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1. Global Political and Economic Trends

1.1 Global Economic Outlook

The "World Economic Situation and Prospects" report is the United Nation's lead publication in the annual discussion of current economic trends and prospects. Its 2016 reporting painted a bleak picture, and the global economy looked to be held back by both slow growth and reduced international trade. However, 2017 has seen a turnaround, and it was estimated that global economic growth reached 3%, representing a large step up from the 2.4% of 2016 and also the greatest global growth rate since 2011. Furthermore, about two-thirds of countries have seen increased growth from the sluggishness which characterized 2016, and globally levels are expected to hold at 3% into 2019.[1]

WGP growth in developed economies increased from 1.6% in 2016 to 2.2% in 2017, with decreases to 2.0% in 2018 and 1.9% in 2019 estimated. As of 2017, synchronised growth is seen across all of the major developed economies. In Europe, both the Union and the Euro Area saw growth improvements over 2016 to 2017, with the new members (EU-13) in particular showing significant growth from 2.9% to 4.2%. This growth among Eastern European and Baltic EU members is attributed to improvements in productivity and capital accumulation. The EU-15 rate also rose to 2.0% in 2017 from 1.8% in 2016, although for all aforementioned regions decreases are forecasted in 2018. Across the Atlantic, the same trend is seen, where the US also saw a rise from 1.5% in 2016 to 2.2% in 2017, but with a drop to 2.1% expected in 2018. Likewise, Japan has seen growth in output from 1.0% in 2016 to 1.7% in 2017, and again a decrease in 2018 to 1.2%.[2]

Overall, transition economies follow a pattern of overall general growth each year in the same period, from a rate of 0.4% in 2016 to an estimated 2.4% in 2019. However, looking at individual regions, different fluctuations are observed: South-Eastern Europe, for example, demonstrates an opposite pattern from the developed economies, with a drop from 2.9% in 2016 to 2.5% in 2017, followed by an estimated growth towards 3.2% in 2018 and on to 3.3% in 2019. The Commonwealth of Independent States and Georgia saw significant growth from a rate of -2.4% in 2015 to 0.3% in 2016 and again significant growth to a rate of 2.2% in 2017. Developing economies overall, however, have also seen a general rise from 3.8% in 2016 to 4.3% in 2017, with further growth estimated at a rate of 4.6% 2018 and 4.7% in 2019, and as a group they are considered to remain the primary drivers of growth worldwide in 2017. South America's rate of -2.7% in 2016 turned up to 0.4% in 2017 and is also forecasted to reach 1.8% in 2018. The African continent is also demonstrating an overall fast upward trend, with its 2016 rate of 1.7% increasingly to 3.0% in 2017 and again to 3.5% in 2018.[3]

The recent strengthened activity seen in global averages and the developed countries has not been observed across all parts of the world. The growth, and in some regions' cases rapid growth, in world gross product is largely attributed to (in order of the scale of contribution to the change in world gross product growth) the USA, Japan, the Euro Area, and Canada. In addition, a third of 2017's global growth is also attributed to cyclical activity in Argentina, Brazil, Nigeria, and Russia. Despite these general improvements, though, effects from the low investment and productivity growth rates resulting from the global financial crisis are still observable in wage growth, debt levels, and policy uncertainty, which themselves are holding back aggregate demand. And despite the general growth rate improvements of 2017, the prospects are not secure regarding the Sustainable Development Goals (SDGs), which aim to eradicate extreme poverty and create decent work for all. In fact, despite the overall positive global trends, forecasts reflect decreased growth for some regions, including for some of the poorest countries. And due to the decrease in GDP per capita in West, Central, and Southern Africa, as well as Latin

[1] "World Economic Situation and Prospects 2018." 11 Dec. 2017. United Nations, 15 Mar. 2018 <https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/WESP2018_Full_Web-1.pdf >

[2] Ibid.

[3] Ibid.

American and the Caribbean in 2016, SDG progress has even been reduced in some countries.[4]

1.2 Political Developments

1.2.1 Geopolitics

North Korea's Weapons Testing in 2017

North Korea's missile and nuclear testing activities continued into 2017 with a series of missile tests including three Intercontinental Ballistic Missile (ICBM) tests and its 6th nuclear test.[5] The ICBM flight tests were the first for the state led by Kim Jung-un, with the first test announced by North Korea on 4 July 2017, as the United States celebrated its national Independence Day; North Korea state television highlighted that the country is now "a full-fledged nuclear power that possesses [a] powerful inter-continental ballistic rocket capable of hitting any part of the world." And as a follow-up in the media, Kim Jung-un also reportedly stated that the United States would not be pleased by this "package of gifts".[6] The third test flight in November flew 960 km and reached an altitude of 4,500 km, thousands of kilometers higher than the International Space Station, and is considered capable of reaching any point in the continental US[7]. The development marks a steady growth in North Korea's technical capability while the rhetoric between the state, its neighbours, and the United States has remained aggressive. It is however not clear how the global community can respond to deescalate the situation. Further complicating the matter, deployment of the American-built Terminal High Altitude Area Defense (THAAD) system began in South Korea in early 2017, but sparked significant diplomatic tension with China[8]. The latter does not consider the system to be a strong deterrent and has concerns about whether THAAD's radar is capable of reaching far into its own territory[9]. And for its part, international relations experts are growing skeptical of China's ability to deter North Korea[10,11]. And this in itself further raises the question of if a military response is the only means capable of deterring the state's behavior, and US President Donald Trump has repeatedly made clear that this would indeed be an option[12]. Lastly, the situation is unique in that it is one of the few current issues around which China, Russia, and the US are generally aligned, all having a common goal of de-escalation[13,14].

US President Trump's First Year in Office

US President Donald Trump's presidency, for which he was inaugurated on 20 January 2017, has been a major media focus in 2017, with his actions, nominations, appointments, the close role of his family in the White House, and public statements having caused significant controversy[15]. Major examples include the withdrawal from the Paris Climate Agreement and his stance in general towards climate change, recognition of Jerusalem as the Israeli capital, and an increase in the use of drones (especially with regards to civilian casualties)[16,17]. From the perspective of diverse interest groups, his actions have been often met with either great satisfaction or outrage, although all agree that the stakes are ex-

[4] Ibid.
[5] "North Korea: A Timeline of Missile and Warhead Tests in 2017." Time.com, 26 Feb. 2018 (retrieved) <http://time.com/5040375/north-korea-nuclear-missile-tests-2017/>.
[6] Campbell, Charlie. "How North Korea's ICBM Test Could Bring Negotiators Back to the Table." 5 July 2017. Time.com, 26 Feb. 2018 <http://time.com/4844829/north-korea-missile-icbm-negotiation/>.
[7] *Op. cit.* - "North Korea: A Timeline of Missile and Warhead Tests in 2017."
[8] Westcott, Ben and Suk, Lauren. "China, South Korea end year-long diplomatic feud over missile system." 31 Oct. 2017. CNN, 26 Feb. 2018 <https://edition.cnn.com/2017/10/31/asia/china-south-korea-thaad/index.html>.
[9] "South Korea to deploy more THAAD units after North Korea ICBM launch." 29 July 2017. Reuters, 26 Feb. 2018 <https://www.reuters.com/article/us-norhtkorea-missiles-thaad/south-korea-to-deploy-more-thaad-units-after-north-korea-icbm-launch-idUSKBN1AE02L>.
[10] Albert, Eleanor. "The China–North Korea Relationship." 28 Mar. 2018. Council on Foreign Relations, 26 Feb. 2018 <https://www.cfr.org/backgrounder/china-north-korea-relationship>.
[11] Fisher, Max. "Bad News, World: China Can't Solve the North Korea Problem." 6 Sep. 2017. The New York Times, 26 Feb. 2018 <https://www.nytimes.com/2017/09/06/world/asia/china-north-korea-nuclear-problem.html?mcubz=0&_r=0>.
[12] *Op. cit.* - "The China–North Korea Relationship."
[13] "Russia, China Urge Peaceful Resolution to North Korea Tensions." 25 Dec. 2017. VOA News, 26 Feb. 2018 <https://www.voanews.com/a/russia-china-north-korea-tensions/4178038.html>.
[14] "Explaining U.S. Policy Toward North Korea." (Interview transcript, with NPR host David Greene) 13 Sep. 2017. NPR, 26 Feb. 2018 <https://www.npr.org/2017/09/13/550607412/explaining-u-s-policy-toward-north-korea>.
[15] Lewis, Tanya. "A Year of Trump: Science Is a Major Casualty in the New Politics of Disruption." 14 Dec. 2017. Scientific American, 26 Feb. 2018 <https://www.scientificamerican.com/article/a-year-of-trump-science-is-a-major-casualty-in-the-new-politics-of-disruption/>.
[16] Lindsay, James M. "Ten Most Significant World Events in 2017." 15 Dec. 2017. Council on Foreign Relations, 26 Feb. 2018 <https://www.cfr.org/blog/ten-most-significant-world-events-2017>.
[17] "'Trump looking to loosen Obama limits on drone strikes'." 22 Sep. 2017. Al Jazeera, 26 Feb. 2018 <https://www.aljazeera.com/news/2017/09/loosen-obama-limits-drone-strikes-170922141205178.html>.

tremely significant. The American space community was, for its part, excited by President Trump's reestablishment of the National Space Council, which was previously disbanded in 1993 and has been given an ambitious mandate of maintaining American space leadership[18]. However, some actions have even resulted in direct resistance from other branches of government; for example, all three iterations of his ban on travel to the US from certain majority-Muslim nations were fought against by federal courts[19,20,21] as well as a White House policy banning service in the military by transgender people[22]. And looming above all of this, Trump's presidency remains under the intense spotlight of a Special Counsel inquiry regarding collusion with Russian actors leading to interference in the 2016 election (led by Robert Mueller of the US Department of Justice), with 19 individuals having already been indicted, including four from his own campaign team or administration.[23]

Brexit Developments in 2017

The path towards the UK's departure from the European Union, which began in earnest with its June 2016 referendum, saw two major developments in 2017: Firstly, the invocation of the Lisbon Treaty's Article 50 on 29 March, being the necessary first step in the withdrawal process and which has given the UK exactly two years to negotiate the terms of its departure. And secondly, the conclusion of an agreement on 8 December which, in an often-used and apt description, enables Britain and the EU to focus on their *divorce* negotiations[24]. The deal importantly covers, among other negotiation points, the future economic relationship between the two actors, the status of the Irish border, the rights of EU and UK citizens living in each other's territories, and the financial settlement of the UK's obligations to the EU, estimated to be as high as €60 billion[25,26,27]. Up next, preliminary discussions on a future trade deal can begin, although the UK cannot sign on any final document while it is still in the Union.[28] And at home, British PM Theresa May is now one step closer to the impossible task of pursuing a Brexit arrangement that satisfies all voices; the debate is largely between supporters of so-called "hard" and "soft" Brexits, with their opinions sometimes expressed in very colourful language[29]. A hard Brexit could see the UK leave the EU single market and return to a trade relationship based on World Trade Organization rules. It would also give priority to Britain having full control over its borders. A soft approach would see the British relationship with the EU try to stick to the status quo as much as possible; it would still have access to the single market, but lose its MEPs and European Commissioner.[30,31] Throughout 2017, the Brexit topic continually represented a dramatic source of news and a final outcome is still not clear. Two big questions linger: Will the resulting relationship look significantly different than that of 2017? And would that make all the effort worth it?

The Conflicts in Iraq and Syria

The conflicts in Iraq and Syria have caused both states' populations to experience horrific conditions and have contributed to a global refugee crisis for which humanitarian systems were not prepared.

In July 2017, Iraqi forces retook Mosul – the city where Abu Bakr al-Baghdadi claimed he was the head of a new caliphate, the Islamic State, three years prior – and in December

[18] "President Trump reestablishes National Space Council." 30 June 2017. SpaceNews, 27 Feb. 2018 <http://spacenews.com/breaking-president-trump-reestablishes-national-space-council/>.
[19] Bradner, Eric. "Resistance to Trump's travel ban mounts." 30 Jan. 2017. CNN, 27 Feb. 2018 <https://edition.cnn.com/2017/01/29/politics/donald-trump-travel-ban-resistance/index.html>.
[20] Siddiqui, Sabrina. "Refugee admissions nearly halved as supreme court mulls Trump travel ban." 24 June 2017. The Guardian, 27 Feb. 2018 <https://www.theguardian.com/us-news/2017/jun/24/us-refugees-donald-trump-travel-ban>.
[21] Zapotosky, Matt. "Federal judge blocks Trumps third travel ban." 17 Oct. 2017. Washington Post, 27 Feb. 2018 <https://www.washingtonpost.com/world/national-security/federal-judge-blocks-trumps-third-travel-ban/2017/10/17/e73293fc-ae90-11e7-9e58-e6288544af98_story.html?utm_term=.8beb83a89936>.
[22] Philipps, Dave. "Judge Blocks Trump's Ban on Transgender Troops in Military." 30 Oct. 2017. New York Times, 27 Feb. 2018 <https://www.nytimes.com/2017/10/30/us/military-transgender-ban.html>.
[23] "Trump Russia affair: Key questions answered." Updated regularly. BBC, 27 Feb. 2018 (retrieved) <http://www.bbc.com/news/world-us-canada-42493918>.
[24] *Op. cit.* - "Ten Most Significant World Events in 2017."
[25] Meyer, David. "Here's What the U.K. and EU Just Agreed To in the Brexit Deal." 8 Dec. 2017. Fortune.com, 28 Feb. 2018 <http://fortune.com/2017/12/08/brexit-deal-uk-eu-agree-explainer/>.
[26] Mason, Rowena. "Main points of agreement between UK and EU in Brexit deal." 8 Dec. 2017. The Guardian, 28 Feb. 2018 <https://www.theguardian.com/uk-news/2017/dec/08/main-points-of-agreement-uk-eu-brexit-deal>.
[27] *Op. cit.* - "Ten Most Significant World Events in 2017."
[28] "Brexit: 'Breakthrough' deal paves way for future trade talks." 8 Dec. 2017. BBC, 28 Feb. 2018 <http://www.bbc.com/news/uk-politics-42277040>.
[29] *Op. cit.* - "Here's What the U.K. and EU Just Agreed To in the Brexit Deal."
[30] Sims, Alexandra. "What is the difference between hard and soft Brexit? Everything you need to know." Independent, 28 Feb. 2018 <http://www.independent.co.uk/news/uk/politics/brexit-hard-soft-what-is-the-difference-uk-eu-single-market-freedom-movement-theresa-may-a7342591.html>.
[31] "Brexit: What are the options?" 12 June 2017. BBC, 28 Feb. 2018 <http://www.bbc.com/news/uk-politics-37507129>.

2017 the Iraqi prime minister Haider al-Abadi formally declared an end of fighting against the extremist group[32,33,34]. Despite this landmark in the fight against the Islamic State, it came at a huge cost and the future remains uncertain for Iraq: Up to possibly 40,000 civilians lost their lives in the fighting for Mosul alone, and the city is in ruins[35]. The 2017 figures also reflect a grave loss of human life resulting from Syria's civil war – where the Islamic State also claims and has held territory – with over 10,000 civilian deaths recorded.[36,37,38] The UNHCR also reports a total of 5,479,277 registered Syrian refugees that have fled their homes as a result of the conflict from 2013 to the end of 2017.[39] By the fall of 2017, Turkey was hosting over 3 million Syrian refugees and as of December 2017 1,015,500 Syrian-citizen asylum applications had been made in Europe.[40,41] Further, host and donor states alike desire for the refugees to return home as soon as possible (due to the costs of supporting the refugees and the extra infrastructural strain), but the fighting in Syria remains intense and polling among refugees indicates that most want to return, but only once the conflict has ended[42,43]. The UNHCR echoes this attitude, stating that it cannot facilitate returns given the ongoing risks[44].

Cyber Threats Growing and Growing more Severe

The year 2017 profoundly demonstrated how the cyber domain, existing in the cables and hard drives of society's communications infrastructure, can be both a tool for and a theatre of war as well as a medium for criminal activity. Cyber-related incidents in 2017 that posed real-world consequences include the WannaCry ransomware attack (effecting 200,000 victims in 150 countries[45] and which terrifyingly disrupted a third of British NHS locations[46]), the leaking of hacking tools believed to belong to the US NSA (which were later used in the WannaCry attack), and the October announcement of the breach in 2013 of Yahoo's 3 billion customer accounts[47]. The cyber domain has also played a significant role in conflict contexts in recent years, with the Syrian civil war providing many examples: the arrest and torture of activists leading to the access of their social media accounts, the tracking of opposition groups' meeting locations via IP addresses, the spamming of US government websites and news sites by the Syrian Electronic Army, as well as a major hacking operation in late 2013 and early 2014 against opposition forces[48]. In the latter incident, "hackers stole a cache of critical documents and Skype conversations revealing the Syrian opposition's strategy, tactical battle plans, supply needs, and troves of personal information and chat sessions", representing

[32] "Iraqi Forces Retake City Of Mosul From ISIS Fighters." (Interview transcript, with NPR host Kelly McEvers) 10 July 2017. NPR, 28 Feb. 2018 <https://www.npr.org/2017/07/10/536505269/iraqi-forces-retake-city-of-mosul-from-isis-fighters>.
[33] Collard, Rebecca. "What We Have Learned Since ISIS Declared a Caliphate One Year Ago." 25 June 2017. Time.com, 28 Feb. 2018 <http://time.com/3933568/isis-caliphate-one-year/>.
[34] Graham-Harrison, Emma. "Iraq formally declares end to fight against Islamic State." 9 Dec. 2017. The Guardian, 28 Feb. 2018 <https://www.theguardian.com/world/2017/dec/09/iraq-formally-declares-end-to-fight-against-islamic-state>.
[35] *Op. cit.* - "Ten Most Significant World Events in 2017."
[36] El Hilali, Nouran Mohamed and Petkova, Mariya. "MAPPED: The battle against ISIL." 15 Oct. 2017. Al Jazeera, 28 Feb. 2018 <https://www.aljazeera.com/indepth/interactive/2017/04/map-isil-syria-iraq-170413092750456.html>.
[37] "10,204 Civilians Killed In Syria In 2017." 28 Jan. 2018. I AM SYRIA, 28 Feb. 2018 <http://www.iamsyria.org/syrian-conflict-in-2017.html>.
[38] "2017…the year of the military change and the rise of the regime and its allies to head the list of military powers and influences followed by the SDF…and the loss of the opposition and the organization to large spaces of their controlled areas." 28 Dec. 2017. The Syrian Observatory for Human Rights, 28 Feb. 2018 <http://www.syriahr.com/en/?p=81564>.
[39] "Operational Portal, Refugee Situations – Syria Regional Refugee Response." data from 31 Dec. 2017. UNHCR, 1 Mar. 2018 <https://data2.unhcr.org/en/situations/Syria>.
[40] "3RP 2017 Progress Report." (Download page) 17 Oct. 2017. UNHCR, 28 Feb. 2018 <http://data.unhcr.org/syrianrefugees/download.php?id=14381>.
[41] *Op. cit.* - "Operational Portal, Refugee Situations – Syria Regional Refugee Response."
[42] Crisp, Jeff. "Why It's Far Too Early to Talk of Return for Syrian Refugees." 11 Aug. 2017. News Deeply, 28 Feb. 2018 <https://www.newsdeeply.com/refugees/community/2017/08/11/why-its-far-too-early-to-talk-of-return-for-syrian-refugees-2>.
[43] El Gantri, Rim and El Mufti, Karim. "Not Without Dignity: Views of Syrian Refugees in Lebanon on Displacement, Conditions of Return, and Coexistence." 9 June 2017. International Center for Transitional Justice, 28 Feb. 2018 <https://www.ictj.org/publication/syria-refugees-lebanon-displacement-return-coexistence>.
[44] *Op. cit.* - "Why It's Far Too Early to Talk of Return for Syrian Refugees."
[45] Belot, Henry and Borys, Stephanie. "Ransomware attack still looms in Australia as Government warns WannaCry threat not over." 16 May 2017. ABC.net.au, 2 Mar. 2018 <http://www.abc.net.au/news/2017-05-15/ransomware-attack-to-hit-victims-in-australia-government-says/8526346>.
[46] "NHS 'could have prevented' WannaCry ransomware attack." 27 Oct. 2018. BBC, 2 Mar. 2018 <http://www.bbc.com/news/technology-41753022>.
[47] Larson, Selena. "The hacks that left us exposed in 2017." 20 Dec. 2017. CNN, 2 Mar. 2018 <http://money.cnn.com/2017/12/18/technology/biggest-cyberattacks-of-the-year/index.html>.
[48] Ruhfus, Juliana. "Syria's Electronic Armies." 18 June 2015. Al Jazeera, 2 Mar. 2018 <https://www.aljazeera.com/programmes/peopleandpower/2015/06/syria-electronic-armies-150617151503360.html>.

data belonging to the opposition and humanitarian aid workers as well as media activists[49]. The hacking group Anonymous has targeted numerous Twitter and Facebook accounts of the Islamic State and has also attacked the Syrian Ministry of Defence[50]. Cyber-attacks in other contexts have also been known to shut down major infrastructure and technological systems, including the electrical power supply for over 230,000 residents in Ukraine[51]– an attack later described as "brilliant" by a member of an investigative team – and an American-Israeli "computer worm" known as Stuxnet which targeted an Iranian nuclear enrichment facility, causing its centrifuges to speed up or down in such a way that they destroyed themselves, all while leaving normal indicators on computer readings.[52] Iran is not the only known American target, with President Barack Obama having also ordered the Pentagon to increase its cyber strikes against North Korea's missile program[53].

In light of these threats and risks, governments worldwide are reacting through the development of national cybersecurity strategies. According to the ITU's Global Cybersecurity Index report of 2017, 38% of countries worldwide have published a cybersecurity strategy, 11% have a standalone and dedicated cybersecurity strategy, and 12% have one in development.[54] There is also discussion on the idea of a digital Geneva Convention, which Microsoft President Brad Smith is calling for[55].

Given the real-world risks resulting from emails being hacked and released (which American intelligence agencies have concluded Russia authorised against the US Democratic National Committee[56]), from power grid interruptions in the winter in Ukraine, and from healthcare appointments being cancelled due to ransomware attacks as in the UK, it is clear that cyber security will continue to grow as a core governance priority.

1.2.2 Environment

The 2015 Paris Agreement aims to keep global average temperature increases to below 2°C above pre-industrial levels, and to make more ambitious efforts to limit temperature increases even further to 1.5°C, and eliminate the increase of greenhouse gas emissions in the second half of the century.[57] Following its creation in the 21st UN Framework Convention on Climate Change Conference of Parties (UN FCCC/COP), it entered into force on 4 November 2016. This was triggered by the ratification of the European Union on 5 October 2016, which met the threshold that at least 55 Parties, accounting for at least an estimated 55% of total global greenhouse emissions, ratify the instrument. China and India, representing two of the greatest contributors to greenhouse gas emissions, are among the ratifying states, and 172 in total had ratified it by the end of 2017[58,59]. However, US President Donal Trump's announcement in June to withdraw the United States' participation was noted with disappointment by the global environmental protection community in 2017, and Russia has yet to ratify it[60,61].

The 23rd UN FCCC/COP, took place in Bonn, Germany, from 6 to 17 November 2017.[62] The event likewise served as the 13th session of the Meeting of the Parties to the Kyoto Protocol, and was the platform for continued discussions of the Paris Agreement's governing body. In order for the Agreement to be fully

[49] "Behind the Syrian Conflict's Digital Frontlines." 2 Feb. 2015. FireEye Inc., 2 Mar. 2018 https://www.fireeye.com/blog/threat-research/2015/02/behind_the_syrianco.html
[50] *Op. cit.* - "Syria's Electronic Armies."
[51] Zetter, Kim. "Inside The Cunning, Unprecedented Hack Of Ukraine's Power Grid." 3 Mar. 2016. Wired, 2 Mar. 2018 <https://www.wired.com/2016/03/inside-cunning-unprecedented-hack-ukraines-power-grid/>.
[52] Szoldra, Paul. "A new film gives a frightening look at how the US used cyberwarfare to destroy nukes." 7 July 2016. Business Insider, <http://www.businessinsider.com/zero-days-stuxnet-cyber-weapon-2016-7?IR=T>.
[53] Broad, William J. and Sanger, David E. "Trump Inherits a Secret Cyberwar Against North Korean Missiles." 4 Mar. 2017. New York Times, 2 Mar. 2018 <https://www.nytimes.com/2017/03/04/world/asia/north-korea-missile-program-sabotage.html>.
[54] "Global Cybersecurity Index 2017." (Download page) 19 July 2017. ITU, 2 Mar. 2018 <https://www.itu.int/pub/D-STR-GCI.01-2017>.
[55] Vanian, Jonathan. "Here's Why Microsoft President Wants a Digital Geneva Convention." 14 Feb. 2017. Fortune, 2 Mar. 2018 <http://fortune.com/2017/02/14/microsoft-president-digital-geneva-convention/>.
[56] *Op. cit.* - "Trump Russia affair: Key questions answered."
[57] "The Paris agreement marks an unprecedented political recognition of the risks of climate change." 12 Dec. 2015. The Economist, 7 Mar. 2018 <http://www.economist.com/node/21683990/>.
[58] "Paris Agreement - Status of Ratification." Updated regularly. UN Climate Change, 7 Mar. 2018 <http://unfccc.int/paris_agreement/items/9444.php>.
[59] "Paris Agreement Reaches 175 Ratifications." 6 Mar. 2018. IISD / SDG Knowledge Hub, 7 Mar. 2018 <http://sdg.iisd.org/news/paris-agreement-reaches-175-ratifications/>.
[60] Volcovici, Valerie. "U.S. submits formal notice of withdrawal from Paris climate pact." 4 Aug. 2017. Reuters, 7 Mar. 2018 <https://www.reuters.com/article/us-un-climate-usa-paris/u-s-submits-formal-notice-of-withdrawal-from-paris-climate-pact-idUSKBN1AK2FM>.
[61] *Op. Cit.* - "Paris Agreement - Status of Ratification."
[62] "About COP23 – Bonn, 2017." UN Climate Change Conference – COP23 Fiji, 7 Mar. 2018 <https://cop23.com.fj/about-cop-23/about-cop23/>.

operational, its Parties' first need to elaborate and adopt decisions on several topics including mitigation (e.g. nationally determined contributions (NDCs)), adaptation communications, finance, transparency, "global stocktake", and market and non-market mechanisms. They aim to do so by the 24th COP in December 2018, ahead of the 2020 timeline from which the agreement was intended to begin, and in Bonn they reaffirmed their commitment to this schedule.[63] Among the main accomplishments of the Bonn Conference was the launch of the InsuResilience Global Partnership, which aims to bring climate and disaster risk insurance solutions to millions who are at risk globally; the German Federal Ministry for Economic Cooperation and Development providd 110 million euros to support this partnership[64,65].

Looking ahead, the 24th UN FCCC/COP will be held in Katowice, Poland in December 2018.[66]

1.2.3 Energy

With the Paris Agreement's ratification by over 170 countries by the end of 2017[67] and the reports that in 2017 the Arctic saw its second warmest year on record and its overall lowest level of sea ice[68], the global energy sector is increasingly under the spotlight. Further, this same dynamic between positive developments and alarming statistics can also be seen throughout the International Energy Agency's (IEA) recent reporting; for example, as of 2016 the energy sector accounted for at least two-thirds of greenhouse gas emissions, but in its 2017 World Energy Outlook, it indicates that from the present to 2040 renewable sources will represent 40% of the increase in primary demand.[69] Likewise, although their levels had recently plateaued, energy-related CO_2 emissions will grow slightly in baseline scenario reporting to 2040, and the demand for energy will grow by 30% in the same period. However, global trends broadly indicate that natural gas, the increasing role of electricity and renewables, and high energy efficient technologies are coming to the fore while coal's dominant years are behind it.[70]

This agrees with the 2016 World Energy Outlook, which indicated that natural gas, as well as oil along with it, will remain the bedrock of the global energy system for many decades to come. The 2017 World Energy Outlook forecasts that through to 2040 the demand for oil will continue to grow, and the US in particular will support this demand by putting out 50% more of oil and gas combined than any other country. In terms of consumption, China's use is expected to exceed the US by 2030, but demand growth India is forecasted to exceed that of China after 2025. In terms of coal, China, known for its coal-oriented energy system, is embracing a new energy approach promoting natural gas and high-efficiency and clean technologies, and in India the level of coal in total consumption will decrease to less than half in 2040 from its current three-quarters share. A decrease in the use of coal since 2000 and into the forecasted period up to 2040 is also clearly seen: the capacity of coal-based power generation grew by nearly 900 gigawatts, although net additions as of 2017 into 2040 are less than half.[71]

The role of electricity is also forecasted to grow significantly as an end-use of energy, representing 40% of the growth in final consumption up through 2040. Electric motor systems at the industrial level, in particular, take one-third of the growth in power demand in baseline scenario reporting. Other contributing factors include the spread of electric cars globally, especially in countries which have policy support for reducing the sale of gas and diesel vehicles like the UK and France; the use of electricity for final consumption in heating and mobility; and furthermore the growing demand for electrical home appliances as incomes rise. However, to facilitate this growth in this consumption of energy through electricity, major consumers like China and India must significantly expand their infrastructure accordingly. The IEA foresees that to facilitate this rise in consumption, China, for example, will need to expand its existing infrastructural capacity with that of the United States today. And as further indication of the rise of electricity, con-

[63] "Earth Negotiations Bulletin." (Volume 12 Number 714) 21 Nov. 2017. IISD Reporting Services, 7 Mar. 2018 <http://enb.iisd.org/vol12/enb12714e.html>.
[64] "Key Achievements from COP23." 18 Nov. 2017. UN Climate Change Conference – COP23 Fiji, 7 Mar. 2018 <https://cop23.com.fj/key-achievements-cop23/>.
[65] "InsuResilience Global Partnership." InsuResilience Global Partnership, 7 Mar. 2018 (retrieved) <http://www.insuresilience.org/>.
[66] "Katowice Climate Change Conference (UNFCCC COP 24)." IISD / SDG Knowledge Hub, 7 Mar. 2018 (retrieved) <http://sdg.iisd.org/events/unfccc-cop-24/>.
[67] *Op. cit.* - "Paris Agreement Reaches 175 Ratifications."
[68] "Arctic saw 2nd warmest year, smallest winter sea ice coverage on record in 2017." 12 Dec. 2017. NOAA, 9 Mar. 2018 <http://www.noaa.gov/media-release/arctic-saw-2nd-warmest-year-smallest-winter-sea-ice-coverage-on-record-in-2017>.
[69] "World Energy Outlook 2016 – Executive Summary." 16 Nov. 2016. IAE, 9 Mar. 2018 <http://www.iea.org/Textbase/npsum/WEO2016SUM.pdf>.
[70] "World Energy Outlook 2017 – Executive Summary." 14 Nov. 2017. IAE, 9 Mar. 2018 <http://www.iea.org/publications/freepublications/publication/WEO_2017_Executive_Summary_English_version.pdf>.
[71] Ibid.

sumer electricity spending had already approached parity with that towards oil products in 2016. [72]

1.2.4 Resources

With very low global trade growth levels in 2016 at 2.2%, the year 2017 saw significant expansion at a rate of 3.7%, reinforced by the general uptick in global economic growth, which hit 3.0% in 2017. This was the highest since the 3.1% economic growth rate of 2011, and a significant increase on the 2.4% of 2016. Furthermore, global trade growth has also been consistently demonstrating calmer fluctuations, overall, since the dramatic rises and falls during and immediately after the financial crisis. The 2017 growth in trade is also largely attributed to a moderate uptake in investment across certain developing and developed countries, which has also boosted trade of intermediate and capital goods in particular. The year 2017 also saw growth in global industrial output as well as the demand for container shipping and international air freight. And although still moderate, 2018 world trade is forecasted to expand by 3.5% and again in 2019 to 3.6%.[73]

In terms of growth of imports and exports in 2016, the former grew by 2.1% and the latter by 1.7%, representing an average growth of just 1.9%. This figure is furthermore still significantly lower than the 7.2% growth rate seen from 2003 to 2007, before the crisis. And given low global demand levels, the global trade situation overall is not expected to promote growth for any particular set of economies. Although global trade demonstrated some recovery in 2017, associated with significantly increased merchandise imports in Asia and more moderate import growth in Latin America and the US, the long-term strength of this recovery is certain. China's growth in exports was perfectly flat at 0.0% in 2016, while the volume of imports did grow, however, by 3.1%. In the US, imports grew at 3.6%, a slight decrease from the 3.7% of 2015, and exports were at -0.2%. Across all developed countries, growth in the volume of imports was 2.7% while volume of exports was just 1.0% in 2016, the latter largely attributed to weak demand from certain developing countries. In the European Union, imports saw a growth of 2.8% in 2016, while exports declined from 3.3% in 2015 to 1.1%. In the UK, in particular, exports saw a boost in the latter half of 2016 after a drop in the pound sterling's value. African, Latin American, and West Asian commodities exporters, specifically, saw declining imports in 2016, the result of decreasing commodity prices. In Africa, for example, growth in the volume of imports was -4.6% in 2016, and in Sub-Saharan Africa in particular, the volume of imports growth decreased from -0.3% in 2015 to -6.6% in 2016. In Latin America and the Caribbean, the rate was -4.2%, and -2.6% in West Asia.[74]

According to the United Nations Conference on Trade and Development (UNCTAD), while commodity prices experienced declines in all group categories, decreasing by 34.3% in 2015, the largest contraction was in crude oil which decreased by 47.2%.[75] Decreases occurred again in 2016, with commodities prices overall decreasing by 8.7% and crude oil by 15.7%. The year 2017 finally saw positive figures again, with UNCTAD forecasting commodities prices to grow by 14.4% and crude oil by 19.5%. And although this represents a significant turnaround, the rates are still well below respective prices observed during the 2000s commodities boom ending in 2014. For example, in oil prices per barrel, the year started at $52/barrel, dropped to a low of $45 in June, and steadily rose again to $62 by December.[76] And with oil and commodity prices still significantly below 2014 levels (when they were just above $100/barrel), recovery is taking place slowly among commodity-exporting economies. Regarding oil in particular, the longevity of the rebound is uncertain, with OPEC taking steps to reduce supply and while there is also a rise in US inventories, largely connected to shale oil production, which appears to be lowering prices.[77]

As stated, UNCTAD forecasted commodities prices to grow by 14.4%. This itself is a jump from the -8.7% percentage change in 2016 and the -34.3% change in 2015. Looking at the specific price growth and contractions figures, all non-fuel commodities were reported to grow by nearly 10% in 2017. Further, all agricultural raw materials prices likewise grew by 10%, while minerals, ores and metals prices expanded by 23%, representing a nearly equal turnaround from the -23% contraction of 2015. Iron ore and Zinc led the way in 2017, with approximately 27% and 28%, respectively. Precious metals, however, were reported to contract by 0.7% in the year 2017, with gold decreasing at nearly the same rate.

[72] Ibid.
[73] *Op. cit.* - "World Economic Situation and Prospects 2018."
[74] "Trade and Development Report 2017." 14 Sep. 2017. UNCTAD, 9 Mar. 2018 <http://unctad.org/en/PublicationsLibrary/tdr2017_en.pdf>.
[75] Ibid.
[76] "countryeconomy.com - OPEC Reference Basket (ORB) US Dollars per Barrel." Regularly updated. Data from those dates mentioned in text. countryeconomy.com, 9 Mar. 2018. <https://countryeconomy.com/raw-materials/opec>.
[77] *Op. cit.* - "Trade and Development Report 2017."

Recent metal price declines in 2017 were largely associated with dropping demand in importing economies, the US and China in particular. Food products prices, though, saw modest growth at 2.5% in 2016 and 1.0% in 2017. In overview, although commodity prices have been returning upwards since the declines seen after the commodities boom, UNCTAD notes that given the most recent declines the rebound may not necessarily continue for long, and that the price movements since the end of the boom are not uniform across all commodity groupings.[78]

1.2.5 Knowledge

By now the advantages of higher education should be seen as worth the effort as employment rates and earnings tend to increase as an adult's level of education and skills increases; moreover, the labour market still regards a diploma or degree as the primary indication of a worker's skills. 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. In the year 2016, the percentage of the European[79] population between 25-to-64 years of age with a tertiary degree reached 34%, just below the G20 average of 35% and further below the OECD average of 37%. This does represent however a 2% growth over the previous year. In comparison, 46% of the same age cohort of the US and 57% in Canada have attained the same level of education in 2016. Among 25-34 year olds in Europe, Lithuania comes first with 55% having attained a tertiary education in 2016, followed by the UK at 52% and Luxembourg at 51%. These are well above the OECD and European averages of 42% and 40% respectively, and they are followed by Norway and Switzerland both at 49% and Sweden at 47%. The three largest contributors to ESA's budget in 2017 were Germany, France, and Italy,[80] and their tertiary attainment rates among 25-34 year olds were 31%, 44%, and 26%, respectively.[81]

According to the OECD, the enrolment rate of 20-to-24 year-olds in tertiary education increased on average from 29% to 33% from 2005 to 2014 across OECD countries.[82] For enrolment in educational programmes in general among 20-24 year olds, the 2017 reporting show that 42% are enrolled across the OECD and 43% across the EU. Further, among 25-65 year old Europeans studying, 13% are in Education; 19% are in the Arts, humanities, social sciences, journalism and information; 21% are in Business, Administration, and Law; 5% are in Natural sciences, mathematics and statistics; 4% are in Information and communications technology (ICT); 18% are in Engineering, manufacturing and construction, and 12% are in Health and welfare. These data align nearly perfectly with the OECD averages. And focusing on the upcoming generation of European students focusing on science, technology, engineering and mathematics (STEM), Germany is leading with nearly 40% of new tertiary-level entrants in STEM. Following are Estonia and Finland with both having nearly 35%, and Slovenia and Austria with each just over 30%. The respective OECD and EU averages are at just over 25%.[83]

In considering gender, the percentages of female students entering STEM tertiary programmes in those same countries are as follows: In Germany, 28% of new STEM entrants are women; 34% in Estonia, 23% in Finland, 29% in Slovenia, and 28% in Austria. The respective OECD and EU averages are both 30%, and, further, the UK and Iceland are leading the way with 37% of women entering STEM programmes. These recent figures reconfirm the progress, but continuing work to be done in reducing the gender disparity in STEM. More broadly speaking, women entering tertiary studies are most represented in Education, where the OECD average is 78%, followed by health and welfare (76%), and thirdly in social sciences, journalism and information (at 64%). In Engineering, they represent only 24% of students entering tertiary programmes, 50% of students in natural sciences, mathematics and statistics, and 19% in ICT. Across many disciplines, Latvia and Iceland are leading the way among European countries. For example, Iceland has the largest percentage of women in OECD countries entering Engineering, at 37%.[84]

[78] Ibid.
[79] Not including Bulgaria, Croatia, Cyprus, Lithuania, Malta, and Romania.
[80] "ESA Budget for 2017." 16 Jan. 2017. ESA, 28 Mar. 2018 <http://www.esa.int/spaceinimages/Images/2017/01/ESA_budget_2017>.
[81] "Education at a Glance 2017." (Download page) 12 Sep. 2017. OECD iLibrary, 28 Mar. 2018 <https://www.oecd-ilibrary.org/education/education-at-a-glance-2017_eag-2017-en>.
[82] "Education at a Glance 2016." (Download page) 15 Sep. 2016. OECD iLibrary, 28 Mar. 2018 <https://www.oecd-ilibrary.org/education/education-at-a-glance-2016_eag-2016-en>.
[83] *Op. cit.* - "Education at a Glance 2017."
[84] Ibid.

1.2.6 Mobility

Maritime transport remains a critical element in the infrastructure of the global economy, carrying over 80% of the world's trade by volume and over 70% of its value. From 2015 to 2016, world seaborne trade grew from 1.8% up to 2.6%, which, although representing growth, is still below the 3% historical average observed during the past forty years. The total volume of seaborne trade in 2016 reached nearly 10.3 billion tons, up from just over 10 billion tons in 2015. In more precise terms, this represented an increase of over 260 million cargo tons over this time period, with more than half of it in tanker trade. A significant influence on global trade levels came from China's strong import demand in 2016, but growth was held back by limited export demand and especially limited import demand from other developing economies. However, and despite this, developing regions are still the major basis for world shipments in seaborne cargo in 2016. Specifically, developing countries represent 59% of the world goods exported and about two-thirds imported. Developed economies, for their part, represent about 35% in both regards. Regionally, Europe represents about nearly 20% of both goods exported and imported in 2016. The most dominant region, however, remains Asia, which loaded 40% of goods in 2016 and unloaded just over 60%. These seaborne shipment levels are significantly higher than the 2nd most active region, being the Americas, which imported 14% of the world trade and exported 22%. Furthermore, and looking ahead, UN reporting indicates that seaborne trade is expected to grow 2.8% and reach 10.6 billion tons of volume in 2017, and over the following five years expanding by 3.2% annually. Looking at the cross-section of the cargo to be shipped, containerized cargo and major dry bulk commodities are anticipated to grow the most.[85]

Security of the ships and crew active in international maritime transport remained a major issue in 2017. Between 1984 and the end of 2015, the number of incidents of piracy and armed robbery against ships totalled 7,346 worldwide.[86] In 2015, specifically, the Maritime Safety Committee reported 303 incidents, which decreased by 27% to a total of 221 incidents in 2016. However, despite this overall reduction, West Africa saw a 77% increase during the same reporting time period. Furthermore, piracy is not the only threat, with cybersecurity representing a growing threat to the maritime sector. At the root, seaborne shipping heavily utilizes computer-based and ICT technologies which are exposed to the same risks as those referred to in the Geopolitics section of this chapter. Essentially, onboard computers or computer systems in other facilities, such as at ports, can be the objects of cyberattacks such as phishing, so-called Trojan horses, hacking, malware, denials of service, and other forms. Results of such attacks can disrupt container inventory and tracking operations or, more dramatically, the navigation systems and control of propulsion on the actual ships. They may also lead to the theft of company data, used for diverse purposes. Ultimately, such threats have very direct and real consequences for individuals working in various applications in the maritime industry and for safety, the environment, in addition to consequences to the economy. Concerns have also been expressed that the industry culture is not sufficiently aware of such risks. However, a major recent regulatory development came in the form of the International Maritime Organization's adoption in 2017 of guidelines on maritime cybersecurity risk management. Several real examples from 2011 to 2017 have occurred, including one targeting Maersk which involved the use of ransomware. Assuming such attacks may occur more frequently, the recent guidelines will hopefully lead to further regulatory activity.

[85] "Review of Maritime Transport 2017." (Download page) 25 Oct. 2017. UNCTAD, 29 Mar. 2018 <http://unctad.org/en/Pages/Publications/Review-of-Maritime-Transport-(Series).aspx>

[86] "Review of Maritime Transport 2016." (Download page) 7 Nov. 2016. UNCTAD, 29 Mar. 2018 <http://unctad.org/en/Pages/Publications/Review-of-Maritime-Transport-(Series).aspx>

2. Global Space Economy

Chapter 2 covers 2017 public budget 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 absence of international standards, developing accurate estimates is a complicated task, especially considering the distinct methods of categorising and distributing funding for space activities in each nation. The relative lack of transparency regarding certain government space programmes, such as military space projects, further complicates calculations. And an additional degree of distortion is introduced by floating currency exchange rates, as all number are reflected in terms of U.S. dollars.

2.1 Global Space Budgets and Revenue

In 2017, the global government space actors figure at close to 50, most of them having an agency or an institute related to space activity and at least nine having a budget exceeding $1 billion (being China, the U.S., France, Germany, Italy, Russia, India, Japan and also the European Commission).

Global space activity accounted for $383.51 billion and the total revenues from the commercial space sector were the 80.1% of the global economic activity in space, or $307.32 billion, including private and public activities[87]. In terms of commercial revenues, the Space Report 2018 indicates that the commercial infrastructure and support industries generated $95.87 billion (+7.5% from 2016), including manufacturing of commercial satellites, provision of launch services, provision of space asset insurance to satellite-launching, and satellite operating companies. The main sources of revenues were from ground stations and equipment, and satellite manufacturing, representing $85.84 billion and 6.82 billion respectively in revenue in 2017. In the navigation sector for 2017, the European Global Navigation Satellite System Agency (GSA) estimated that devices for Global Navigation Satellite Systems (GNSS) generated $57 billion in revenue, a healthy increase (+7.8%) from $52.9 million of 2016.[88]

2.2 Overview of the institutional Space Budgets

The total institutional spending on space in 2017, including that of intergovernmental organizations, is estimated to be approximately $76.197 billion, an increase of 4.8% compared to 2016.[89] While the U.S institutional spending decreased slightly to $43.344 billion from $44.444 billion of 2016, the U.S spent $22.7 billion on civil space activities in 2017 – up 0.9% from the previous year. Approximately half of the U.S. government spending went toward national security space activities within the Department of Defense (DoD) budget, the National Reconnaissance Office (NRO) and the National Geospatial-Intelligence Agency (NGA). According to the Space Report 2018, DoD programs made up 47.7% of the total U.S. space budget in FY 2017, representing $20.7 billion or 6.0% lower than $22.0 billion estimated in 2016.

[87] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: 4.
[88] Ibid. p. 6.
[89] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: 8.

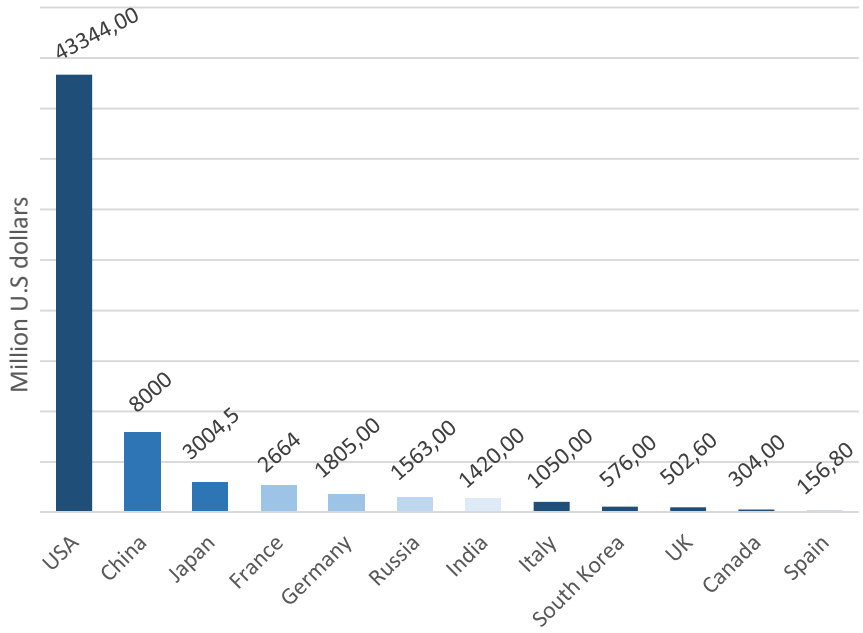


Figure 2.1: Public Space budgets of major space power in 2017 (Source: The Space Report 2018) – Military space budgets excluded

Figure 2.1 and the following figure (Fig. 2.2) present a relative picture of the space sector. They should be viewed holistically, and compared to each other may not reflect the real output of spacefaring countries.

The state hierarchy is not far from 2016 one, even considering China's recent growth. While spending among space actors saw significant changes in 2017, they should not be ranked against each other given the fluctuations in currency exchange rates as these budgets are converted to U.S. dollars (in Fig. 2.1).[90]

The U.S column of Fig. 2.1 shows that it continues to have the largest space budget, remaining around $43.344 billion (2.5% less than 2016), while it decreased its military expenditure 6.0 percentage points[91] and increased its civilian space spending to $22.656 billion in 2017. Confirming the data analysed for 2016, China's budget is still the second largest, doubling in 2017 to $8.006 billion[92] in comparison to the $4.317 billion of 2016 – attesting a growth of 85.4%. Japan's space budget for 2017 is $30.446 billion (¥342.1 billion), the result of an increase of JAXA's allocated supplemental budget.

France (at €2.334 billion, which reflects +13.2% growth), Russia ($1.563 billion, -11.5%), India ($1.417 billion, +21.9%) and Germany ($1.805 billion, +11.6%) all follow Japan, while also witnessing a Russian budget decrease that began in 2015. India had an increase of 870% in the number of commercial spacecraft launched given that in 2017 a total of 138 spacecraft were launched, 113 (82%) of which were commercial[93]. The Italian budget was $1.05 billion (+19,4% from 2016), while the UK budget grew by 4% reaching $502,6 million, including ESA budget.

Moreover, national contributions to ESA's budget were included within these figures. In 2017, ESA operated with €5.75 billion ($6.56 billion), increasing from 2016 by 12.8% (€5.25 billion or $5.82 billion). The Members' contributions grew up to €3.78 billion ($4.32 billion) and the majority of funds came from optional contributions as determined by the interest of the member states. Among ESA members, the five biggest contributors are Germany and France both at 22.7%, Italy at 14.6%, UK at 7.9% and Belgium at 5.5%. Spain was the next highest contributor at 4%, followed by Switzerland at 3.8% for seventh position in the 2017 budget[94].

[90] Ibid. at page 8.
[91] Ibid. at page 15.
[92] Chinese space budget is not publicly available. The calculation is a Space Foundation´s estimate.
[93] The Space Report 2018. Space Foundation 2018: 8.
[94] Italy, UK, Belgium and Spain contribute the same % of amount as 2016. "ESA Budget 2017". 16th January 2017. ESA 6th August 2018:< http://www.esa.int/spaceinimages/Images/2018/01/ESA_budget_2018>

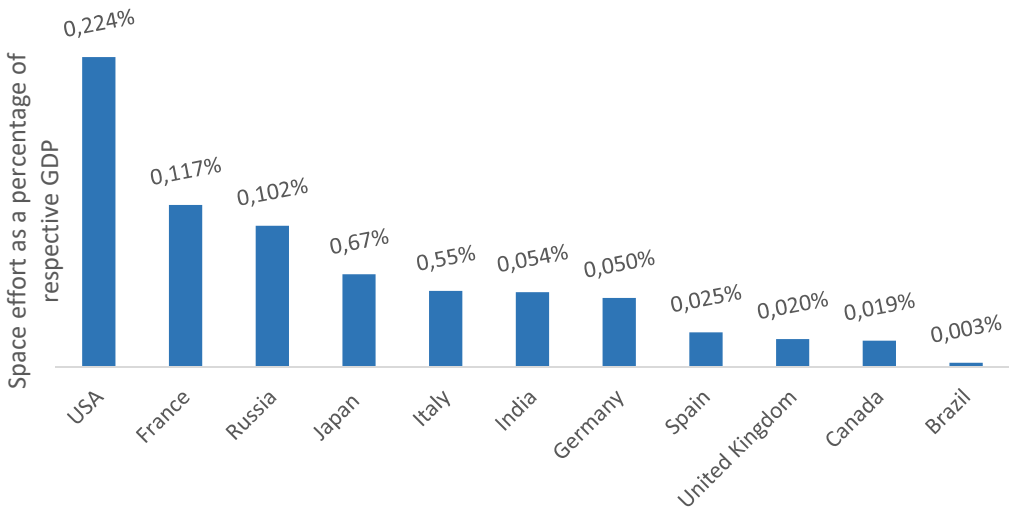


Figure 2.2: Public Space Budgets as a share of nom. GDP in 2017 (Source Space Report 2018)

In order to measure the concrete effort provided by a country in the space sector it is necessary to measure the investments with regard to GDP generated in 2017 (Fig.2.2).

The U.S. position confirms its strong engagement in space activities, although its spending decreased to 0.224% from the 0.239% of 2016. France enjoyed a slight increase from 0.113% to 0.117%, whereas Russia dropped to 0.102% from 0.127% in 2016. Japan came next with 0.067%, followed by Italy with 0.055%. Other leading space countries in Europe and the rest of the world invested less than 0.050% of their GDP in space activities. An additional perspective is furnished by the space budget per capita (Figure 2.3) where the U.S is holding undisputedly the first position, although its spending decreased 2.5%.

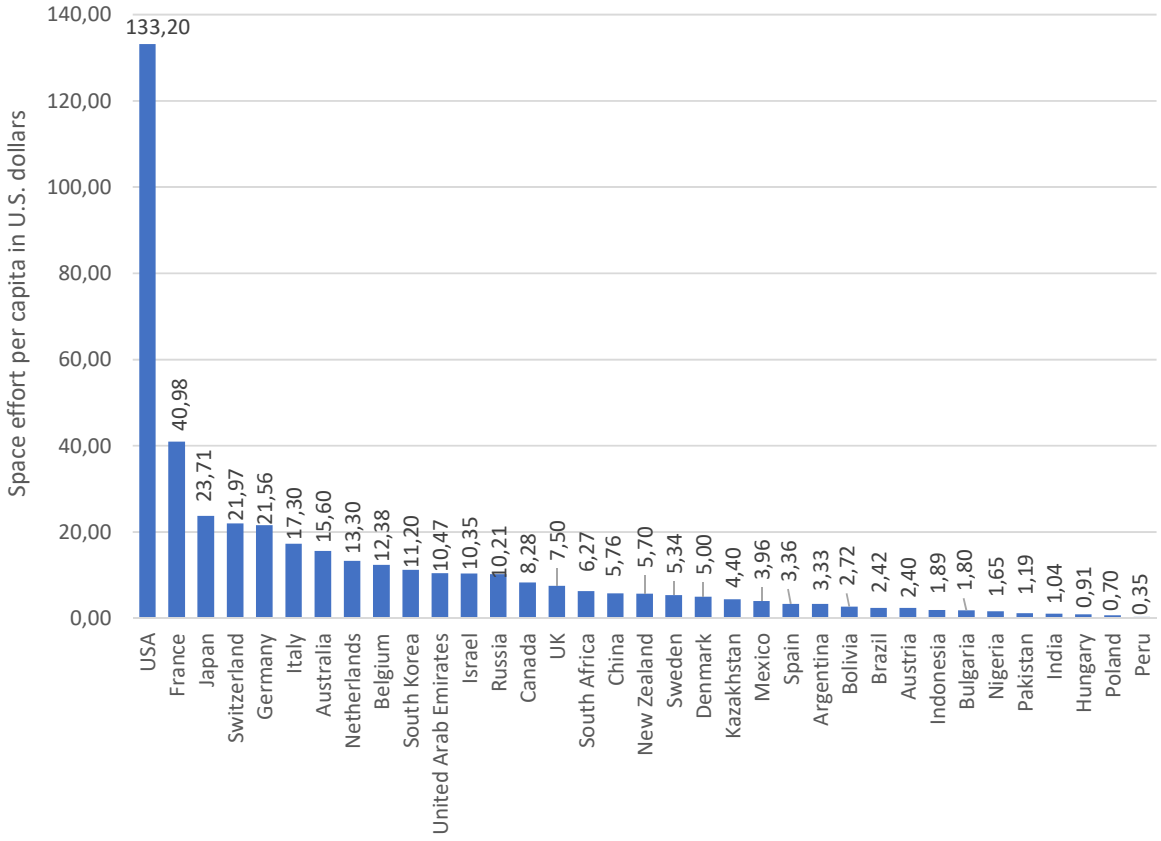


Figure 2.3: Public space budgets per capita (selection) in 2017 (Source: The Space Report and Population Reference Bureau)

The second in ranking is France at $40.98 (a decrease from the $43.22 of 2016), followed Japan ($23.71), Switzerland ($21.97), and looking to China ($5.7) its relatively lower figure is clear. The situation is similar for India (at $1.04), a unique position with a large part of its GDP spent on space although having a budget per capita well behind the other space-faring nations. Some caution is needed when considering these figures, though, due to fluctuating exchange rates and the uncertainty of reported values.

2.3 Overview of Commercial Space Markets

The Satellite Industry Association (SIA) reported that global industry revenues from satellites services, satellite manufacturing, launch industry and ground equipment segments grew by 3% in 2017, reaching $269 billion in 2017, up from the $261 billion in 2016 (representing 79% of the space economy in 2017)[95].

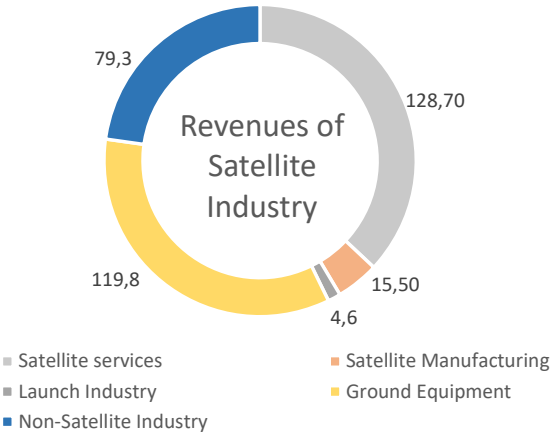


Figure 2.4: Status of the Satellite Industry (Source: SIA)

2.3.1 Satellite Services

According to the SIA, the revenue earned from satellite services hovered around the same value of 2016, growing 1% and reaching $128.7 billion in 2017 – up from $127.7 billion in 2016[96]. Considering satellites services subgroups, the highest revenue comes from direct-to-home television at $97 billion, while Earth observation was $2.2 billion[97]. Satellite services can further be deconstructed into their components parts, including consumer services (i.e. satellite TV (DBS/DTH), satellite radio and satellite broadband services), fixed satellite services (e.g. transponder agreements, and managed network services), as well as mobile services (voice and data), and Earth observation. The following is a breakdown of the industry's key developments and trends, according to the nature of the services provided (Figure 2.4).

Consumer Services

As mentioned above, consumer services include satellite television, radio, and broadband services. The segment's downstream services revenue experienced a slight decrease, from $104.7 billion in 2016 to $104.5 billion in 2017. The television revenues were $97 billion, $5.4 billion for radio, and $2.1 billion for broadband. The general consumer equipment (including GNSS devices like Garmin and TomTom, satellite TV dishes, etc.) increased by 5.6% to $108 billion. The network equipment (VSATs, gateways, etc.) revenues were §11.8 billion, and according to SIA the total revenues from ground equipment were $119.8 billion. With around 220 million satellite television subscribers worldwide, DBS/DTH customers, increasingly in emerging markets, are a key driver in consumer services revenue; however, there is the potential for a further slowdown in demand growth for DBS/DHT services as customers opt for internet-based video services[98].

Fixed Satellite Services (FSS) refers to the use of spacecraft that utilise land terminals in fixed positions to broadcast (such as through Intelsat, SES, Inmarsat, etc). 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. The FSS segment saw figures comparable to 2015, earning $17.9 billion of revenues in 2017, likened to the $17.4 billion earned in 2016.

Mobile Satellite Services (MSS) offer both mobile data service and mobile voice service (including satellite phones). The MSS revenue grew by 17.6% in 2017, earning $4 billion from the $3.4 billion of 2016.

Earth Observation Services

Earth Observation Services (offered for example by Airbus and Digital Globe) refers to com-

[95] "2018 State of the Satellite Industry Report." 13th June 2018. Satellite Industry Association and Bryce Space Technology. 6th August < https://www.sia.org/wp-content/uploads/2018/06/2018-SSIR-2-Pager-.pdf >

[96] Ibid.
[97] Ibid.
[98] Ibid.

mercial companies that provide optical and radar images to the open market; however, demand for such services is mostly driven by government entities. Moreover, this sector is rapidly growing and changing; new entrants such as Terra Bella and Planet (formerly Planet Labs) have continued to raise capital, and have begun deploying constellations. The majority of the revenue is generated through the development of value added services, information products, and big-data enabled analytics[99]. The latter includes the processing and analysis of multiple images and a variety of datasets in order to extrapolate statistical information not in the base data itself[100]. Earth Observation services saw a robust growth of 11.1%, increasing to $2.2 billion in 2017 from the $2.0 billion in 2016[101].

2.3.2 Satellite Manufacturing

The total revenue of satellite manufacturers (such Thales Alenia Space, Airbus, OHB, Boeing, etc.), serving both governmental and commercial customers, reached $15.5 billion (up +10%) from the $13.9 billion of 2016, although still did not return to the $16.0 billion of 2015 (Fig.2.6). It should be noted that the manufacturing sector, while mostly driven by the telecommunications sector, remains sensitive to downturns which took place despite the emergence of new players driving an increase in competition. U.S manufacturers' revenues were static from 2016, passing from $8.9 billion in 2016 to $8.8 billion in 2017; however, this activity nevertheless generated half of the overall revenues. In contrast, non-U.S. manufacturers' revenues grew up to $6.7 billion from $5.0 billion in 2016. The overall market growth is calculated at 10%. Furthermore, Earth Observation Services accounted for 49% of the revenues generated for the year, followed by Commercial communications, which earned 18% of the total revenue. Next, Meteorology services represented 15% of revenues, R&D and Military Surveillance each accounted for 6%, Civil/Military Communications stood at 3%, and Navigation and Scientific satellites represented 2% and 1% respectively.[102]

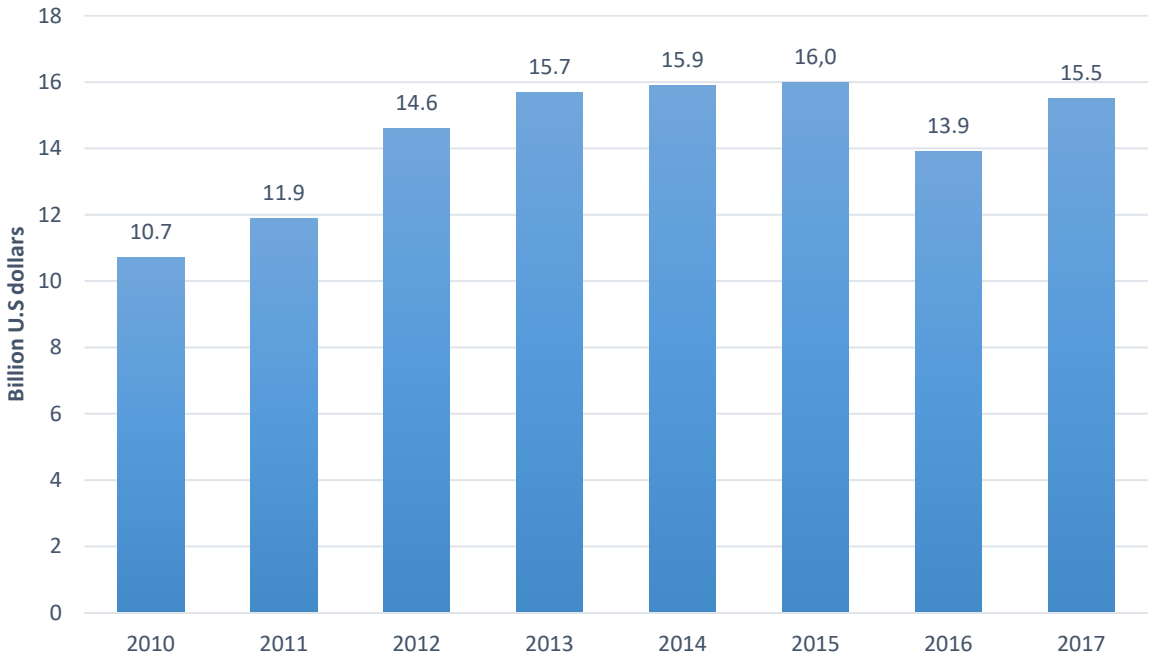


Figure 2.6: Worldwide satellite manufacturing revenue (Source: SIA)

[100] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: 7.
[101] "2018 State of the Satellite Industry Report." 13th June 2018. Satellite Industry Association and Bryce Space Technology. 6th August < https://www.sia.org/wp-content/uploads/2018/06/2018-SSIR-2-Pager-.pdf >.
[102] "2018 State of the Satellite Industry Report." 13th June 2018. Satellite Industry Association and Bryce Space Technology. 6th August < https://www.sia.org/wp-content/uploads/2018/06/2018-SSIR-2-Pager-.pdf >.

2.3.3 Launch Sector

In 2017, a total of 90 orbital launches were conducted, 33 of which were commercial. Five of the 90 launches failed and in these are included four government launches. Specifically, these include a Soyuz 2.1b carrying the Meteor-M 2-1 satellite and 18 secondary payloads, a PSLV XL carrying the IRNSS-1H satellite, a Long March 5A carrying the Shijan 18-01 satellite, an Electron carrying the Humanity Star, and a SS-520 Upgrade carrying the TRICOM-1 satellite. China's Long March 3B launch in June was a partial success when Chinasat 9A (Sinosat 4) was located in an incorrect orbit. For comparison, in 2016 there were 85 launches, including 22 commercial launches[103]. Revenues from the 33 commercial orbital launches in 2017 are estimated at roughly over $3 billion, growing from the $2.5 billion in 2016.

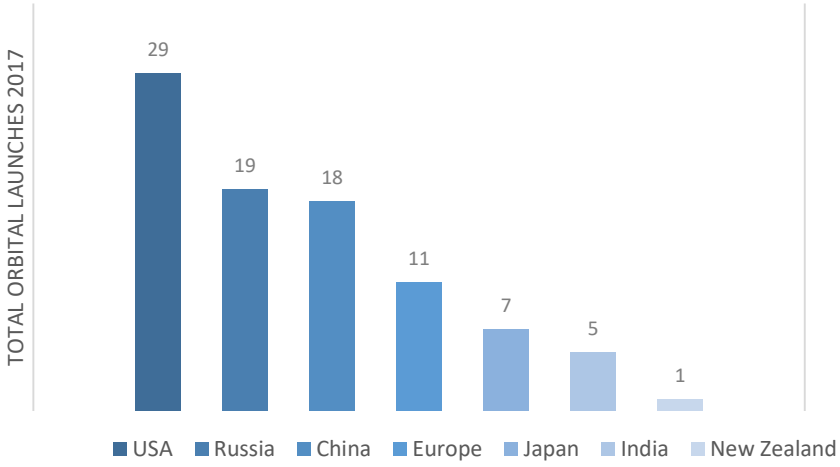


Figure 2.6: Total orbital launches in 2017 (Source: ESPI database)

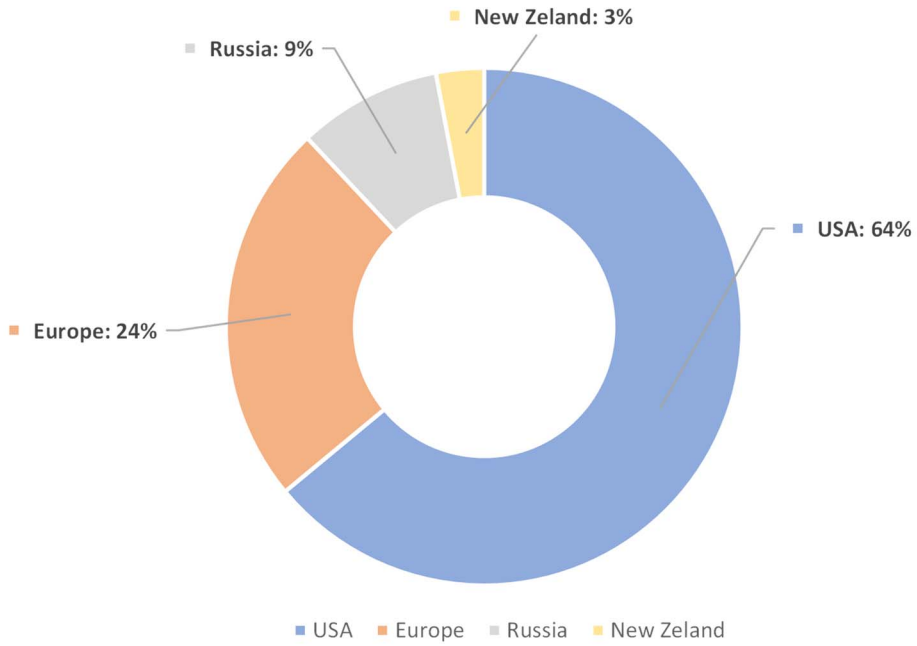


Figure 2.7: Commercial Launch Activity by Country in 2017 (Source: FAA)

[103] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2018. Washington DC: FAA, Jan. 2018: 39.

For U.S. providers, the commercial orbital launch revenues are estimated at $1.7 billion, compared to $1.2 billion in 2016. In 2017, U.S launch providers conducted 22 commercial orbital launches, compared to 11 licensed launches in 2016, with a share of 64% of the commercial launches. SpaceX's Falcon 9 conducted 18 launches, of which 10 were conducted for commercial purposes, including for Iridium, EchoStar, SES, Inmarsat, Bulsatcom, Intelsat, and KT Sat[104].

China conducted 18 non-commercial launches, but did not have any commercial launches in 2017. Russia was third in terms of launches, with only 3 out of 19 launches for commercial purposes. Moreover, its share of total commercial launches lowered to 9% from 9.5% in 2016. Europe conducted 8 commercial launches and 3 non-commercial launches in 2017 (the same figures of 2016), representing a share of commercial-launch activity of 24%. Japan conducted 7 non-commercial launches, India 5 non-commercial launches, and New Zealand a single commercial launch.

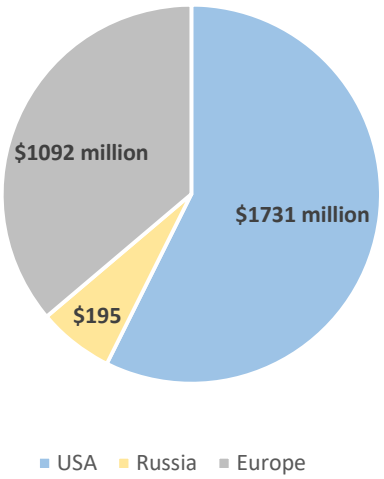


Figure 2.8: Commercial Launch Revenues by Country in 2017 (Source: FAA)

U.S launch commercial revenue decreased to $1.731 million from $1.185 million in 2016, when it had nearly doubled its commercial launch revenue from $617 million in 2015 (Figure 2.8). Europe generated the second highest revenue for 2017, despite decreasing to $1.092 million in 2017 from $1.152 million in 2016. Russia held the third position earning an estimated $195 million, increasing from the $130 million earned in 2016.[105] Those results come from a combination of factors; due to the arrival of SpaceX's Falcon 9 vehicle on the global market in 2014, U.S. providers have begun to cut into the existing share of commercial launches that before were covered by Russian providers. Over the past few years, the Russian space industry was affected by issues that led some customers to find alternative providers[106]. Europe remains a steadfast option, however, with Arianespace offering services though the Ariane 5, Soyuz, and Vega launchers. Arianespace conducted a total of 11 launches from its French Guiana spaceport in 2017. Its Ariane 5 ECA launcher had 5 launches, lifting 9 commercial payloads to orbit (Intelsat 32e, Telkom 03s, Koreasat 07, SDGC 1, Eutelsat 172B, ViaSat 02, Hellas-Sat 3 / Inmarsat-S-EAS, BSat 4A, and Intelsat 37e) and a single civil governmental telecommunication satellite to LEO (GSat 17). The Ariane 5 ES launcher had one launch, placing 4 Galileo navigation satellites (Galileo FOC – 15, -16, -17, -18) to medium Earth orbit (MEO) for the European Commission. The Europeanized Soyuz had 2 launches, lifting Hispasat 36W-1 into GEO, and the second that lifted SES 15 into GEO. The Vega launcher conducted 3 launches, lifting 4 civil governmental Earth Observation satellites to GEO, including Sentinel 2B, OPTSAT-3000, VENμS, and Mohammed VI A.

2.3.4 Ground Equipment

Ground Equipment revenue includes infrastructures 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 GNSS chip sets.

Ground equipment revenues increased by 5.6% to $119.8 billion in 2017 from $113.4 billion in 2016, driven by growth in consumer equipment for satellite navigation including standalone devices and embedded chipsets for smartphones, traffic information systems, and transport vehicles, and by increasing demand for network equipment for managed network services. Consumer equipment for satellite TV, satellite radio, and satellite broadband saw a growth from $84.6 billion in 2016 to $108 billion in 2017, while network equipment (VSATs, gateways) saw a flatter growth to $11.8 billion in 2017 from $10.3 billion[107].

The two companies leading the PND market, Garmin and TomTom, present a static income

[104] ESPI database.
[105] Federal Aviation Administration "The Annual Compendium of Commercial Space Transportation: 2018". Washington DC: FAA, Jan. 2018: 40, figure 7.
[106] Ibid. p.1
[107] "2018 State of the Satellite Industry Report." 13th June 2018. Satellite Industry Association and Bryce Space Technology. 28th August

situation for 2017 (Table 2.1). TomTom earned €903 million ($1.082 billion) in revenue for the year ending 31 December 2017, a 9% decrease from 2016. Its Automotive & Enterprise segment reached €328.8 million (+22%), and +4% for Telematics (€162.1 million). Both segments were offset by a -27% decrease in revenue in the Consumer segment (€412.5 million)[108]. Conversely, Garmin's total revenue was $3.087 million, growing 2% over the prior year, with outdoor, fitness, marine and aviation segments collectively growing 9% over the prior year and contributing 76% of total revenue[109].

Companies	Total Revenues	2017	2016
TomTom		**€903 million ($1.084 billion)**	€987.239 million ($1.040 billion)
Garmin		**$3.087 billion**	$3.019 billion
	Geographical Sales		
Tom Tom	Europe	€704.34 million ($838.164 million)	€773.235 million ($814.649 million)
	North America	€144.48 million ($171.931 million)	€167.361 million ($176.325 million)
	Rest of World	€54.18 million ($64.474 million)	€46.733 million ($49.236 million)
Garmin	Europe/ Middle East/ Africa	$1,175.155 billion	$1.111 billion
	Americas	$1,475.661 billion	$1.521 billion
	Asia Pacific region	$436.188 million	$386.549 million

Table 2.1: TomTom & Garmin variables 2017.

2.3.5 Insurance Sector

Roughly 60% of orbital launches were insured in 2017, including half of commercial GEO satellites. In 2017, net premiums reached $712 million (+12.7%). Losses of $451 million are estimated for the same year, while profits are estimated at $261 million[110]. The global insurance market is roughly $5 trillion dollars per year, and space insurance represents about $500 million to $1 billion per year, or approximately $750 million. At the moment, there are around 30 insurers; they can compete on coverage terms and capacity, but most are only competing on price. Typically packaged together in most insurance products, there is a distinction between property (first party) and liability insurance (third party). Property insurance insures against the failure of a satellite during launch or operation and will typically cover the cost of the satellite, while excluding lost future revenue. Conversely, liability insurance of a satellite insures against damage caused to a third-party by the operator's satellite. On-orbit liability insurance is required by a small number of countries; the vast majority of all satellite ventures carry property insurance, and it is typically their third-largest expenditure after launch and manufacturing.[111] Considering the events of 2017, in April ExactEarth received a nearly $2.7 million insurance pay-out for EV5, an AIS satellite from Fairfax, Virginia-based SpaceQuest that ceased communicating in February. The satellite had been launched in November 2013 on a Kosmotras Dnepr rocket[112]. The same occurred for ViaSat, which expects to file an insurance claim for an antenna glitch that reduced the performance of its newest satellite by around 15%, according to statements from CEO Mark Dankberg. The antenna malfunction on ViaSat-2, revealed seven months after the satellite's launch, specifically affects a set of antennas designed to target pockets of high-demand customers. As a consequence, some areas are already experiencing bandwidth shortages[113]. ViaSat does not expect to be

[108] "TomTom Annual Report 2017." 31 December 2017. TomTom 20th July 2018 p.34: <http://files.shareholder.com/downloads/TOMTOM/0x0x971824/D69A3581-1EBD-4174-A248-0791015F088C/Annual_Report_2017.pdf>

[109] Garmin Reports Solid Fiscal 2017 Revenue and Operating Income Growth" 21 February 2018. Garmin 20th July 2018 < https://www8.garmin.com/aboutGarmin/invRelations/releases/2017_Q4_Press_Release.pdf>

[110] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: 6.

[111] Stimson Centre and the Secure World Foundation (SWF) "Insurance and Responsible Behaviour in Space Event Report", 3rd April 2018. Stimson, 29th August 2018. <https://www.stimson.org/sites/default/files/fileattachments/2018_stimson_swf_insurance_event_report.pd>

[112] Caleb Henry "Spire, 40 cubesats in orbit, competing more directly in space-based ship-tracking market", Space News 31st August 2017. <https://spacenews.com/spire-40-cubesats-in-orbit-competing-more-directly-in-space-based-ship-tracking-market/ > 28th August 2018.

[113] Caleb Henry "Viasat preps big insurance claim for ViaSat-2 antenna anomaly", 30th May 2018 SpaceNews.

compensated in the existing quarter and as a result the company will focus on "near-term" cost reduction for 2018.[114]

Further, in 2017 the Angolan communication satellite Angosat-1 was delivered into orbit by the Russian rocket Zenit-3F. Despite there having been no problem at launch, on 23 April 2018 the Angolan government declared the satellite a loss. The Angola government accepted from Roscosmos to build a replacement for the satellite (Angosat-2), and the cost of the construction will be partially covered by an insurance payment of $121 million[115].

2.4 Sectoral Overview

2.4.1 Launch Sector

The Launch sector is an enabler rather than a primary economic activity. With the growth in low-cost launch services, the marginal revenue the launch sector generates is becoming a more important factor to watch.

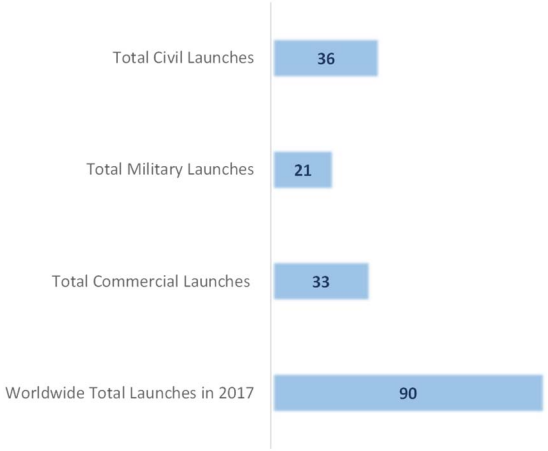


Figure 2.9: Total Worldwide Orbital Launches by status (Source: ESPI Database)

In 2017, there were 90 launch attempts (Figure 2.9) and the launch activity increased from 2016, which counted 85 launches. Five of the 90 launches failed, including four government launches: the Meteor-M 2-1 satellite with 18 secondary payloads carried by a Soyuz 2.1b, a PSLV XL carrying the IRNSS-1H satellite, a Long March 5A carrying the Shijan 18-01 satellite, an Electron carrying a telemetry package called Humanity Star, and a SS-520 Upgrade carrying the TRICOM-1 satellite[116].

The worldwide launch activity (Figure 2.9) accounted for 33 commercial launches in 2017 (37% of the total) and 57 non-commercial (63% of the total), conducted by the United States (representing 32% of all launches), Russia (21%), China (20%), Europe (12.2%), Japan (7.7%), India (5.5%), and New Zealand (1.1%). The total amount of revenues estimated from the 33 commercial orbital launches are at $3 billion for 2017, comparing with $2.5 billion in 2016.[117]

The nations with the highest launch rates remained the same as in 2016 with a shifted ranking.

Standing on the number of commercial launches provided by the FAA's Annual Compendium of Commercial Space Transportation, it should be noted that its definition of a commercial launch includes either one where the primary payload's launch contract was awarded according to a fair and open process or where the launch is privately financed by a private actor without government support[118].

When looking into the number of payloads launched by specific countries (Table 2.2 and Figure 2.10), India held the first position with the number of payloads designed to generate revenue, while the situation of 2016 showed the US in the leading position. Over a total of 471 payloads, 289 were commercial, 80 were governmental, 35 were military, and an increased number of 63 related to education and 4 considered dual use[119]. As was the case in 2016, Europe was in second position in terms of number of commercial launches in 2017 (24% of the total), followed by Russia (9%) and New Zealand (1%). The U.S. was at the first position with 21 commercial launches (64%), of which 17 were conducted by SpaceX, launching seven payloads to GEO, nine to LEO and one to SSO. Three out of nine LEO launches were for the ISS Commercial Resupply Services programme (NASA CRS) and it was the first provider to reuse the first stage of the launcher. India tripled the Russian record of the largest number of satellites launched in a single mission by launching 104

<https://spacenews.com/viasa t-preps-big-insurance-claim-for-viasat-2-antenna-anomaly/> 29th August 2018.

[114] Craig Barner "Soaring inflight connectivity growth boosts ViaSat as insurance claim and JV questions linger", 29th May 2018 Satellite Finance. <https://www.satellitefinance.com/insights/soaring-inflight-connectivity-growth-boosts-viasat-insurance-claim-and-jv-questions-linger> 30th August 2018.

[115] Jarowslav Adamowski "Angola eyes new satellite as African space race accelerates", 12th June 2018. SpaceNews 30th August 2018.<https://spacenews.com/angola-eyes-new-satellite-as-african-space-race-accelerates>.

[116] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2018. Washington DC: FAA, Jan. 2018: 39-40.

[117] Ibid.

[118] Ibid. at p. 93.

[119] ESPI database.

satellites in February, carried by a PSLV-XL[120]. The new launch vehicle Electron was also tested, unsuccessfully, but Rocket Lab announced on 7 August 2018 an agreement with a Dubai- based smallsat company for ten launches. The agreement foresees launches starting at the end of 2019 from Rocket Lab's New Zealand launch site[121].

Launch country	Commercial	Governmental Civil	Military	Education	Dual	Grand Total
USA	72	22	18	42		154
India	113	10		14	1	138
Russia	81	23	6	5		115
China	10	11	9	2	2	34
Europe	11	8	1			20
Japan		6	1		1	8
Others	2					2
Grand Total	**289**	**80**	**35**	**63**	**4**	**471**

Table 2.2: Worldwide payloads launched in 2017 per country and commercial status. (Source: ESPI database)

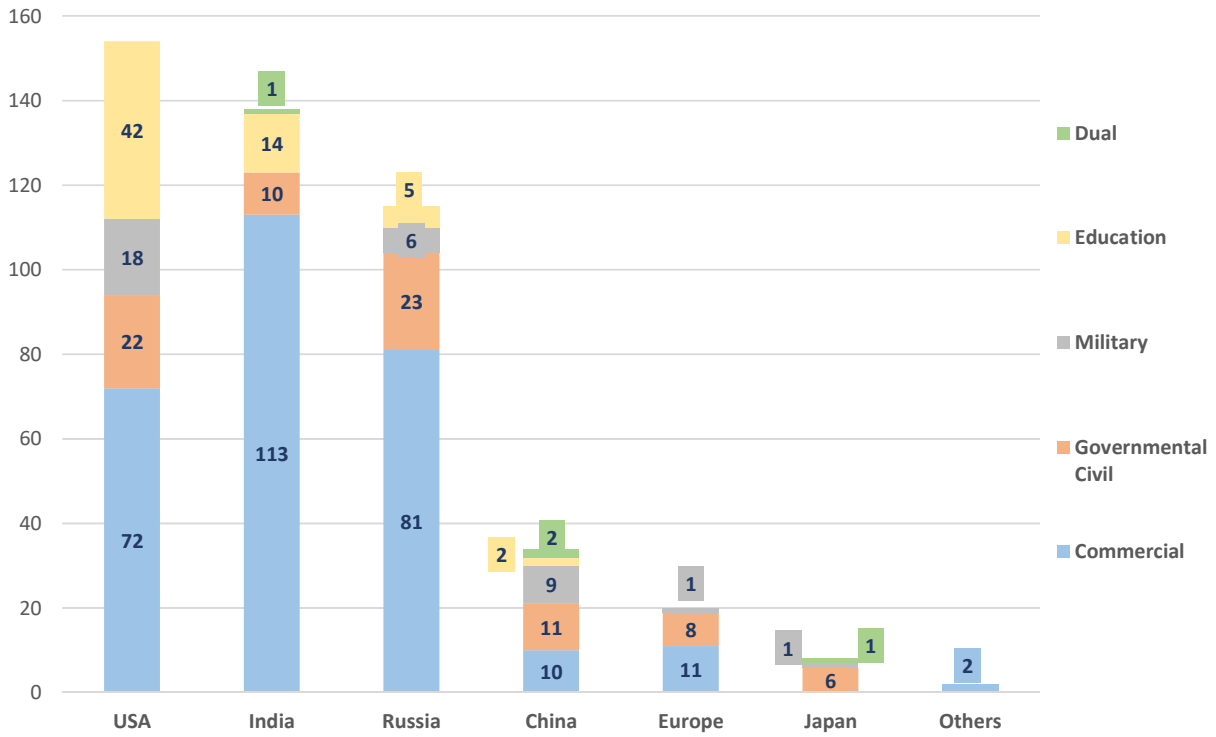


Figure 2.10 Total payloads launched in 2017 by country and market (Source: ESPI Database)

[120] Federal Aviation Administration. The Annual Compendium of Commercial Space Transportation: 2018. Washington DC: FAA, Jan. 2018: 40.

[121] Jeff Foust „Rocket Lab announces order for 10 Electron launches from new Dubai company", Space News 8th August 2018. < https://spacenews.com/rocket-lab-announces-order-for-10-electron-launches-from-new-dubai-company/> 30th August 2018.

In terms of the global share of payloads launched in 2017 (Table 2.2 and Figure 2.10), the total number of spacecraft doubled from 2016, including the increasing number of small satellites that are changing this market sector. In relation to this increase, in February 2018 ESA announced that five companies will study potential small launch vehicles for the agency's Future Launchers Preparatory Programme (FLPP); a European microlauncher for commercial purposes could meet the growing demand for services related to small satellites[122].

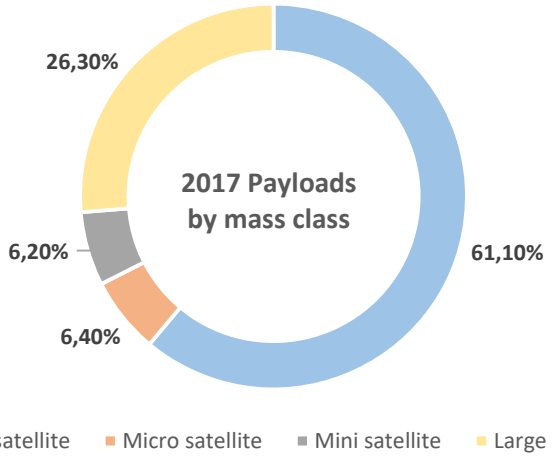


Figure 2.11: Distribution of the payloads launched in 2017 by mass class (Source: ESPI database)

Payloads by mass class	Number of spacecraft in 2017	Percentage	Average mass (kg)	Total mass (kg)
Nano satellite	288	61,1%	4,3	1.238
Micro satellite	30	6,4%	43,3	1.300
Mini satellite	29	6,2%	266,6	7.732
Large satellite	124	26,3%	3.149,1	390.483
	471	**100,0%**	**850,9**	**400.754**

Table 2.3: Distribution of the payloads launched in 2017 by mass class (Source: ESPI database)

In 2017, there were also come changes in the distribution of payload sizes (Figure 2.11 and Table 2.3). The number of payloads increased from 222 (2016) to 471 and the total mass is approximately valued at the same weight, i.e., 390,040 kg in 2016 and 400,754 in 2017. The average mass of spacecraft launched into orbit is reduced to 850.9 kg in 2017 comparing with 1,756.9 of 2016. Figure 2.11 shows the large share of Nano satellites launched, representing 61.1% of the total in 2017; moreover, the number of Nano satellites launched in 2017 is higher than the total number of spacecraft launched in 2016.

Once again, Arianespace conducted the most launches to GEO in 2017, with a 29,73% share, followed by SpaceX with a 18,92% share (Figure 2.12 and Table 2.4). China Aerospace Science Corporation (CASC), the U.S United Launch Alliance, Russia´s International Launch Service, and Mitsubishi Heavy Industries shared the same number of GEO satellites placed in orbit (i.e., 4), representing a 10,81% share. Arianespace placed 11 commercial telecommunication satellites into GEO orbit using nine Ariane 5 ECA launchers and 2 Soyuz-ST-B Fregat-MT launchers, carrying a

[122] ArianeGroup, MT Aerospace, European Launch Vehicle, Deimos and PLD Space.
Caleb Henry "ESA awards five smallsat launcher study contract", Space News 8th February 2018.
<https://spacenews.com/esa-awards-five-smallsat-launcher-study-contracts/> 30th August 2018.

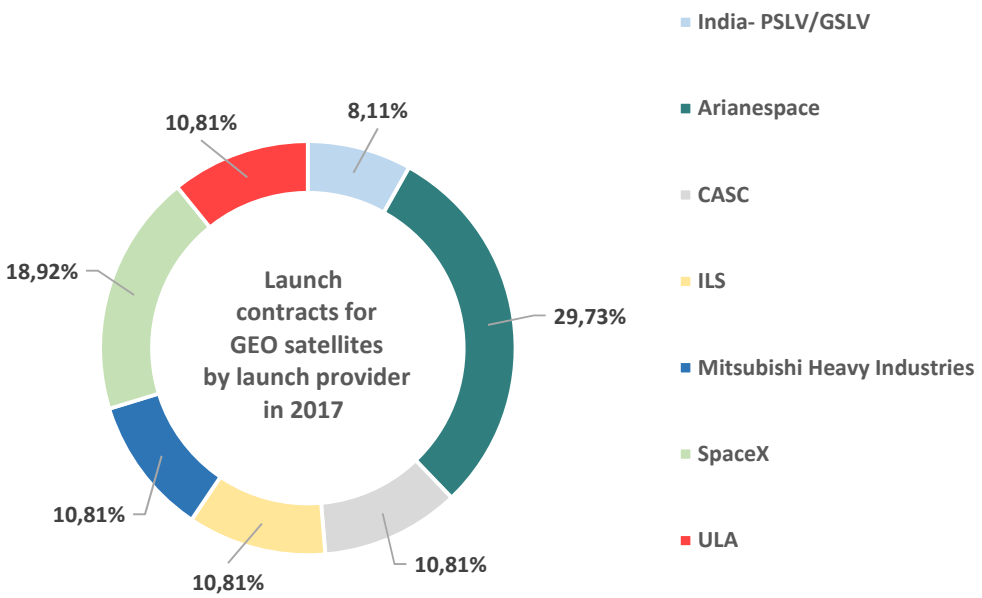


Figure 2.12: Share of launch contracts for GEO Satellites in 2017 by launch service provider (Source: ESPI database)

total of 50,195.00 kg. SpaceX had seven launches with Falcon 9 v1.2, lifting telecommunication satellites (EchoStar 23, SES 10, Inmarsat 5 F4, BulgariaSat 1, Intelsat 35e, EchoStar 105 / SES 11, Koreasat 05A) for a total of 36,100.00 kg. China's CASC had 4 launches, 3 with Long March 3B E (CZ-3B/G2) and one with a Long March 5 (CZ-5) for a total mass of 20,300.00 kg. Considering the partial failure of ZhongXing 09A / ChinaSat 9A and the failure of the ShiJian 18 (both commercial telecommunication satellites), the two successful launches of governmental civil technology demonstration satellites were of Tongxin Jishu Shiyan 02 and the ShiJian 13. The ULA had 3 launches with Atlas-5 (2 launches, including one for the military SBIRIS-GEO 03 satellite and the governmental telecommunication TDRS 13 satellite with the 401 Atlas version, and another for the military telecommunication SDS 402 / Quasar 21 satellite with the 421 version) and one for a military telecommunication satellite (WGS 09) with a Delta-4M+ (5,4 upgrade), representing four in total and carrying a total mass of 19,841.00 kg to GEO. Russia's International Launch Services conducted 3 launches with a Proton-M Briz-M (Ph.3) for three telecommunication satellites (EchoStar 21, Blagovest 11L, Amazonas 05) and one launch with a Proton-M Briz-M (Ph.4) carrying a commercial telecommunication satellite AsiaSat 9. The total amount of transported satellite mass was 23,912.00 kg. Mitsubishi Heavy Industries carried 16,700.00 kg of total mass for three navigation satellites (QZS 02 / 03/ 04) and one telecommunication satellite (Kirameki 02). And lastly, India's PSLV-XL launcher lifted the navigation satellite IRNSS 1H while its GSLV Mk.2 and Mk.3 launched the two telecommunication satellites GSat 09 and GSat 19. With a share of 8.11%, India carried a total mass of 6,756.00 kg into GEO orbit[123].

Service Provider	GEO
India- PSLV and GSLV	3
Arianespace	11
CASC	4
ILS	4
Mitsubishi Heavy Industries	4
SpaceX	7
ULA	4
Grand Total	**37**

Table 2.4: Launch contracts for GEO satellites in 2017 by launch service provider (Source: ESPI database)

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 of global trends in the space industry.

[123] ESPI database

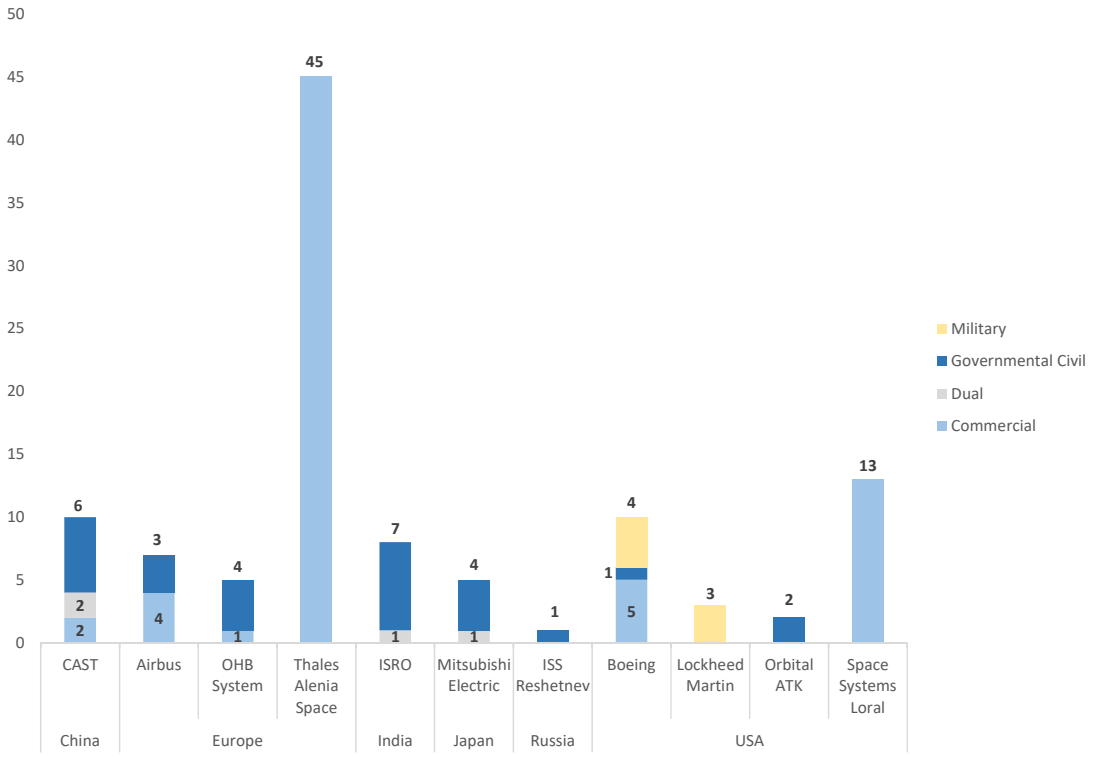


Figure 2.13: Satellites launched in 2017 by selected manufacturer and commercial status (Source: ESPI database)

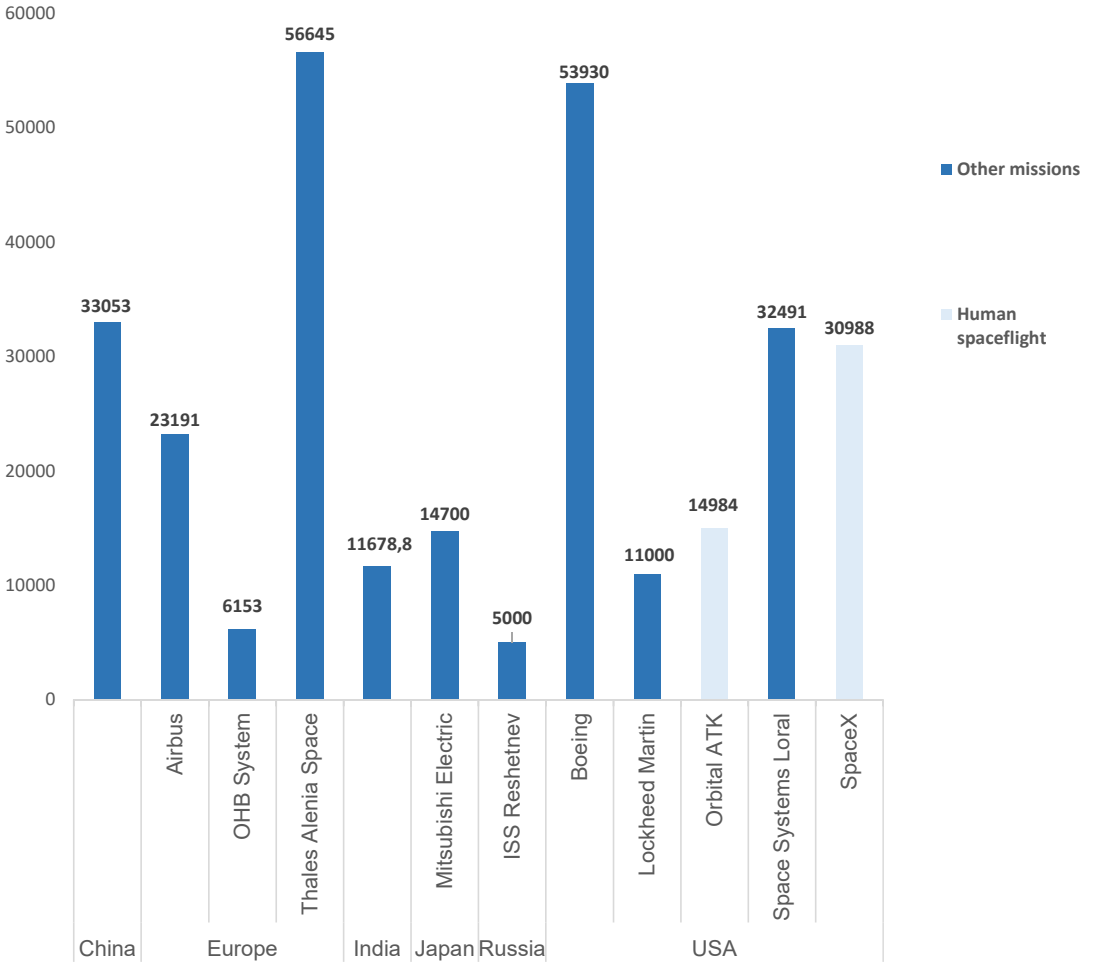


Figure 2.14: Comparison of Human spaceflight mission total mass and other missions' total mass in 2017. (Source: ESPI database)

In 2017, 471 payloads were launched (including 445 satellites and cubesats, 26 transfer vehicles including crewed and cargo, or hardware missions to the ISS, ISS infrastructure and technology demonstration). Europe, with its 88 satellites, mostly built for communications and four for Galileo, accounted for 18.68% of the payloads launched. As figure 2.13 shows, commercial satellites are predominant in the 2017 market.India held the primacy for the largest amount of total satellite mass launched at 11,678.8 kg, although it represented a smaller number of satellites produced, comparing with Europe (which represented 85,989 kg in total) and the United States (143,393 kg in total). The same evaluation can be made in comparison with human spaceflight missions, where the total mass carried up was 45,972 kg. The overall mass manufactured by the selected industries stands at 293,813.8 kg (Figure 2.14).

The main manufacturers in Europe as Airbus, OHB System, and Thales Alenia Space, which produced 57 satellites total, 50 of which being commercial. Out of 109 payloads only four were dual use (2 from China, 1 from Japan, and 1 from India) and 7 related to the military market (Figure 2.13).

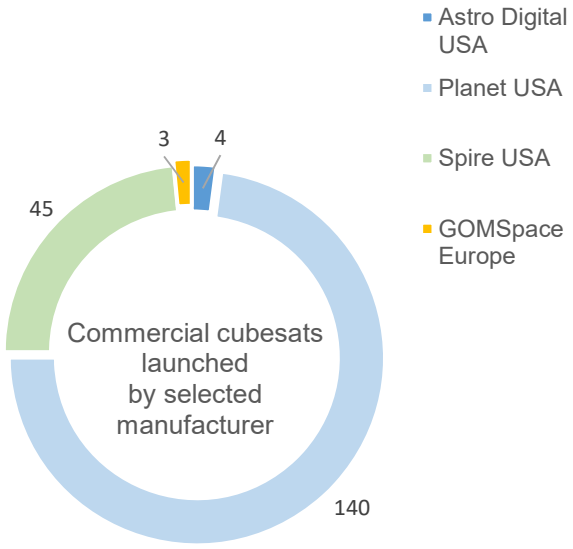


Figure 2.15: Commercial cubesats launched in 2017 by selected manufacturer (Source: ESPI database)

In 2017, the rise of the number of cubesats is impressive, representing a total of 194 out of 445 satellites launched, all of which being commercial (Figure 2.15)(for comparison, in 2016 the total amount of cubesats was 84). Planet was the main actor with 140 commercial cubesats launched; from a European perspective, the principal manufacturer was GOMSpace with 3 cubesats out of a total of 5 (the others including 1 from D-Orbit and 1 from German Orbital System).

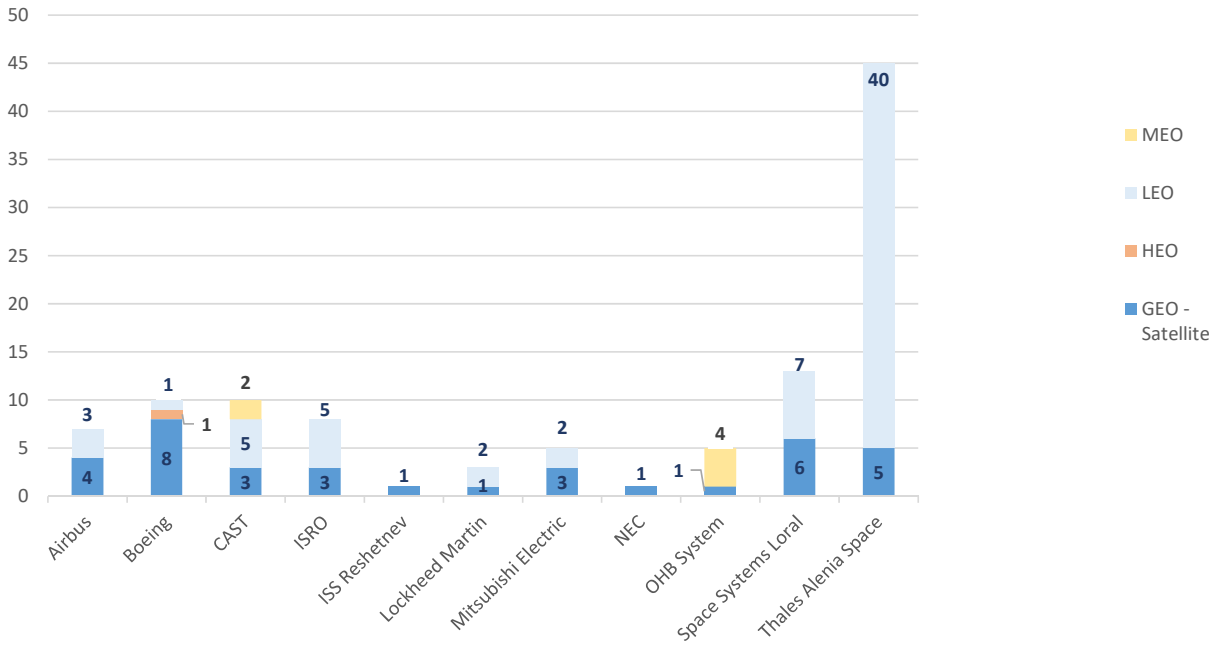


Figure 2.16: Satellites launched in 2017 by manufacturer and orbit types (Source: ESPI database)

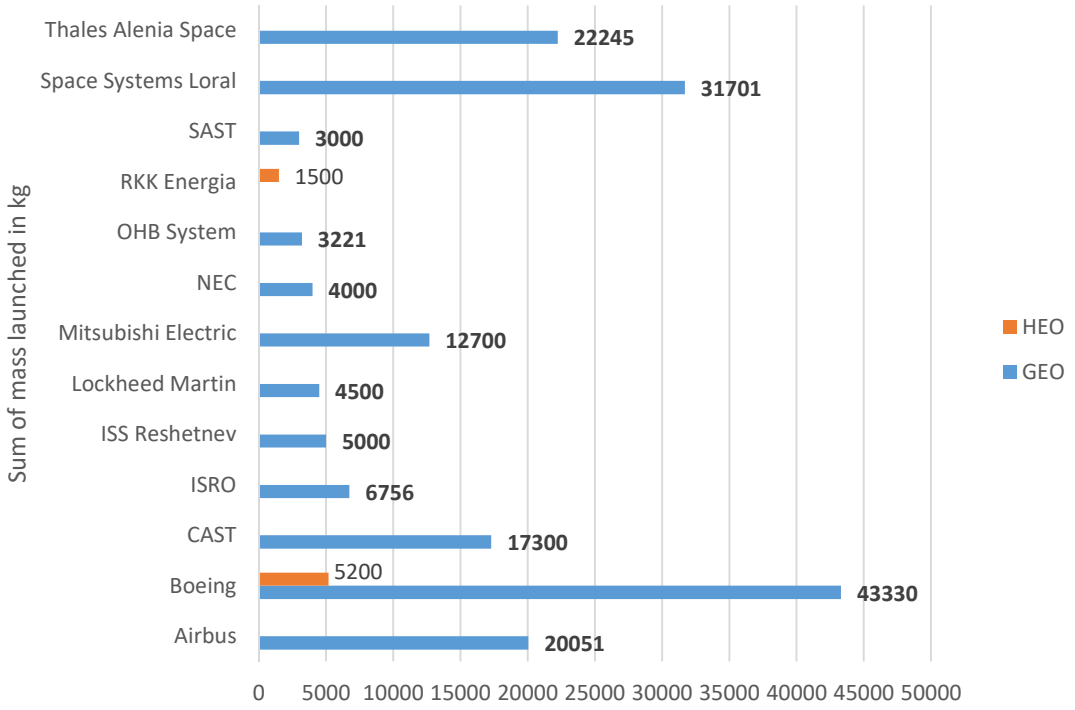


Figure 2.17: Satellite mass launched in GEO and HEO by manufacturer in 2017 (Source: ESPI database)

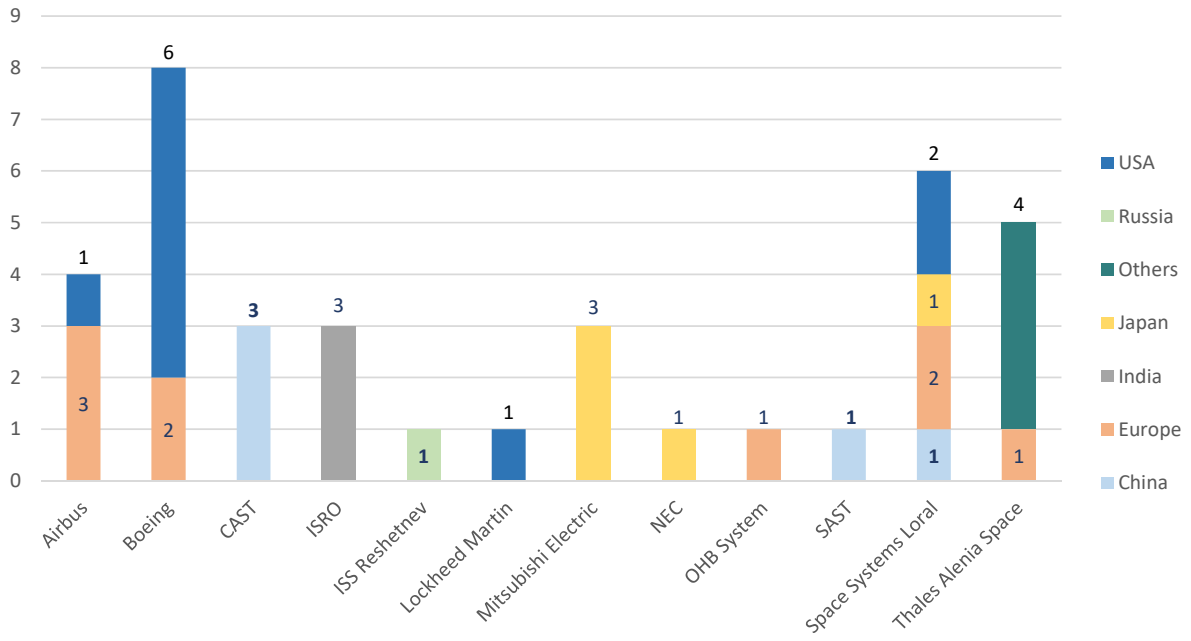


Figure 2.18: GEO satellite orders in 2017 by manufacturer and customer region (Source: ESPI database)

In 2017, the largest number of satellites had LEO as their destination, followed by GEO (Figure 2.16). In terms of mass launched to GEO (Figure 2.17), Boeing (representing 43,330 kg launched), Space System Loral (31,701 kg) and Thales Alenia Space (22,245 kg) launched the largest amount of satellite mass. Despite the 37 GEO satellites launched, 2017 was less fruitful for the leading satellite manufacturers in Europe, with the number of contracts awarded in the region for geostationary communication satellites dropping to only four. However, from a satellite operator perspective, they can now improve profit margins through serving the same clients without reintegrating their fleet of GEO satellites. Moreover, the telecommunication market is going through a general diversification, aiming to

link constellations in a mix of LEO and MEO orbits[124]. The joint venture between Airbus and the broadband start-up OneWeb is a key figure from the market revolution perspective, aiming to launch a small LEO telecommunication constellation composed of 900 satellites (with a maximum weight of 145 kg per satellite[125]) to begin launching at the end of 2018. Arianespace will launch the first satellite generation – with 21 Soyuz launches already contracted – and is willing to carry the second generation with the Ariane 6.[126] In this regard, the analysis concerning exclusively GEO orders won't reflect the prosperity of the satellite sector in the future (Figure 2.18).

In 2017, ten new geostationary and MEO commercial satellite contracts were signed, despite the lower number in comparison with 2016. In Europe, Airbus won two GEO communication satellite orders for Türksat 5A and 5B, Thales Alenia Space won a contract for an Inmarsat communication satellite Inmarsat-5 F5 (GX 5), and OHB received an order for Heinrich Hertz (H2Sat), to be operated by DLR and launched in 2021 with an Ariane 5 ECA[127]. The U.S.' Space System Loral won two contracts for Star One D2 and Jupiter 3, while Boeing was contracted for JCSat 18 / Kacific 1. In 2018, the contracts for commercial satellites expanded to twelve, with Airbus winning two contracts to launch Hotbird 13F and 13G, while Thales Alenia is confirmed with one contract for Eutelsat's Konnect VHTS. They are to be launched in 2021.[128]

2.5 International Sectoral Comparison

In order to assess the scope and dynamism of the activities, strategies, and plans of the main space-faring nations, key factors such as the ability to launch missions and the number and type of missions launched, must be considered.

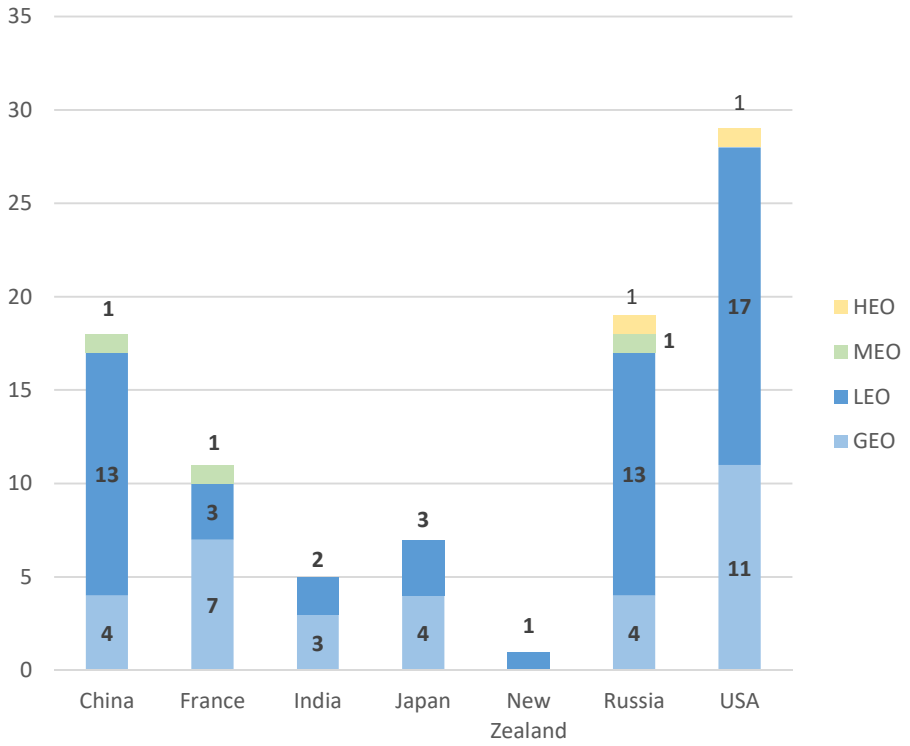


Figure 2.19: Total orbital launches per country and orbit (Source: ESPI database)

[124] Bryan Berger "Are Geo satellites orders still a good measure of industry health?", Space News 15th September 2017. <https://spacenews.com/are-geo-satellite-orders-still-a-good-measure-of-industry-health/> 3rd of September 2018.
[125] Caleb Henry "OneWeb says regulatory concerns main reasons it´s foregoing inter-satellite links" 2nd of July 2018. <https://spacenews.com/oneweb-says-regulatory-concerns-main-reason-its-forgoing-inter-satellite-links/> 3rd of September 2018.
[126] Caleb Henry "OneWeb shifts the first launch to year's end", Space News, 1st of May 2018. <https://spacenews.com/oneweb-shifts-first-launch-to-years-end/>, 3rd September 2018.
[127] Gunter´s space page "Recently awarded GEO-Sat contract".<https://space.skyrocket.de/doc_sat/sat-contracts.htm> 4th September 2018.
[128] Ibid.

2.5.1 Launch Sector

The possession of launch vehicles and spaceports is a central element in enabling independence in space activities. Moreover, the number of launches and the level of activity of the space bases give an indicator of the dynamism of a country in the space sector.

In 2017, seven countries carried out a total of 90 launches, up from the 85 orbital launches of eight countries in 2016. (Fig. 2.19)

The number of total launches conducted to GEO was 33, with 52 to LEO, only 3 to MEO, and 2 to HEO. The U.S. carried out a large number of launches to both GEO (11) and LEO (17), along with China which also conducted 13 LEO launches. (Figure 2.19)

In 2017, the number of missions grew to 471 from 223 in 2016.[129] Although the number of large satellite missions stood at 124, a total of 288 missions concerned nano satellites. Most of the countries having a single mission could afford access to space thanks to the reduction of satellite mass, which brings with it a consequent reduction in price.

Country	Large satellite	Micro satellite	Mini satellite	Nano satellite	Grand Total
China	13	9	9	3	**34**
Europe	18		2		**20**
India	5	3		130	**138**
Japan	6		1	1	**8**
New Zealand		1		1	**2**
Russia	17	14	3	81	**115**
USA	65	3	14	72	**154**
Grand Total	**124**	**30**	**29**	**288**	**471**

Table 2.5.A: Distribution of the payloads launched in 2017 by country (Source: ESPI database)

Table 2.5.A presents the distribution of the total number of payloads launched according to launching state in 2017. While the total number of missions in recent years is partly skewed due to the growth in nano satellite missions, removing the 288 nanosatellites from consideration does not yield a different outcome in terms of national rankings of overall mass launched. In considering only the 183 missions that would remain, the U.S. would still hold the first position with 65 large satellites and the second one would be Europe. The strong presence of India in Table 2.5.A is due to the 130 nanosats launched, 103 of which deployed in the same mission reaching a new record on 13 February with PSLV-C37 (employing an XL version of the Indian Space Research Organization's Polar Satellite Launch Vehicle)(Figure 2.24). Moreover, on 6 July, India demonstrated its launch capability with its most powerful rocket, the GLSV MK3, which is capable of lifting 4 tonnes to GTO or 10 tonnes to LEO.

In 2017, 187 missions (Figure 2.20) were classified as civilian Earth observation (including cubesats mostly from Planet). (Figure 2.22 removes Earth observation missions from consideration.) The U.S. conducted 157 remote sensing missions (representing 9,094 kg of total mass), China conducted 10 (7,684.5 kg of total mass), while Europe 4 (2,402 kg of total mass) and likewise Russia (3,246.4 kg of total mass). In terms of mass (Table 2.5.B), China launched 10,708 kg of total mass for only 4 technology and demonstration missions, while the U.S. launched 5,472.6 kg of mass for 21 missions. Europe's navigation activity centred on launching 4 Galileo navigation satellites, carrying up 2,932 kg of total mass for the navigation market. Next, ten cargo missions were conducted, four using the SpaceX Dragon (30,988.00 kg launched), three with the Russian Progress-MS (21,855.00 kg), two with Cygnus (14,984.00 kg), and one with the Chinese Tianzhou 01 (12,910.00 kg). Eight launches were conducted for the ISS infrastructure, lifting to orbit 3,599.00 kg of mass. Each of Soyuz-MS 4 crew launches were carried out with a total mass of 7,220.00 kg at launch.

[129] ESPI database.

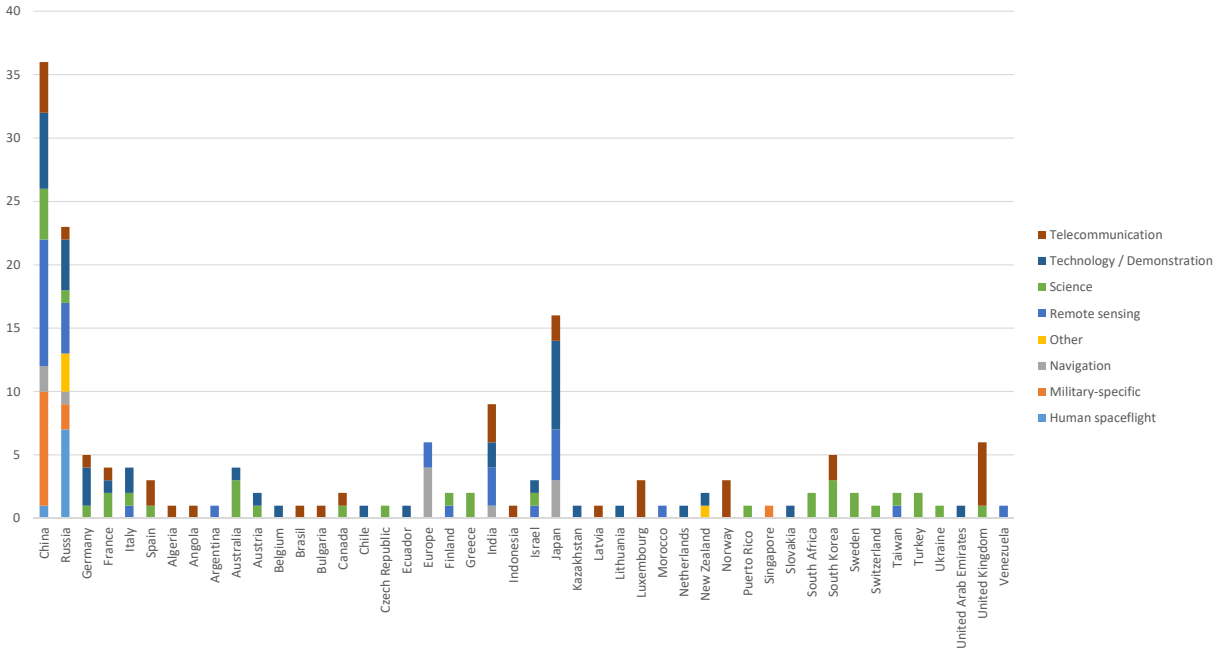


Figure 2.20: Types of missions launched into orbit in 2017, excluding the U.S. (Source: ESPI database)

The first launch of 2017 was a Long March 3B-E XiChang on 5 January, and on 9 January the Kuaizhou 1A (KZ-1A) flew for the first time from Jiuquan Satellite Launch Centre. As in 2016, the SpaceX Falcon 9 V1.2 was in the most use in 2017 (Figure 2.23) with 15 launches. Europe's Ariane 5 ECA was the second most used launch system with 5 launches. After a long investigation over a 2016 accident, Falcon 9 orbited 10 Iridium-NEXT units for the replacement of the LEO communication satellite constellation. On 19 February, Falcon 9 delivered the CRS-10 Dragon spacecraft with cargo for the ISS from the Kennedy Space Center Launch Complex, launching from the prior NASA Space Shuttle launch site. On 30 March, SpaceX launched a re-used Falcon 9 first stage for the first time.

On 15 December, the re-used stage helped orbit a used Dragon cargo capsule for NASA. The United Launch Alliance's Atlas 5 also launched Orbital-ATK's Cygnus cargo to the ISS in April. Russia's Soyuz-U launch vehicle performed its final flight on 22 February when it boosted the Progress MS-05 robotic cargo carrying the spacecraft into orbit from Baikonur Cosmodrome, Kazakhstan. A Soyuz FG rocket additionally launched Russia's Soyuz MS-04 spacecraft from Baikonur with two ISS crew. A further two vessels were sent to the ISS, including with the Soyuz 2-1a with three ISS crew in July and a further three in September. The final and fourth crewed launch of 2017 lifted off in December with the Soyuz FG delivering the Soyuz MS-07 spacecraft. Further, China launched another new rocket, the KT-2 (Kaitou 2) as well as the Long March 7 carrying Tianzhou 1, the robot cargo ship for the Tiangong 2 space station. Japan demonstrated a new capability by lifting two satellites into two different orbits with the H-2A-202. In 2017, five launch failures occurred: the Japanese small experimental rocket SS-520-4, Rocket Lab's Electron during its inaugural test launch from New Zealand (without 2 payloads), China's Long March 5 carrying a large experimental communications satellite, India's PSLV XL, and a Soyuz-2-1b Fregat-M that lost the weather satellite Meteor M2-1[130].

[130] ESPI database and Gunter´s Space Page.

Country	Human spaceflight	Military-specific	Navigation	Other	Remote sensing	Science	Technology / Demonstration	Telecommunication	Grand Total
Algeria								5225	5225
Angola								1550	1550
Argentina					37				37
Australia						6	4		10
Austria						2	3		5
Belgium							4		4
Brasil								5735	5735
Bulgaria								3669	3669
Canada						4		70	74
Chile							1		1
China	12910	2700	2028		7684,5	2506	10708	15886	54422,5
Czech Republic						2			2
Ecuador							1		1
Europe			2932		2030				4962
Finland					4	2			6
France						4	1	3551	3556
Germany						2	142	4	148
Greece						4			4
India			1425		1443		17,8	8808	11693,8
Indonesia								3550	3550
Israel					264	2	4		270
Italy					368	15	7		390
Japan			12700		3610		408	7520	24238
Kazakhstan							2		2
Latvia								5	5
Lithuania							4		4
Luxembourg								12802	12802
Morocco					1110				1110
Netherlands							4		4
New Zealand				10			50		60
Norway								51,5	51,5
Puerto Rico						2			2
Russia	50735	8000	1415	410	3246,4	13	112,8	5000	68932,2
Singapore		22							22
Slovakia							1		1
South Africa						4			4
South Korea						6		7180	7186
Spain						2		9121	9123
Sweden						6			6
Switzerland						3			3
Taiwan					475	2			477
Turkey						4			4
Ukraine						2			2
United Arab Emirates							1		1
United Kingdom						3		11868	11871
USA	49571	16340		2	9094	35	5472,6	88013	168528
Venezuela					1000				1000
Grand Total	**113216**	**27062**	**20500**	**422**	**30365,9**	**2631**	**16948,2**	**189608,5**	**400754**

Table 2.5.B: Table of the mass of satellites by type of mission per Country (Source: ESPI database)

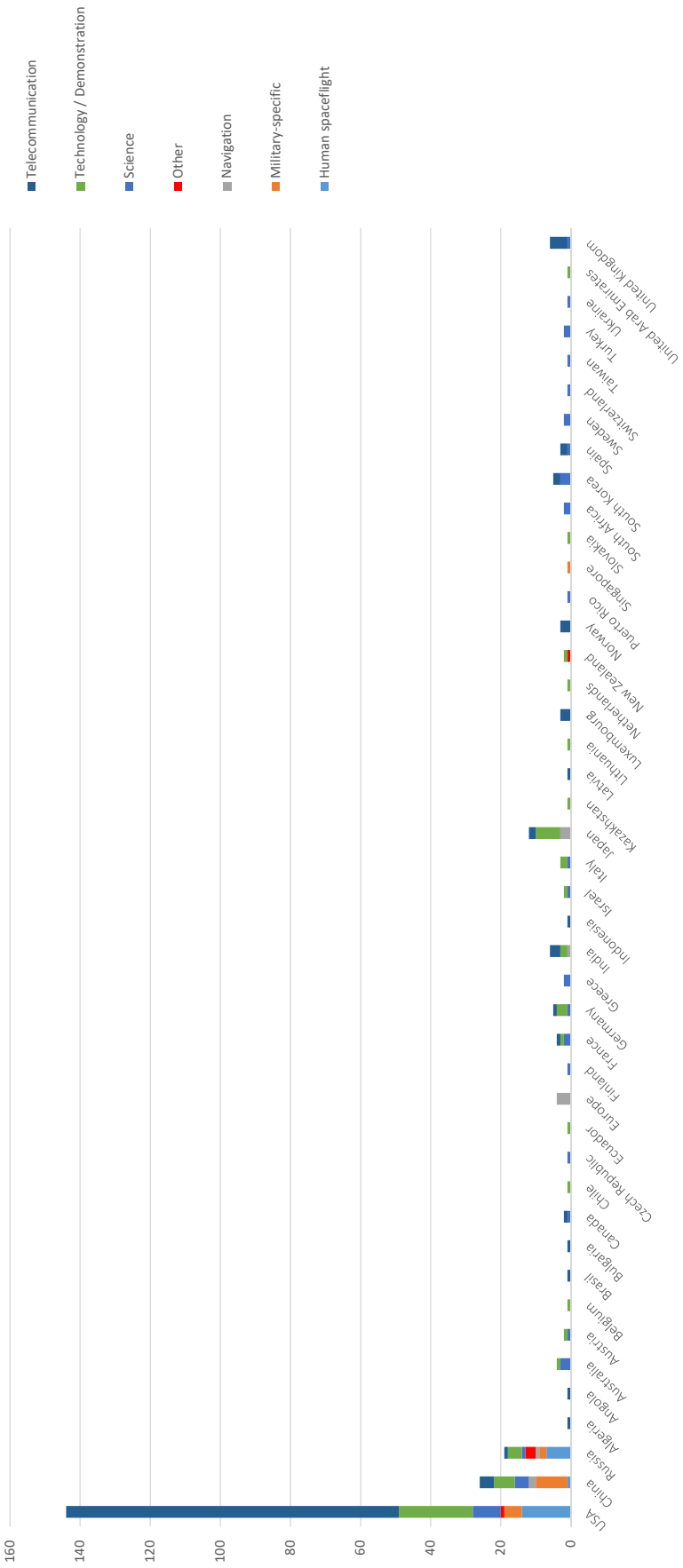


Figure 2.21: Types of missions launched into orbit in 2017, including the U.S. (Source: ESPI database)

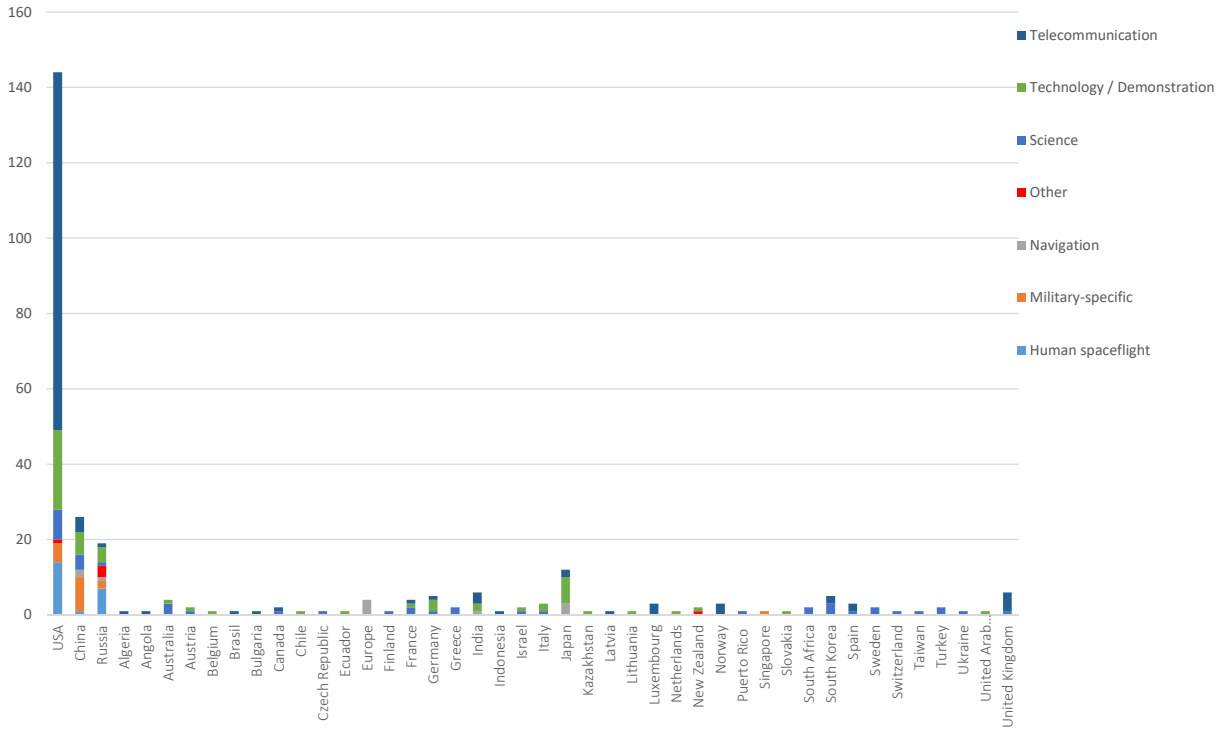


Figure 2.22: Types of missions launched into orbit in 2017, excluding Earth observation (Source: ESPI database)

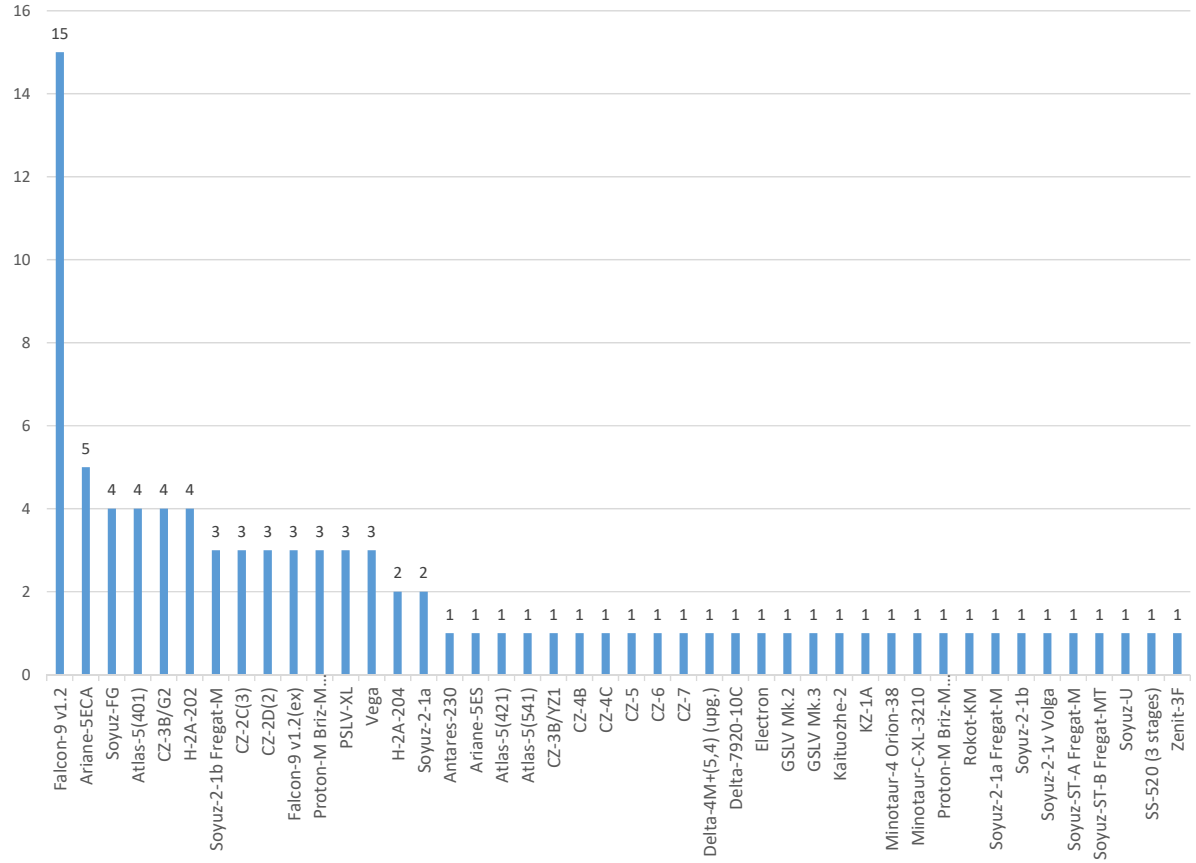
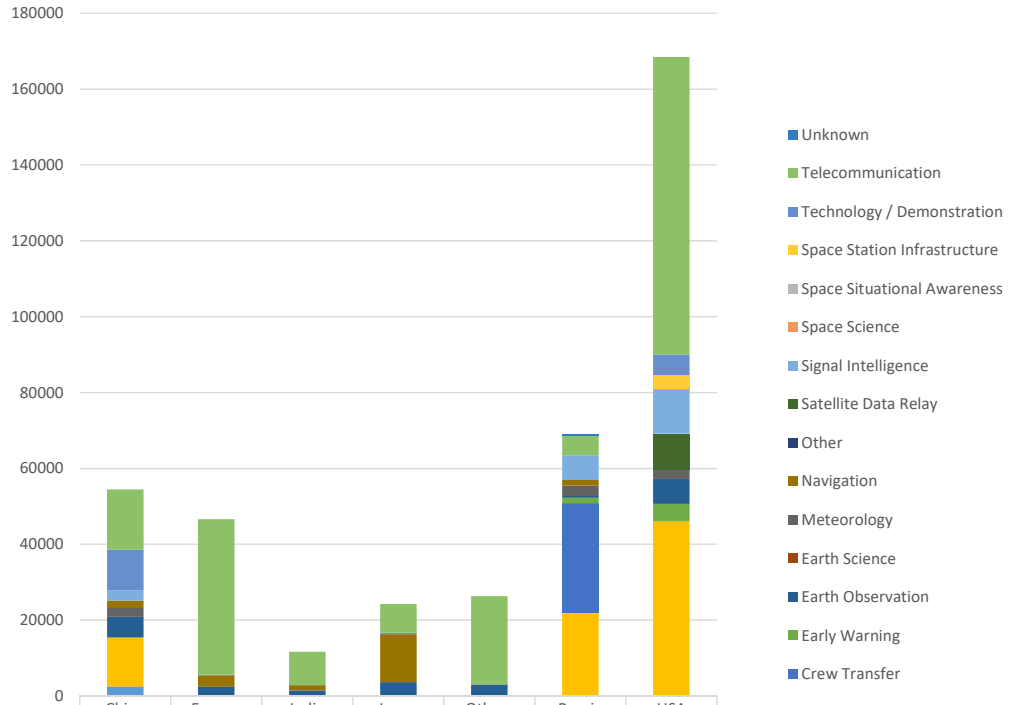


Figure 2.23: Worldwide orbital launches per launch system in 2017 (Source: ESPI database)



	China	Europe	India	Japan	Others	Russia	USA
Unknown						410	
Telecommunication	15841	41015	8808	7520	23310	5000	78475
Technology / Demonstration	10708	166	17,8	408	63	112,8	5472,6
Space Station Infrastructure							3599
Space Situational Awareness					22		140
Space Science							8
Signal Intelligence	2700					6500	11700
Satellite Data Relay							9354
Other					10		2
Navigation	2028	2932	1425	12700		1415	
Meteorology	2200					2750	2540
Earth Science	6	27			32	13	13
Earth Observation	5484,5	2402	1443	3610	2886	496,4	6554
Early Warning						1500	4500
Crew Transfer						28880	
Cargo Transfer	12910					21855	45972
Biology		3					11
Automatic Identification System	45	56,5					184
Astronomy	2500	15					3

Figure 2.24: Type of missions per mass class. (Source ESPI database)

	Launcher	Launches	Mass of Launcher (metric ton)	Mass Sum
	Ariane-5ECA	5	777	3885
	Ariane-5ES	1	773	773
	Soyuz-ST-A Fregat-M	1	306,6	306,6
	Soyuz-ST-B Fregat-MT	1	308	308
Europe	Vega	3	137	411
	Antares-230	1	298	298
	Atlas-5(401)	4	334,5	1338
	Atlas-5(421)	1	428	428
	Atlas-5(541)	1	540,3	540,3
	Delta-4M+(5,4) (upg.)	1	404,6	404,6
	Delta-7920-10C	1	232	232
	Falcon-9 v1.2	15	549	8235
	Falcon-9 v1.2(ex)	3	505,8	1517,4
	Minotaur-4 Orion-38	1	77	77
USA	Minotaur-C-XL-3210	1	86,3	86,3
New Zealand	Electron	1	105	105
	Kaituozhe-2	1	40	40
	KZ-1A	1	30	30
	CZ-2C(3)	4	192	768
	CZ-2D(2)	3	232,3	696,9
	CZ-3B/G2	4	325,8	1303,2
	CZ-3B/YZ1	1	456	456
	CZ-4B	1	249,2	249,2
	CZ-4C	1	250	250
	CZ-5	1	867	867
	CZ-6	1	103,2	103,2
China	CZ-7	1	594	594
	PSLV-XL	3	320	960
	GSLV Mk.2	1	414	414
India	GSLV Mk.3	1	630,6	630,6
	H-2A-202	4	285	1140
Japan	H-2A-204	2	443	886
	SS-520 (3 stages)	1	260	260
	Proton-M Briz-M (Ph.3)	3	712,8	2138,4
	Proton-M Briz-M (Ph.4)	1	705	705
	Rokot-KM	1	107	107
	Soyuz-2-1a	2	303	606
	Soyuz-2-1a Fregat-M	1	308	308
	Soyuz-2-1b	1	303	303
	Soyuz-2-1b Fregat-M	3	312	936
	Soyuz-2-1v Volga	1	158	158
	Soyuz-FG	4	305	1220
	Soyuz-U	1	313	313
Russia	Zenit-3F	1	465	465

Table 2.6: Distribution of the mass of launch system launched by launching state in 2017 (Source: ESPI database)

Figure 2.25: Worldwide orbital launches per launch site in 2017. (Source: ESPI Database)

Figure 2.26: Total payload mass launched per launch site in 2017. (Source: ESPI Database)

Country	Spaceport	Large satellite	Micro satellite	Mini satellite	Nano satellite	Total
Europe	Kourou, French Guiana	18		2		20
USA	Vandenberg	44		7	9	60
	Cape Canaveral	6		3	41	50
	Wallops Flight Facility	1	1		15	17
	Kennedy Space Centre	14	2	4	7	27
China	Jiuquan	4	5		2	11
	Wenchang	2			1	3
	Xichang	6		9		15
	Taiyuan	1	4			5
Japan	Kagoshima				1	1
	Tanegashima	6		1		7
Russia	Baikonur	12	8	2	67	89
	Vostochny	1	5		13	19
	Plesetsk	4	1	1	1	7
India	Satish Dhawan	5	3		130	138
New Zealand	Onenui		1		1	2
	Grand Total	**124**	**30**	**29**	**288**	**471**

Table 2.7: Distribution of the payloads launched in 2017 by Launch site (Source: ESPI database)

Tables 2.6, 2.7, and 2.8 present the distribution of the total mass of launch systems by launching state and spaceport in 2017. Space transportation infrastructure is another factor that helps assess space capacity, as spaceports are integral for independent access to space (see Figure 2.25). The number of spaceports used by a country, as well as the frequency of launches conducted from them, are important indicators of the momentum of a country's space activities. In 2017, Baikonur (Kazakhstan) held the first position with 13 launches (14.4% of total launch activity); Kennedy Space Centre in the U.S. was the second most active launch site with 12 launches (13.3%); Europe's Kourou Spaceport in French Guiana was the next most active spaceport with 11 launches, losing a position compared with the previous year (representing 12.2% in 2017). The U.S. Vandenberg AFB with 9 launches held the fourth position in 2017 (10%), followed by Xichang (9%), Cape Canaveral (7.8%), Jiuquan (6.7%), Tanegashima (6.7%), Plesetsk (5.5%), Satish Dhawan (5.5%), Wenchang (2.2%), Taiyuan (2.2%), Wallops Flight Facility (1.1%), Kagoshima (1.1%), and Vostochny (1.1%). The Onenui spaceport (1.1%) is located in New Zealand and was active for the first time in 2017[131].

[131] ESPI database.

Country	Spaceport	Launches
Europe	Kourou, French Guiana	11
	Vandenberg	9
USA	Cape Canaveral	7
	Wallops Flight Facility	1
	Kennedy Space Centre	12
	Jiuquan	6
China	Wenchang	2
	Xichang	8
	Taiyuan	2
	Kagoshima	1
Japan	Tanegashima	6
	Baikonur	13
Russia	Vostochny	1
	Plesetsk	5
India	Satish Dhawan	5
New Zealand	Onenui	1

Table 2.8: Orbital launches by spaceport (Source: ESPI database)

2.6 State of the European Industry

The financial results of Europe's space manufacturing industry in 2017 provide insight into the industry's overall 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[132].

The European space industry continued to see a steady incremental increase in turnover in recent years, increasing to €8.762 billion in 2017 from €8.247 billion in 2016 (Figure 2.27). Despite that increase, the number of commercial GEO communication satellite orders won by European prime contractors decreased to a combined share of 4 (out of 10). European prime contractor Airbus Defence & Space won 2 contracts from a non-European institutional customer, while its competitor Thales Alenia Space won a single contract from a European private customer; this marks a reduction from the 5 (out of 10) contracts awarded to European prime contractors in 2016.[133]

Employment levels are another way to gauge the situation of the main companies in the space sector (Figure 2.28). The number of jobs created has steadily increased in recent years, growing by close to 5,000 jobs from 2013 to 2017. Around 1,331 full time jobs were created in 2017 alone, marking a growth of 3.2%.

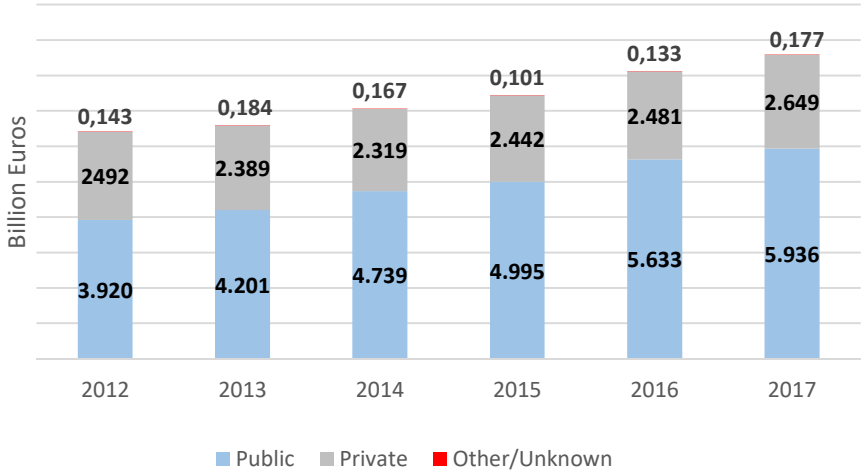


Figure 2.27: Estimated turnover of the European space sector in Euros
(Copyright by Eurospace - all right reserved, used with permission, reproduction forbidden)

[132] ASD-Eurospace. "Facts and figure- The European Space industry in 2017." 22nd edition. June 2018.

[133] "Recently awarded GEO-Sat contracts." Gunter's Space Page, 3rd of September 2017. <https://space.skyrocket.de/doc_sat/sat-contracts.htm>

In the European space sector, most funding goes toward institutional civil programmes rather than to institutional military programmes. Here, ESA's role continues to increase, aided by the development of the EU's two flagship space programmes, Copernicus and Galileo. In 2017, 79.9% of the final sales in Europe's space industry came from European customers, while 20.1% of final sales came from exports[134].

In the European domestic market, sales to European commercial customers (both civil and military) were the main source of revenues, reaching 79% in 2017, while sales to European private customers (such as satellite or launch service operators, e.g., Eutelsat, Arianespace) generated 19%, and the remaining 2% was generated by other sources[135]. (Figure 2.27)

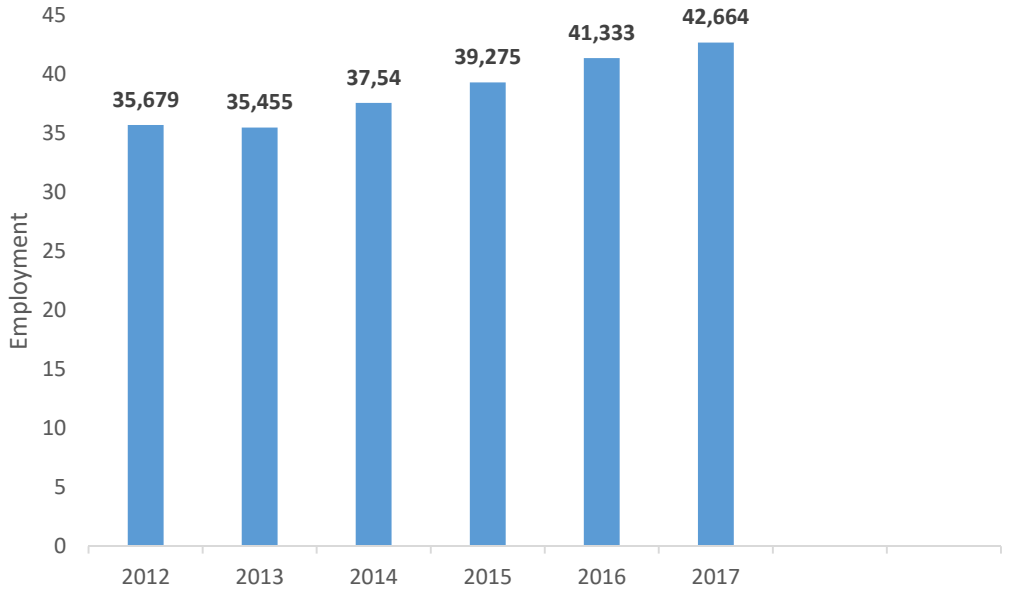


Figure 2.28: European space industry employment
(Copyright by Eurospace- all right reserved, used with permission, reproduction forbidden)

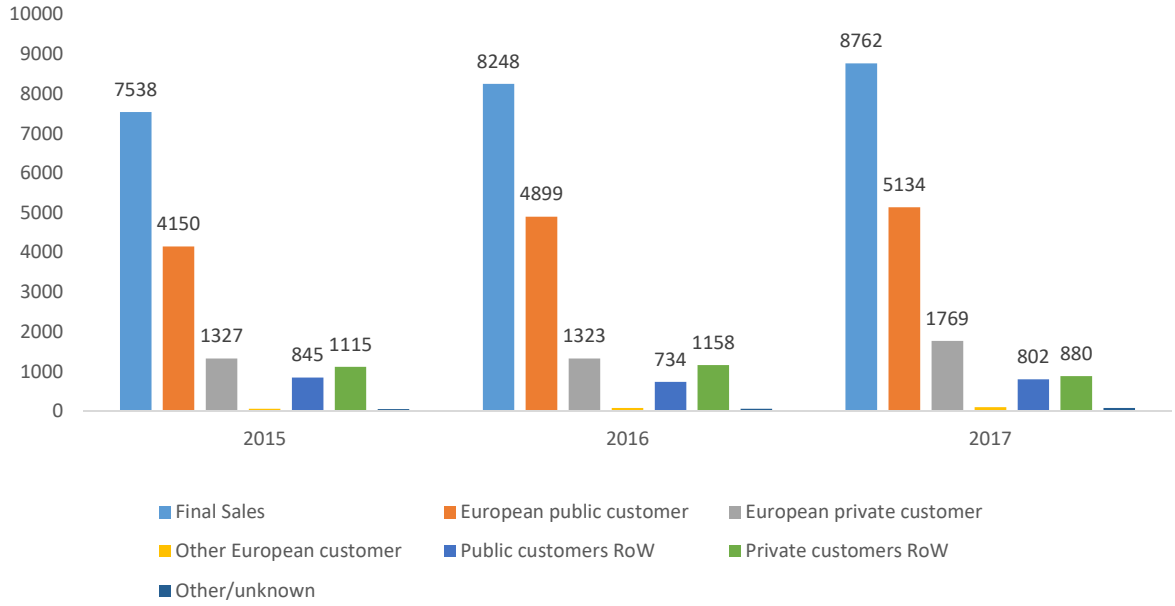


Figure 2.29: Estimated share of the European turnover per institutional customer
(Copyright by Eurospace - all right reserved, used with permission, reproduction forbidden)

[134] ASD-Eurospace. "Facts and figure- The European Space industry in 2017." 22nd edition. June 2018: 5.

[135] Ibid. at p.6.

As seen in Figure 2.29, the turnover in institutional civil programmes saw an increasing share, with ESA as the main driver in developing and procuring satellites for the Copernicus and Galileo EU flagship programmes, along with meteorological satellites on behalf of EUMETSAT. National programmes – mainly CNES, DLR and ASI – also represent a sizable share of turnover.

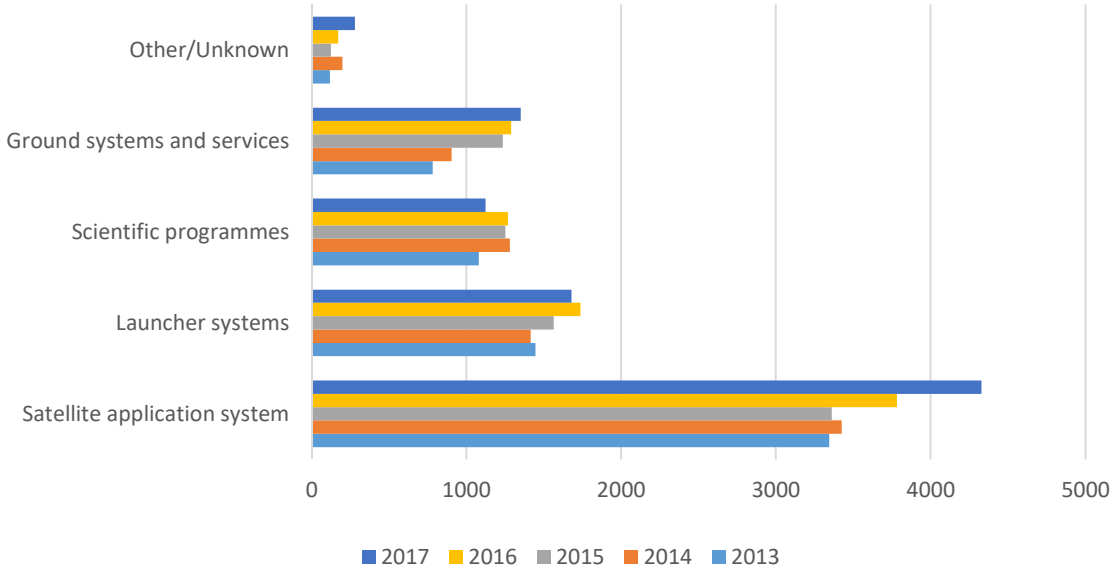


Figure 2.30: Estimated share of European space industry consolidated turnover per sector.
(Source: Eurospace - all rights reserved, used with permission, reproduction forbidden)

When looking at the European space industry by sector (Figure 2.30), there was an overall increase in turnover in 2017, with the most growth coming from satellite applications increasing by 14.4%. The launcher developments and production suffered a decrease of 31% from €1,732 million in 2017 to €1,678 million in 2017. It is possible to notice the same situation for the scientific programmes which decreased by 11%. Ground system and services grew by 4.65% and the "other" segment had a healthy increase by 61.84%.

While Figure 2.30 displays the impact of the sales 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 2017, the 14.4% growth turnover in satellite applications varied among the three parts of the satellite application sector (i.e., telecommunications, Earth observation, and navigation/localisation systems). While sales in Earth observation systems (e.g., Copernicus) jumped from €1.397 billion in 2016 to €1.864 billion in 2017, turnover in navigation systems increased by 38.6% to €269 million (from €194 million in 2016). However, it is still far from the €400 million of 2015. Lastly, the total sales from the telecommunication systems segment (included within satellite applications) reached €2,151 million in 2017.[136]

In launcher development and production, it should be noted that European launcher developments are funded almost exclusively by ESA. In 2017, expenditure on launcher development activities appears to have decreased after the visible impact of development of Ariane 6. The development activities in 2016 reached an expenditure of close to €900 million, while in 2017 the expenditure dropped to approximately €700 million[137]. Moreover, turnover of scientific programmes increased by 16.6% to €1,050 million, surpassing the levels of 2015 (€1 billion). The main explanation for this growth is based in science and exploration programs which represented 79% of the scientific programme sales[138].

[136] Ibid. at p.16.
[137] Ibid. at p.14.
[138] Ibid. at p.16.

3. Space Industry Evolutions

Chapter three focuses on major developments in the private space sector.

The year-end results of major launch companies, satellite operators, and satellite prime contractors, and other competitors are provided, along with elaboration on notable achievements within the industry, organised by region.

Company	Revenue	EBIT	EBITDA	Operating Profit	Net income	Backlog
Arianespace	€1.3 B					
Eutelsat	€1.477 B		€1.133 B	€614.8 M	€351.8M	€5.2 B
SES	€2.04 B		€1.324 B	€610.6 M		€7.5 B
Intelsat	€1.79 B		€1.36 B	€762.6 M		€6.5 B
HISPASAT	€235.1 M		€192.1 M		€80.5M	
Telenor	€704.6 M					
Inmarsat	€1.17 B		€604.94 M	€268.07 M		
Airbus	€10.804 B	€212M	€651 M			€37.4 B
Thales Group	€5.985 B		€767.9 M	€601.5 M		€8.850 B
OHB SE	€859.7 M		€58.8 M			€2.198 B
RUAG	€312 M		€39.33 M			
Boeing	€17.51 B			€1.85 B		€41.34 B
Lockheed Martin	€7.9 B			€827.98 M		€14.43 B
Orbital ATK	€1.07 B			€118.74 M		
Mitsubishi Electric Co.	€35.6 B					
NEC	€22.3 B					
AsiaSat	€144.4 M					
Maxar Technologies (MDA)	€1.36 B		€315.77 M		€88.05 M	

Figure 3.1: Compilation of Financial Results for Chapter 3 (all results are converted to euros. Figures derived from text below)

3.1 Europe

ArianeGroup

As of 1 July 2017, the corporate name of Airbus Safran Launchers was changed to ArianeGroup, along with seven of its subsidiaries. As announced by ArianeGroup, its new name "strengthens the coherence of the image with its Arianespace subsidiary".[139] Under its new name, ArianeGroup continued its development of the Ariane 6 launcher in 2017, which it is building as the lead contractor and under the oversight of ESA.[140,141] As reported, the new launcher is envisioned to begin operations in 2020 and cost about half the price of its predecessor, the Ariane 5.[142] In January 2018, it was announced that ArianeGroup and the Arianespace subsidiary had an order for 10 further Ariane 5 launch vehicles, all to be launched from the Guiana Space Centre. The

[139] "Airbus Safran Launchers to Become ArianeGroup." 17 May 2017. Safran, 5 June 2018 <https://www.safran-group.com/media/airbus-safran-launchers-become-ariane-group-20170517>.

[140] "CNES And ArianeGroup Step Up Cooperation In The Launch Vehicles Sector." 20 Sep. 2017. ArianeGroup, 5 June 2018 <https://www.ariane.group/en/news/cnes-and-arianegroup-step-up-cooperation-in-the-launch-vehicles-sector/>.

[141] Henry, Caleb. "ESA signs up as Ariane 6 inaugural customer with two Galileo missions." 14 Sep. 2017. SpaceNews, 5 June 2018 <http://spacenews.com/esa-signs-up-as-ariane-6-inaugural-customer-with-two-galileo-missions/>.

[142] Henry, Caleb. "Eutelsat awards three launches to Arianespace, hints at Ariane 6 interest." 2 June 2017. SpaceNews, 5 June 0218 <http://spacenews.com/eutelsat-awards-three-launches-to-arianespace-hints-at-ariane-6-interest/>.

order comes to a value of over one billion euros for the European space industry, and it leads to a total of 23 Ariane 5 launchers to be built or under production.[143] These will be launched over 2020 to 2022, creating a three-year overlap with Ariane 6 operations.[144] Further, ArianeGroup also announced in December 2017 that it will start production of the first Ariane 6 launcher; the first unit will be an Ariane 62, which is one of the two configurations of the new launch vehicle.[145] And in September of 2017, ESA signed the first launch contract for the Ariane 6, to launch a total of four Galileo satellites on two Ariane 62 launchers near the end of 2020 and in the middle of 2021.[146] Eutelsat had also expressed interest in June of 2017 in launching with the new launch vehicle.[147] And looking further ahead, ArianeGroup agreed on a contract with ESA in July 2017 around the development of the Prometheus reusable engine demonstrator, envisioned for powering European launch vehicles from 2030.[148]

Arianespace

In 2017, Arianespace put 20 satellites in orbit over 11 launches for 18 commercial and institutional customers and from this activity generated a turnover of €1.3 billion. These included 6 launches of the Ariane 5, two Soyuz launches, and three Vega launches. Breaking these satellites down by categories, 12 were destined to geostationary orbit, 4 to Medium Earth Orbit, and 4 to Sun-synchronous orbit. Further, 14 were commercial and 6 were institutional. And 12 were for telecommunications, 4 for earth observation, and 4 for navigation. Arianespace won 19 new launch contracts over the year, which account for 27 satellites. These will include 8 on Ariane 5, 1 on Vega and the first 3 to use Vega C, 5 for Soyuz, and the first 2 employing Ariane 6 with ESA (for the European Commission). On the order book, Arianespace currently has 29 customers employing 58 launches, and with a total coming to €5 billion. 66% will be commercial and 34% will be governmental. In terms of application, 7% are in science and technology, 7% in navigation, 24% in Earth observation, and 62% in telecommunications. Looking to 2018, Arianespace is aiming to hit a record of 14 launches.[149] Concerning the Ariane 6 launch vehicle, it is built for approximately 5 institutional missions annually, and according to the company these missions are there up to and after 2022, coming in particular from ESA, Eumetsat, governments, and the European Commission.[150]

Eutelsat

In the year ending 30 June 2017, Eutelsat earned a revenue of just over €1.477 billion, representing a 3.3% decrease from the previous reporting period of €1.529 billion. Its EBITDA at mid-2017 was €1,133.6 billion, down 2.7% from €1.165 billion in mid-2016. Eutelsat's operating profit also decreased 7.1% from €662 million in mid-2016 to €614.8 million over the following year. Its net income grew by nearly 1% to €351.8 million.[151] Eutelsat's share of revenue from the European region dropped to 52.3% by mid-2017 from the 56.1% from one year prior. Aside from Asia and the "Other" region, whose shares both dropped 0.1% during the reporting period, the share of revenue from all other regions increased, with values at: the Americas (22.3%); the Middle East (15.8%); and Africa (7.2%).[152] Eutelsat's backlog decreased 8% to €5.2 billion by mid-2017.[153] However, notable contract activity came in the form of a multi-year agreement with NTV-Plus of Russia as well as continuation of capacity with Digitürk

[143] "Arianespace And ArianeGroup Kick Off Production For The Final 10 Ariane 5 Launchers Across Europe's Space Industry In Parallel To The Operational Debut Of Ariane 6." 9 Jan. 2018. ArianeGroup, 5 June 2018 <https://www.ariane.group/en/news/arianespace-and-arianegroup-kick-off-production-for-the-final-10-ariane-5-launchers-across-europes-space-industry-in-parallel-to-the-operational-debut-of-ariane-6/>.

[144] Henry, Caleb. "Ariane 5 down to two dozen launches before Ariane 6 takes over." 16 Jan. 2018. SpaceNews, 5 June 2018 <http://spacenews.com/ariane-5-down-to-two-dozen-launches-before-ariane-6-takes-over/>.

[145] "ArianeGroup To Start Production Of The First Ariane 62." 18 Dec. 2017. ArianeGroup, 5 June 2018 <https://www.ariane.group/en/news/ariane6-production-en/>.

[146] *Op. cit.* - "ESA signs up as Ariane 6 inaugural customer with two Galileo missions."

[147] *Op. cit.* - "Eutelsat awards three launches to Arianespace, hints at Ariane 6 interest."

[148] "ArianeGroup Signs A First Contract With ESA To Develop The Future Prometheus Engine." 21 June 2017. ArianeGroup, 5 June 2018 <https://www.ariane.group/en/news/arianegroup-signs-a-first-contract-with-esa-to-develop-the-future-prometheus-engine/>

[149] "After meeting its commitments in 2017, Arianespace prepares for an intense 2018 and looks to the future with Ariane 6 and Vega C." 9 Jan. 2018. Arianespace, 5 June 2018 <http://www.arianespace.com/press-release/after-meeting-its-commitments-in-2017-arianespace-prepares-for-an-intense-2018-and-looks-to-the-future-with-ariane-6-and-vega-c/>.

[150] *Op. cit.* - "Ariane 5 down to two dozen launches before Ariane 6 takes over."

[151] "Eutelsat Communications Full Year 2016-17 Results." 28 July 2017. Eutelsat, 6 June 2018 <http://news.eutelsat.com/pressreleases/eutelsat-communications-full-year-2016-17-results-2085832>.

[152] "2016-17 Reference Document – eutelsat communications." Eutelsat, 6 June 2018 (retrieved): p. 162 <https://www.eutelsat.com/files/contributed/investors/pdf/Eutelsat_Communications_Reference_Document_2016-17.pdf>.

[153] *Op. cit.* - "Eutelsat Communications Full Year 2016-17 Results."

and Arqiva.[154] On 15 June 2016 and 2 June 2017, Eutelsat launched EUTELSAT 117WB (entering service in January of 2017) and EUTELSAT 172B, respectively.[155] The latter employs electric propulsion, as will two future units that Eutelsat will launch, including the African Broadcast Satellite and EUTELSAT 7C.[156] During the reporting period, Eutelsat also pursued a new launch contract with Blue Origin for its New Glenn rocket as well as a contract for multiple launches with Arianespace, which will cover the two aforementioned electric propulsion satellites. The company's EUTELSAT 5 West B unit was also selected "by the European Global Navigation Satellite Systems Agency (GSA) for the next-generation EGNOS payload" worth approximately 100 million euros for a period of 15 years. [157]

SES

In the year ending 31 December 2017, SES, with headquarters in Luxembourg, earned €2.035 billion in revenue, a drop of 1.6% from the previous year's €2.069 billion. EBITDA decreased 8.8% from €1.452 billion in 2016 to €1.324 billion in 2017, and the EBITDA margin likewise dropped from 70.2% to 65.1% in the year. SES' operating profit stood at €610.6 million, down 54% from the €1.315 billion in 2016. This is the value of the operating profit "excluding the reported gain on deemed disposal of equity interest of EUR 495.2 million which was recognised directly after the consolidation of O3b (August 2016) and consequently not repeated in 2017". The company's backlog of "fully protected" contracts reached €7.5 billion down from the €8.1 billion of 2016.[158] As announced in its Annual Report 2017, SES planned to deploy a total of 7 satellites in 2018, all of which have been launched.[159,160,161,162]

Intelsat

Intelsat earned $2.149 billion in revenue for the year ending 31 December 2017, representing a 1.8% decrease from the 2016 result of $2.188 billion. EBITDA stood at $1.629 billion and adjusted EBITDA at $1.665 billion, representing 77% of revenue as well as 0.85% growth from the previous year's $1.651 billion. Operating profit dropped to $914.6 million from the $920.6 million of the previous year, and the company experienced a net loss of $178.7 million, down from the $990.2 million net profit in 2016. The company's contracted backlog – future revenue from current contracts – furthermore dropped to $7.8 billion from the $8.7 billion reported at the end of 2016. In terms of launch activity, the satellites Intelsat 32e (an Epic Next Generation Ku-band unit), Intelsat 35e, and Intelsat 37e were all launched in February, July, and September of 2017, respectively.[163,164,165] Satellites to be launched in 2018 include Intelsat 38e in Q2 2018 and Horizons 3e in the latter half of 2018.

HISPASAT

HISPASAT earned €235.1 million in revenue for the year 2017, which equals a 2.7% increase over last year's €228.9 million. Space capacity revenues dropped to €218.8 million in 2017, though, from the approximately €225 million the year before. As reported by the company, this was a consequence of a satellite market experiencing significant evolution. HISPASAT obtained a net profit of €80.5 million – a 220% rise over the last fiscal year, during which the accounts were faced with extraordinary expenditures. Concerning EBITDA, it grew 9.4% to €192.1 million, attributed to "strict control over managing the operating revenues which, during last fiscal year, dropped by more than 10 million Euros, representing more than 19% of consolidated savings." Its backlog of guaranteed long-term satellite capacity contracts is reported at 4.4

[154] *Op. cit.* - "2016-17 Reference Document – eutelsat communications." at p. 02
[155] *Op. cit.* - "2016-17 Reference Document – eutelsat communications." at p. 138
[156] *Op. cit.* - "2016-17 Reference Document – eutelsat communications." at p. 02
[157] *Op. cit.* - "2016-17 Reference Document – eutelsat communications." at p. 06
[158] "SES Annual Report 2017 - New Frontiers." 5 April 2018. SES, 7 June 2018 <https://www.ses.com/sites/default/files/2018-04/SES_AR_2017_web.pdf>.
[159] "SES-14: Now launched." 18 Jan. 2018. SES, 7 June 2018 <https://www.ses.com/newsroom/ses-14-now-launched>.
[160] Clark, Stephen. "SpaceX rocket flies on 60th anniversary of first U.S. satellite launch." 31 Jan. 2018. SPACEFLIGHT NOW, 7 June 2018 < https://spaceflightnow.com/2018/01/31/spacex-rocket-flies-on-60th-anniversary-of-first-u-s-satellite-launch/>.
[161] "Seamlessly Scaling our O3b Fleet to Meet Exponential Demand for Connectivity." 26 Feb. 2018. SES, 7 June 2018 <https://www.ses.com/newsroom/seamlessly-scaling-our-o3b-fleet-meet-exponential-demand-connectivity>.
[162] "SES-12 Mission." 3 June 2018. SpaceX, 7 June 2018 <http://www.spacex.com/news/2018/06/03/ses-12-mission>.
[163] "Intelsat Announces Fourth Quarter and Full-Year 2017 Results." 26 Feb. 2018. INTELSAT, 7 June 2018 <http://www.intelsat.com/wp-content/uploads/2018/02/4Q17ERFINAL.pdf>.
[164] "Intelsat Announces Fourth Quarter and Full-Year 2016 Results." 28 Feb. 2017. INTELSAT, 7 June 2018 <http://www.intelsat.com/wp-content/uploads/2017/03/Intelsat4Q2016EarningsRelease2.29.17.pdf>.
[165] "Capture New Growth with the World's Most Advanced Satellite Platform." INTELSAT, 7 June 2018 (retrieved) <http://www.intelsat.com/global-network/satellites/fleet/intelsat-35e/>.

times its revenues, which comes to just above €1 billion. Geographically, Europe represents 36.4% and the Americas 62.7% of its revenues from leasing its space capacity; just under 1% belongs to "other regions". HISPASAT has furthermore reduced by €2.4 million its recurring operating costs and launched the satellites Amazonas 5 and Hispasat 36W-1 during the year 2017. €115.1 million of investment was also directed to innovation projects and the aforementioned satellite programmes, as well as Hispasat 30W-6, whose construction was also finalised in 2017. This investment is "to provide a response to the challenges and opportunities present in the market."[166]

Telenor

Telenor Satellite, based near Oslo, Norway, is entirely owned by Telenor Broadcast Holding AS, itself owned by Telenor Group.[167] Among its broadcast revenues breakdown, Telenor Group's reported 2017 revenue for satellite services came to 892 million kroner (€90.6 million as of the 1 January 2018 exchange rate[168]), down 6.6% from the 955 million kroner of 2016. EBITDA for satellite services dropped as well from 650 million kroner (€66 million) for the year 2016 to 585 million kroner in 2017, representing a negative 10% decrease. Total Broadcast revenues represent globally satellite services, Canal Digital DTH (revenues from subscriptions to Nordic DTH as well as households in SMATV networks), and Norkring (terrestrial radio and TV transmission). For the year 2017, total broadcasting revenue stood at 6.071 billion kroner (€614 million), down about 5% from the 6.366 billion kroner of 2016.[169] Telenor attributes this drop to the "shut-down of FM broadcasting in Norway and a settlement in Norkring in 2016".[170]

Inmarsat

Inmarsat earned $1.400 billion in revenue for the year ending 31 December 2017, an increase of 5.4% from the $1.329 billion of 2015. The breakdown of this revenue according to its business groups, including percentage change from 2016, is as follows: Maritime (-1.8% to $564.7 M); Government (+11% to $366.7 M); Aviation (+36.7% to $195 M); Enterprise (-8.3% to $132.6 M); and Other (Central Services and Ligado Networks, +3.8% to $141.2 M). The strong growth on the part of the Aviation section is in part explained by revenues coming from In-Flight Connectivity installation. Inmarsat's EBITDA dropped however 8% from $794.8 million in 2016 to $731.5 million in 2017. Furthermore, adjusted EBITDA dropped $43.4 million or by 5.5% to $751.4 million.[171] Operating profit decreased 28.1% from $447.1 million to $321.5 million in 2017, which is partly attributed to an increase in depreciation and amortisation related to two new satellites entering service.[172] This included, in particular, the launch of Inmarsat-5 F4 in May as well as Inmarsat S EAN in June. The former is Inmarsat's fourth satellite in its Global Xpress constellation and the latter an "S-band satellite for the European Aviation Network".[173,174]

Airbus

As initially announced in late 2016, Airbus implemented a significant merger in 2017 between its Group structure and the biggest of its divisions, Commercial Aircraft. The Helicopters as well as Defence and Space segments remain as divisions under Airbus.[175,176] Focusing on the latter, the Airbus Defence and Space (D&S) comprises four programmatic sections: Military Aircraft; Communications,

[166] "HISPASAT reaches a net profit of 80.5 million Euros." 8 Mar. 2018. HISPASAT, 6 June 2018 <https://www.hispasat.com/en/press-room/press-releases/archivo-2018/311/hispasat-reaches-a-net-profit-of-805-million-euros>.
[167] "Telenor Satellite – One of Europe's leading satellite operators." Telenor – Satellite, 8 June 2018 (retrieved) <http://www.telenorsat.com/our-business/>.
[168] "xe.com – Current and Historical Rate Tables." data for the Norwegian Krone from 1 Jan. 2018. xe.com, 8 June 2018 <https://www.xe.com/currencytables/?from=NOK&date=2018-01-01>.
[169] "telenor group Q4 – 2017 Interim report January – December 2017." 30 Jan. 2018. Telenor Group, 8 June 2018: p. 9 <https://www.telenor.com/wp-content/uploads/2018/01/Telenor-Group-Q4-2017-report-182c40290db6af1b736fccdd6cd644d6.pdf>.
[170] "telenor group Annual Report 2017." 20 Mar. 2018. Telenor Group, 8 June 2018: p. 9 <https://www.telenor.com/wp-content/uploads/2018/04/iPDF-Annual-Report-2017-Q-3e7f8e04515b822ddfe375bf65839757.pdf>.
[171] "Inmarsat plc reports Preliminary Full Year Results 2017." 9 Mar. 2018. Inmarsat, 7 June 2018 <https://investors.inmarsat.com/wp-content/uploads/2018/03/Inmarsat-plc-Preliminary-Full-Year-Results-2017-Final.pdf>.
[172] "Inmarsat PLC Annual Report and Accounts 2017." 9 Mar. 2018. Inmarsat, 7 June 2018 <https://investors.inmarsat.com/wp-content/uploads/2018/04/2017-Annual-Report.pdf>.
[173] "Inmarsat confirms successful launch of the fourth Global Xpress satellite."16 May 2017. Inmarsat, 7 June 2018 <https://www.inmarsat.com/press-release/inmarsat-confirms-successful-launch-fourth-global-xpress-satellite/>.
[174] "Inmarsat confirms successful launch of S-band satellite for the European Aviation Network." 29 June 2017. Inmarsat, 7 June 2018 <https://www.inmarsat.com/press-release/inmarsat-confirms-successful-launch-s-band-satellite-european-aviation-network/>.
[175] "Airbus Annual Report 2017 – Connecting the skies." 11 Apr. 2018. Airbus, 4 June 2018: p. 012 <http://www.airbus.com/content/dam/corporate-topics/financial-and-company-information/AIRBUS_Annual_Report_2017.pdf>.
[176] "Company united under single brand following corporate reorganisation." 3 July 2017. Airbus, 4 June 2018 <http://www.airbus.com/newsroom/press-releases/en/2017/06/airbus-flying-as-one.html>.

Intelligence & Security; Unmanned Aerial Systems, and Space Systems. The D&S division earned €10.804 billion in revenue in the year ending on 31 December 2017, as compared with €11.854 billion over 2016 (and a further drop from the €13.080 billion of 2015).[177] The decrease from 2016 to 2017 represents a value of €1,050 million or -8.9% and was attributed to "perimeter changes for defence activities"; however, close to last year's 31%, the Space Systems section contributed 29% of the division's revenue in 2017.[178,179] Further, at the close of 2017 the D&S division's EBIT and EBIT Adjusted were €212 million and €872 million, respectively. The EBIT of €212 million represents an increase from €-93 million in 2016, with the growth attributed to "stable core business performance" as well as inputs from ArianeGroup and MBDA.[180] The division's EBITDA for 2017, furthermore, was €641 million, as compared with the €390 million of 2016.[181,182] The Defence and Space division's order backlog fell again from €42.9 billion in 2015 and €41.5 billion in 2016 to €37.4 billion in 2017.[183] Its order intake also dropped from €15.4 billion in 2016 to €8.9 billion in 2017.[184] In March of 2017, OneWeb Satellites, a joint venture between Airbus and OneWeb, began construction of its satellite production centre in Florida;[185] as announced in November 2017, Airbus will build two satellites for Türksat that will be based on the Eurostar E3000 platform and will employ Electric Orbit Raising[186]; Airbus Aerial was founded in May 2017 and targets remote sensing, connectivity, and cargo drone services.[187]

Thales Group

The Thales Group's Aerospace operating segment includes the Avionics and Space Global Business Units. The latter is connected to Thales' partnership – known as the Space Alliance – with Rome-based Leonardo (whose name changed in early 2017), built around their mutual ownership in Thales Alenia Space and Telespazio.[188] The Aerospace segment earned €5.985 billion in revenue for the year 2017, up 3% from the €5.812 billion of 2016. EBITDA reached €767.9 million in 2017, compared to €753.8 million in 2016. Operating profit grew again in 2017 to €601.5 million from the €571 million in 2016, representing 5.3% growth. The Thales Aerospace segment however saw a decline in its order backlog, dropping from €9.914 billion in 2016 to €8.850 billion. Overall, of Thales' three operating segments, Aerospace represented 38% of the Group's sales in 2017. Thales Alenia Space furthermore signed a number of contracts or took on opportunities in 2017, which can be broken down by application area: In telecommunications, a contract for the build of Inmarsat GX, a very-high-throughput satellite for Inmarsat; in EO, a contract for the MicroCarb satellite's integration in the UK; in science, a study regarding the design of the payload module for the Solar Wind Magnetospheric Ionospheric Link Explorer (SMILE) mission; in exploration, a development contract with ESA "for Space Rider, a new generation European reusable transport system from low orbit"; in observation and geolocalisation, and a "contract for the Argos NEO instrument for the nano-satellite demonstrator Angels for geolocalisation data collection".[189] Furthermore, as announced in May 2017, Thales Alenia Space will build an automated manufacturing facility for photovoltaic assemblies, used on satellites' solar panels.[190]

OHB SE

OHB SE earned €859.7 million in total revenue for the year 2017, an increase of 18% from the €728.39 million earned over 2016. OHB's

[177] *Op. cit.* - "Airbus Annual Report 2017 – Connecting the skies." at p. 27 (Registration Document section)
[178] *Op. cit.* - "Airbus Annual Report 2017 – Connecting the skies." at p. 29 (Financial Statements section)
[179] *Op. cit.* - "Airbus Annual Report 2017 – Connecting the skies." at p. 038
[180] *Op. cit.* - "Airbus Annual Report 2017 – Connecting the skies." at p. 84 (Registration Document section)
[181] *Op. cit.* - "Airbus Annual Report 2017 – Connecting the skies." at p. 27 (Financial Statements section)
Figure derived from EBIT + depreciation and amortisation
[182] "Airbus Financial Statements 2016." 22 Feb. 2017. Airbus, 4 June 2018: p. 27 (Financial Statements section)
Figure derived from EBIT + depreciation and amortisation
[183] *Op. cit.* - "Airbus Annual Report 2017 – Connecting the skies." at p. 81 (Registration Document section)
[184] *Op. cit.* - "Airbus Annual Report 2017 – Connecting the skies." at p. 27 (Registration Document section)
[185] Henry, Caleb. "OneWeb breaks ground on a Florida factory that will build thousands of satellites." 16 Mar. 2017. SpaceNews, 4 June 2018 <http://spacenews.com/oneweb-breaks-ground-on-a-florida-factory-that-will-build-thousands-of-satellites/>.
[186] "Airbus to build Türksat 5A and 5B satellites." 9 Nov. 2017. Airbus, 4 June 2018 <http://www.airbus.com/newsroom/press-releases/en/2017/11/Airbus-tobuildTurksat5Aand5Bsatellites.html>.
[187] *Op. cit.* - "Airbus Annual Report 2017 – Connecting the skies." at p. 46 (Registration Document section)
[188] "Video - Leonardo: Finmeccanica inspired by 'genius'." 2 Jan. 2017. aeronewstv.com, 8 June 2018 <http://www.aeronewstv.com/en/industry/commercial-aviation/3678-leonardo-finmeccanica-inspired-by-genius.html>.
[189] "THALES 2017 Registration Document Including the Annual Financial Report." 3 Apr. 2018. Thales, 8 June 2018 <https://www.thalesgroup.com/sites/default/files/asset/document/2017_registration_document.pdf>.
[190] "Thales Alenia Space To Build A New Automated Facility Dedicated To Photovoltaic Assemblies For Satellite Solar Panels." 5 Feb. 2017. Thales, 8 June 2018 <https://www.thalesgroup.com/en/worldwide/space/press-release/thales-alenia-space-build-new-automated-facility-dedicated>.

EBITDA rose from €55.08 million (7.6% of revenue) in 2016 to €58.8 million in 2017 (6.8% of revenue). Furthermore, operating profit grew from €42.70 million in 2016 to €44.2 million in 2017. OHB's Space Systems business unit generated €661.3 million in non-consolidated total revenues in 2017, up from €559.5 million in 2016, and the unit's order backlog at the end of 2017 reached €2.198 billion. This represents a considerable increase over the €1.341 billion backlog at the end of 2016, attributed to several satellite or satellite-related contracts. Notable business events over the past year include, among others: two contracts from ESA and the European Commission for the assembly of a total of 12 satellites for the Galileo programme, valued together at €482 million; the launch on 12 December 2017 of four OHB-built Galileo programme satellites, for which it is the principal contractor; a contract to MT Mechatronics (subsidiary of MT Aerospace, itself a member of the OHB Group) to build a 40 metre radio telescope for the National Astronomical Research Institute of Thailand; a contract from Boeing to MT Aerospace "for further development and assembly work for" NASA's Space Launch System; a contract to OHB System AG from the DLR "for the assembly, testing and launch of the" German national Heinrich Hertz satellite; and a further contract between OHB System AG and Germany "for the installation of a satellite system for global electro-optical reconnaissance".[191]

RUAG

The RUAG Space division of RUAG Group achieved net sales of CHF 365 million for the year 2017 (€312 million as of the 1 January 2018 exchange rate[192]), representing a 6% increase from the CHF 344 million of 2016. The RUAG Space division's EBITDA dropped to CHF 46 million (€39.33 million) in 2017, representing 12.6% of revenue, from CHF 48 million in 2016. Further, operating profit reached CHF 34 million (€29 million) in 2017 from the CHF 32 million of 2016.[193] The Division also saw several major events in 2017, including notably the inauguration of two new facilities in June in Linköping, Sweden and in July in Titusville, Florida, US. The more than 4000 m^2 Swedish facility will focus on satellite separation systems, launcher adapters, and dispensers[194]; the Florida facility meanwhile will produce satellite structures for OneWeb.[195] And in December 2017, the prime contractor for the satellites of the Galileo programme – OHB System AG – contracted RUAG Space to provide the Control and Data Units for a further 12 Galileo satellites. These should be delivered over November 2018 to October 2019. RUAG has significant heritage in the Galileo programme and also provided Control and Data Units for the four Galileo satellites launched 12 December 2017.[196]

3.2 United States

Boeing

Boeing's Defense, Space & Security division earned $21.057 billion for the year ending 31 December 2017, a 7% decrease from the $22.563 billion of 2016. In particular, approximately 79% of the 2017 revenues came from the US Department of Defense, which is a main customer of the division. Its operating earnings for 2017 increased to $2.223 billion (10% of revenue) from $1.966 billion (8.7% of revenue) in 2016. Further, the Defence, Space & Security division's order backlog rose to $49.577 billion at the end of 2017, up from $44.825 billion at the end of 2016.[197] During the year 2017, several new opportunities were secured: under an agreement with the US Air Force announced in February, Boeing will maintain its mission support of the GPS 2A and 2F units on orbit for five years[198]; with NASA, a contract announced in February providing up to five further Soyuz crew seats[199]; a public

[191] "European Access to Space – OHB Annual Report 2017." 20 Mar. 2018. OHB, 19 June 2018 <https://www.ohb-system.de/tl_files/system/images/mediathek/downloads/pdf/OHB_GB17_e_s.pdf>.
[192] "xe.com – Current and Historical Rate Tables." data for the Swiss franc from 1 Jan. 2018. xe.com, 19 June 2018 <https://www.xe.com/currencytables/?from=CHF&date=2018-01-01>.
[193] "RUAG Annual Report 2017." 23 Mar. 2018. RUAG, 19 June 2018: pp. 11 & 46 <https://annualreport.ruag.com/sites/ar17/files/media_document/2018-03/RUAG_Annualreport_2017_full_EN.pdf>.
[194] "RUAG Space Sweden opens new facility in Linköping and doubles its onsite capacity." 27 June 2017. RUAG, 19 June 2018 <https://www.ruag.com/en/news/ruag-space-sweden-opens-new-facility-linkoping-and-doubles-its-on-site-capacity>.
[195] "RUAG Space kicks-off production at a new Florida manufacturing facility, celebrating its latest U.S. facility opening." 12 July 2017. RUAG, 19 June 2018 <https://www.ruag.com/en/news/ruag-space-kicks-production-new-florida-manufacturing-facility-celebrating-its-latest-us-facility>.
[196] "Contract renewed: RUAG Space will continue to build the brain of each Galileo satellite." 11 Dec. 2017. RUAG, 19 June 2018 <https://www.ruag.com/en/news/contract-renewed-ruag-space-will-continue-build-brain-each-galileo-satellite>.
[197] "The Boeing Company 2017 Annual Report." 12 Feb. 2018. Boeing, 21 June 2018 <http://s2.q4cdn.com/661678649/files/doc_financials/annual/2017/2017-Annual-Report.pdf>.
[198] Swarts, Phillip. "Boeing, Air Force, pen agreement to oversee GPS 2 for next five years." 2 Feb. 2017. SpaceNews, 21 June 2018 <http://spacenews.com/boeing-air-force-pen-agreement-to-oversee-gps-2-for-next-five-years/>.
[199] Foust, Jeff. "NASA signs agreement with Boeing for Soyuz seats." 28 Feb. 2017. SpaceNews, 21 June 2018

private partnership award announced in May, whereby Boeing will "develop an experimental reusable first stage", its so-called Phantom Express, for the US Defense Advanced Research Projects Agency – the overall programme goal being to reduce costs for launching medium-sized payloads[200] ; and a contract with SES to build seven O3b mPower satellites, destined for medium earth orbit.[201]

Lockheed Martin

Lockheed Martin's Space business segment earned $9.473 billion for the year ending 31 December 2017, approximately a 1% increase over the year 2016 earnings of $9.409 billion.[202] The segment's 2017 revenue equals to 19% of Lockheed Martin's total consolidated net sales, and sales for satellite products and services in particular came to 11% of the company's total consolidated net sales in 2017, down from the 13% of 2016 and 15% of 2015. US institutional customers represented 85% of the segment's sales, international customers 14%, and US commercial and others 1%.[203] Moreover, the Space segment's operating earnings dropped to $993 million (10.5% of segment revenue) at the end of 2017 from $1.289 billion (13.7% of revenue) at the end of 2016.[204] This decrease of 23% was largely attributed to a 2016 pre-tax gain stemming from the consolidation of AWE Management Limited as well as "declines in space transportation and government satellite work", among other reasons.[205] Further, its order backlog dropped to $17.3 billion at the end of 2017 from $18.8 billion at the end of 2016, attributed to a lower order volume for government satellite programmes, although offset to a certain degree by orders connected to the Orion programme.[206]

ULA

Following a report in September 2017 that "technical and funding challenges" would necessitate the continued use of Russian RD-180 engines on ULA Atlas V rockets until the mid-2020s,[207] ULA President and CEO Tory Bruno announced the following month that this information was incorrect, stating the company is confident that development on ULA's next generation Vulcan launcher will meet a 2022 deadline issued by the US Congress to cease orders for Russian engines.[208] As of May 2018, ULA was still evaluating the Blue Origin BE-4 engine as a replacement to the RD-180, along with Aerojet Rocketdyne's AR1 engine, although ULA and Blue Origin are in the process of developing a production contract for the BE-4.[209] This would be in line with the National Defense Authorization Act for Fiscal Year 201 (NDAA-18), which limits the use of NDAA-authorised funds used for the EELV program to development of an American propulsion system "to replace non-allied space launch engines", among other items.[210]

Orbital ATK

As announced 6 June 2017, Orbital ATK was acquired by Northrop Grumman Corporation and became Northrop Grumman Innovation Systems, representing a fourth and new segment of the latter's business activities. Orbital ATK's prior chief operating officer, Blake Larson, becomes corporate vice president and president of the new segment.[211] Financial results under the Orbital ATK name for the full

<http://spacenews.com/nasa-signs-agreement-with-boeing-for-soyuz-seats/>.
[200] Foust, Jeff. "DARPA selects Boeing for spaceplane project." 24 May 2017. SpaceNews, 21 June 2018 <http://spacenews.com/darpa-selects-boeing-for-space-plane-project/>.
[201] "Boeing to Design and Build Seven Medium Earth Orbit Satellites for SES." 11 Sep. 2017. Boeing, 21 June 2018 <http://boeing.mediaroom.com/news-releases-statements?item=130014>.
[202] "Lockheed Martin Reports Fourth Quarter And Full Year 2017 Results." 29 Jan. 2018. Lockheed Martin, 22 June 2018 <https://news.lockheedmartin.com/2018-01-29-Lockheed-Martin-Reports-Fourth-Quarter-and-Full-Year-2017-Results>.
[203] "2017 Annual Report Lockheed Martin Corporation." 6 Feb. 2018. Lockheed Martin, 22 June 2018 <https://www.lockheedmartin.com/content/dam/lockheed-martin/eo/documents/annual-reports/2017-annual-report.pdf>.
[204] *Op. cit.* - "Lockheed Martin Reports Fourth Quarter And Full Year 2017 Results."
[205] Foust, Jeff. "Lockheed Martin space sales growth lags." 30 Jan. 2018. SpaceNews, 22 June 2018 <http://spacenews.com/lockheed-martin-space-sales-growth-lags/>.
[206] *Op. cit.* - "2017 Annual Report Lockheed Martin Corporation."
[207] Pasztor, Andy. "Pentagon Faces Delays in Shift Away From Russian Rocket Engines." 4 Sep. 2017. The Wall Street Journal, 20 June 2018 <https://www.wsj.com/articles/pentagon-faces-delays-in-shift-away-from-russian-rocket-engines-1504526402?mod=e2fb>.
[208] Bruno, Tony. "Building on a successful record in space to meet the challenges ahead." (Op-ed) 10. Oct. 2017. SpaceNews, 20 June 2018 <http://spacenews.com/op-ed-building-on-a-successful-record-in-space-to-meet-the-challenges-ahead/>.
[209] Foust, Jeff. "Blue Origin expects BE-4 qualification tests to be done by year's end." 3 May 2018. SpaceNews, 20 June 2018 <http://spacenews.com/blue-origin-expects-be-4-qualification-tests-to-be-done-by-years-end-2/>.
[210] Messier, Doug. "An Update on the Evolved Expendable Launch Vehicle Program." 6 June 2018. Parabolic Arc, 20 June 2018 <http://www.parabolicarc.com/2018/06/06/eelv-report/>.
[211] "Northrop Grumman Completes Orbital ATK Acquisition, Blake Larson Elected to Lead New Innovation Systems Sector." 6 June 2018. Northrop Grumman, 25 June 2018 <https://news.northropgrumman.com/news/releases/northrop-grumman-completes-orbital-atk-acquisition-blake-larson-elected-to-lead-new-innovation-systems-sector>.

year 2017 were shared via press release, and its structure of three business segments remained unchanged, including the Flight Systems, Defense Systems, and Space Systems groups. Space Systems earned $1.284 billion in revenue over 2017, an increase of 3.7% ($46 million) from the $1.238 billion of 2016. Operating earnings also grew, reaching $142.4 million, representing 6.8% growth ($9.1 million) over the $129.5 million of 2016. These gains were attributed "to higher activity on Satellite Systems and Space Components Divisions contracts." The Flight Systems group earned $1.681 billion in revenue, up 12.4% ($185 million) from the $1.497 billion earned in 2016. This was attributed to greater profit margins from 2017 Aerospace Structures contracts.[212]

Notable events over the reporting period include the launch of an Orbital ATK Minotaur-C rocket delivering 10 Planet satellites on 31 October 2017[213] as well as the announcement on 4 January 2018 that Orbital ATK had won its second in-space servicing contract from Intelsat.[214]

Digital Globe

Announced 5 October 2017, DigitalGlobe – a commercial high-resolution Earth observation satellite imagery provider – was acquired for $2.4 billion by MacDonald Dettwiler and Associates, which also rebranded itself on this occasion as Maxar Technologies Ltd. 215 The acquisition ultimately resulted in four companies coming together under the new name, as MDA had previously purchased SSL in 2012 and DigitalGlobe had also purchased Radiant Group in 2016.[216] As part of the 2017 acquisition, DigitalGlobe executive vice president for imagery Timothy Hascall becomes the Maxar chief operations officer.[217] Prior to the acquisition, MDA stated that the DigitalGlobe purchase would both "help offset the revenue peaks and valleys of MDA's satellite manufacturing business"[218] as well as improve its product-service offer to US defence and intelligence agencies, including imagery and analysis.[219]

Blue Origin

Blue Origin made progress on multiple fronts in 2017 and 2018. Concerning the New Shepard reusable launch system, the company conducted its seventh and eighth test flights on 12 December 2017 and 29 April 2018.[220] The crew capsule reached 107 km in altitude, which also represents Blue Origin's target for operations.[221] And although a starting date for operations has not been offered, nor the ticket price, Senior Vice President Rob Meyerson announced on 19 June 2018 that Blue Origin plans to sell tickets starting from 2019.[222] In terms of the New Glenn rocket under development – whose first launch is forecasted for quarter 4 of 2020 – the company has secured four customers as of March 2018.[223] These include SKY Perfect JSAT, mu Space, Eutelsat, and OneWeb, which has reserved five launches.[224] As announced in April 2018, Blue Origin's BE-4 engine – which is to be used in the New Glenn launcher and is also under consideration for ULA's next-generation Vulcan launch vehicle – is expected to finish qualification testing by the end of 2018.[225]

[212] "Orbital ATK Announces Fourth Quarter and Full Year 2017 Financial Results." 22 Feb. 2018. phx.corporate-ir.net, 25 June 2018 <http://phx.corporate-ir.net/phoenix.zhtml?c=81036&p=irol-newsArticle&ID=2333926>.
[213] Foust, Jeff. "Minotaur launches 10 satellites for Planet." 31 Oct. 2017. SpaceNews, 25 June 2018 <http://spacenews.com/minotaur-launches-10-satellites-for-planet/>.
[214] Erwin, Sandra & Henry, Caleb. "Orbital ATK lands second Intelsat satellite servicing deal." 4 Jan. 2018. SpaceNews, 25 June 2018 <http://spacenews.com/orbital-atk-lands-second-intelsat-satellite-servicing-deal/>.
[215] Henry, Caleb. "MDA closes DigitalGlobe merger, rebrands as Maxar Technologies." 5 Oct. 2017. SpaceNews, 3 July 2018 <http://spacenews.com/mda-closes-digitalglobe-merger-rebrands-as-maxar-technologies/>.
[216] Henry, Caleb. "Meet Maxar, the space industry's newest tech giant." 6 Nov. 2017. SpaceNews, 3 July 2018 <http://spacenews.com/meet-maxar-the-space-industrys-newest-tech-giant/>.
[217] *Op. cit.* – "MDA closes DigitalGlobe merger, rebrands as Maxar Technologies."
[218] Henry, Caleb. "MDA views DigitalGlobe merger as hedge against cyclical satellite market." 23 May 2017. SpaceNews, 3 July 2018 <http://spacenews.com/mda-views-digitalglobe-merger-as-hedge-against-cyclical-satellite-market/>.
[219] Werner, Debra. "MDA seeks to provide extensive support to U.S. intelligence and defense agencies." 8 June 2017. SpaceNews, 3 July 2018 <http://spacenews.com/mda-seeks-to-provide-extensive-support-to-u-s-intelligence-and-defense-agencies/>.
[220] "Crew Capsule 2.0 First Flight." 12 Dec. 2017. Blue Origin, 22 June 2018 <https://www.blue-origin.com/news/news/crew-capsule-2.0-first-flight>.
[221] "Apogee 351,000 Feet." 29 Apr. 2018. Blue Origin, 22 June 2018 <https://www.blueorigin.com/news/news/apogee-351000-feet>.
[222] Foust, Jeff. "Blue Origin plans to start selling suborbital spaceflight tickets next year." 21 June 2018. SpaceNews, 22 June 2018 <http://spacenews.com/blue-origin-plans-to-start-selling-suborbital-spaceflight-tickets-next-year/>.
[223] Henry, Caleb. "Blue Origin switches engines for New Glenn second stage." 29 Mar. 2018. SpaceNews, 22 June 2018 <http://spacenews.com/blue-origin-switches-engines-for-new-glenn-second-stage/>.
[224] Henry, Caleb. "Blue Origin signs Sky Perfect JSAT as fourth New Glenn launch customer." 12 Mar. 2018. SpaceNews, 22 June 2018 <http://spacenews.com/blue-origin-signs-sky-perfect-jsat-as-fourth-new-glenn-launch-customer/>.
[225] *Op. cit.* – "Blue Origin expects BE-4 qualification tests to be done by year's end."

SpaceX

SpaceX's annual financial reporting is not made widely available, but in its latest fund-raising activity the company has earned, according to Crunchbase, $214 million in a series I funding round in April 2018 and approximately $1.9 billion in total funds since 2002.[226] And as according to different sources, its total current valuation ranges from $25 to $28 billion.[227,228] And as of May 2018, SpaceX had re-launched first stages 12 times – demonstrating increasing market acceptance of the technology[229] – but the business case of first stage reusability is influenced by a large range of factors[230] and as of February 2018 SpaceX does not foresee significant price reductions for launches with used stages in the near future.[231] In terms of overall launch activity, SpaceX achieved a company record of 18 launches over 2017[232] and on 6 February 2018 successfully conducted a demonstration launch of the Falcon Heavy.[233] Looking ahead, the US Air Force has provided a further $40.7 million to SpaceX "for the development of the Raptor rocket propulsion system prototype for the Evolved Expendable Launch Vehicle program", as announced in October of 2017,[234] as well as a contract worth $290 million covering three GPS 3 missions, as announced in March of 2018.[235] The Air Force has also, thirdly, given the company a contract worth $130 million for a satellite launch employing the Falcon Heavy, as announced in June 2018.[236] And on March 29 2018, the US FCC approved the SpaceX Starlink constellation of over 4,400 broadband non-geostationary satellites.[237]

3.3 Russia

Sea Launch

The sale of Sea Launch's assets came to an official close in April 2018, thereby transferring the company's ocean platform, support ship, and other equipment and intellectual property rights to S7 Group, a Russian air holding company.[238] This marks the end of a process which initially began in September 2016, when S7 stated its intention to make the purchase, and comes after the December 2017 US Department of State approval of the transfer.[239] New owner S7 also announced in December 2017 that launches would resume as of 2019[240]; however, complicating the matter is that Sea Launch had used the Zenit rocket, whose availability was disrupted following the 2014 Russian annexation of Crimea from Ukraine.[241] The Soyuz-5 is another possibility, considered an "analog" to the Zenit, but is only expected to be ready in four to five years.[242]

[226] "Overview - SpaceX." Updated regularly. Crunchbase.com, 26 June 2018 <https://www.crunchbase.com/organization/space-exploration-technologies#section-locked-charts>.
[227] Trefis Team. "What's Driving SpaceX's Sky High Valuation?" 30 May 2018. Forbes, 26 June 2018 <https://www.forbes.com/sites/greatspeculations/2018/05/30/whats-driving-spacexs-sky-high-valuation/#1d7a75cbbde9>.
[228] "Equidate - SpaceX." Updated regularly. Equidate, 26 June 2018 <https://equidateinc.com/company/space-exploration-technologies>.
[229] Foust, Jeff. "SpaceX achievements generate growing interest in reusable launchers." 23 May 2018. SpaceNews, 2018. SpaceNews, 26 June 2018 < http://spacenews.com/spacex-achievements-generate-growing-interest-in-reusable-launchers/>.
[230] de Selding, Peter B. "SpaceX's reusable Falcon 9: What are the real cost savings for customers?" 25 Apr. 2016. SpaceNews, 26 June 2018 <http://spacenews.com/spacexs-reusable-falcon-9-what-are-the-real-cost-savings-for-customers/>.
[231] Werner, Debra. "Don't expect deep discounts on preflown SpaceX boosters." 6 Feb. 2018. SpaceNews, 26 June 2018 <http://spacenews.com/dont-expect-deep-discounts-on-preflown-spacex-boosters/>.
[232] Henry, Caleb. "SpaceX concludes 2017 with fourth Iridium Next launch." 22 Dec. 2017. SpaceNews, 26 June 2018 <http://spacenews.com/spacex-concludes-2017-with-fourth-iridium-next-launch/>.
[233] Foust, Jeff. "Updated | SpaceX successfully launches Falcon Heavy." 6 Feb. 2018. SpaceNews, 26 June 2018 <http://spacenews.com/spacex-successfully-launches-falcon-heavy/>.
[234] Foust, Jeff. "Air Force adds more than $40 million to SpaceX engine contract." 21 Oct. 2017. SpaceNews, 26 June 2018 <http://spacenews.com/air-force-adds-more-than-40-million-to-spacex-engine-contract/>.
[235] Erwin, Sandra. "Air Force awards big launch contracts to SpaceX and ULA." 14 Mar. 2018. SpaceNews, 26 June 2018 <http://spacenews.com/air-force-awards-big-launch-contracts-to-spacex-and-ula/>.
[236] Erwin, Sandra. "SpaceX wins $130 million military launch contract for Falcon Heavy." 21 June 2018. SpaceNews, 26 June 2018 <http://spacenews.com/spacex-wins-130-million-military-launch-contract-for-falcon-heavy/>.
[237] Henry, Caleb. "FCC approves SpaceX constellation, denies waiver for easier deployment deadline." 29 Mar. 2018. SpaceNews, 26 June 2018 <http://spacenews.com/us-regulators-approve-spacex-constellation-but-deny-waiver-for-easier-deployment-deadline/>.
[238] Henry, Caleb. "S7 closes Sea Launch purchase, future rocket TBD." 17 Apr. 2018. SpaceNews, 28 June 2018 <http://spacenews.com/s7-closes-sea-launch-purchase-future-rocket-tbd/>.
[239] Henry, Caleb. "Sea Launch CEO Sergey Gugkaev to leave company when S7 purchase closes." 13 Mar. 2018. SpaceNews, 28 June 2018 <http://spacenews.com/sea-launch-ceo-sergey-gugkaev-to-leave-company-when-s7-purchase-closes/>.
[240] "Sea Launch floating spaceport's new owner to resume launches." 12 Dec. 2017. TASS, 28 June 2018 <http://tass.com/science/980483>.
[241] *Op. cit.* – "Sea Launch CEO Sergey Gugkaev to leave company when S7 purchase closes."
[242] Op. cit. – "S7 closes Sea Launch purchase, future rocket TBD."

3.4 Japan

Mitsubishi Electric Co. (Information and Communication Systems)

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 portion of the total revenue earned by this segment. For the year ending 31 March 2017, Melco earned ¥4.239 trillion (€35.6 billion as of 31 March 2017[243]), down from the ¥4.394 trillion of the year ending 31 March 2016. Its ICS segment in 2017 represented 9.2% of total company sales; it earned ¥447.7 billion in net sales, which was down 20% from the ¥561.119 billion the previous year. The ICS operating income dropped to ¥12.7 billion, dropping a second year in a row from the ¥14.9 billion of 2016. These declines were attributed to drops in sales in communications infrastructure equipment as well as in system integrations.[244]

Mitsubishi Heavy Industries

Chosen by JAXA in 2014, Mitsubishi Heavy Industries (MHI) is the prime contractor of the next-generation H3 launcher, a next-generation rocket which is supposed to halve the price per kilogramme.[245] According to MHI, the H3 will be capable of delivering 10 to 20 satellites per launch and lift a maximum of 7 metric tonnes to a geostationary transfer orbit. It is to begin operations in 2020, and MHI aims to reach a launch rate of two launches per three-week period. With current infrastructure limiting MHI to about 4 launches per year, the company announced in March of 2018 it will convert both the H2A and H2B launch pads at the Tanegashima spaceport to enable the desired launch frequency.[246]

NEC Corporation

NEC Corporation's satellite-related revenue is based within its Public Business segment under its Public Infrastructure business line, along with several other sectors including for example air traffic control and postal tracking; as such, its satellite-related business should only be seen as generating a portion of the total revenue earned by this segment and the company as a whole. For the year ended 31 March 2017, NEC earned ¥2.655 trillion (€22.3 billion as of 31 March 2017[247]), dropping from the ¥2.825 trillion of the previous reporting year. The Public Business segment earned ¥766.2 billion in revenue, representing 29% of total NEC revenue as well as a 2.6% drop from the previous year's ¥786.5 billion. The segment earned moreover ¥33.2 billion in operating profit for the year, a negative 37.8% drop from the ¥53.4 of the previous year. This drop in operating profit was attributed to weaker profitability of the space business.[248]

Announced in May 2017, Sky Perfect JSAT has agreed to invest in LeoSat, which aims to start launching in 2019 a constellation of 108 high-throughput communications satellites at LEO.[249,250]

Sky Perfect JSAT

Tokyo-based satellite operator Sky Perfect JSAT's activities are based on a Media Business as well as Space & Satellite Business, and as of July 2018 has a fleet of 18 satellites.[251] For the year ending 31 March 2017, the company earned ¥192.9 billion in overall revenues ($1.7 billion), an increase of 18.4% over the ¥162.9 billion of the previous reporting year. EBITDA reached ¥47.7 billion for the year ended 31.3.2017 ($425.5 million)(24.7% of revenue), up from the ¥46.7 billion (28.6% of revenue) of the previous reporting year, and operating profit grew to ¥24.4 billion ($217.8 million) in 2017, up from ¥24.2 billion in 2016. In terms of segment, the Space & Satellite Business represented 81.8% of operating

[243] "xe.com – Current and Historical Rate Tables." data for the Japanese Yen from 31 Mar. 2017. xe.com, 29 June 2018 <https://www.xe.com/currencytables/?from=JPY&date=2017-03-31>.
[244] "Mitsubishi Electric 2017 Annual Report." 29 June 2017. Mitsubishi Electric, 29 June 2018 <http://www.mitsubishielectric.com/en/investors/library/annual_report/pdf/ar2017.pdf>.
[245] Henry, Caleb. "MHI says H3 rocket development on track for 2020." 26 June 2017. SpaceNews, 29 June 2018 <http://spacenews.com/mhi-says-h3-rocket-development-on-track-for-2020/>.
[246] Henry, Caleb. "Japan to modernize spaceport launch pads to support H3 rocket." 23 Mar. 2018. SpaceNews, 29 June 2018 <http://spacenews.com/japan-to-modernize-spaceport-launch-pads-to-support-h3-rocket/>.
[247] *Op. cit.* – "xe.com – Current and Historical Rate Tables." data for the Japanese Yen from 31 Mar. 2017.
[248] "NEC Annual Report 2017." 22 June 2017. NEC, 29 June 2018 <https://www.nec.com/en/global/ir/pdf/annual/2017/ar2017-e_two.pdf>.
[249] Foust, Jeff. "Japanese satellite operator Sky Perfect JSAT will invest in broadband company LeoSat." 11 May 2017. SpaceNews, 29 June 2018 <http://spacenews.com/japanese-satellite-operator-sky-perfect-jsat-will-invest-in-broadband-company-leosat/>.
[250] "SKY Perfect JSAT and LeoSat Sign Strategic Partnership & Investment Agreement." 11 May 2017. BusinessWire, 29 June 2018 <https://www.businesswire.com/news/home/20170510006791/en/SKY-Perfect-JSAT-LeoSat-Sign-Strategic-Partnership>.
[251] Henry, Caleb. "Sky Perfect JSAT mulls future technology investments." 1 July 2018. SpaceNews, 4 July 2018 <http://spacenews.com/sky-perfect-jsat-mulls-future-technology-investments/>.

profit earned and 42.9% of total revenue earned.[252] Sky Perfect JSAT has made a series of investments in recent years, including in LeoSat Enterprises in May 2017 – to support its Ka-band constellation[253] – and in February 2018 in KVH Industries, purchasing $4.5 million in stock.[254]

3.5 China

AsiaSat

AsiaSat of Hong Kong earned HK$1.354 billion (€144.4 million as of 1 January 2018[255]) for the year 2017, a 6% increase over the HK$1.272 billion of 2016. HK$1.309 billion or 96.7% of the 2017 revenue represents recurring "income from provision of satellite transponder capacity". Asiasat's gross profit likewise grew about 6.5% to HK$714 million in 2017 (52.7% of revenue) from HK$645.0 million in 2016 (50.7% of 2016 revenue). Moreover, operating profit also grew to HK$642 million in 2017 from HK$511.3 million in 2016. Revenue gains in 2017 were attributed in financial reporting to the February 2017 full lease of Asiasat 8's Ku-band payload as well as greater data services demand and the migration from Standard to High Definition broadcasting.[256] In fleet activity, the Asiasat-9 satellite – built by Space Systems Loral – was launched 29 September 2017 and replaces Asiasat-4. The new unit offers high-throughput Ka-band service and provides new coverage for Indonesia, Mongolia, and Myanmar.[257,258]

DFH-4 derived satellite launches

The year 2017 saw the launch of three communications satellites based on the DFH-4 platform, developed by CAST, including:

- Shijian 13 (also known as SJ-13 & Chinasat 16), launched 12 April 2017[259]
- Chinasat 9A, launched 18 June 2017[260]
- Alcomsat 1, 10 December 2017[261]

Shijian 13 is intended to provide internet connectivity to rural areas in China as well as to rail and air travellers; Chinasat 9A is owned and operated by China sitcom and will provide direct-to-home TV service; Alcomsat 1 is Algeria's first communications satellite and employs over 30 operational transponders.

3.6 India

Antrix

ISRO's Antrix commercial arm earned ₹19.911 billion in revenue for the year ending 31 March 2017 (€287 million as of 31 March 2017[262]), representing a 3.5% increase over the previous reporting period. Gross profit grew from ₹3,104 million for the year ending 31.3.2016 to ₹3,352 million for the year ending 31.3.2017, and net profit grew from ₹2,054 million for the year ending 31.3.2016 to ₹2,180 million for the year ending 31.3.2017.[263] Moreover, the Indian Government's Department of Space reports that over the period 2016-2017, Antrix earned €34 million in revenue associated with commercial launches for foreign country clients, including Algeria, Canada, Germany, Indonesia, Israel,

[252] "SKY Perfect JSAT Annual Report 2017 – Active on a Universal Scale." 23 June 2017. SKY Perfect JSAT, 4 July 2018 <https://www.skyperfectjsat.co.jp/load_pdf.php?pTb=t_annual_&pRi=78&pJe=1>.
[253] Henry, Caleb. "LeoSat confident Jsat investment will spur other investors." 14 May 2017. SpaceNews, 4 July 2018 <http://spacenews.com/leosat-confident-jsat-investment-will-spur-other-investors/>.
[254] Henry, Caleb. "Sky Perfect Jsat investing $4.5 million in maritime satcom company KVH." 28 Feb. 2018. SpaceNews, 4 July 2018 <http://spacenews.com/sky-perfect-jsat-investing-4-5-million-in-maritime-satcom-company-kvh/>.
[255] "xe.com – Current and Historical Rate Tables." data for the Hong Kong Dollar from 1 Jan. 2018. xe.com, 2 July 2018 <https://www.xe.com/currencytables/?from=HKD&date=2018-01-01>.
[256] "AsiaSat Annual Report 2017." 23 Mar. 2018. AsiaSat, 2 July 2018 <https://www.asiasat.com/sites/default/files/2017-annual-report-en.pdf>.
[257] Henry, Caleb. "ILS Proton to launch AsiaSat-9 on Sept. 28." 31 July 2017. SpaceNews, 2 July 2018 http://spacenews.com/ils-proton-to-launch-asiasat-9-on-sept-28/
[258] Henry, Caleb. "ILS Proton launches AsiaSat-9, completes 2017 commercial manifest." 29 Sep. 2017. SpaceNews, 2 July 2018 <http://spacenews.com/ils-proton-launches-asiasat-9-completes-2017-commercial-manifest/>.
[259] Clark, Stephen. "China's highest-capacity communications satellite launched into orbit." 12 Apr. 2017. Spaceflight Now, 2 July 2018 <https://spaceflightnow.com/2017/04/12/chinas-highest-capacity-communications-satellite-launched-into-orbit/>.
[260] Clark, Stephen. "Chinese TV broadcasting satellite reaches operational orbit after off-target launch." 13 July 2017. Spaceflight Now, 2 July 2018 <https://spaceflightnow.com/2017/07/13/chinese-tv-broadcasting-satellite-reaches-operational-orbit-after-off-target-launch/>.
[261] Clark, Stephen. "Chinese rocket launches with first Algerian communications satellite." 10 Dec. 2017. Spaceflight Now, 2 July 2018 <https://spaceflightnow.com/2017/12/10/chinese-rocket-launches-with-first-algerian-communications-satellite/>.
[262] "xe.com – Current and Historical Rate Tables." data for the Indian Rupee from 31 Mar. 2017. xe.com, 3 July 2018 <https://www.xe.com/currencytables/?from=INR&date=2017-03-31>.
[263] "ANTRIX Annual Report 2016-17." 24 July 2017. ANTRIX, 3 July 2018 <http://www.antrix.co.in/sites/default/files/article-attachments/ANNUALREPORT-2016-17-English.pdf>.

the Netherlands, Kazakhstan, the UAE, and the US.[264]

3.7 Rest of the World

Maxar Technologies, formerly MacDonald, Dettwiler and Associates

On 5 October 2017, Canada's MacDonald, Dettwiler and Associates announced its acquisition of DigitalGlobe. The purchase was reportedly worth $2.4 billion, and on the same occasion the firm rebranded itself as Maxar Technologies Ltd.[265] This move results in four companies coming together under the new Maxar Technologies name, as MDA had previously purchased SSL in 2012 and DigitalGlobe had also purchased Radiant Group in 2016.[266] As part of the 2017 acquisition, DigitalGlobe executive vice president for imagery Timothy Hascall becomes the Maxar chief operations officer, and William McCombe of SSL becomes the chief financial officer of the new Maxar.[267] MDA stated that the purchase would both "help offset the revenue peaks and valleys of MDA's satellite manufacturing business"[268] as well as improve its product-service offer to US defence and intelligence agencies, including imagery and analysis.[269]

The company earned $1.631 billion (in US currency, no longer reported in Canadian dollars) for the year 2017, representing an increase of 4.7% over the $1.558 billion of 2016. EBITDA grew 41.5% to $378.7 million in 2017 from the $267.6 million of 2016; net profit, however dropped from $105.6 million to $100.4 million over 2016 to 2017. Moreover, the order backlog rose from $1.8 billion in 2016 to $3.3 billion for the year 2017, incorporating the $1.7 billion DigitalGlobe backlog. And in line with the DigitalGlobe merger, Maxar adapted its reporting to include the following segments: Space Systems, Imagery, and Services. Space Systems earned total revenues of $1.27 billion, up from $1.421 billion in 2016. The Imagery segment earned $230.1 million in total revenues in 2017, up from $41.8 million in 2016. And the Services segment earned $144.6 million in 2017, likewise up from the $99.7 million of 2016.[270]

[264] "Commercial Launching of Satellite." 4 Jan. 2018. Press Information Bureau, Government of India, Department of Space, 3 July 2018 <http://pib.nic.in/newsite/PrintRelease.aspx?relid=175312>.
[265] *Op. cit.* – "MDA closes DigitalGlobe merger, rebrands as Maxar Technologies."
[266] *Op. cit.* – "Meet Maxar, the space industry's newest tech giant."
[267] *Op. cit.* – "MDA closes DigitalGlobe merger, rebrands as Maxar Technologies."
[268] *Op. cit.* – "MDA views DigitalGlobe merger as hedge against cyclical satellite market."
[269] *Op. cit.* – "MDA seeks to provide extensive support to U.S. intelligence and defense agencies."
[270] "Maxar Technologies – 2017 Annual Report." 22 Feb. 2018. Maxar Technologies, 4 July 2018 <http://s22.q4cdn.com/683266634/files/doc_financials/annual/Maxar-Annual-Report-2017-Final-R1[4].pdf>.

4. European Institutional and Country Level Updates

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 purpose of this report, as both organizations 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.

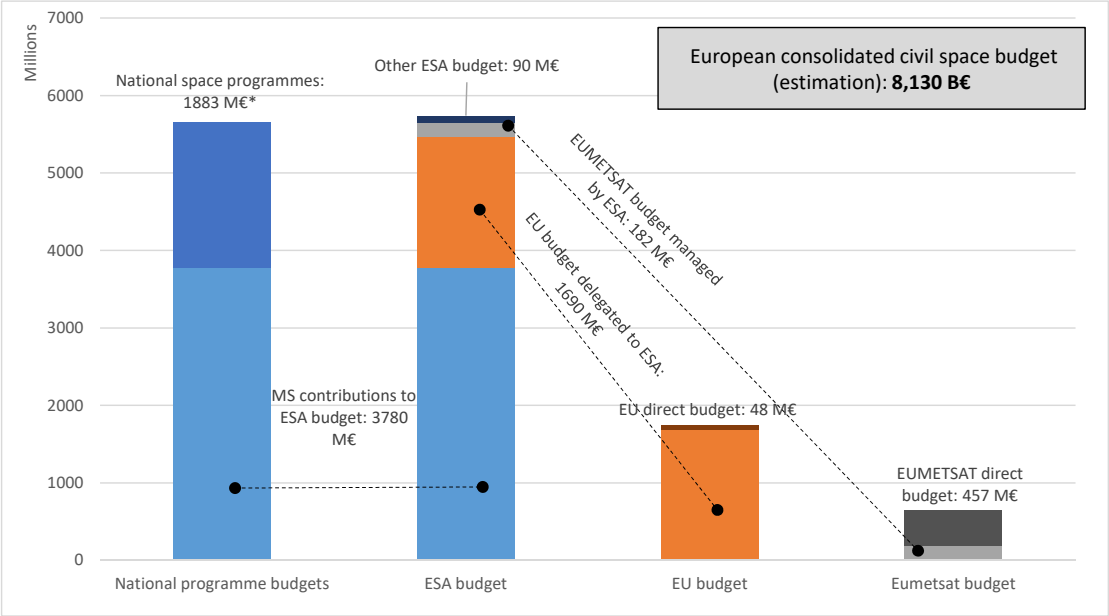


Figure 4.1: Best estimates of the European civil space budget in 2017 (ESA, The Space Report 2018 and best estimates) (*France, Germany, Italy, UK, Sweden, Netherlands, Finland, Poland, Greece, Switzerland, Luxembourg, Czech Republic, Hungary, Austria, Estonia, Norway, Belgium, Denmark.)

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. The European consolidated public budget is €8.130 billion of which €1,883 million is the total sum of the majority of the national space programmes, €3,780 million is the contribution to ESA from the Member States, and €1,690 million is the European Union budget delegated to ESA.

The consolidated budget for European national civil space programmes in 2017 is provided in Fig. 4.1. Moreover, the total ESA budget grew from €5.252 billion in 2016 to €5.75 billion in

2017, while the total EU budget is estimated to approach €1.747 billion, and best estimates of the total contributions to EUMETSAT saw an increase from €432.3 million in 2016 to €539.1 million in 2017. Concerning the EU's contribution to ESA, it is mainly destined toward the implementation of the EU's flagship Galileo and Copernicus programmes. Regarding space security, the related European space activities in both its share-size and amount invested are still a fraction of what was spent by the US: As based on the Space Report, the non-U.S. military space budget for 2017 was $6.964 billion whereas the U.S. Department of Defense (DoD) had a space budget of $20.688 billion.[271]

4.2 European Space Agency

In considering the European Space Agency's budget over 2017 and 2018, it stood at €5.75 billion in 2017 and dropped to €5.6 billion in 2018 (see figures 4.2 and 4.3). The biggest relative change in budget allocation occurred in Navigation, which decreased from €1,010.8 million (17.6% of the 2017 total budget) to €782.6 million in 2018 (14% of the budget), as according to the needs of the EU-funded Galileo programme. Human Spaceflight, Micro. and Exploration received the highest increase in funding, reaching €731.9 million from the €633 million of 2017, along with Space Situational Awareness which received €22.9 million in 2018 (0.4% of 2018 total budget), up from €15.1 million in 2017 (0.3% of the 2017 total budget). Telecom & Integrated Applications as well as Earth Observation also saw marginal decreases in funding, while Space transportation increased from €1,088.4 million to €1,110.7 million in 2018.

ESA is currently developing a spaceplane, Space Rider, aiming to provide affordable access and return to low earth orbit; it will be integrated with a Vega-C to provide an on-orbit laboratory and it is fully or partially reusable. The phase-B1 of the project was completed on 21 December 2017 and the second phase B2/C started on 25 January 2018[272]. In the field of space science, ESA will launch in October 2018 the interplanetary mission Bepi-Colombo, to map Mercury's surface and to investigate its magnetosphere. As a joint mission between ESA and JAXA, and under ESA executive leadership, it is the closest European mission to the Sun[273].

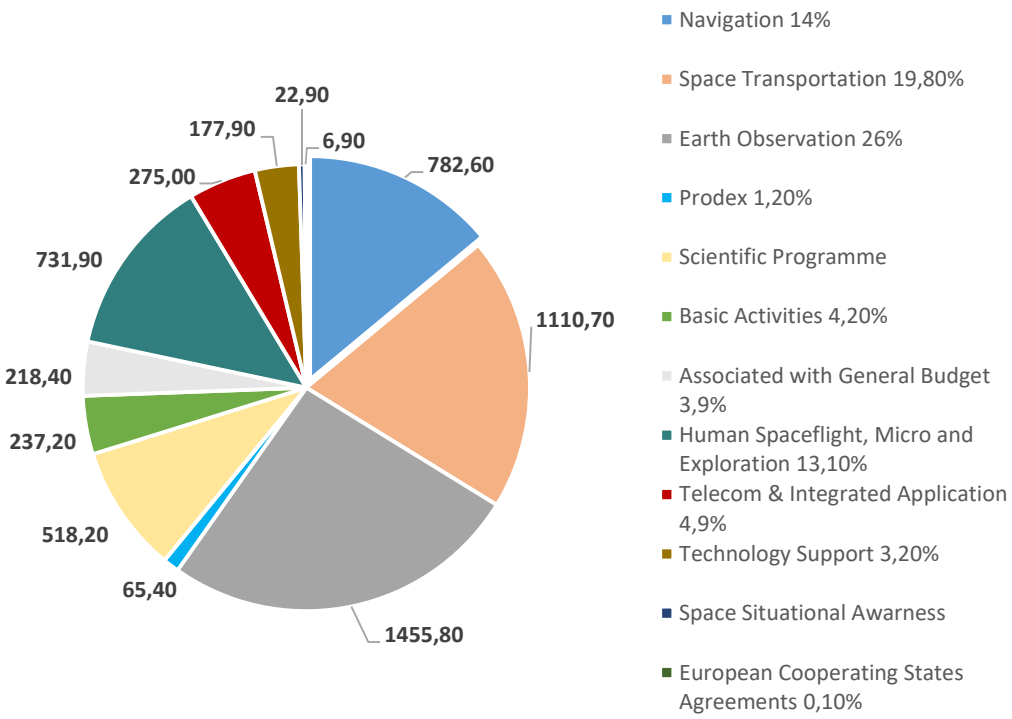


Figure 4.2: ESA programmatic budget allocations for 2018, millions of euros (Source: ESA)

[271] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: 8-9.
[272] Space Transportation: SPACE RIDER < https://www.esa.int/Our_Activities/Space_Transportation/Space_Rider >, 5th September 2018.
[273] Space Science: BEPICOLOMBO OVERVIEW, 20th February 2018. <https://www.esa.int/Our_Activities/Space_Science/BepiColombo_overview2>. 6th September 2018.

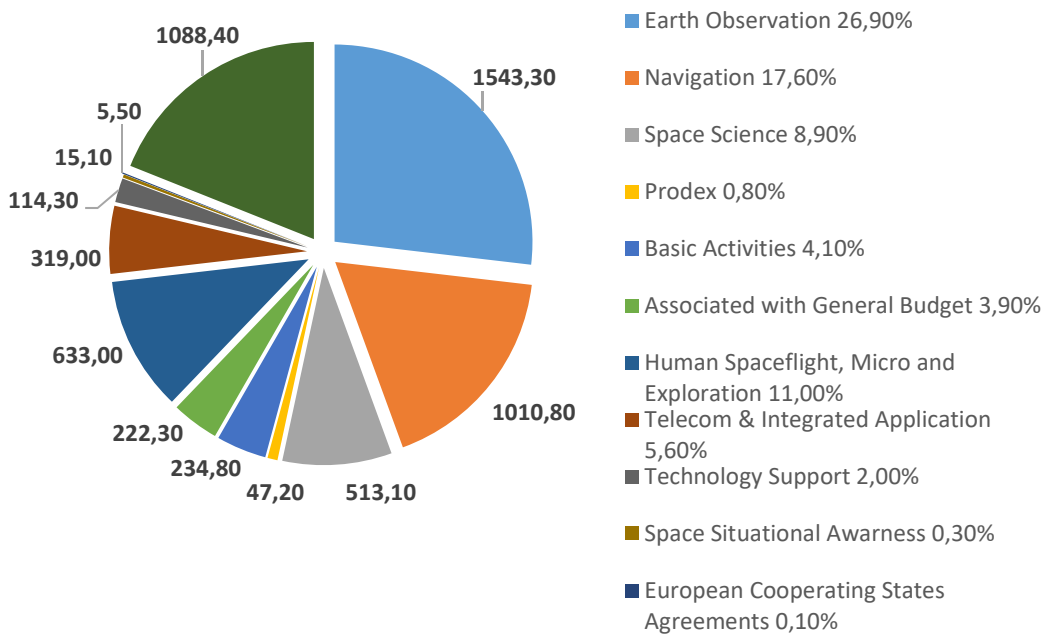


Figure 4.3: ESA Programmatic Budget Allocation for 2017, millions of euros (Source: ESA)

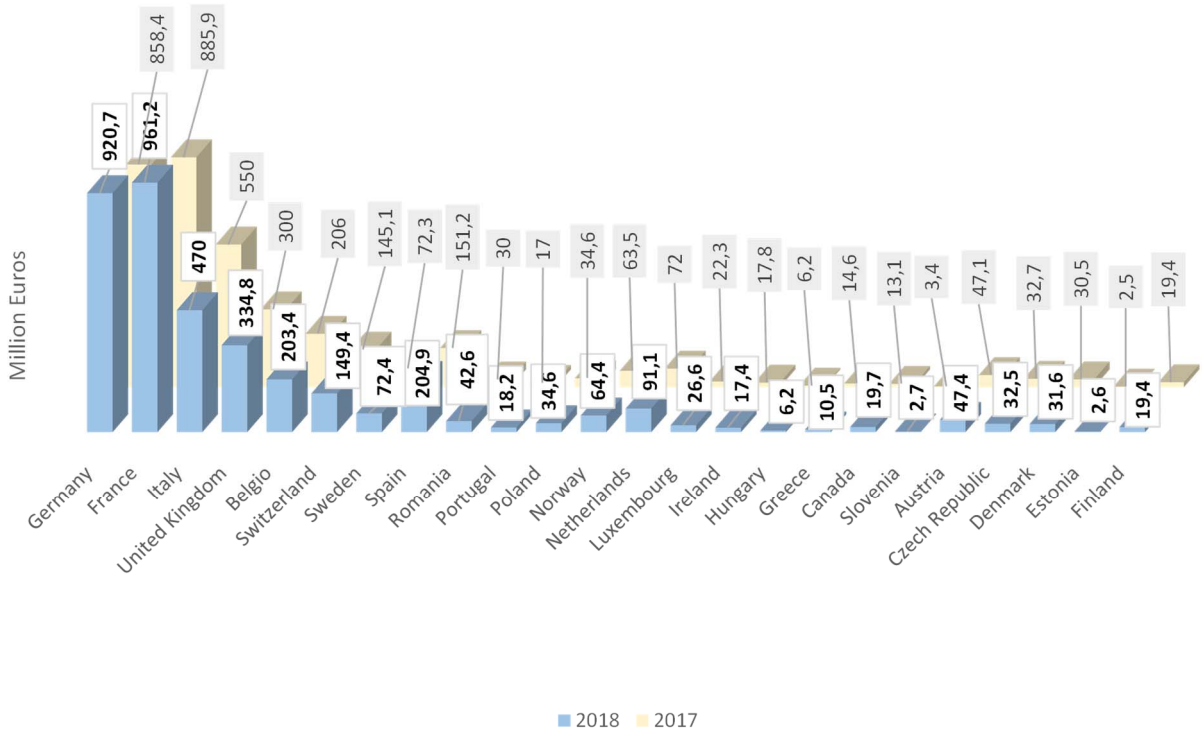


Figure 4.4: Member´s State contributions to ESA's budget from 2017 to 2018 in million euros (Source: ESA)

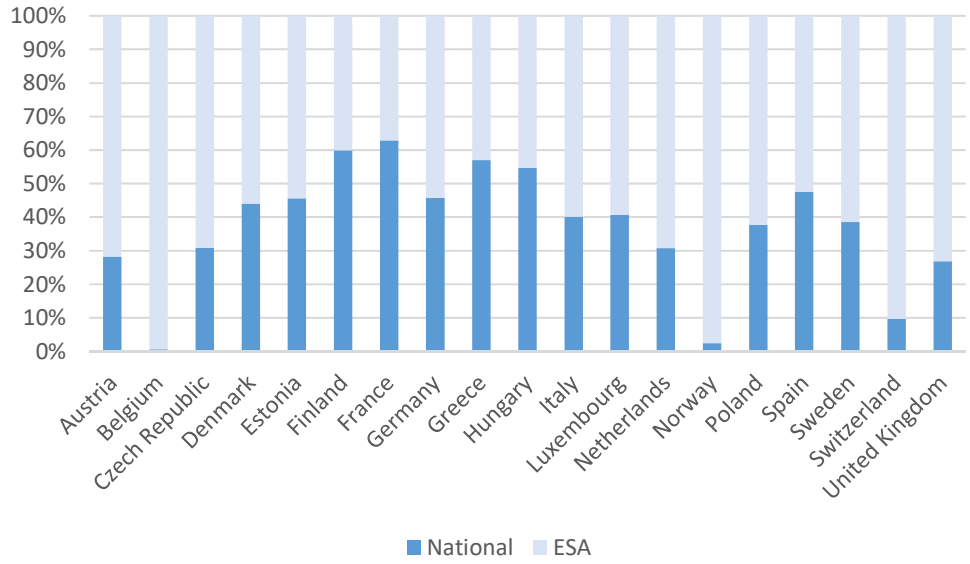


Figure 4.5: Estimated civil investments of ESA Members in 2017 (Source: The Space Report 2018, ESA – The European Space Technology Master Plan 2017)

4.3 EUMETSAT

"The Challenge 2025" establishes the framework for EUMETSAT to reach an optimum realisation of the portfolio of programmes acquired in recent years and addresses its future role in Copernicus and the "big data" challenge. The 10 year strategy was endorsed by EUMETSAT's Council in 2016, and it confirms EUMETSAT's commitment to the full implementation of the Copernicus Sentinel -3, -4, -5 and -6 missions[274]. EUMETSAT also decided to launch the two second generation replacements of polar satellites, Metop-SG A1 and Metop-SG B1, on Arianespace's Soyuz or Ariane 6, between 2021 and 2023.[275]

The vast Majority of EUMETSAT's funding comes from contributions from its Member States and Cooperating States. Member States' contributions are calculated on the basis of their Gross National Income (GNI). In 2017, the percentage distributions grew from 2016 up to a total estimated member state contribution of €538.53 million (Figure 4.6). German likely remains the largest contributor, followed by France and Spain. In 2017, EUMETSAT's total expenditure is estimated to have increased by 16.9% to €639.8 million from €531.7 million in 2016, as the intergovernmental organization sough to play a more defined role in the EU's Copernicus flagship programme, and to ensure continuity of service throughout the next decade. The general estimated budget increased by 23.3% to reach €36.9 million in 2017.

[274] See Eumetsat Annual Report 2016. Eumetsat 6th of September 2018: 2.
< file:///C:/Users/gbordacchini/Downloads/PDF_AR2016_EN.pdf>.

[275] Caleb Henry "Eumetsat launching two, possibly three Metop-SG satellites with Arianespace." 11th September 2017. Space News 6th September 2018< https://spacenews.com/eumetsat-launching-two-possibly-three-metop-sg-satellites-with-arianespace>.

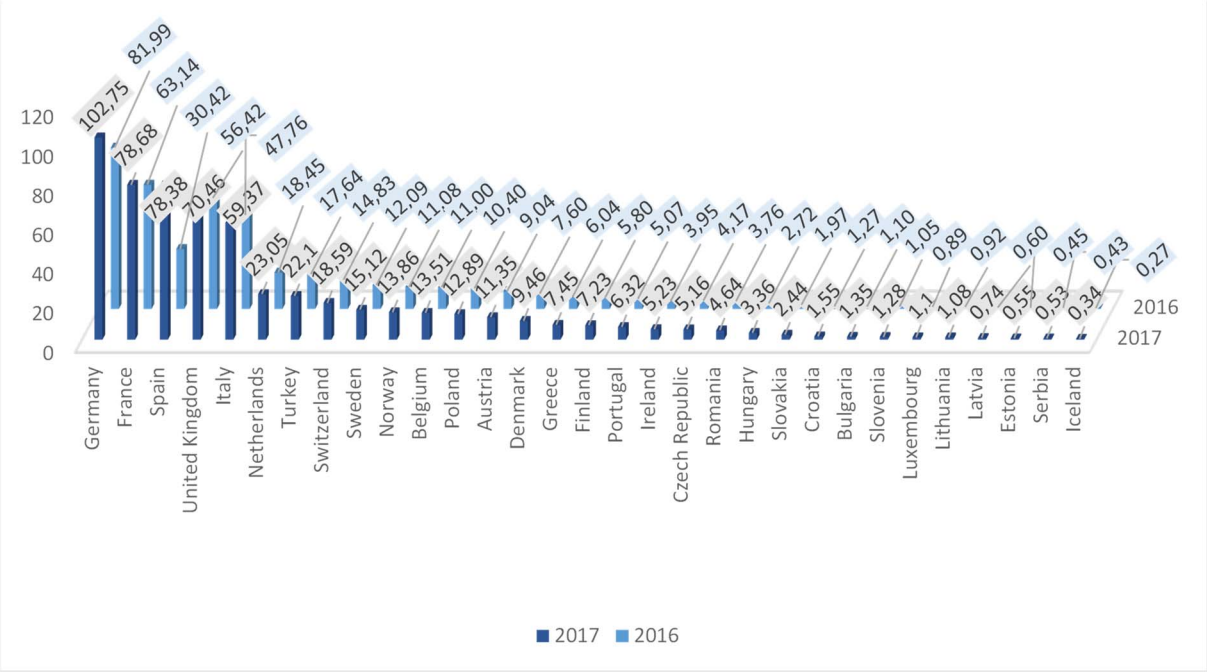
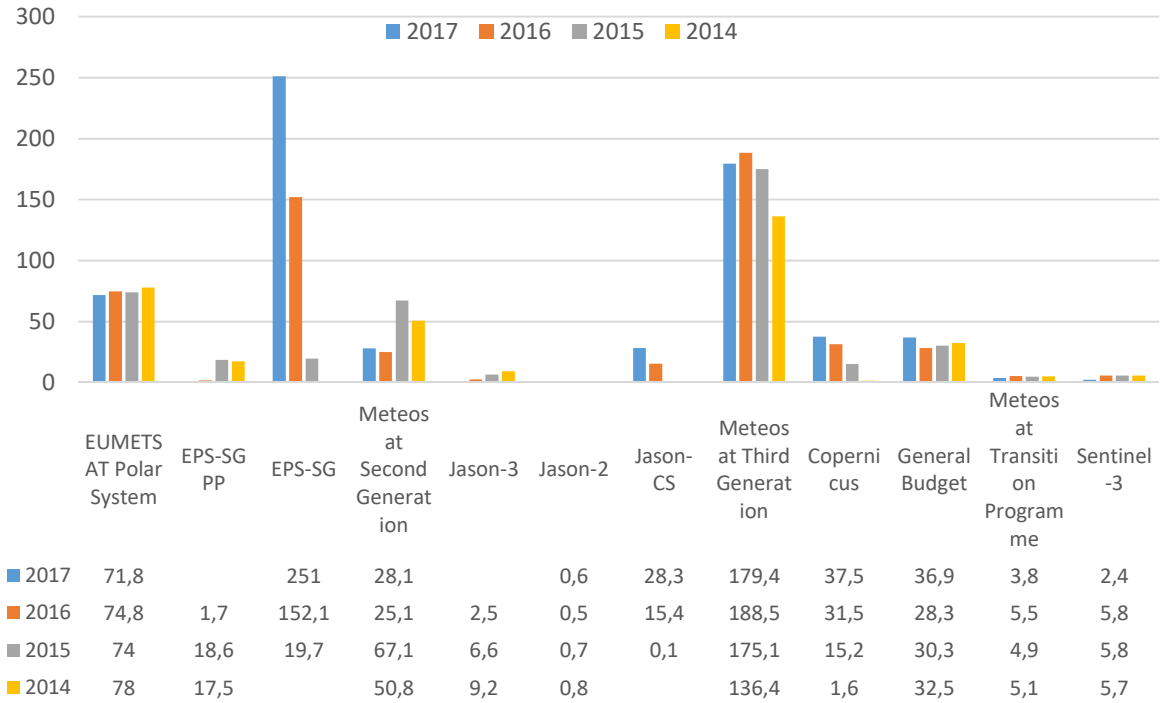


Figure 4.6: Member state´s contributions to Eumetsat from 2015 to 2017
(Source: EUMETSAT Annual Report 2015, 2016 and best estimates)



	EUMETSAT Polar System	EPS-SG PP	EPS-SG	Meteos at Second Generation	Jason-3	Jason-2	Jason-CS	Meteos at Third Generation	Copernicus	General Budget	Meteos at Transition Programme	Sentinel-3
2017	71,8		251	28,1		0,6	28,3	179,4	37,5	36,9	3,8	2,4
2016	74,8	1,7	152,1	25,1	2,5	0,5	15,4	188,5	31,5	28,3	5,5	5,8
2015	74	18,6	19,7	67,1	6,6	0,7	0,1	175,1	15,2	30,3	4,9	5,8
2014	78	17,5		50,8	9,2	0,8		136,4	1,6	32,5	5,1	5,7

Figure 4.7: Major Programmatic Allocations of EUMETSAT 2017-2014
(Source: EUMETSAT Report 2014, 2015, 2016 and best estimates)

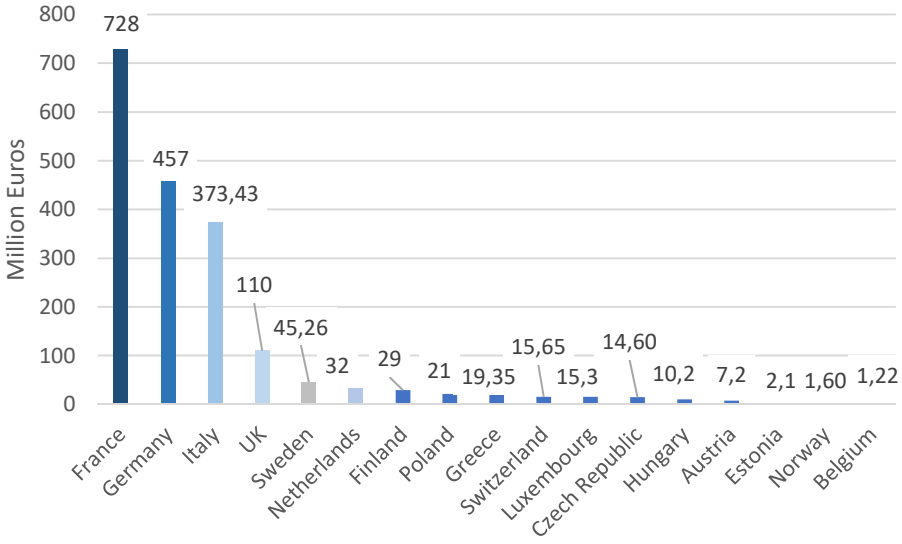


Figure 4.8: National civilian programmes 2017 in million euros
(Source: The Space Report 201 and the European Space Technology Master Plan 2017)

4.4 European Union

4.4.1 Copernicus

The EU Copernicus flagship programme is in its operational phase with seven Sentinel spacecraft currently in orbit as of August 2018. Sentinels 1A and 1B, Sentinels 2A and 2B, and Sentinel 3A having already been launched, the current reporting period saw the launch of Sentinel-5P (precursor to Sentinel 5) on 13 October 2017[276] as well as Sentinel 3B on 25 April 2018.[277] Sentinels 4, 5, and 6 all remain to be launched. Sentinels 4 and 5 "are two families of atmospheric chemistry monitoring missions", the former to be in GEO and the latter in LEO.[278] Sentinel 4, in particular is not a single satellite, but rather represents two Ultra-violet Visible Near-infrared (UVN) spectrometers fitted on the two Meteosat Third Generation Sounding Satellites (MTG-S, of EUMETSAT), forecasted for launch no sooner than 2021.[279,280] Sentinel 5 is likewise a payload (an Ultra-Violet Visible Near Infrared / Short Wave Infrared spectrometer)[281] to be launched on a MetOp-SG satellite (also from EUMETSAT) no sooner than 2021.[282] Thirdly, the Sentinel 6 is a radar altimeter mission that will "continue high precision ocean altimetry measurements in the 2020–2030 time-frame using two successive, identical satellites, Jason-CS-A and Jason-CS-B", which are both co-affiliated with EUMETSAT.[283] 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.[284]

[276] "Sentinel-5P." ESA Sentinel Online, 10 Sep. 2018 (retrieved) <https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-5p>.
[277] Kramer, Herbert J. "Copernicus: Sentinel-3." eoPortal Directory, 10 Sep. 2018 (retrieved) <https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/copernicus-sentinel-3>.
[278] Kramer, Herbert J. "Copernicus." eoPortal Directory, 10 Sep. 2018 (retrieved) <https://earth.esa.int/web/eoportal/satellite-missions/c-missions/copernicus>.
[279] Kramer, Herbert J. "Copernicus: Sentinel-4." eoPortal Directory, 10 Sep. 2018 (retrieved) <https://earth.esa.int/web/eoportal/satellite-missions/c-missions/copernicus-sentinel-4>.
[280] "Meteosat Third Generation (MTG) is EUMETSAT's next generation of geostationary satellites, following on from earlier successful missions." EUMETSAT, 10 Sep. 2018 (retrieved) <https://www.eumetsat.int/website/home/Satellites/FutureSatellites/MeteosatThirdGeneration/index.html>.
[281] Kramer, Herbert J. "Copernicus: Sentinel-5." eoPortal Directory, 10 Sep. 2018 (retrieved) <https://earth.esa.int/web/eoportal/satellite-missions/c-missions/copernicus-sentinel-5>.
[282] "The EPS follow-on system (EPS-SG) will provide continuity of observations and respond to the needs of the users in the 2021–2040 time frame." EUMETSAT, 10 Sep. 2018 (retrieved) <https://www.eumetsat.int/website/home/Satellites/FutureSatellites/EUMETSATPolarSystemSecondGeneration/index.html>.
[283] "The Sentinel-6 radar altimeter mission is part of the Copernicus Programme, with the objective of providing high-precision measurements of global sea-level." EUMETSAT, 10 Sep. 2018 (retrieved) <https://www.eumetsat.int/website/home/Satellites/FutureSatellites/CopernicusSatellites/Sentinel6/index.html>.
[284] "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>.

4.4.2 Galileo

As of August 2018, a total of 26 Galileo units have been launched, including 24 Full Operational Capability (FOC) units launched since 2014 and the four In-Orbit Validation units launched over 2011 and 2012. During the reporting period, two launches occurred on 12 December 2017 and on 24 July 2018; both launches carried four satellites.[285] The EU Galileo flagship GNSS programme entered its operational phase on 15 December 2016, following the European Commission's Declaration of Initial Service.[286] As of the entry into operations, the Galileo system provides: Open Service to its positioning, navigation and timing signals for the mass-market; its Public Regulated Service (PRS) for government-authorised users (including full encryption to provide service continuity for government users during emergencies or crisis situations); and its Search and Rescue Service as Europe's contribution to the international distress beacon locating organisation COSPAS-SARSAT. These Initial Services are managed by the European GNSS Agency (GSA), based in Prague, Czech Republic, and are free of charge for European citizens, business and authorities; moreover, Galileo is expected to offer full service in 2020.[287] Looking ahead, it was announced in June 2017 that OHB System AG of Germany and Surrey Satellite Technology Ltd. of the UK will build a further 8 units as per a contract valued at €324 million.[288]

4.4.3 Horizon 2020

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 from 2014 to 2020, i.e. €200 million per year.[289] The work programme for EU Space R&D focuses on prioritising the EU's Copernicus and Galileo Flagship programmes; ensuring support for the protection of space infrastructure; ensuring support to EU industry in enhancing competitiveness and its value-chain in the global market in line with the Commission's Space Industrial Policy; ensuring that Europe's investments made in space infrastructure are exploited to the benefit of citizens; as well as supporting European space science; and enhancing Europe's standing as an attractive partner for international partnerships in space science and exploration.[290] While the actual amount allocated to space research under Horizon 2020 lowered to €167.1 million in 2016, the budget increased to €183.9 million in 2017.[291] Moreover, in October 2017 the European Commission released the last Horizon 2020 Work Programme for 2018-2020, wherein the 2018 budget allocated to space research rose to €197.4 million and is slated at €207.2 million in 2019 and €218.1 million in 2020 (all estimates).[292]

4.4.4 Multiannual Financial Framework for 2021-2027

Furthermore, in May 2018 the European Commission released its proposals for the next EU long-term budget – The Multiannual Financial Framework for 2021-2027 – wherein it lists €16.235 billion over the entire period for the item "space", which covers the European Space Programme. The Framework document reads "A fully integrated space programme will bring together all of our activities in this highly strategic field. This will provide a coherent framework for future investment, offering increased visibility and more flexibility. By improving efficiency, it will ultimately help roll out new space-driven services that will benefit all EU citizens."[293]

[285] "Galileo System." European Commission, 10 Sep. 2018 (retrieved) <https://ec.europa.eu/growth/sectors/space/galileo/launches_en>.
[286] European Commission - Press release. "Galileo goes live!" 14 Dec. 2016. European Commission 1 Sept. 2017 <http://europa.eu/rapid/press-release_IP-16-4366_en.htm>.
[287] "Galileo." European Commission 1 Sept. 2017 <http://ec.europa.eu/growth/sectors/space/galileo_en>.
[288] Clark, Stephen. "German-British consortium wins deal to build eight more Galileo satellites." 28 June 2017. Spaceflight Now, 10 Sep. 2018 <https://spaceflightnow.com/2017/06/28/german-british-consortium-wins-deal-to-build-eight-more-galileo-satellites/>.
[289] "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>.
[290] "Space." European Commission 1 Sept. 2017 <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/space>.
[291] Commission of the European Communities. Horizon 2020 – Work Programme 2016-2017. 5 iii. Leadership in Enabling and Industrial Technologies – Space, European Commission Decision C(2016)4614 of 25 July 2016. Brussels: European Union <http://ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-leit-space_en.pdf>.
[292] "Horizon 2020 Work Programme 2018-2020 – 5.iii. Leadership in Enabling and Industrial Technologies - Space." 24 July 2018. European Commission, 8 Sep. 2018 <http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-leit-space_en.pdf>.
[293] "Communication From The Commission To The European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions – A Modern Budget for a Union that Protects, Empowers and Defends The Multiannual Financial Framework for 2021-2027." 2 May 2018. European Commission, 10 Sep. 2018 <https://eur-lex.europa.eu/resource.html?uri=cellar:c2bc7dbd-4fc3-11e8-be1d-01aa75ed71a1.0023.02/DOC_1&format=PDF>.

4.5 Country Level Updates

In 2017, the hierarchy of European national space budgets changes somewhat compared to 2016 which might be due to the use of estimates derived from different sources. France remained in first position in national space expenditure, with Germany maintaining the second position, followed by Italy and the UK. Here, France, Germany, Italy and the UK accounted for a combined share of around 90% of the total expenditure on European national space programmes.

4.5.1 France

Regarding the French Space Agency CNES' activities in French Guiana, it signed two contracts on Ariane 6 development at the occasion of the International Paris Air Show in June 2017. The first concerns Ariane 6 mechanical ground transport systems, signed with APCO Technologies of Switzerland. The second is for the development of cryogenic interfaces between the launcher and the ground systems, signed with a consortium including Latecoere Services (as lead), Air Liquide, and Cegelec Projets Espace et Caraïbes.[294] Further, in reaffirming and strengthening their cooperation, CNES and ArianeGroup signed a cooperation agreement on 15 September 2017, whereby the two actors will "pursue close cooperation under the roadmap designed to shape the long-term evolution of the Ariane launcher family".[295]

In terms of technical progress in activities at the Guiana Space Centre, the first test of the Ariane 6 and Vega C common P120 C engine (under development by ArianeGroup and Avio) took place 16 July 2018 on CNES' BEAP solid booster test stand; "The test was designed to validate the booster's design, fabrication and performance, as well as its overall behaviour and components."[296] The engine can be used on Vega-C's first stage and for the strap-on boosters for Ariane 6; this common production model is aimed at "aggressively reducing production costs" for the launchers.[297]

In other launcher activity, development continues on the Callisto rocket, whose first version will measure just over 13 metres and as a project aims at studying "different aspects of recovery and reuse." The project is a collaborative effort between CNES and Germany's DLR, and its first launch is expected in 2020.[298]

Lastly, similar to Japan's recent activities (see Japan in ch. 6), it was reported in May 2018 that CNES will establish an investment fund worth €80 to 100 million for space start-ups.[299]

4.5.2 Germany

In addition to the aforementioned and ongoing collaboration with CNES on the Callisto rocket, on 24 July 2017 the German space agency (DLR) introduced, along with Germany's Federal Ministry for Economic Affairs and Energy, the DLR's new strategy, entitled Strategy 2030. Implementation of the strategy began in 2018, and it has for an overarching goal to benefit both the society and economy, with focus areas on space and aeronautics, digitalisation, energy, transport, and security.

Speaking at the presentation, State Secretary Matthias Machnig explained "DLR will implement this strategy to address current societal and economic policy challenges, as well as to adapt to the future in the area of digitisation in particular." Chair of the DLR Executive Board Pascale Ehrenfreund added that "Smart connectivity between the research areas of aeronautics, space, energy, transport, security and digitalisation will allow us to generate a tangible added value for society, the economy and the scientific community".

The strategy introduces 10 cross-sectoral projects on cyber security, broadband rollout, and future fuels, among others, and it will see the DLR establish seven new research institutes.[300,301] These were approved at the DRL Senate's June 2017 meeting, and the German

[294] "CNES signs two Ariane 6 development contracts for French Guiana." 21 June 2017. CNES, 6 Sep. 2018 <https://presse.cnes.fr/sites/default/files/drupal/201706/default/cp101-2017_-_siae_guyane_contrats_a6_va.pdf>.
[295] "CNES and ArianeGroup step up Cooperation in the Launch Vehicles Sector." 21 Sep. 2017. CNES, 6 Sep. 2018 <https://presse.cnes.fr/en/cnes-and-arianegroup-step-cooperation-launch-vehicles-sector>.
[296] "[Ariane 6] New P120c Engine Successfully Tested." 16 July 2018. CNES, 6 Sep. 2018 <https://cnes.fr/en/ariane-6-new-p120c-engine-successfully-tested>.
[297] Henry, Caleb. "Ariane 6 is nearing completion, but Europe's work is far from over." 15 Aug. 2018. SpaceNews, 6 Sep. 2018 <https://spacenews.com/ariane-6-is-nearing-completion-but-europes-work-is-far-from-over/>.
[298] Henry, Caleb. "France, Germany studying reusability with a subscale flyback booster." 8 Jan. 2018, SpaceNews, 6 Sep. 2018 <https://spacenews.com/france-germany-studying-reusability-with-a-subscale-flyback-booster/>.
[299] Henry, Caleb. "CNES creating a space startup fund." 7 May 2018. SpaceNews, 6 Sep. 2018 <https://spacenews.com/cnes-creating-a-space-startup-fund/>.
[300] "DLR in 2018." 1 Feb. 2018. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-25907/year-2018/151_page-2/#/gallery/14331>.
[301] "DLR and the German Federal Ministry for Economic Affairs and Energy present their new strategy." 24 July 2017. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-23429/year-2017/151_page-3/#/gallery/27704>.

federal government will provide €42 million annually in funding. The institutes include the following:

- Institute of Test and Simulation for Gas Turbines – Augsburg
- Institute for the Protection of Maritime Infrastructures – Bremerhaven
- Institute of Software Methods for Product Virtualisation – Dresden
- Institute of System Architectures in Aeronautics – Hamburg
- Institute of Maintenance, Repair and Overhaul – Hamburg
- Institute of Data Science – Jena
- Institute of Networked Energy Systems – Oldenburg

The DLR was originally requested to build the above institutes via a resolution from the Budgetary Committee of the German Bundestag in late 2016. Further, the scientific focus areas of these institutes were considered by industry, scientific institutions, and other international reviewers.[302]

4.5.3 Italy

As Europe's launch sector continues substantial development to grow more competitive in the global market, Arianespace's Vega launcher – manufactured by ELV (a joint venture[303] between the Italian Space Agency and Avio) – has launched a total of 12 times since 2012, all successfully.[304] Over the reporting period in particular (including up to August 2018), Vega launched three times in 2017 and once in 2018.[305] Looking to the future, and as part of overall efforts to increase the Vega's competitiveness on the launch market, ESA and Avio have been developing since 2016 a new Small Spacecraft Mission System adaptor (SMSS), which can deliver cubesats and microsats up to 400 kg to orbit. In 2018, Arianespace secured four customers on the first SMSS, scheduled for 2019, including Spaceflight Inc. (American), ISIS (Dutch), and the Italian Sitael and D-Orbit. The SMSS is intended for 1 to 2 flights per year. Moreover, the P120 C engine under development by ArianeGroup and Avio, intended for both the next generation Vega C and Ariane 6, is to be produced in up to 35 units per year and "will provide scale meaningful enough to drive prices lower, according to Arianespace and Avio officials."[306] Lastly, with the Vega C still scheduled for its first flight in 2019, Avio is also developing a further launcher, known as Vega E (Evolution), expected for launch in 2024; ESA has additionally committed to the latter in a contract with Avio valued at €53 million. According to SpaceNews.com, this represents only a "first tranche".[307]

[302] "DLR Senate gives the go-ahead for the foundation of seven DLR institutes." 29 June 2017. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-23037/year-2017/151_page-4/#/gallery/27334>.
[303] "Frequently Asked Questions on Vega." 10 May 2017. ESA, 7 Sep. 2018 <https://www.esa.int/Our_Activities/Space_Transportation/Launch_vehicles/Frequently_asked_questions_on_Vega>.
[304] Graham, William. "Arianespace's Vega rocket launches ESA's Aeolus." 22 Aug. 2018. NASA Spaceflight, 7 Sep. 2018 <https://www.nasaspaceflight.com/2018/08/arianespaces-vega-rocket-esa-aeolus-launch/>.
[305] "Gunter's Space Page – Vega (P80 based)." Data from 2017 and 2018. Gunter's Space Page, 7 Sep. 2018 <https://space.skyrocket.de/doc_lau/vega_p80.htm>.
[306] Henry, Caleb. "Vega's long-awaited (small) successes." 8 Aug. 2018. SpaceNews, 7 Sep. 2018 <https://spacenews.com/vegas-long-awaited-small-successes/>.
[307] Henry, Caleb. "ESA pours $107 million into Vega E and a reusable spaceplane." 30 Nov. 2017. SpaceNews, 7 Sep. 2018 <https://spacenews.com/esa-pours-107-million-into-vega-e-and-a-reusable-spaceplane/>.

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 Overview, Military Space Spending & Launch

The Space Report 2018 reports that overall government space spending grew 4.8% from the $72.7 billion of 2016 to $76.2 billion over 2017.[308] Of this, it finds military space spending in 2017 to be $27.652 billion, a 3.5% decrease of about $1 billion from the $28.655 billion reported for 2016. These figures show that military space spending in 2017 represented 36.3% of the 2017 overall government space spending, which is a drop from the 39.4% it represented in 2016. However, 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, according to the Space Report figures, US military space spending (via the Department of Defense) represented 74.8% ($20.688 billion) of global military space spending in 2017, a slight drop from the 76.8% ($22 billion) in 2016. Non-U.S. global military spending increased from 23.2% ($6.655 billion) in 2016 to 25.2% ($6.964 billion) in 2017. [309] However, as in previous years, a direct comparison of these figures in fixed dollar values does not present a clear picture of the differing countries' relative space defence efforts, since fluctuating exchange rates, variations in purchasing power, and different employment costs distort the impact of these investment amounts.

In terms of launch activity, the Space Report finds that military activity across the US, Russia, China, Europe, Japan, and India accounted for a total of 22 launch attempts in 2017. Further, the military spacecraft launched over the year account for a total value of approximately $13 billion, and the launch services in 2017 for military activity were valued at $1.6 billion.[310]

5.2 Europe

The European Commission released its Space Strategy in late 2016, comprising four strategic goals, with the overarching aim of building a sustainable space economy. In addition to this, it aims to advance Europe's space situational awareness capability and Governmental Satellite Communications (GOVSATCOM) programme.[311] Moreover, on 30 November 2016, the European Commission released its European Defence Action Plan, comprising three main pillars: 1) Launching a European Defence Fund; 2) Fostering investments in defence supply chains; and 3) Reinforcing the single

[308] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: p. 8.
[309] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: p. 15.
[310] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: p. 5.
[311] "Space." Regularly updated. European Commission, Growth, Sectors, Space, 18 July 2018 (retrieved) <http://ec.europa.eu/growth/sectors/space_en>.

market for defence. Moreover wherever appropriate the Commission will promote civil and military synergies within EU policies. [312,313]

With regards to Governmental Satellite Communications (GOVSATCOM), the initiative was defined in 2013 by the European Council as one of the four capability development programmes, and is planned to "Provide by 2018 EDA Member States and European CSDP actors with access to a GOVSATCOM capability based on existing, pooled, governmental SATCOM resources". It is highlighted in both the Space Strategy and the Defence Action Plan, and moreover, "GOVSATCOM's objective is to ensure in both the civil and military environment reliable, secure and cost-effective satellite communication services for EU and national public authorities managing security critical missions and operations."[314] Ultimately, it is envisaged as a "capability that is placed in between the commercial satellite communication market and the highly protected military satellite communication capability".[315] Its inclusion within the European Space Policy underlines its importance for the European Commission, and important steps were taken in 2017: In March, both a GOVSATCOM Common Staff Requirements and a connected Business Case were approved by the European Defence Agency (EDA) Steering Board, and in June the Outline Description for the Governmental Satellite Communications Pooling and Sharing demonstration project was additionally accepted, with the project led by Spain and comprising fourteen EDA Member States as well as Norway. This demonstration project aims to begin offering services to governmental users by the summer of 2018. It will provide the platform of the project ultimately to be led by the European Commission, which is anticipated to be operational in 2020.[316] Lastly, near the end of 2017, an Implementing Arrangement was signed between the EDA and ESA towards supporting the European Commission in the GOVSATCOM initiative.[317]

A further development in 2017 included "the elaboration of a Military Satellite Navigation Policy to scope the potential European secure use of positioning, navigation & timing information" – which is the first of its kind and was adopted by the EDA Steering Board on 23 March 2017. A "military user needs document" was requested by Member States to follow.[318,319]

In terms of military space spending in 2017, France's military space programme held a €300 million budget for the year, while Germany's Ministry of Defense provided €32.64 million to the DLR for defence-related activity.[320]

5.3 United States

The U.S. Department of Defense (DoD) *unclassified* space budget reached an estimated $10.1 billion for the fiscal year 2017, up 5% from the recorded $9.7 billion for 2016.[321] Further, the Missile Defense Agency budget for fiscal year 2017 was $7.9 billion,[322] up $421.8 million from the 2017 DoD President's Budget Submission released in February 2016.[323]

[312] "European Defence Action Plan: Towards a European Defence Fund." 30 Nov. 2016. European Commission Press Release Database, 18 July 2018 <http://europa.eu/rapid/press-release_IP-16-4088_en.htm>.
[313] "Communication From The Commission To The European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions – European Defence Action Plan." 30 Nov. 2016. European Commission, 18 July 2018 <https://eeas.europa.eu/sites/eeas/files/com_2016_950_f1_communication_from_commission_to_inst_en_v5_p1_869631.pdf>.
[314] "Governmental Satellite Communications (GovSatcom)." 15 June 2017. European Defence Agency, 18 July 2018 <https://www.eda.europa.eu/what-we-do/activities/activities-search/governmental-satellite-communications-(govsatcom)>.
[315] "Future European GOVSATCOM programme takes next step." 12 Sep. 2017. European Defence Agency, 18 July 2018 <https://eda.europa.eu/info-hub/press-centre/latest-news/2017/09/12/future-european-govsatcom-programme-takes-next-step>.
[316] Pultarova, Tereza. "Govsatcom demonstration aims to start service next summer." 8 Nov. 2017. SpaceNews, 18 July 2018 <http://spacenews.com/govsatcom-demonstration-aims-at-start-service-next-summer/>.
[317] "Chief Executive Domecq at ESA." 5 Feb. 2018. European Defence Agency, 18 July 2018 <https://eda.europa.eu/info-hub/press-centre/latest-news/2018/02/05/chief-executive-domecq-at-esa>.
[318] "European Defence Agency Annual Report 2017." 12 Mar. 2018. European Defence Agency, 18 July 2018 <https://eda.europa.eu/docs/default-source/eda-annual-reports/eda-2017-annual-report-final>.
[319] Domecq, Jorge & Wörner, Johann-Dietrich. "Space and Security: Crucial synergies for European citizens." 13 Dec. 2017. *European Defence Matters*, Issue 13, 18 July 2018: p. 20 <https://www.eda.europa.eu/docs/default-source/eda-magazine/edmissue13lowresweb>.
[320] The Space Report 2018. Colorado Springs: The Space Foundation, 2018: p. 12.
[321] "Aeronautics and Space Report of the President Fiscal Year 2016 Activities." NASA, 10 July 2018 (retrieved) <https://history.nasa.gov/presrep2016.pdf>.
[322] Williams, Ian. "FY 2017 Missile Defense Agency Budget Tracker." 29 Mar. 2017 (modified 15 June 2018). CSIS Missile Defense Project – Missile Threat, 10 July 2018 <https://missilethreat.csis.org/fy-2017-missile-defense-agency-budget-tracker/>.
[323] "Department of Defense – Fiscal Year (FY) 2017 President's Budget Submission – Missile Defense Agency." 15 Feb. 2016. US Department of Defense, 10 July 2018: pg. 36 (PDF count, not number on page) <https://comptroller.defense.gov/Portals/45/Documents/defbudget/FY2017/budget_justification/pdfs/03_RDT_and_E/

As indicated in the US Air Force's 2019 budget request[324] released February 2018 and in media reporting, the Air Force is aiming to end and transition from the Space Based Infrared System (SBIRS) following the launch of its 6th satellite in 2022, with funding for the originally planned 7th and 8th units being redirected to a new programme known as "Next Generation Overhead Persistent Infrared" (OPIR).[325] According to the Air Force, it "is implementing rapid procurement authorities and is targeting the first Next-Gen OPIR launch in 2023".[326] Further, the follow-on OPIR programme is seen as a "pacesetter" in a broader initiative towards reforms for acquisitions in the US Air Force.[327] On 23 March 2018, a National Space Strategy was released by the White House, focusing on "four pillars" concerning "more resilient space architectures", "deterrence and warfighting options", "foundational capabilities, structures, and processes", and "conducive domestic and international environments".[328]

Further, the National Defense Authorization Act for Fiscal Year 2018 (NDAA-18) was signed into law on 12 December 2017 by US President Donald Trump and marks a period of evolution in the US military's space organisation.[329] Having been approved by the US Congress' House of Representatives, the controversial proposal for a so-called Space Corps ultimately did not get through the Senate, but significant reform was nevertheless introduced. Firstly, the position of Principal Department of Defense Space Advisor was removed from the Secretary of the US Air Force.[330] In connection to this action, the 2018 NDAA also directs the Deputy Secretary of Defense to establish a plan to create a separate military department for national security space activities, by the end of 2018.[331] Additionally, Deputy Defense Secretary Patrick Shanahan has disbanded the Defense Space Council, and the position of commander of the Air Force Space Command was established as a Joint Force Space Component Commander under the US Strategic Command. The service term of the commander of the Air Force Space Command was also extended to six years.[332] And included in this position's scope of responsibility is the oversight of acquisitions for defence in space as well as the procurement for the Department of Defense of all commercial satellite communications.[333]

5.4 Russia

Russian defence spending had followed a general upwards curve for the past decade, reaching a peak $60.825 billion in 2016 (4.5% of GDP), but shrinking 30.5% to $42.278 billion in 2017 (3.1% of GDP).[334] And in late December 2017, the 2018 budget was announced to be $46 billion (2.8% of GDP),[335] representing growth again, but not equalling the 2016 values.

The recent pattern of overall growth is itself attributed to a strong general rearmament initiative. The latest State Armament Programme, for 2018 to 2027, was approved in

MDA_RDTE_MasterJustificationBook_Missile_Defense_Agency_PB_2017_1.pdf>.

[324] "Department of Defense – Fiscal Year (FY) 2019 Budget Estimates – Air Force." 1 Feb. 2018. US Department of the Air Force, 10 July 2018 <http://www.saffm.hq.af.mil/Portals/84/documents/FY19/Proc/Air%20Force%20Space%20Procurement%20FY19.pdf?ver=2018-02-12-190223-850>.

[325] Erwin, Sandra. "The end of SBIRS: Air Force says it's time to move on." 19 Feb. 2018. SpaceNews, 10 July 2018 <http://spacenews.com/the-end-of-sbirs-air-force-says-its-time-to-move-on/>.

[326] "AF plans to accelerate defendable space with Next-Gen OPIR." 4 May 2018. Secretary of the Air Force Public Affairs, 10 July 2018 <http://www.af.mil/News/Article-Display/Article/1512949/af-plans-to-accelerate-defendable-space-with-next-gen-opir/>.

[327] Erwin, Sandra. "Air Force confident it can build satellites faster. A bigger concern: software." 28 Apr. 2018. SpaceNews, 10 July 2018 <http://spacenews.com/air-force-confident-it-can-build-satellites-faster-a-bigger-concern-software/>.

[328] "President Donald J. Trump is Unveiling an America First National Space Strategy." 23 Mar. 2018. whitehouse.gov – Infrastructure & Technology, 10 July 2018 <https://www.whitehouse.gov/briefings-statements/president-donald-j-trump-unveiling-america-first-national-space-strategy/>.

[329] "Remarks by President Trump at Signing of H.R. 2810, National Defense Authorization Act for FY2018." 12 Dec. 2017. whitehouse.gov – National Security & Defense, 10 July 2018 <https://www.whitehouse.gov/briefings-statements/remarks-president-trump-signing-h-r-2810-national-defense-authorization-act-fy2018/>.

[330] Erwin, Sandra. "2018 a big year of transition for military space." 28 Dec. 2017. SpaceNews, 10 July 2018 <http://spacenews.com/2018-a-big-year-of-transition-for-military-space/>.

[331] Cowen-Hirsch, Rebecca. "NDAA: A Step Forward to Stronger, Unified Satcom." 22 Mar. 2018. Via Satellite, 10 July 2018 <https://www.satellitetoday.com/government-military/2018/03/22/ndaa-a-step-forward-to-stronger-unified-satcom/>.

[332] Erwin, Sandra. "DoD delivers report to Congress on space reforms: Air Force acquisition system a big problem." 6 Mar. 2018. SpaceNews, 10 July 2018 <http://spacenews.com/dod-delivers-report-to-congress-on-space-reforms-air-force-acquisition-system-a-big-problem/>.

[333] *Op. cit.* – "NDAA: A Step Forward to Stronger, Unified Satcom."

[334] "Russia Military Power." 28 June 2017. US Defense Intelligence Agency, 11 July 2018 <http://www.dia.mil/Portals/27/Documents/News/Military%20Power%20Publications/Russia%20Military%20Power%20Report%202017.pdf>.

[335] "Russia to shell out $46 bln on defense spending in 2018." 22 Dec. 2017. TASS, 11 July 2018 <http://tass.com/defense/982575>.

December 2017 and gives considerable attention to military satellite capabilities, including a new reconnaissance system forecasted to begin operations in 2018 and a possible anti-satellite missile system.[336] According to media sources as of October 2017, Russia had 81 military satellites, second only to the US[337] and 55 of which were launched over 2012 to 2017. Furthermore, it had put in orbit two of its new Tundra units as of the end of 2017, with the goal being to place six in operation by 2020.[338] Moreover, Russian President Vladimir Putin has stated in May of 2017 the goal of having a minimum of 15 satellites operational by 2020 capable of monitoring ballistic missile launch.

In terms of larger space objectives, the US Director of National Intelligence Mr. Daniel Coats has stated, also in May 2017, "Russia aims to improve intelligence collection, missile warning, and military communications systems to better support situational awareness and tactical weapons targeting. Russian plans to expand its imagery constellation and double or possibly triple the number of satellites by 2025"[339]

5.5 China

China's military space capability attracts significant commentary and its intentions in space draw much speculation, as the country's space sector has long been intimately connected to the People's Liberation Army (PLA). Currently, two high-level directing documents with space implications for national defence activity are in place, including 'China's Military Strategy' – the country's first military strategy white paper, released in May 2015 by the Ministry of National Defence (MOD)[340] – as well as the fourth version of its White Paper on space activities, released in December 2016.[341] 'China's Military Strategy' of 2015 observes that "the first signs of weaponization of outer space have appeared" and states that "Outer space and cyber space have become new commanding heights in strategic competition among all parties." Further, as per the 2016 White Paper on space activities, China is "to meet the demands of economic, scientific and technological development, national security and social progress". The White Paper's Vision additionally aims to "To build China into a space power in all respects" as well as "to effectively and reliably guarantee national security".[342]

Furthermore, all Chinese government-issued statements are consistent with a public stance against the militarisation of space, as highlighted in the Military Strategy, which states "China has all along advocated the peaceful use of outer space, opposed the weaponization of and arms race in outer space, and taken an active part in international space cooperation."[343]

However, it is in the above context over recent years that an apparently large number of technology development and testing programmes have occurred, comprising systems of a clearly ASAT purpose (such as direct-ascent ASAT missiles) as well as technologies ostensibly conceived for debris removal, inspection, repair, and refuelling, but which possess clear potential counterspace applications. China's counterspace weapons development activity is outlined in the CSIS 'Space Threat Assessment 2018',[344] while the US Director of National Intelligence's 'Worldwide Threat Assessment of the US Intelligence Community', published

[336] "New Research Division Publication: "The Russian State Armament Programme, 2018 – 2027"." 3 May 2018. NATO Defense College, 11 July 2018 <http://www.ndc.nato.int/news/news.php?icode=1167#>.
[337] Luzin, Pavel. "Space Power: What is Russia's Military Strategy in Outer Space?" 25 Oct. 2017. intersectionproject.eu, 11 July 2018 <http://intersectionproject.eu/article/security/space-power-what-russias-military-strategy-outer-space>.
[338] *Op. cit.* – "New Research Division Publication: "The Russian State Armament Programme, 2018 – 2027"."
[339] Blank, Stephen. "Space and the Russian Military: New Trends." 14 June 2017. The Jamestown Foundation, 11 July 2018 <https://jamestown.org/program/space-russian-military-new-trends/>.
[340] Minnick, Wendell. "White Paper Outlines China's Ambitions." 27 May 2015. Defense News, 16 July 2018 <http://www.defensenews.com/story/defense/policy-budget/warfare/2015/05/26/china-us-pentagon-taiwan-report-south-east-sea-islands-reefs-s400-su35-missiles-satellite-space-deterrence/27957131/>;
See also "China's Military Strategy." 26 May 2015. Ministry of National Defense – The People's Republic of China, 16 July 2018 <http://eng.mod.gov.cn/Database/WhitePapers/index.htm>.
[341] "China's Space Activities in 2016 – the 4th version of white paper." 30 Jan. 2017. China National Space Administration (powerpoint hosted online by unoosa.org), 16 July 2018 <http://www.unoosa.org/documents/pdf/copuos/stsc/2017/tech-01E.pdf>.
[342] "Full text of white paper on China's space activities in 2016." 28 Dec. 2016. The State Council – english.gov.cn, 16 July 2018 <http://english.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm>.
[343] "IV. Building and Development of China's Armed Forces." (Excerpt from China's Military Strategy of May 2015) 26 May 2015. Chinese Ministry of Defense, 16 July 2018 <http://eng.mod.gov.cn/Database/WhitePapers/2015-05/26/content_4586713.htm>.
See also: "China's Military Strategy." 26 May 2015. Chinese Ministry of Defense, 16 July 2018 <http://eng.mod.gov.cn/Database/WhitePapers/2014.htm>.
[344] Harrison, Todd; Johnson, Kaitlyn; & Roberts, Thomas G. "Space Threat Assessment 2018." 12 Apr. 2018. Center for Strategic and International Studies (CSIS), 16 July 2018 <https://aerospace.csis.org/wp-content/uploads/2018/04/Harrison_SpaceThreatAssessment_FULL_WEB.pdf>.

February 2018, notes that "Chinese destructive ASAT weapons probably will reach initial operational capability in the next few years".[345]

Moreover, western analysts' commentaries identify the following major components in China's approach, including: its projection as committed to the peaceful use of space, its development of counterspace capabilities, and its aim – quoting the U.S.-China Economic and Security Review Commission in the 'Space Threat Assessment 2018' – "to deter U.S. strikes against China's space assets, deny space superiority to the United States, and attack U.S. satellites." The latter is likewise informed by a perceived vulnerability of US space systems.[346]

5.6 Japan

Japan's defence budget has increased gradually from 2012 to 2018; moreover, from 2016 to 2017 and from 2017 to 2018 it has seen 0.8% growth for each year. In 2018, the budget stood at ¥4.94 trillion (€37.2 billion as of mid-December 2017, the same month the figures were published[347]), up from the ¥4.90 trillion of 2017.[348] In 2017, Ministry of Defense general space-related activities had a total budget of ¥42.7 billion and space-related programmes within Ballistic Missile Defense had a budget of ¥40 billion. Within general space activities, budgetary items included Space Situational Awareness, satellite communications, "Use of commercial imagery satellites and meteorological satellite information", "Research for the enhancement of C4ISR* functions through the use of outer space", and lastly "Dispatch of personnel to the U.S. Air Force Space Operations Course".[349] Among these, the largest recipient was satellite communications, encompassing among other activities the partial procurement of a defence communications satellite (to follow Superbird C2).

As stated, the Ballistic Missile Defense budget for 2017 reached ¥40 billion, reflecting its priority within Japanese strategic military thinking. Furthermore, this priority is additionally seen in the Ministry of Defense Annual White Paper for 2017 which raises directly the threat of space debris and antisatellite systems.[350] The White Paper furthermore states that Japan aims to improve "information collection capability using satellites" as well as "improve the survivability of satellites though such initiatives as space situational awareness."[351] And as announced in January 2018, Japan has requested to purchase four Standard Missile-3 (SM-3) Block IIA missiles from the US government – a system used as defence against ballistic missiles.[352] According to the US Missile Defense Agency, the system is "developed jointly by a Japanese and U.S. government and industry team, is vitally important to both our nations and will ultimately improve our ability to defend against increasing ballistic missile threats around the world".[353]

5.7 India

Separate from the civil space activities of ISRO, India is developing a Ballistic Missile Defence (BMD) Programme through its Defence Research Development Organization (DRDO) to counter threats raised by Pakistan's Strategic Missile Group which is developing its own medium-range ballistic missiles. The BMD Programme is a two-tiered system to provide high and low altitude cover against incoming ballistic missiles. While the DRDO's Advanced Air Defence (AAD) system is optimised for surface-to-air strikes against aircraft and UAVs at endoatmospheric altitudes between 20-to-40 km, the Prithvi Air Defense (PAD) missile provides exoatmospheric defence at altitudes of

[345] Coats, Daniel R. "Worldwide Threat Assessment of the US Intelligence Community." 13 Feb. 2018. US Office of the Director of National Intelligence, 16 July 2018 <https://www.dni.gov/files/documents/Newsroom/Testimonies/2018-ATA---Unclassified-SSCI.pdf>.
[346] *Op. cit.* – "Space Threat Assessment 2018."
[347] "xe.com – Current and Historical Rate Tables." data for the Japanese Yen from 15 Dec. 2017. xe.com, 12 July 2018 <https://www.xe.com/currencytables/?from=JPY&date=2017-12-15>.
[348] "Defense Programs and Budget of Japan – Overview of FY2018 Budget." Dec. 2017. Japanese Ministry of Defense, 12 July 2018 <http://www.mod.go.jp/e/d_budget/pdf/300329.pdf>.
[349] "Defense Programs and Budget of Japan – Overview of FY2017 Budget Bill." Aug. 2016. Japanese Ministry of Defense, 12 July 2018 <http://www.mod.go.jp/e/d_budget/pdf/290328.pdf>.
[350] "Section 4 – Outer Space and Security." (Excerpt from Defense of Japan 2017 (Annual White Paper)) Japanese Ministry of Defense, 12 July 2018 (retrieved) <http://www.mod.go.jp/e/publ/w_paper/pdf/2017/DOJ2017_1-3-4_web.pdf>.
See also: "Defense of Japan 2017." (Annual White Paper) Japanese Ministry of Defense, 12 July 2018 (retrieved) <http://www.mod.go.jp/e/publ/w_paper/2017.html>.
[351] "Chapter 2 – Building a Dynamic Joint Defense Force." (Excerpt from Defense of Japan 2017 (Annual White Paper)) Japanese Ministry of Defense, 12 July 2018 (retrieved) <http://www.mod.go.jp/e/publ/w_paper/pdf/2017/DOJ2017_2-2-1_web.pdf>.
[352] "Japan – Standard Missile-3 (SM-3) Block IIA Missiles." 9 Jan. 2018. Defense Security Cooperation Agency, 12 July 2018 <http://www.dsca.mil/major-arms-sales/japan-standard-missile-3-sm-3-block-iia-missiles>.
[353] Swarts, Phillip. "U.S., Japan hope next-generation interceptor will be future of missile defense." 7 Feb. 2017. SpaceNews, 12 July 2018 <https://spacenews.com/u-s-japan-hope-next-generation-interceptor-will-be-future-of-missile-defense/>.

50-to-80 km.[354] On 28 December 2017, the DRDO ran its third live test of the AAD, and successfully intercepted "an incoming Prithvi ballistic missile within 30 kilometers of the earth atmosphere".[355] The second test had occurred 1 March 2017 and was also successful.[356]

It should be noted that the PAD missile can also be seen as a further step for India in 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 PAD. 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 the U.S. and China.[357] Moreover, India appears to have been pursuing antisatellite technology for several years already – The DRDO is quoted announcing already in 2012 that "we have developed all the building blocks for an anti-satellite (ASAT) capability".[358]

India's pursuit of this technology as well as its BMD Programme is largely influenced by the general global increase in militarisation of the space environment, as well as by the missile programmes of China and its neighbour Pakistan.[359] Further, Lt. Gen. PM Bali, Director General, Perspective Planning, of the Indian Army was quoted stating in February 2017 that (*as paraphrased in the source text*) the developing global and regional conditions require the country to possess space-based military assets as well as develop a dedicated military space programme.[360]

5.8 North Korea

Following its last launch in February 2016 of the Kwangmyongsong 4 earth observation satellite into sun-synchronous LEO on its Unha-3 rocket.[361, 362] North Korea has launched no new satellites in 2017 or the first half of 2018.[363] However, its missile and nuclear testing activities continued into 2017 with a series of missile tests including three Intercontinental Ballistic Missile (ICBM) tests and its 6th nuclear test[364]. The ICBM flight tests were the first for the state led by Kim Jung-un, with the first test announced by North Korea on 4 July 2017; North Korea state television highlighted that the country is now "a full-fledged nuclear power that possesses [a] powerful inter-continental ballistic rocket capable of hitting any part of the world."[365] The third test flight in November flew 960 km and reached an altitude of 4,500 km and is considered capable of reaching any point in the continental US[366]. Moreover, the latest launch in 2016 as well as North Korea's satellite deployment campaign in general are seen largely by many nations as well as the UN as a cover for missile systems testing.[367,368] Furthermore, deployment of the American-built Terminal High Altitude Area Defense (THAAD) system began in South Korea in early 2017, but sparked significant diplomatic tension with China[369].

[354] Gady, Franz-Stefan. "Did India Hide a Failed Supersonic Missile Test?" 26 May 2016. The Diplomat, 13 July 2018 <http://thediplomat.com/2016/05/did-india-hide-a-failed-supersonic-missile-test/>.
[355] Gady, Franz-Stefan. "India's Advanced Air Defense Interceptor Destroys Incoming Ballistic Missile in Test." 28 Dec. 2017. The Diplomat, 13 July 2018 <https://thediplomat.com/2017/12/indias-advanced-air-defense-interceptor-destroys-incoming-ballistic-missile-in-test/>.
[356] "India Tests Ballistic Missile Defense System." 6 Mar. 2017. Missile Threat – Center for Strategic and International Studies, 13 July 2018 <https://missilethreat.csis.org/india-tests-ballistic-missile-defense-system/>.
[357] "India Contemplates Anti-Satellite Vehicle Integration with Agni-III Ballistic Missile." 15 Oct. 2013. Missile Threat – Center for Strategic and International Studies, 13 July 2018 <http://missilethreat.com/india-contemplates-anti-satellite-vehicle-integration-with-agni-iii-ballistic-missile/>.
[358] Unnithan, Sandeep. "'India attains the capability to target, destroy space satellites in orbit'." 28 Apr. 2012. India Today, 13 July 2018 <https://www.indiatoday.in/magazine/nation/story/20120507-agni-v-launch-india-takes-on-china-drdo-vijay-saraswat-758208-2012-04-28>.
[359] *Op. cit.* – "India's Advanced Air Defense Interceptor Destroys Incoming Ballistic Missile in Test."
[360] "India to get all its energy from the moon by 2030? This ISRO prof thinks so." 19 Feb. 2017. Business Standard, 13 July 2018 <https://www.business-standard.com/article/current-affairs/india-to-get-all-its-energy-from-the-moon-by-2030-this-isro-prof-thinks-so-117021800715_1.html>.
[361] Wall, Mike. "North Korea Launches Satellite to Space." 8 Feb. 2016. Space.com, 13 July 2018 <https://www.space.com/31860-north-korea-satellite-launch.html>.
[362] Krebs, Gunter Dirk. "Kwangmyŏngsŏng 4 (KMS 4)." 29 Dec. 2017. Gunter's Space Page, 13 July 2018 <http://space.skyrocket.de/doc_sdat/kwangmyongsong-4.htm>.
[363] *Op. cit.* – "Space Threat Assessment 2018."
[364] "North Korea: A Timeline of Missile and Warhead Tests in 2017." Time.com, 26 Feb. 2018 (retrieved) <http://time.com/5040375/north-korea-nuclear-missile-tests-2017/>.
[365] Campbell, Charlie. "How North Korea's ICBM Test Could Bring Negotiators Back to the Table." 5 July 2017. Time.com, 26 Feb. 2018 <http://time.com/4844829/north-korea-missile-icbm-negotiation/>.
[366] *Op. cit.* – "North Korea: A Timeline of Missile and Warhead Tests in 2017."
[367] *Op. cit.* – "North Korea Launches Satellite to Space."
[368] Onyanga-Omara, Jane. "North Korea vows to launch more satellites into orbit." 30 Oct. 2017. USA Today, 13 July 2018 <https://eu.usatoday.com/story/news/world/2017/10/30/north-korea-vows-launch-more-satellites-into-orbit/812313001/>.
[369] Westcott, Ben & Suk, Lauren. "China, South Korea end year-long diplomatic feud over missile system." 31 Oct. 2017. CNN, 13 July 2018 <https://edition.cnn.com/2017/10/31/asia/china-south-korea-thaad/index.html>.

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

With the EU's three flagship space programmes (Copernicus, Galileo and EGNOS) being well advanced, Europe has shifted its focus from building space infrastructure toward ensuring strong market uptake of their space data and services by the public and private sectors. Building on this, the European Commission released its Space Strategy in late 2016, comprising four strategic goals, with the overarching aim of building a sustainable space economy. In addition to this, it aims to advance Europe's space situational awareness capability and Governmental Satellite Communications (GOVSATCOM) programme.370 It furthermore aims to boost investment in start-ups through its Investment Plan for Europe and via the Pan-European Venture Capital Fund-of-Funds, supporting European venture capital.

In overview of the Strategy, its first goal aims to "maximise the benefits of space for society and the EU economy" by encouraging the uptake of space services and data, and advancing the EU space programmes and meeting new user needs. Its second goal is to "foster a globally competitive and innovative European space sector" by supporting research and innovation and development of skills, and fostering entrepreneurship and new business opportunities. Its third goal is to "reinforce Europe's autonomy in accessing space in a safe and secure environment"; ensuring access to radio frequency spectrum; ensuring the protection and resilience of critical European space infrastructure; and reinforcing synergies between civil and security space activities. And, fourthly, the Commission aims to "strengthen Europe's role as a global actor and promoting international cooperation" by pursuing space dialogues with strategic international partners, by taking space policy into account in EU export control dialogues with third countries, and it will use economic diplomacy and trade policy instruments to assist European companies active in global markets and to address societal challenges.[371]

A major component of the Strategy is the Investment Plan for Europe, which has a stated aim of investing 315 billion euros as a programme total, of which 256 billion had been approved by the end of 2017.[372] This financing is split up across numerous sectors, including Agriculture; Digital; Energy; Environment and Resource Efficiency; Research, Development and Innovation; Social; and Transport. Furthermore, through the Pan-European Venture Capital Fund-of-Funds, which forms part of the aforementioned Investment Plan, will provide up to €300 million in cornerstone investments to one or multiple venture capital Fund of Funds, with a total budget of €400 million. With EU investments limited to 25%, selected promotors are then to raise the remaining funds, leading to a total at around €1.6 billion. The Fund of Funds programme aims to enlarge European venture capital funds, increase the amount of private investment relative to public funding, and thirdly expand the operational scope across multiple European states.[373]

370 "Space." Regularly updated. European Commission, Growth, Sectors, Space, 18 July 2018 (retrieved) <http://ec.europa.eu/growth/sectors/space_en>.
371 "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Space Strategy for Europe." 26 Oct. 2016. European Commission, 3 Apr. 2018 <https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/COM-2016-705-F1-EN-MAIN.PDF>.
372 "Investment Plan results – Breakdown of results by country and sector from the European Fund for Strategic Investments (EFSI)." 12 Dec. 2017. European Commission webpage archived via the Internet Archive Wayback Machine, 3 Apr. 2018 <https://web.archive.org/web/20180124070047/https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/investment-plan-europe-juncker-plan/investment-plan-results_en#infographic>.
373 "Commission and EIF start selecting Pan-European Venture Capital Fund-of-Funds promoters." 7 Feb. 2017. European Commission, 4 Apr. 2018 <http://ec.europa.eu/research/index.cfm?pg=newsalert&year=2017&na=na-070217>.

Furthermore, in December of 2017, the Competitiveness Council of the Council of the European Union convened and, among other topics, focused on the implementation of the Space Strategy for Europe, introduced approximately one year prior. Ministers present pressed for closer ties between the space sector and the digital economy. Lastly, the Council of the European Union also adopted late in the year the conclusions of the mid-term reviews of Galileo, EGNOS, and Copernicus.[374, 375] Conclusions from the reporting place a clear emphasis on the facilitation and creation of downstream applications, built around these programmes' services, including through their integration.[376,377]

6.2 European Space Agency

ESA's budget increased by 9.52% to €5.75 billion in 2017 from €5.25 billion in the previous year. Direct funding from ESA Member States increased by about 1% to €3.78 billion, while funding from the EU and EUMETSAT grew by just over 30% to €1.97 billion for the year.[378] *Navigation* saw the largest boost across all budgetary items, growing nearly 66% to 1010.8 million euros, reflecting an increase of 401.3 million euros. This boost occurs in line with the implementation in 2016 of the new Navigation Innovation and Support Programme – of the Directorate of the Galileo Programme and Navigation-related Activities – which is an optional programme and reflects ESA's large and ongoing focus on navigation capabilities through the EGNOS and GALILEO programmes.[379] Funding for both *Earth Observation* and *Telecommunications & Integrated Applications* decreased in 2017, the former by almost 4% (dropping to €1,543 million), and the latter by approximately 11% (reaching €319 million). Space Science saw a 1% growth, reaching 513.1 million euros in 2017 from 507.9 the year before. And Space Situational Awareness grew by 17% (a value of 2.2 million) to 15.1 million euros in 2017. The remaining 8.1% of funding was allocated to ESA's *Basic Activities*, activities *Associated with the General Budget*, and the *European Cooperating States Agreements*. In 2017, two budgetary label changes occurred: specifically, *Human Spaceflight* and *Robotic Exploration & PRODEX* were reorganised as *Human Spaceflight & Robotic Exploration* (HRE) and *PRODEX*. In other words, Human Spaceflight was coupled with Robotic Exploration in the budgetary breakdown for 2017 while PRODEX was separated. HRE in 2017 received 633 million euros and PRODEX received 47.2 million.[380]

During the reporting period, several formal steps were taken to promote cooperation between ESA and other partners, including Croatia, Japan, Luxembourg, and the satellite industry, indicating significant collaboration around ongoing and new projects into the future. In early 2018, ESA signed a Cooperation Agreement with the Republic of Croatia, a process which had begun already in 2014. This Agreement will lead to the two creating a framework for further and more intensive activity in ESA programmes.[381] The signing of this Agreement also marks the establishment of formal cooperation between ESA and all EU Member States that are not already ESA Member States. The Japan Aerospace Exploration Agency JAXA and ESA also prepared a joint statement regarding their collaboration to date and their future cooperation. As stipulated in the joint statement, lunar exploration as well as cooperation around data concerning terrestrial greenhouse gases will be the objects of continued collaboration.[382] In 2017, at the

[374] "Competitiveness Council, 30/11-01/12/2017." 1 Dec. 2017. European Council | Council of the European Union, 4 Apr. 2018 <http://www.consilium.europa.eu/en/meetings/compet/2017/11/30-01/>.
[375] "Transport, Telecommunications and Energy Council, 04-05/12/2017." 5 Dec. 2017. European Council | Council of the European Union, 4 Apr. 2018 <http://www.consilium.europa.eu/en/meetings/tte/2017/12/04-05/>.
[376] "Council conclusions on 'The Mid-term Evaluation of the Galileo and EGNOS programmes and of the performance of the European GNSS Agency' − Council conclusions (adopted on 5 December 2017)." 5 Dec. 2017. Council of the European Union, 4 Apr. 2018 <http://data.consilium.europa.eu/doc/document/ST-15435-2017-INIT/en/pdf>.
[377] "Copernicus space programme: conclusions on mid-term review." 1 Dec. 2017. European Council | Council of the European Union, 4 Apr. 2018 <http://www.consilium.europa.eu/en/press/press-releases/2017/12/01/the-mid-term-evaluation-of-the-copernicus-programme-council-adopts-conclusions/>.
[378] "ESA Budget 2017." 16 Jan. 2017. ESA, 10 Apr. 2018 <http://m.esa.int/spaceinimages/Images/2017/01/ESA_budget_2017>.
See also: "ESA Budget for 2016." 20 Jan. 2016. ESA, 10 Apr. 2018 <http://www.esa.int/spaceinimages/Images/2016/01/ESA_budget_2016>.
[379] "Green Light for ESA's Advanced SATNAV Technology and Innovation Programme." 5 Dec. 2016. ESA – Navigation, 10 Apr. 2018 <https://www.esa.int/Our_Activities/Navigation/Green_light_for_ESA_s_advanced_satnav_technology_and_innovation_programme>.
[380] "ESA budget 2017: by domain." 16 Jan. 2017. ESA, 10 Apr. 2018 <http://www.esa.int/spaceinimages/Images/2017/01/ESA_budget_2017_by_domain>.
See also: "ESA budget 2016 by domain." 14 Jan. 2016. ESA, 10 Apr. 2018 <http://m.esa.int/spaceinimages/Images/2016/01/ESA_budget_2016_by_domain>.
[381] "Croatia Signs Cooperation Agreement." 19 Feb. 2018. ESA, 25 Apr. 2018 <https://www.esa.int/About_Us/Welcome_to_ESA/Croatia_signs_Cooperation_Agreement>.
[382] "ESA and JAXA Confirm Further Cooperation in Space." 8 Mar. 2018. ESA, 25 Apr. 2018 <https://www.esa.int/Our_Activities/Human_Spaceflight/ESA_and_JAXA_confirm_further_cooperation_in_space>.

Paris Air Show, ESA and Luxembourg signed a joint statement concerning the study of technical, scientific, and other aspects of the exploration and use of space resources. With this step, Luxembourg has further demonstrated its proactive approach towards the utilisation of space resources, and ESA will gain experience and expertise across its related technical and regulatory aspects.[383] Also taking place at the 2017 Paris Air Show, 16 leaders of the European satellite industry and the European Space Agency signed a joint statement regarding cooperation on Satellite for 5G, in which the signatories express their intention to support satellite and 5G convergence efforts, and thus further support efforts already in place by the European Commission, such as through Horizon 2020 and the 5G Infrastructure Public Private Partnership. As part of ESA's *Satellite for 5G initiative* over 2018 to 2020, the agency will work with industry towards 5G service trials, in line with the EC Action Plan, and incorporating terrestrial telecommunication infrastructure, with a focus on public safety, transport, entertainment, and media. Other activities will include interoperability demonstration, standardisation, and applications development.[384] Days after the announcement of this joint statement, ESA and ESPI co-hosted a conference on 'Space and SATCOM for 5G: European Transport and Connected Mobility'.[385]

With the last ESA Council at Ministerial Level having taken place in Switzerland in 2016, the next is scheduled for late 2019 in Spain. Discussion will likely include the progress thus far of Director General Jan Wörner's strategy proposal "Space 4.0 for a United Space in Europe" as well as its further implementation.[386]

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.

EUMETSAT's 87th Council meeting took place in Darmstadt, Germany, on 27 June 2017. At the meeting, the Council reached three major decisions.[387] Firstly, it formally approved to extend operations of the Jason-2 programme, an ocean surface topography mission supporting oceanography, originally launched in 2008. The extended period will cover 1 January 2018 to the end of 2019. This programme marks a transition from research activities to operations, and involves collaboration between Europe's EUMETSAT and CNES as well as the US' NASA and NOAA.[388] The extension supports the Jason-3 high precision ocean altimetry mission, launched in 2016. Secondly, contracts were awarded to Arianespace and Telespazio around both launch services as well as Launch and Early Operations services for the first two Metop-SG satellites (including a spare unit), forecasted for launch in late 2021 and 2022. These units will be employed in the Second Generation of the EUMETSAT Polar System, a EUMETSAT mandatory programme which will contribute to the Joint Polar System, planned with the US' NOAA.[389] Thirdly, a contract was approved which extends at higher bandwidth the EUMETCast Africa data service and includes arrangements for deploying a distributed Copernicus Data and Information Access Service platform.

The Council's 88th meeting followed in early December 2017, when it (1) decided on a seven year extension of Meteosat Second Generation and EUMETSAT Polar System exploitation as well as (2) approved ground segment contracts for the (mandatory) Meteosat Third Generation programme and (optional) Jason-CS (Continuity of Service) systems.[390] The Sentinel-6 mission will be carried out with the Jason-CS systems, and the mission overall is

[383] "Luxembourg and ESA Announce Enhanced Cooperation on Space Resources." 21 June 2017. Spaceresources.lu, 25 Apr. 2018 <https://spaceresources.public.lu/en/actualites/2017/Luxembourg-ESA-Cooperation-signed.html>.
[384] "Signing Up For Satellite-5g Convergence." 24 July 2017. ESA – ARTES, 25 Apr. 2018 <https://artes.esa.int/news/signing-satellite-5g-convergence>.
[385] "ESA/ESPI Conference on 'Space and SATCOM for 5G: European Transport and Connected Mobility'." ESA, 25 Apr. 2018 (retrieved) <https://artes.esa.int/esaespi-conference-%E2%80%98space-and-satcom-5g-european-transport-and-connected-mobility>.
[386] "European Ministers Ready ESA for a United Space in Europe in the Era of Space 4.0." 2 Dec. 2016. ESA, 25 Apr. 2018 <https://www.esa.int/About_Us/Ministerial_Council_2016/European_ministers_ready_ESA_for_a_United_Space_in_Europe_in_the_era_of_Space_4.0>.
[387] "EUMETSAT Extends Jason-2 Operations and Approves Contracts for the Deployment of EPS-Second Generation and the Improvement of Data Access Services." 28 June 2017. EUMETSAT, 4 May 2018 <https://www.eumetsat.int/website/home/News/DAT_3536769.html?lang=EN&pState=1>.
[388] "JASON-2." EUMETSAT, 4 May 2018 (retrieved) <https://www.eumetsat.int/website/home/Satellites/CurrentSatellites/Jason2/index.html>.
[389] "EUMETSAT Polar System - Second Generation." EUMETSAT, 4 May 2018 (retrieved) <https://www.eumetsat.int/website/home/Satellites/FutureSatellites/EUMETSATPolarSystemSecondGeneration/index.html>.
[390] "EUMETSAT takes steps to extend Meteosat and EPS Operations and approves Ground Segment Contracts for Next Generation Systems." 6 Dec. 2017. EUMETSAT, 4 May 2018 <https://www.eumetsat.int/website/home/News/DAT_3745326.html?lang=EN&pState=1>.

referred to as Jason-CS/Sentinel-6.[391] As such, it contributes to the Copernicus programme and will employ two Jason-CS satellites maintaining a continuity of ocean surface topography observations with and following Jason-3.[392] In Europe, ESA is also participating in the mission as well as NASA and NOAA in the US.[393] The first of the two units is forecasted for launch in 2020. The Meteosat Third Generation's first satellite is forecasted for launch in 2021 and the mission is a cooperative one with ESA. The first unit is forecasted for launch in 2023.

6.4 National Governments

6.4.1 France

During the 2017-2018 reporting period, France, through the French space agency (CNES), took a number of diverse cooperative steps with foreign authorities, including in Australia, China, Ethiopia, Germany, India, Malta, Mexico, Saudi Arabia, the UAE, the UK, and the US. With China, in particular, CNES President Jean-Yves Le Gall and his counterpart Wu Yanhua of the China National Space Administration (CNSA) signed in January 2018 a memorandum of understanding on climate actions and space exploration. The MoU will place a priority on the dissemination of data from the CFOSat (Chinese-French Oceonography Satellite) mission, which is due to launch in mid-2018 and represents a main element in joint Chinese/French activities concerning climate change. The signing took place in the presence of Chinese President Xi Jinping and French President Emmanuel Macron.[394] Likewise, in March 2018, Jean-Yves Le Gall and ISRO Chairman K. Sivan signed an agreement in the presence of President Macron and Indian Prime Minister Narendra Modi for the joint development and operation of a microsatellite constellation for remote-sensing and telecommunications. President Macron and Prime Minister Modi additionally adopted a general policy statement affirming the strategic value of the French and Indian cooperation in space activities.[395] In April 2018, during President Macron's US state visit, CNES and the US' National Aeronautics and Space Administration (NASA) signed a joint statement around the two agencies' continuing partnership in ocean and atmospheric observation as well as space exploration.[396]

On 7 December 2017, the CNES Board of Directors came to two key decisions at its 353rd session. Firstly, the French contribution to the JUICE mission – a large (L-class) mission within the ESA Cosmic Vision 2015-2025 programme – was approved to move forward. The mission will send a satellite to the Jovian system (the planet Jupiter and its magnetosphere and moons) to make observations on the system's habitability and mechanisms. The Board of Directors additionally approved a resolution on the renewal of draft industrial contracts for the Guiana Space Centre; the contracts concern, notably, launch operations support services from 2018 to 2024.[397]

6.4.2 Germany

On 24 July 2017, the German space agency (DLR) introduced, along with Germany's Federal Ministry for Economic Affairs and Energy, the DLR's new Strategy 2030. Implementation of the strategy began in 2018, and it has for an overarching goal to benefit both the society and economy, with focus areas on space and aeronautics, digitalisation, energy, transport, and security.[398] The strategy introduces 10 cross-sectoral projects on cyber security, broadband rollout, and future fuels, among others, and it will see the DLR establish seven new research institutes.[399] These were ap-

[391] Kramer, Herbert J. "Sentinel-6/Jason-CS." eoPortal Directory, 11 Sep. 2018 (retrieved) <https://directory.eoportal.org/web/eoportal/satellite-missions/content/-/article/jason-cs>.
[392] "Copernicus Satellites." EUMETSAT, 4 May 2018 (retrieved) <https://www.eumetsat.int/website/home/Satellites/FutureSatellites/CopernicusSatellites/index.html>.
[393] "JASON-CS Programme enters into force – Two Months ahead of COP 21." 11 Sep. 2015. EUMETSAT, 4 May 2018 <https://www.eumetsat.int/website/home/News/DAT_2779482.html?lang=EN&pState=1>.
[394] "State Visit of President Emmanuel Macron to the People's Republic of China: France and China Step Up Space Cooperation in the Fields of Climate And Exploration." 10 Jan. 2018. CNES, 9 May 2018 <https://presse.cnes.fr/en/state-visit-president-emmanuel-macron-peoples-republic-china-france-and-china-step-space-cooperation>.
[395] "French President Emmanuel Macron and Indian Prime Minister Narendra Modi Adopt General Policy Statement Extending Scope of Space Cooperation between France and India." 10 Mar. 2018. CNES, 9 May 2018 <https://presse.cnes.fr/en/french-president-emmanuel-macron-and-indian-prime-minister-narendra-modi-adopt-general-policy>.
[396] "State Visit of President Macron to United States CNES and Nasa Step Up their Cooperation." 25 Apr. 2018. CNES, 9 May 2018 <https://presse.cnes.fr/en/state-visit-president-macron-united-states-cnes-and-nasa-step-their-cooperation>.
[397] "353rd Session of CNES Board of Directors." 7 Dec. 2017. CNES, 25 Apr. 2018 <https://presse.cnes.fr/en/353rd-session-cnes-board-directors>.
[398] "DLR in 2018." 1 Feb. 2018. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-25907/year-2018/151_page-2/#/gallery/14331>.
[399] "DLR and the German Federal Ministry for Economic Affairs and Energy present their new strategy." 24 July

proved at the DRL Senate's June 2017 meeting, and the German federal government will provide €42 million annually in funding.[400]

Further, in 2017 and in the first months of 2018 the DLR formed and reinforced several collaborative relationships with partners in Australia, Canada, France, Israel, Japan, and South Africa, and additionally signed a Memorandum of Understanding with the UN Human Settlements Programme. With Japan, in particular, several milestones occurred in 2017. In March, Chair of the DLR Executive Board Pascale Ehrenfreund, Programme Director of DLR Energy Research Bernhard Milow, and president of the Japanese National Institute of Advanced Industrial Science and Technology (AIST) Ryoji Chubachi signed a memorandum of understanding concerning scientific collaboration around energy research.[401] In April 2017, two agreements were signed with JAXA and one with Japan's Electronic Navigation Research Institute, all concerning aeronautics research generally, and specifically dealing with air traffic management, electric aviation, and research on reduction of the sonic boom.[402] In September 2017, the DLR, JAXA, and AIST signed two cooperation agreements again around energy research, focusing in particular on high-performance batteries for space missions. And in December 2017, the DLR, Japan's National Institute for Environmental Studies (NIES), and JAXA signed a collaboration agreement on validating satellite systems used for greenhouse gases measurements.[403]

6.4.3 Italy

In 2017, Italy, through the Italian space agency (ASI), established and/or reinforced several collaborative relationships with institutional partners from Argentina, China, Kenya, and the US. In late 2016, Italy and Kenya renewed their agreement around ASI's Luigi Broglio Space Center, based in Malindi, Kenya, and in January 2017 ASI President Roberto Battiston, Italian Ambassador Mauro Massone, and Kenya's Defence Secretary Kirimi Kaberia prepared in the context of the first Italy-Kenya Joint Steering Committee the operational and technical aspects of this renewed agreement.[404] The agreement covers, in particular, the development of a regional Earth observation centre, accessibility of earth observation data, telemedicine as well as educational and training activities, and support generally to the Kenyan National Space Agency.[405] In Beijing in February 2017 during Italian President Sergio Mattarella's state visit to China, an accord was signed by ASI President Battiston and Wang Zhaoyao, Director-General of the China Manned Space Agency (CMSA). The activities covered by the agreement will concern scientific experimentation on long-duration astronaut missions in the context of the Chinese space station programme. It additionally will lead to the creation of a Joint Cooperation Committee by ASI and CMSA which will meet yearly and address various aspects of the collaboration.[406] In May 2017, ASI and the Argentinian Comisión Nacional de Actividades Espaciales (CONAE) signed an agreement around commercial exploitation of satellite data from the SIASGE radar technology programme, which includes the Argentinian SAOCOM and Italian COSMO-SkyMed satellite constellations. SIASGE is the Spanish acronym for the Italian-Argentine System of Satellites for the Management of Environmental Emergencies and Economic Development and is an earth observation / natural disaster prevention system.[407] And in June 2017, ASI furthered its collaboration with NASA, firstly, through the signing of an implementing arrangement providing ASI associate membership in the Solar System Exploration Research Virtual Institute managed by NASA Ames.[408] Additionally, NASA's then acting administrator Robert Lightfoot and ASI President Roberto Battiston signed an agreement around ASI's coopera-

2017. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-23429/year-2017/151_page-3/#/gallery/27704>.

[400] "DLR Senate gives the go-ahead for the foundation of seven DLR institutes." 29 June 2017. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-23037/year-2017/151_page-4/#/gallery/27334>.

[401] "DLR and Japanese research organisation AIST agree on cooperation on energy research." 23 Mar. 2017. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-21784/year-2017/151_page-6/#/gallery/26642>.

[402] "DLR expands cooperation with Japanese partners in aeronautics research." 5 Apr. 2017. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-21980/year-2017/151_page-6/#/gallery/26764>.

[403] "DLR and Japan sign collaboration agreement on climate research." 12 Dec. 2017. DLR, 16 May 2018 <http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-25401/year-2017/151_page-1/#/gallery/29335>.

[404] Zanini, Andrea. "First meeting of the Italy-Kenya Joint Steering Committee." 23 Jan. 2017. ASI, 16 May 2018 <https://www.asi.it/en/news/first-meeting-italy-kenya-joint-steering-committee>.

[405] "ASI in Kenya for the first Joint Steering Committee." 27 Jan. 2017. Research Italy, 16 May 2018 <https://www.researchitaly.it/en/news/asi-in-kenya-for-the-first-joint-steering-committee/>.

[406] "Agreement Italy-China." 22 Feb. 2017. ASI, 16 May 2018 <https://www.asi.it/en/news/agreement-italy-china>.

[407] "Italy-Argentina: el espacio clásico." 10 May 2017. ASI, 16 May 2018 <https://www.asi.it/en/news/italia-argentina-el-espacio-clasico>.

[408] "A new covenant for planetary exploration." 15 June 2017. ASI, 16 May 2018 <https://www.asi.it/en/news/a-new-covenant-planetary-exploration>.

tion in the IXPE mission which will take measurements on the polarisation of cosmic x-rays.[409]

6.4.4 United Kingdom

The UK aims to further develop its space sector through both the government's new Industrial Strategy published in November 2017 as well as a series of initiatives directed specifically at space activity.[410] The latter focus in particular around commercial launch in the UK, and include the passage in March 2018 of the Space Industry Act. This legislation provides for the operation of spaceports within the UK and launching of spacecraft from its territory, and it will be complemented by later legislation.[411,412] Additionally, a campaign led by the UK Space Agency and grouped under the LaunchUK title aims to promote the national commercial launch industry. At the campaign's March 2017 launch, issues relevant to space launch in the UK were discussed and nine prospective spaceport sites were presented, from sites across England, Wales, and Scotland.[413] Further, a programme worth £50 million was also announced, at the same time as the UK's Industrial Strategy, which will support satellite launch activities from British spaceports.[414] This was also preceded in February 2017 by a £10 million grant programme to support the national commercial launch sector. The British government has furthermore published a series of guidance resources on regulatory aspects of operating spaceports in the UK, launching from the UK, and on spaceplane and sub-orbital flight activities.[415]

Beyond the activities described above, the UK Space Agency and the French space agency CNES signed a joint statement in January 2018 to enhance space activities cooperation, in particular around projects on climate action and Mars exploration, as well as space applications and the European space programme.[416] The Agency's Corporate Plan for 2017-2018 was also released in August 2017, and it details the Agency's four priorities for the period, including: the publication of a Space Strategy; enabling UK commercial space access; oversight of key national and international programmes; and fourthly reform of the British space regulatory regime.[417]

6.5 United States

On June 30, 2017, US President Trump's signed an executive order which re-established the National Space Council. The Council had been previously disbanded in 1993, and in its new form was given an ambitious mandate of maintaining American space leadership.[418] It held its first meeting on October 5, 2017, a second on February 21, 2018, and a third on 18 June, 2018. At the first, US Vice President Mike Pence directed NASA to create plans for human lunar missions which would lead on to future Mars missions. The Vice President additionally referred the US Office of Management and Budget Director and the Secretaries of Commerce and Transportation to make a review of the US commercial space regulatory framework, with an eye to making operations more efficient.[419] At the National Space Council's second meeting, four recommendations were put forward to reform commercial space regulations, concerning launch licensing, consolidation of the Office of Space Commerce and the Commercial Remote Sensing Regulatory Affairs Office, protection of the radiofrequency spectrum in commercial space activity, and reform of export control.[420] At the third

[409] "IXPE mission, NASA teams with ASI." 20 June 2017. ASI, 16 May 2018 <https://www.asi.it/en/news/ixpe-mission-nasa-teams-asi>.
[410] "Industrial Strategy: building a Britain fit for the future." (Download page) 27 Nov. 2017. Government of the United Kingdom, 16 May 2018 <https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future>.
[411] Pultarova, Tereza. "U.K. Space Industry Act to future-proof against Brexit." 10 Apr. 2018. SpaceNews, 16 May 2018 <http://spacenews.com/u-k-space-industry-act-to-future-proof-against-brexit/>.
[412] Hirst, Paul & Payne, Lauren. "The sky's no longer the limit for the UK." 20 Mar. 2018. Addleshaw Goddard LLP, 16 May 2018 <https://www.lexology.com/library/detail.aspx?g=66d366b2-b49b-4d7d-88c9-6c4330df8982>.
[413] "LaunchUK: campaign launch." 7 Mar. 2017. Government of the United Kingdom, 16 May 2018 <https://www.gov.uk/government/publications/launch-uk-event>.
[414] "UK space launch programme receives £50 million boost in Government's Industrial Strategy." 27 Nov. 2017. Government of the United Kingdom, 16 May 2018 <https://www.gov.uk/government/news/uk-space-launch-programme-receives-50-million-boost-in-governments-industrial-strategy>.
[415] "Commercial spaceflight." 8 Feb. 2017. Government of the United Kingdom, 16 May 2018 <https://www.gov.uk/government/collections/commercial-spaceflight>.
[416] "UK-France space co-operation at Sandhurst Summit." 18 Jan. 2018. Government of the United Kingdom, 16 May 2018 <https://www.gov.uk/government/news/uk-france-space-co-operation-at-sandhurst-summit>.
[417] "UK Space Agency Corporate Plan 2017-18." 24 Aug. 2017. Government of the United Kingdom, 16 May 2018 <https://www.gov.uk/government/publications/uk-space-agency-corporate-plan-2017-18>.
[418] "President Trump reestablishes National Space Council." 30 June 2017. SpaceNews, 18 May 2018 <http://spacenews.com/breaking-president-trump-reestablishes-national-space-council/>.
[419] Foust, Jeff. "National Space Council calls for human return to the moon." 5 Oct. 2017. SpaceNews, 18 May 2018 <http://spacenews.com/national-space-council-calls-for-human-return-to-the-moon/>.
[420] Foust, Jeff. "National Space Council backs incremental space regulatory reform." 21 Feb. 2018. SpaceNews, 18

meeting, President Trump signed a space policy directive on space traffic management (known also as Space Policy Directive 3), largely based on a draft policy revealed by Vice President Pence two months prior. The Directive focuses on a range of space traffic management topics and relocates core responsibilities from the Department of Defense to the Commerce Department. Media quote Vice President Pence referring to the original draft as the US' "the first comprehensive space traffic management policy".[421] Moreover, on 11 Dec. 2017, President Trump signed Space Policy Directive 1, which builds on the first National Space Council meeting in instructing NASA to again conduct human missions to the moon.[422]

6.5.1 National Aeronautics and Space Administration (NASA)

US President Trump's signed the NASA Transition Authorization Act of 2017 on March 21 2017, which authorised a $19.5 billion budget for NASA in fiscal year 2017 and provided support to the Orion spacecraft (a human spaceflight capsule) and the heavy-lift Space Launch System which will launch it, both under development.[423]

Further, the White House released an initial budget blueprint for the fiscal year 2018 on 16 March 2017, with a complete budget request released later on 23 May.[424] Under this final budget request, NASA was to receive $19.1 billion in 2018, representing a drop from the $19.653 billion the agency received for fiscal year 2017.[425] Notably, the White House budget request proposed to cancel the Asteroid Redirect Mission, strengthen NASA's cybersecurity capabilities, allocate $3.7 billion for the Orion capsule and Space Launch System heavy lift rocket, and reduce earth science activity support by $102 million, thereby cancelling four missions.[426] The final outcome, as seen in the omnibus spending bill passed by Congress and signed by President Trump on 23 March 2018, resulted in broad budgetary increases for science and research activities generally, including for NASA and other science agencies.[427] For NASA's part, it received $20.74 billion for the 2018 fiscal year, which represents a 6% increase over its fiscal year 2017 budget. Human Exploration received an 11% increase to $4.79 billion in 2018; Space technology also received an 11% increase, reaching $0.76 billion, the Science Mission Directorate received an 8% increase, leading to $6.22 billion in funding, and Aeronautics received a 4% increase to $0.69 billion, and Space operations dropped 4% to $4.75 billion. And whereas the White House budget request would have eliminated the NASA Office of Education, it received unchanged funding into 2018 at $0.10 billion. Within the Science Mission Directorate, the Planetary Science Division's budget in particular increased to $2.23 billion, a 21% gain.[428] Further, the Orion capsule and heavy lift Space Launch System programmes received the same funding as in the 2017 fiscal year.[429]

6.5.2 National Oceanic and Atmospheric Administration (NOAA)

US President Donald Trump signed on April 18, 2017 the Weather Research and Forecasting Innovation Act, which provides new direction from the US Congress for NOAA with regards to weather research and forecasting as well as observation programmes, and it is seen as the first comprehensive policy on weather since previous legislation from 1992. The third of its five titles deals entirely with 'Weather Satellite and Data Innovation' and tasks NOAA to, among other steps, "complete the COSMIC-2 microsatellite system, including deployment of constellations in both the equatorial and polar orbits, and to integrate the resulting data into

May 2018 <http://spacenews.com/national-space-council-backs-incremental-space-regulatory-reform/>.
[421] Foust, Jeff. "President to sign space traffic management policy." 28 June 2018. SpaceNews, 18 May 2018 <http://spacenews.com/president-to-sign-space-traffic-management-policy/>.
[422] Foust, Jeff. "Trump formally establishes lunar landing goal, but without details." 11 Dec. 2017. SpaceNews, 18 May 2018 <https://spacenews.com/trump-formally-establishes-lunar-landing-goal-but-without-details/>.
[423] Cofield, Calla. "President Trump Signs NASA Authorization Bill." 21 Mar. 2017. Space.com, 18 May 2018 <https://www.space.com/36154-president-trump-signs-nasa-authorization-bill.html>.
[424] Smith, Marcia. "NASA's FY2018 Budget Request." 26 Mar. 2018. SpacePolicyOnline.com, 18 May 2018 <https://spacepolicyonline.com/wp-content/uploads/2017/03/NASA-FY2018-budget-request-Mar-24-2018.pdf>.
[425] Smith, Marcia. "NASA Budget to soar over $20 Billion in Final FY2018 Appropriations." 21 Mar. 2018. SpacePolicyOnline.com, 18 May 2018 <https://spacepolicyonline.com/news/nasa-budget-to-soar-over-20-billion-in-final-fy2018-appropriations/>.
[426] *Op. Cit.* – "NASA's FY2018 Budget Request."
[427] Koren, Marina. "Congress Ignores Trump's Priorities for Science Funding." 23 Mar. 2018. The Atlantic, 18 May 2018 <https://www.theatlantic.com/science/archive/2018/03/trump-science-budget/556229/>.
[428] Thomas, Will. "Final FY18 Appropriations: NASA." 30 Mar. 2018. American Institute of Physics, 18 May 2018 <https://www.aip.org/fyi/2018/final-fy18-appropriations-nasa>.
[429] "American Institute of Physics – Federal Science Budget Tracker." Data for NASA from FY2018. American Institute of Physics, 18 May 2018 <https://www.aip.org/fyi/federal-science-budget-tracker/FY2018#tabs-section-nasa>.

'all national operational and research weather forecast models'".[430]

The White House under US President Donald Trump released an initial budget blueprint for the fiscal year 2018 on 16 March 2017, with a complete budget request released later on 23 May. The final budget request sought $4.775 billion in overall funding for NOAA, representing an approximately 16% drop from the $5.675 billion it received in its fiscal year 2017 final budget. According to the budget request, several of NOAA's programmes would lose varying percentages of funding, including a 17.6% drop down to $1.816 billion for the National Environmental Satellite, Data and Information Service (NESDIS).[431] The final outcome, however, as seen in the omnibus spending bill passed by Congress and signed by President Trump on 23 March 2018 resulted in a 4% overall increase to the NOAA budget, reaching $5.9 billion for fiscal year 2018. Much of the new funding is to support the implementation of the aforementioned Weather Research and Forecasting Innovation Act. In particular, Office of Oceanic and Atmospheric Research funding will rise to $549 million, the National Ocean Service funding will rise 8% to $565 million, the National Marine Fisheries Service will increase its funding to $948 million, the National Weather Service funding will increase 3% to $1.2 billion, and the NESDIS Service will see a drop of 5% to $2.1 billion. And although this represents a much less severe cut to the NESDIS Service than as included in the original White House budget it is still a significant decrease for a major satellite programme. Standing alone, however, is the Office of Marine Aviation Operations which saw a 54% growth in funding. It will receive $458 million, a large portion of which will go to the purchase of a 'Gulfstream IV Hurricane Hunter' airplane.[432]

6.6 Canada

On 18 April 2017, Canada's Innovation, Science and Economic Development (ISED) Minister Navdeep Bains announced the renewal of the Government of Canada's Space Advisory Board. The process of renewing the Board had been announced previously in October of 2016, and its members were chosen via a merit-based application procedure. The Space Advisory Board is composed of a Chair person and ten members with space sector expertise and is mandated to engage with the Canadian public towards the development of a "new vision for Canada's space sector", to advise the government on space objectives, and to identify the core aspects of a new space strategy.[433]

As part of its mandate, the Board conducted a series of roundtable discussions throughout early 2017 with Canadian space sector stakeholders.[434] The major findings from these discussions were published in a final report released in August 2017 and are ultimately intended to assist in defining the new space strategy. The Board's findings can be outlined in two main recommendations: (1) that space be designated "as a national strategic asset to ensure that" a platform of priorities can be achieved, with a focus on Canada's ability to enjoy the benefits of space activities. And (2) to further mandate the Space Advisory Board in supporting the implementation of the eventual Space Strategy and the evaluation thereof. A third central commentary strongly expressed "the need for a reinvigorated and fully funded set of space activities and supporting policies".[435] However, although it was previously announced that the strategy would be published in June of 2017, the final publication date has been extended to allow for revision after comments were received following the circulation of a draft version.[436,437]

[430] Henry, Mike. "First Comprehensive Weather Policy Update Since 1992 Now Law." 21 Apr. 2017. American Institute of Physics, 18 May 2018 <https://www.aip.org/fyi/2017/first-comprehensive-weather-policy-update-1992-now-law>.
[431] "NOAA Cut 16% in President Trump's Budget Request." 31 May 2017. The Bridge, 18 May 2018 <http://thebridge.agu.org/2017/05/31/noaa-cut-16-president-trumps-budget-request/>.
[432] Wolfe, Alexis. "Final FY18 Appropriations: National Oceanic and Atmospheric Administration." 6 Apr. 2018. American Institute of Physics, 18 May 2018 <https://www.aip.org/fyi/2018/final-fy18-appropriations-national-oceanic-and-atmospheric-administration>.
[433] "Space Advisory Board." Government of Canada, 22 May 2018 (retrieved) <https://www.ic.gc.ca/eic/site/ad-ad.nsf/eng/h_ad03983.html>.
[434] *Ibid*.
[435] "Consultations on Canada's future in space: What we heard." 30 Oct. 2017. Government of Canada, 22 May 2018 <https://www.ic.gc.ca/eic/site/ad-ad.nsf/eng/ad03996.html>.
[436] Boucher, Marc. "New Canadian Space Strategy Not Ready – Exclusive." 19 Mar. 2018. SpaceQ, 22 May 2018 <http://spaceq.ca/new-canadian-space-strategy-not-ready/>.
[437] Boucher, Marc. "New Canadian Space Strategy Delayed." 21 June 2017. SpaceQ, 22 May 2018 <https://spaceq.ca/new-canadian-space-strategy-delayed/>.

6.7 Russia

As made known in government documents and announcements throughout 2017, Russia is continuing to pursue construction and operations of it spaceports with significant investments. As announced by Russian Prime Minister Dmitry Medvedev, the federal programme for the development of spaceports and their infrastructure over 2017 to 2025 is to be more than $5.9 billion.[438] For the Vostochny Cosmodrome in particular, which has been under construction since 2010, the Russian Finance Ministry is to provide $39 million, which is from funds classified in the budget for Outer Space Exploration and Use. This funding will be transferred specifically to Roscosmos for the operation of the spaceport's ground infrastructure and maintenance of supporting infrastructure.[439] A further $630 million will be used for the construction at Vostochny of the future Angara rocket's launch infrastructure, forecasted for completion in 2022.[440]

The Russian Space Agency Roscosmos also strengthened its ties with its counterpart agencies in the US and China in 2017 and 2018. On 27 September 2017, at the 68th International Astronautical Congress in Australia, Roscosmos and NASA signed a joint statement "on Researching, Exploring Deep Space" and which focuses in particular on research which may lead to development of NASA's concept Deep Space Gateway.[441,442] And on 3 March 2018, The Chinese National Space Administration with Roscosmos signed an agreement around cooperation in lunar and deep space exploration as well as the creation of a Russian-Chinese Data Center for lunar projects. Two possible avenues of implementing this cooperation include the Russian Luna-Resurs-1 (Luna-26) and Chinese lunar south pole missions.[443]

6.8 Japan

Important developments occurred in 2017 related to Japan's industrial, legal, and other efforts to increase domestic launch activity. Regarding the H3 rocket, the government of Japan through JAXA awarded a contract to Mitsubishi Heavy Industries in 2014 for the construction of the H3, Japan's next generation launcher which will follow its H-2A and H-2B rockets. In this contract, JAXA stipulated that the launch price per kilogram should be cut by 50% as compared with the H-2A, and it was announced in 2018 that Japan plans to adapt the Tanegashima spaceport's infrastructure to enable an increase in its launch rate with the new launcher.[444] Currently, Tanegashima hosts one pad for the H2-A and one for the H2-B, both of which MHI will adapt for the H3. The H3 is scheduled to start launching in 2020 and is intended to boost the overall launch rate to ten per year from the current approximately four per year.[445] Furthermore, in November 2017, the Japanese Cabinet Office began to take applications for launching and operating satellites under new space activities legislation passed in November 2016, opening up private sector involvement in access to space activities.[446,447]

In further support to the private sector, Prime Minister Shinzo Abe announced an initiative on 20 March 2018 to provide venture capital from a fund worth $940 million to support Japan's space startups. The programme will run during a period of five years, with funding from the Development Bank of Japan and the Industrial Innovation Organization, among others, and will also match investors with startups.[448] Furthermore, the Japanese Cabinet Office's Committee of National Space Policy has also released a Space Industry Vision 2030, aiming to double the Japanese space industry's market size from the current 1.2 trillion Yen to 2.4

[438] "More than $5.9 billion to be invested in spaceports development by 2025 — Russian PM." 13 Sept. 2017. TASS, 11 July 2018 <http://tass.com/science/965379>.
[439] "Russian government allocates $39 mln for Vostochny spaceport operation." 18 Aug. 2017. TASS, 11 July 2018 <http://tass.com/science/960961>.
[440] "Russia to spend $630 mln on launch pad for Angara carrier rocket at Vostochny spaceport." 11 Aug. 2017. TASS, 11 July 2018 <http://tass.com/science/959991>.
[441] Warner, Cheryl. "NASA, Roscosmos Sign Joint Statement on Researching, Exploring Deep Space." 27 Sept. 2017. NASA, 11 July 2018 <https://www.nasa.gov/feature/nasa-roscosmos-sign-joint-statement-on-researching-exploring-deep-space>.
[442] Foust, Jeff. "NASA and Roscosmos to study Deep Space Gateway." 28 Sept. 2017. SpaceNews, 11 July 2018 <http://spacenews.com/nasa-and-roscosmos-to-study-deep-space-gateway/>.
[443] Messier, Doug. "Russia, China Sign Lunar Cooperation Agreement." 7 Mar. 2018. Parabolic Arc, 11 July 2018 <http://www.parabolicarc.com/2018/03/07/russia-china-sign-lunar-cooperation-agreement/>.
[444] Henry, Caleb. "MHI says H3 rocket development on track for 2020." 26 June 2017. SpaceNews, 12 July 2018 <http://spacenews.com/mhi-says-h3-rocket-development-on-track-for-2020/>.
[445] Henry, Caleb. "Japan to modernize spaceport launch pads to support H3 rocket." 23 Mar. 2018. SpaceNews, 12 July 2018 <http://spacenews.com/japan-to-modernize-spaceport-launch-pads-to-support-h3-rocket/>.
[446] "Japan Legal Update – Volume 32." Jones Day, 12 May 2018 (retrieved) <http://www.jonesday.com/files/Publication/d3cb154e-014a-4014-9b83-60baf57dbcf4/Presentation/PublicationAttachment/c150f476-2611-4188-8823-cda77404824d/Japan%20Legal%20Update%20Dec%202017%20Jan%202018.pdf>.
[447] Setsuko, Aoki. "New Law Aims to Expand Japan's Space Business." 3 Mar. 2017. Nippon.com, 12 July 2018 <https://www.nippon.com/en/currents/d00294/>.
[448] Foust, Jeff. "New fund to boost Japanese space startups." 21 Mar. 2018. SpaceNews, 12 July 2018 <http://spacenews.com/new-fund-to-boost-japanese-space-startups/>.

trillion yen ($21 billion as of May 2017).[449,450,451]

In terms of space exploration, it was announced in June 2017 that JAXA aims to send an astronaut to the moon by 2030. JAXA intends to join the lunar-orbiting Deep Space Gateway mission led by NASA and use it as a platform for access to the moon's surface. JAXA intends to develop water and air purifiers in its cooperation in the Deep Space Gateway, and further programme descriptions were announced for 2018.[452,453]

With a series of diverse cooperative instruments, JAXA also continued to pursue its cooperation with external partners throughout 2017 and 2018, including:

- An implementing arrangement with the French space agency CNES,[454]
- Two joint statements on bilateral cooperation with ESA,[455,456]
- A joint statement on bilateral cooperation with the German space agency DLR,[457]
- A cooperation agreement with the Vietnam National Space Center,[458]
- An implementation arrangement with the Indian Space Research Organisation ISRO[459]
- A collaboration agreement mutually with the Japanese National Institute for Environmental Studies NIES, ESA, and the DLR,[460]
- A joint statement on space exploration with NASA,[461]
- And a partnership agreement with the University of Tokyo.[462]

Lastly, the Cabinet Office of Japan released an Implementation Plan of the Basic Plan on Space Policy, revised for fiscal year 2017 and dated 12 December 2017. Its first objective is to "Ensure space security" as well as "Promote the use of civil space" and "Maintain and strengthen the science and technology industrial base". To pursue these objectives, the Implementation Plan leverages satellite positioning, satellite remote sensing, satellite communications and broadcasting, space transportation, Space Situational Awareness, Maritime Domain Awareness, early-warning functions, "strengthening of guarantee for functions of the overall space systems", and space science, exploration and manned space activity.[463]

6.9 China

China released the fourth version of its White Paper on space activities on 27 December 2016, detailing its major objectives for the following five years as well as development measures and policies, with a core principal being that China's space activity be "subject to

[449] Messier, Doug. "NewSpace Business Book Published in Japan." 27 May 2018. Parabolic Arc, 12 July 2018 <http://www.parabolicarc.com/2018/05/27/space-business-book/>.
[450] "Japan aims to double its space market to $21bn by 2030s." 12 May 2017. Nikkei Asian Review, 12 July 2018 <https://asia.nikkei.com/Economy/Japan-aims-to-double-its-space-market-to-21bn-by-2030s>.
[451] Tsuruda, Masanori. "Japanese Space Industry Policy Overview – Space industry in the big data era." 6 Sept. 2017. Japanese Ministry of Economy, Trade and Industry, 12 July 2018 <https://www.eu-japan.eu/sites/default/files/imce/1._meti_tsuruda_1.pdf>.
[452] Foust, Jeff. "Japan has plans to land astronauts on the moon by 2030 — with a little help from the United States." 29 June 2017. SpaceNews, 12 July 2018 <http://spacenews.com/mda-establishes-company-to-commercialize-satellite-servicing-technology/>.
[453] "JAXA reveals plans to put a Japanese on the moon by 2030." 1 July 2017. The Japan Times, 12 July 2018 <https://www.japantimes.co.jp/news/2017/07/01/national/science-health/jaxa-reveals-plans-put-japanese-moon-2030/#.Wwa7tu6FO70>.
If page expired, see: <https://web.archive.org/web/20171223144400/https://www.japantimes.co.jp/news/2017/07/01/national/science-health/jaxa-reveals-plans-put-japanese-moon-2030/#.W2hSZ9Uza70>.
[454] "JAXA and CNES Make and Sign Implementing Arrangement on Martian Moons Exploration (MMX)." 10 Apr. 2017. JAXA, 12 July 2018 <http://global.jaxa.jp/press/2017/04/20170410_cnes.html>.
[455] "JAXA-ESA Joint Statement concerning the bilateral cooperation." 15 May 2017. JAXA, 12 July 2018 <http://global.jaxa.jp/press/2017/05/20170515_esa.html>.
[456] "JAXA-ESA Joint Statement concerning the bilateral cooperation." 3 Mar. 2018. JAXA, 12 July 2018 <http://global.jaxa.jp/press/2018/03/20180303_esa.html>.
[457] "DLR-JAXA Joint Statement concerning the bilateral cooperation." 20 Sept. 2017. JAXA, 12 July 2018 <http://global.jaxa.jp/press/2017/09/20170920_dlr.html>.
[458] "Topics 2017." JAXA, 12 July 2018 (retrieved) <http://global.jaxa.jp/news/2017/>.
[459] "Japan Aerospace Exploration Agency (JAXA) Signs Implementation Arrangement (IA) with Indian Space Research Organization (ISRO) concerning joint study of Joint Lunar Polar Exploration." 6 Dec. 2017. JAXA, 12 July 2018 <http://global.jaxa.jp/press/2017/12/20171206_isro.html>.
[460] *Op. cit.* – "Topics 2017."
[461] "NASA-JAXA Joint Statement on Space Exploration." 26 Jan. 2018. JAXA, 12 July 2018 <http://global.jaxa.jp/press/2018/01/20180126_nasa.html>.
[462] "UTokyo and JAXA Partnership Agreement to Promote Kibo Use." 26 Apr. 2018. JAXA, 12 July 2018 <http://global.jaxa.jp/press/2018/04/20180426_kibo.html>.
[463] "Implementation Plan of the Basic Plan on Space Policy." (Download page) 12 Dec. 2017. Japanese Cabinet Office, 12 July 2018 <http://www8.cao.go.jp/space/english/basicplan/basicplan.html>.

and serves the national overall development strategy."[464] Key objectives include: [465]

- the launch of the Tianzhou-1 cargo vessel and its docking with the Tiangong-2 space laboratory;
- assemble and operate the space station;
- launch both the Chang'e-5 lunar probe (sample return mission) by the end of 2017 (ultimately delayed to 2019 by the failed launch of a Long March 5 in July 2017[466]);
- the launch of the Chang'e-4 lunar probe in 2018, which is to make a soft landing on the far side of the moon (its relay satellite having been launched in May 2018 to the Earth - Moon L2 Lagrange Point[467])

As well as a wide-reaching policy approach to promote the space sector across many levels, including enhancing innovation and improving the industry's capacity.

An additional component of the White Paper is the promotion of international cooperation in Chinese space activities. As of 2017, the People's Republic of China has signed 43 memoranda of understanding or cooperation agreements with 29 international organisations, space agencies, or other countries since 2011.[468] Most recently, this has included a memorandum of understanding on climate actions and space exploration with the French space agency CNES. CNES President Jean-Yves Le Gall and his counterpart Wu Yanhua of the China National Space Administration (CNSA) signed the memorandum in January 2018 in the presence of Chinese President Xi Jinping and French President Emmanuel Macron.[469] China also signed a series of cooperation documents with Cambodia on 11 January 2018. Among these is a framework agreement between the Royal Group of Cambodia and the China Great Wall Industry Corp. around the build, launch, insuring, and ground systems of a new geostationary telecommunications satellite.[470]

And in further pursuit of international cooperation, China (through the China Manned Space Agency) and the United Nations Office for Outer Space Affairs signed a memorandum of understanding in 2016 around experiment opportunities for UN Member States aboard the China Space Station. An Announcement of Opportunity was made jointly on 28 May 2018 by UNOOSA and the Permanent Mission of China to the UN and Other International Organizations in Vienna, and application instructions were made available. Operations on the future space station are forecasted from 2022; this cooperation aims to "promote international cooperation in human space flight and activities related to space exploration", as well as "provide flight experiment and space application opportunities on-board the CSS for United Nations Member States", among other objectives.[471]

6.10 India

Although heavily oriented towards civilian space activities, India's space sector is increasingly emphasising defence and security, especially through international cooperation, and in particular with Japan, the US, and France.[472]

The Indian Space Research Organisation formed and/or reinforced a number of collaborative relationships in the reporting period over 2017 to 2018, showing a continuing emphasis on international cooperation in its ac-

[464] "China's Space Activities in 2016 – the 4th version of white paper." 30 Jan. 2017. China National Space Administration (powerpoint hosted online by unoosa.org), 16 July 2018 <http://www.unoosa.org/documents/pdf/copuos/stsc/2017/tech-01E.pdf>.
[465] "Full text of white paper on China's space activities in 2016." 28 Dec. 2016. The State Council – english.gov.cn, 16 July 2018 <http://english.gov.cn/archive/white_paper/2016/12/28/content_281475527159496.htm>.
[466] Jones, Andrew. "China reveals cause of Long March 5 failure; lunar sample mission to follow return-to-flight." 16 Apr. 2018. SpaceNews, 16 July 2018 <http://spacenews.com/china-reveals-cause-of-long-march-5-failure-lunar-sample-mission-to-follow-return-to-flight/>.
[467] Barbosa, Rui C. & Bergin, Chris. "Queqiao relay satellite launched ahead of Chang'e-4 lunar mission." 20 May 2018. NASASPACEFLIGHT.com, 16 July 2018 <https://www.nasaspaceflight.com/2018/05/queqiao-relay-satellite-launched-change-4-lunar-mission/>.
[468] *Op. cit.* – "China's Space Activities in 2016 – the 4th version of white paper."
[469] "State Visit of President Emmanuel Macron to the People's Republic of China: France and China Step up Space Cooperation in the Fields of Climate and Exploration." 10 Jan. 2018. CNES, 16 July 2018 <https://presse.cnes.fr/en/state-visit-president-emmanuel-macron-peoples-republic-china-france-and-china-step-space-cooperation>.
[470] Henry, Caleb. "Cambodia to buy Chinese satellite as relations tighten on Belt and Road Initiative." 12 Jan. 2018. SpaceNews, 16 July 2018 <http://spacenews.com/cambodia-to-buy-chinese-satellite-as-relations-tighten-on-belt-and-road-initiative/>.
[471] "United Nations and China invite applications to conduct experiments on-board China's Space Station." 28 May 2018. United Nations Office for Outer Space Affairs, 16 July 2018 <http://www.unoosa.org/oosa/en/information-for/media/2018-unis-os-496.html>.
[472] Rajagopalan, Rajeswari Pillai. "India changing tack on space policy." 3 Apr. 2018. ORF, 13 July 2018 <https://www.orfonline.org/research/india-changing-tack-on-space-policy/>.

tivities. These include 15 implementing arrangements, memoranda of understanding, or other agreements with 19 actors, including:[473]

- the California Institute of Technology (Caltech)
- the Canadian Space Agency CSA
- the French space agency CNES[474]
- Geoscience Australia (a national agency of Australia)
- the Israel Space Agency ISA
- the Japan Aerospace Exploration Agency JAXA
- the National Remote Sensing Department of Vietnam[475]
- the US National Aeronautics and Space Administration NASA

Beyond the scope of ISRO, India has also entered into cooperative agreements with several actors, including between:

- The Indian Department of Space and the European Commission, in a Cooperation Agreement around the sharing of earth observation data[476]
- The Indian Department of Science and Technology and the Israeli National Technological Innovation Authority, in a Memorandum of Understanding[477]
- The Indian Institute of Space Science and Space Technology, of the Indian Science Ministry, and the Technion – Israel Institute of Technology, in a Memorandum of Understanding[478]
- The governments of India and France through the India-France Joint Vision for Space Cooperation, which lays out future areas of cooperation between ISRO and CNES[479,480]
- The Governments of Armenia, Bangladesh, the Netherlands, and Portugal (four Memoranda of Understanding).[481]

[473] "Government of India – Department of Space Annual Report 2017 - 2018." 12 Jan. 2018. ISRO, 13 July 2018 <https://www.isro.gov.in/sites/default/files/flipping_book/AnnualReport2017-18-en/files/assets/common/downloads/annualreport2017-18-en.pdf>.
[474] "France-India Space Cooperation - Agreements Signed on Future Launchers and Lunar Exploration." 9 Jan. 2017. CNES, 13 July 2018 <https://presse.cnes.fr/en/france-india-space-cooperation-agreements-signed-future-launchers-and-lunar-exploration>.
[475] "India, Vietnam sign two agreements." 24 Jan. 2018. The Economic Times, 13 July 2018 <https://economictimes.indiatimes.com/news/politics-and-nation/india-vietnam-sign-two-agreements/articleshow/62639822.cms>.
[476] "European Commission and India to share satellite data." 17 Apr. 2018. UN-SPIDER, 13 July 2018 <http://www.un-spider.org/news-and-events/news/european-commission-and-india-share-satellite-data>.
[477] Goh, Deyana. "Modi, Netanyahu sign space cooperation agreements between ISRO and ISA." 6 July 2017. SpacetechAsia, 13 July 2018 <http://www.spacetechasia.com/modi-netanyahu-sign-space-cooperation-agreements-between-isro-and-isa/>.
[478] Siegel-Itzkovich, Judy. "Space Exploration Cooperation Agreement Signed While Netanyahu in India." 18 Jan. 2018. The Jerusalem Post, 13 July 2018 <https://www.jpost.com/HEALTH-SCIENCE/Space-exploration-cooperation-agreement-signed-while-Netanyahu-in-India-538147>.
[479] Datta, Anusuya. "India, France to collaborate on satellite technology to tackle Climate Change." 12 Mar. 2018. Geospatial World, 13 July 2018 <https://www.geospatialworld.net/blogs/india-france-collaboration-on-satellite-technology/>.
[480] "India-France Joint Vision for Space Cooperation (New Delhi, 10 March 2018)." 10 Mar. 2018. Government of India, Ministry of External Affairs, 13 July 2018 <http://mea.gov.in/bilateral-documents.htm?dtl/29597/IndiaFrance+Joint+Vision+for+Space+Cooperation+New+Delhi+10+March+2018>.
[481] *Op. cit.* – "Government of India – Department of Space Annual Report 2017 - 2018."

List of Acronyms

Acronym	Explanation
A	
AAD	Advanced Air Defence
ABS	Asia Broadcast Satellite
AG	Aktiengesellschaft
Airbus D&S	Airbus Defence and Space
AIS	Automatic Identification Satellites
AIST	Advanced Industrial Science and Technology
APAC	China and other Asia Pacific
ASAT	Anti-Satellite
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ASL	Airbus Safran Launchers
ATV	Automated Transfer Vehicle
AWE	AWE Management Limited
B	
BMD	Ballistic Missile Defence
C	
CALTECH	California Institute of Technology
CASC	China Aerospace Science and Technology Corporation
CAST	China Aerospace Science and Technology Corp.
CDOP 3	Third Continuous Development and Operations Phase
CEO	Chief Executive Officer
CFOSat	Chinese-French Oceanography Satellite
CGWIC	China Great Wall Industry Corporation
CHF	Swiss franc
CLARREO	Climate Absolute Radiance and Refractivity Observatory
CMA	Governing Body of the Paris Agreement
CNES	Centre National d'Études Spatiales (French Space Agency)
CONAE	Argentinian Space Agency
COP	Conference of the Parties
CRS	Commercial Resupply Services
CS	Continuity of Service
CSA	Canadian Space Agency

Acronym	Explanation
CSDP	Common Security and Defence Policy
CSIS	Centre for Strategic and International Studies
D	
DARS	Digital Audio Radio Service
DBS	Direct Broadcast Services
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)
DoD	Department of Defence
DRDO	Defence Research and Development Organisation
DSCOVR	Deep Space Climate ObserVatoRy
DTH	Direct To Home
E	
EBIT	Earnings Before Interest and Taxes
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization
ECA	Evolution Cryotechnique type A
EDA	European Defence Agency
EELV	U.S. Evolved Expendable Launch Vehicle Program
EIB	European Investment Bank
EIF	European Investment Fund
ELV	European Launch Vehicle
EM	Exploration Mission
EON-MW	Earth Observing Nanosatellite-Microwave
EPS-SG	European Polar System Second Generation
ESA	European Space Agency
ESA DG	ESA Director General
EU	European Union
EUMETSAT	The European Organisation for the Exploitation of Meteorological Satellites
EUTELSAT	European Telecommunications Satellite Organisation
F	
FAA	Federal Aviation Administration
FCC	Federal Communication Commission
FSS	Fixed Satellite Services
FY	Fiscal Year
G	
GDP	Gross Domestic Product
GEO	Geostationary Earth Orbit

Acronym	Explanation
GmbH	Gesellschaft mit beschränkter Haftung
GNI	Gross National Income
GNSS	Global Navigation Satellite Systems
GOES-R	Geostationary Operational Environmental Satellite R
GOVSATCOM	Governmental Satellite Communication
GPS	Global Positioning System
GSA	European GNSS Agency
GSLV	Geosynchronous Satellite Launch Vehicle
GSSAP	Geosynchronous Space Situational Awareness Program
GTO	Geosynchronous Transfer Orbits
H	
HTV	H-2 Transfer Vehicle
HRE	Human and Robotic Exploration
I	
ICBM	Intercontinental Ballistic Missile
ICS	Information and Communication Systems
ICT	Information and Communication Technology
IEA	International Energy Agency
IGS	International GNSS Service
ILS	International Launch Services
IMF	International Monetary Fund
IODC	Indian Ocean Data Coverage
IPP	International Partnership Programme
IRNSS	India Regional Navigation Satellite System
ISC	International Satellite Company Limited
ISED	Innovation, Science and Economic Development
ISIS	Islamic State
ISRO	Indian Space Research Organization
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
J	
JAXA	Japan Aerospace Exploration Agency
JPSS	Joint Polar Satellite System
JUICE Mission	JUpiter ICy moons Explorer
K	

Acronym	Explanation
KARI	Korea Aerospace Research Institute (Korean Space Agency)
L	
LEO	Low Earth Orbit
M	
MDA	MacDonald, Dettwiler and Associates Ltd.
Melco	Mitsubishi Electric Co.
MEO	Medium Earth Orbit
MERLIN	Methane Remote Sensing LIDAR Mission
Metop	Meteorological Operational Satellite
Metop-SG	Metop Second Generation
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MFG	Meteosat First Generation
MOD	Ministry of National Defense
MOKV	multi-object kill vehicle
MoU	Memorandum of Understanding
MSG	Meteosat Second Generation
MSS	Mobile Satellite Service
MTG	Meteosat Third Generation
N	
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organisation
NCSTE	China's National Centre for Science and Technology Evaluations
NDAA	National Defense Authorization Act
NDCs	Nationally Determined Contributions
NEC	Nippon Electric Company
NEO	Near-Earth Orbit
NGA	National Geospatial-Intelligence Agency
NIES	National Institute for Environmental Studies
NOAA	National Oceanic and Atmospheric Administration
NRO	National Reconnaissance Office
O	
OCO	Orbiting Carbon Observatory
OECD	Organisation for Economic Co-operation and Development
OHB	Orbitale Hochtechnologie Bremen
OPEC	Organization of the Petroleum Exporting Countries

Acronym	Explanation
OPIR	Overhead Persistent Infrared
ORB	OPEC Reference Basket
P	
PACE	Plankton, Aerosol, Cloud, ocean Ecosystem
PAD	Prithvi Air Defense
PLA	People's Liberation Army
PND	Portable Navigation Devices
PRS	Public Regulated Service
PRODEX	PROgramme de Développement d'Expériences scientifiques
PSLV	Polar Satellite Launch Vehicle
Q	
QZSS	Quasi-Zenith Satellite System
R	
RCM	RADARSAT Constellation Mission
RKV	Redesigned Kill Vehicle
Roscosmos	Roscosmos State Corporation
S	
SAF	Satellite Application Facilities
SAOCOM	SAtellite Argentino di Osservazione COn Microonde
SBIRS	Space Based Infrared System (SBIRS)
SDGs	Sustainable Development Goals
SES	Société Européenne des Satellites
SIA	Satellite Industry Association
SIASGE	Sistema Italo Argentino di Satelliti per la Gestione delle Emergenze (Italian-Argentine System of Satellites for the Management of Environmental Emergencies and Economic Development)
SLS	Space Launch System
SpaceX	Space Exploration Technologies
SS/L	Space Systems/Loral
SSO	Sun-synchronous orbit
STEM	Science, technology, engineering and mathematics
T	
TDP	Technology Demonstration Programme
TEU	Treaty on European Union
THAAD	Terminal High Altitude Area Defense system

Acronym	Explanation
TRAI	Telecom Regulatory Authority of India
U	
UAE	United Arab Emirates
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
ULA	United Launch Alliance
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
U.S.	United States of America
U.S. MDA	Missile Defense Agency
USAT	Ultra Small Aperture Terminals
V	
VAST	Vietnamese Academy of Science and Technology
VSAT	Very Small Aperture Terminals
VKO	Aerospace Defence Forces
VSAT	Very Small Aperture Terminals
W	
WGP	World Gross Product

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