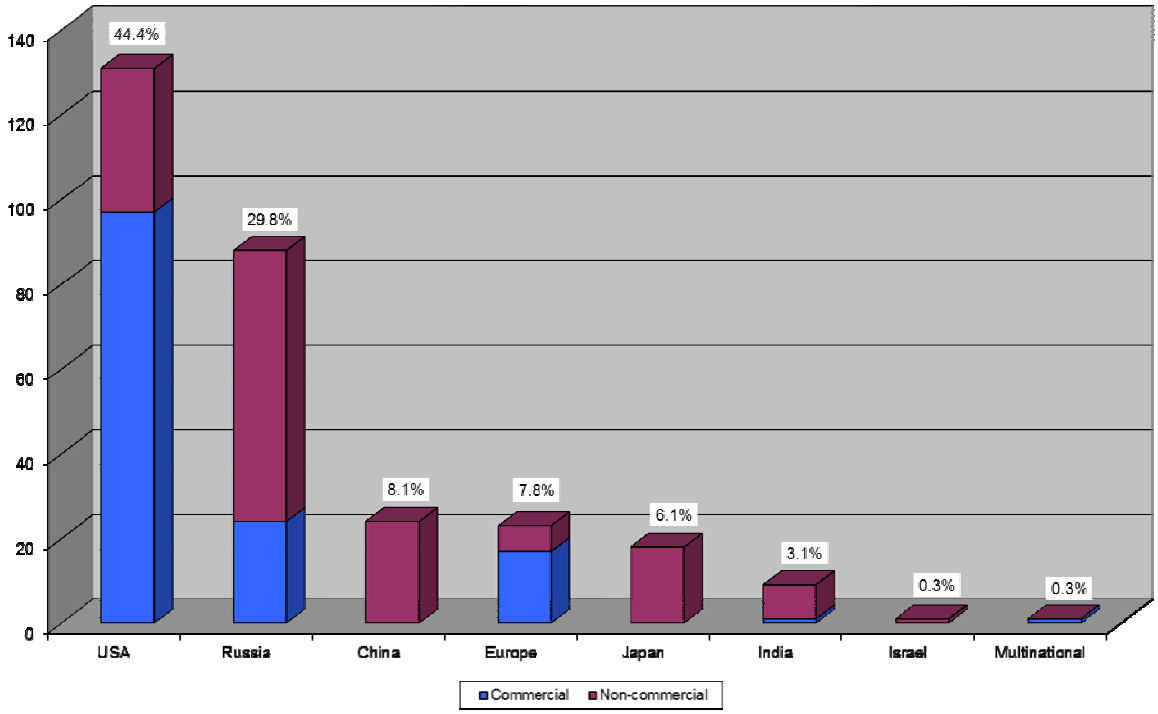

Figure 2.10: Total payloads launched in 2014 by country, share and commercial status (Source: FAA)

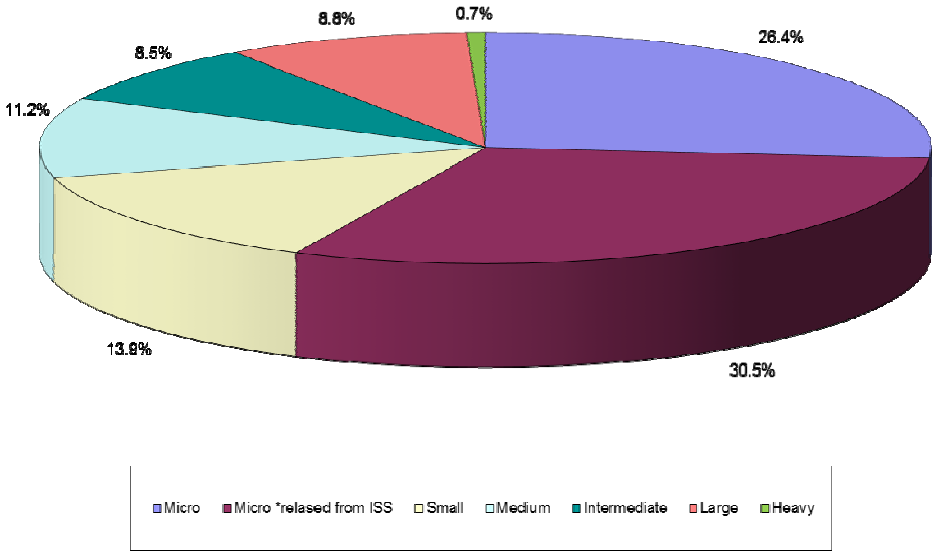

Figure 2.11: Distribution of the payloads launched in 2014 by mass class (Source: FAA)

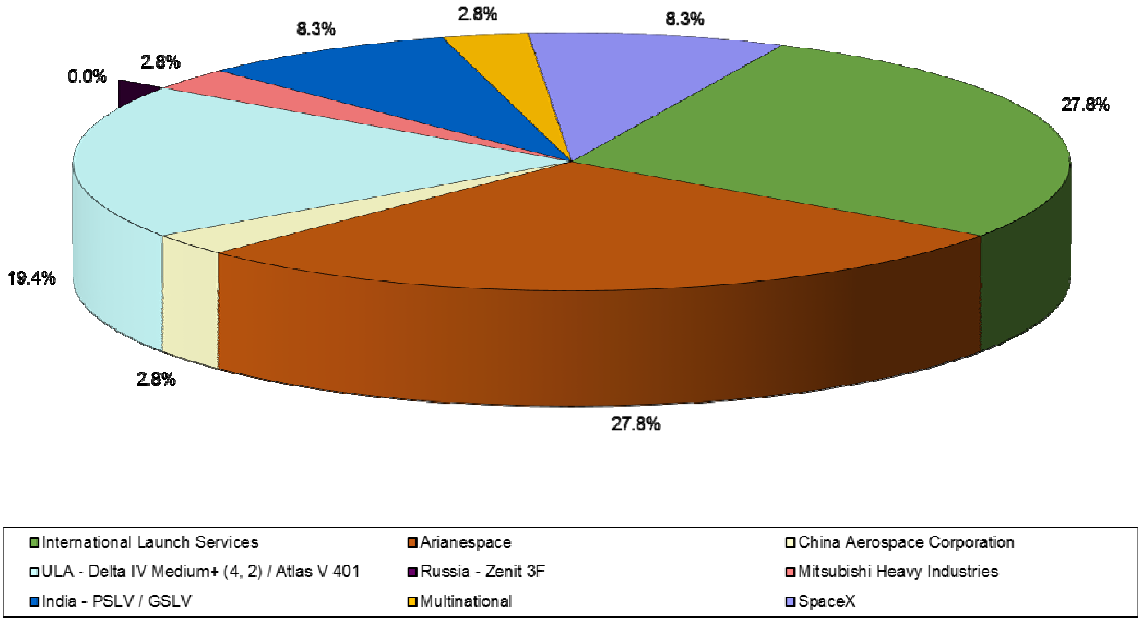

Figure 2.12: Share of launch contracts for GEO satellites in 2014 by launch service provider

In 2014, Arianespace and International Launch Services (ILS) held the top position in terms of launches in GEO, each with 27.8%, followed by United Launch Alliance (ULA) with 19.4% (Figure 2.12). Arianespace placed 10 communications satellites into GEO orbit with the use of five Ariane 5 ECA launchers. The Russian ILS launched 10 GEO communication satellites on eight Proton M launchers; including the failed launch of the Express AM4R satellite. The U.S. ULA conducted 7 launches to place seven payloads into GEO orbit. India's PSLV launcher was used twice to launch the IRNSS 1B and IRNSS 1C navigation satellites to GEO orbit, while its GSLV launched the Gsat 14 communications satellite. And the SpaceX Falcon 9 was used 3 times to launch three commercial communications satellites (Asiasat 8, 6, and Thaicom 6) into GEO orbit. Lastly, Japan used its H-IIA 202 launcher to place its Himawari 8 Meteorological satellite into GEO orbit, while the Multinational Sea Launch placed the Eutelsat 3B commercial communications satellite into orbit.

2.4.2 Manufacturing Sector

Looking at the market share of satellites launched and ordered in a given year provides a good indication of the vitality of domestic space industries, while also providing clues to global trends in the space industry.

In 2014, 295 payloads were launched (including an estimated 168 cube satellites, 14 crewed or cargo missions to the ISS, 1 test launch of the U.S. Orion EFT-1 capsule, and the launch of China's Chang'e 5 experimental lunar mission). The U.S. commissioned 47.5% of the launched payloads (including 110 cubesats), while Russia accounted for 13.2%, and Europe 11.5%. China accounted for 8.5% of the payloads launched, while Japan stood at 8.1% and India accounted for 1.4%. The remaining 9.8% of payloads were commissioned from various parts of Asia, the Middle East, and the Americas.[87]

Of the 279 satellites launched in 2014[88], 143 were non-commercial. As in recent years, China's CAST led in manufacturing 16 non-commercial satellites, followed by the Reshetnev Company which produced 13 non-commercial satellites, while the regions of Asia, North America, Europe, and Russia also showed a strong presence in this market.

[87] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2014. Washington DC: FAA, Feb. 2015: 9-10. Payloads are assigned to the nation that commissioned them, not according to the nationality of the manufacturer.

[88] I.e. not counting the 14 crewed or cargo missions to the ISS, the 1 test launch of the U.S. Orion EFT-1 capsule, and the launch of China's Chang'e 5 experimental lunar mission.

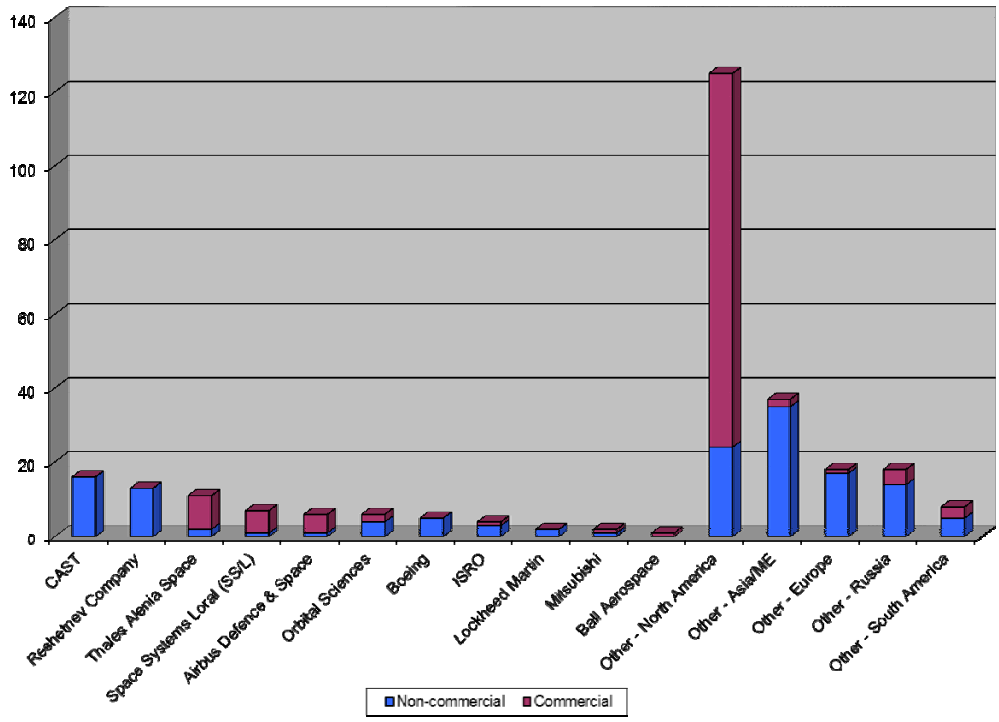

Figure 2.13: Satellites launched in 2014 by manufacturer and commercial status (Source: Futron)

Boeing produced only 5 non-commercial satellites, followed by Orbital Sciences with 4 non-commercial satellites, and 3 non-commercial satellites developed by ISRO. Both Thales Alenia Space and Lockheed Martin each provided 2 non-commercial satellites, while Canada's Space Systems Loral (SS/L), Airbus Defence & Space, and Mitsubishi each developed 1 non-commercial satellite (Figure 2.13).[89]

Europe's Thales Alenia Space took the lead among the top commercial prime contractors with the launch of 9 commercial satellites. SS/L took second position manufacturing 6 commercial satellites, while Airbus Defence & Space was third in terms of its 5 commercial satellites. Orbital Sciences built 2 commercial satellites, while ISRO, Mitsubishi, and Ball Aerospace each developed 1 commercial satellite (Figure 2.13).[90]

In 2014, 12.5% of the 279 satellites launched were geostationary satellites; yet that number is slanted as the total number of launches includes the 168 cubesats launched in 2013 which were sent mainly to LEO orbits with some to SSO (Figure 2.14). 42.9% of the 35 GEO satellites came from North America (i.e., 6 by SS/L, 5 by Orbital Sciences, 1 by Boeing, 1 by Lockheed Martin, and 2 additional satellites listed under Other – North America). Europe provided 17.1% of the GEO satellites (i.e., 4 by Airbus Defence & Space and 2 by Thales Alenia Space). Russia's Reshetnev Company held a 20.0% share of GEO satellites launched into orbit, launching a total of 7 for Russia. Japan's Mitsubishi provided 2 satellites, while India's ISRO launched 4, in addition to 1 other satellite by Other – Asia/ME. China's CAST did not launch any satellite to GEO orbit in 2014. However, when contrasting the 244 non-GEO orbiting satellites, North America maintained a 47.0% share (i4 by Boeing, 1 by SS/L, 1 by Orbital Sciences, 1 by Lockheed Martin, 1 by Ball Aerospace, and another 123 – mostly cube satellites - from other parts of North America).[91] Asian manufacturers held a 21% share with 52 non-GEO satellites (16 by CAST, while another 36 were developed by Other – Asia/ME). Europe's share was 11.9% with its 29 non-GEO satellites (9 by Thales Alenia Space, 2 by Airbus Defence & Space, and the remainder from other European makers). Russia had a 9.8% share, with its 24 non-GEO satellites (6 by the Reshetnev Company, and the remaining by Other Russian manufacturers). The remaining 8 non-GEO satellites were developed in South America, and accounted for a 3.3% share.[92]

[89] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2014. Washington DC: FAA, Feb. 2015: 190-194.
[90] Ibid.
[91] Discounting the 101 U.S. cube satellites, the U.S. share was 21.0% of the remaining 143 non-GEO satellites that were launched.
[92] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2014. Washington DC: FAA, Feb. 2015: 190-194.

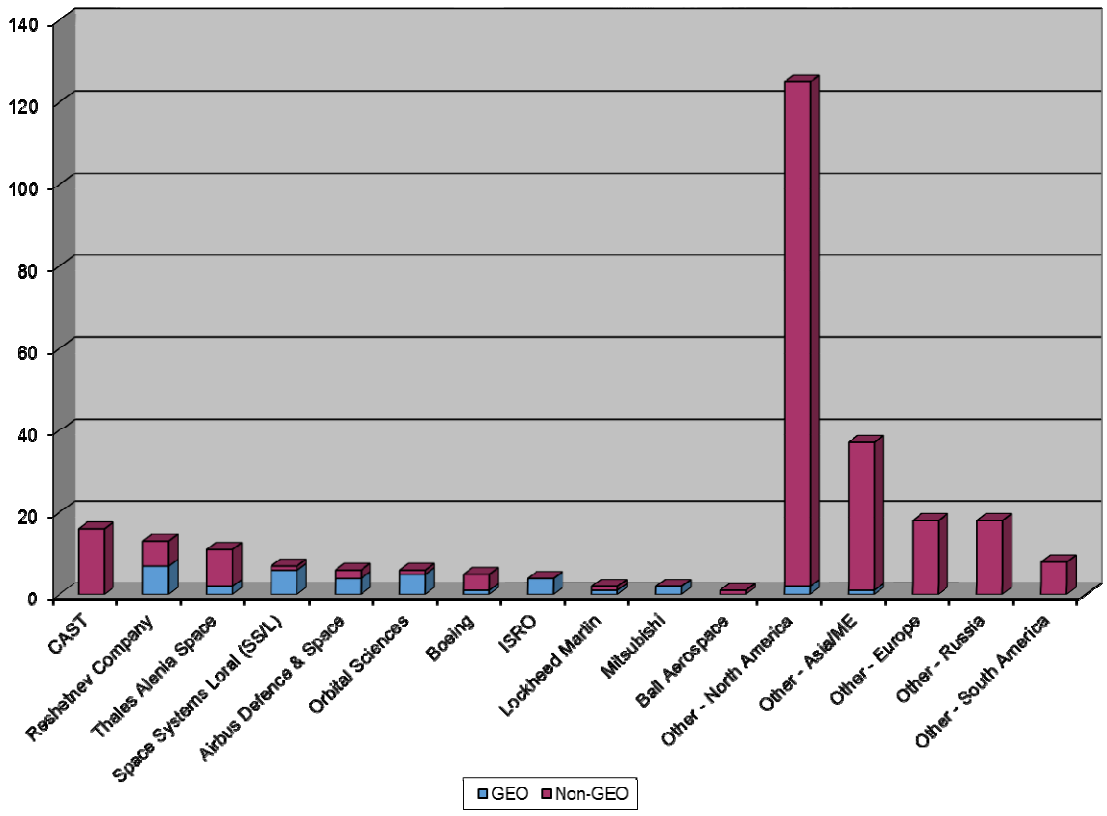

Figure 2.14: Satellites launched in 2014 by manufacturer and orbit type (Source: Futron)

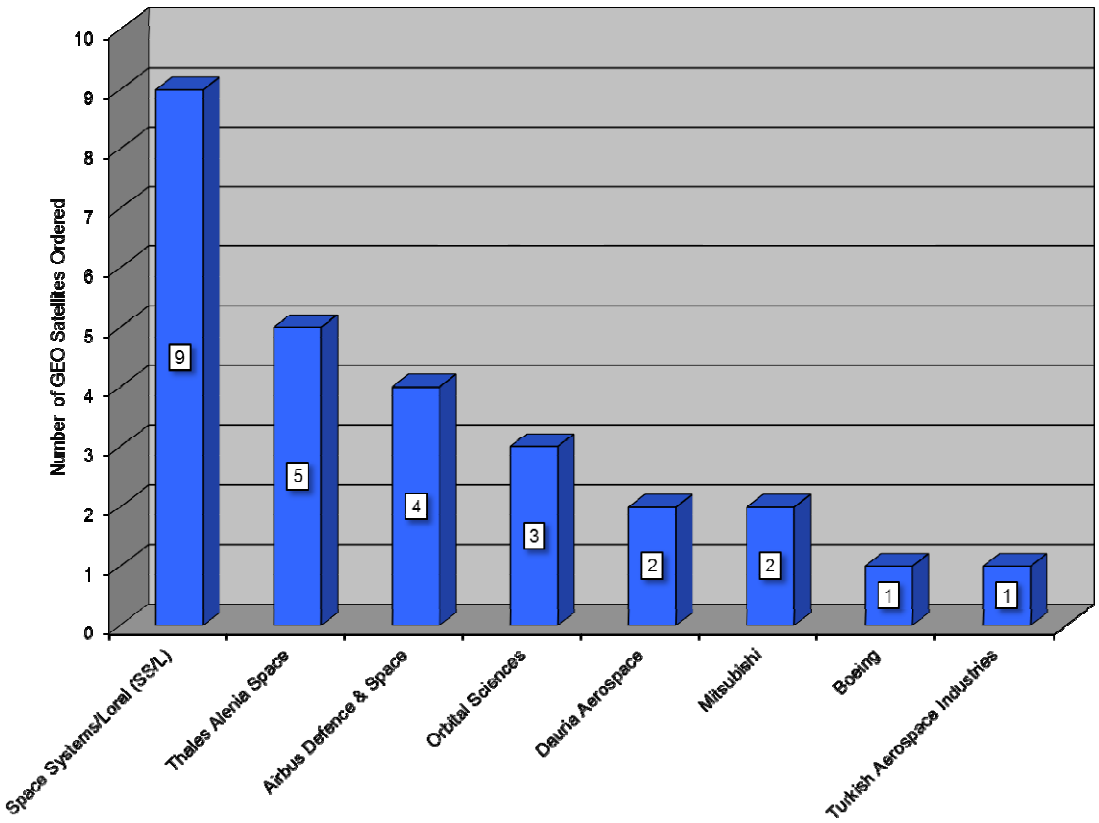

Figure 2.15: GEO satellite orders in 2014 by manufacturer

In 2014, North American prime spacecraft manufacturers held a strong lead in orders for commercial GEO communications satellites, accounting for 48.1% of the contracts awarded, European contracts grew to 33.3% of the available awards. SS/L took the competitive lead in commercial orders, winning 9 of 27 contracts (including the Amazonas 5, BRIsat, BulgariaSat1, Echostar23, Hispasat1F, Intelsat 36, JCSat15, JCSat16, and PSN 6). Europe's Thales Alenia Space came next with 5 orders (EuropaSat/HellasSat3, Koreasat5A, Koreasat7, Telkom 3S, and Yamal 601), followed by Airbus Defence & Space, which had 4 orders (Echostar105/SES11, Eutelsat172B, SES 10, and SES 12). Next U.S. prime contractors' Orbital Sciences had 3 contracts (Al Yah 3, Hylas 4, and Thaicom 8), while Boeing won 1 commercial contract for the year (Intelsat 35e). Russia and Japan each took a 7.4% share by winning 2 contracts; Russia's Dauria Aerospace will build the NexStar 1, and NexStar 2 satellites, and Japan's Mitsubishi will build the Es'hail2, and Superbird8 satellites. Lastly, Turkish Aerospace Industries (TAI) won a domestic contract to build the Türksat 6A, resulting in a 3.7% share.[93]

2.5 Transatlantic Industrial Comparison

Europe (all actors) and the United States remain the two major space actors that invest the most in space activities (cf. Figure 2.1). They also have the most diverse and competitive industrial bases. An overview of their respective structures and capabilities is therefore necessary to assess the health and competitiveness of their industrial bases. This follows in the next two subsections, beginning with Europe.

2.5.1 State of the European Industry

The financial results of Europe's space manufacturing industry in 2014 provide insight into the European space industry's long-term developments and character, operating as both a strategic sector and infrastructure supplier. The trends reviewed in this section are mainly based on statistics generated by ASD-Eurospace.[94]

As can be seen in Figure 2.16, there has been a steady incremental increase in turnover in the years following the financial crisis. By 2014, it grew to €7.258 billion ($8.812 billion), from €6.815 billion ($9.395 billion) in 2013. This growth is in line with the increased number of commercial GEO communications satellite orders in 2014, where European prime contractors Thales Alenia Space and Airbus Defence & Space won a combined share of 33.3% of the 27 orders placed in 2014 (5 and 4 respectively) from 21.7% in 2013 (1 and 4 respectively). Indeed, the overall number of orders for 2014 had also grown by 17.4% from the 23 commercial GEO satellite orders made in 2013.[95]

Employment levels are another way to gauge the situation of the main companies in the space sector (Figure 2.17). Around 2,049 jobs were created in 2014, marking a significant boost compared to the smaller incremental growth in previous years.

In the European space sector, most funding goes toward institutional civil programmes rather than to institutional military programmes. Here, ESA's role has continued to increase, aided by increased contributions from its Member States, and by the development of EU's two flagship space programmes, Copernicus and Galileo. In 2014, 76% of the final sales in Europe's space industry came from European customers, while 24% of final sales came from exports.[96] In recent years, the share of revenue generated by exports has been increasing. In 2011 the ratio of European sales to exports was 81.3% to 18.7%[97]; in 2012 79.7% to 20.3%[98], and 76.8% to 23.2% in 2013.[99] When counting only domestic sales to European customers, institutional programmes (both civil and military) were the main source of revenue reaching 71.8% in 2014, while sales to European commercial customers such as satellite or launch service operators (e.g. Eutelsat, Arianespace, etc.) generated 25.6%, and the remaining 2.6% was generated by other/unknown.[100]

[93] "Satellite Orders Report - 2014 Year-End Summary." Futron 13 July 2015 <http://www.futron.com/upload/wysiwyg/Resources/FoF/2015/FutronSM2014-EOY.pdf>.
[94] ASD-Eurospace. "Facts & figures – The European Space Industry in 2014." 19th edition. June 2015.
[95] "Satellite Orders Report - 2014 Year-End Summary." Futron.
[96] ASD-Eurospace. "Facts & figures – The European Space Industry in 2014." 19th edition. June 2015: 10.
[97] ASD-Eurospace. "Facts & figures – The European Space Industry in 2011." 16th edition. June 2012: 9.
[98] ASD-Eurospace. "Facts & figures – The European Space Industry in 2012." 17th edition. June 2013: 9.
[99] ASD-Eurospace. "Facts & figures – The European Space Industry in 2013." 18th edition. June 2014: 13.
[100] ASD-Eurospace. "Facts & figures – The European Space Industry in 2014." 19th edition. June 2015: 6.

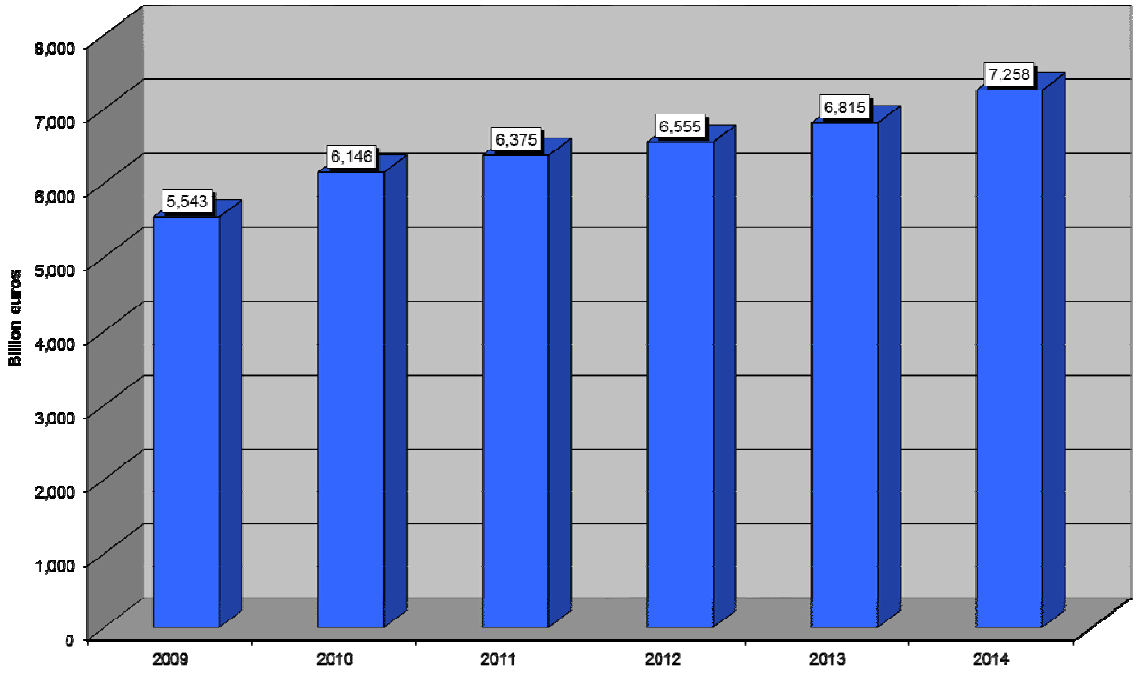

Figure 2.16: Estimated consolidated turnover of the European space sector in Euros (copyright by Eurospace – all rights reserved, used with permission, reproduction forbidden)

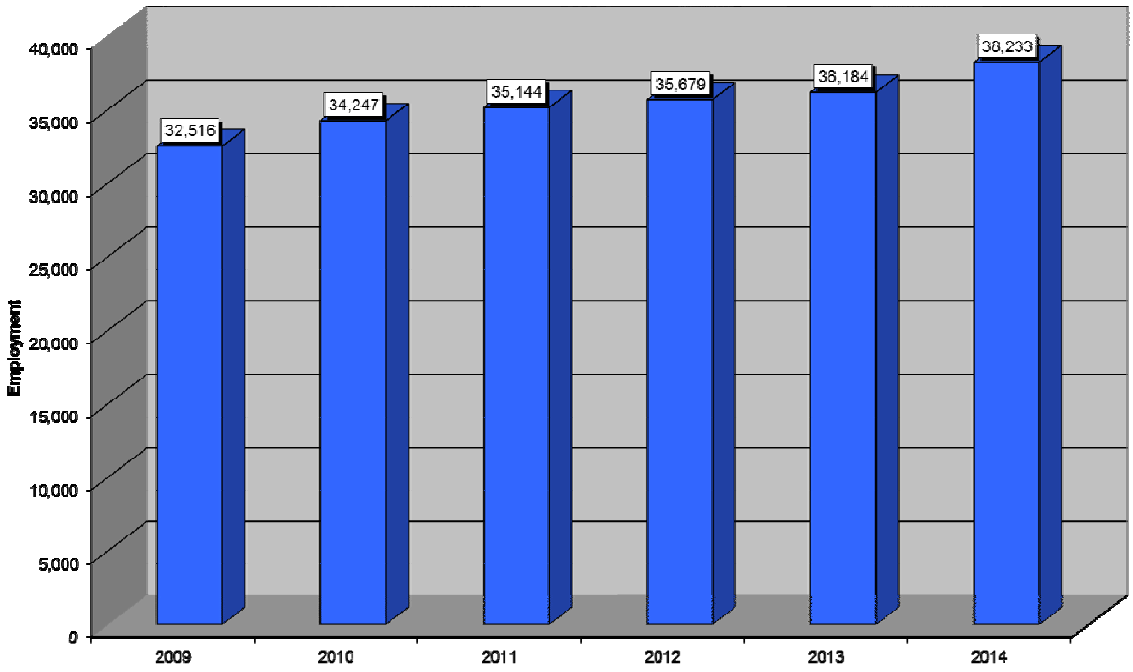

Figure 2.17: European space industry employment (copyright by Eurospace – all rights reserved, used with permission, reproduction forbidden)

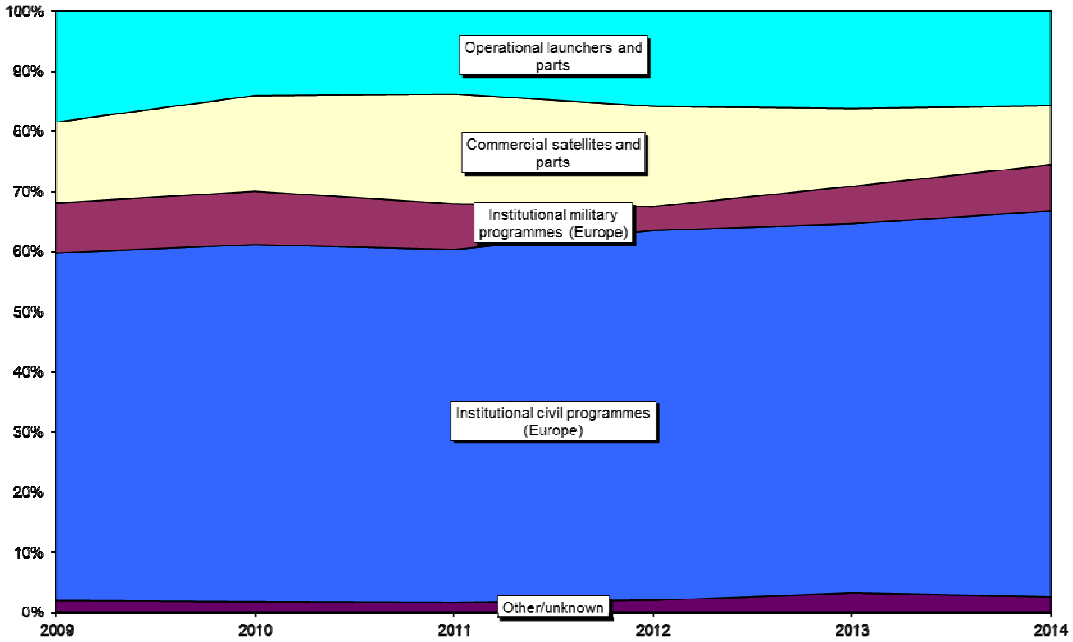

Figure 2.18: Estimated share of European space industry consolidated turnover per institutional customer (copyright by Euro-space – all rights reserved, used with permission, reproduction forbidden)

When looking at the European space industry by sector (Figure 2.19), there was a 6.5% overall increase in turnover in 2014, and that increase had the greatest impact on scientific programmes, along with support and test activities, which grew by 18.2% and 11.4% respectively. Additionally, satellite applications (e.g. navigation systems and telecommunications systems) saw a 3.2% increase in 2014, whereas launcher developments and production dipped slightly by 2.2%.

While Figure 2.19 displays the impact of the turnover per sector, and provides a historical timeline, it is possible to drill down further into each category to assess the impact of the increase in turnover. In 2014, while there was a slight overall decrease in the turnover of European satellite applications, the effect varied among the three parts of the satellite applications sector (i.e., telecommunication, earth observation, and navigation/localisation systems). Revenue from telecommunications systems in the European sector continued to decrease, this time by 9.9% to €730 million from €810 million in 2013. However, revenue from European navigation systems increased by 6.3% to €422 million in 2014 from €396 million in 2013. Next, Earth observation systems revenue remained relatively unchanged in 2014, generating €822 million from €818 million in 2013.[101]

In launcher development and production, it should be noted that European launcher developments are funded almost exclusively by ESA. In 2014, expenditure on launcher development remained just under €600 million, whereas the financial impact of the 2014 ESA Ministerial decision is expected to be more visible in 2015 figures. In contrast, operational launcher systems and parts revenue remained at nearly €900 million in 2014.[102] Next, scientific programmes saw a substantial increase in revenue in 2014, generating about €1.28 billion from 1.08 billion in 2013, which comes mainly from the design, development and production of spacecraft with unique science programme features, while human spaceflight and microgravity segments also experienced some increase in revenue for 2014.[103] These programmes are promoted almost exclusively by European institutions, with ESA at the forefront.

[101] Ibid. at 17.

[102] Ibid. at 15.
[103] Ibid. at 17.

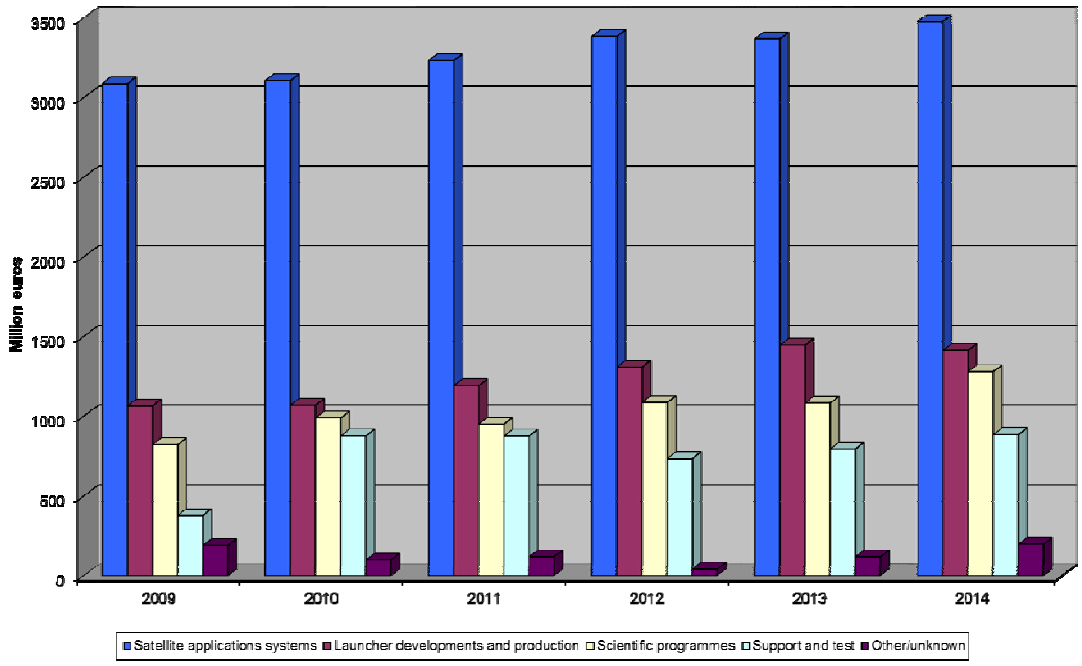

Figure 2.19: Estimated share of European space industry consolidated turnover per sector (copyright by Eurospace – all rights reserved, used with permission, reproduction forbidden)

2.5.2 State of the United States Space Industry

The trends reviewed in this section come mainly from the Aerospace Industry Association's (AIA) 2014 Year-End Review and Forecast report.[104] In 2014, the U.S. aerospace industry's preliminary revenues earned in the space segment grew to $48.83 billion from $46.27 billion in 2013. Even with the setbacks the U.S. space sector experienced in late 2014, such as the destruction of the Antares 130 ISS commercial resupply mission, the AIA expects revenues to increase into 2015. It should be noted that the data published by the AIA differs significantly from Eurospace in its collection methodology and should therefore not be taken as a direct comparison in terms of revenue, employment and exports.

With the harsh budget climate in the U.S. during 2014, following the effects of the earlier government budget sequestration and shrinking defence budgets, the U.S. labour force in space is expected to have decreased even below the 71,000 people employed in 2013.

Whereas the total revenue earned by the U.S. space sector is available, determining the revenues derived from U.S. civil space exports is difficult as that the U.S. Census Bureau has not published specific data since 2009. However, total civil export data is available for aerospace products taken as a whole (including aircraft, parts, and missile systems). In 2014, there was an additional 7.0% increase in total civil exports reaching $104.14 billion (preliminary assessment) from the $97.33 billion generated in 2013.[105]

Fortunately, the specific data for U.S. military space exports is publically available, allowing a better assessment of the trends in sales. With a narrow focus on sales of 'spacecraft, satellites & parts', revenues fell to $571 million in 2014 from $602 million in 2013; on a similar note, export revenue from 'missiles, rockets & parts' also dropped to $1.72 billion in 2014 from $2.57 billion in 2013.[106]

Within the United States, a disaggregation approach to military procurement is setting in. For instance, the USAF's budget request for 2015 looks to spread military space capabilities on a wider variety of platforms, rather than concentrating technologies on custom-made large platforms. This new space architecture model places more reliance on satellites for bandwidth, and on their ability to host dedicated payloads such as CHIRP at a lower cost.[107] Released on 4 March 2015, the budget request calls for staggered production of the USAF's third generation GPS 3 constel-

[104] Aerospace Industry Association. "AIA: 2014 Year-End Review and Forecast." 17 Dec. 2014. AIA Aerospace 25 Sept. 2015 <http://www.aia-aerospace.org/assets/2014_AIA_Annual_report_web.pdf>.

[105] Ibid. at 17.

[106] Ibid.

[107] Gruss, Mike. "News from Satellite 2014 | Disaggregation Still Has Hearts and Minds to Win at Pentagon." 11 Mar. 2014. SpaceNews 23 July 2015 <http://spacenews.com/39800news-from-satellite-2014-disaggregation-still-has-hearts-and-minds-to/>.

lation by buying fewer satellites than intended for the year 2015, which also means it will conduct fewer launches of the constellation in the year.[108] Similarly, the USAF's planned Weather System Follow-On (WSF), which will replace its Defense Meteorological Satellite Programme, will take a disaggregated system-of-systems approach, leveraging civilian and international partnerships in the near term.[109]

The USAF's approach to disaggregation will also affect the competitive environment surrounding the space launches it had planned to competitively award in the period 2015-2017, related to the reduced production of the GPS-3 system. Previously, in November 2012, the U.S. DoD had authorized the USAF to purchase up to 50 rocket cores during the next five years under its Evolved Expendable Launch Vehicle (EELV) programme. While 14 cores would be procured competitively, with the first of these competitive awards expected in 2015, the other 36 would be procured from the DoD's traditional prime contractor United Launch Alliance (ULA) on a sole-source basis.[110] However, the USAF now intends to halve the number of competitively procured space launches to 7 rocket cores.[111]

[108] Gruss, Mike. "U.S. Air Force's 2015 Budget Request Funds Fewer GPS 3 Satellites." 4 Mar. 2014. SpaceNews 23 July 2015 <http://spacenews.com/39725us-air-forces-2015-budget-request-funds-fewer-gps-3-satellites/>.
[109] Gruss, Mike. "Disaggregation Gets Traction in 2015 Pentagon Budget Request." 7 Mar. 2014. SpaceNews 23 July 2015 <http://spacenews.com/39773disaggregation-gets-traction-in-2015-pentagon-budget-request/>.
[110] Leone, Dan. "Pentagon Approves EELV Block Buy, with Competitive Twist." 4 Dec. 2012. SpaceNews 15 May 2014 http://www.spacenews.com/article/military-space/32657pentagon-approves-eelv-block-buy-with-competitive-twist.
[111] Gruss, Mike. "U.S. Air Force Halves Size of Competitive EELV Procurement." 7 Mar. 2015. SpaceNews 23 July 2015 <http://spacenews.com/39772us-air-force-halves-size-of-competitive-eelv-procurement/>.

3. Space Industry Evolutions

3.1 Europe

The Arianespace commercial launch company reported revenue of €1.399 billion ($1.7 billion) in 2014; a 41.5% increase from €989 million ($1.32 billion) in 2013. Its operating income for 2014 was €3 million ($3.65 million), while its backlog of orders stood at €4.11 billion ($5.00 billion).[112] In 2014, Arianespace won 14 additional launch contracts, including 9 contracts for commercial launches into GTO on the Ariane 5 ECA, in addition to two contracts to launch Galileo satellites on the Ariane 5 ES launcher, two contracts to launch four O3b satellites, the Sentinel 1B on the Europeanized Soyuz launcher, and one Vega launch which will place the OPTSAT 3000 and Venμs spacecraft into Sun-synchronous orbit. At least twelve launches are planned to be performed by Arianespace in 2015, including six launches of Ariane 5, three launches of the Europeanized Soyuz, and three launches of Vega.[113]

Eutelsat reported total revenue for the twelve months ending 30 June 2014 of €1.348 billion ($1.84 billion), a 5.0% increase from the €1.284 billion ($1.67 billion) earned in the previous year.[114] The majority of this came from European regions (64.0%), which diminished slightly from the previous year, whereas the Americas garnered the second highest share (15.6%), followed by the Middle East at (12.6%), Africa (5.5%) and Asia (2.2%).[115] In the six months ending 31 December 2014, Eutelsat reported revenue of €722.8 million ($878.55 million), up 11.6% from the €647.4 million ($891.2 million) earned in the same six-month period a year earlier.[116] These figures do not consider the impact of the acquisition of Satmex, which was finalized on 1 January 2014. The acquisition of Satmex, financed with a €930 million ($1.28 billion) 6-year bond issue on 13 December 2013, increased Eutelsat's presence in Latin America at a time when demand for satellite capacity in Latin America is expected to grow an average of 4.2% per year over the 2013-2018 period.[117]

On 3 June 2014, Abertis Telecom, the Spanish telecommunications infrastructure provider, sold its remaining 5% stake in Eutelsat to qualified investors for a total of €275 million.[118] Formerly Eutelsat's largest shareholder, Abertis Telecom began the divestment of its 32% stake in January 2012, first selling a 16% share of Eutelsat to investors in a transaction valued at about €1 billion[119], followed by the sale of another 7% stake in June 2012 for €385.2 million, and of an additional 3% in March 2013 for €182 million.[120]

Hispasat reported a nominal increase of 0.34% in revenue generating €202.1 million ($245.6 million) by the end of 2014, from €201.4 million ($277.2 million) in 2013. Its net profit went down by 15.6% to €45.6 million ($55.4 million), from €54.0 million ($74.3 million) in 2013. The company faced some challenges in 2014, such as the anomaly experienced on Amazonas 4A, which resulted in reduced available capacity and a delayed release on the market, which had a negative impact on the revenue anticipated

[112] 2014 Annual Report. Arianespace 23 July 2015 <http://www.arianespace.com/about-us-corporate-information/Annual-Report-2014-EN.pdf>.
[113] "Arianespace at a glance." Arianespace 23 July 2015 <http://www.arianespace.com/about-us/service-solutions.asp>.
[114] "Full Year 2013-2014 Results." 31 July 2014. Eutelsat 9 Feb. 2015 <http://www.eutelsat.com/home/investors/financial-information/financial-press-releases/2013-2014/press-list-container/full-year-2013-2014-results.html>.
[115] Reference Document 2013-2014. Eutelsat Communications 9 Feb. 2015: 137 <http://www.eutelsat.com/files/contributed/investors/pdf/reference-document-2013-2014.pdf>.
[116] Press Release. "First Half 2014-2015 Results." 12 Feb. 2015. Eutelsat Communications 18 Aug. 2015 <http://www.eutelsat.com/files/contributed/news/press/en/2015/PR-H1-2014-15.pdf>.
[117] Reference Document 2013-2014. Eutelsat Communications 9 Feb. 2015: 14 <http://www.eutelsat.com/files/contributed/investors/pdf/reference-document-2013-2014.pdf>..
[118] "Abertis sells final 5% Eutelsat stake for €275 million." 4 June 2014. DigitalTVEurope.net 9 Feb. 2015 <http://www.digitaltveurope.net/188672/albertis-sells-final-5-eutelsat-stake-for-e275-million/>.
[119] De Selding, Peter B. "Chinese Investment Firm Taking 7 Percent Stake in Satellite Fleet Operator Eutelsat." 22 June 2012. Space News 25 Feb. 2014 <http://www.spacenews.com/article/chinese-investment-firm-taking-7-percent-stake-satellite-fleet-operator-eutelsat>.
[120] "Abertis sells final 5% Eutelsat stake for €275 million." 4 June 2014. DigitalTVEurope.net 9 Feb. 2015 <http://www.digitaltveurope.net/188672/albertis-sells-final-5-eutelsat-stake-for-e275-million/>.

for the year. Moreover, unfavourable exchange rates and the downturn in demand in European markets had a negative effect on returns. In 2014, €197.2 million ($239.7 million) of the total revenue came from space capacity rentals, whereof 60.6% came from clients in the Americas, where the operator has consolidated a strong presence and a significant market share, while the remaining 39.4% came from clients in Europe and North Africa.[121]

Telenor Satellite Broadcasting of Norway reported a 1.20% decrease in revenue for the year ending 2014, with the decline attributable to its divestment of its subsidiary Conax, which had been deconsolidated on 25 March 2014. The Oslo-based satellite fleet operator reported revenue of 959 million kroner ($128.7 million) from 971 million kroner ($158.6 million) in 2013.[122] Telenor expects to enhance its commercial broadcasting capacity following the launch of the Thor 7 satellite on 26 April 2015.[123]

Inmarsat reported a 1.9% increase in revenue for the year ending 31 December 2014, generating $1.286 billion compared to the $1.262 billion earned in 2013. In addition to the underlying growth stemming from Maritime, Enterprise, and Aviation, the increase also reflected the LightSquared Cooperation Agreement (which earned $75.4 million of the total revenue) and additional revenues following the acquisition of Globe Wireless. Yet, Inmarsat has seen a continued slowdown in its government business, which decreased by 21.7% to $319.9 million from $408.3 million in 2013, and a reduction in revenue due to the disposal of the majority of the retail energy business to the company RigNet.[124]

Following Airbus Group's recent consolidation of its Astrium space hardware and services division with the Cassidian and Airbus Military divisions to form Airbus Defence and Space (Airbus D&S), Airbus D&S reported €13.025 billion ($15.832 million) in revenue for 2014, a near 1% reduction from the restated revenue of €13.121 billion ($18.062 million) earned in 2013. Airbus D&S' Space Systems accounted for 31% of that 2014 amount, or €4.04 billion ($4.911 million). New orders for the company overall increased by 3.5%, amounting to €12.225 billion ($14.859 million) from €11.808 billion ($16.255 million) in 2013.[125] While prior to the reorganisation the Astrium division had been required to eliminate up to 2,470 Astrium positions from its pool of 18,000 employees over three years, the four telecommunications satellites and 10 Earth observation satellite orders its satellite division won in 2014 have resulted in a lowering of planned cuts by 600 positions.[126]

The tight budgetary situation throughout Europe, and the increasing competition in the global market, has led Airbus to seek to divest its commercial satellite communications services business, which is mainly devoted to mobile satellite services, and focus on its core space, military aircraft, and missile divisions. Airbus D&S had purchased its commercial mobile satellite division, Vizada, in 2011 from Apax Partners of France for $960 million, from which it earned around $660 million in revenue in 2011 and 2012. Despite divestment plans, Airbus D&S intends to keep the minor government portion of business services of Vizada.[127] In November 2014, Inmarsat indicated its interest in purchasing Vizada from Airbus D&S, as the purchase would give Inmarsat a dominant share of the mobile satellite services reseller business in addition to its role as a wholesale provider of satellite capacity.[128] However, Inmarsat later decided not to enter bidding out of concerns that European regulators would protest about its dominant competitive position. By the end of May 2015, Vizada's previous owner Apax was finalizing negotiations with Airbus D&S to

[121] "Last year, HISPASAT generated a 9% increase in its revenue from America." 19 Feb. 2015. Hispasat 2 Apr. 2015 <http://www.hispasat.com/en/press-room/press-releases-2015/166/hispasat-aumenta-en-un-9-sus-ingresos->.

[122] Q4/2014 – Interim report | January – December 2014. 10 Feb. 2015. Telenor Group 2 July. 2015 <http://www.telenor.com/wp-content/uploads/2014/09/Telenor-Q4-report-2014-110215.pdf>.

[123] Clark, Stephen. "Ariane 5 sends Thor 7 and Sicral 2 satellites into orbit." 26 Apr. 2015. Spaceflight Now 30 Sept. 2015 <http://spaceflightnow.com/2015/04/26/ariane-5-sends-thor-7-and-sicral-2-satellites-into-orbit/>.

[124] "Inmarsat plc reports Preliminary Full Year Results 2014." 5 Mar. 2015. Inmarsat 18 July 2015 <http://www.inmarsat.com/press-release/inmarsat-plc-reports-preliminary-full-year-results-2014/>.

[125] "FY Results 2014." 27 Feb. 2015. Airbus Group 1 Apr. 2015: 14 <http://www.airbusgroup.com/dam/assets/airbusgroup/int/en/investor-relations/documents/2015/Closing/FY14/Airbus-Group-FY2014-Presentation/Airbus Group FY2014 Presentation.pdf>.

[126] De Seldinh, Peter B. "Successes in 2014 Prompt Airbus To Reduce Space Layoffs." 20 Jan. 2015. SpaceNews 26 Aug. 2015 <http://spacenews.com/successes-in-2014-prompt-airbus-to-reduce-planned-layoffs-in-space-business/>.

[127] De Selding, Peter B. "Airbus To Divest Commercial Mobile Satellite Services Division." 16 Sept. 2014. SpaceNews 23 July 2015 <http://spacenews.com/41881airbus-to-divest-commercial-mobile-satellite-services-division/>.

[128] De Selding, Peter B. "Inmarsat Eyeing Airbus Mobile Satellite Services Division." 10 Nov. 2014. SpaceNews 23 July 2015 <http://spacenews.com/42499inmarsat-eyeing-airbus-mobile-satellite-services-division/>.

repurchase the company.[129] The sale of Vizada should be concluded by mid-2015.

Thales Alenia Space posted total revenue of more than €2.1 billion ($2.55 billion) in 2014, of which 62% came from Earth Observation, exploration and navigation satellites, while the remaining 38% came from telecommunications satellites. The company also gained €2.2 billion ($2.67 billion) in new orders.[130] In mid-October, the company began the construction of a new building for the integration and testing of high-resolution optical observation instruments, as the last step in company's 2008 Odyssée programme to expand the company's Cannes site.[131] While marketing high-resolution optics presents a major economic and strategic challenge, it also brings into focus the limits that can be placed on high-resolution satellites sold for export, and whether the selling state can require "shutter-control". Yet, the company seeks to efficiently address the changing requirements of a booming global market.

OHB AG of Germany increased its total revenue to €728.15 million ($885.05 million) for the 2014 fiscal year; amounting to a 7.1% increase from the €680.12 million ($936.25 million) earned in 2013.[132] In January 2014, OHB's subsidiary CGS S.p.A was awarded a sub-contract worth €44 million ($59.9 million) from prime contractor Telespazio S.p.A for the Italian defence ministry's OPSAT (OPtical SATellite) 3000 programme, scheduled for launch sometime in 2016. In June 2014, OHB's Sweden branch opened its new production facility, while in the following month another facility was opened in Oberpfaffenhofen, near Munich, Germany. Also in July 2014, OHB shareholders passed a resolution approving the conversion of OHB AG into a Societas Europae (SE) in 2015, which will allow for more Europeanization of space technology, as the change in corporate structure will make it easier for the group to establish new branches in other parts of the European Union, while also permitting a more uniform and clearer governance system.[133] The conversion of the legal structure took place on 26 March 2015.[134] On 31 December 2014, OHB's employees numbered 2086 (a reduction of 326 from the previous year) which was due to the deconsolidation of its subsidiary Aerotech Peissenberg GmbH & Co.; by the end of the year, 78.9% of OHB's employees were based in companies in Germany, while 15.9% were in other parts of Western Europe, and the remaining 5.2% were located in Chile and French Guyana.[135]

RUAG Space is continuing toward an industry leadership role as Europe's largest independent supplier of space technology, recording a 4.9% increase in revenue in 2013 earning CHF 299 million ($335.76 million)[136], followed by an additional 7.7% increase in 2014 which brought CHF 322 million ($325.39 million).[137] Based in Switzerland, Sweden, and Austria, the company now employs 1,163 personnel.[138] At the end of 2014, RUAG announced an agreement to purchase the space unit of Finnish company Patria. In the 17 December 2014 announcement, the transaction included Patria Space's business operations and assets, in addition to the transfer of 32 Patria employees to be employed in the newly founded company RUAG Space Finland.[139] As the key product areas of Patria's Space unit are in spacecraft control electronics, electrical power subsystems, electronic units and related test equipment, its acquisition will enhance RUAG's portfolio with the potential to broaden its technology base. On 18 December 2014, RUAG took a stake in INNOCAMPUS AG, the operating company of Swiss Innovation Park (SIP) Biel-Bienne, Switzerland, investing a total of CHF

[129] De Selding, Peter B. "Apax Looks Set to Repurchase Airbus Mobile Satcom Unit." 22 May 2015. SpaceNews 30 Sept. 2015 <http://spacenews.com/airbus-to-sell-mobile-satcom-unit-to-previous-owner/>.
[130] De Selding, Peter B. "Thales Alenia Space Chief Touts Program Progress, Cost-cutting Efforts." 24 Mar. 2015. Thales Alenia Space 1 Apr. 2015 <http://spacenews.com/thales-alenia-space-chief-touts-program-progress-cost-cutting-efforts/>.
[131] "Thales Alenia Space to build new space optics facility - Invests 8 million euros to extend Cannes plant." 9 Dec. 2014. Thales Group 1 Apr. 2015 <https://www.thalesgroup.com/en/worldwide/space/press-release/thales-alenia-space-build-new-space-optics-facility-invests-8-million>.
[132] Annual Report 2014. 26 Mar. 2015. OHB 31 Mar. 2015: 2 <http://www.ohb.de/tl_files/ohb/pdf/finanzberichte_hauptversammlung/2014/OHB_GB_14_E.pdf>.
[133] Ibid.
[134] Ad hoc announcements. "OHB AG converted into OHB SE." 26 Mar. 2015. OHB 30 Sept. 2015 <http://www.ohb.de/ad-hoc-bulletins-detail/ohb-ag-converted-into-ohb-se.html>.
[135] Annual Report 2014. 26 Mar. 2015. OHB 31 Mar. 2015: 2 <http://www.ohb.de/tl_files/ohb/pdf/finanzberichte_hauptversammlung/2014/OHB_GB_14_E.pdf>.
[136] RUAG Annual Report 2013. 18 Mar. 2015. RUAG 1 Apr. 2015: 98 <http://www.ruag.com/fileadmin/ruag/Divisions/Aerostructures/Aerostructures_home/About_us/RUAG_GB_2013_EN.pdf>.
[137] RUAG Annual Report 2014. 17 Mar. 2015. RUAG 1 Apr. 2015: 66 <http://www.ruag.com/fileadmin/ruag/group/Annual_Report/GB/RUAG_2014_GB_EN.pdf>.
[138] Ibid. at 18.
[139] Media release. "RUAG acquires Patria's Space Business." 17 Dec. 2014. RUAG 1 Apr. 2015 <http://www.ruag.com/space/media/media-releases/news/ruag-acquires-patrias-space-business/5faeadbc8094ec868a0d76b27f9b3a45/>.

132 million ($136.98 million).[140] RUAG's aim is to increase its expertise in additive manufacturing technology (i.e. 3D printing) for use in structures that will operate in space.

3.2 United States

Following the 2012 acquisition of the U.S. Space Systems/Loral (SS/L) by Canada's MacDonald, Dettwiler and Associates Ltd. (MDA), MDA was able to reduce SS/L's debt in 2013, and began to focus on growing its capacity, including additional acquisitions. In 2013, SS/L won 6 of the 23 commercial satellites ordered for the year[141]; and by 31 October 2014, SS/L had booked another 8 commercial orders.[142] SS/L also won a contract with Skybox Imaging to build 13 small satellites, valued in the comparably modest tens of millions of US dollars. Generally, six to seven large satellite orders per year are needed by SS/L to maintain operations.[143] For 2014 and 2013, MDA revenues were C$2.1 billion ($1.8 billion) and C$1.8 billion ($1.7 billion) respectively, whereas in 2012 its revenue was C$879.9 million ($882.6 million).[144]

Boeing's Network & Space Systems segment within its Defence, Space & Security division reported revenue of $8.003 billion for the year ending 31 December 2014; a 6.0% decrease from the $8.512 billion earned in 2013. Its backlog stood at $8.9 billion in 2014, from $8.8 billion in 2013.[145]

Lockheed Martin's Space Systems segment reported $8.065 billion in revenue for the year ended 31 December 2014; a 1.3% increase from the $7.958 billion earned in 2013. The increase primarily came from sales related to the first unmanned test flight of the Orion MPCV and commercial launch-related activities, but the increase was offset by lower net sales for government satellite programs with decreased volume purchases for the AEHF, GPS-III and MUOS and various other programs as a result of disaggregated government spending. By the end of 2014, its backlog stood at $18.9 billion, from $20.5 billion in 2013.[146]

On 9 February 2015, Orbital Sciences completed its merger with Alliant Techsystems Inc. (ATK) to form Orbital ATK Inc. Valued at $4.5 billion, the merger combines Orbital and ATK's aerospace and defence groups, and is organised into three separate business groups: flight systems, defence systems, and space systems. While the space systems group is the smallest of the three, it will employ 2,700 people and expects to generate sales of about $1.2 billion annually.[147]

Following GeoEye's acquisition by DigitalGlobe in 2013 and uncertainty regarding U.S. government commitments, it was business as usual for DigitalGlobe, with U.S. government revenue rising 53% from the previous year.[148] For the year ending 31 December 2014, DigitalGlobe reported revenue of $654.6 million; a 6.8% increase from the $613 million earned in 2013.[149] The image provider had initially predicted revenues of $699 million but unexpected competition in the emerging market business, and a 2.5 month delay in the launch of its WorldView-3 satellite resulted in reduced returns for the year.[150] By mid-year, business with Russia had nearly halted due to the Ukrainian crisis,

[140] Media release. "RUAG takes a stake in INNOCAMPUS AG." 18 Dec. 2014. RUAG 1 Apr. 2015 <http://www.ruag.com/group/media/media-releases/news/ruag-takes-a-stake-in-innocampus-ag/fe80c95c94dc7c2230bb47dad3ba5dd8/>.
[141] De Selding, Peter B. "Canada's MDA Awaiting U.S. Government's Return from 'Capex Holiday'." 26 Feb. 2014. SpaceNews 25 June 2015 <http://spacenews.com/39632canadas-mda-awaiting-us-governments-return-from-capex-holiday/>.
[142] De Selding, Peter B. "Canada's MDA Suggests Lack of Government Support May Prompt Another Move." 31 Oct. 2014. SpaceNews 29 June 2015 <http://spacenews.com/42383canadas-mda-suggests-lack-of-government-support-may-prompt-another/>.
[143] De Selding, Peter B. "Canada's MDA Awaiting U.S. Government's Return from 'Capex Holiday'." 26 Feb. 2014. SpaceNews 25 June 2015 <http://spacenews.com/39632canadas-mda-awaiting-us-governments-return-from-capex-holiday/>.
[144] MDA 2014 Annual Report. 25 Feb. 2015. MDA 28 Oct. 2015 <http://www.mdacorporation.com/corporate/Investor/financial_reports/mda_2014_annualreport.pdf>.
[145] "Boeing Reports Record 2014 Revenue, Core EPS and Backlog and Provides 2015 Guidance." 28 Jan. 2015. Boeing 28 Oct. 2015 <http://boeing.mediaroom.com/2015-01-28-Boeing-Reports-Record-2014-Revenue-Core-EPS-and-Backlog-and-Provides-2015-Guidance>.
[146] "Lockheed Martin Reports Fourth Quarter and Full Year 2014 Results." 27 Jan. 2015. Lockheed Martin 29 Oct. 2015 <http://www.lockheedmartin.com/us/news/press-releases/2015/january/0123hq-earnings.html>.
[147] Berger, Brian. "Orbital ATK Org Charts Detail the Newly Merged Company." 12 Feb. 2015. SpaceNews 29 Oct. 2015 <http://spacenews.com/orbital-atk-org-charts-detail-the-newly-merged-company/>.
[148] De Selding, Peter B. "DigitalGlobe Revenue Up Sharply Despite U.S. Spending Slowdown." 1 Nov. 2013. SpaceNews 3 Mar. 2014 <http://www.spacenews.com/article/military-space/37960digitalglobe-revenue-up-sharply-despite-us-spending-slowdown>.
[149] DigitalGlobe Annual Report 2014. DigitalGlobe 17 July 2015 <https://www.last10k.com/sec-filings/DGI/0001558370-15-000193.htm>.
[150] De Selding, Peter B. "Unexpected Competition, Launch Delay Are Drag on DigitalGlobe Revenue." 27 Feb. 2014. SpaceNews 19 May 2014 <http://www.spacenews.com/article/financial-report/39648unexpected-competition-launch-delay-are-drag-on-digitalglobe-revenue>.

yet, this loss of business did not have a substantial impact due to matched growth from India, the Middle East, oil and gas companies, and NGOs.[151]

SpaceX is planning to use a new launch pad at Vandenberg US Air Force Base to launch the standard Falcon 9 rocket and its upcoming heavy-lift variant. SpaceX currently launches its Falcon 9 only from Canaveral Air Force Station, whereas the new pad will be built to also accommodate the developmental Falcon 9 Heavy launch vehicle, now expected to debut in late-2015.[152] The company will spend between $20-30 million to renovate the site, unused since 2005; the Titan 4 was the last rocket launched from there. SpaceX will also update its launch facility in Cape Canaveral, enabling the heavy-lift rocket to launch from both coasts. SpaceX's Florida base is undergoing general upgrades; additional hangars are being built to prepare the Falcon 9 rockets and customer payloads for launch. With an expected flight rate of 10 to 12 launches per year, the current facility (Space Launch Complex 40) will receive a 16,000 square-meter addition, including an unused Delta 2 processing building. SpaceX will receive $7.3 million from Space Florida, a state-funded agency, toward the upgrades.[153] While SpaceX is a closely held company, it was valued at around $10 billion by 2015, including 50 launches worth $5 billion on its manifest, and additional contracts worth $4.2 billion for hauling U.S. astronauts and supplies to the ISS.[154]

By the end of 2014, Virgin Galactic had begun rebuilding its SpaceShipTwo (SST), following the tragic destruction on 31 October that killed one of its pilots and injured another. Prior to the loss, the SST was in the final phases of obtaining a commercial launch licence for the SST, having successfully completed its third rocket-powered test flight on 10 January 2014, in addition to a "cold flow" test without ignition on 28 August after switching to a plastic-based fuel source.[155] A second SST is expected to be ready for testing in late 2016, with commercial service expect to begin within the following year.[156] Designed to be released from its carrier at an altitude of 15km, its rocket engine will ignite to propel the craft to an apex altitude of up to 110km. By 28 May 2014, more than 700 passengers had reserved a flight on the spacecraft, each at $250,000 per seat.[157] Among these customers are scientists along with their experiments, and space tourists. Soon, other companies might also be able to provide similar suborbital space travel products, including *inter alia* XCOR Aerospace, Blue Origin and Armadillo Aerospace.[158] So far, the closely held Virgin Galactic has received up to $600 million in investment; $380 million of which was provided by Aabar (Abu Dhabi's state investment agency), while $89 million came from advanced ticket sales, and the remaining $220 million was invested by Virgin Galactic's parent company.[159]

3.3 Russia

On 2 December 2013, Russia's President Vladimir Putin signed a decree ordering the creation of the United Rocket and Space Corporation (URSC), wherein several federal state-owned unitary space enterprises will be reorganized into open joint stock companies to be fully owned by the federal government, with each enterprise contributing 100% of shares minus one share to the new corporation's authorized capital.[160] The consolidation stage is to be completed in mid-2015. Initial steps taken in early 2014 were intended to reduce costs in the industry by consolidating the country's space industry into a single company to eliminate excess manufacturing capacity, in addition to streamlining the purchasing of foreign electronic components to be able to negotiate volume-based dis-

[151] De Selding, Peter B. "DigitalGlobe Revenue up Despite Steep Drop in Russian Business." 1 Aug. 2014. SpaceNews 29 Jan. 2015 <http://spacenews.com/41459digitalglobe-revenue-up-despite-steep-drop-in-russian-business/>.
[152] "SpaceX Breaks Ground on West Coast Launch Pad." Space News 25 July 2011: 8.
[153] Klotz, Irene. "SpaceX Expanding Florida Facilities to Meet Launch Demand." Space News 28 Nov. 2011: 5.
[154] Lippert, John. "SpaceX Profitable as Musk Pulls In NASA Contracts, Google Cash." 4 Mar. 2015. BloombergBusiness 2 Nov. 2015 <http://www.bloomberg.com/news/articles/2015-03-04/spacex-profitable-as-musk-pulls-in-nasa-contracts-google-cash>.
[155] Foust, Jeff. "Virgin Galactic Delays First Commercial Flights to 2015." 11 Sept. 2014. SpaceNews 9 Apr. 2015 <http://spacenews.com/41837virgin-galactic-delays-first-commercial-flights-to-2015/>.
[156] Messier, Doug. "SpaceShipTwo Test Flights in Late 2016?" 6 May 2015. Parabolic Arc 30 Sept. 2015 <http://www.parabolicarc.com/2015/05/06/spaceshiptwo-test-flights-late-2016/>.
[157] Klotz, Irene. "Virgin Galactic Hoping for SpaceShipTwo Altitude Boost with New Fuel." 28 May 2014. SpaceNews 9 Apr. 2015 <http://spacenews.com/40719virgin-galactic-hoping-for-spaceshiptwo-altitude-boost-with-new-fuel/>.
[158] Wall, Mike. "Virgin Galactic Aims for 1st Rocket-Powered Flight This Year." 28 Feb. 2012. SPACE.com 3 May 2012 <http://www.space.com/14706-virgin-galactic-spaceshiptwo-powered-flight.html>.
[159] Gordon, Sarah. "Virgin group: Brand it like Branson." 5 Nov. 2014. The Financial Times 2 Nov. 2015 <http://www.ft.com/intl/cms/s/2/4d4fb05e-64cd-11e4-bb43-00144feabdc0.html>.
[160] "Putin Signs Decree on Creation of United Rocket and Space Corporation." 2 Dec. 2013. ITAR TASS 30 Apr. 2014 <http://en.itar-tass.com/russia/709849>.

counts.[161] Initially, the reform was meant to split the Federal Space Agency, Roscosmos, between a demand and supply side, where Roscosmos would act as a customer, responsible for space policy, research and ground infrastructure[162], while URSC would act as the contractor.[163] However, by the end of 2014, the Russian government had proposed to unify Roscosmos with URSC, as the division of functions of customer and contractor had not considerably improved the sector's efficiency.[164]

The major catalyst for the reversal was serious shortcomings that arose in the construction of the Vostochny Cosmodrome. By mid-2014, there were signs that the new spaceport would miss its aim of being ready before the end of 2015, as construction was behind schedule by up to three months, and the 6,000 workers at the site were less than half of what was needed. The delay required a cash infusion of an additional 50 billion roubles ($1.3 billion) to finish construction on time.[165] Moreover, in October, the head of a company involved in building the spaceport was arrested and charged with embezzling 1.8 billion roubles ($43 million) from the project.[166] The Vostochny Cosmodrome will give Russia an alternative launch port to the Baikonur Cosmodrome, which has been leased from Kazakhstan since the Soviet Union's collapse in 1991.[167]

The Russian-Ukrainian-owned Sea Launch AG consortium (Sea Launch) is estimated to have earned $95 million in its single launch for 2014, relatively on par with the $100 million estimate for a failed launch in 2013 - but modest when compared to the $300 million earned for three launches in 2012.[168] The company has continued to experience setbacks stemming from launch failures and difficulties in winning launch contracts in 2014, requiring a series of cost-reduction measures to remain afloat before activities are expected to resume in mid-2015. Those measures will likely include laying-off staff, and reducing operating expenses by laying-up the Sea Launch Commander and Odyssey vessels. For the remainder of the year the Russian government is considering whether to move Sea Launch operations to Russia, which will give it access to Russian institutional launch contracts that are currently out of reach for the international company.[169] Other proposals have included moving launch operations to Vietnam, or Brazil, or selling Sea Launch to an Israeli company.[170] Sea Launch hopes to have 3 missions in 2015, followed by an even greater launch capacity in the years that follow.[171]

3.4 Japan

Mitsubishi Electric Co. (Melco) of Japan develops satellites within its Information and Communication Systems (ICS) business segment; however, as this segment does not separate satellite-related revenue from its telecommunication, information systems, and electronic systems business, it should only be seen as generating a small portion of the total revenue earned by this segment. In the year ending 31 March 2014, the ICS segment generated 11.8% of Melco's total sales. The ICS segment increased net sales by 4.9%, reaching ¥548.2 billion ($5.33 billion) in 2014, from ¥522.4 billion ($5.54 million) in 2013. Operating income began climbing to previous levels, increasing to ¥5.5 billion ($53.49 million) in 2014, from ¥1.6 billion ($16.98 million) in 2013, due partly to an increase in sales.[172] The revenue generated

[161] "Putin Signs Legal Decree Consolidating Russian Industry." 9 Dec. 2013. SpaceNews 30 Apr. 2014 <http://www.spacenews.com/article/civil-space/38551putin-signs-legal-decree-consolidating-russian-industry>.
[162] "Russia Bets on Sweeping Reform to Revive Ailing Space Industry." 26 Dec. 2013. Reuters 4 Mar. 2014 <http://www.reuters.com/article/2013/12/26/us-russia-space-idUSBRE9BP02S20131226>.
[163] "Overhaul pending in Russian space sector." 3 Dec. 201. ITAR-TASS News Agency 4 Mar. 2014 <http://en.itar-tass.com/russia/763105>.
[164] "Duma proposes to merge Roscosmos with United Rocket Space Corporation." 20 Dec. 2014. TASS.ru 21 July 2015 <http://tass.ru/en/non-political/768257>.
[165] Bodner, Matthew. "Cash Infusion Reaffirms Putin's Commitment to New Launch Complex." 3 Sept. 2014. SpaceNews 16 July 2015 <http://spacenews.com/41747cash-infusion-reaffirms-putins-commitment-to-new-launch-complex/>.
[166] Sweet, Rod. "Russia tightens control of troubled cosmodrome project." 24 Nov. 2014. Global Construction Review 16 July 2015 <http://www.globalconstructionreview.com/news/russia-tightens-control-trou7b7led-c0os6mo6dro4m4e/>.
[167] Soldatkin, Vladimir. "Putin orders building hastened at new Russian spaceport." 27 Aug. 2014. Reuters 16 July 2015 <http://www.reuters.com/article/2014/09/02/us-russia-space-idUSKBN0GX1AV20140902>.
[168] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2014. Washington DC: FAA, Feb. 2015: 9.
[169] Messier, Doug. "Sea Launch Cuts Back as Manifest Gap Looms." 23 Aug. 2014. Parabolic Arc 21 July 2015 <http://www.parabolicarc.com/2014/08/23/sea-launch/>.
[170] Messier, Doug. "Will Sea Launch End Up in Brazil?" 24 Dec. 2014. Parabolic Arc 20 July 2015 <http://www.parabolicarc.com/2014/12/24/sea-launch-brazil/>.
[171] Henry, Caleb. "A Heavyweight Battle: How Sea Launch Plans to Stay Afloat With SpaceX in its Waters." 13 Dec. 2013. ViaSatellite 6 Mar. 2014 <http://www.satellitetoday.com/launch/2013/12/13/a-heavyweight-battle-how-sea-launch-plans-to-stay-afloat-with-spacex-in-its-waters/>.
[172] 2014 Annual Report. 31 July 2014. Mitsubishi Electric 10 Feb. 2015: 12

for the 2014 fiscal year stemmed from an increase in the communications infrastructure business, along with growth in the system integration business, and increased sales due to progress in orders already received for projects in the space system business.[173]

On 6 November 2014, the Japanese government launched its Advanced Satellite with New System Architecture for Observation, or ASNARO-1, on a Russian Dnepr rocket from the Russian Yasny launch base. The ASNARO-1 is the first of a new generation of low-cost Earth observation satellite platforms built by NEC Corp. Rather than develop a more powerful bus for Western customers, its focus is on emerging Asian and South American countries that do not yet require powerful bus systems. With over 40 years of experience in building around 7000 communication subsystems for more than 200 satellites (including 67 satellite development projects under its leadership)[174], NEC plans to offer its low cost satellites in package deals that include communications, ground support and, in the case of Earth observation satellites, geospatial information products and services to enable full use of the systems.[175] NEC's public business segment revenue grew by 8.5%, earning ¥738.4 billion ($7.18 billion) in the year ending 31 March 2014, while its operating income grew by 9.6 billion to reach ¥58.6 billion ($57.0 million).[176]

3.5 China

AsiaSat of Hong Kong had a 8.9% decrease in revenue and a 19.1% decrease in operating profit for the year ended 31 December 2014, with sales reaching HK$1.365 billion ($175.95 million) from HK$1.499 billion ($193.3 million) in 2013, while operating profit was HK$726.3 million ($93.62 million) from HK$897.7 million ($115.76 million).[177] The lowered profitability during the first half of 2014 had been expected by AsiaSat, which was partly related to a reduction in turnover stemming from a major customer's significant contract extension at a lower rate, along with incremental depreciation on AsiaSat 7, and an increase in operating expenses.[178] AsiaSat now has six satellites in operation; its two most recent satellites, AsiaSat 8 and AsiaSat 6, were launched on 5 August 2014 and 7 September 2014, respectively.[179]

3.6 India

India's Antrix Corporation Limited is the commercial arm of the Indian government's Department of Space, globally marketing ISRO's space products and services. For the year ending 31 March 2014, Antrix's total income amounted to 16.087 billion ($268.734 million), a 24.2% increase from the 12.953 billion ($236.992 million) earned in 2013. In 2014, its earnings after taxes amounted to 2.005 billion ($33.493 million), an increase of 13.2% from the 1.77 billion ($32.398 million) in 2013.[180]

3.7 World

The Canadian satellite component manufacturer Com Dev International reported a decrease in total revenue for the fiscal year-ended 31 October 2014, earning C$208.2 million ($185.98 million), down 3.4% from C$215.5 million ($205.94 million) in 2013 due mainly to continued U.S. government spending constraints.[181] By the end of the fiscal year ending 31 October 2014, Com Dev's backlog had decreased by 5.8% to C$155.1 million ($138.55 million) down from C$164.7 million ($157.39 million) in 2013. However, the company's full year revenue from its commercial segment showed 26.5% growth in 2014, earning C$137.4 million

<http://www.mitsubishielectric.com/company/ir/library/annual_report/pdf/ar2014.pdf>.

[173] "Investor Relations – Results by Business Segment." 28 Apr. 2014. Mitsubishi Electric 10 Feb. 2015 <http://www.mitsubishielectric.com/company/ir/highlights/segment/index.html>.

[174] "Satellite Systems | Heritage – Major Japanese Satellites Integrated by NEC." NEC 18 Aug. 2015 <http://www.nec.com/en/global/solutions/space/satellite_systems/index.html>.

[175] Kallender-Umezu, Paul. "Japan's NEC Looks To Expand Commercial Market Footprint." 24 Nov. 2014. SpaceNews 11 Feb. 2015 <http://spacenews.com/42644japans-nec-looks-to-expand-commercial-market-footprint/>.

[176] Annual Report 2014 (Financials). 9 Sept. 2014. NEC 30 Oct. 2015 <http://www.nec.com/en/global/ir/pdf/annual/2014/ar2014_fin.pdf>.

[177] Reaching Further, Bringing You Closer - 2014 Annual Report 2014. AsiaSat 17 July 2015: 54 <http://www.asiasat.com/asiasat/EN/upload/doc/support_reports/ar2012_eng.pdf>.

[178] Ibid. at 4.

[179] "Satellite Fleet." 2014. AsiaSat 10 Feb. 2015 <http://www.asiasat.com/asiasat/contentView.php?section=3&lang=0>.

[180] Annual Report 2013-14. 5 Aug. 2014. Antrix 30 Oct. 2015 <http://www.antrix.gov.in/pdf/ANNUAL_REPORT_2013_2014_English.pdf>.

[181] "COM DEV Announces Fourth Quarter and Year-End Fiscal 2014 Results." 15 Jan. 2015. COM DEV International 10 Feb. 2015 <http://www.comdev.ca/images/financial-reports/CDV_Q4_14_Financial_Release2.pdf>.

($122.74 million) from C$108.6 million ($103.78 million) in 2013.[182]

In 2014, Thaicom of Thailand generated revenue of 10.004 billion Thai Baht ($303.41 million), an increase of 26% from the 7.896 billion Thai Baht ($239.86 million) earned in 2013. Thaicom also enjoyed substantial profits from its operations for its third consecutive year, generating 1.832 billion Thai Baht ($55.56 million) in 2014, an increase of 62% from the 1.128 billion Thai Baht ($34.27 million) earned in 2013.[183] Satellite services amounted to 87.8% of the revenue generated in 2014, a marginal change from the 88.2% share of revenue generated in the previous year. And following the launch of its Thaicom 6 satellite on 6 January 2014, along with Thaicom 7 on 7 September 2014, transponder lease revenue had a dramatic increase of 26.1%, though the transponders available to the local and regional markets are not sufficient to meet the demand.[184]

[182] Ibid.
[183] "Connecting The Future – Annual Report 2014." 6 Mar. 2015. Thaicom Public Company Limited 2 Apr. 2015: 150 <http://thcom.listedcompany.com/misc/AR/20150327-thcom-ar2014-en.pdf>.
[184] Ibid. at 19, 49-51.

4. European Institutional Market

This chapter analyses institutional space spending in Europe along distinct internal categories. The contributions are explained and contrasted with each other, displaying significant ratios and proportions regarding European space activities, and establishing a basis for comparison with space actors outside Europe.

4.1 Civilian Space Expenditure

National space budgets in Europe usually encompass both European and national components. The former normally consist of contributions to the European Space Agency (ESA) and EUMETSAT, and are regarded as civilian for the purposes of this report, as both organisations are broadly labelled as civilian despite the presence of dual-use products and services. While direct Member State contributions to the European Union do not officially have a space related designation, even prior to the Lisbon Treaty, EU funds have been increasingly used to finance space activities, including the two EU flagship programmes Galileo and Copernicus. In this section they are only visible through the ESA budget or are wrapped into the budgets of other actors.

While some European countries are engaged in multinational cooperation through participation in ESA, they may also have bilateral agreements on space activities between them. Through this cooperation, certain security related space projects are funded simultaneously by European institutions (notably the European Commission and the European Defence Agency) and by other sources.

Not all European states invest in military and intelligence gathering space activities; and in any event, most institutional spending is directed toward civilian activity. In 2014, the total sum of European institutional spending on space increased by 7.9% to reach €8.451 billion from €7.835 billion in 2013. In 2014, ESA and national civil programme expenditures decreased by a combined total of €142.4 million to be €4.102 billion and

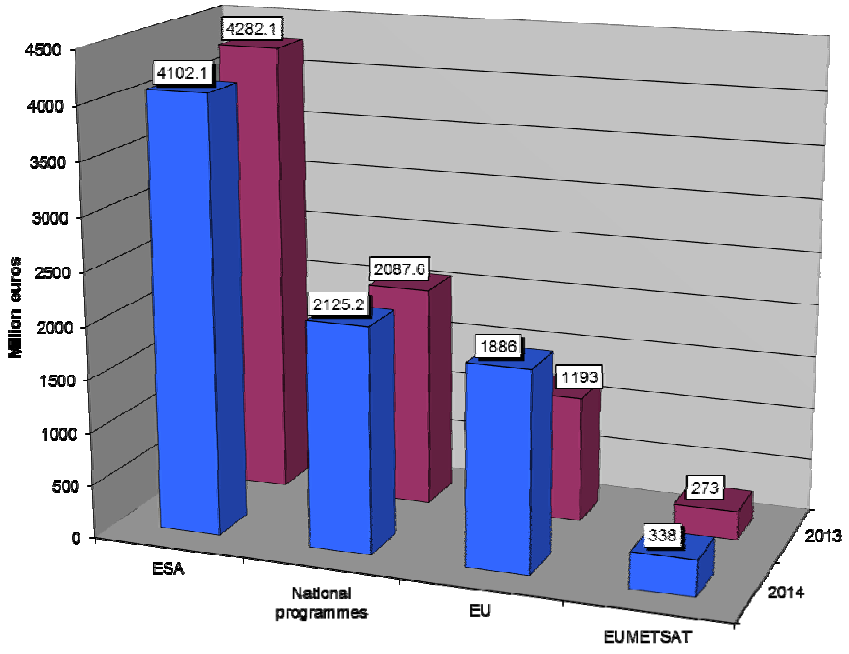

Figure 4.1: Estimated European civil public expenditures in 2014.

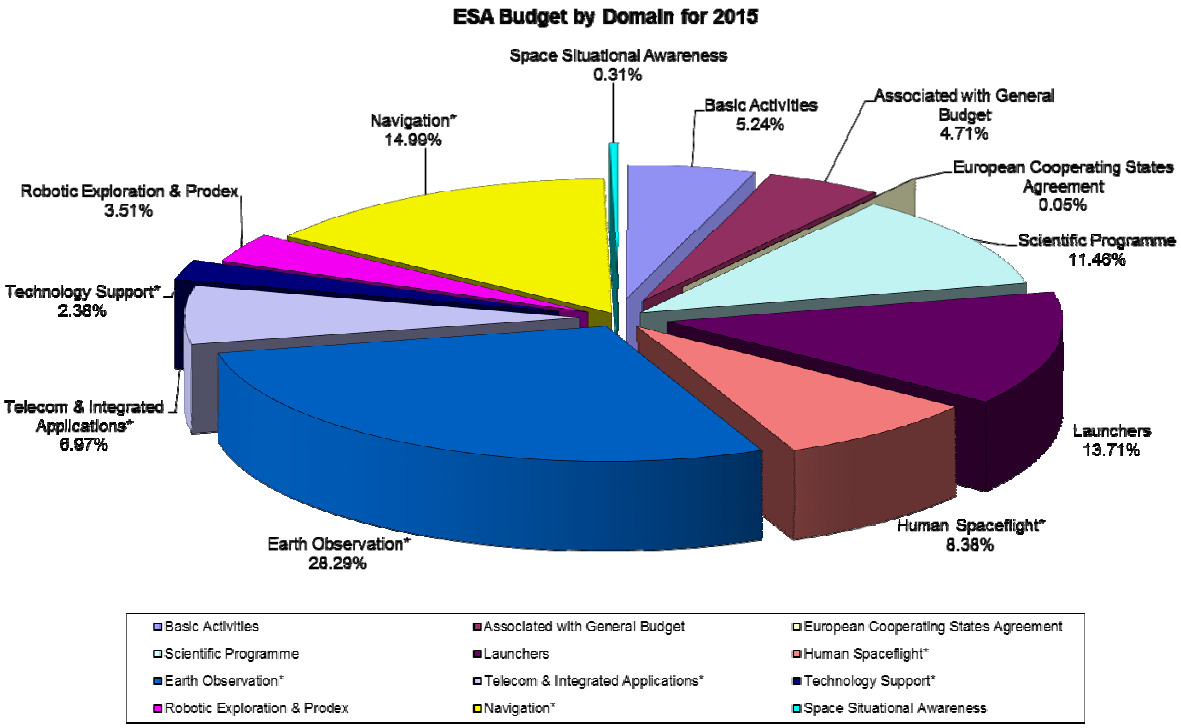

Figure 4.2: ESA Programmatic Budget Allocations for 2015 (Source: ESA)

€2.125 billion respectively. However, expenditures by the EU increased by €693 million to €1.886 billion, while Eumetsat expenditure increased by a combined €65 million to €338 million. According to Euroconsult figures, Europe's investment share between civilian and military funding can be estimated to be around 89% civilian and 11% military. However, Europe's security-related space activities in both its share-size and amounts invested are still a fraction of what was spent by the U.S. In 2014, European expenditure on defence space programmes was $1.232 billion (~€920 million), whereas U.S. expenditure in security-related space activities was $22.483 billion (~€16.900 billion) in 2014.[185]

4.2 European Space Agency (ESA)

The European Space Agency's budget increased by 8.1% in 2015 to €4.433 billion from €4.102 billion in 2014. The increase follows in the wake of the decisions made during the December 2014 ESA Ministerial Council meeting where ESA's member governments agreed to develop its next generation launcher (NGL) systems (i.e. Ariane 6, and an upgraded Vega launcher) and to commit funding for the international space station (ISS) through 2017. In 2015, funding for Earth observation increased substantially accounting for 28.3% (€1.254 billion) of ESA's budget, while Navigation moderately increased to reach €664.5 million (15.0%) indicating a refocus on flagship programme priorities within the space agency. Space Situational Awareness had the greatest relative increase in funding, reaching €13.9 million from €9.1 million in 2014, while Robotic Exploration & Prodex also had an increase reaching €155.8 million (3.5%). Funding for Space Science was relatively unchanged at €507.9 million (11.5%). On the other hand, funding for Launchers slightly decreased from the previous year, reaching €607.7 million (13.7%); and Telecom & Integrated Applications, and Technology Support had more substantial reductions, decreasing to €309.2 million and €105.3 million respectively.[186]

In 2014, ESA`s budget decreased by 4.2% to €4.102 billion, with Technology Support (3.58%) seeing the biggest relative increase in funding by reaching €146.8 million. Except for funding Associated with the General Budget (5.1%), which saw a slight increase from 2013, all other programmes saw reduc-

[185] Euroconsult 2015. Profiles of Government Space Programs: 16.

[186] "ESA Budget 2015 by Domain. 15 Jan. 2015. ESA 11 Sept. 2015 <http://www.esa.int/spaceinimages/Images/2015/01/ESA_Budget_2015_by_domain>.

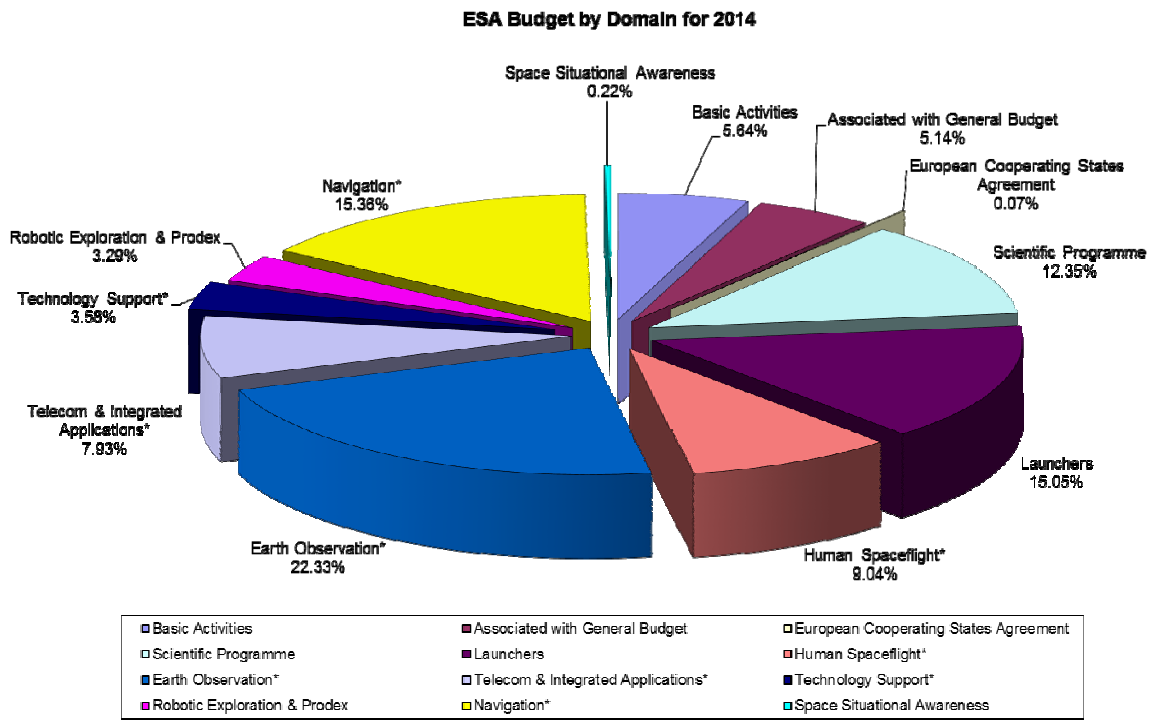

Figure 4.3: ESA Programmatic Budget Allocations for 2014 (Source: ESA)

tions in funding. Earth Observation received the largest amount of funding accounting for 22.3% (€915.9 million), followed by Navigation at 15.4% (€630.2 million) and Launchers at 15.1% (€617.4 million). The funding for the rest of ESA's programmes was overshadowed by these programmes, with Space Science receiving 12.4% (€506.5 million), Human Spaceflight receiving 9.4% (€370.9 million), and Telecommunications receiving 7.9% (€325.3 million).[187]

Although the life of the ISS has been extended by another 5 years, ESA is stopping the production of Automated Transfer Vehicles (ATVs). ESA began its final ATV-5 mission on 29 July 2014, to pay for its contribution to the operation of the ISS until 2017.

ESA's dues for the utilization of the ISS after 2017 will be paid by supplying NASA with an ATV-derived service module for NASA's Orion spacecraft.[188] The provision of ESA's ATV-technology for the Orion module will cover ESA's 8.3% share of the ISS's annual operating costs for the period 2018-2020; estimated at a total of €455 million.

ESA's contribution to the development of public private partnerships (PPPs) in European space programmes progressed further in 2014, with several launches to be conducted in 2015. The European Data Relay System (EDRS), developed between ESA and Airbus Defence & Space, will relay data from satellites in non-geostationary orbit, to dramatically decrease latency time in signal transmission and provide near-real-time services on a global scale. The first EDRS payload (EDRS-A) will be hosted on a Eutelsat-9B commercial telecommunications satellite that will be launched by mid-2015; however, a demonstration EDRS terminal was also launched in April 2014 on the Sentinel-1A to test the EDRS business case by sending imagery to a laser terminal aboard Inmarsat's Alphasat satellite in geostationary orbit.[189] Another PPP exists between ESA and an industrial team, led by OHB System AG, for the development of the SmallGEO, intended as a general-purpose small geostationary satellite platform to buttress European industry's position in the commercial telecom market. The SmallGEO is expected to launch in the second half of 2015.[190]

[187] "ESA Budget by Programme (2014). ESA 21 Mar. 2011 <http://download.esa.int/docs/DG/ESA_2011_Budget_040111_rev2.ppt>.
[188] "ESA Workhorse to Power NASA's Orion Spacecraft." 16 Jan. 2013. ESA 8 Apr. 2014 <http://www.esa.int/Our_Activities/Human_Spaceflight/Research/ESA_workhorse_to_power_NASA_s_Orion_spacecraft>.
[189] De Selding, Peter B. "ESA Members Defer Funding Guarantee for Airbus-backed Data-relay System." 5 Sept. 2014. SpaceNews 25 June 2015 <http://spacenews.com/41767esa-members-defer-funding-guarantee-for-airbus-backed-data-relay-system/>.
[190] "No 48-2014: Press Breakfast With ESA's Director General." 18 Dec. 2014. SpaceNews 26 June 2015 <http://www.esa.int/For_Media/Press_Releases/Press_Breakfast_with_ESA_s_Director_General>.

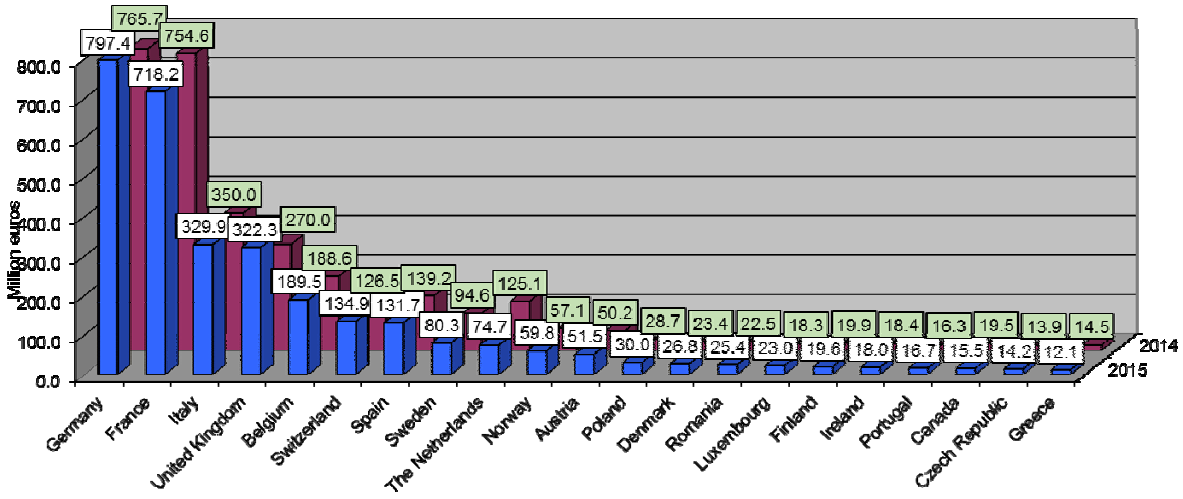

Figure 4.4: Member States' Contributions to ESA's Budget from 2014 to 2015 (Source: ESA)

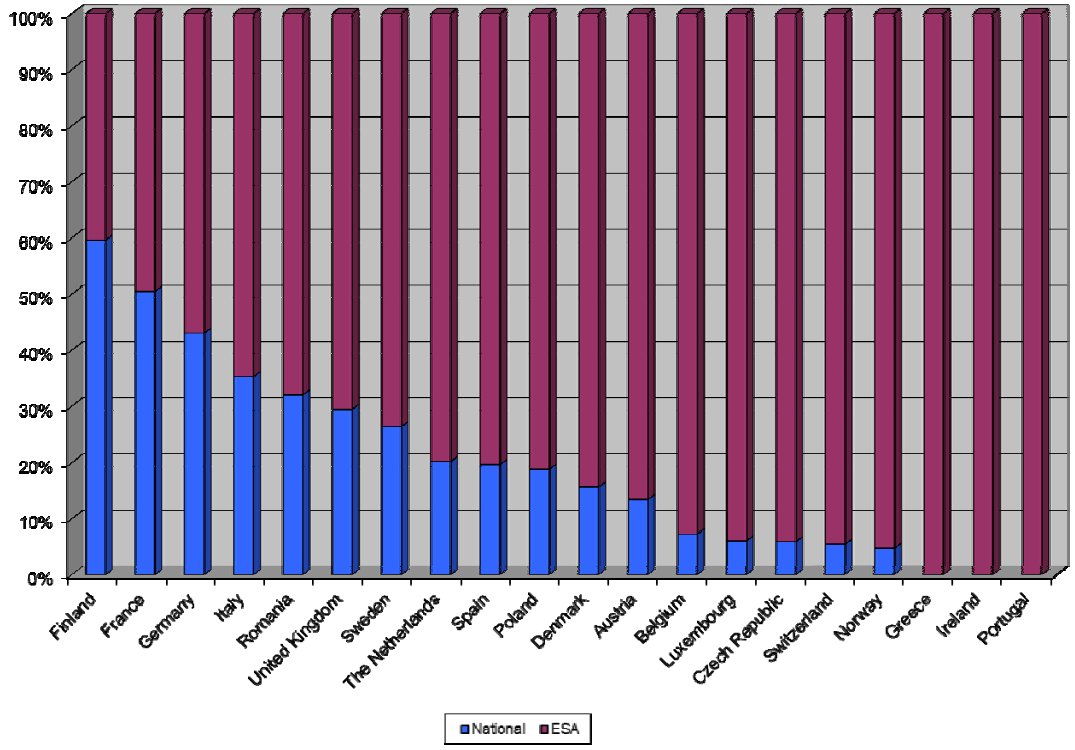

Figure 4.5: Estimated Shares of European National Institutional Investment in Civilian Space of ESA Members in 2015 (Source: ESA, European Space Technology Master Plan 12th Edition, The European Space Directory 2015)

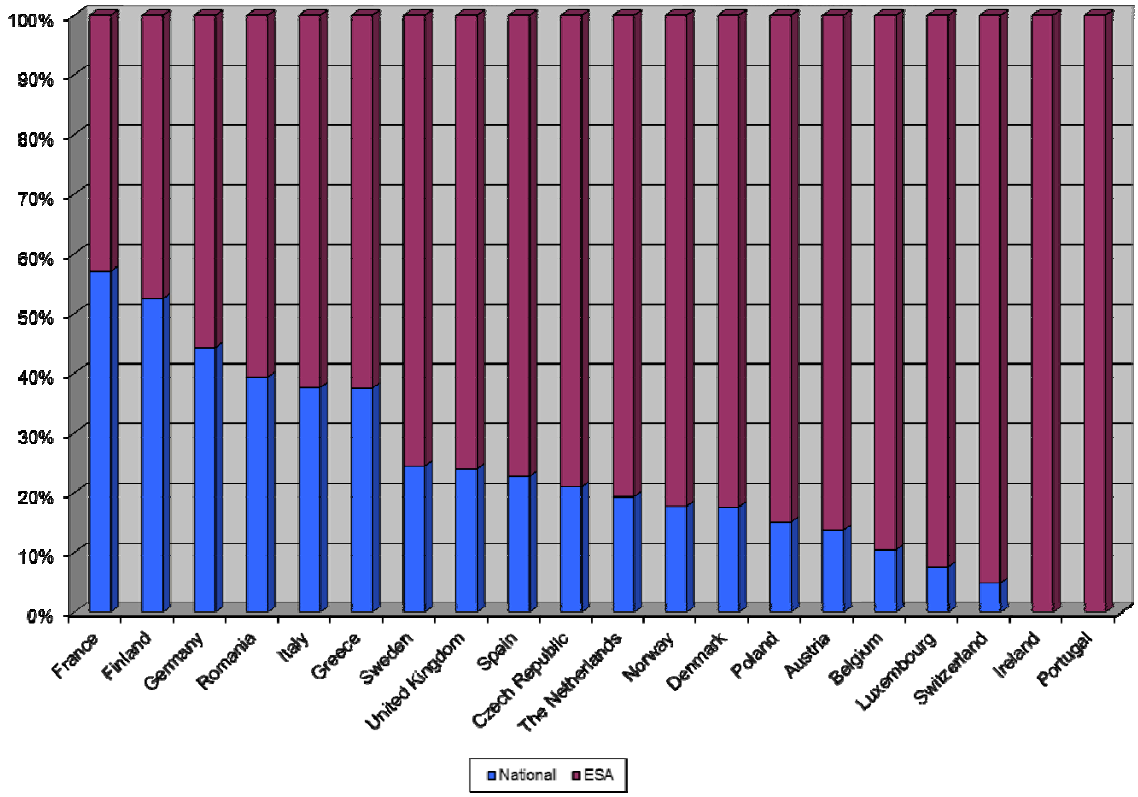

Figure 4.6: Estimated Shares of European National Institutional Investment in Civilian Space of ESA Members in 2014 (Source: ESA, Euroconsult, The European Space Directory 2015)

4.3 EUMETSAT

Eumetsat had a productive year in 2014, completing major ground system upgrades for more efficient operations, in addition to preparations for the launches of the MSG-4, Jason-3 and Sentinel-3A satellites which are expected to occur in 2015. It also began the approval process for the EPS-SG programme, in addition to becoming more active within the EU Copernicus programme. By mid-2014, Eumetsat's membership had grown to 30 Member States and 1 Cooperating State (Serbia) from 27 Member States in 2013. Lithuania became a full member on 1 January, while Iceland joined on 22 January, and Bulgaria became a member as of 30 April 2014.[191] Their membership allows them to be fully involved in the strategic decisions of Eumetsat's Council, and allows their respective industries to bid for contracts. Serbia is expected to become a full Member State in 2017, when the extension of its Cooperating State Agreement is set to expire.[192]

The vast majority of Eumetsat's budget comes from contributions from its Member States and Cooperating States. Member contributions are calculated on the basis of their Gross National Income (GNI). In 2014, the percentage distribution of contributions was relatively unchanged from the previous year, aside from the shift of Estonia to the second last position (Figure 4.7). In 2014, nearly all Member States, except some of the newest, had increased their contributions to Eumetsat by around 5%. Germany remains the largest contributor with an 18.76% share contribution in 2014, from 18.72% in 2013. France followed next with a diminished share contribution of 14.87% in 2014 down from 14.92% in 2013. Close behind, the United Kingdom's share was 14.01% in 2014, from 14.1% in 2012; likewise, Italy's share stayed at 11.65% in 2014 from 11.64% in 2013. Spain and the Netherlands rounded out the major contributors at about 7.91% and 4.38% in 2014, respectively. In 2014, these

[191] See further "EUMETSAT is a user-governed operational organisation, formed in 1986, which serves the needs of its Member States." Eumetsat 24 June 2015 <http://www.eumetsat.int/website/home/AboutUs/WhoWeAre/MemberStates/index.html>.

[192] See Eumetsat Annual Report 2014. 1 July 2015. Eumetsat 28 Sept. 2015: 6 <http://www.eumetsat.int/website/home/AboutUs/Publications/AnnualReport/index.html>.

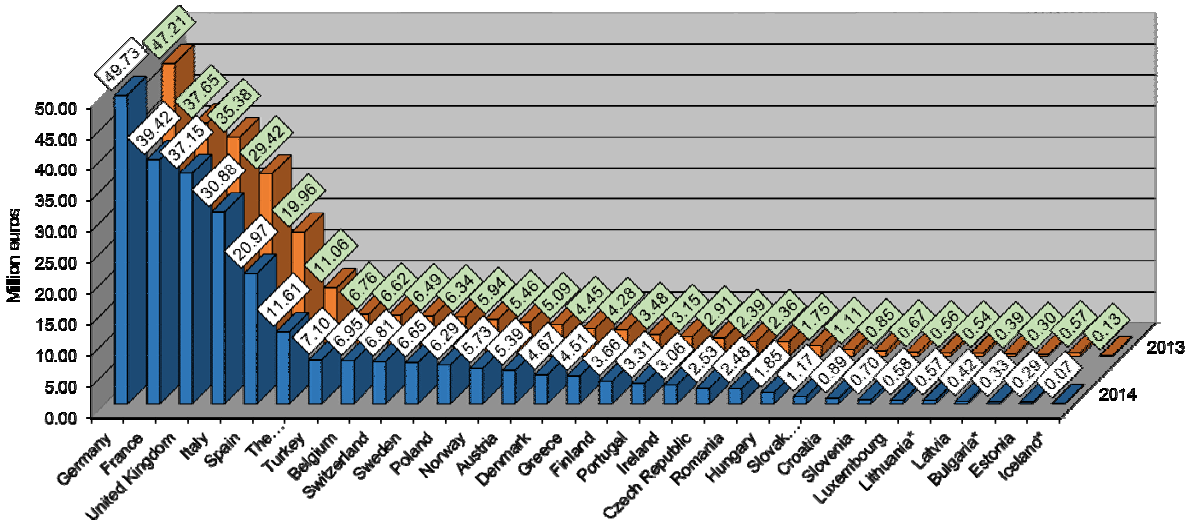

Figure 4.7: Member states' contributions to Eumetsat in 2014 and 2013 (Source: EUMETSAT)

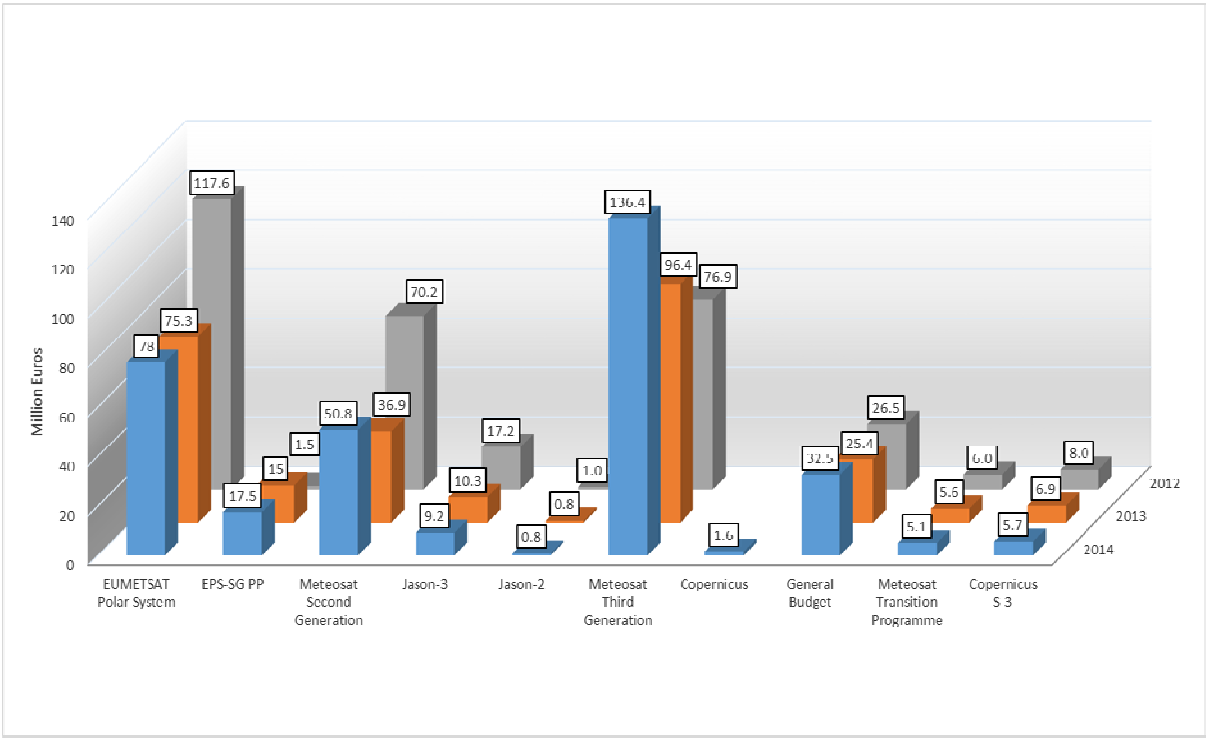

Figure 4.8: Major Programmatic Allocations of Eumetsat 2014-2012

six states accounted for a slightly diminished 71.58% of the total allocation. The contributions from the remaining Member States ranged from 2.68% to as low as 0.03% in 2014.[193]

In 2014, Eumetsat's total expenditure grew to €337.6 million from €272.6 million in 2013, as the intergovernmental organisation sought to diversify its activities in order to play a more defined role in the EU's Copernicus flagship programme. In 2014, funding for

[193] See Eumetsat Annual Report 2014. 1 July 2015. Eumetsat 28 Sept. 2015: 62 <http://www.eumetsat.int/website/home/AboutUs/Publications/AnnualReport/index.html>.

the Meteosat Third Generation Programme increased by 41.5% to €136.4 million, while the Meteosat Second Generation also increased by 37.7% to €50.8 million, following a substantial reduction in funding in 2013. Funding for the Meteosat Transition Programme decreased only slightly to €5.1 million in 2014. On the other hand, while funding for Jason-2 was unchanged at €800,000, funding for Jason-3 continued to decrease by 10.7% to €9.2 million in 2014. The Eumetsat Polar System and its EPS Second Generation Preparatory Programme stayed relatively unchanged in funding, both increasing by around €2.5 million to be €78 million and €17.5 million in 2014. In 2014, Eumetsat funding toward the Copernicus Sentinel-3 satellite decreased slightly to €5.7 million, it spent an additional €1.7 million toward diversification activities related to Copernicus. The general budget also increased by 28.0% to reach €32.5 million.[194]

4.4 National Agencies

In 2014, the hierarchy of European national civilian space programmes (not including contributions to ESA) saw some changes compared to 2013, with the majority of the smaller national programmes decreasing in funding. While the national civil space budgets of France, Germany and the UK slightly increased, most of the remaining countries experienced funding decreases. In 2014, Spain was surpassed for the fourth position by the UK, while Sweden moved ahead of the Netherlands, and Belgium ahead of Finland. Euroconsult have been used to provide the majority of these national budgets for 2014, however, some caution is required in terms of estimating France's national space budget as other authorities such as the European Space Technology Master Plan 12th Edition, the Space Report 2015, and the 2015 European Space Directory 30th Edition report conflicting amounts ranging from €703 million to €1.227 billion to €1.29 billion for 2014, respectively.

4.4.1 France

Following the outcome of the 2014 Ministerial Council meeting, France will fund 28% of ESA's total programme commitments over the next three years, which includes a 52% stake in the development of the €4 billion ($5 billion) Ariane 6, expected to launch in 2020.[195] The second largest contributor is Germany, followed by Italy and the other five ESA member states (Belgium, Spain, the Netherlands, Sweden, and Switzerland) that are currently funding the optional Ariane 6 launcher programme.[196] France's largest involvement in ESA is in respect of launch vehicle development, including other launch systems such as the Ariane 5, the Europeanized Soyuz launcher, and minority-share participation in the development of the Italian-led Vega small satellite launcher.[197]

The French space sector supports 16,000 jobs within the European continent, in addition to 1,700 jobs in French Guiana, which in turn generates indirect jobs for around 20% of the Guianese population.[198]

4.4.2 Germany

Shortly after the 2014 Ministerial Council meeting, it was announced that Germany's Johann-Dietrich Woerner had been elected as Director General of ESA, to take effect at the beginning of July 2015.[199] Woerner had been the Chairman of the Executive Board of the German Space Agency (DLR) since 1 March 2007.[200] He is succeeding Jean-Jacques Dordain, who had been in that role for the past 12 years.

Following the 2014 Ministerial Council meeting, Germany will provide 25% of ESA's total programme commitment; Germany will also have a 23% stake in the development of the €4 billion ($5 billion) Ariane 6.[201]

4.4.3 Italy

In Italy, following the resignation of former Italian Space Agency (ASI) president Enrico Saggese on 7 February 2014, the Italian government appointed Aldo Sandulli, a law professor at a Naples university, to oversee ASI's affairs until a new agency management

[194] Ibid. at 61.
[195] De Selding, Peter B. "ESA Ministerial Produces a Few Surprises." 12 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/esa-ministerial-produces-a-few-surprises/>.
[196] "Ariane 6 | Les Chiffres Clés." 2 Dec. 2014. CNES 12 Aug. 2015 <https://cnes.fr/sites/default/files/drupal/201506/default/is_ariane6-chiffres.pdf>.
[197] 2015 European Space Directory 30th Edition, 2015: 80.
[198] Ibid.
[199] De Selding, Peter B. "How ESA's Next Director-General Got the Job." 23 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/dlrs-woerner-to-head-esa/>.
[200] "Johann-Dietrich Wörner - Chairman of the Executive Board." 30 Oct. 2013. DLR 22 June 2015 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10329/510_read-204>.
[201] De Selding, Peter B. "ESA Ministerial Produces a Few Surprises." 12 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/esa-ministerial-produces-a-few-surprises/>.

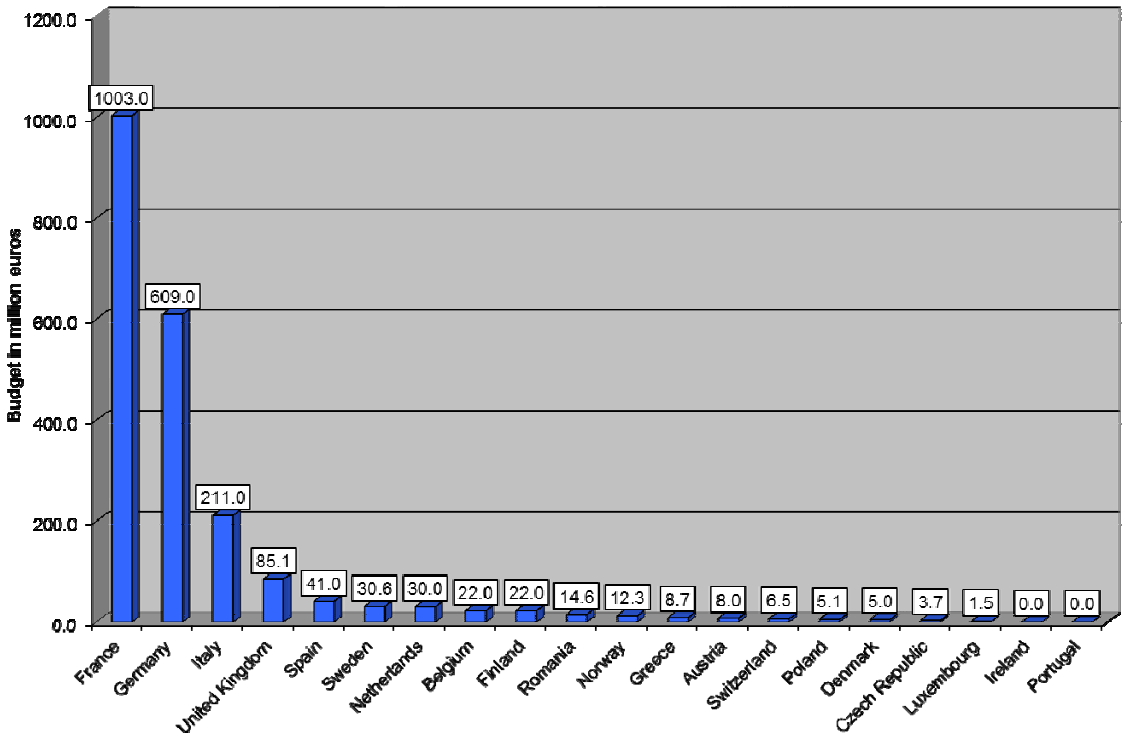

Figure 4.9: National civilian programmes 2014 in million euros

team was in place.[202] On 17 May 2014, ASI's new president Roberto Battiston, a former advanced physics professor at Trento University, took over the post expressing Italy's intent to push for upgrades to the Italian-led Vega small-satellite launcher at the Ministerial Council meeting in December 2014.[203] While the exact funding commitments for the Vega launcher during the reporting period are not available, it is noted that Italy will provide 13% of the €15 billion ($18.75 billion) in total programme commitments provided for the next three years, and its commitment to the Vega launcher will be on an equal footing to Germany's commitment.[204] The contract for the Vega C launcher is estimated to be around €395 million.[205]

4.5 European Union (EU)

The EU Copernicus flagship programme (formerly known as the Global Monitoring for Environment and Security, or GMES) made some headway in 2014, following the successful launch of the Sentinel-1A satellite on 3 April 2014. However, in previous years funding had become uncertain, e.g. during the Commission's development of the seven-year Multiannual Financial Framework (MFF) for 2014 - 2020, the €5.8 billion requested for Copernicus was taken out of the intended budget; instead, it was expected to be funded on an à la carte basis by individual participating states. However, following scrutiny by European industry officials, ESA, and the European Parliament, the Commission re-introduced the Copernicus programme in the new MFF budget, albeit with a €2 billion reduction, thus amounting to €3.8 billion (in 2011 prices).[206] The 34.4% budget cut was approved by the European Parliament, meaning that replacement satellites likely will not be built in time to take over from Sentinel satellites, if they are to have seven-year life

[202] De Selding, Peter. "Italy Taps Law Professor To Lead ASI after Saggese Resigns amid Corruption Probe." 14 Feb. 2014. SpaceNews 30 May 2014 <http://www.spacenews.com/article/civil-space/39491italy-taps-law-professor-to-lead-asi-after-saggese-resigns-amid-corruption>.

[203] De Selding, Peter. "Italy's New Space Chief Seeks To Close the Chapter on Corruption." 26 May 2014. SpaceNews 30 May 2014 <http://www.spacenews.com/article/civil-space/40683italy%E2%80%99s-new-space-chief-seeks-to-close-the-chapter-on-corruption>.

[204] De Selding, Peter B. "ESA Ministerial Produces a Few Surprises." 12 Dec. 2014. SpaceNews 25 June 2015 <http://spacenews.com/esa-ministerial-produces-a-few-surprises/>.

[205] "Ariane 6 and Vega C begin development." 12 Aug. 2015. ESA 30 Oct. 2015 <http://m.esa.int/Our_Activities/Launchers/Ariane_6_and_Vega_C_begin_development>.

[206] "For Europe's Embattled GMES, Good and Bad News." 7 Dec. 2012. SpaceNews 25 Apr. 2014 <http://spacenews.com/article/civil-space/32717for-europe%E2%80%99s-embattled-gmes-good-and-bad-news>.

spans.[207] In coordinating the evolution of the Copernicus Space Component, ESA has prepared a long-term plan for the content and associated funding needs, covering the operation of the Sentinels up to 2020, and the procurement of recurrent Sentinel satellites and instruments and access to data available from contributing missions up to 2028.[208] The Sentinel-2A was expected to launch in June 2015[209], while the second Sentinel-1B satellite is expected to launch in late 2015.[210]

Switzerland joined the EU's Galileo programme at the beginning of 2014, following an agreement that requires Switzerland to make catch-up payments to the EU totalling €80.05 million ($108.05 million), for the period 2008 to 2013, along with annual fees of €27 million ($36.44 million)[211] in return for access to Galileo's restricted Public Regulated Service (PRS) signals that will commence initial services in 2015.[212] Moreover, the EU is considering whether to make use of the PRS signals mandatory for the 28 member states, in addition to whether to make them available to non-EU ESA member states, Norway and Canada, and whether to grant PRS signal access to the U.S. and Chinese governments.[213]

Funding for Horizon 2020, the EU's Research and Innovation programme that includes a large variety of space research efforts, is estimated to be €1.4 billion over the 7-year period, i.e. €200 million per year.[214] However, the actual amount allocated to space research under Horizon 2020 fell short of that estimate for at least 2014 and 2015. Under the Horizon 2020 Work Programme 2014-2015, the 2014 space research budget was €165.75 million, while the 2015 indicative budget was slightly higher at €181.9 million.[215]

[207] Cf. De Selding, Peter B. "Copernicus Backers Worry EU Cuts Will Discourage Investment." 8 Feb. 2013. SpaceNews 30 May 2014 <http://www.spacenews.com/article/civil-space/33564copernicus-backers-worry-eu-cuts-will-discourage-investment>.

[208] "Green Light for GMES Copernicus." 4 July 2013. ESA 28 Apr. 2014 <http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Green_light_for_GMES_Copernicus>.

[209] "Arianespace delivers for the Americas! DirecTV-15 and SKY México-1 are orbited by Ariane 5." 27 May 2015. Arianespace 30 Sept. 2015 <http://www.arianespace.com/news-mission-update/2015/1301-success.asp>.

[210] "European Commissioner for Industry presented Sentinel – 1A." 25 Nov. 2013. New Europe 25 Apr. 2014 <http://www.neurope.eu/article/copernicus-satellite-will-launch-april-or-may>.

[211] De Selding, Peter B. "Switzerland To Join Galileo Program under Agreement with EU." 4 Feb. 2014. SpaceNews 19 May 2015 <http://spacenews.com/39388switzerland-to-join-galileo-program-under-agreement-with-eu/>.

[212] Palestini, Claudio. "Current Status Of Galileo PRS Service And User Segment Development." 24 Oct. 2014. European GNSS Agency 27 Oct. 2015 <http://www.satellite-masters-conference.eu/archive/2014/pdf/presentations/141024_session_5_the_future_galileo_public_regulated_service/claudio_palestini_gsa.pdf>.

[213] De Selding, Peter B. "Late or Not, Galileo Positioned for a Global Embrace." 13 June 2014. SpaceNews 19 May 2015 <http://spacenews.com/40893late-or-not-galileo-positioned-for-a-global-embrace/>.

[214] "Space Programs Facing Cuts in Seven-year EU Budget." 1 Feb. 2013. SpaceNews 25 Apr. 2014 <http://spacenews.com/article/space-programs-facing-cuts-in-seven-year-eu-budget>.

[215] Commission of the European Communities. Horizon 2020 – Work Programme 2014-2015. Annex 8. European Commission Decision C(2013)XXX of 10 December 2013. Brussels: European Union <http://ec.europa.eu/enterprise/policies/space/files/research/horizon-2020/h2020-leit-space-work-programme-2014-2015_en.pdf>.

5. The Defence Perspective

This chapter considers key developments in the field of military space activities. These developments include military space government programmes and related spending, industrial achievements in military space technologies, and the evolution of space security doctrines of all the major space-faring nations. Given the confidential nature of military space spending, calculating the exact volume and nature of these activities is difficult as the analysis is based only on open sources. Consequently, the facts and figures presented must be considered as incomplete in assessing the full range of military space programmes and should be treated accordingly. For these reasons, the following figures are conservative estimates and it is very likely that actual military space budgets far exceed the amounts that are reported. This is particularly the case with Russian and Chinese programmes that are often classified. With these factors in mind, readers can take from this chapter a relative assessment of global military space activities as per key space faring states, along with an overall estimate of the general trends in this field.

5.1 Trends in Military Expenditure

The Space Report 2015 listed space-related military spending in 2014 as having reached $35.325 billion, an increase from $31.9 billion in 2013 following renewed defence spending in the U.S., and by non-U.S. space actors.[216] On the other hand, Euroconsult noted a reduction in defence spending, listing world government expenditures for defence space programs as $24.45 billion in 2014, down from $27.97 billion in 2013; the reduction came mainly from an anticipated reduction in U.S. defence spending.[217] While there is a significant discrepancy between the two authorities, it is likely due to the availability of information at their times of publication as well as the different programmes considered. As is typical with the nature of dual-use technology in space activity, there is a risk that certain military activities have been already included in larger budgets, which can result in double counting. Moreover, while missions listed as civil programmes may also serve dual-purpose military objectives, their expenditure is not included in this section.

The Space Report 2015 estimated the U.S. to account for about 63.6% of global military space spending in 2014, less than the 68.3% it estimated for 2013. In contrast, non-U.S. global military spending grew to 36.4% in 2014 from 31.7% in 2013.[218] Interestingly, the Euroconsult report presented the same defence expenditure ratio of 63.6% of global military space spending attributed to U.S. defence expenditure, while non-U.S. military spending accounted for the remaining share; however, U.S. spending was estimated to be $15.56 billion, while the rest of the world spent an estimated $8.90 billion.[219] Russia, China, and Japan were next in line in military space spending estimates, with $4.33 billion, $1.91 billion, and $842 million in 2014, with Russia and Japan's budget decreasing by 5.5% and 12.8% respectively, while China's budget increased by 14.1% from 2013.[220] However, due to fluctuating exchange rates, variations in purchasing power, and different employment costs, a direct comparison of the budgets of these countries in fixed dollar values does not present a clear picture of their relative space defence efforts.

5.2 Europe

EU Member States continued to dominate spending on European military space programmes. Military space programmes are undertaken by all major European space faring nations, with an even larger number of European countries participating on the basis of bilateral or multilateral agreements and arrangements. From Euroconsult estimates, total European space defence spending in 2014 appears to have increased by 15.0% reaching $1.23 billion in 2014 from $1.07

[216] See: The Space Report 2014. Colorado Springs: The Space Foundation, 2014: 40.
[217] Euroconsult 2015. Profiles of Government Space Programs: 16.
[218] The Space Report 2015. Colorado Springs: The Space Foundation, 2015: 39.
[219] Euroconsult 2015. Profiles of Government Space Programs: 16.
[220] Ibid.

billion in 2013.[221] The combined expenditures of France, the United Kingdom, Italy, and Germany amounted to $1.146 billion in 2014 from the $995 million estimated for 2013.[222] France's space defence budget increased by 15.6% reaching $585.20 million (€440 million) in 2014. Euroconsult estimates that the UK spends $249.15 million (£151 million) annually, with nearly 93% of expenditure in 2014 directed toward its military satellite communications.[223] Italy's space defence budget is estimated to be $247.38 million (€186 million) for the purchase of space capability from commercial operators for security and defence purposes, whereas in 2013 it was estimated at $190 million.[224] Lastly, Germany's space defence budget is estimated by Euroconsult to have been $65.17 million (€49 million) in 2014, however that rather modest amount might be due to the nature of dual-use technology in space activity that is funded through larger budgets.[225] The other military space budgets in Europe remained relatively unchanged from the 2013 military space budgets.[226]

On 1 October 2014, Germany became the 10th member of an EDA-led programme to pool and share purchases of commercial satellite bandwidth for military and government use in the EU. It joined Belgium, Finland, France, Greece, Italy, Luxemburg, Poland, Romania, and the UK in a pay-per-use model for services, rather than having to pay a regular fee. The EDA acts as the central purchasing body on behalf of the Contributing Members. Since May 2013 a total of 18 orders for satellite bandwidth have been placed for a total value of around €2 million ($2.6 million).[227] The EDA hopes that this programme will give EU member states a sample of the type of savings that can be attained by group purchases, and is another step towards consolidation of military satellite communications efforts in Europe.[228]

France and Italy's military and civil space authorities shared the cost of the Athena-Fidus broadband satellite that launched on 6 February 2014. The Athena-Fidus carries an extremely high frequency/Ka-band payload for Italy and a Ka-band payload for France.[229] The Defence Ministries of both France and Italy also have separate telecommunications payloads on the Sicral 2 satellite, which was constructed by Thales Alenia Space, and launched on 26 April 2015.[230]

On 30 October 2014, ESA and the U.S. Strategic Command signed a space surveillance data-sharing agreement to exchange space situational data as the space environment continues to become more congested. The U.S. has signed nearly 50 similar data-sharing agreements with other governments and private-sector entities, including France, Italy, the UK, Canada, Japan, Australia, and South Korea. The agreement provides ESA with more timely information about the space environment, in exchange for position, radio-frequency information and planned orbit manoeuvres of some European satellites.[231]

5.3 The United States

While the U.S. DoD space budget slightly increased by 3.5%, to $22.483 billion in 2014 from $21.717 in 2013, the budget for the U.S. Missile Defense Agency (U.S. MDA) continued to decrease in 2014, reflecting overall changes in U.S. military space spending to prioritize new capabilities. The U.S. MDA had a 1.9% decrease in its budget, receiving $7.6 billion in 2014; it has requested $7.5 billion for 2015. However, the new request allocates nearly $99.5 million to the redesign of its Exoatmospheric Kill Vehicle (EKV) that is launched from the Ground-based Midcourse Defence (GMD) interceptor. The redesign stemmed from concerns about the system's reliability following three intercept failures that were attributable to issues with the EKV. This new Capability Enhancement-2 version of the EKV will have a modular open architec-

[221] Euroconsult 2015. Profiles of Government Space Programs: 16.
[222] Ibid.
[223] Euroconsult 2015. Profiles of Government Space Programs. Paris: Euroconsult, 2015.
[224] C.f. Euroconsult 2015. Profiles of Government Space Programs. Paris: Euroconsult, 2015, and "Piano Triennale di Attività 2013-2015." 25 Jan. 2013. ASI 29 Mar, 2015: 8, 71 <http://www.asi.it/files/PTA_2013-2015_INTEGRATO_DELIBERE_132-159.pdf>.
[225] Euroconsult 2014. Profiles of Government Space Programs: 12.
[226] Euroconsult 2015. Profiles of Government Space Programs: 16.
[227] "Germany joins the EU Satcom Market." 1 Oct. 2014. EDA 23 July 2015 <https://www.eda.europa.eu/info-hub/news/article/2014/10/01/germany-joins-the-eu-satcom-market>.
[228] De Selding, Peter B. "Germany Joins European Military Bandwidth-sharing Program." 1 Oct. 2014. SpaceNews 23 July 2015 <http://spacenews.com/42048germany-joins-european-military-bandwidth-sharing-program/>.
[229] De Selding, Peter B. "Italian Military Buys $100M Spy Satellite from Israel in Exchange Deal." 6 July 2012. SpaceNews 6 May 2014 <http://spacenews.com/article/italian-military-buys-100m-spy-satellite-israel-exchange-deal>.
[230] Clark, Stephen. "Ariane 5 sends Thor 7 and Sicral 2 satellites into orbit." 26 Apr. 2015. Spaceflight Now 30 Sept. 2015 <http://spaceflightnow.com/2015/04/26/ariane-5-sends-thor-7-and-sicral-2-satellites-into-orbit/>.
[231] Gruss, Mike. "U.S. Strategic Command, ESA Sign Space Surveillance Data-sharing Agreement." 31 Oct. 2014. SpaceNews 23 July 2015 <http://spacenews.com/42384us-strategic-command-esa-sign-space-surveillance-data-sharing-agreement/>.

ture, along with common interfaces and standards to allow for easier upgrades and a wider vendor and supply base. The 2015 budget request also includes $435 million to buy 30 Standard Missile 3 Block 1B interceptors, which will complement the U.S. Pentagon's purchase of 44 of the interceptors announced in January and March 2014.[232]

Throughout 2014, SpaceX aggressively vied to attain certification to launch military payloads, in addition to bringing injunction proceedings in the U.S. federal court to challenge the USAF's $11 billion 36 rocket core block-buy arrangement with the DoD's traditional prime contractor United Launch Alliance (ULA).[233] The matter arose from the U.S. DoD's November 2012 decision to authorize the USAF to purchase up to 50 rocket cores during the next five years under its Evolved Expendable Launch Vehicle (EELV) programme. While 14 cores were to be procured competitively, with the first of these competitive awards expected in 2015 for a mission launching in 2017, the other 36 will be procured from ULA on a sole-source basis.[234] Another matter complicating the situation is the USAF's recent disaggregation approach to funding, as it now intends to halve the number of competitively procured space launches to 7 rocket cores, limiting the available contracts on which SpaceX may competitively bid.[235]

5.4 Russia

As in previous years, Russian military spending appears to be dwarfed by U.S. military expenditure - the ratio of Russian to U.S. military space spending being estimated to be about 1:4 in 2013. Euroconsult estimates the total amount Russia put towards its military program to have been at least $4.33 billion (i.e. 137.36 billion roubles) in 2014 (including dual-use programmes), however that value might not take into account purchase power parities, and is based on fluctuating exchange rates.[236]

Russia formed its Aerospace Defence Forces (ADF) on 1 December 2011, to monitor its airspace and track space objects above its territory. The ADF completed development of its first military space surveillance complex, in Altai, West Siberia, in December 2014, and began tests of the laser-optical and radio engineering complexes that will provide the capability to track small objects and debris currently in orbit. Russia also conducted tests of the modernized Okno-M optoelectronic space surveillance station, located in Tajikistan. Russia plans to build around ten specialized space control complexes to track satellites and other space objects by 2018.[237]

In November 2014, a Russian space object began exhibiting unusual behaviour. The object had been assumed to be space debris stemming from the launch of three Rodnik military communication satellites in May 2014. Following launch, the object known as 2014-28E changed its orbit, and then manoeuvred back to a similar orbit to the Rokot launcher's spent upper stage, with the two objects rendezvousing shortly after.[238] Whether for civilian or military purposes, the object has piqued the interest of observers tracking the object.[239] One speculation is whether the object, and similar manoeuvres performed by China's Shijian 15 satellite in May 2014, is related to Russia and China's push for a binding treaty on the Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT).

5.5 Japan

Japan's space budget for the fiscal year 2014, running from 1 April 2014 through 31 March 2015, increased by 18.8%, totalling $3.78 billion (¥382.7 billion) for space programs

[232] Gruss, Mike. "$7.5B MDA Budget Request Includes $100M for Kill Vehicle Redesign." 10 Mar. 2014. SpaceNews 23 July 2015 <http://spacenews.com/3978975b-mda-budget-request-includes-100m-for-kill-vehicle-redesign/>.
[233] Gruss, Mike. "SpaceX Challenge to ULA Block Buy Could Hinge on Questions of Timing." 9 May 2014. SpaceNews 23 July 2015 <http://spacenews.com/40524spacex-challenge-to-ula-block-buy-could-hinge-on-questions-of-timing/>.
[234] Leone, Dan. "Pentagon Approves EELV Block Buy, with Competitive Twist." 4 Dec. 2012. SpaceNews 15 May 2014 http://www.spacenews.com/article/military-space/32657pentagon-approves-eelv-block-buy-with-competitive-twist.
[235] Gruss, Mike. "U.S. Air Force Halves Size of Competitive EELV Procurement." 7 Mar. 2015. SpaceNews 23 July 2015 <http://spacenews.com/39772us-air-force-halves-size-of-competitive-eelv-procurement/>.
[236] Euroconsult 2015. Profiles of Government Space Programs. Paris: Euroconsult, 2015.
[237] Staff Writers. "Russia Tests First Military Space Surveillance Complex." 3 Dec. 2014. SpaceDaily.com 19 May 2015 <http://www.spacedaily.com/reports/Russia_Tests_First_Military_Space_Surveillance_Complex_999.html>.
[238] Boyle, Alan. "Russian Space Object 2014-28E Sparks Worries About 'Satellite Killer'." 18 Nov. 2014. NBC News 19 June 2015 <http://www.nbcnews.com/science/space/russian-space-object-2014-28e-sparks-worries-about-satellite-killer-n251111>.
[239] Jones, Sam. "Object 2014-28E – Space junk or Russian satellite killer?" 17 Nov. 2014. Financial Times 19 June 2015 <http://www.ft.com/cms/s/2/cdd0bdb6-6c27-11e4-990f-00144feabdc0.html>.

across the government of Japan, with $737 million (¥74.6 billion) budgeted for defence spending.[240]

Geopolitical tensions in the region, particularly with neighbours such as North Korea and China (especially in the South China Sea), in addition to recent natural disasters have motivated the country to refocus its efforts from its traditional strict "peaceful-use-only" position in space activities to the space security and defence areas. The need for closer integration of space into the nation's defence strategy is becoming more visible, which is likely to continue with closer cooperation with the U.S. military, and increased communications, remote sensing, and navigation capabilities. For instance, the 20 August 2014 update to Japan's five-year Basic Plan of 2012 recommends that the QZSS be increased from one satellite to four, and that a full seven satellite constellation should be developed as soon as possible, as it would enable stable management of the stand-alone regional navigation system.[241]

5.6 China

In recent years China's space defence budget is estimated to have seen considerable increases on a year-to-year basis, having increased by 17.6% to $1.41 billion in 2012, followed by 18.6% to $1.67 billion in 2013.[242]

The manner in which China develops its technical capabilities and the depth of its military interest in the space program merits analysis. It seems to be clear that Chinese space efforts are intimately connected to the Chinese army, principally because many space activities are under the direct control of the People's Liberation Army (PLA). Moreover, all Chinese space operation facilities are entirely manned and operated by the PLA. In the case of manned space activities, all development and plans are directly under the control of the Chinese military and political bureau. This does not mean that all space activities conducted by the Chinese military are military per se, but it shows the central role of the Chinese military in the Chinese space architecture.

China's space defence perspective continues to be difficult to identify due to a dearth of unclassified sources. In April 2014, the U.S. DoD presented its Annual Report to Congress on 'Military and Security Developments Involving the People's Republic of China 2014', which highlighted the activities conducted by the country in 2013, and brought to light increasing focus on counterspace capability as central to enabling modern, "information-ized" warfare. Among other developments and trends mentioned, the report says some PLA writings emphasize the necessity of' using anti-satellite weapons to 'blind and deafen the enemy', and that destroying or capturing satellites and other sensors will deprive an opponent of initiative on the battlefield, making it difficult to bring their precision guided weapons into full play.[243] China conducted at least eight space launches in 2013 to expand its space-based intelligence, surveillance, reconnaissance, meteorological, and communications satellite constellations.

In May 2014, the Chinese satellite Shijian 15, in orbit since July 2013, began to converge toward another Chinese satellite Shijian 7, exhibiting atypical propulsion capabilities, followed by an interception with the possible use of a remote capture arm and close proximity operations. While such capability can have civil applications, such as to refuel or tow a satellite, military applications are also possible, such as the possibility of disabling an active payload belonging to a foreign nation without creating additional debris in space.[244]

Moreover, on 21 November 2014, China launched its second Kuaizhou ("quick vessel") launcher, which is designed to launch a Kuaizhou small satellite quickly into a low-Earth orbit to support "natural disaster monitoring." The first Kuaizhou launch occurred on 25 September 2013. However, there are some indications that the Kuaizhou's Feitan Space Emergency Response System, FT-1, may be related to the Dong Neng 2, DN-2 ASAT system.[245]

Renewed concern over ASAT testing occurred throughout the reporting period, following a March 2014 paper by the Secure World Foundation which highlighted facts that strongly

[240] The Space Report 2015. Colorado Springs: The Space Foundation, 2015: 34.
[241] GPS World Staff. "QZSS May Expand to Meet Japan's Surveillance Needs." 22 Aug. 2014. GPS World 15 June 2015 <http://gpsworld.com/qzss-may-expand-to-meet-japans-surveillance-needs/>.
[242] Profiles of Government Space Programs. Paris: Euroconsult, 2014: 14.
[243] Office of the Secretary of State. "Annual Report to Congress - Military and Security Developments Involving the People's Republic of China 2014." 5 June 2014. Defense.gov 12 June 2015: 40 <http://www.defense.gov/pubs/2014_DoD_China_Report.pdf>.
[244] Jones, Sam. "Object 2014-28E – Space junk or Russian satellite killer?" 17 Nov. 2014. Financial Times 19 June 2015 <http://www.ft.com/cms/s/2/cdd0bdb6-6c27-11e4-990f-00144feabdc0.html>.
[245] Fisher (Jr.), Richard D. "China launches second Kuaizhou mobile SLV." 26 Nov. 2014. HIS Jane's 360 16 July 2015 <http://www.janes.com/article/46360/china-launches-second-kuaizhou-mobile-slv>.

suggested that a May 2013 scientific launch mission by China may have also tested the rocket component of a new direct ascent anti-satellite weapons system derived from a road-mobile ballistic missile.[246] Furthermore, on 23 July 2014, China is believed to have conducted a "non-destructive" test of an anti-satellite weapon, while China stated that the launch was a ballistic missile intercept, similar to the tests conducted by the U.S. and other countries.[247]

5.7 India

India is developing its own space military programme; however, the majority of the activities of the Indian Space Research Organization (ISRO) still focus on civil applications. More specifically, India's total space expenditure was estimated to be $1.026 billion in 2014, but only around 2% of that funding went to military space activities.[248]

On 27 April 2014, India's Defence Research Development Organization (DRDO) conducted the first test launch of its newly developed interceptor missile from launch pad-IV of the Integrated Test Range at Wheeler Island, about 100 km from Odisha. Expecting to connect with its target at an altitude of 120 km, the missile's infrared seeker successfully tracked the target missile throughout the test, however no direct contact was made as the distance between the interceptor and the target was more than had been expected.[249] Even so, the test was announced to be at least a partial success by DRDO officials, who said the main objective was to track the target missile and see the performance of the infrared (IR) seeker in the interceptor.[250] India's Prithvi Defence Vehicle (PDV), part of India's Ballistic Missile Defense (BMD) programme, has the potential to destroy incoming missiles with a strike range of around 2,500 km outside the earth's atmosphere (at an altitude of over 150 km).[251]

India's PDV can also be seen as a further step toward developing its own anti-satellite capabilities. In this pursuit, the DRDO is looking at the feasibility of developing such an anti-satellite vehicle by integrating its Angi-3 missile with its PDV. If it succeeds, the anti-satellite missile would have an effective range of about 1400-1500 km, and would advance India's missile capabilities to be on a par with U.S. and China.[252]

[246] Gruss, Mike. "Report Rekindles Suspicions About Chinese Rocket Launch." 21 Mar. 2014. SpaceNews 12 May 2015 <http://spacenews.com/39936report-rekindles-suspicions-about-chinese-rocket-launch/>.
[247] Gruss, Mike. "U.S. State Department: China Tested Anti-satellite Weapon." 28 July 2014. SpaceNews 12 June 2015 <http://spacenews.com/41413us-state-department-china-tested-anti-satellite-weapon/>.
[248] Euroconsult 2015. Profiles of Government Space Programs. Paris: Euroconsult, 2015.
[249] Rout, Hemant Kumar. "Prithvi Defence Vehicle Fails to Intercept." 15 May 2014. New Indian Express 12 June 2015 <http://www.newindianexpress.com/states/odisha/Prithvi-Defence-Vehicle-Fails-to-Intercept/2014/05/15/article2225945.ece>.
[250] "Interceptor spot on, though without blast: DRDO." 28 Apr. 2014. The Hindu 12 June 2015 <http://www.thehindu.com/news/national/interceptor-spot-on-though-without-blast-drdo/article5953934.ece#comments>.
[251] Rout, Hemant Kumar. "DRDO Planning to Test-fire High-altitude 'Killer' Missile in January." 30 Nov. 2013. The New Indian Express 12 May 2014 <http://www.newindianexpress.com/nation/DRDO-Planning-to-Test-fire-High-altitude-Killer-Missile-in-January/2013/11/29/article1917837.ece>.
[252] "India Contemplates Anti-Satellite Vehicle Integration with Agni-III Ballistic Missile." 15 Oct. 2013. Missile Threat 12 May 2014 <http://missilethreat.com/india-contemplates-anti-satellite-vehicle-integration-with-agni-iii-ballistic-missile/>.

6. Space Policies and Strategies around the World

The following chapter presents an overview and analysis of the space policies of all major space-faring countries. Attention is particularly given to high-level policy developments and general trends that reveal the different actors' strategic rationales. Military space and defence related policies were considered in more detail in Chapter Five.

6.1 European Union

In 2008, the European Union initiated the procedure to develop a draft International Space Code of Conduct for Outer Space Activities (ICoC) in response to UN General Assembly Resolutions 61/75 of 2006 and 62/43 of 2007, which had invited all members to submit concrete proposals on international outer space TCBMs in the interest of maintaining international peace and security and promoting international cooperation and the prevention of an arms race in outer space. Initial draft versions of ICoC had received lukewarm reactions because the code had been developed within the EU system and lacked a parallel diplomatic process involving the rest of the international community. However, following several revisions and three open-ended multilateral consultations (held in Kiev, Ukraine in May 2013, in Bangkok, Thailand in November 2013, and Luxembourg in May 2014), the fifth draft of ICoC, issued on 31 March 2014 gained wider acceptance.[253]

Intended to be a non-binding set of principles and guidelines agreed to on a voluntary basis, the ICoC is based on three broad main principles: 1) freedom for all to use outer space for peaceful purposes, 2) preservation of the security and integrity of space objects in orbit, and 3) due consideration for the legitimate security and defence needs of states. Following the completion of the consultative phase, the EU aimed to begin a multilateral "negotiation process" in the middle of 2015, after which the ICoC will be opened for signature by individual states. In parallel to the development of the non-binding, soft law of the ICoC – Russia and China have been promoting a binding draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT), which was introduced to the UN Conference on Disarmament (CD) in 2008, and subsequently updated in June 2014 following the last open-ended multilateral consultation on the ICoC in Luxembourg. The PPWT focuses mainly on security issues regarding the placement of weapons in outer space and does not address issues of ASAT missile testing and space debris.

Following the EU's explicit space competence under Article 189 of the Treaty on the Functioning of the European Union (TFEU), communications have been exchanged between the European Commission, the Council, and the European Parliament on developing a space strategy and establishing appropriate relations with ESA. Earlier proposals sought to transform ESA into a European Union agency, however the idea was met with opposition from several major ESA players including Germany and the UK, which prefer ESA's geographic return rule over the EU's value-for-money only basis under its competition rules. Ultimately, a 6 February 2014 progress report by the Commission determined that transforming ESA into an EU agency would require political consensus that may be difficult to reach in the foreseeable future.[254] On 26 May 2014, a meeting in the EU Competitiveness Council '*Towards a shared EU-ESA vision for space fostering competitiveness*' removed the earlier proposals from consideration, instead suggesting further study on how ESA's work for the Commission could be subject to different rules within ESA through the creation of an "EU pillar"; or alternatively, whether the current ESA-EU agreement could be modified slightly in the short term, while in the long term ESA would progressively align its accounting, internal control and audit proce-

[253] *See further* "Code of Conduct for Outer Space Activities." European Union External Action 24 June 2015 <http://eeas.europa.eu/non-proliferation-and-disarmament/outer-space-activities/index_en.htm>.

[254] European Commission. Report from the Commission – Progress report on establishing appropriate relations between the European Union and the European Space Agency (ESA). European Commission COM(2014) 56 final of 6 February 2014. Brussels: European Union <http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%205978%202014%20INIT>.

dures with the corresponding EU rules.[255] On 5 December 2014 the conclusions of the Competitiveness Council meeting, entitled '*Underpinning the European space renaissance: orientations and future challenges*', invited both the Commission and ESA to review the European Space Policy and to identify to what extent it may require to be updated, with due regard to the TFEU and the ESA Convention, to appropriately meet the long-term needs of European users.[256]

6.2 European Space Agency

The European Space Agency (ESA) Ministerial Council meeting was held on 2 December 2014. At the meeting, ESA's member governments agreed to develop the next generation Ariane 6 launcher, to upgrade its small-satellite Vega launcher, and to commit funding for the international space station (ISS) through 2017 by supplying the propulsion module for NASA's Orion capsule in lieu of ATV cargo supply missions.[257] Instead of a mid-life upgrade of the Ariane 5 ECA, additional funding will be provided for the use of its current configuration and continued used of the current Vega launcher. The next ESA Ministerial Council meeting is scheduled for 2016 in Switzerland.

The outcome of the 2014 Ministerial Council meeting resulted in ESA's total programme commitments from its 20 member states reaching €15 billion ($18.75 billion) over the next three years, with 74% of the funding coming from four members: France (28%), Germany (25%), Italy (13%), and the UK (8%). Funding for the development of the €4 billion ($5 billion) Ariane 6, expected to launch in 2020, will come mainly from France which has a 52% stake, in addition to Germany's 23% share[258], followed by Italy and the other five ESA member states (Belgium, Spain, the Netherlands, Sweden, and Switzerland) that are currently funding the optional Ariane 6 launcher programme.[259]

In contrast to the Ariane 5 launcher, which received state funding to offset periodic losses in times of low commercial launch demand, responsibility for the commercial exploitation of the Ariane 6 and Vega C will rest with industry. Hence, to balance the commercial risk, industry will also become the design authority. Airbus Defence & Space and Safran will lead the development of Europe's next generation launch systems through a joint venture called 'Airbus Safran Launchers' which was to start operations on 1 January 2015, with a work force of 450 people.[260]

At the 2014 Ministerial Council meeting, ESA was given €800 million ($990.5 million) by ten of its participating member governments (Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden and Switzerland) to cover ISS costs for the three year period between 2015 and 2017.[261] Following the ESA Ministerial, Germany remains the lead contributor to the ISS programme, followed by France, and Italy. Moreover, the UK's share in the ISS has increased to 4.6% with its commitment of €40 million at the meeting.[262]

ESA's budget decreased by nearly €200 million to €4.102 billion ($5.7 billion) in 2014. This 4.2% decline mainly came from a reduction in funding from the EU, whereas fluctuations in the level of investment from ESA's member states tended to be modest by comparison. Despite reduced funding by Italy, the UK, and Spain, overall funding by ESA member states grew, with substantial increases by the Netherlands, Switzerland, and Sweden.[263] Following the 2014 Ministerial meeting, ESA's

[255] De Selding, Peter B. "European Union Delays Decision on ESA Changes." 26 May 2014. SpaceNews 25 June 2015 <http://spacenews.com/40685european-union-delays-decision-on-esa-changes/>.
[256] Council of the European Union. Underpinning the European space renaissance: orientations and future challenges. Competitiveness Council meeting of 5 December 2014. Brussels: European Union <http://italia2014.eu/media/4061/council-conclusions-on-underpinning-the-european-space-renaissance-orientations-and-future-challenges.pdf >.
[257] De Selding, Peter B. "ESA Members Agree To Build Ariane 6, Fund Station Through 2017." 2 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/42699esa-members-agree-to-build-ariane-6-fund-station-through-2017/>.
[258] De Selding, Peter B. "ESA Ministerial Produces a Few Surprises." 12 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/esa-ministerial-produces-a-few-surprises/>.
[259] "Ariane 6 | Les Chiffres Clés." 2 Dec. 2014. CNES 12 Aug. 2015 <https://cnes.fr/sites/default/files/drupal/201506/default/is_ariane6-chiffres.pdf>.
[260] Henry, Caleb. "ESA Hands Reins to Industry on New Launchers." 3 Dec. 2014. Satellite Today 22 June 2015 <http://www.satellitetoday.com/launch/2014/12/03/esa-hands-reins-to-industry-on-new-launchers/>.
[261] De Selding, Peter B. "Italian Space Increase Falls Short, Clouding Outlook for ESA Ministerial." 1 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/42638italian-space-increase-falls-short-clouding-outlook-for-esa-ministerial/>.
[262] De Selding, Peter B. "ESA Ministerial Produces a Few Surprises." 12 Dec. 2014. SpaceNews 25 June 2015 <http://spacenews.com/esa-ministerial-produces-a-few-surprises/>.
[263] "ESA Budget for 2014." ESA 26 June 2015 <http://www.esa.int/For_Media/Highlights/ESA_budget_2014>.

budget for 2015 is to grow by 8% to be $4.433 billion ($5.222 billion).[264]

ESA's Rosetta mission turned out to be a stunning success, following its mid-2014 rendezvous with the comet 67P/Churyumov-Gerasimenko, and the release of its lander Philae which accomplished the first soft-landing on a comet's nucleus. By November 2014, following Philae's successful landing on the comet, and prior to its hibernation, the lander had utilized its instruments (including a sampling drill to penetrate the dust covered surface ice and collect a soil sample) and relayed the data to Earth via Rosetta, marking the unprecedented success of the Rosetta mission in exploring the surface of a comet.[265] Some findings from the Rosetta mission have already provided insight into the origin of Earth's oceans, as Rosetta's Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) measured the comet's deuterium/hydrogen (D/H) ratio to be more than three times greater than for Earth's oceans and for other recorded Kuiper Belt comets; it also measured higher than previous Oort cloud comets as well, potentially indicating that comets in the Kuiper belt may have formed over a wider range of distances than previously thought.[266]

Despite geopolitical tensions between Russia and the U.S. and Europe related to Russia's actions in Ukraine, it seems unlikely that the European-Russian ExoMars programme and other joint space ventures (such as the ISS) will be affected by the current situation. However, European funding for the ExoMars programme remained an issue leading up to the 2014 Ministerial Council meeting. Prior to the meeting, the €1.2 billion mission planned for January 2016 and May 2018 still lacked around €185 million ($240 million). While funds for the 2016 portion of the mission were secure, funding for the 2018 portion was expected to last only until mid-2015.[267] Fortunately, the ESA member governments at the 2014 Ministerial Council meeting secured the absent funds.[268]

As regards ESA's rapprochement with the EU, decisions on the direction of ESA's evolution were delayed pending further studies of how changes would affect Europe's space industrial base.[269]

6.3 EUMETSAT

The European Organisation for the Exploitation of Meteorological Satellites (Eumetsat) is an intergovernmental organisation that supplies weather and climate-related satellite data to the National Meteorological Services of its Member and Cooperating States in Europe, and other users worldwide. While support for Eumetsat's second-generation European Polar System (EPS-SG) had been hindered by the sovereign-debt crisis in previous years, the programme's approval process appeared to be progressing following its 82nd council meeting in Darmstadt, Germany, held on 26 November 2014. At the meeting, 86.86% of the funding needed for the EPS-SG was secured; yet the programme will need to secure 95% of its financial envelope before it can be started. The EPS-SG sets of satellites will succeed the current Metop three-satellite programme, and are expected to make observations from polar orbit in the 2021-2042 timeframe.[270]

Eumetsat's current Metop program consists of three identical satellites launched at six-year intervals between 2006 and 2018, with operations running until 2023. The second polar-orbiting meteorological satellite, Metop-B, was successfully placed into orbit on 17 September 2012, where it began operating in tandem with Metop-A, which had launched in October 2006. The third identical Metop satellite, Metop-C, is expected to launch sometime between late 2016 and late 2018. The entire cost of the Metop program (including development of the three satellites, their launches and the related ground infrastructure) reached €3.2 billion (at 2011 prices),

[264] "ESA Budget for 2015." ESA 26 June 2015 <http://www.esa.int/For_Media/Highlights/ESA_budget_2015>.
[265] De Selding, Peter B. "Philae Mission May be Done." 15 Nov. 2014. SpaceNews 14 May 2015 <http://spacenews.com/42565philae-mission-may-be-done/>.
[266] "Rosetta fuels debate on origin of Earth's oceans." 10 Dec. 2014. ESA 9 Mar. 2015 <http://www.esa.int/Our_Activities/Space_Science/Rosetta/Rosetta_fuels_debate_on_origin_of_Earth_s_oceans>.
[267] De Selding, Peter B. "65th International Astronautical Congress | ExoMars Funding Commitment Needed in December, Thales Alenia Says." 1 Oct. 2014. SpaceNews 25 June 2015 <http://spacenews.com/4206165th-international-astronautical-congress-exomars-funding-commitment-needed/>.
[268] De Selding, Peter B. "ESA Members Agree To Build Ariane 6, Fund Station Through 2017." 2 Dec. 2014. SpaceNews 25 June 2015 <http://spacenews.com/42699esa-members-agree-to-build-ariane-6-fund-station-through-2017/>.
[269] De Selding, Peter B. "European Union Delays Decision on ESA Changes." 26 May 2014. SpaceNews 25 June 2015 <http://spacenews.com/40685european-union-delays-decision-on-esa-changes/>.
[270] "The 82nd meeting of the EUMETSAT Council took place in Darmstadt, Germany, on 26 November." 28 Nov. 2014. Eumetsat 24 June 2015 <http://www.eumetsat.int/website/home/News/DAT_2430686.html?lang=EN&pState=1>.

with Eumetsat covering 75% of the cost, and ESA covering the rest.[271]

Metop Second Generation (Metop-SG) is the space segment of Eumetsat's EPS. In terms of funding for the Metop-SG, ESA will spend about €800 million ($1.1 billion) on the design and construction of the two Metop-SG satellites, while Eumetsat has budgeted the program at €3.323 billion over more than 20 years, including the construction of the four satellites under full Eumetsat responsibility.[272] The strained financial situation of many member governments had prompted Eumetsat's Council to reduce costs for Metop-SG by 5% from the earlier estimate of €3.4 billion. On 7 April 2014, Airbus Defence and Space was selected to be the prime contractor for the Metop-SG.[273] The Metop-SG will feature 6 satellites, operating in 3 pairs, each carrying a different but complementary suite of instruments.[274] Airbus will also provide the Sentinel-5 spectrometer payload for the first Metop-SG satellite to be launched in 2021.[275]

The Meteosat Third Generation (MTG) system is a series of sounding and imaging satellites in geostationary orbit, being developed by France's Thales Alenia Space and Germany's OHB AG, and is aimed at providing services for 20 years starting in 2018. In July 2014, the Eumetsat Council approved contracts to develop the ground infrastructure for the MTG system, with €18.9 million ($25.7 million) going toward the Mission Data Acquisition Facility, including five years of operations; and €11.7 million ($15.9 million) for the telemetry, tracking and command system to monitor the satellites.[276]

The existing Meteosat programme consists of two generations of active satellites, i.e. the Meteosat First Generation (MFG) and the Meteosat Second Generation (MSG), operating in geostationary orbit over Europe and Africa. While only one satellite, Meteosat-7, remains operating until 2016 under the MFG programme; the MSG programme has three satellites in operation, Meteosat 8 to -10, which are expected to end service in 2019, 2021, and 2022 respectively. The primary role of the Meteosat satellites is to help detect and forecast rapidly developing high impact weather, including thunderstorms, volcanic ash, and fog, up to six hours ahead through continuous monitoring.[277]

6.4 National Governments

6.4.1 France

In 2014, France returned to the top position in terms of ESA spending, having increased by 7.8% to €854.4 million to meet its commitments for the next generation launcher. However, its spending was partially offset by a decrease in France's non-ESA-related space activities; thus overall spending at CNES increased by only 1.3% to €1.43 billion for 2014.[278]

In April 2014, the French government proposed its Law on Space Operations requiring French launch providers to direct the upper stages of their launchers into courses that would cause them to drop into open waters or disintegrate immediately after launch in Earth's atmosphere. The new national space law is meant to reduce orbital debris and prevent liability from upper stages re-entering the atmosphere and causing injury or property damage. The first of its kind, this new law will gradually take effect in the coming years, and will be applicable to all European launch systems. While this law is meant to contribute to an improvement of the space environment, the fact that France is the only launching state to have this requirement might have a negative impact when it comes to the commercial launch environment, as

[271] "European Weather Satellite Launched after 4-Month Delay." 27 Sept. 2012. SpaceNews 28 Apr. 2014 <http://spacenews.com/article/european-weather-satellite-launched-after-4-month-delay>.
[272] De Selding, Peter. "Formal Approval for Lower-cost Metop-SG Expected by Year's End." 10 July 2014. SpaceNews 8 Jan. 2015 <http://spacenews.com/41212formal-approval-for-lower-cost-metop-sg-expected-by-years-end/>.
[273] De Selding, Peter. "Airbus Bests Thales Alenia-OHB Team for Billion-dollar ESA Weather Satellite Contract." 7 Apr. 2014. SpaceNews 8 Jan. 2015 <http://spacenews.com/40109airbus-bests-thales-alenia-ohb-team-for-billion-dollar-esa-weather/>.
[274] "MetOp-SG (MetOp-Second Generation Program)." eoPortal Directory 29 Apr. 2014 <https://directory.eoportal.org/web/eoportal/satellite-missions/m/metop-sg>.
[275] De Selding, Peter. "ESA Orders Nearly $200 Million Weather Instrument from Airbus." 28 Mar. 2014. SpaceNews 7 Jan. 2015 <http://spacenews.com/40016esa-orders-nearly-200-million-weather-instrument-from-airbus/>.
[276] De Selding, Peter. "Formal Approval for Lower-cost Metop-SG Expected by Year's End." 10 July 2014. SpaceNews 8 Jan. 2015 <http://spacenews.com/41212formal-approval-for-lower-cost-metop-sg-expected-by-years-end/>.
[277] "There are two generations of active Meteosat satellites, Meteosat First Generation (MFG) and Meteosat Second Generation (MSG), providing images of the full Earth disc, and data for weather...." Eumetsat 30 May 2014 <http://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Meteosat/index.html>.
[278] "France Favors CNES with Better-than-inflation Budget Bump." 26 Sept. 2013. SpaceNews 28 Apr. 2014 <http://spacenews.com/article/civil-space/37395france-favors-cnes-with-better-than-inflation-budget-bump>.

competitors in the U.S., Russia, China, and India are not yet subject to equivalent formal constraints.[279] Even so, international debris mitigation guidelines do exist, which have been deliberated on in the UNCOPOUS[280], and have led to a voluntary international standard for debris mitigation (ISO 24113), in addition to several standards and technical reports; yet unlike the French law, they are not formally enforceable.[281]

6.4.2 Germany

On 20 May 2014, Germany's BAE System Intelligence and Security, and Airbus Defence & Space announced that they would market data from German radar satellite data to the U.S. government and certain commercial and international customers. More specifically, this is radar data from the TerraSAR-X, launched in June 2007, and TanDEM-X, launched in June 2010. BAE systems will provide software integration and other services. The commercial sale of TerraSAR-X and TanDEM-X data is exclusively done by Airbus, which was granted the commercial licence by DLR.[282]

In May 2014, Germany informed ESA that German spending on launch vehicles would remain flat for the upcoming decade, complicating ESA's push to secure funding and consensus for the future development of the Ariane launcher. Germany's position on launcher development softened at the December 2014 Ministerial Council meeting, where it agreed to take a 22% stake in the Ariane 6 launcher, and forego the development of the mid-life evolution to the Ariane 5 launcher.[283] Barring an increase of launcher development funding by any other member ESA, Germany's decision means that ESA's annual launcher budget will be €850 million per year from 2015 to 2024.[284]

Another outcome of the 2014 Ministerial Council meeting came from the German government's agreement to take a 7% stake in the Vega launcher, amounting to €15 million ($18.75 million), in addition to a 23% stake in the P120 launcher stage programme, amounting to around €147 million ($182.8 million); putting Germany on an equal footing with Italy as a programme contributor. The P120 will be the enhanced first stage for the upgraded Vega-C launcher, and will also serve as strap-on boosters for the Ariane 6 launcher.[285]

6.4.3 Italy

Following its sharp reduction to 10% of ISS funding in 2012 due to the crippling effect of the financial crisis, and further to around 8% by mid-2014[286], on the insistence of Germany's delegation at the 2014 Ministerial Council, Italy agreed to return to its previous contribution level of 19% in total contributions over the next six years, instead of the three-year commitment that was requested by ESA. The reason for the six-year commitment was because Italy's contribution will be lower than the 19% share level during 2015-2017; but as the funding costs for the ISS are expected to decline during 2018-2020, Italy's contribution will be above the 19% share level for the latter three years. In return, Germany redirected to the Italian-led ExoMars project €15 million in funding it had designated to go to ISS.[287]

Prior to the meeting, budget constraints had already been visible, as funding for the Italian Space Agency (ASI) had fallen short of expectations. Italy was able to raise its contribution share to the ISS thanks to a €200 million ($250 million) funding boost over 2015-2017 provided by the Italian government. The infusion is also intended to help finance continued work on the second gen-

[279] De Selding, Peter B. "French Debris-mitigation Law Could Pose Issue for Arianespace." 10 Apr. 2014. SpaceNews 25 June 2015 <http://spacenews.com/40171french-debris-mitigation-law-could-pose-issue-for-arianespace/>.
[280] "Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space." 2010 United Nations Office for Outer Space Affairs 13 Aug. 2015 <http://orbitaldebris.jsc.nasa.gov/library/Space%20Debris%20Mitigation%20Guidelines_COPUOS.pdf>.
[281] Finkleman, Dave. "Commentary | Rethinking Space Debris Mitigation." 25 Aug. 2014. SpaceNews 25 June 2015 <http://spacenews.com/41659rethinking-space-debris-mitigation/>.
[282] De Selding, Peter B. "BAE To Market German Radar Satellite Data to U.S. Government." 21 May 2014. SpaceNews 25 June 2015 <http://spacenews.com/40644bae-to-market-german-radar-satellite-data-to-us-government/>.
[283] De Selding, Peter B. "ESA Ministerial Produces a Few Surprises." 12 Dec. 2014. SpaceNews 25 June 2015 <http://spacenews.com/esa-ministerial-produces-a-few-surprises/>.
[284] De Selding, Peter B. "Germany's Budget Straitjacket Complicates Europe's Ariane Funding Outlook." 22 May 2014. SpaceNews 25 June 2015 <http://spacenews.com/40655germanys-budget-straitjacket-complicates-europes-ariane-funding-outlook/>.
[285] De Selding, Peter B. "ESA Ministerial Produces a Few Surprises." 12 Dec. 2014. SpaceNews 25 June 2015 <http://spacenews.com/esa-ministerial-produces-a-few-surprises/>.
[286] De Selding, Peter B. "Profile | Roberto Battiston, President, Italian Space Agency." 26 Nov. 2014. SpaceNews 25 June 2015 <http://spacenews.com/42669profile-roberto-battiston-president-italian-space-agency/>.
[287] De Selding, Peter B. "ESA Members Agree To Build Ariane 6, Fund Station Through 2017." 2 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/42699esa-members-agree-to-build-ariane-6-fund-station-through-2017/>.

eration of Italy's Cosmo-SkyMed radar Earth Observation system, which could otherwise face production delays.[288] The first satellite of the second generation system is to be launched in 2016, with a second satellite to be launched the following year.

6.4.4 United Kingdom

During the sixth high-level Conference on EU Space Policy, 'What direction for Europe in space between now and 2020?', held on 28–29 January 2014 in Brussels, Belgium, it was revealed that the UK government had decided to block a European Commission effort to set common European regulations on the sale of high-resolution imagery outside of Europe. Despite the fact that European industry has become transnational, the UK considered the action to be overreaching into the domain of national satellite imagery-export policies. It concluded that a blanket EU regulation would undermine Europe's commercial high-resolution satellite industry, as the regulation may limit the industry's ability to compete with non-European companies that also offer high-resolution imagery.[289]

While France has taken steps to reduce orbital debris and prevent liability from upper stages re-entering the atmosphere and causing injury or property damage through its Law on Space Operations, the British government has taken a different approach to risk by focussing on reducing space insurance requirements, and easing small satellite licensing rules. On 30 April 2014, the UK government published its 'Government Response to the UK Space Innovation and Growth Strategy 2014 – 2030', in which it seeks to reduce the amount of insurance needed by satellite companies before government guarantees on third-party liability take effect from £80 million ($134.5 million) to a ceiling of £60 million ($100.9 million) by modifying the UK's Outer Space Act.[290] It is also reassessing how cubesats are regulated in terms of obtaining an operating licence to improve the UK space sector's international competitiveness. Moreover, the UK Space Agency (UKSA) will soon issue initial conclusions from its National Space Flight Coordination Group on developing a UK spaceport and starting commercial space flight from the UK.[291]

On 30 April 2014, the UK government published its 'U.K. National Space Security Policy' stressing the need for a terrestrial alternative to space-based navigation, positioning, and timing systems in case of potential loss of access to GNSS signals, either through malice or due to space weather.[292] The document highlighted that many critical infrastructures, e.g. military, civil government, and commercial, have become dependent on GPS, and that some crucial services may already have lost the know-how needed to survive a satellite outage. Hence the need for increased resiliency measures including added redundancy, encryption and anti-jamming measures.[293]

Anticipating the 2015 launch of British astronaut Tim Peake to the ISS, the UK increased its funding to the ISS at the 2014 Ministerial Council meeting to around €40 million or 4.6% of total ESA funding through 2017.[294] Whereas in previous years the UK's involvement in the ISS had been minimal, its investment will now provide a UK built communications terminal, and will allow its researchers new opportunities such as the deployment of cubesats as part of technical demonstrations and science experiments conducted from the ISS.

On 15 July 2014, the UK unveiled a broad strategy document designed to create the necessary regulatory regime to permit suborbital spaceplane flights by 2018 as part of a long term goal of establishing a domestic small-satellite launch capability. The UK Civil Aviation Authority (CAA) has selected eight existing airports as potential suborbital spaceports, six of them in Scotland. The U.S. FAA and UK CAA signed an MOU on the following day for better coordination between the two regions, yet UK-based industry has

[288] De Selding, Peter B. "Italian Space Increase Falls Short, Clouding Outlook for ESA Ministerial." 1 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/42638italian-space-increase-falls-short-clouding-outlook-for-esa-ministerial/>.
[289] De Selding, Peter B. "U.K. Blocks Bid To Create Common European Imagery Policy." 30 Jan. 2014. SpaceNews 24 June 2015 <http://spacenews.com/39328uk-blocks-bid-to-create-common-european-imagery-policy/>.
[290] "Government Response to the UK Space Innovation and Growth Strategy 2014 – 2030." 30 Apr. 2014. UKSA 29 June 2015 <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/307347/Government_response_-_space_growth_action_plan.pdf>.
[291] De Selding, Peter B. "Britain To Reduce Space Insurance Requirements, May Ease Smallsat Licensing Rules." 30 Apr. 2014. SpaceNews 25 June 2015 <http://spacenews.com/40417britain-to-reduce-space-insurance-requirements-may-ease-smallsat-licensing/>.
[292] "National Space Security Policy." 30 Apr. 2014. UKSA 29 June 2015 <https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/307346/National_Space_Security_Policy.pdf>.
[293] De Selding, Peter B. "U.K. Policy Stresses Terrestrial Backup for Space-based Navigation." 1 May 2014. SpaceNews 25 June 2015 <http://spacenews.com/40430uk-policy-stresses-terrestrial-backup-for-space-based-navigation/>.
[294] De Selding, Peter B. "ESA Ministerial Produces a Few Surprises." 12 Dec. 2014. SpaceNews 22 June 2015 <http://spacenews.com/esa-ministerial-produces-a-few-surprises/>.

some challenges to overcome especially in the areas of U.S. ITAR restrictions, flight safety regulations, and liability exposure.[295]

6.5 United States of America

On 19 December 2014, the U.S. National Defense Authorization Act for 2015 (NDAA-15) was signed into law. With tensions increasing between the U.S. and Russia, the NDAA-15 draws a line under continued U.S. use of Russian made rocket engines for its launchers. The act prohibits U.S. companies from contracting with Russian suppliers of rocket engines or renewing current contracts for space launch activities.[296] As the United Launch Alliance (ULA) Atlas 5 launcher uses the Russian built RD-180 engine for its main stage, this restriction essentially prohibits the use of the RD-180 engine after 2019.[297] However, the act exempts ULA's use of the nearly 2-year supply of RD-180 engines already in its possession; it also exempts a batch of 29 RD-180 engines that were ordered while the NDAA-15 was still pending.[298] Moreover, the NDAA-15 calls for a demonstration of a U.S. made replacement engine by 2019.[299]

In mid-2014, U.S. lawmakers began preparations to update the U.S. Commercial Space Launch Amendments Act of 2004. The new legislation will *inter alia* address whether the FAA can begin to write human spaceflight safety regulations.[300] Up to October 2015, suborbital spacecraft developer Virgin Galactic and similar U.S. firms have a regulatory grace period extension on developing suborbital spacecraft without Federal Aviation Administration (FAA) imposed passenger and crew safety rules. The new legislation will also address changes to the formula the FAA uses to determine how much insurance commercial launch providers must carry; and some changes to the National Oceanic and Atmospheric Administration's (NOAA) licensing regime for commercial remote sensing satellites. However, it is unclear whether the new law will allow the FAA to regulate what commercially launched spacecraft can do while they are on orbit; that hot-button issue is currently being reviewed by congress.[301]

6.5.1 National Aeronautics and Space Administration (NASA)

As ties between the U.S. and Russia continue to deteriorate, U.S. lawmakers are increasingly becoming aware of the impact that inconsistent funding support has had on the state of U.S. human spaceflight capabilities, especially in regard to its Commercial Crew Program (CCP) and the development of the Space Launch System (SLS). On 27 March 2014, at a budget hearing before members of the House Appropriations Commerce, Justice, Science and Related Agencies Subcommittee, NASA Administrator Charles Bolden said that had NASA received the amounts the White House had requested each year for the CCP program, at least one of the three competing companies would have been ready before 2015. The program is at risk of slipping to 2017 if it continues to receive less funding than requested. However, funding requests for NASA's SLS rocket and deep space Orion capsule might overshadow the requests for CCP. The CCP has received about $2 billion in total since 2010, while the SLS receives nearly $3 billion annually. Nevertheless, to Bolden, commercial access to LEO orbit is a precursor to NASA's deep space exploration programme, as the ISS will allow NASA to test some elements of programmes such as its Asteroid Redirect Mission (ARM), which will also be used as a stepping-stone for reaching Mars.[302] While NASA has not formally committed to this Asteroid Redirect Mission (ARM) – especially following the lukewarm response from Congress - should the mission proceed, it would use a solar-

[295] De Selding, Peter B. "News from the Farnborough International Airshow | Britain Plots Course for Domestic Small-satellite Launcher." 18 July 2014. SpaceNews 9 Apr. 2015 <http://spacenews.com/41296news-from-the-farnborough-international-airshow-britain-plots-course-for/>.
[296] Section 1608. Carl Leven and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, Pub. L. no 113-291 (2014) <http://www.gpo.gov/fdsys/pkg/CPRT-113HPRT92738/pdf/CPRT-113HPRT92738.pdf>.
[297] Gruss, Mike. "Compromise Appropriations Bill Includes $220 Million for RD-180 Replacement." 11 Dec. 2014. SpaceNews 22 July 2015 <http://spacenews.com/compromise-appropriations-bill-includes-220-million-for-new-rocket-engine/>.
[298] Gruss, Mike. "House-Senate Conference Measure To End Pentagon Use of RD-180." 5 Dec. 2014. SpaceNews 22 July 2015 <http://spacenews.com/42701house-senate-conference-measure-to-end-pentagon-use-of-rd-180/>.
[299] Gruss, Mike. "Compromise Appropriations Bill Includes $220 Million for RD-180 Replacement." 11 Dec. 2014. SpaceNews 22 July 2015 <http://spacenews.com/compromise-appropriations-bill-includes-220-million-for-new-rocket-engine/>.
[300] Leone, Dan. "Hill Staffers: Commercial Space Launch Bill Is Coming This Year." 26 May 2014. SpaceNews 9 Apr. 2015 <http://spacenews.com/40694hill-staffers-commercial-space-launch-bill-is-coming-this-year/>.
[301] Leone, Dan. "Hill Staffers: Commercial Space Launch Bill Is Coming This Year." 26 May 2014. SpaceNews 14 July 2015 <http://spacenews.com/40694hill-staffers-commercial-space-launch-bill-is-coming-this-year/>.
[302] Leone, Dan. "Bolden, Lawmakers Point Fingers about State of U.S. Human Spaceflight." 27 Mar. 2014. SpaceNews 22 July 2015 <http://spacenews.com/40007bolden-lawmakers-point-fingers-about-state-of-us-human-spaceflight/>.

powered robotic spacecraft to push a 10-meter asteroid into a deep retrograde orbit around the Moon. While no formal cost estimate for ARM has been determined, estimates put the mission cost at approximately $2.6 billion. To be successful, it will need to fit within overall financial considerations, in addition to satisfying political interests.[303] By 8 May, the House Appropriations Committee had approved $17.9 billion in funding for NASA for the fiscal year 2015; however, its CCP programme received 7.5% less than its request for 2015, i.e. $785 million. Nevertheless, that amount exceeded its 2014 request by nearly 13%.[304]

6.5.2 National Oceanic and Atmospheric Administration (NOAA)

The U.S. National Oceanic and Atmospheric Administration (NOAA) finances and operates space systems related to meteorology to supply operational data for environment purposes. In the 2014-2015 reporting period, satellite security, polar orbit gap mitigation plans, commercial weather satellite data, and budget issues were the main points of interest for the year.

In October 2014, four NOAA websites had been the targets of cyber attacks that had temporarily disrupted the flow of some satellite data to the U.S. National Weather Service. Upon detection, unscheduled maintenance was performed by NOAA staff to mitigate the attacks. Not surprisingly, warning signs had existed as early as 2009, following a government audit that criticized NOAA's Satellite and Information Service for inadequate cyber security planning.[305] In fact, a 21 August 2014 report by the U.S. Commerce Department's Office of Inspector General found 9,100 instances where the JPSS ground network was left exposed by out-of-date software, missing security patches, incorrectly configured software or unnecessarily granted user privileges.[306] The inspector general's memo report found that even with recent efforts to limit the vulnerabilities, the number of "high-risk" security gaps has increased by nearly 66% since 2012, which could allow attackers to "significantly disrupt" the JPSS mission.[307]

On 15 January 2015, the U.S. Government Accountability Office (GAO) released a report that raised concerns about the potential for near-term polar orbiting satellite data gaps, in light of recent cost growth on key components that have the potential to bring the Joint Polar Satellite System (JPSS) programme outside its cost and schedule baselines.[308] The main concern is that the current Suomi National Polar-orbiting Partnership (Suomi-NPP) mission, launched in October 2011, is expected to operate for a 5-year lifetime, culminating in October 2016. However, the first of the two JPSS satellites is expected to launch in March 2017; the JPSS-2 is expected to launch in 2021.[309] To respond to that gap, it is likely that NOAA will need to purchase commercial data.

Throughout the year, the U.S. Congress encouraged NOAA to consider whether commercial satellites by commercial actors could play an increasing role in supplying weather and environmental data. On 1 April 2014, the U.S. House of Representatives passed the revised 'The Weather Forecasting Improvement Act', which was designed to strengthen the NOAA's weather forecasting capabilities in addition to laying the groundwork for integrating commercial satellite data into its activities.[310] The bill was originally introduced in 2013, but the new revision omitted provisions that diverted resources from climate change research.[311] However, the bill did not get approval by the U.S. Senate, which has in

[303] Leone, Dan. "Bolden: Capabilities-based Approach Is All NASA Can Afford." 22 Oct. 2013. SpaceNews 29 Apr. 2014 <http://www.spacenews.com/article/civil-space/37808bolden-capabilities-based-approach-is-all-nasa-can-afford>.
[304] Leone, Dan. "NASA Budget Bill Would Boost Commercial Crew, Keep SOFIA Flying, Kill Hosted Climate Instrument." 7 May 2014. SpaceNews 22 July 2015 <http://spacenews.com/40494nasa-budget-bill-would-boost-commercial-crew-keep-sofia-flying-kill-hosted/>.
[305] Gruss, Mike. "NOAA Admits to Cyberattack on Satellite Data Networks." 14 Nov. 2014. SpaceNews 29 Sept. 2014. SpaceNews 29 Sept. 2015 <http://spacenews.com/42561noaa-admits-to-cyberattack-on-satellite-data-networks/>.
[306] Inspector General Memorandum. "Expedited Efforts Needed to Remediate High-Risk Vulnerabilities in the Joint Polar Satellite System's Groun System – Final Memorandum." 21 Aug. 2014. U.S. Department of Commerce 29 Sept. 2015: 4 <https://www.oig.doc.gov/OIGPublications/OIG-14-027-M.pdf>.
[307] Gruss, Mike. "Report Cites Vulnerability in NOAA's Satellite Ground Stations." 27 Aug. 2014. SpaceNews 29 Sept. 2015 <http://spacenews.com/41685report-cites-vulnerability-in-noaas-satellite-ground-stations/>.
[308] "Polar Weather Satellites | NOAA Needs To Prepare for Near-term Data Gaps." 16 Dec. 2014. GAO 29 Sept. 2015 <http://www.gao.gov/assets/670/667581.pdf>.
[309] Smith, Marcia S. "NOAA Downplays Weather Satellite Gap, House Committee Wants Commercial Data Buys." 15 Feb. 2015. Space Policy Online 29 Sept. 2015 <http://www.spacepolicyonline.com/news/noaa-downplays-weather-satellite-gap-house-committee-wants-commercial-data-buys>.
[310] Leone, Dan. "Bill with Commercial Weather Study Mandate Passes House." 3 Apr. 2014. SpaceNews 28 Sept. 2015 <http://spacenews.com/40092bill-with-commercial-weather-study-mandate-passes-house/>.
[311] SpaceNews. "Editorial | An Improvement in More Ways than One." 28 Apr. 2014. SpaceNews 29 Sept. 2015 <http://spacenews.com/40374editorial-an-improvement-in-more-ways-than-one/>.

recent years focussed on cost and schedule overruns and the age of NOAA's current satellites programmes.[312] On 19 May 2015, the U.S. House of Representatives passed the 'Weather Research and Forecast Innovation Act of 2015' which would require NOAA to publish standards for commercial data buys by the end of 2015, and buy data from at least one such provider by 31 October 2016. However, by the end of May the bill had not yet gone to the U.S. Senate for consideration.[313]

On 2 February 2015 NOAA released its 2016 fiscal year budget request, which includes mitigation plans for follow-on JPSS-3 and JPSS-4 satellites that would replace the JPSS system that is currently being developed. In NOAA's 2016 budget, the JPSS funding would decrease by 11.7% to $809.0 million; however, the Polar Follow-On programme (incl. JPSS-3 and JPSS-4) was presented as a gap-filler, for which an additional initial funding of $380 million was requested. Moreover, NOAA's other flagship Geostationary Operational Environmental Satellite Systems programme (GOES-R) also had an 11.1% reduction in funding, total funding amounting to $871.8 million in 2014. Funding for the joint U.S.-Taiwan COSMIC-2 constellation increased considerably, jumping from $6.8 million in 2015 to $20 million in 2016. Finally, funding for Jason 3 decreased by 67.7% to $7.5 million, while funding for the DSCOVR programme also decreased by 84.8% to $3.2 million for 2016.[314] U.S. House Appropriators reviewed the overall request on 26 March 2015, but by the end of May 2015, the request had not yet been submitted for a vote.[315]

6.6 Canada

On 7 February 2014, the Canadian government released Canada's Space Policy Framework, which outlines broad national goals for its space programme. The framework was developed in response to a major study ordered by the Canadian government on the country's aerospace and space sectors, which was released on 29 November 2012, and had called on the government to recognize the importance of space to national security and economic prosperity. Its core principles are based on the following: Canadian Interests First, Positioning the Private Sector at the Forefront of Space Activities, Progress through Partnerships, Excellence in Key Capabilities, and Inspiring Canadians.[316] The new policy framework calls for the continuation of Canada's astronaut programme, further investments in the development of advanced systems and scientific instruments as part of major international missions, and an increase in support for technology development, especially in areas of proven strength among domestic firms. Nevertheless, the space budget for the Canadian Space Agency (CSA) dropped by 13% to CDN$260 million ($235 million) during 2014-2015.[317]

At the beginning of 2014, Canada's Department of National Defence (DND) and the U.S. Strategic Command signed an updated accord permitting the exchange of advanced space situational awareness data. The agreement streamlines the request process to gather SSA data for satellite manoeuvre planning, collision avoidance, and anomaly mitigation from the U.S. Strategic Command's Joint Space Operations Centre located at Vandenberg Air Force Base in California.[318]As of September 2014, the U.S. government has signed nearly 50 data-sharing agreements with other governments, e.g. the UK, Japan, Australia, Italy, France, and the Republic of Korea, as well as private sector entities.[319] Canada has also signed a memorandum of understanding with the U.S., Australia, and the UK, to work more closely together on SSA activities, allowing for more effective and coordinated use of capabilities.[320]

[312] Leone, Dan. "Commercial Weather Bill Praised, but No Floor Vote in Forecast." 7 Apr. 2015. SpaceNews 29 Sept. 2015 <http://spacenews.com/companies-praise-commercial-weather-data-bill-but-no-floor-vote-yet/>.
[313] "H.R. 1561: Weather Research and Forecasting Innovation Act of 2015." 19 May 2015. Govtrack.us 29 Sept. 2015 <https://www.govtrack.us/congress/bills/114/hr1561>.
[314] Leone, Dan. "NOAA Looks To Begin Work on Gap-filler Satellite in 2016." 3 Feb. 2015. SpaceNews 29 Sept. 2015 <http://spacenews.com/noaa-looks-to-begin-work-on-gap-filler-satellite-in-2016/>.
[315] "House Appropriators Review FY 2016 NOAA Request" 26 Mar. 2015. American Institute of Physics 29 Sept. 2015 <https://www.aip.org/fyi/2015/house-appropriators-review-fy-2016-noaa-request>.
[316] "Canada's Space Policy Framework | Launching the Next Generation." 7 Feb. 2014. CSA 29 June 2015 <http://www.asc-csa.gc.ca/pdf/eng/publications/space-policy/canadas-space-policy-framework.pdf>.
[317] Pugliese, David. "Canadian Policy Outlines Broad National Goals for Space Program." 7 Feb. 2014. SpaceNews 29 June 2015 <http://spacenews.com/39412canadian-policy-outlines-broad-national-goals-for-space-program/>.
[318] Ferster, Warren. "U.S., Canadian Governments Sign SSA Data Sharing Accord." 9 Jan. 2014. SpaceNews 25 June 2015 <http://spacenews.com/39003us-canadian-governments-sign-ssa-data-sharing-accord/>.
[319] Gruss, Mike. "UK Joins List of US Allies Agreeing To Strengthen Space Surveillance Sharing." 25 Sept. 2014. SpaceNews 25 June 2015 <http://spacenews.com/41995uk-joins-list-of-us-allies-agreeing-to-strengthen-space-surveillance/>.
[320] Gruss, Mike. "News from the 30th Space Symposium | U.S., Three Allies Sign Space Situational Awareness

6.7 Russia

Following a July 2013 review by Russia's Audit Chamber, which found Russia's Federal Space Program of 2006-2015 to be ineffective, due largely to the poor management of space activities and budget funds allocated for space projects, Russia was in the midst of revising its space programme in 2014.[321] Following a December 2013 decree by Russia's President, Vladimir Putin, ordering the creation of the United Rocket and Space Corporation (URSC), Russia's government began taking steps to reorganize its space industry under the umbrella of the state-owned URSC.[322] By the end of 2014, Russia's government decided to merge its Federal Space Agency, Roscosmos, with the URSC instead of arranging an arms-length customer and contractor relationship between the organizations, with the hope of improving the sector's efficiency.[323] The consolidation stage is to be completed before the end of 2015.

Moreover, Russia plans to spend an estimated 2.1 trillion roubles (~$63 billion) including extra-budgetary sources, to boost the development of its national space activities from 2013 to 2020. In addition to enabling effective participation in forward-looking projects, such as the ISS, the study of the Moon, Mars and other celestial bodies in the solar system, the programme is designed to maintain Russia's leading position as a global space power, while also supporting its defence capability, and boosting economic and social development.[324] The government's decision to increase Russia's space budget will enable Russia to surpass China and reach spending parity with Europe. With only one-fifth of its domestic demand for geospatial imagery currently able to be met by Russia's own satellites and with Russian meteorological satellites being below international standards, this funding could help Russia redress its past underinvestment in Earth observation and meteorology satellites.[325]

Development of the Vostochny Cosmodrome, located in the Far Eastern region of Russia, is continuing with the goal of ensuring completion of the spaceport's Soyuz-2 and Angara launch pads by 2016; which should also coincide with the completion of the Angara launcher.[326] The final construction stage of the Vostochny Cosmodrome - to take place between 2016 and 2018 - will develop facilities for a super-heavy launch vehicle that will be capable of delivering 120-150 tons into space by 2020.[327]

On 9 July 2014, Russia succeeded in test launching its new indigenous Angara launcher, the first new rocket designed by Russia's space industry in over twenty years.[328] The inaugural sub-orbital flight of the Angara 1.2 was postponed from its intended 27 June 2014 launch date due to a drop in oxidizer pressure that stemmed from a poorly sealed valve on the launcher's liquid oxygen tank.[329] The Angara is a two stage launcher, with a main core that burns kerosene and liquid oxygen, which can be supplemented with additional boosters to increase power. Different upper stage designs can be used depending on the intended orbit altitude. The 9 July test launch was of the Angara 1 - its simplest configuration – that should be capable of launching up to 4 tons to LEO orbit. The variants are planned to extend to a heavy-lift Angara 5 version intended to carry up to 7.5 tons to GEO orbit. The Angara will launch from both the Plesetsk spaceport and the Vostochny Cosmodrome.[330] The Angara is meant to replace

Accord." 22 May 2014. SpaceNews 25 June 2015 <http://spacenews.com/40651news-from-the-30th-space-symposium-us-three-allies-sign-space/>.

[321] "Russia's Space Program Is Ineffective – Audit Chamber." 4 July 2013. RIA NOVOSTI 30 Apr. 2014 <http://en.ria.ru/russia/20130704/182063035.html>.

[322] "Putin Signs Decree on Creation of United Rocket and Space Corporation." 2 Dec. 2013. ITAR TASS 30 Apr. 2014 <http://en.itar-tass.com/russia/709849>.

[323] "Duma proposes to merge Roscosmos with United Rocket Space Corporation." 20 Dec. 2014. TASS.ru 21 July 2015 <http://tass.ru/en/non-political/768257>.

[324] "Russia Launches $70 Bln Space Program for 2013-2020." 27 Dec. 2012. RIA NOVOSTI 30 Apr. 2014 <http://en.ria.ru/science/20121227/178432916/russia_launches.html>.

[325] "Russia Boosting Space Budget To Surpass China, Equal Europe." 5 June 2013. SpaceNews 30 Apr. 2014 <http://www.spacenews.com/article/civil-space/35638russia-boosting-space-budget-to-surpass-china-equal-europe>.

[326] Nowakowski, Tomasz. "Putin pledges $1.5 billion for completion of Vostochny Cosmodrome, OKs plans for creating super-heavy rockets." 9 Sept. 2014. Spaceflight Insider 16 July 2015 <http://www.spaceflightinsider.com/organizations/roscosmos/putin-pledges-1-5-billion-completion-vostochny-cosmodrome-oks-plans-creating-super-heavy-rockets/>.

[327] Bodner, Matthew. "Putin Pledges $1 Billion for Completion of New Cosmodrome." 2 Sept. 2014. The Moscow Times 16 July 2015 <http://www.themoscowtimes.com/business/article/putin-pledges-1-billion-for-completion-of-new-cosmodrome/506321.html>.

[328] De Selding, Peter B. "Russia's Angara 1.2 Rocket Succeeds in Inaugural Flight, Khrunichev Says." 9 July 2014. SpaceNews 16 July 2015 <http://spacenews.com/41184russias-angara-12-rocket-succeeds-in-inaugural-flight-khrunichev-says/>.

[329] Bodner, Matthew. "Angara Launch Troubles Reflect Russia's Struggling Space Industry." 1 July 2014. The Moscow Times 16 July 2015 <http://www.themoscowtimes.com/business/article/angara-launch-troubles-reflect-russias-struggling-space-industry/502809.html>.

[330] Amos, Jonathan. "Russia's Angara rocket 'makes debut'." 9 July 2014. BBC.com 16 July 2015 <http://www.bbc.com/news/science-environment-28058633>.

Russia's somewhat unreliable Proton M launcher to remain competitive with commercial launcher providers such as SpaceX.

In parallel to the development of the European initiated non-binding International Code of Conduct for Outer Space Activities (ICoC), Russia and China are promoting a draft Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT), which was introduced to the UN Conference on Disarmament (CD) in 2008, and subsequently updated in June 2014 following the last open-ended multilateral consultation for the ICoC in Luxembourg in May 2014. The PPWT focuses mainly on security issues regarding the placement of weapons in outer space, but does not address issues of ASAT missile testing and space debris.

6.8 Japan

On 20 August 2014, Japan's government released its policy report "A Comprehensive Space Strategy to Implement Japan's National Strategy" as an update to Japan's five-year Basic Plan of 2012, and to function as a blueprint to realign Japan's space activity and space spending with security and economic priorities. The report recommends the creation of a national security-focused space agency in addition to building closer collaboration with the U.S. in areas such as navigation, maritime surveillance, space situational awareness and missile warning.[331] The document recommends an expansion of Japan's QZSS navigation system to a full seven satellite constellation, in addition to expanding the number of Japan's optical and radar information gathering satellites (IGS) from the current four to ten satellites, including data-relay communication satellites.[332] Yet there remains some possible misalignment with Japan's Ministry of Education, Sports, Science and Technology (MEXT), which governs Japan's civilian space agency, JAXA, and views the creation of another agency as affecting its own role and budget.

The new focus of Japan on space and security has been in development since 2008, when the Japanese government passed its 5-year Basic Plan. In June 2012, Japan's government passed legislation implementing the Basic Plan, enabling the Prime Minister's Cabinet Office to take control of the planning and budgeting of Japan's government space program, and providing JAXA with the ability to pursue military space programs.[333] On 25 January 2013, Japan's Space Strategy Headquarters released the latest version of its Basic Plan that lays out the priorities for most of Japan's space development for the five years that started in April 2013. The new Basic Plan has three main targets: national security and disaster management, development of industries, and space science.[334]

Japan plans to develop a lower-cost, commercially viable successor to its H-2A rocket. On 17 May 2013, Japan's Space Transportation Systems Subcommittee of its Cabinet-level Office of National Space Policy (ONSP) presented a draft midterm report recommending an H-3 successor launcher.[335] On 24 December 2013, the Japanese government approved initial funding of $70 million for 2014 for the development of the launcher, estimated to need $1.9 billion for full development. The two-stage H-3 is tentatively scheduled to have its first launch in 2020, and is projected to lift up to 6.5 metric ton payloads to GTO at a cost ranging between $50 million and $70 million per launch.[336] Mitsubishi Heavy Industries Corp. was selected by JAXA as the prime contractor, with the launcher expected to feature a liquid hydrogen/liquid oxygen core stage with up to six solid-fuel strap-on boosters to offer a wide range of payload-to-orbit capabilities.[337]

[331] Kallender-Umezu, Paul. "Profile | Hiroshi Imazu, former Chairman, Space Policy Committee, Liberal Democratic Party of Japan." 27 Oct. 2014. SpaceNews 30 June 2015 <http://spacenews.com/42331profile-hiroshi-imazu-former-chairman-space-policy-committee-liberal/>.

[332] "Recommendation for a Comprehensive Space Strategy to Implement Japan's National Strategy." 26 Aug. 2014. Hiroshi-i.net 30 June 2015 <http://hiroshi-i.net/10/wp-content/uploads/b785de34e6cd85a6423eb90542522d2d.pdf>.

[333] Kallenar-Umezu, Paul. "Japan Passes Overhaul of Space Management Structure." 2 July 2012. SpaceNews 30 Apr. 2014 <http://spacenews.com/article/japan-passes-overhaul-space-management-structure>.

[334] "Profile | Naoki Okumura, President, Japan Aerospace Exploration Agency." 9 Dec. 2013. SpaceNews 30 Apr. 2014 <http://spacenews.com/search?search_api_views_fulltext=Japan&sort_by=created&sort_order=DESC&page=2>

[335] Kallendar-Umezu, Paul. "Japanese Government Recommends Developing H-2A Successor." 27 May 2013. SpaceNews 30 May 2014 <http://www.spacenews.com/article/launch-report/35499japanese-government-recommends-developing-h-2a-successor>.

[336] Onuki, Misuzi. "Japan Approves $1.9B for H-3 Rocket." 13 Jan. 2014. SpaceNews 30 May 2014 <http://www.spacenews.com/article/civil-space/39069japan-approves-19b-for-h-3-rocket>.

[337] Onuki, Misuzu. "MHI Formally Selected as H-X Prime Contractor, Operator." 25 Mar. 2014. SpaceNews 30 May 2014 <http://www.spacenews.com/article/financial-report/39971mhi-formally-selected-as-h-x-prime-contractor-operator>.

6.9 China

Chinese space policy revolves around the country's five-year economic development plans. The country's space programme is therefore intended to support overall development objectives, while maintaining a comprehensive set of objectives for space activities.

In 17 October 2014, China completed the construction of its fourth and largest spaceport, the Wenchang Satellite Launch Centre on the north-eastern coast of the southern Hainan Island.[338] At an estimated total cost of around $810 million this new spaceport is meant to lift large space stations and manned missions to the Moon and Mars.[339] The facility will accommodate launches of both Long March 5 and Long March 7; both of which are expected to fly before the end of 2015 as part of China's 12th Five-Year Plan for space. The Long March 5 is closely tied to the development of China's space station in which it will be mainly used for the lofting of China's manned space station, with the capacity to carry an 18 metric tons payload to NEO. The Long March 7 will be able to launch 12 metric tons into NEO, and will be capable of launching a cargo spacecraft to the country's manned space station. That said, a new Tiangong 2 space laboratory is planned for launch into orbit by 2016[340], followed by an experimental core module of the larger space station, and by 2022, China's manned space station should be completed. Both the Long March 5 and Long March 7 have been improved by using non-toxic and pollution-free propellant.[341]

While the upcoming Long March 5, 6 and 7 should be capable of undertaking the country's space activities planned for the coming 10 years; their capabilities will not be enough for China's long-term space programmes, which require a super-heavy rocket for deep-space exploration projects. Hence, China has begun planning a Long March 9 Super-Heavy launcher that is intended to be more powerful than the Saturn V launcher of the Apollo Moon missions, and will match the lift capacity of NASA's planned SLS Block 2 launcher. Still on the drawing board, the Long March 9 is expected to have a maximum launch capacity of 130 metric tons to LEO, and is expected to conduct its first launch in 2028.[342]

The Long March 5 is expected to conduct its first launch sometime in 2016, from the Hainan spaceport.[343]

On 21 November 2014, China conducted the second launch of its Kuaizhou mobile satellite launch vehicle (SLV), intended to have a rapid satellite repopulation capability, following the first launch on 25 September 2013.[344] Also, China is developing a second emergency response launch vehicle, Long March 11, to allow it to rapidly enter space and meet the emergency launching demand in the event of disasters and contingencies. It is expected to launch sometime in 2015.[345]

In the field of satellite development, the new Chinese space policy describes a comprehensive programme embracing all fields of satellite and spacecraft use. It calls for the development of improved weather and communications satellites, as well as of an entirely new Earth observation and electromagnetic monitoring satellite series. The key plank of this programme will be the development of a satellite fleet capable of all-weather 24-hour operations worldwide, which would imply making significant advancements in space borne SAR and high resolution optical instrument technologies. By the end of 2014, China had launched three Earth observation satellites, including the Gaofen 2, CBERS (a joint collaboration with Brazil), and Fengyun 2G, in addition to 11 Yaogan series remote sensing satellites (Yaogan 20A, 20B, 20C, 21, 22, 23, 24, 25A, 25B, 25C, and Yaogan 26) for China's defence programme.[346]

[338] Wan, Adrian. "China's fourth spaceport completed in boost for space programme." 17 Oct. 2014. South China Morning Post 20 July 2015 <http://www.scmp.com/news/china/article/1618422/construction-mainlands-fourth-spaceport-finished>.
[339] "Chinese Rocket Engine Test a Big Step for Space Station Project." 15 July 2013. Space.com 2 May 2014 <http://www.space.com/21957-china-rocket-engine-test-space-station.html>.
[340] Wenz, John. "China to Launch a New Space Station in 2016." 10 Mar. 2015. Popular Mechanics 30 Sept. 2015 <http://www.popularmechanics.com/space/a14480/china-space-station-2016-tiangong-2/>.
[341] "Long March 7 Launch Vehicle Completed Booster Engine Firing Test." 26 Nov. 2013. China Manned Space Engineering 2 May 2014 <http://en.cmse.gov.cn/show.php?contentid=1355>.
[342] Lei, Zhao. "New Long March launcher on the drawing board." 9 Dec. 2014. SpaceDaily 16 July 2015 <http://www.spacedaily.com/reports/New_Long_March_launcher_on_the_drawing_board_999.html>.
[343] Wenz, John. "China to Launch a New Space Station in 2016." 10 Mar. 2015. Popular Mechanics 30 Sept. 2015 <http://www.popularmechanics.com/space/a14480/china-space-station-2016-tiangong-2/>.
[344] Fisher (Jr.), Richard D. "China launches second Kuaizhou mobile SLV." 26 Nov. 2014. HIS Jane's 360 16 July 2015 <http://www.janes.com/article/46360/china-launches-second-kuaizhou-mobile-slv>.
[345] Profiles of Government Space Programs. Paris: Euroconsult, 2014: 18.
[346] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2014. Washington DC: FAA, Feb. 2015: 190.

6.10 India

India's government approved its 12th five-year plan (2012-2017) in October 2012, which puts emphasis on speeding up the implementation of infrastructure projects, and aims to achieve an annual average economic growth rate of 8.2%.[347] However, India's space programmes are driven by a decade profile and directions for 2025. Over the next decade, India's space programme aims to strengthen its operational services in communications and navigation; enhance its remote sensing imaging capability; continue space science missions for better understanding of the solar system and the universe; and build on its experience in planetary exploratory missions.

Remarkably, ISRO's Mars Orbiter Mission (MOM), which lifted into space on 5 November 2013, reached the planet on 24 September 2014.[348] On reaching Mars, the spacecraft - carrying five indigenous scientific payloads consisting of a camera, two spectrometers, a radiometer, and a photometer – began observing Mars' surface, atmosphere and exosphere to gain a better understanding of the planet's evolution.[349] In this context, in September 2014 NASA and ISRO officials signed an agreement to establish a working group to explore potential coordinated observations and science analysis of Mars.[350]

India's space programme also aims to build on its development of heavy lift reusable launch vehicles, and to develop its own human space flight programme. While a human spaceflight mission will not be commenced before the year 2017, there are funds in the 12th five-year plan to continue with pre-project studies and to develop critical technologies associated with the proposed mission. Following the successful launch of India's Geosynchronous Satellite Launch Vehicle (GSLV)-Mark II on 5 January 2014, India now has a launcher capable of lifting a two-member crew to LEO orbit.[351] Furthermore, its GSLV-Mark III, which had its first sub-orbital test launch on 18 December 2014, will have additional mass left for conducting scientific experiments in addition to hosting a two-member crew.[352] The GSLV-Mark III launcher will begin commercial launches starting in 2017.[353]

Lastly, ISRO's Chairman Koppillil Radhakrishnan retired on 31 December 2014, following the success of ISRO's MOM orbiter, and the development of GSLV.[354] On 12 January 2015, the Indian government appointed ISRO science veteran, A S Kiran Kumar as Radhakrishnan's replacement for a tenure of three years.[355]

6.11 Brazil

Despite long-standing obstacles to Brazil's space and R&D development, and the lack of expertise in its workforce, Brazil is becoming an important space player of the future due to its geographic position close to the equator, and its economic potential.

In terms of partnerships with space powers around the globe, Brazil in collaboration with China, launched the CBERS-4 Earth observation satellite on 7 December 2014. The China-Brazil Earth Resources Satellite (CBERS) project has been an outlet for the two nations to have an ongoing global strategic partnership since 1988.[356] The first CBERS-1 launched in 1999, followed by CBERS-2 in 2003, CBERS-2B in 2007, and the failed launch of the CBERS-3 satellite on 9 December 2013 due to a malfunction in the

[347] "Government Approves 12th Five Year Plan." 4 Oct. 2012. The Times of India 3 May 2014 <http://timesofindia.indiatimes.com/business/india-business/Government-approves-12th-five-year-plan/articleshow/16672927.cms>.
[348] "Mars Mission: India creates history as Mangalyaan successfully enters Mars orbit in first attempt." 24 Sept. 2014. The Economic Times 22 Mar. 2015 <http://economictimes.indiatimes.com/news/science/mars-mission-india-creates-history-as-mangalyaan-successfully-enters-mars-orbit-in-first-attempt/articleshow/43299562.cms>.
[349] "Indian Space Research Organisation | Mars Orbiter Mission." Indian Space Research Organisation 31 Mar. 2014 <http://www.isro.org/mars/home.aspx>.
[350] Laxman, Srinivas. "Mars Orbiter Mission activates all science instruments as NASA, ISRO form joint Mars working group." 1 Oct. 2014. Planetary.org 22 Mar. 2015 <http://www.planetary.org/blogs/guest-blogs/2014/10010914-mars-orbiter-mission.html>.
[351] "GSLV." ISRO 19 Apr. 2013 <http://www.isro.org/launchvehicles/GSLV/gslv.aspx>.
[352] "India Not to Undertake Human Space Flight Before 2017: ISRO." 17 Sept. 2012. The Economic Times 3 May 2014 <http://articles.economictimes.indiatimes.com/2012-09-17/news/33902713_1_cryogenic-engine-gslv-mk-iii-radhakrishnan-today>.
[353] De Selding, Peter B. "65th International Astronautical Congress | India Poised To Expand Presence in Global Launch Market." 1 Oct. 2014. SpaceNews 14 July 2015 <http://spacenews.com/4205565th-international-astronautical-congress-india-poised-to-expand-presence/>.
[354] Jayaraman, K.S. "Nayak Named Interim Chief at ISRO." 6 Jan. 2015. SpaceNews 19 Aug. 2015 <http://spacenews.com/nayak-named-interim-chief-at-isro/>.
[355] Ram, Arun. "Government appoints Kiran Kumar Alur Seelin as Isro chairman." 12 Jan. 2015. Times of India 30 Sept. 2015 <http://timesofindia.indiatimes.com/india/Government-appoints-Kiran-Kumar-Alur-Seelin-as-Isro-chairman/articleshow/45859188.cms>.
[356] Ibid.

third stage of China's Long March 4B rocket.[357]

Brazil is also participating in cooperative programs with Ukraine to build six Cyclone-4 rockets that could launch heavy satellites into low Earth orbit (LEO) and small communications satellites to geostationary transfer orbit as part of Brazil's goal to have an autonomous operational launch capability. Brazil and Ukraine created the binational company "Alcântara Cyclone Space" (ACS), with financing divided equally, for commercial launches using the Ukrainian vehicle Cyclone-4 from the Alcântara Launch Center (CLA) whose proximity to the equator gives the launch vehicle more capacity to orbit than can be offered from alternative spaceports.[358] The launcher development program is estimated to cost 1.58 billion reals ($802.5 million) over the 10-year period. The Cyclone-4 program, listed as a separate budget item, has been allocated an additional 459.8 million reals ($233.8 million) during the 10-year period. Moreover, around 1.9 billion reals ($970 million) has been allocated for space infrastructure improvements, mostly going toward development of the ALC.[359] In 2014, Brazil's launcher development programme continued to receive the lion's-share of funding within the space programme, with 53% of the total space budget.[360] Brazil hopes to launch the Cyclone-4 rocket from the ALC sometime in 2015.

Other launch vehicles under development in Brazil include its Satellite Launch Vehicle (VLS-1) project and its Microsat Launch Vehicle (VLM) project. The VLS-1 project was paused in 2003, following an explosion on the launch pad killing 21 people, but development picked up again late in 2013, albeit with a shortage of funding and trained personnel. Under a previous agreement between Roscosmos and the Brazilian Space Agency (AEB), Russia will provide launcher technology to help complete the project.[361] Moreover, Brazil has partnered with the Germany DLR to develop its VLM, which was originally intended to be for suborbital mission purposes, but has evolved to have small satellite launch capabilities.[362]

And in December 2014, it appeared that Russia might increase its ties with Brazil, as it is considering moving its Sea Launch mobile platform and command ship from the coast of California, USA, to the coast of Brazil. However, for Brazil involvement with the Russian-Ukrainian owned Sea Launch AG has some drawbacks, including the use of foreign produced Zenit launchers, possible incompatibility with future plans for a follow-on Cyclone 5 rocket, and uncertainty regarding Sea Launch's reliability which has been plagued by failures and a gap in planned launches.[363]

6.12 Emerging Space Actors

In line with the development of South Korea's upgraded KSLV-2 launcher, the government intends to send the KSLV-2 to the Moon, carrying a probe and lunar rover to search for rare minerals on the surface by 2020.[364] In November 2014, the South Korean government reached the budget deliberation stage after the project had passed the feasibility study phase. South Korea's current Park Geun-hye government has made it a priority to develop its lunar orbiter and lunar module by 2020; five years earlier than planned by the previous Roh Moo-hyun administration's Space Development Roadmap and the Lee Myung-bak administration's Basic Promotion Plan for Space Development. The government anticipates the economic value of the mission to be approximately 3.8 trillion won ($3.469 billion), or 5.17 times the budget input, and expects to create 4,800 jobs. To accelerate development, South Korea signed a joint research agreement with NASA in July 2014, wherein KARI benefits from the core orbiter and probe technology transferred, while the

[357] "China Blames Long March Failure on Third-stage Malfunction." 10 Dec. 2013. SpaceNews 3 May 2014 <http://www.spacenews.com/article/launch-report/38585china-blames-long-march-failure-on-third-stage-malfunction>.
[358] "News from the 64th International Astronautical Congress | Backers Insist Brazilian Spaceport Is Nearing Launch Readiness." 4 Oct. 2013. SpaceNews 3 May 2014 <http://www.spacenews.com/article/launch-report/37550news-from-the-64th-international-astronautical-congress-backers-insist>.
[359] "Brazil Scales Back Launch Vehicle Plans." 10 Feb. 2013. Parabolic Arc 3 May 2014 <http://www.parabolicarc.com/2013/02/10/brazil-scales-back-launch-vehicle-plans/>.
[360] Euroconsult 2015. Profiles of Government Space Programs.
[361] "Russia Offers Brazil New Joint Space Projects." 20 Oct. 2013. RIA NOVOSTI 3 May 2014 <http://en.ria.ru/russia/20131020/184250734.html>.
[362] "Brazil Scales Back Launch Vehicle Plans." 10 Feb. 2013. Parabolic Arc 3 May 2014 <http://www.parabolicarc.com/2013/02/10/brazil-scales-back-launch-vehicle-plans/>.
[363] Messier, Doug. "Will Sea Launch End Up in Brazil?" 24 Dec. 2014. Parabolic Arc 20 July 2015 <http://www.parabolicarc.com/2014/12/24/sea-launch-brazil/>.
[364] "South Korea Reveals Moon-lander plans." 13 Nov. 2013. Nature.com 4 May 2014 <http://www.nature.com/news/south-korea-reveals-moon-lander-plans-1.14159>.

U.S. is able to do more economically attractive space research.[365]

In the Middle East region, Iran continued to establish itself as a regional space actor through the implementation of a comprehensive space programme. On 10 April 2014, Iran was said to have signed a protocol with Russia's Roscosmos on wide cooperation in space exploration, ranging from training Iranian cosmonauts in Russia to potential technology transfers in developing remote sensing and telecommunication satellites. Iran also intends to build domestic communication stations capable of receiving information from Russia's Resurs-DK and Resurs-P satellites, and it may contract with Russia for the construction and launch of a reconnaissance satellite and a telecommunications satellite, which might concern the U.S. and parts of the Middle East due to its potential civilian and military applications.[366]

[365] "Korea Ready to Become 7th Country to Reach the Moon." 13 Nov. 2014. Business Korea 20 July 2015 <http://www.businesskorea.co.kr/article/7278/lunar-exploration-project-korea-ready-become-7th-country-reach-moon>.

[366] "Russia to train Iranian cosmonauts, build recon sats – report." 7 May 2014. RT.com 20 July 2015 <http://www.rt.com/news/157496-russia-iran-space-satellite/>.

List of Acronyms

Acronym	Explanation
A	
ABS	Asia Broadcast Satellite
ACS	Alcântara Cyclone Space
ADF	Aerospace Defence Forces
AEB	Agência Espacial Brasileira (Brazilian Space Agency)
AG	Aktiengesellschaft
AIA	Aerospace Industry Association
Airbus D&S	Airbus Defence and Space
ARM	Asteroid Redirect Mission
ASAT	Anti-Satellite
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ATV	Automated Transfer Vehicle
B	
BMD	Ballistic Missile Defence
C	
CAA	Civil Aviation Authority
CAGR	Compound Annual Growth Rate
CAST	China Aerospace Science and Technology Corp.
CBERS	China-Brazil Earth Resources Satellite
CCP	Commercial Crew Programme
CD	Conference on Disarmament
CHF	Swiss franc
CHIRP	Commercially Hosted Infrared Payload
CLA	Alcântara Launch Center
CNES	Centre National d'Études Spatiales (French Space Agency)
COP	Conference of the Parties
CRS	Commercial Resupply Services
CSA	Canadian Space Agency
D	
DARS	Digital Audio Radio Service
DBS	Direct Broadcast Services

Acronym	Explanation
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DND	Department of National Defence
DoD	Department of Defence
DoT	Department of Telecom
DRDO	Defence Research and Development Organisation
DSCOVR	Deep Space Climate ObserVatoRy
DTH	Direct To Home
E	
EAP	Environmental Action Programme
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
ECA	Evolution Cryotechnique type A
EDA	European Defence Agency
EDRS	European Data Relay Satellite System
EELV	Evolved Expendable Launch Vehicle
EFT	Exploration Flight Test
EKV	Exoatmospheric Kill Vehicle
EPS-SG	European Polar System Second Generation
ESA	European Space Agency
EU	European Union
EUMETSAT	The European Organisation for the Exploitation of Meteorological Satellites
EUTELSAT	European Telecommunications Satellite Organisation
F	
FAA	Federal Aviation Administration
FSS	Fixed Satellite Services
G	
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEO	Geostationary Earth Orbit
GmbH	Gesellschaft mit beschränkter Haftung
GMD	Ground-based Midcourse Defence
GMES	Global Collaborative Space Programme Monitoring for Environment and Security
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
GSLV	Geosynchronous Satellite Launch Vehicle
GTO	Geosynchronous Transfer Orbits

Acronym	Explanation
H	
HTV	H2A Transfer Vehicle
I	
IAC	International Astronautical Congress
ICoC	International Space Code of Conduct for Outer Space Activities
ICS	Information and Communication Systems
IGS	International GNSS Service
ILS	International Launch Services
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contributions
IR	Infrared
IS	Islamic State or ISIS
ISRO	Indian Space Research Organization
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
IXV	Intermediate Experimental Vehicle
J	
JAXA	Japan Aerospace Exploration Agency
K	
KSLV	Korea Space Launch Vehicle
L	
LEO	Low Earth Orbit
M	
MDA	MacDonald, Dettwiler and Associates Ltd.
Melco	Mitsubishi Electric Co.
MEO	Medium Earth Orbit
Metop	Meteorological Operational Satellite
Metop-SG	Metop Second Generation
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MFF	Multiannual Financial Framework
MFG	Meteosat First Generation
MSG	Meteosat Second Generation
MSS	Mobile Satellite Service
MTG	Meteosat Third Generation

Acronym	Explanation
N	
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organisation
NDAA	National Defense Authorization Act
NEC	Nippon Electric Company
NEO	Near-Earth Orbit
NOAA	National Oceanic and Atmospheric Administration
NRO	National Reconnaissance Office
O	
OECD	Organisation for Economic Co-operation and Development
OHB	Orbitale Hochtechnologie Bremen
ONSP	Office of National Space Policy)
OPEC	Organization of the Petroleum Exporting Countries
OPSAT	OPtical SATellite
P	
PDV	Prithvi Defence Vehicle
PLA	People's Liberation Army
PND	Portable Navigation Devices
PPP	Public-Private Partnership
PPWT	Treaty on Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects
PRS	Public Regulated Service
PSLV	Polar Satellite Launch Vehicle
Q	
QZSS	Quasi-Zenith Satellite System
R	
ROSINA	Rosetta's Orbiter Spectrometer for Ion and Neutral Analysis
S	
SAR	Synthetic Aperture Radar
SE	Societas Europae
SES	Société Européenne des Satellites
SIA	Satellite Industry Association
SIP	Swiss Innovation Park
SLS	Space Launch System
SLV	Satellite Launch Vehicle

Acronym	Explanation
SpaceX	Space Exploration Technologies
SS/L	Space Systems/Loral
SSA	Space Situational Awareness
SST	SpaceShip Two
T	
TAI	Turkish Aerospace Industries
TCBM	Transparency and Confidence Building Measures
TFEU	Treaty on the Functioning of the European Union
U	
UK	United Kingdom
UKSA	UK Space Agency
ULA	United Launch Alliance
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
UNREDD	United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
U.S.	United States of America
U.S. MDA	Missile Defense Agency
USAF	U.S. Air Force
USAT	Ultra Small Aperture Terminals
V	
VLM	Brazil's Microsat Launch Vehicle
VLS-1	Brazil's Satellite Launch Vehicle
VSAT	Very Small Aperture Terminals
W	
WGP	World Gross Product

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