

Summary of 2016 in Space: The Significance of the Space Activities of Governments

Annual Trend Analysis

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Yuval Ne'eman Workshop for Science, Security and Technology

Tel Aviv University

May 2017

The present report reviews the main space events of 2016, and analyzes key trends in the space activity of states, in relation to matters such as industrial and technological development, space research, and collaborations. The report also lists the main events by several individual states which are the main space-faring nations as of today.

The total number of launches in 2016 was 85, of which 83 were successful, and 2 failed.¹ China and the US carried out 22 launch operations each, followed by Russia, with 19 launches. The European Space Agency carried out nine launch operations, India – seven, and Japan – four. In early 2016, North Korea carried out one launch, but its satellite apparently did not enter into orbit.² In September, Israel launched a locally produced satellite. Of the total launches, 42 were made to LEO, 31 – to GEO and the remaining ones – to other orbits.

In all, about 206 satellites were launched in 2016³ (58 of them from the ISS). Most of the satellites were on testing and technology demonstration missions. 28 satellites were on Earth observation and remote sensing missions (excluding mini-satellites launched from the ISS), 25 communication satellites were launched to GEO, 15 were navigation satellites, 13 – meteorological satellites, and eight were logistic missions to the ISS. Four manned

¹ The data are based on information published over 2016 in Space News and on the UCS satellite database, as well as on information accumulated in the knowledge center over the year. The failed launches were the following: On 31 August 2016, the Chinese Long March 4C launcher carrying the satellite Gaofen 10 failed at the third stage. On 1 December 2016, the launcher Soyuz-U, which was on a supply mission to the ISS, failed and fell apart a few minutes after launching. The Falcon-9, which exploded on the launching pad on 1 September 2016 is added to this list.

² Ju-min Park and Louis Charbonneau, North Korean rocket puts object into space, angers neighbors, U.S, *Space News*, February 8, 2016. <http://spacenews.com/north-korean-rocket-puts-object-into-space-angers-neighbors-u-s-2/>

³ This includes scientific research missions.

missions were launched to the ISS, and one manned mission was launched to China's experimental space station (Tiangong-2).

Industry and technology

A number of topics will be addressed in the sphere of industry and technology. First is **the continuing trend of reusable launchers development**. In April, SpaceX demonstrated its ability to bring back a first stage and land it on a rig at sea.⁴ In July, SpaceX successfully launched the Dragon spacecraft, and succeeded in landing back its first stage.⁵ It has since had five more similar successes.⁶ Blue Origin has also succeeded returning the launchers of its January,⁷ April⁸ and June⁹ missions. These achievements have encouraged other states, including France,¹⁰ China¹¹ and India,¹² to explore developing reusable launcher capabilities. The next step towards realizing the vision of reusable launch vehicles was a demonstration of a space launch with a reused first stage that had been safely returned and landed beforehand, as done by SpaceX on March 2017.¹³

Second is **developing on-orbit satellite services**, such as lifespan extension and deorbiting.¹⁴ For example, it was announced that Orbital was to cooperate with NASA in developing a commercial robotic infrastructure that would enable on-orbit production and assembly services. The purpose of the program is promoting and developing robotic technologies for on-orbit production and assembly of structures and infrastructures, to

⁴ Peter B. de Selding, SpaceX's reusable Falcon 9: What are the real cost savings for customers? *Space News*, April 25, 2016. <http://spacenews.com/spacexs-reusable-falcon-9-what-are-the-real-cost-savings-for-customers/>

⁵ Jeff Foust, SpaceX launches Dragon spacecraft, successfully lands first stage, *Space News*, July 18, 2016. <http://spacenews.com/spacex-launches-dragon-spacecraft-successfully-lands-first-stage/>

⁶ Mike Wall, A Sixth Success! SpaceX Again Lands Rocket on a Ship at Sea, *Space.com*, August 14, 2016. <http://www.space.com/33742-spacex-satellite-launch-rocket-landing.html>

⁷ Christian Davenport, Jeff Bezos launches and lands again in another first for booming space industry, *The Washington Post*, January 23, 2016. <https://www.washingtonpost.com/news/the-switch/wp/2016/01/23/jeff-bezos-launches-and-lands-again-in-another-first-for-booming-space-industry/>

⁸ Jeff Foust, ULA narrows cause of Atlas 5 launch anomaly, *Space News*, April 1, 2016. <http://spacenews.com/ula-narrows-cause-of-atlas-5-launch-anomaly/>

⁹ Jeff Foust, Blue Origin Flies New Shepard again, *Space News*, June 19, 2016. <http://spacenews.com/blue-origin-flies-new-shepard-again/>

¹⁰ Peter B. de Selding, French government commissions report on rocket reuse, competitiveness, *Space News*, January 21, 2016. <http://spacenews.com/french-government-commissions-report-on-rocket-reuse-competitiveness/>

¹¹ Staff Writers, China testing own reusable rocket technologies, *Space Daily*, April 25, 2016.

http://www.spacedaily.com/reports/China_testing_own_reusable_rocket_technologies_999.html

¹² ¹² Staff Writers, India to test Reusable Launch Vehicle in June, *Space Daily*, April 26, 2016.

http://www.spacedaily.com/reports/India_to_test_Reusable_Launch_Vehicle_in_June_999.html

¹³ Chelsea Leu, Watch SpaceX Launch Its First Truly Reusable Rocket, *Wired*, March 30, 2017.

<https://www.wired.com/2017/03/watch-spacex-launch-first-truly-reusable-rocket/>

¹⁴ Staff Writers, Program Aims to Facilitate Robotic Servicing of Geosynchronous Satellites, *Robo Daily*, Mar 29, 2016.

http://www.robodaily.com/reports/Program_Aims_to_Facilitate_Robotic_Servicing_of_Geosynchronous_Satellites_999.html

facilitate space and solar system research.¹⁵ EES has also raised funds and invested in this sphere,¹⁶ announcing that it would invest in developing capabilities to provide services that would extend the lifespan of satellites on orbit.¹⁷ DARPA has also been operating in this field, and has announced its intention to set up a consortium to discuss, study and develop procedures and international standards in this field.¹⁸

The third sphere involves the **development of heavy launchers** for commercial and other purposes. In September, Blue Origin introduced its new heavy launcher, New Glenn, which will join the competition on the commercial launcher market, and will be ready for launching by the end of the decade.¹⁹ It will compete with SpaceX's Falcon Heavy. The then NASA Administrator Charles Bolden, referring to these developments, said he was not enthusiastic about the development of large launchers, and did not support commercial investment in this type of launchers. His statement was criticized voicing the argument that the private market was balancing off NASA's deficient capabilities.²⁰

In October, China successfully launched its newest and largest launcher, Long March 5, intended for launching missions to China's space station and Mars, and for deep-space research missions.²¹ In November, it was again announced that Russia was developing a super-heavy launcher for a logistic mission to build a base on the moon. The project is currently undergoing technical design.²²

The fourth sphere involves **development of propulsion capabilities for space missions**. Russia has announced its plan to develop a nuclear propulsion system for voyages to the

¹⁵ Veronica Magan, Orbital ATK, Space Logistics to Develop In-Orbit Assembly Tech with NASA, *satellitetoday*, November 30, 2016. <http://www.satellitetoday.com/government/2016/11/30/orbital-atk-space-logistics-develop-orbit-assembly-tech-nasa/>

¹⁶ Effective Space Solutions Signs a Multi-Year Life-Extension Service LOI for GEO Communication Satellite, *Business wire*, March 7, 2016. <http://www.businesswire.com/news/home/20160307005992/en/Effective-Space-Solutions-Signs-Multi-Year-Life-Extension-Service>

¹⁷ Peter B. de Selding, SES ready to invest in reusable rockets, in-orbit satellite servicing, *Space News*, April 8, 2016. <http://spacenews.com/ses-ready-to-invest-in-reusable-rockets-in-orbit-satellite-servicing/>

¹⁸ Debra Werner, DARPA to establish satellite-servicing consortium to discuss on-orbit repair standards, *Space News*, August 22, 2016. <http://spacenews.com/darpa-to-establish-satellite-servicing-consortium-to-discuss-on-orbit-repair-standards/>

¹⁹ Staff Writers, Amazon's chief Jeff Bezos unveils new rocket design, *Space Daily*, September 12, 2016. http://www.spacedaily.com/reports/Amazons_chief_Jeff_Bezos_unveils_new_rocket_design_999.html

²⁰ Eric Berger, Falcon Heavy? New Glenn? NASA chief says he's not a "big fan", *Arstechnica*, September 19, 2016. <https://arstechnica.com/science/2016/09/nasa-chief-says-hes-not-a-big-fan-of-private-investment-in-large-rockets/>

²¹ Marcia S. Smith, China Readies Long March 5 for First Launch, *SpacePolicyOnline*, October 29, 2016. <http://www.spacepolicyonline.com/news/china-readies-long-march-5-for-first-launch>

²² Julian Robinson, Russia is developing a mega-rocket that will transport supplies to build a base on the MOON, Deputy PM Reveals, *Daily mail Online*, November 28, 2016. <http://www.dailymail.co.uk/news/article-3978816/Russia-developing-mega-rocket-transport-supplies-build-base-MOON-Deputy-PM-reveals.html>

moon and to Mars. To this end, it will invest about 60 million USD between 2016-2018.²³ In December, China tested an electromagnetic propulsion system (EmDrive). Testing is apparently conducted on board the Tiangong-2 space laboratory.²⁴

Other than these trends, it is worth mentioning that in September, SpaceX' Falcon-9 exploded with the satellite Amos-6. This obliged the company to freeze its space launches for several months. The US Air Force participated in the event's investigation, as the US Department of Defense is set to use SpaceX for launching national security payloads. SpaceX's first such launch is scheduled for spring 2017, and the approval of the Falcon-9 launcher for national security missions remains valid.²⁵ In contrast, Inmarsat has announced that consequent to the accident, it means to weigh other options for launching one of its satellites, whose launching had originally been planned on the Falcon 9.²⁶ In October, SpaceX announced that it would change its hardware testing policy in view of the explosion.²⁷

As for insurance, it is assessed that the Falcon-9 launcher accident would cause a rise in the pre-launch insurance rates of launchers, which were considered relatively low until now. After about a decade of reductions in launching insurance prices, an increase is expected.²⁸ Notably, a November report of the US comptroller's office warned that US commercial spaceports are not clear about insurance requirements.²⁹

Another noteworthy event is that **Virgin Galactic has resumed the test flights of its space aircraft**, after the previous model broke apart in the air in a fatal accident about two years ago.³⁰ In September, Space Ship Two completed its first test flight.³¹

²³ Staff Writers, Russia to spend \$60M in 2016-2018 to fund space voyages to Moon, Mars, *Moon Daily*, June 28, 2016. [http://www.moondaily.com/reports/Russia to spend 60M in 2016 2018 to fund space voyages to Moon Mars 999.html](http://www.moondaily.com/reports/Russia%20to%20spend%2060M%20in%202016%202018%20to%20fund%20space%20voyages%20to%20Moon%20Mars%20999.html)

²⁴ China Claims Testing of EmDrive in Space, *Parabolic Arc*, December 28, 2016. <http://www.parabolicarc.com/2016/12/28/china-claims-testing-emdrive-space/>

²⁵ Peter B. de Selding, SpaceX: Sept. 1 failure likely caused by breach in Falcon 9 second-stage helium tank, *Space News*, September 23, 2016. <http://spacenews.com/spacex-sept-1-failure-appears-to-lie-in-falcon-9-second-stage-helium-tank/>

²⁶ David Z. Morris, SpaceX Has Explained Its Falcon 9 Explosion, but May Still Lose a Launch Order, *Fortune*, November 05, 2016. <http://fortune.com/2016/11/05/spacex-satellite-launch-order/>

²⁷ Jeff Foust, Shotwell says SpaceX "homing in" on cause of Falcon 9 pad explosion, *Space News*, October 10, 2016. <http://spacenews.com/shotwell-says-spacex-homing-in-on-cause-of-falcon-9-pad-explosion/>

²⁸ Peter B. de Selding, Space insurers warn that current low rates are not sustainable, *Space News*, October 10, 2016. <http://spacenews.com/space-insurers-warn-that-current-low-rates-are-not-sustainable/>

²⁹ Jeff Foust, Report finds commercial spaceports confused about insurance requirements, *Space News*, November 23, 2016. <http://spacenews.com/report-finds-commercial-spaceports-confused-about-insurance-requirements/>

³⁰ Virgin Galactic to resume flight-testing in August, *SpaceWatchMe*, July 12, 2016. <http://spacewatchme.com/2016/07/virgin-galactic-resume-flight-testing-august/>

³¹ Jeff Foust, Second SpaceShipTwo completes first test flight, *Space News*, September 9, 2016. <http://spacenews.com/second-spaceshiptwo-completes-first-test-flight/>

Collaborations

The ongoing trend of intergovernmental space collaboration continued this year, despite existing geopolitical tensions and instability. For example, Russia and the European Space Agency continue collaborating on the ExoMars mission. In June, the ESA approved backing the second ExoMars mission.³² In November, the ExoMars lander Schiaparelli crashed as a result of a measurement error. Following the crash, there was concern that several European governments would withhold their € 300 million (\$ 323 million) budget to finance the mission's continuation in 2020 as planned.³³

The nuclear deal signed with Iran in July 2015 has reopened the possibility of resuming space collaboration with Iran. This has enabled Iran to bolster its space program³⁴ and promote the launching of an Iranian astronaut to space through Russia³⁵ or China.³⁶ The Asia Pacific Space Cooperation Organisation (APSCO) will also cooperate with Iran on issues concerning APSCO's databases and manpower development.³⁷

As part of its effort to promote its space station project, China has proposed cooperating with various countries and has tightened its cooperation with the UN.³⁸ Changes have also been occurring in China's relations with NASA in spite of congress restrictions. The two have been discussing cooperation on the earth sciences.³⁹ China and Russia have reached an agreement on intellectual property rights of space technology. The agreement is to be signed before they start negotiations on the transfer of Russian RD-180 engines to China, and before an agreement is signed for the purchase of Chinese space-related electronic components.⁴⁰ In July, China and Poland signed a space cooperation agreement, mainly dealing with cooperation on space research, sharing and using satellite data, and developing

³² Jeff Foust, Despite delays, ESA backs Mars mission plans, *Space News*, June 16, 2016. <http://spacenews.com/despite-delays-esa-backs-mars-mission-plans/>

³³ Peter B. de Selding, ESA: Mars lander crash caused by 1-second inertial measurement error, *Space News*, November 23, 2016. <http://spacenews.com/esa-mars-lander-crash-caused-by-1-second-inertial-measurement-error/>

³⁴ Iranian Space Agency announces future satellite plans, *SpaceWatchMe*, May 12, 2016. <http://spacewatchme.com/2016/05/iranian-space-agency-announces-future-satellite-plans/>

³⁵ Staff Writers, Russian Space Agency discussing possible training of Iranian astronaut, *Space Daily*, January 21, 2016. http://www.spacedaily.com/reports/Russian_Space_Agency_discussing_possible_training_of_Iranian_astronaut_999.html

³⁶ China may send astronauts to the Moon – will an Iranian be among them?, *SpaceWatchMe*, May 11, 2016. <http://spacewatchme.com/2016/05/china-may-send-astronauts-moon-will-iranian-among/>

³⁷ Iranian satellites to share information system of the Asia Pacific Space Cooperation Organisation, *SpaceWatchMe*, September 16, 2016. <http://spacewatchme.com/2016/09/iranian-satellites-share-information-system-asia-pacific-space-cooperation-organisation/>

³⁸ United Nations and China agree to increased space cooperation, *SpaceWatchMe*, June 29, 2016. <http://spacewatchme.com/2016/06/united-nations-china-agree-increased-space-cooperation/>

³⁹ Jeff Foust, Earth science discussion latest sign of NASA-China ties, *Space Daily*, August 4, 2016. <http://spacenews.com/earth-science-discussion-latest-sign-of-nasa-china-ties/>

⁴⁰ Staff Writers, Russia, China to Sign Intellectual Property Deal on Rocket Tech, *Space Daily*, June 22, 2016. http://www.spacedaily.com/reports/Russia_China_to_Sign_Intellectual_Property_Deal_on_Rocket_Tech_999.html

space technologies, particularly in the sphere of communications.⁴¹ India's space agency and NASA's JPL have been jointly developing a satellite, to be named NISAR (NASA-ISRO Synthetic Aperture Radar).⁴²

Space Research

The year 2016 saw many developments in space research, particularly in Mars and Moon research missions. In an opinion article he published in October, President Obama underlined the importance of NASA's space research program, and repeated his vision that manned flights will be made to Mars by 2030.⁴³ In this context, NASA has been contemplating a possible public-private partnership (PPP) with SpaceX for the Red Dragon mission.⁴⁴ In August, China revealed its robotic mission to Mars project, scheduled to be launched in 2020 using the Chinese launcher Long March-5.⁴⁵

The private market has also been displaying Interest in a manned voyage to Mars. In September, Elon Musk unveiled his grand plan to start voyages to Mars in 2018, and launch manned voyages in 2024.⁴⁶ The cost per person is estimated at about \$200,000. At this price, says Musk, "ordinary" people will themselves buy the ticket and finance the establishment of a future colony, and will be its first settlers.⁴⁷

Russia is interested in the moon. It is planning to start launching unmanned missions in 2026, launch a takeoff and landing module in 2027, a new spacecraft, the Federation, in 2030, and a first manned moon mission in 2033.⁴⁸

The ESA also looks to the moon, and will cooperate with Russia in a moon mission, among other things by sending a drill on Russia's Luna Resurs mission, scheduled to begin in a few

⁴¹ Brian Berger, Poland signs space partnership deal with China, eyes increased industry cooperation, *Space News*, July 4, 2016. <http://spacenews.com/poland-signs-space-partnership-deal-with-china-eyes-increased-industry-cooperation/>

⁴² Staff Writers, India to launch satellite jointly developed with US in 2021, *Space Daily*, July 26, 2016. http://www.spacedaily.com/reports/India_to_launch_satellite_jointly_developed_with_US_in_2021_999.html

⁴³ Making Human Settlement of Space a Reality, *SpaceRef*, October 13, 2016. <http://spaceref.com/nasa-hack-space/making-human-settlement-of-space-a-reality.html>

⁴⁴ Jeff Foust, NASA exploring additional cooperation with SpaceX's Red Dragon mission, *Space News*, June 9, 2016. <http://spacenews.com/nasa-exploring-additional-cooperation-with-spacexs-red-dragon-mission/>

⁴⁵ Jeff Foust, China unveils the design of its 2020 Mars lander and rover, *Space News*, August 24, 2016. <http://spacenews.com/china-unveils-the-design-of-its-2020-mars-lander-and-rover/>

⁴⁶ Christian Davenport, Elon Musk provides new details on his 'mind blowing' mission to Mars, *The Washington Post*, June 10, 2016. https://www.washingtonpost.com/news/the-switch/wp/2016/06/10/elon-musk-provides-new-details-on-his-mind-blowing-mission-to-mars/?utm_term=.94d9562ec36b

⁴⁷ Miriam Kramer, Here are the top 5 takeaways from Elon Musk's big Mars speech, *Mashable*, September 28, 2016. <http://mashable.com/2016/09/27/elon-musk-spacex-mars-top-5-takeaways/#hbmCWgOGSaqW>

⁴⁸ Julian Robinson, Russia is developing a mega-rocket that will transport supplies to build a base on the MOON, Deputy PM reveals, *Mail Online*, 28 November 2016. <http://www.dailymail.co.uk/news/article-3978816/Russia-developing-mega-rocket-transport-supplies-build-base-MOON-Deputy-PM-reveals.html>

years. At the same time, a debate is underway at the ESA about the preferred destination. While most participants agree to the formula "Moon first, Mars next", French space scientists gave preference to Mars over the moon.⁴⁹

A number of commercial companies have also shown interest in the moon, and have begun developing missions to this end. In August, the US government granted Moon Express approval for a moon landing mission, even though no regulatory procedure has been formulated as yet for approving missions of this kind. In this context, a White House report submitted to Congress on this matter has recommended responsibility transfer to the Federal Aviation Agency, a move that requires legislation.⁵⁰

Space Mining

The vision of space mining has recently received further support. Luxembourg announced it would back this developing field by allocating budgets amounting to hundreds of millions USD, to encourage private companies to enter this field and base their headquarters in its territory. Following in the footsteps of the US, Luxembourg has begun advancing the required regulation and legislation mechanisms.⁵¹ Japan, joining the US and Luxembourg, has also begun a legal procedure. In November, the Japanese parliament took a decision in support of space mining.⁵²

On the technological front, the Japanese company Ispace, specializing in the development of micro-robotic technologies for space resource mining, has announced the signing of an MOU with Japan's space agency (JAXA), to design a roadmap for the development and exploitation of natural resources on the moon. According to the MOU, the two sides will develop a work plan towards setting up a resource retrieval complex on the moon, and developing transportation means.⁵³

⁴⁹ Peter B. de Selding, ESA plans Euro-Russian lunar exploration to go beyond Apollo 'gift shop visit', *Space News*, July 14, 2016. <http://spacenews.com/esa-sets-euro-russian-lunar-exploration-goals-to-go-beyond-apollo-gift-shop-visit/>

⁵⁰ Jeff Foust, Moon Express wins U.S. government approval for lunar lander mission, *Space News*, August 3, 2016. <http://spacenews.com/moon-express-wins-u-s-government-approval-for-lunar-lander-mission/>

⁵¹ Nathaniel Scharping, We're getting serious about mining Asteroids, *Discover*, June 6, 2016.

<http://blogs.discovermagazine.com/d-brief/2016/06/06/luxembourg-mine-asteroids/#.WJIZ6PI942z>

⁵² Lunar Exploration Company ispace Gains Powerful Support as The National Diet of Japan Adopts Resolution, *SpaceRef*, November 9, 2016. <http://spaceref.com/news/viewpr.html?pid=49831>

⁵³ Doug Messier, Private Lunar Exploration Company ispace Collaborates With JAXA on Lunar Resource Development Initiative, *Parabolic Arc*, December 19, 2016. <http://www.parabolicarc.com/2016/12/19/private-lunar-exploration-company-inspace-collaborates-jaxa-lunar-resource-development-initiative/>

Deep Space Industries has unveiled a new satellite platform designed to analyze and catalogue asteroids with a mining potential. The first launch is scheduled for the end of the decade.⁵⁴

Multi-satellite communication constellations

Private companies continue to show interest in launching satellite fleets to provide communication services to large and/or remote areas. OneWeb, a pioneer in this field, plans to launch and operate a constellation of about 650 satellites in LEO. In November, SpaceX applied to the ITU for permission to launch a constellation of 4425 small satellites, for global communication coverage.⁵⁵ The Canadian satellite operator Telesat has also filed for authorization to launch a new constellation of 117 communication satellites in two orbit configurations (polar and inclined). The requirements of the US military were taken into consideration in designing the new fleet. However, it may also serve the planned Canadian project of a network of satellites in polar orbits.⁵⁶ LeoSat and the GlobalSat group have agreed to collaborate on launching up to 108 communication satellites.⁵⁷

This growing trend increases the need to advance regulation that would address all the issues of security and safety in space. An increase is noticed in this context in the influence of the private market, which encourages discussion of these matters, and has been promoting standards independently.⁵⁸ One such example is Planet, which has announced that it would operate under strict standards.⁵⁹

⁵⁴ Jeff Foust, Deep Space Industries unveils first asteroid prospecting spacecraft, *Space News*, August 10, 2016.

<http://spacenews.com/deep-space-industries-unveils-first-asteroid-prospecting-spacecraft/>

⁵⁵ Doug Messier, SpaceX Files for FCC Approval for 4,425 Satellite Global Broadband Constellation, *Parabolic Arc*, November 16, 2016. <http://www.parabolicarc.com/2016/11/16/spacex-files-fcc-approval-4425-satellite-global-broadband-constellation/>

⁵⁶ Peter B. de Selding, Telesat prepares shareholder payday, outlines 117-satellite constellation, *Space News*, November 17, 2016. <http://spacenews.com/telesat-prepares-shareholder-payday-outlines-117-satellite-constellation/>

⁵⁷ LeoSat Lands A Launch Partner With Globalsat Group, *Satnews Daily*, November 30, 2016.

<http://www.satnews.com/story.php?number=1101501682>

⁵⁸ Jeff Foust, White House report endorses FAA oversight of commercial space missions, *Space News*, May 2, 2016.

<http://spacenews.com/white-house-report-endorses-faa-oversight-of-commercial-space-missions/>

⁵⁹ Keeping Space Clean: Cubesat Constellations & Space Debris, *medium.com*, January 20, 2016.

<https://medium.com/@planetlabs/keeping-space-clean-cubesat-constellations-space-debris-f30fcf9ca85b#bk0bsqe0r>

Safety, Security and Sustainability in Space

Space debris: In the past few years, national and international awareness has been growing of the dangers of space debris. As a result, international organizations and various countries have been tackling this issue and began to develop a normative framework to handle this matter. The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) is promoting understandings on dealing with space debris. Ultimately, it aims to establish an international system that would register existing debris on a voluntary basis, to enable mapping and cataloguing all the objects known to be in space.⁶⁰

In June, experts from the ESA Space Debris Office issued a report on the status and envisaged danger of objects in a geo-synchronous orbit. This year, the ESA announced that its vision was "clearing off" the debris of satellites that are no longer operational by means of an e.Deorbit platform that will "catch" the non-operational satellite, and "push" it down, to be burned out in a controlled way in the atmosphere.⁶¹

There is interest in this matter also on the part of countries that are relatively new to space operations. For example, the UAE has announced it was formulating national legislation on this matter based on the existing ESA legislation, and calls for international cooperation on clearing off space debris.⁶² Such examples reflect the growing awareness of the need to handle space debris.

Cyber threats in space: The interface between space and cyber continues to present a significant threat, and international awareness of this issue has been growing. This year, the US and France signed a military-security cooperation agreement on space and cyber.⁶³ The Chatham House policy institute published a research report that warns against the implications of a cyber attack against space infrastructures and assets. It assessed that technology alone is unable to resolve these weaknesses in space, and called on the world to

⁶⁰ Elizabeth Howell, How the UN's Top Outer Space Boss Will Fight Space Debris, *Motherboard*, June 30, 2016.

https://motherboard.vice.com/en_us/article/how-the-uns-top-outer-space-boss-will-fight-space-debris-david-kendall?utm_content=buffer3ffa8&utm_medium=social&utm_source=facebook.com&utm_campaign=buffer

⁶¹ Setting a Satellite to Catch a Satellite, *esa*, July 8, 2016.

http://www.esa.int/Our_Activities/Space_Engineering_Technology/Clean_Space/Setting_a_satellite_to_catch_a_satellite

⁶² Mohammed Al Ahababi, Space debris is no longer just a nuisance ... now it's a threat, *The National*, September 4, 2016.

<http://www.thenational.ae/opinion/comment/space-debris-is-no-longer-just-a-nuisance--now-its-a-threat?>

⁶³ Staff Writers, US, France to Sign Military Space Cooperation Agreement, *Space War*, November 30, 2016.

http://www.spacewar.com/reports/US_France_to_Sign_Military_Space_Cooperation_Agreement_999.html

cooperate and set up a community of strong states and international organizations that would act together.⁶⁴

The Internet of Things (IoT) is expected to continue developing and create an increase in the use of satellite communications. This aspect increases the existing threat, and must be addressed by the satellite operators. In 2016, the operators Thuraya and Inmarsat joined the LoRa Alliance group, which develops standards for IoT products.⁶⁵

Anti-terror warfare satellites: The US has identified the potential of using satellites in anti-terror warfare, and a decision was taken to use the Space-based Infrared System (SBIRS), originally developed to warn against missile launches, in the war against ISIS. US satellites are to provide high-temperature signature identification capabilities, such as small explosions, fires and various military operations.⁶⁶

International Space Station (ISS)

The international space station is scheduled to remain active until 2024, but its mode of operation may undergo changes. In the US, democrat and republican senators have proposed a bill that would oblige NASA to make changes to its mode of operation in the ISS. They maintain that NASA, which currently has full control in this field, should be made primary contractor by an organized and orderly process, and its missions should be redirected to commercial bodies and companies for implementation.⁶⁷ A report prepared by NASA's Office of The Inspector General stated that safety problems revealed in SpaceX and Boeing, would hinder their manned missions to the international space station scheduled for 2017. Given the predicted delay, NASA signed an agreement with Russia's Space Agency to proceed with its launches from Russian territory.⁶⁸ Russia has announced that it was planning to cut down the number of its cosmonauts in the space station from

⁶⁴ Robert Abel, Cyber space wars may require new international regimes, *SC Magazine US*, September 23, 2016. <https://www.scmagazine.com/when-cyber-space-attacks-the-world-may-need-a-new-regime/article/529712/>

⁶⁵ Caleb Henry, Thuraya joins Internet of Things industry group, *Space News*, November 21, 2016. <http://spacenews.com/thuraya-joins-internet-of-things-industry-group/>

⁶⁶ U.S. military missile warning satellite valuable asset in fight with Daesh, *SpaceWatchMe*, October 18, 2016. <http://spacewatchme.com/2016/10/u-s-military-missile-warning-satellite-valuable-asset-fight-daesh/>

⁶⁷ Jeff Foust, NASA bill calls for hard look at Asteroid Redirect Mission, *Space News*, September 16, 2016. <http://spacenews.com/senators-introduce-nasa-authorization-bill/>

⁶⁸ Keith Cowing, NASA OIG Report Predicts Commercial Crew Delay To Late 2018, *NASA Watch*, September 2, 2016. <http://nasawatch.com/archives/2016/09/nasa-oig-report-8.html>

three to two. The reason for this decision is the small number of logistic missions reaching the space station, and the need to make it more efficient.⁶⁹

Use of Small Satellites

The field of small satellites has been gathering momentum. According to a Forecast International study, satellite operators are expected to build in the next decade about 1935 remote-sensing small satellites, amounting to about \$ 29 billion.⁷⁰ This would require developing designated launching means. Launching is the weak point in this field, as it currently relies on launchers that are mainly designed for large satellites. Several projects around the world have been making efforts to develop less expensive and more effective systems. For example, Sweden has begun exploring the option of permitting commercial companies to launch small satellites commercially.⁷¹ **In October, the White House announced a small-satellite initiative** titled Harnessing the Small Satellite Revolution. Great emphasis is being placed on ongoing efforts and initiatives of NASA, the Pentagon and other federal agencies, intended to assist the development of small satellites and enhance utilizing the information received from them.⁷²

NASA has been exploring the option of acquiring scientific information from small satellite operators. To this end, it is to allocate about \$25 million for two or more acquisition agreements, in late 2017.⁷³ **On the military scene,** Raytheon has been developing tiny satellites for real-time support of troops in the field. The project is part of the DARPA SeeMe initiative, which aims to send high-resolution imaging to field mobile devices with a delay of up to about 90 minutes. According to plan, a prototype is to be launched in 2017.⁷⁴ However, a senior US Department of Defense staff member said that despite the remarkable innovation and huge development in the capabilities of small satellites, they are not yet sufficiently effective for military use. Small satellites may save money, but they lack the defensive capabilities required in military space assets, and are unable to offer all the

⁶⁹ Keith Cowing, Russia Begins To Reduce ISS Participation, *NASA Watch*, August 22, 2016.
<http://nasawatch.com/archives/2016/08/russia-begins-t.html>

⁷⁰ SmallSats Play Growing Role in \$29 Billion Remote Sensing Satellite Market, *SpaceWatchMe*, July 19, 2016.
<http://spacewatchme.com/2016/07/smallsats-play-growing-role-29-billion-remote-sensing-satellite-market/>

⁷¹ Behovet av mindre satelliter i omloppsbanan, *regeringen*, May 6, 2016.

<http://www.regeringen.se/artiklar/2016/05/behovet-av-mindre-satelliter-i-omloppsbanan/>

⁷² Jeff Foust, White House announces small satellite initiative, *Space News*, October 21, 2016.

<http://spacenews.com/white-house-announces-small-satellite-initiative/>

⁷³ Jeff Foust, NASA seeks to purchase Earth science data from smallsats, *Space News*, November 9, 2016.

<http://spacenews.com/nasa-seeks-to-purchase-earth-science-data-from-smallsats/>

⁷⁴ David Wichner, Raytheon developing tiny satellites to help troops on ground, *Stars and Stripes*, October 16, 2016.

<http://www.stripes.com/news/us/raytheon-developing-tiny-satellites-to-help-troops-on-ground-1.434391>

desired communication, navigation and intelligence capabilities.⁷⁵ In this context, renewed interest is noticed in **Responsive space** and its principles.⁷⁶ Another satellite will possibly be developed in the series developed in the past.⁷⁷ The renewed interest in this field may have to do with innovations and developments linked with the "new space" trend, whose implementation was impossible or difficult in the past.

Activity details by state

The United States

At the focus of the 2016 events in the USA were the presidential elections and the change of administration. The election results give rise to considerable tension in the US space community including NASA, the national security system and the American space industry towards the entry of President Trump into the White House. Trump appointed an interim team for space matters, and is expected to accelerate the development of offensive capabilities in space.⁷⁸ In this context, researchers have proposed that the US Administration should reassess the US national security strategy in space, towards implementing an approach known as "proactive prevention" that would guarantee ongoing space activity in the next generations, and prevent confrontations in space.⁷⁹ NASA is awaiting the nomination of a new chief. Over 2016, NASA has avoided on several occasions taking weighty decisions before the new administration settles in.

Despite funding constraints, NASA has proceeded with its asteroid redirect mission (ARM). It continued looking for commercial partners to enter certain parts of the program, such as launching additional research payloads and solar electric propulsion.⁸⁰ In 2021, NASA plans to redirect part of an asteroid, and send astronauts in 2026 to test the

⁷⁵ Phillip Swarts, Smallsats still need to prove their military utility, Air Force space official says, *Space News*, October 25, 2016. <http://spacenews.com/smallsats-still-need-to-prove-their-military-utility-air-force-space-official-says/>

⁷⁶ Mike Gruss, A twist in the Air Force's outyear budget: funding for ORS, *Space News*, January 28, 2016. <http://spacenews.com/a-twist-in-the-air-forces-outyear-budget-funding-for-ors/>

⁷⁷ Mike Gruss, U.S. STRATCOM considering a follow-on to ORS-1 surveillance satellite, *Space News*, May 27, 2016. <http://spacenews.com/u-s-stratcom-considering-a-follow-on-to-ors-1-surveillance-satellite/>

⁷⁸ Doug Messier, Trump Expected to Boost Missile Defense, Space Weapons, *Parabolic Arc*, November 23, 2016. <http://www.parabolicarc.com/2016/11/23/trump-expected-boost-missile-defense-space-weapons/>

⁷⁹ Marcia S. Smith, Atlantic Council Experts Argue for New "Proactive Prevention" National Security *Space Strategy*, *SpacePolicyOnline.com*, June 21, 2016. <http://www.spacepolicyonline.com/news/atlantic-council-experts-argue-for-new-proactive-prevention-national-security-space-strategy>

⁸⁰ Jeff Foust, NASA planning asteroid mission reviews despite funding uncertainty, *Space News*, June 23, 2016. <http://spacenews.com/nasa-planning-asteroid-mission-reviews-despite-funding-uncertainty/>

redirected part and retrieve samples for further research.⁸¹ In September, NASA successfully launched the unmanned spacecraft OSIRIX-Rex, whose mission is to land on the asteroid Bennu and collect dust and other samples to bring back to earth in 2023.⁸² In spite of criticism and doubts about the program's contribution, and although there were demands to stop its funding in 2017,⁸³ NASA went on advancing it.⁸⁴

In 2016, a process was embarked on to revise the powers of the Federal Aviation Administration (FAA) in two spheres: **Responsibility for space situational awareness, and regulation of commercial launches in the US.**⁸⁵ The two processes are currently underway, and require the approval of the House of Representatives and relevant legislation. Over 2016, US legislators brought up the need to transfer the responsibility for providing information on space situational awareness from the USAF to a civilian agency, preferably the FAA.⁸⁶ The new administration is responsible for promoting the reform.⁸⁷ The FAA and some industrialists expressed support for the idea of transferring the responsibility for space traffic management and collision alerts from the USAF to the FAA. Although the FAA is currently considering ways to perform this task, preliminary cost estimates stand at about \$ 20 million per year.⁸⁸ The supporters of this move argue that once the USAF stops monitoring civilian space assets, it would be able to go on protecting its security assets, while diverting manpower to national security missions.⁸⁹

The second process focuses on enhancing supervision on commercial launches. To this end, the FAA has developed a more effective system to coordinate commercial space launches. At present, the airspace of broad areas must be closed for space launches. This seriously undermines the routine activity of aircraft, especially considering the increasing rate of commercial space launches. The FAA is therefore looking for ways to improve automatic

⁸¹ Rob Verger, NASA is going to an asteroid, and it wants your help, *FoxNews.com*, August 17, 2016.

http://www.foxnews.com/science/2016/08/17/nasa-is-going-to-asteroid-and-it-wants-your-help.html?cmpid=NL_SciTech

⁸² Jeff Foust, Atlas 5 launches NASA asteroid sample return mission, *Space News*, September 8, 2016.

<http://spacenews.com/atlas-5-launches-nasa-asteroid-sample-return-mission/>

⁸³ Jeff Foust, Congress questions report on benefits of Asteroid Redirect Mission, *Space News*, November 30, 2016.

<http://spacenews.com/congress-questions-report-on-benefits-of-asteroid-redirect-mission/>

⁸⁴ Jeff Foust, NASA moves ahead with Asteroid Redirect Mission despite cost increase, *Space News*, August 16, 2016.

<http://spacenews.com/nasa-moves-ahead-with-asteroid-redirect-mission-despite-cost-increase/>

⁸⁵ Jeff Foust, Proposed legislation would close commercial space regulatory gap, *Space News*, September 15, 2016.

<http://spacenews.com/proposed-legislation-would-close-commercial-space-regulatory-gap/>

⁸⁶ Jeff Foust, Bridenstine to introduce space policy bill in April, *Space News*, February 26, 2016.

<http://spacenews.com/bridenstine-to-introduce-space-policy-bill-in-april/>

⁸⁷ Jeff Foust, Commercial space industry seeks regulatory reforms in the Trump administration, *Space News*, November

17, 2016. <http://spacenews.com/commercial-space-industry-seeks-regulatory-reforms-in-the-trump-administration/>

⁸⁸ Jeff Foust, FAA estimates space traffic management costs at under \$100 million, *Space News*, October 26, 2016.

<http://spacenews.com/faa-estimates-space-traffic-management-costs-at-under-100-million/>

⁸⁹ Brian Weeden, Time For The U.S. Military To Let Go Of The Civil Space Situational Awareness Mission, *Space News*, September 12, 2016. http://bt.e-ditionsbyfry.com/display_article.php?id=2583589&id_issue=337564

tracking of space launches and landings, to reduce significantly flight disruption due to airspace closures.⁹⁰ The US House of Representative has also promoted a bill on FAA authority regarding the activities of space ports used for launches.⁹¹

In the sphere of **space security**, awareness of threats against US space assets kept growing. There is concern about development of anti-satellite capabilities by Russia and China.⁹² The Pentagon and the Intelligence Community have expressed increasing concern about the ability of foreign countries to attack national and commercial satellites on Department of Defense missions.

Given the need to deal with the threats facing the US space assets, the USAF has significantly changed its task definitions and has expanded its space-warfare training program. Its underlying ideological guideline is the Space Enterprise Vision (SEV) initiative, developed under General Hayten, which aims to prepare the US space forces for the next conflict by joining the different forces, bolstering space power and developing threat-reaction capabilities. Attaining these goals would require the following: Enhanced space situational awareness, bridging the divide between different intelligence agencies and spreading out important assets to create strategic flexibility.⁹³ As part of the program, the combat forces will exercise operating military satellites in a hostile environment, including threat reaction tactics. This will ensure that the training of space system operators will match that of the aerial forces. The program aims to challenge the traditional approach, and reassess recent developments in the field, to prevent space wars.⁹⁴

In 2016, the Joint Interagency Combined Space Operations Center (JICSPOC), carried out five test and training rounds to check the reaction of the US defense system to hostile activity in space.⁹⁵ The Department of Homeland Security has taken the necessary measures

⁹⁰ Jeff Foust, Virgin Galactic receives FAA license for SpaceShipTwo tests, *Space News*, August 2, 2016.

<http://spacenews.com/virgin-galactic-receives-faa-license-for-spaceshiptwo-tests/>

⁹¹ Jeff Foust, House advances commercial space and astronaut health bills, *Space News*, September 22, 2016.

<http://spacenews.com/house-advances-commercial-space-and-astronaut-health-bills/>

⁹² Staff Writers, Role of Diplomacy in Keeping Outer Space Safe, Secure and Sustainable, *Space Safety*, July 9, 2016.

<http://www.spacesafetymagazine.com/space-on-earth/space-policy/role-diplomacy-keeping-outer-space-safe-secure-sustainable/>

⁹³ Colin Clark, Space Command readies for War with “Space Enterprise Vision”, *Breaking Defense*, June 20, 2016.

<http://breakingdefense.com/2016/06/space-command-readies-for-war-with-space-enterprise-vision/>

⁹⁴ Mike Gruss, U.S. Air Force expands space warfare training, *Space News*, July 20, 2016. <http://spacenews.com/u-s-air-force-expands-space-warfare-training/>

⁹⁵ Dee Ann Divis, Homeland Security, PNT ExCom Move on Backing up GPS, *Inside GNSS*, June 30, 2016.

<http://www.insidegnss.com/node/5010?>

to create backup capabilities for data received from the GPS system, with a view to develop capabilities to protect critical infrastructures against timing disruptions or spoofing.⁹⁶

In the sphere of **space situational awareness**, the USAF has acted to improve its ability to track space situation by using a telescope developed by DARPA, that would considerably enhance surveillance of objects in space.⁹⁷ Once the Space Fence system becomes operational in 2018, it will be able to identify and track space objects as small as 5cm, thus significantly improving existing surveillance capabilities. This enhanced accuracy will face the USAF with the need to track and manage data on some 200,000 objects, a vast increase compared to the current 20,000 objects.⁹⁸ Spain joined the international network the US is setting up through bilateral agreements.⁹⁹ The UAE also joined this US initiative.¹⁰⁰

General John Raymond, who took office this year as Commander, USAF Space Command, announced he was planning to change significantly the nature of the USAF space and cyber activities. He maintains that the Space Command must collaborate with the intelligence community and other government agencies, alongside the US allies and the commercial-civilian sector, to meet the new challenges and threats more effectively. His goals to this end include improving satellite durability, using less expensive launchers, achieving shorter launching processes and enhancing situational space awareness.¹⁰¹

The recent trend of commercializing and privatizing the US space activities, which became more prominent in 2015 continued through 2016. One of its supporters is Doug Loverro, Deputy Assistant Secretary of Defense for Space Policy, who said that the US administration must rethink its policy of work with private commercial companies, to improve work methods and enhance economic and business efficiency.¹⁰² Privatization had two main focuses this year – space launches and imaging.

⁹⁶ Dee Ann Divis, Homeland Security, PNT ExCom Move on Backing up GPS, *Inside GNSS*, June 30, 2016.
<http://www.insidegnss.com/node/5010?>

⁹⁷ DARPA to Transfer Space Surveillance Telescope to U.S. Air Force, *DARPA*, October 18, 2016.
<http://www.darpa.mil/news-events/2016-10-18>

⁹⁸ Mike Gruss, More satellite collision warnings to come with Space Fence data, *Space News*, September 22, 2016.
<http://spacenews.com/more-satellite-collision-warnings-to-come-with-space-fence-data/>

⁹⁹ Staff Writers, US, Spain to Jointly Monitor Outer Space Traffic, *Space Daily*, February 18, 2016,
http://www.spacedaily.com/reports/US_Spain_to_Jointly_Monitor_Outer_Space_Traffic_999.html

¹⁰⁰ Brian Berger, U.S. agrees to share space situational awareness data with UAE, *Space News*, April 12, 2016.
<http://spacenews.com/u-s-agrees-to-share-space-situational-awareness-data-with-uae/>

¹⁰¹ Staff Writers, Raymond returns to a different Space Command, *Space War*, November 21, 2016.
http://www.spacewar.com/reports/Raymond_returns_to_a_different_Space_Command_999.html

¹⁰² Phillip Swarts, Loverro: U.S. government needs to rethink how it works with private space ventures, October 26, 2016.
<http://spacenews.com/csis-space-panel-story/>

Launches:

- In late July, a classified NRO satellite was launched aboard the Atlas-5 launcher.¹⁰³
- In August, the Air force signed an exclusive contract with ULA for the development, construction and launching of two Delta 4 heavy launchers, on a secret NRO mission.¹⁰⁴ Note that as part of its new program, ULA will be able to launch main payloads aboard the Atlas-5 at about three months notice. This move is meant to improve the services ULA offers on the launch market.¹⁰⁵

Imaging:

- In July, the two American space intelligence agencies – National Geospatial Intelligence Agency and NRO) announced they would collaborate on acquiring data and imaging from commercial satellites, as part of an initiative titled GEOINT.¹⁰⁶ Experts in this field have expressed satisfaction with this move, and stated it would enable more efficient utilization of the information.¹⁰⁷
- In June, the DIA signed a contract with DigitalGlobe to provide advanced analytic services.¹⁰⁸
- According to an August report, the US Army has expressed interest in small satellite system detectors, to acquire imaging and information that would improve space situational awareness.¹⁰⁹
- In September, the NOAA began a first-of-its-kind pilot for receiving information from commercial weather satellites, as part of a precedential program that might lead to extensive use of information from commercial satellites.¹¹⁰

¹⁰³ Justin Ray, Mystery payload for spy satellite agency launching aboard next Atlas 5, *Spaceflight Now*, July 10, 2016. <http://spaceflightnow.com/2016/07/10/mystery-payload-for-spy-satellite-agency-launching-aboard-next-atlas-5/>

¹⁰⁴ Mike Gruss, No complaint from SpaceX as Air Force skips competition for pair of NRO missions, *Space News*, August 8, 2016. <http://spacenews.com/u-s-air-force-plans-to-buy-2-delta-4-heavy-rockets-for-nro-missions/>

¹⁰⁵ Mike Gruss, ULA says it could accommodate additional Atlas 5 launch next year, *Space News*, September 14, 2016. <http://spacenews.com/ula-says-it-could-accommodate-additional-atlas-5-launch-next-year/>

¹⁰⁶ Mike Gruss, Intelligence agencies announce new cooperation on commercial imagery, *Space News*, July 17, 2016. <http://spacenews.com/intelligence-agencies-announce-new-cooperation-on-commercial-imagery/>

¹⁰⁷ Improving What The IC Sees, *Space News*, August 15, 2016. http://bt.editionsbyfry.com/display_article.php?id=2558741&id_issue=329533

¹⁰⁸ Staff Writers, DigitalGlobe Awarded Sole-Source Contract to Provide Advanced Analytic Services to the DIA, *Space Daily*, June 24, 2016. http://www.spacedaily.com/reports/DigitalGlobe_Awarded_Sole_Source_Contract_to_Provide_Advanced_Analytic_Services_to_the_DIA_999.html

¹⁰⁹ Phillip Swarts, Air Force picks ADS to demo an all-commercial alternative to Space-Track catalog, *Space News*, November 4, 2016. <http://spacenews.com/air-force-picks-ads-to-demo-an-all-commercial-alternative-to-space-track-catalog/>

¹¹⁰ Jeff Foust, Two companies win first NOAA commercial weather contracts, *Space News*, September 15, 2016. <http://spacenews.com/two-companies-win-first-noaa-commercial-weather-contracts/#sthash.IXUgMHSf.dpuf>

DARPA and NASA continued negotiations for further cooperation on the satellite services initiative, including developing safety and operational procedures for on-orbit satellite service missions.¹¹¹ As part of this initiative, DARPA has been promoting the project of Robotic Servicing of Geosynchronous Satellites (RSGS), a robotic service platform capable of performing various activities in geosynchronous orbits, such as damage control or "release" of a "stuck" solar panel. The system is scheduled for first launching in late 2020 or early 2021.¹¹²

The Russian launcher-engine affair and future of the US launchers: The prohibition on incorporating Russian-made engines in American launchers is far from being resolved. The affair, initially an international one, has turned into an internal US political issue. Various elements in congress have been pressuring to maintain a strict approach, while the US security system felt that creative solutions must be sought to enable using the engines for longer periods. The reasons behind this argument are the delay in developing alternatives and the wish to develop a new launcher rather than invest efforts in developing an alternative engine.¹¹³

An initiative for using ballistic missiles as launchers in the space industry is on the agenda of government, military and commercial bodies, which have been expressing diverse views on this issue: Orbital has been pressuring the US legislators to remove the ban on using old ballistic missiles as launchers.¹¹⁴ In late April, an advisory committee of the Federal Aviation Agency recommended not to change the current procedure regarding the use of ballistic missiles, especially in view of the concern expressed by commercial companies.¹¹⁵ In contrast, General Hyten thinks the US must approve selling decommissioned ICBMs to the space industry. He maintains that the missiles should be sold to the industry at a price that would prevent flooding the growing launcher market.¹¹⁶

¹¹¹ Debra Werner, Nasa, Darpa, *Space News*, June 20, 2016. http://bt.editionsbyfry.com/display_article.php?id=2513387&id_issue=313583

¹¹² Mike Gruss, SSL wins \$20 million DARPA contract to build robotic arms, *Space News*, July 22, 2016. <http://spacenews.com/ssl-wins-20-million-darpa-contract-to-build-robotic-arms/>

¹¹³ Mike Gruss, White House requests \$1.2 Billion for new rocket in Air Force budget, *Space News*, February 9, 2016. <http://spacenews.com/white-house-requests-1-2-billion-for-new-rocket-in-air-force-budget/>

¹¹⁴ Staff Writers, Space Subcommittee examines commercial challenges, *Space Daily*, April 22, 2016. http://www.spacedaily.com/reports/Space_Subcommittee_examines_commercial_challenges_999.html

¹¹⁵ Jeff Foust, FAA advisory committee recommends no changes to ICBM motor policy, *Space News*, April 29, 2016. <http://spacenews.com/faa-advisory-committee-recommends-no-changes-to-icbm-motor-policy/#sthash.w1yFVMIJ.dpuf>

¹¹⁶ Lara Seligman, Hyten: Let Industry Buy ICBMs for Space Launch at Fair Price, *Defense One*, April 14, 2016. <http://www.defensenews.com/story/defense/show-daily/space-symposium/2016/04/14/hyten-let-industry-buy-icbms-space-launch-fair-price/83052938/>

The US administration promoted temporary legislation to keep budgeting the import-export bank. The Obama administration acted to formulate a temporary amendment that would enable Ex-Im Bank to continue financing large deals, such as commercial satellite ones. The bank is currently restricted in its ability to finance projects of over \$10 million. The administration argued that inability to finance high-cost projects has resulted in American companies taking their businesses abroad, where foreign financing companies give them the required credit. The bank's former customers included companies such as Boeing and Orbital ATK.¹¹⁷ In the first four months of 2017, the Trump administration has been acting to enable continuation of the bank's work.¹¹⁸

Russia

Russia is interested in deepening its **involvement in the global space industry** by taking active part in international commercial projects. Its ultimate goal is getting recognition as a significant power in that industry.¹¹⁹ To this end, Russia's space agency has begun developing new heavy launchers that would be installed with the RD-171 launcher engine.¹²⁰ These launchers will be capable of launching and transporting the supplies required to build a moon base.¹²¹ However, economic constraints have obliged Russia to spread out its planned schedules and seek collaborations that would help her cover the costs.¹²²

Russia continued promoting its **military space activities**. American sources have reported that Russia conducted two tests with an anti-satellite system. In a test apparently performed in late May, Russia tested an upgraded rocket weapon system, capable of intercepting

¹¹⁷ Jeff Foust, Temporary spending bill could end Ex-Im Bank logjam, *Space News*, August 31, 2016.

<http://spacenews.com/temporary-spending-bill-could-end-ex-im-bank-logjam/>

¹¹⁸ Jeff Foust, Trump nominates two former congressmen to Ex-Im Bank board, *Space News*, April 17, 2017.

<http://spacenews.com/trump-nominates-two-former-congressmen-to-ex-im-bank-board/#sthash.eN6hyFM4.dpuf>

¹¹⁹ Staff Writers, Russia must strengthen role in global space industry, *Space Daily*, November 17, 2016.

http://www.spacedaily.com/reports/Russia_must_strengthen_role_in_global_space_industry_999.html

¹²⁰ Staff Writers, Russia to design super-heavy carrier rocket, *Space Daily*, August 24, 2016.

http://www.spacedaily.com/reports/Russias_Space_Agency_Roskosmos_Begins_to_Design_Super_Heavy_Carrier_Rocket_999.html

¹²¹ Julian Robinson, Russia is developing a mega-rocket that will transport supplies to build a base on the Moon, Deputy PM reveals, *Mail Online*, November 28, 2016. <http://www.dailymail.co.uk/news/article-3978816/Russia-developing-mega-rocket-transport-supplies-build-base-MOON-Deputy-PM-reveals.html>

¹²² Staff Writers, Russia postpones manned lunar mission to 2035, *Moon Daily*, January 21, 2016.

http://www.moondaily.com/reports/Russia_postpones_manned_Lunar_mission_to_2035_999.html

satellites on orbit.¹²³ American sources reported In December that Russia performed another test with an anti-satellite missile.¹²⁴

A new spaceport: In late April, a new spaceport was inaugurated in Vostochny. Russia invested enormous sums of money in the project.¹²⁵

July reports mentioned that Russia was developing a nuclear bomber that would operate in space, similar to the US secret aircraft, X-37B. The Russian aircraft is expected to be larger and capable of dropping nuclear bombs.¹²⁶

Russia is planning to deploy a new system to track objects in space. The system is defined as a "next generation" one and will be installed with cutting-edge hardware.¹²⁷ In June, Russia announced initial testing of a telescope designed to identify asteroids at distances of thousands of kilometers away from the earth, to alert against possible collisions.¹²⁸

Satellite development:

- Russia has been advancing towards testing its new-generation surveillance satellites. Senior functionaries in Russia's space agency have stated that the agency will begin testing the surveillance satellites system, Rsurs-PM, in 2020.¹²⁹
- Another new intelligence satellite system, Razdan, is also under development. It is estimated that Russia is planning to upgrade significantly the optical and encrypted communication capabilities of the system's components.¹³⁰

¹²³ Bill Gertz, Russia Flight Tests Anti-Satellite Missile, *The Washington Free Beacon*, March 27, 2016.

<http://freebeacon.com/national-security/russia-flight-tests-anti-satellite-missile/>

¹²⁴ Doug Messier, Report: Russia Tested Anti-Satellite Missile, *Parabolic Arc*, December 22, 2016.

<http://www.parabolicarc.com/2016/12/22/report-russia-tested-antisatellite-missile/>

¹²⁵ Staff Writers, Russia Spend \$1.3Bln on Vostochny Cosmodrome So Far, *Space Daily*, May 17, 2016.

http://www.spacedaily.com/reports/Russia_Spent_1_3Bln_on_Vostochny_Cosmodrome_So_Far_999.html

¹²⁶ David Axe, Russia is building a nuclear space bomber, *The Daily Beast*, July 14, 2016.

<http://www.thedailybeast.com/articles/2016/07/14/russia-is-building-a-nuclear-space-bomber.html>

¹²⁷ Staff Writers, Russia to Deploy New Space Surveillance System Elements in Four Regions, *Space War*, November 29, 2016.

http://www.spacewar.com/reports/Russia_to_Deploy_New_Space_Surveillance_System_Elements_in_Four_Regions_999.html

¹²⁸ Staff Writers, High-Tech Telescope for Dangerous Asteroids Detection Launched in Russia, *Space Daily*, June 20, 2016.

http://www.spacedaily.com/reports/High_Tech_Telescope_for_Dangerous_Asteroids_Detection_Launched_in_Russia_999.html

¹²⁹ Staff Writers, Russian New Generation Satellites to Undergo First Flight Tests in 2020, *Space Daily*, November 16, 2016.

http://www.spacedaily.com/reports/Russian_New_Generation_Satellites_to_Undergo_First_Flight_Tests_in_2020_999.html

¹³⁰ Staff Writers, Russian New Generation Satellites to Undergo First Flight Tests in 2020, *Space Daily*, November 16, 2016.

http://www.spacedaily.com/reports/Russian_New_Generation_Satellites_to_Undergo_First_Flight_Tests_in_2020_999.html

- Russia's space agency has been developing new generation communication satellites for the Russian military. Once completed, the Russian military forces will be equipped with a high-quality communication system considered superior to similar systems around the world.¹³¹

China

China continues its efforts to bolster its status on the global space scene. To this end, it has **reorganized its land forces and set up a strategic arm** that would include, among other things, space and cyber components. As part of this reorganization, a Strategic Support Corps was established, to take command of China's space, electronic warfare and network warfare forces. China will focus its efforts on preparing to fight and win the "local information war". The establishment of a Strategic Support Corps points at the way China envisages managing the next war: The importance of space warfare will increase at the expense of the ground forces. China's president expects a forward boost and accelerated development of various warfare methods. The Chinese army is to play a significant role in space warfare, electronic warfare and network warfare. At the onset of the reorganization process, many cyber responsibilities were transferred to the new arm.¹³²

In late 2016, China issued a document that summarized its recent space activities (China's Space Activities in 2016). The document describes China's space activities in the past five years, and outlays its vision for the next five years. The writers underline the importance of China's use of space for peaceful purposes, and state its vision of being a space superpower that carries out independent research and trains expert teams. The writers also point out that since 2011, China has invested much effort in developing manned space missions, and will continue this trend in the next five years while investing in its industry. In 2018, China plans a moon landing, and by 2020 it plans to land a spacecraft on Mars. By 2020, the BeiDou navigation system will comprise 35 satellites and will offer global coverage.¹³³

In 2016, China has continued advancing its space station project, with a view to promote the technologies and knowledge required for a long stay in space and for energy production

¹³¹ Staff Writers, Russian New Generation Satellites to Undergo First Flight Tests in 2020, *Space Daily*, November 16, 2016.

http://www.spacedaily.com/reports/Russian_New_Generation_Satellites_to_Undergo_First_Flight_Tests_in_2020_999.html

¹³² Dean Cheng, The dragon reorganizes for space, *Space News*, January 28, 2016. <http://spacenews.com/the-dragon-reorganizes-for-space/>

¹³³ China's Space Activities in 2016, *People Daily Online*, December 27, 2016. <http://en.people.cn/n3/2016/1227/c90000-9159803-5.html>

in space.¹³⁴ The space laboratory Tiangong-2 was launched in September as an early test module for the future space station.¹³⁵ For the first time in about three years, China launched a manned mission, Shenzhou-11, in which two taikonauts spent 30 days in the space station.¹³⁶ China announced its wish to promote collaboration on operations related to the space station, and said it was planning for other countries to help finance the tests via the UN.¹³⁷

China has kept investing in the development of launching capabilities. It has been promoting the development of new launchers that would make deep space missions possible, and has inaugurated four new launchers in less than 14 months, two of which in 2016. In 2017, it plans to launch for the first time a small launcher from a site outside China.¹³⁸

China and the US continued their dialogue, and convened for the first time in Washington in May 2016, to discuss information exchange on space security. Priorities were set for advancing scientific activity in space for the benefit of the Earth. An experts' workshop was designed to reduce space debris and prevent satellite collision, and thus enhance the safety of operations in outer space.¹³⁹ The parties undertook to act towards achieving these goals by intensive collaboration, expanding their agreements and taking confidence-building measures. In October, China and the US conducted a second strategic dialogue on civilian space, during which their representatives exchanged information on space policy, space programs and potential future collaboration related to Earth, the space sciences, weather, space debris and flight safety.¹⁴⁰

On the military scene, China successfully launched a secret satellite, the Roaming Dragon, officially designed to collect space debris by controlled shifting of old platforms or spacecraft back to earth. However, some of the satellite's features enable converting it into a

¹³⁴ Staff Writers, China's ambition after space station, *Space Daily*, March 8, 2016.

http://www.spacedaily.com/reports/Chinas_ambition_after_space_station_999.html

¹³⁵ Mike Wall, China Launches Tiangong-2 Space Lab to Prep for 2020's Space Station, *Space.com*, September 15, 2016.

<http://www.space.com/34077-china-launches-tiangong-2-space-lab.html>

¹³⁶ Jeff Foust, China's Shenzhou-11 docks with the Tiangong-2 module for month-long stay, *Space News*, October 19,

2016. <http://spacenews.com/chinas-shenzhou-11-docks-with-the-tiangong-2-module-for-month-long-stay/>

¹³⁷ Peter B. de Selding, China prepares assembly of its space station, invites collaboration through U.N., *Space News*, June

20, 2016. <http://spacenews.com/china-prepares-assembly-of-its-space-station-invites-collaboration-through-u-n/>

¹³⁸ Doug Messier, China on a Tear with New Launch Vehicles, *Parabolic Arc*, November 3, 2016.

<http://www.parabolicarc.com/2016/11/03/china-tear-launch-vehicles/>

¹³⁹ Staff Writers, China, U.S. hold first dialogue on outer space safety, *Space Daily*, May 16, 2016.

http://www.spacedaily.com/reports/China_U_S_hold_first_dialogue_on_outer_space_safety_999.html

¹⁴⁰ Doug Messier, Second Meeting of the U.S.-China Space Dialogue Conducted, October 25, 2016.

<http://www.parabolicarc.com/2016/10/25/meeting-uschina-space-dialogue-conducted/>

weapon that could disrupt or de-orbit the satellites of enemy countries.¹⁴¹ China also launched an experimental "hack-proof" communication satellite that will test the using quantum technology in transmitting encrypted satellite messages. If the experiment proves successful, it will be an innovative landmark in encrypted global communications, as quantum encryption is non-crackable and changes with every interruption of the message.¹⁴²

India

In 2016, India began privatizing its space industry, as part of a general privatization trend. India's space agency signed a contract with the six-company consortium Alpha Design Technologies, under which a satellite will be developed and produced for the first time exclusively by India's industry. The contract covers development, assembly, integration and testing of two spare navigation satellites within eighteen months.¹⁴³

A decision was taken to hand over the operation of the PSLV launcher to the private sector.¹⁴⁴ This decision is in line with the trend of privatizing LEO operations that has been noticed among other leading players on the space scene.

India is simultaneously acting to upgrade its GEO launching capabilities by developing a new enhanced-capability GSLV launcher.¹⁴⁵ By mid-2016, the IRNSS project had been completed with the launching of the sixth¹⁴⁶ and seventh¹⁴⁷ satellites.

Over 2016, India bolstered her regional connections, setting up satellite monitoring stations in Vietnam and Indonesia.¹⁴⁸

¹⁴¹ David Axe, Is China's mysterious new satellite really a junk collector – or a weapon?, *The Daily Beast*, July 5, 2016. <http://www.thedailybeast.com/articles/2016/07/05/is-china-s-mysterious-new-satellite-really-a-junk-collector-or-a-weapon.html>

¹⁴² Swati Khandelwal, China launches world's 1st 'Hack-Proof' Quantum Communications Satellite, *The Hacker News*, August 15, 2016. <http://thehackernews.com/2016/08/quantum-communication-satellite.html>

¹⁴³ Doug Messier, ISRO signs deal for privately built satellite, *Parabolic Arc*, December 22, 2016. <http://www.parabolicarc.com/2016/12/22/isro-signs-deal-privately-built-satellite/>

¹⁴⁴ Jeff Foust, India to hand over PSLV operations to private sector, *Space News*, February 15, 2016. <http://spacenews.com/india-to-hand-over-pslv-operations-to-private-sector/>

¹⁴⁵ Pallava Bagla, '100% Success' Says ISRO As PSLV Rocket Places 8 Satellites Into Orbit: 10 Points, NDTV.com, September 26, 2016. <http://www.ndtv.com/india-news/in-isros-longest-mission-rocket-launched-with-8-satellites-1466389>

¹⁴⁶ Staff Writers, ISRO launches PSLV C32, India's sixth navigation satellite, *Space Daily*, March 10, 2016. http://www.spacedaily.com/reports/ISRO_launches_PSLV_C32_Indias_sixth_navigation_satellite_999.html

¹⁴⁷ Staff Writers, Operation of 'Indian GPS' will take some more time: ISRO, *GPS Daily*, May 4, 2016. http://www.gpsdaily.com/reports/Operation_of_Indian_GPS_will_take_some_more_time_ISRO_999.html

¹⁴⁸ India establishes satellite monitoring station in Vietnam for South China Sea activities, *Satnews*, January 4, 2016. <http://www.satnews.com/story.php?number=183056000>

A significant event occurred in June, when India joined the Missile Technology Control Regime (MTCR). India's participation may facilitate signing coveted weapon deals with other member countries. Against this backdrop, the USA was considering to revise its policy and permit launches from India.¹⁴⁹

Japan

Japan's need for military communication capabilities has grown owing to the tension with China along China's eastern coast. However, the launching of a Japanese military communication satellite has been delayed due to an accident that occurred en route to the launching base.¹⁵⁰ According to a November announcement, Japan's Ministry of Defense was planning to launch the military communication satellite in January 2017. The satellite is to replace civilian communication systems currently used by the Japanese military.¹⁵¹

As mentioned above, Japan has been displaying interest in space mining, and has begun formulating the required regulation. At the end of 2016, Japan's space agency signed an MOU with the Japanese company ispace that specializes in micro-technologies designed to utilize space resources. Under the contract, a roadmap will be designed towards developing and utilizing moon resources. The parties plan to develop a work plan for setting up an ore mining and resource development industry on the moon, and developing ore transportation means.¹⁵²

Europe

The European Commission declared a new space strategy intended to attract private investments and develop space startup companies. The Commission's space budget for 2014-2020 amounts to €12 billion (about \$13.5 billion). Most of the budget will be allocated to the Galileo navigation system and to the Copernicus program. In the coming decade, about 30 satellites will be launched as part of these programs.

¹⁴⁹ Jeff Foust, House committee seeks details on Indian launch policy, *Space News*, July 6, 2016.

<http://spacenews.com/house-committee-seeks-details-on-indian-launch-policy/>

¹⁵⁰ Nobuhiro Kubo, Sources: Tarpaulin delays Japanese military communications satellite by two years, *Space News*, July 19, 2016. <http://spacenews.com/sources-tarpaulin-delays-japanese-military-communications-satellite-by-two-years/>

¹⁵¹ Staff Writers, Japan to Launch First Military Communications Satellite on January 24, *Space War*, November 29, 2016. http://www.spacewar.com/reports/Japan_to_Launch_First_Military_Communications_Satellite_on_January_24_999.html

¹⁵² Doug Messier, Private Lunar Exploration Company ispace Collaborates with JAXA on Lunar Resource Development Initiative, *Parabolic Arc*, December 19, 2016. <http://www.parabolicarc.com/2016/12/19/private-lunar-exploration-company-ispace-collaborates-jaxa-lunar-resource-development-initiative/>

Europe's policy simultaneously focuses on formulating a viable space economy that involves private initiatives and investments. Europe aspires to follow the US example, which relies heavily on private investments, specifically ones made by the two billionaire owners of SpaceX and Blue Origin, who have been investing in space without definite prospects of profit in the near future. Other than private investments, the European Commission will also invest in a program for the enhancement of space situational awareness, to protect critical infrastructures from space debris, weather hazards and cyber attacks.

The Commission has also undertaken to resume supporting the GovSatCom program designed to update the European states' military needs for satellite communication , a challenge which had not been met earlier due to various sovereignty issues. The European Defense Action Plan was to be published in late 2016, and should resolve the difficulties encountered in implementing the GovSatCom program.¹⁵³

In October, **The European Space Agency** and the European Commission announced their joint vision and goals for Europe in space. Three main goals were defined for the next few years: 1) Maximizing the integration between space, European society and the economy by implementing space technologies and applications. 2) Upholding the international competitiveness of Europe's space sector by sponsoring research, innovation, initiative and additional jobs. 3) Ensuring Europe's capability to access space and utilize it.¹⁵⁴

The 18% increase in the ESA 2016 budget was mainly dedicated to the EU Copernicus and Galileo projects.¹⁵⁵ In December, the agency announced that the Galileo navigation system had reached initial operational readiness, and would begin providing services to users in Europe. Additional launches are scheduled, to improve the system's quality and coverage.¹⁵⁶

Investments made this year were used to set up business incubators to promote everyday application of space technologies. The initiative includes about 15 incubators in nine

¹⁵³ Peter B. de Selding, EU's new space policy to invest in startups, boost private investment, October 26, 2016. <http://spaceneews.com/eu-commissions-new-space-policy-to-invest-in-startups-to-boost-private-investment/>

¹⁵⁴ ESA, Shared Vision and Goals for the Future of Europe in Space, *ESA*, October 26, 2016.

http://m.esa.int/About_Us/Welcome_to_ESA/Shared_vision_and_goals_for_the_future_of_Europe_in_space

¹⁵⁵ Peter B. de Selding, ESA members give space agency an 18-percent budget boost, *Space News*, January 15, 2016.

<http://spaceneews.com/esa-members-give-space-agency-an-18-percent-budget-boost/>

¹⁵⁶ Galileo Gets Going, *Satnews*, December 19, 2016. <http://www.satnews.com/story.php?number=526600238>

European countries receiving technical support from the ESA and business support from partner companies.¹⁵⁷

In November, the ESA ratified its commitment to complete the development of the Ariane 6 launcher by 2023, amounting to €2.4 billion (\$2.5 billion).¹⁵⁸ The ESA has been advancing its plan to build a permanent research station on the moon. The agency has begun preparations to develop moon-landing capabilities, and an agreement was signed with Airbus to this end.¹⁵⁹

Strengthening the space sector: In the past few years, the **United Kingdom** has invested considerable efforts into promoting its space sector. Studies have shown that this investment is bearing fruit and the sector is rapidly growing.¹⁶⁰ In view of this, activities have continued to advance the space program further by legislation that would boost commercial activities.¹⁶¹ In July, the British government signed contracts with five industrial research groups, to investigate the feasibility and practicability of setting up and operating a commercial spaceport on British soil. Emphasis was placed on developing and operating commercial launching platforms.¹⁶²

Following the **Brexit vote**, concern has grown about the fate of Britain's space program, given the possible implications of Britain's detachment from the EU. Although this is expected to be a gradual two-year process, it is not clear how Britain's quitting Europe's space programs (but not the ESA) will impact the programs and Britain's part in them. About 75% of Britain's space investments are made to the ESA, which is not part of the EU. Therefore, no changes are foreseen in this arena due to the Brexit. In contrast, Britain's part in the Galileo and Copernicus programs is unclear, as quitting may affect Britain's space investments.¹⁶³ Nevertheless, British politicians are resolved to protect the local space

¹⁵⁷ ESA, Space Spin-Off Fosters 400 New Companies, *ESA*, March 8, 2016.

http://m.esa.int/Our_Activities/Space_Engineering_Technology/TTP2/Space_spin-off_fosters_400_new_companies

¹⁵⁸ Doug Messier, Airbus Safran Launchers, ESA Sign Confirmation of Ariane 6 Program, *Parabolic Arc*, November 10, 2016. <http://www.parabolicarc.com/2016/11/10/airbus-safran-launchers-esa-sign-confirmation-ariane-6-program/>

¹⁵⁹ Staff Writers, Airbus Defence and Space to guide lunar lander to the Moon, *Moon Daily*, June 3, 2016.

http://www.moondaily.com/reports/Airbus_Defence_and_Space_to_guide_lunar_lander_to_the_Moon_999.html

¹⁶⁰ Peter B. de Selding, Is Britain's 5-year-old space investment locomotive running out of steam?, *Space News*, April 12, 2016. <http://spacenews.com/is-britains-5-year-space-investment-locomotive-running-out-of-steam/>

¹⁶¹ Alan Tovey, Britain launches itself back into the space race, *The Telegraph*, May 21, 2016.

<http://www.telegraph.co.uk/business/2016/05/21/britain-launches-itself-back-into-the-space-race/>

¹⁶² Peter B. de Selding, Britain selects U.S., French, British teams to study spaceport feasibility, *Space News*, July 13, 2016. <http://spacenews.com/britain-selects-u-s-french-british-teams-to-study-spaceport-feasibility/>

¹⁶³ Peter B. de Selding, Britain's quitting the EU, but will it be forced out of EU space programs?, *Space News*, June 24, 2016. <http://spacenews.com/britains-quitting-the-eu-but-will-it-be-forced-out-of-eu-space-programs/>

industry in the wake of the decision to quit the EU.¹⁶⁴ In November, the British government rejected a parliamentary bill to divide Britain's space budget between its national space program and the ESA. By that, the government reaffirmed the budgeting of Britain's activity with the ESA.¹⁶⁵ In Scotland, concern has been expressed about possible collateral damage to local space initiatives and collaborations with international companies.¹⁶⁶

In August, **Germany** revealed that its space center, DLR, has been developing anti-jamming receivers to overcome ongoing GPS jamming, especially at sea. Jamming is prevented by incorporating an extra antenna in the ship's GPS receiver, to attenuate disruptive signals and minimize their effect on GPS signal reception. In June 2016, the DLR and other German bodies successfully tested the system in the Baltic Sea.¹⁶⁷ Germany's Federal Intelligence Agency (BND) plans to procure an observation satellite before 2022. Once completed, the project will lessen the BND dependence on American and German military satellites for its routine work.¹⁶⁸

In June, **Denmark** passed a new space law that expands, adopts and legalizes several clauses of its official space policy. The new legislation is designed to meet the needs of Denmark's space activities, generate private and commercial interest in them, and ensure that Denmark's future private and other space activity abides by international law.¹⁶⁹

In October, **Poland published for the first time its national space strategy**. The writers of the document acknowledged that the current space budget, amounting to about 0.01% of the GDP, is low compared to other European countries such as Germany or France. Poland therefore undertook to increase this budget as part of its plan to direct its economy towards innovation, knowledge and technological development. One goal of the new strategy is building a first Polish satellite. The authors of the strategy aspire to make Poland a regional

¹⁶⁴ Jennifer Manner, My take – What Brexit means to satellite operators, *Space News*, July 4, 2016. http://bt.editionsbyfry.com/display_article.php?id=2526074&id_issue=317775

¹⁶⁵ Peter B. de Selding, Britain endorses ESA, promises increased export-credit support for industry, *Space News*, November 25, 2016. <http://spacenews.com/britain-endorses-esa-promises-increased-export-credit-support-for-industry/>

¹⁶⁶ Debra Wener, The View From Scotland, *Space News*, July 4, 2016. http://bt.editionsbyfry.com/display_article.php?id=2526079&id_issue=317775

¹⁶⁷ German Space Agency Develops Anti-Jamming and Spoofing System for Maritime Domain, *SpaceWatchME*, August 11, 2016. <https://spacewatchme.com/2016/08/german-space-agency-develops-anti-jamming-spoofing-system-maritime-domain/>

¹⁶⁸ Staff Writers, Germany's Spy Agency may get its own satellite by 2022, *Space War*, November 14, 2016. http://www.spacewar.com/reports/Germanys_Spy_Agency_May_Get_Its_Own_Satellite_by_2022_999.html

¹⁶⁹ Michael Listner, A comprehensive first look at Denmark's domestic space law, *The Space Review*, May 31, 2016. <http://www.thespacereview.com/article/2994/1>

technological incubator that would be based on innovation, and will attract professional talents.¹⁷⁰

In July, **Poland's space agency signed a cooperation agreement with China's space agency**. The primary goals of the agreement are collaboration on space research, sharing and utilizing satellite information, and developing space technologies, especially in the sphere of communications.¹⁷¹ In November, Poland's deputy prime minister and minister of science announced that China and Poland would tighten their cooperation and jointly build a satellite installed with systems and devices to be developed by Polish scientists. The satellite is scheduled for launching in 2018, on a Chinese launcher.¹⁷²

In July, the French Space Agency (CNES) announced its latest policy, stating that it endorsed extending the ISS operation, and was looking forward to coming to terms with Germany on this issue.

France affirmed its wish to boost the European effort of developing next-generation launchers, given the growing competition on the part of American and global industries. Over 2016, France urged European partners to co-invest in developing the new French-made launcher engine Prométhée. The engine will be capable of carrying the next-generation launcher Ariane, and will offer a much cheaper alternative to the Vulcan engine currently in use with the Ariane-5.¹⁷³

As already mentioned, **in 2016 the government of Luxembourg increased its support of the developing industry of space mining**, as part of its ambition to become the "Silicone Valley" of space. In June, it announced its decision to invest over \$200 million in research and technology of space mining. In November, it adopted a Space Law draft that would create a legal basis for commercial companies to maintain a viable industry and regulate issues of conflict such as ownership claims on mined space ores. The process has not been completed yet.¹⁷⁴ Luxembourg's government has also decided to buy over 49% of the

¹⁷⁰ Jaroslaw Adamowski, Poland unveils new space strategy, eyes space spending hike, *Space News*, October 12, 2016. <http://spacenews.com/poland-unveils-new-space-strategy-eyes-space-spending-hike/>

¹⁷¹ Brian Berger, Poland signs space partnership with China, eyes increased industry cooperation, *Space News*, July 4, 2016. <http://spacenews.com/poland-signs-space-partnership-deal-with-china-eyes-increased-industry-cooperation/>

¹⁷² Jaroslaw Adamowski, Poland, China to jointly build satellites, boost space cooperation, *Space News*, November 3, 2016. <http://spacenews.com/poland-china-to-jointly-build-satellites-boost-space-cooperation/>

¹⁷³ Peter B. de Selding, French space minister calls for European rocket R&D effort, says SpaceX victory still TBD, *Space News*, June 1, 2016. <http://spacenews.com/french-space-minister-calls-for-european-rocket-rd-effort-says-spacex-victory-still-tbd/>

¹⁷⁴ David Z. Morris, Luxembourg to Invest \$227 Million in Asteroid Mining, *Fortune*, June 5, 2016. <http://fortune.com/2016/06/05/luxembourg-asteroid-mining/>

shares of the asteroid mining company Planetary Resources as part of its European operations.¹⁷⁵

In December, the Canadian Minister of Science, Innovation and Economic Development announced that in June 2017 the government would unveil its new space strategy. In the formulation of the strategy, Canada's long-term space goals will be rethought, focusing on the potential contribution of advanced technology to the country's economic growth. According to the minister, Canada's aerospace industry is mostly comprised of small and medium businesses, whose growth must be assisted by the government.

The Canadian Army wishes to deploy a satellite system that would provide non-stop communications in the Arctic region. To cut down costs, Canada seeks international cooperation in return for communication services. Countries such as the US, Denmark and Norway, who all have arctic regions, have expressed preliminary consent to join in.¹⁷⁶

The Middle East

In September, **Israel** successfully launched its reconnaissance satellite Ofek-11 from Israel.¹⁷⁷ A few days earlier, on September 1, 2016, an explosion destroyed the Falcon-9 carrying the Israeli-made commercial communication satellite Amos-6. The explosion exposed **gaps in Israel's space planning.** Amos-6 was intended to improve Israel's communication capabilities and provide broad international coverage to remote areas for about 16 years. Israel's State Comptroller had begun investigating earlier the Israeli communication satellites program. According to unofficial publications, initial findings indicated that many gaps existed in the future planning of satellites. The findings will be included in the State Comptroller's report for 2017. In view of the crisis, a governmental committee was set up to investigate Israel's space activities. The committee, chaired by the director general of the Ministry of Science, Technology and Space, submitted its recommendations in December 2016. They included: embarking on a multi-year program, to ensure Israel's capability to develop, manufacture and operate communication satellites

¹⁷⁵ Peter B. de Selding, Luxembourg taking major stake in Planetary Resources' European business, *Space News*, June 13, 2016. <http://spacenews.com/luxembourg-government-to-buy-up-to-49-of-planetary-resources-european-business/>

¹⁷⁶ Mike Gruss, Canada eyes \$2.4 billion Arctic satellite communications constellation, *Space News*, June 30, 2016. <http://spacenews.com/canada-eyes-2-4-billion-arctic-satellite-communications-constellation/>

¹⁷⁷ Israel's Great Space Recovery? IAI engineers fixing Ofek-11 in orbit, First images transmitted, *SpaceWatchME*, September 22, 2016. <https://spacewatchme.com/2016/09/israels-great-space-recovery-iai-engineers-fixing-ofek-11-orbit-first-images-transmitted/>

with an annual budget of NIS 70 million; assisting Spacecom in bridging the gap created the loss of a communication satellite until a new satellite replaces the Amos-6; and allocating an additional NIS 30 million budget to the Israel's Space Agency.¹⁷⁸

The Egyptian government has adopted a draft bill for setting up a space agency that would coordinate Egypt's space policy. The bill coincides with Egypt's ongoing difficult economic situation. Egypt has applied to the International Monetary Fund for a loan of about \$12 billion, in addition to the support it has been receiving from Saudi Arabia and the UAE. The timing of the bill has been criticized in Egypt, as more pressing basic needs are not being addressed. It is not known when the new agency is scheduled to start operating, if at all.¹⁷⁹

Early in 2016, **Turkey announced that it was going to set up a national space agency.**¹⁸⁰ The failed coup of July 15, resulted in political tension and personnel instability. In August, Turkey shelved its plan to set up a space agency, partly because of the coup's aftereffects within the air force, which is in charge of Turkey's space program.¹⁸¹

In spite of this, Turkey continues its space activities:

- It signed an agreement with Japan for cooperation in the international space station.¹⁸²
- It is building a satellite in collaboration with Azerbaijan, and the two countries have agreed to share satellite information.¹⁸³
- In December it launched a military remote-sensing satellite.¹⁸⁴

Iran has been making efforts to achieve advanced capabilities in its space program by in-country development of small satellites, including the Mesbah-2, and several other homemade satellites such as Autsat, Nahid-1 and Dousti, whose development will be

¹⁷⁸ Conclusions of the space committee: Israel must develop and build a new communication satellite every five years, *Techtime*, 19 December 2016. <http://techtime.co.il/2016/12/19/space-6/>

¹⁷⁹ Egypt on the road to establishing national space agency amidst controversy, *SpaceWatchMe*, August 8, 2016. <https://spacewatchme.com/2016/08/egypt-road-establish-national-space-agency-amidst-controversy/>

¹⁸⁰ Burak Ege Bekdil, Turkey to launch space agency in three months, *Defense News*, April 10, 2016. <http://www.defensenews.com/story/defense/air-space/2016/04/10/turkey-launch-space-agency-three-months/82864510/>

¹⁸¹ Politics bite back: Turkish space ambitions on hold after attempted coup, *SpaceWatchMe*, August 22, 2016. <https://spacewatchme.com/2016/08/politics-bite-back-turkish-space-ambitions-hold-attempted-coup/>

¹⁸² Turkey and Japan sign space cooperation agreement for International Space Station, *SpaceWatchMe*, September 14, 2016. <https://spacewatchme.com/2016/09/turkey-japan-sign-space-cooperation-agreement-international-space-station/>

¹⁸³ Turkey offers to build satellites for Azerbaijan, share satellite data, *SpaceWatchMe*, October 10, 2016. <https://spacewatchme.com/2016/10/turkey-offers-build-satellites-azerbaijan-share-satellite-data/>

¹⁸⁴ Burak Ege Bekdil, Turkey launches new military satellite, *Defense News*, December 9, 2016. <http://www.defensenews.com/articles/turkey-launches-new-military-satellite>

completed in 2017.¹⁸⁵ Simultaneously, Iran has been procuring advanced communication and observation satellites with the assistance of other governments and international companies.

Since the signing of the 2015 nuclear deal, **Iran has intensified its space collaborations.** These include collaboration with Russia on building an Iranian remote-sensing satellite,¹⁸⁶ and a space cooperation agreement with Azerbaijan, in which the sides undertook to share information and coordinate allocation of frequency ranges for transmissions along the border.¹⁸⁷ Iran's space agency Chairman, Mohsen Bahrami, said in October that Iran has tightened its international cooperation on space after the signing of the nuclear agreement, and expressed interest in cooperating with NASA as well.¹⁸⁸ At an October meeting between the French ambassador to Iran and the Iranian minister of communications and information technology, the ambassador said that Eutelsat wished to cooperate with Iran's space agency.¹⁸⁹

The United Arab Emirates continued promoting its space program by advancing a national space bill and formulating a national R&D program.¹⁹⁰ In September, the UAE cabinet approved a new national space policy that would direct the UAE's political and strategic efforts in space, to establish regional supremacy in this field, and to turn the UAE into a space activity incubator. Great emphasis has been placed on training more professionals and bolstering international and local cooperation.¹⁹¹ As part of its effort to tighten international cooperation, the UAE has signed a cooperation agreement with NASA on civilian utilization of space. The two agencies will collaborate on space science, earth observations and space-related activities such as education and safety.¹⁹²

¹⁸⁵ Iran to launch two homemade satellites by March 2017, *SpaceWatchMe*, July 14, 2016.

<https://spacewatchme.com/2016/07/iran-launch-two-homemade-satellites-march-2017/>

¹⁸⁶ Iran and Russia to jointly build a remote sensing satellite for Tehran, *SpaceWatchMe*, August 3, 2016.

<https://spacewatchme.com/2016/08/iran-russia-jointly-build-remote-sensing-satellite-tehran/>

¹⁸⁷ Iran, Azerbaijan cement space cooperation agreement, *SpaceWatchMe*, August 5, 2016.

<https://spacewatchme.com/2016/08/iran-azerbaijan-cement-space-cooperation-agreement/>

¹⁸⁸ Staff Writers, Iran interested in connecting with NASA, *Space War*, October 6, 2016.

http://www.spacewar.com/reports/Iran_interested_in_connecting_with_NASA_999.html

¹⁸⁹ Eutelsat satellite plans to build satellite for Iran, *Iranian Students' News Agency*, October 23, 2016.

<http://en.isna.ir/news/95080201406/Eutelsat-satellite-plans-to-build-satellite-for-Iran>

¹⁹⁰ UAE's Emirates Space Innovation Group meets to set out space technology roadmap, priorities, *SpaceWatchMe*, May 10, 2016. <https://spacewatchme.com/2016/05/uaes-emirates-space-innovation-group-meets-set-space-technology-roadmap-priorities/>

¹⁹¹ UAE National Space Policy: An initial assessment, *SpaceWatchMe*, November, 2016.

<https://spacewatchme.com/2016/11/uae-national-space-policy-initial-assessment/>

¹⁹² UAE Space Agency and NASA partner up for space exploration, *SpaceWatchMe*, June 12, 2016.

<https://spacewatchme.com/2016/06/uae-space-agency-nasa-partner-space-exploration/>

In March 2016, the UAE looked into the option of launching a Mars mission, and in November the UAE Prime Minister and Vice President gave the green light for developing the next phase of the first UAE unmanned mission to Mars. Launching is scheduled for 2021.¹⁹³

As part of its general effort, the UAE has been promoting local space capabilities and production of a first homemade satellite is underway. The satellite will be entirely built in the UAE by local experts, and will serve for observation.¹⁹⁴

Latin America

In August, the **space agencies of Mexico and Argentina** signed an agreement to join forces in using space for peaceful purposes. The agreement leans on the common characteristics of the two countries, and is expected to have offshoots, including knowledge exchange between the two countries' research institutions.¹⁹⁵

Brazil has proceeded with its new communication satellites project in spite of the significant economic slump it has been experiencing. Among other things, development of the communication satellite project will enable connecting remote Amazonas regions to the internet.¹⁹⁶

In September, **Peru successfully launched its first observation satellite**, built by Airbus. The satellite will be used by government authorities and the Peruvian army, and will provide imaging at resolutions of up to 70 centimeters.¹⁹⁷

¹⁹³ Sheikh Mohammed Bin Rashid Al Maktoum green lights next phase of UAE mission to Mars, *SpaceWatchMe*, November 3, 2016. <https://spacewatchme.com/2016/11/sheikh-mohammed-bin-rashid-al-maktoum-green-lights-next-phase-uae-mission-mars/>

¹⁹⁴ Ibid.

¹⁹⁵ Staff Writers, Mexico, Argentina sign space cooperation agreement, *Space Daily*, August 5, 2016. http://www.spacedaily.com/reports/Mexico_Argentina_sign_space_cooperation_agreement_999.html

¹⁹⁶ Damian Wroclavsky, Brazil to pursue satellite, nuclear sub projects: Minister, *Space War*, November 27, 2016. http://www.spacewar.com/reports/Brazil_to_pursue_satellite_nuclear_sub_projects_minister_999.html

¹⁹⁷ Peter B. de Selding, Europe's Vega launches 1 Peruvian and 4 Terra Bella Earth observation satellite, *Space News*, September 16, 2016. <http://spacenews.com/europes-vega-launches-1-peruvian-and-4-terra-bella-earth-observation-satellites/>

In conclusion, one of the important processes of 2016 which deserve further attention is the growing launching capabilities and especially the continuing trend of private reusable launchers which increases the tension between the private and public sectors and will continue to characterize the space activity in the coming years. Another significant trend is the growing number of planned small satellites constellations in LEO, which will have an effect on the characteristics of space activity in this orbit. In the field of space exploration, a large number of spacefaring nations have marked the moon and the asteroid-mining missions as their focal point for the coming years and we can say this race has already started.