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Invited Paper

Trends in space activities in 2014: The significance of the space activities of governments

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ABSTRACT

This article addresses the principal events of 2014 in the field of space activities, and extrapolates from them the primary trends that can be identified in governmental space activities. In 2014, global space activities centered on two vectors. The first was geopolitical, and the second relates to the matrix between increasing commercial space activities and traditional governmental space activities. In light of these two vectors, the article outlines and analyzes trends of space exploration, human spaceflights, industry and technology, cooperation versus self-reliance, and space security and sustainability. It also reviews the space activities of the leading space-faring nations.

1. Introduction

In 2014, global space activities centered on two vectors. The first vector was geopolitical, originating in the strategic tension that arose in the spring of 2014 between Russia on the one hand, and the U.S. and other nations on the other, over the Ukrainian crisis. This tension, although not directly related to governmental space activities, was manifested in various aspects of world activities in space. The other vector relates to the matrix between increasing commercial space activities and traditional governmental space activities. In this context, 2014 began in an optimistic spirit, with expectations of significant progress in fulfilling the dreams of private entrepreneurs, spearheaded by human commercial spaceflights. However, 2014 ended with the sense that there's still a long way to go to fulfill this vision.

This article addresses the principal events of 2014 in the field of space activities, and extrapolates from them the primary trends that can be identified in governmental space activities. The first part of the article deals with the following subjects at the global level: space exploration, human spaceflights, industry and technology, cooperation versus self-reliance, space security and a sustainable space environment. The second part of the article reviews the space activities of the leading space-faring nations.

2. Space exploration

Observation of space exploration during the past year leads to the conclusion that the relationship between space exploration and political conflict around the globe is again intensifying. Manned and unmanned exploratory flights to areas far from the Earth: to the Moon and Mars; exploration of asteroids, comets and other celestial bodies; are synonymous in the world's experience with criteria for technological advancement. Such high technological achievements bestow high status in the international arena on the countries involved in this field. These achievements are proof of their overall abilities and power, not necessarily militarily. This prowess is expressed in new national exploration programs, in allocation of resources

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and in the statements of decision-makers and senior government and space agency officials in these nations. For example, in his speech after the Philae probe landed on comet 67P, the Director General of the European Space Agency [ESA], Jean-Jacques Dordain said, "We are the first to do this, and that will stay forever" [58]. Dordain's message was a clear indication that this scientific and technological achievement was not the sole objective. Rather, this successful mission also has political and strategic significance for the ESA and for all of Europe.

India's important achievement, attained when its Mars mission the Mangalayan (launched in December 2013) successfully entered Mars orbit in September 2014, is another example of the political and strategic significance of space exploration in world politics. The success of the mission proved that even with a modest budget, significant achievements can be accomplished [6]. Later, in December 2014, India succeeded in launching a capsule and have it return to earth, an important step in attaining human flights [88].

These events, and the way in which they were treated, point to the importance of these achievements, and are evidence of the developing trend amongst the leading space-faring nations to go further away from earth and deeper into space. In recent years, the U.S., Russia, China, India, Japan and the ESA have all announced their intentions to reach the Moon, Mars and even much more distant objectives in unmanned and human spaceflights. Some of these countries have already begun to make efforts to fulfill this vision.

What is intriguing is that in some of the cases, there is interest in carrying out these programs using the PPP (public-private partnership) model. For instance, NASA is entertaining the possibility of involving commercial satellites in its missions to the Moon and Mars. In January, 2014, NASA announced that it was seeking ways to increase its cooperation with commercial companies, in order to begin flights to the Moon. Specifically, NASA sought proposals from commercial companies to partner with it in developing small lunar landers, capable of delivering cargo to the Moon. NASA was willing to provide the infrastructure, facilities and computer programs, but not funding, as part of its Lunar Cargo Transportation and Landing by Soft Touchdown (Lunar CATALYST) [44] initiative. Last spring, NASA announced that it was involved in various projects to send people to Mars [1,54] In July, 2014, NASA issued a Request for Information (RFI) to investigate the possibility of using commercial satellites to provide telecommunications capabilities for future robotic missions to Mars [77].

To achieve these goals, a need exists for strong, heavy launchers, capable of traveling far while carrying especially large and heavy cargo. The three leading space-faring countries, the U.S., Russia and China have begun to develop such launchers, capable of transporting more than 100 t.

3. Human spaceflights

Two principal aspects of human spaceflights should be addressed. One, as noted above, is the tension between Russia and the U.S. over the Ukrainian crisis, which threatens to affect the functioning of the international space station and the lives of the astronauts and cosmonauts who live on the station. The other aspect is the future of private/commercial human spaceflights.

The crisis between Russia and the U.S. over Ukraine proves once again that human spaceflights are extremely important strategically to both countries. Such flights constitute a symbol of advanced technology and national capability, and thus serve as strategic cards in the conflict between them. The U.S. had been seeking an alternative to its dependency on Russia to launch American astronauts to the international space station, an effort made more intense by the crisis. Thus, NASA announced that it had extended its partnership with private American companies [46]. Beyond the strategic aspect, NASA's decision is a statement of trust in the ability of the private market to develop the necessary technology, at the level of security required, to carry out commercial human spaceflights. The statement also reflects NASA's belief that the venture can be profitable.

At the beginning of 2014, expectations for progress in this field were high. January saw a number of successes. Among them was Virgin Galactic's successful launch of a spacecraft in a test flight; it reached a height of 71,000 feet above earth [60]. Orbital Sciences successfully sent a Cygnus cargo ship to the international space station, its second successful unmanned mission to the station, that same month [59]. However, in October, the third Orbital Sciences' cargo ship to the international space station exploded upon its launch [98].

At the same time, China announced that it would send tourists and taikonauts into space by the end of 2014, through an agreement with the Space Expedition Corporation, a Dutch company [39]. Later, China announced that more than 300 Chinese citizens had purchased tickets for the spaceflights. Each ticket cost 100,000 USD [74]. In the end, none of the planned flights took place during 2014.

The investment in human spaceflights by the private market is still not a foregone conclusion. Doubts were further exacerbated by the fatal crash of Virgin Galactic's SpaceShipTwo at the end of October, 2014, in which the co-pilot was killed.

The accident renewed interest and discussion about the technological feasibility and economic profitability of space endeavors for the private market. Headlines proclaimed the end of the dream of space tourism and then calls to end space tourism activities, because of the high risks involved.[1] Quite probably, conclusions about the reasons for the accident will have an impact on the future of such initiatives. Nonetheless, the challenge of conducting human commercial spaceflights will not disappear. The nature of the social and technological processes that have begun is that they will continue and not simply end. Detailed, careful and precise investigations of the reasons leading to the failure will be conducted. It can be assumed that even though this accident might delay the process,

[1] For example: [96].

the conclusions of the investigation will help to improve the technological tools and methods used.

Despite the technological difficulties, progress to commercialized spaceflight also encourages the regulatory system to address the challenges facing it. In May, 2014, the U.S. Congress examined ways in which it could put commercial spaceflights, while in orbit, under the supervision and regulation of the Federal Aviation Administration (FAA). To do so, they planned to update the Commercial Space Launch Act for the first time in a decade [48].

4. Industry and technology

Several industrial and technological developments that affect the structure of the space market must be noted. The first of these is the trend to miniaturize satellites. The number of small (up to 50 kg) satellites launched has increased each year, and they have become a significant portion of the satellites launched annually, with almost 150 such satellites launched this past year alone.[2]

The second area of note, related to miniaturization, is called New Space. The term means the introduction of a range of new players into space activities. Most of the new undertakings are private, commercial ones, offering various developmental and business models for their innovative initiatives, which are very different from the traditional approaches to space activities. For example, in 2014, Google Inc. announced that it was expanding its activities to space. As part of this expansion, it acquired Skybox Imaging.[3] At the same time, Google began to establish a wireless network for remote areas of the world, to provide internet access for people living there. To achieve this goal, Google announced it will invest a billion dollars to establish a fleet of communication satellites, and is recruiting employees with backgrounds in space technology [43,97,99]. The company SpaceX also announced that it intended to develop a giant network of some 4000 satellites to provide broad band internet access to remote areas that are cut off from the internet today [55]. These initiatives can dramatically change the structure of space activities. Already, many questions are being raised about these endeavors, including regulation issues, as well as their possible effects on the economics of space [23].

5. Cooperation vs. self-reliance

In recent years, the trend to deepen and broaden international cooperation in the field of space has increased. Two incentives spurred this trend. The first is the need to cope with reduced financial resources available for space projects. The second incentive is that many phenomena and problems cannot be solved without the cooperation of a large number of nations. Examples include the issues of mitigating space debris and the need to guarantee the smooth and sustainable operations of all the space systems.

As noted, exacerbation of international tensions during the past year affect international cooperation. For instance, the International Space Station (ISS), the flagship of space cooperation, became a focus of the conflict between the U. S. and Russia over the Ukrainian crisis. For its part, the U.S. wants to extend the period of time that the two countries cooperate on the space station. However, Russia announced that it was uninterested in doing so, beyond the present date of completion, which is 2020, in order to free up resources for other projects [15]. Another manifestation of the increasing geo-political tension can be found in the decision of many countries to strengthen their independence in space, in order to secure their access to space and retain their independence of action in this environment.

Alongside these examples are more than a few examples of cooperation. India's and the U.S.'s separate missions to Mars in 2013 encouraged both countries to examine the possibility of cooperation between the two Mars missions [95]. The U.S. and France acted to strengthen their ties as well. In January, the space agencies of the two countries signed an agreement to cooperate in launching an additional spacecraft to Mars in 2016, as part of the InSight Mission [40]. In May, another agreement was signed between the two countries, this time to develop research satellites to study the oceans and seas, the Surface Water and Ocean Topography (SWO) project. The satellite dedicated for this purpose is due to be launched in 2020 [14].

Another example of cooperation is the reinforcement of the relationship between the U.S. and Japan. As part of Tokyo's Space Initiative, Japan is seeking to enhance its cooperation with the U.S. in the field of space. From the American point of view, that fits in nicely with its military strategy in Asia and its search for partners that will enable it to expand its satellite coverage in that region. The joint plans of the two countries will include mutual defense of the communication satellites, monitoring space debris, ocean observation, surveillance and more [78].

Russia and Europe are also strengthening their ties in this realm: ExoMars, the spacecraft that was built jointly by Russia and Europe, is expected to begin its voyage to Mars in January 2016[4]. In addition, it was announced that Russian scientists would develop radiation detection equipment for ESA's probe to Jupiter. The mission's objective is to explore Jupiter and its moons. Its launch is planned for 2022, and the probe is expected to reach Jupiter after a journey of eight years [64].

Russia is also strengthening its ties to China, partly as a result of the tension with the U.S. Thus, Russia and China agreed on three mechanisms of cooperation between them, including a group of space projects [4]. Space navigation, meant to create an alternative to the American GPS

[2] In the first half of 2014, i.e. from January to July, 122 satellites weighing up to 50 kg (110 lbs.) were launched, and the estimation is that another 20 small satellites were launched by the end of the year [28,5].

[3] Skybox is a company created with the idea of launching cheap satellites, using off-the-shelf components [11].

[4] Staff Writers, "Russian-European spacecraft to go on Martian mission in Jan. 2016", *Mars Daily*, February 13, 2014 [63]. http://www.spacedaily.com/reports/Russia_to_Build_Equipment_for_European_Jupiter_Probe_999.html Accessed on February 15, 2014.

system, is one of the foremost areas of cooperation for both countries [72]. They signed a Memorandum of Understanding to this effect in July. The two countries are planning to build navigation satellites and "monitoring stations in each other's territory, which will promote the integration of the two satellite navigation systems and improve their performance" [76]. The desire to establish an alternative to the American navigation system has also encouraged China to seek cooperation with other Asian nations; Russia, too, is seeking cooperation with other nations around the globe.

For its part, China continues to make efforts to enhance its ties with nations new to space activities, as well as countries with long-established space programs. In March 2014, a cooperative agreement was signed between China and France. The first tangible manifestation of this agreement is the joint development of an astronomical SVOM, or Space-based Variable Object Monitor, to examine gamma ray bursts. The project, announced in August, will mount the Gamma-Ray-Burst Astronomy Satellite on a Chinese Long March rocket, to be launched in 2021 [20].

6. Space security and sustainability

Ensuring security and sustainable use of space is one of the most significant issues in the interaction between nations. These interactions are accompanied by a certain degree of tension. This natural tension is the result of the desire and need of nations to maintain their freedom of action in space and defend their space systems on the one hand; and to sustain the space environment and thus cooperate with other countries, on the other. Sometimes, these aims are mutually exclusive: Maintaining a sustainable space environment requires that nations follow certain rules, which limit freedom of action in space. Furthermore, the need to function transparently, to cooperate and primarily to share data, despite lack of trust and fears that the data would be used for dual purposes, sometimes aggressive ones, creates tension.[5]

In recent years, a number of international processes have taken place with the goal of formulating rules of operation and agreements, so as to ensure use of space and a sustainable space environment. In the spring of 2014, progress was seen in the announcement of the fourth draft of the International Code of Conduct for Space Activities. In May, the last of three open-ended consultations[6] held to discuss this draft proposal by the EU was held in Luxembourg; more than 80 countries took part in the discussions.

Although the present draft provides mechanisms for creating greater transparency, the challenge is to bridge the gaps to enable trusting relationships between the nations to develop. The meeting held in May 2014 was positive, although disagreements remained. Principal among the unresolved issues relate to the application of the Code. In general, the U.S., European Union nations, Canada, Australia and others, are interested in a holistic approach, according to which the Code would apply to all space activities. By contrast, Russia and China and a number of other countries line up behind a more limited approach: they want the Code to apply only to civilian and commercial space activities, with military activities regulated by other means. Another source of tension which has not yet been resolved is the issue of the right to self-defense in space, under the UN charter.

At this stage, the most significant contribution of the Code to the dialogue on security and sustainability in space is the setting of clear standards and norms against creating space debris; it is considered to be the heart of the Code. The meeting in Luxembourg ended with the agreement of the participating nations that the momentum must be utilized and the process should continue until it is completed. However, by the end of 2014 no course was chosen.

The strategic tension between the U.S. and Russia is obvious when it comes to security in space and ensuring space activities, making it less likely that the two nations will come to an agreement. Progress in multilateral diplomacy has slowed to the point of deadlock, and the future of the aforementioned International Code of Conduct is enveloped in fog. Nonetheless, increasing awareness in various countries of the need to take responsibility and address important issues regarding space can be discerned. Progress exists in bilateral channels and even technological ones. Several nations have been operating independently to reduce the space debris that they produce or to monitor the objects in space. Space Situational Awareness systems that provide data and warnings of expected collisions have been updated and improved. Several countries have signed cooperative agreements. For example, in May 2014, the United States, Australia, Great Britain and Canada signed a Memorandum of Understanding to cooperate on Space Situational Awareness Activities [37].

Russia announced that it was working on improving its capabilities to identify objects in space [83]. Efforts are underway in Europe to develop European capabilities for monitoring objects in space. The ESA announced that as part of its Space Situational Awareness (SSA) program, it is developing an automatic telescope, nicknamed the Fly-Eye, that will scan the night skies and automatically identify new near-Earth objects (NEOs) [81]. In September, Japan's space agency announced that when it launches "[I]ts new Epsilon small-satellite rocket, its upper stage will be discarded in an orbit low enough to re-enter Earth's atmosphere….". Thus, it will not be left in space to disintegrate over a long period of time [22]. France passed a law that limits the creation of space debris from its launches, and requires that launch providers ensure that the upper stages of their rockets return to the Earth's atmosphere quickly, and come down over water [13]. China, too, announced that it was promoting policies and regulations concerning civil space launches and registration of objects in space, to prevent and reduce the creation of space debris [87].

[5] For more information, see: [92,49,2].

[6] The first was in Kiev in May 2013 and the second in Bangkok in November 2013.

In addition to these actions, activities have been undertaken to develop technological solutions for dealing with space debris and to clean up space: The ESA announced that it was investigating the possibility of developing a space vehicle that would trap derelict satellites that have drifted away from their orbits around earth, at a distance of 800 to 1000 km [500–620 miles]. Called the e.DeOrbit, the mission would operate under a directive of the Clean Space Initiative. The goal would be to reduce the impact of derelict objects on the space environment, and thereby reduce the real dangers to operational spaceflights and to the Earth itself. [41].

In addition to these activities, Russia and China have continued to promote restricting space weapons and controlling such weapons through the UN's Conference on Disarmament. In June, they presented a new draft for the Treaty on Prevention of the Placement of Weapons in Outer Space (PPWT). The U.S. announced that it opposes the new draft treaty, because of its concerns that China and Russia are themselves developing space weaponry systems [31].[7]

7. Disruption and threats to space Systems

The issue of disruption and damage to the on-going activities of space systems is sharpening, and awareness of it is increasing. In June, 2014, Eutelstat, a communication service provider to Middle Eastern and African countries, reported that it experienced disruptions due to jamming. Jamming, in fact, was the cause of some 15% of the communication problems that the company suffered in 2013, compared to 5% in 2010. [17]. The surge in incidences of satellite communication disruptions has increased awareness of the importance of protecting satellite communications. As awareness and understanding grows, so does allocation of resources to develop solutions and prevent disruptions, as has multilateral thinking about the problems. This year, the Boeing Company announced that it is developing anti-jamming technology, to protect government signals sent through military and commercial satellites. Boeing's experiments were successful: it transmitted protected signals to the sixth Wideband Global SATCOM (WGS-6) [61].

As part of this phenomenon, increasing and intensifying attention is being paid to the interface between the cyber and space worlds [53]. A number of reports published throughout the year by research institutions as well as private companies spotlighted the cyber threat to space systems, and indicated that it was becoming significant. Thus, the Council on Foreign Relations reported in April that the U.S. is becoming more and more vulnerable, because its infrastructure depends on satellites that are very vulnerable to space debris as well as to cybernetic attacks [67].

The American Air Force cautioned that a gap exists between its need for secure satellite communications and its ability to provide this, and that various companies in the space industry are in the process of developing different solutions [34]. These problems are being addressed in other places as well. A high-level official in the European Defense Agency (EDA) defined the link between cyber and space as the Achilles heel of Europe, requiring preparations and solutions at every level.[8]

In August, the U.S. Department of Commerce's Inspector General issued a warning about weaknesses in protecting ground stations of the Joint Polar Satellite System (JPSS). Despite the warning about problems in protecting the system, no action was taken. At the end of September, the National Oceanic and Atmospheric Administration (NOAA) system was apparently hacked. The cyberattack wasn't discovered until October 20th, and NOAA only notified the appropriate authorities at the beginning of November [27].

8. Overview of activities of leading space-faring nations and regions

8.1. The United States[9]

Reference to the United States requires another mention of the tension between the U.S. and Russia, which is manifest in two principal issues that flow together into one– the American desire to reduce its dependency on Russia. At this stage, the U.S. depends on Russia to launch its astronauts to the international space station. This year, emphasis on progress in commercial human flights could be discerned; such flights would enable NASA to reduce its dependence on Russia [82]. The second issue concerns the motors that American commercial flight companies purchases from Russia, to install on U.S. launchers. According to evidence provided by U.S. Air Force, available motors will allow launchers to operate until 2017. Developing a replaceable American motor is expected to cost $1.5 billion and take about six years[10]. Given the fact that space assets provide a unique advantage to those who use them, and are a key element in managing wars, the necessity to assure U.S. access to space is clearly recognized. Therefore, there is growing discussion in the United States on the need to strengthen its national capacity to independently launch national security payloads into space.[11]

Another growing trend is that of privatizing space activities, reflected in a number of processes described

[7] [40].Toward a new formulation: http://www.reachingcriticalwill.org/images/documents/Disarmament-fora/cd/2014/documents/PPWT2014.pdf Accessed on March 20, 2015.

[8] This was said by Rini Goos, Deputy Chief Executive, European Defense Agency, at the Space and Security Conference which took place in Athens in June, 2014.

[9] For more information about the American space strategy, see: [52].

[10] "Russian rocket engine replacement to cost US $1.5 Billion, Take 6 Years" Space Travel, May 26, 2014, http://www.space-travel.com/reports/Russian_Rocket_Engine_Replacement_to_Cost_US_1_point_5Bln_Take_6_Years_999.html Accessed on September 15, 2015.

[11] Ingalsbe, Torry, "USAF will provide assured access to space", Space War, July 24, 2014, http://www.spacewar.com/reports/USAF_will_provide_assured_access_to_space_999.html Accessed on September 16, 2015.

below. The SpaceX company is in conflict with the U.S. Air Force, demanding that it be allowed to compete for Air Force procurement contracts. SpaceX complained that the Air Force refused to use launchers that the company developed, even though NASA does use the company's services [32]. The Air Force claims that this derives from its need to ensure the highest level of reliability, which SpaceX has not yet proven [45]. The company turned to the federal court for remedy, and as a result of a ruling by the U.S. Court of Federal Claims, [69] in May of 2014, the Air Force announced that the company would be allowed to compete for its contracts [36]. At the beginning of 2015, the two parties settled the lawsuit via mediation [38].

The American Air Force is continuing the aforementioned trend, begun in recent years, to privatize space activities. Thus, for example, the Air Force is going ahead with its program of Hosted Payloads, whereby military payloads are carried by commercial spacecrafts. The purpose of this program is to enable the Air Force to act more quickly and flexibly [35].

The American government approved the request by DigitalGlobe to sell higher resolution satellite imagery on the private market than what it had sold until now. Thus, the company will be able to sell the highest resolution photos possible, with features smaller than 50 cm. (20 in.) visible [94].

The reforms in export controls that began a number of years ago were finalized in 2014 [33]. In May, the U.S. Departments of State and Commerce published changes in the export regulations for satellites and related components. The changes affected the category of Spacecraft and Satellites, allowing for most commercial, scientific and civil satellites and components to be removed from the U. S. Munitions List (USML), and instead placed on the Department of Commerce's Commerce Control List (CCL). The reforms are meant to increase the competitiveness of American technological products "[B]y better aligning … export controls with national security priorities" [3].

8.1.1. *Future space exploration missions*

In addition to the aforementioned regarding human space exploration, in early July, the Orion capsule was successfully launched on a test flight. The capsule was launched on the rocket Delta-4 to a height of 5800 km., returning to the atmosphere in order to prove, *inter alia*, that its instruments are protected against overheating and thus it is capable of protecting its astronauts on their return from missions in deep space.[12] Alongside this technological development, NASA's future plans for manned expeditions to Mars and other places require preparation for humans to remain in space for a relatively long period. To this end, NASA is conducting a number of studies and missions in which it is developing the knowledge and skills needed for missions of this kind. For example, NASA is developing the Robonaut 2, a robot that could perform medical activities in space, and is currently in advanced stages of development. [13]In addition, NASA is funding various research initiatives aimed at investigating the physical, psychological and molecular effects of long-term spaceflight on the human body.[14]

In order to meet its goals of sending a human spaceflight to Mars, NASA is promoting development of a heavy launcher, capable of carrying extremely heavy weights. In September, NASA announced that it had completed a meticulous review of the Space Launch System (SLS), capable of launching a heavy spacecraft of the Exploration Class, which is under development, to carry a human on a mission beyond Earth's orbit. The most advanced version of the SLS will be capable of carrying an unprecedented 143 metric tons, thus enabling longer-range missions within the solar system, including to objectives like asteroids and comets. In addition to breakthroughs in human exploratory spaceflights, the launcher can be used for scientific missions, which cannot be undertaken by commercial spacecraft. The first launch is planned for 2018; development will cost approximately 12 billion USD [50,80].

NASA is also working to advance robotic space exploration through tasks designed to investigate the existence of water on the Moon;[15] a mission to map Europa, one of Jupiter's moons,[16] for which NASA has started preliminary development of a "swarm" of small satellites;[17] and various missions to explore Asteroids. In March, it was announced that NASA is seeking proposals for projects related to its initiative: Redirect Asteroid Mission Concepts Development. NASA is to select 25 proposals, in which it will invest a total of $6 million.[18] It is worth noting that in August, Congress approved the Asteroids Act which is aimed at exploring possible uses of resources and minerals derived from asteroids, and promote the development of an asteroid resources industry in the U.S.[19]

[12] Klotz, Irene, "Policy debate aside, NASA preparing for Orion capsule test flight", Space News, July 7, 2014, http://bit.ly/1smVJSm Accessed on September 18, 2015.

[13] Staff Writers, "RoboDoc to the rescue: NASA to send robotic doctor to space", Space Daily, Feb 24, 2014 http://bit.ly/1lo7TbW Accessed on September 18, 2015.

[14] Barton, David J., "NASA to fund 26 proposals for investigating astronaut health in deep space environments", *ExecutiveGov*, May 7, 2014, http://bit.ly/1oJym7G, Accessed on September 18, 2015. "NASA selects 10 proposals for unprecedented twin astronaut study", *NASA.gov*, March 7, 2014, http://www.nasa.gov/press/2014/march/nasa-selects-10-proposals-for-unprecedented-twin-astronaut-study/.Uzvudah_uSp. Accessed on September 18, 2015.

[15] Klotz, Irene "NASA planning for mission to mine water on the moon", *Space News*, January 28, 2014, http://bit.ly/1cpBHVs Accessed on September 18, 2015.

[16] Leone, Dan, "NASA to seek ideas for $1 billion mission to Europa March 6, 2014, *Space News*, March 6, 2014 http://www.spacenews.com/article/civil-space/39756nasa-to-seek-ideas-for-1-billion-mission-to-europa, Accessed on September 18, 2015

[17] Hsu, Jeremy, "Swarm of tiny spacecraft to explore Europa's surface with rapid response", *Space Daily*, October 8, 2014, http://www.spacedaily.com/reports/Swarm_of_Tiny_Spacecraft_to_Explore_Europas_Surface_with_Rapid_Response_999.html

[18] Staff Writers, "NASA seeks proposals on asteroid redirect mission concepts development, *NASA.gov*, March 21, 2014, http://www.nasa.gov/press/2014/march/nasa-seeks-proposals-on-asteroid-redirect-mission-concepts-development/.UzwoQah_uSp. Accessed on September 18, 2015.

[19] Blount, P. J., H.R. 5063: Asteroids Act, *Res Communis*, August 5, 2014, http://bit.ly/1tdCSNP. Accessed on September 18, 2015.

8.1.2. Space security

Beyond what has already been noted about space security, the U.S.'s need to address threats in space has sharpened. In testimony to the Senate Intelligence Committee, James Clapper, U.S. Director of National Intelligence, warned that throughout 2014 and into the future, the U.S. is anticipating that it will have to deal with increased threats to its space assets, primarily from China and Russia [62].

8.2. Russia

In 2014, like the year before that, Russia experienced failures and crises in its space activities.[20] The political leadership in Russia considers their space program to be of the utmost strategic importance, and are therefore very attentive to the crises that the program experienced last year. These failures are perceived as damaging Russia's prestige. Therefore, according to what was published, the government increased its oversight and involvement, as well as its investment, in the space program. Furthermore, in order to place Russia at the forefront of the world's space activities, Russia announced its intention to continue to invest in deep space and close the gaps vis-à-vis other countries in that sphere.

Russia is reinforcing and improving its Glonass satellite navigation system. For this purpose, Russia is working to expand the system's network of ground stations beyond its national borders, and is establishing stations in more than 35 countries [68]. Russia is especially interested in improving the system's competitiveness in the BRICS countries: Brazil, Russia, India, China and South Africa. According to assessments, the market in those countries encompasses some three billion people and constitutes a huge potential market for Russia [71].

By contrast, due to the crisis between the U.S. and Russia, the continued operation of the ground stations in the U.S. is unclear. Throughout 2014, the U.S. and Russia held inconclusive talks on the subject. At the end of December, senior Russian officials announced Russia's intention to turn to the U.N. in response to the U.S.'s refusal to allow the system to continuing to operate on its territory. At the beginning of December, the U.S. Federal Communications Commission announced that the establishment and utilization of the Russian system will only be conducted under strict regulatory rules. In Russia's view, these regulations will make the Russian system much less attractive to potential customers. The concern is that other countries will take similar steps against the Russian system [89].

As noted above, due to the crisis between Russia and the U.S., Russia announced that it was not interested in continuing to operate the international space station after 2020; instead, it wants to divert resources to new explorations of space with human spaceflight [70]. In light of the various sanctions imposed on it, Russia is working to reinforce its independent capabilities and to reduce its reliance on foreign infrastructure and equipment. According to reports, more than 80% of the components that Russia uses in its space programs are of foreign make, and Russia wants to change that situation [25].

8.3. China

During 2014, China continued to strengthen its satellite navigation system, with the goal of increasing the system's geographic coverage. China predicts that it will complete the system and provide global service before 2020. In July, an agreement for space cooperation was signed between China and Thailand, to expand the satellite navigation system. This is the first step in a process to broaden the system's activities to the ASEAN (Association of Southeast Asian Nations) market [75].

China's attempt to keep up with the leading spacefaring nations is reflected in its announcement that it, too, would launch a spacecraft to Mars. China has not yet announced the official mission for its spacecraft, but did announce its intention to land on Mars in 2020, collect soil samples, and return them to Earth by 2030 [86]. In addition, China continued implementing its plans to build its own space station. Establishing the Chinese space station is expected to begin in 2018 with the launch of its base unit; the station is expected to be completed by 2022 [10].

On top of that, China continues to advance its Lunar Exploration program. In October, China conducted a Lunar "Test Orbiter" with the long term goal of launching the Chang'e 5 in 2017, to collect samples of rocks and soil and return them to Earth. [21,1] In addition, it was reported that Chinese scientists are also developing systems to allow the existence of life on the Moon.[22]

In the military and defense field, China appears to be moving forward and even accelerating its program. In April, the President of China ordered the Chinese Air Force to strengthen its military capabilities in space, and in general its ability to attack in space [29]. In October, it was reported that in 2019, China is expected to launch a new series of SAR satellites. The satellites will have a key role in protecting China's maritime rights, supervision and enforcement of maritime laws, management of maritime sovereignty and maritime assistance in emergencies. [23]At the end of 2014, the U.S.-China Economic and Security Review Commission presented its annual report to

[20] In May, its launch of the Proton-M failed and disintegrated above Russia's Far East [7].

[22] Leyi, Huang, Fei, Yu, "Chinese scientists prepare for lunar base life support system", *Space Daily*, July 1, 2014, http://bit.ly/1uG7M3Z Accessed September 19, 2015.

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Congress. The report emphasized the Chinese threat to American space assets [100].

8.4. Europe

The internal disagreement on the relationship between the European Union and its space agency continued in 2014. At this stage, the government of the European Union agreed to delay a decision concerning the future relationship between the EU and the ESA. The EU is waiting to make a final decision when the examination regarding the impact of this relationship on the European space industry is completed. At the same time, the ESA believes that in the near future, all 28 member states of the EU will also become members of the ESA [16].

The ESA is continuing to complete its space navigation system. In 2014, additional system satellites were launched, but a launch problem sent them into different orbits than the ones planned. A number of maneuvers were necessary to bring the satellites into the planned orbits [79]. Another issue that arose in Europe regarding its Galileo satellite navigation system was whether to make using Galileo mandatory for the citizens of the EU. The concern is that such a move would cause protest from other countries, like Russia, China, and perhaps even the U. S., who will object to this clear protectionism and stifling of competition [18].

At the beginning of 2014, the European Parliament adopted the Copernicus observation project, formerly known as GMES, (Global Monitoring for Environment and Security) to observe the Earth [66]. Later in the year, the first satellite in the Copernicus system began functioning. The Sentinel-1A can take radar pictures and be used for a range of purposes e.g. following the structure of the ice cover and the movement of icebergs over the oceans, physical changes on land; as well as respond to emergencies [26].

8.4.1. The European space agency

In January, it was reported that Gaia, which was launched at the end of 2013, successfully entered its operational orbit.[24] One of the ESA's outstanding events in 2014 was the Rosetta mission and the landing on comet P67. The ESA continued its space exploration activities, and announced the successful landing of a rover on Mars, via a dropship, part of the StarTiger program [24].

In February, it was reported that as part of ESA's Cosmic Vision Program for the years 2015–2025, it had selected PLATO (Planetary Transits and Oscillations of stars), a mission aimed at monitoring nearby stars. The launch of PLATO is scheduled for 2024;[25] it will include 34 telescopes and cameras. [26]Later that year, it was also reported that Thales Alenia is progressing in the development of a reentry vehicle, the Intermediate eXperimental Vehicle (IXV), for the ESA. Plans call for launching the IXV on the Vega launcher to test new technologies, in order to improve the capabilities of the ESA in this area. [27]The original launch of the Vega bearing the IXV was set for November, but was postponed indefinitely.[28]

On the subject of Earth monitoring, it was announced that the ESA signed a contract with the Eumetsat Corporation for developing and launching three pairs of advanced satellites for weather forecasting and climate monitoring. Thus, operation of the current series of satellites, which provides important information for Europe, will be continued.[29] In addition, the ESA had previously announced that it is working to unite efforts with other agencies, in order to develop the capability of a global response in the event that an asteroid heads toward Earth.[30]

8.4.2. European launch capability

One of the principal issues preoccupying Europe in general and the ESA in particular in 2014, was the future of the Ariane launcher. The member nations of the ESA were divided on the issue. One group, led by Germany, were adamant that the existing model should be improved, while the other group, led by France, maintained that a new model, Ariane-6, should be developed. Toward the end of 2014, the disagreement was decided in favor of developing Ariane-6. The cost of developing the new launcher is estimated at four billion Euro, and the project is expected to take eight years to complete [21].

8.5. India

India had two significant achievements in 2014 in the realm of space exploration. The first was a continuation of India's impressive success at the end of 2013, when it launched a mission to Mars. Eight months later, at the end of September 2014, the spacecraft successfully entered into orbit around Mars. India sees this success as proof of its ability and high status in the international community,

[24] Space Writers, "Europe's star-hunter enters orbit: agency", *Space Daily*, January 8, 2014, http://www.spacedaily.com/reports/Europes_star-hunter_enters_orbit_agency_999.html, Accessed on September 20, 2015.

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[29] Staff Writers, "Europe secures new generation of weather satellites", *Space Daily*, October 20, 2014, http://www.spacedaily.com/reports/Europe_secures_new_generation_of_weather_satellites_999.html. Accessed September 20, 2015.

[30] Space Writers, "Global space agencies to join in asteroid defense planning", *Deep Impact*, January 31, 2013, http://bit.ly/1fjbov7. Accessed on September 20, 2015.

while emphasizing the modest cost of the mission [84,85]. India chronicled another accomplishment toward the end of 2014, when its experiment to return an unmanned capsule to Earth was successful. These missions are part of India's program to send exploratory missions to the Moon and the sun.

India has achieved notable successes with its launch program as well. The successful Mars mission was aided by its PSLV (Polar Satellite Launch Vehicle) launcher, which is in high demand from other countries that are seeking to launch their own satellites. Nineteen countries have ordered the PSLV, to launch 40 satellites. India has announced that it has developed a new launcher, the GSLV (Geostationary Satellite Launch Vehicle), but has not yet signed any contracts for its use [85].

8.6. Japan

As part of its efforts to place itself amongst the leading space-faring nations, Japan sees importance in having its own independent launch capability. To that end, it has begun to develop a new launch vehicle. At the same time, Japan is exploring the possibility of involving the private sector and expanding its role in planning its spacecraft and investing in space [65]. Japan is also active in reinforcing its space defense capabilities.

8.7. Great Britain

Britain's space activities were a continuation of the national program to expand its space activities.[31] Thus, the British government is working to improve the space sector in Great Britain, and so announced that it would be "more user friendly" to its space industry. Among the steps the government took was an announcement that it would exempt the space industry from the 6% tax on insurance for launches and orbiting satellites [12]. The British government also announced that it intended to build its first Spaceport, based on expectations of increased space tourism and growth in the space industry by 2030. Building the Spaceport is predicted to cost an estimated 85.5 USD.[32]

8.8. Canada

In 2014, Canada announced its space plans for the coming years. Among the principal aspects of its plans are: placing the private space sector as its first priority; and promoting cooperation and increasing the involvement of Canadians in space activities. Also emphasized is Canada's use of space to reinforce its sovereignty, strengthen national security and create more jobs [56].

8.9. Israel

Israel had two significant successes with its satellite program. One was the launching of the Ofek-10 radar-based observation satellite [8]. The second was the successful launch and orbit of a nano-satellite, Duchifat-1, which was built by high school students [42]. At the same time, Israel continues to operate at the international level to expand its space activities.

In Israel too, the private sector has awakened to the possibilities inherent in space activities. The activities of a number of start-up companies, like SpacePharma and Effective Space Solutions, can be noted.[33] In addition, at the end of 2014 Israel announced the establishment of an incubator for start-ups in the space industry [30, 91].[34]

It must be noted here that because Israel will host the Annual International Space Conference in 2015 in Jerusalem, a range of activities were undertaken in 2014 to promote space.[35]

8.10. The Middle East

A number of interesting developments in the Middle East are worthy of note. Despite the difficult situation in Syria and the civil war that has been raging there, or perhaps precisely because of the war, the Syrian government announced the establishment of a space agency [57]. Egypt acquired and launched another observation satellite. Iran is continuing its space program and even announced that it is developing a spacecraft that will be capable of carrying three astronauts [73]. In June, Iraq launched a small student satellite via a Russian launcher [47]. Algeria is reinforcing its space activities and signed an agreement with the British company Surrey Satellite Technology Ltd. (SSTL) to build an observation satellite, the Alsat-1B, and train Algerians in satellite work [19]. The UAE announced that they intended to launch the first satellite which they will build themselves, the Khalifa Sat, in 2017. That will be the fifth satellite owned by the UAE, but the first that they produce independently [93]. In addition, a space agency will be established in the UAE, to send the first Arab astronaut to Mars by 2021.

In summary, space activities during 2014 took place under the impact of geo-political tensions, which characterized world activities in general; and under the effect of the growth of the commercial space market and the entry of new private players into the realm of space. This

[31] For details see: National Space Technology Strategy, April 2014 http://sec.kingston.ac.uk/uklaunch/docs/National%20Space%20Technology%20Strategy%20April%202014.pdf Accessed on March 20, 2015 [51].

[32] [9] For more information on the subject, see: [90].

[33] For additional information about these companies, see: http://www.effective-space.com and http://www.space4p.com/

[34] Goldenberg, Roy, "Israel Aerospace Industries MBT Space Division head Opher Doron announced the move at the "Globes" Israel Business Conference". *Globes*, December 10, 2014. http://www.globes.co.il/en/article-iai-to-found-space-tech-incubator-1000992761 Accessed on March 20, 2015. For additional information about Israel's space activities, see: Tepper, Eytan, "New Israeli Civil Space Policy to Boost R&D and Commercial Space Industrial Base", *New Space,* Volume: 2 Issue 1, March 2014: 16-22.

[35] International Astronautical Conference (IAC2015), Oct 2015, Jerusalem, SpacePolicyOnLine.com, http://www.spacepolicyonline.com/events/international-astronautical-congress-2015-iac2015-oct-2015-jerusalem Accessed on March 20, 2015.

trend of commercialization introduces a new spirit to the economics of space, and is likely to effect dramatic changes in space activities, which in turn will be very significant for governmental space activities. These changes will be manifest by technological advances, by the way research and development is conducted, in regulation of space activities, and by space policies and cooperation between players.

With all of these changes in the background, the conflict over the way operations in space should be carried out will continue. The challenges waiting in the wings, among other reasons because of the significant increase in commercial space activities, will require that the international community find a way to protect new and on-going activities in space. Furthermore, nations will demand that a unique category be found for their space activities, by contrast to the services provided by the private endeavors. Thus, it can be assumed that space exploration and human spaceflights will be affected, and will become the heart of national governments' space activities.

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