INTRODUCTION TO SPACE ACTIVITIES
Space Foundation Mission

*Be the preeminent resource for space education, a trusted source of space information, and a provider of exceptional forums for the exchange of ideas.*

The Space Foundation embraces the entire global space community. We are a leader in space awareness activities, industry services, research and analysis for the global space industry and educational programs that bring space into the classroom. We are one of the few space-related organizations that address the totality of the space community. The Space Foundation annually conducts the premier space industry event – the [Space Symposium](#) – and additional focused events.

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The Space Foundation created *Introduction to Space Activities* as a broad educational and informative tool for individuals interested in learning more about space activities. This introduction includes basic information about the mechanics of space activities and the space industry.

**SECTORS OF SPACE**  
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SECTORS OF SPACE

Mission Control Room, Johnson Space Center. Image Credit: NASA
The space industry is commonly divided into four sectors: civil, defense, intelligence and commercial. Although these sectors operate programs largely independent of one another, they share an industrial base, workforce and infrastructure.

Often, the defense and intelligence sectors are jointly referred to as “national security space.” The defense sector refers primarily to Department of Defense (DoD) activities in support of the military. The intelligence sector encompasses all space-based or space-enabled intelligence capabilities that support national interests.

Civil space includes all non-defense government space activities, primarily those of the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA).

Commercial space is generally segmented into satellite manufacturing, support ground equipment manufacturing, and the launch industry. The commercial sector includes prime contractors, entrepreneurial space companies and emerging markets for space capabilities.

For more information about space industry sectors, please refer to The Space Report: The Authoritative Guide to Global Space Activity.
U.S. GOVERNMENT SPACE PROGRAM

NASA's Europa mission spacecraft. Image Credit: NASA
The U.S. government pursues space activities in a number of areas. The President creates space policy for all government agencies and initiatives.

Congress is responsible for approving funding for and routine oversight of the space activities of the federal government. Various White House offices are involved in setting out and implementing space policy— including the Office of Science and Technology Policy (OSTP), the National Security Council (NSC) and the Office of Management and Budget (OMB). These federal agencies are charged with executing the space activities of the U.S. government.

Another executive body called the National Space Council plays a large role in the formulation and execution of U.S. space policy. This group of advisors and experts existed from the early years of NASA through the Apollo program under a different name, and was reestablished once in 1989 for four years, and again in 2017. It is chaired by the Vice President of the United States.

**National Aeronautics and Space Administration (NASA) – Headquartered in Washington, D.C.**

NASA was formed in 1958 after the Soviet Union launched the first satellite, “Sputnik” in 1957. The mission of NASA is to pioneer the future in space exploration, scientific discovery and aeronautics research.

NASA carries out its work across four mission directorates: Space Technology, Aeronautics Research, Science, and Human Exploration and Operations. It also operates multiple Earth-observing and remote sensing scientific satellites. NASA Headquarters provides overall guidance and direction to the agency. The ten NASA field centers are:

- Joseph S. Ames Research Center, Moffett Federal Airfield, CA
- Neil A. Armstrong Flight Research Center, Edwards Air Force Base, CA
- John C. Stennis Space Center, Bay St. Louis, MS
- John H. Glenn Research Center at Lewis Field, Cleveland, OH
- Robert H. Goddard Space Flight Center, Greenbelt, MD
- Jet Propulsion Laboratory, Pasadena, CA
- John F. Kennedy Space Center, Cape Canaveral, FL
- Lyndon B. Johnson Space Center, Houston, TX
- Langley Research Center, Hampton, VA
- George C. Marshall Space Flight Center, Huntsville, AL

**National Oceanic and Atmospheric Administration (NOAA) – Headquartered in Washington, D.C.**

NOAA was established in 1970 and is charged with providing reliable information about the oceans and atmosphere, including weather warnings and forecasts, as well as climate, ecosystems and commerce.

NOAA has nine key focus areas: Weather, Climate, Oceans & Coasts, Fisheries, Satellites, Research, Marine & Aviation, Charting, and Sanctuaries. Using space capabilities is vital for NOAA to complete many of its activities.

The Office of Space Commercialization (OSC), part of the NOAA Satellite and Information Service, is the principal unit for space policy activities within the Department of Commerce. Its mission is to foster the conditions for the economic growth and technological advancement of the U.S. commercial space industry. Other organizations across the Department of Commerce that handle space include: NOAA's Commercial Remote Sensing Regulatory Affairs Office; NOAA's National Geodetic Survey; International Trade Administration; Bureau of Industry and Security; National Telecommunications and Information Administration; National Institute of Standards and Technology; NOAA Weather Satellites; and NOAA National Environmental Satellite, Data and Information Service (NESDIS).
Federal Aviation Administration (FAA)
Headquartered in Washington, D.C.

The Federal Aviation Administration of the United States is a national authority with powers to regulate all aspects of civil aviation. Within the Federal Aviation Administration exists the Office of Commercial Space Transportation (FAA AST), which is responsible for ensuring protection of the public, property and the national security and foreign policy interests of the U.S. during a commercial launch or re-entry activity. AST also encourages, facilitates and promotes U.S. commercial space transportation.

The FAA was formed in 1958. AST was established by the Commercial Space Launch Act of 1984, but was originally an agency of the Department of Transportation until its move to FAA in 1995.

Department of Defense (DoD)
Headquartered in Washington, D.C.

The Department of Defense is charged with coordinating and supervising all agencies and functions of the government concerned directly with national security and the United States Armed Forces. Within the Department of Defense are multiple organizations and offices that take part in the department’s space activities, both classified and unclassified. The DoD was formed in 1947.

Missile Defense Agency (MDA)
Headquartered in Fort Belvoir, VA

The Missile Defense Agency's (MDA) mission is to develop, test and field an integrated, layered, ballistic missile defense system to defend the United States, and its deployed forces, allies and friends against all classes and ranges of enemy ballistic missiles in all phases of flight. The MDA uses satellites and ground-based sensors to provide worldwide coverage. The MDA was established in 1983.

Federal Communications Commission (FCC)
Headquartered in Washington, D.C.

The FCC has regulated interstate communications by radio, television, wire, satellite, and cable since 1934. The Office of Engineering and Technology (OET) within the Federal Communications Commission oversees policies, rules, procedures and standards for licensing and regulating orbital assignments for satellites. The OET also conducts technical studies of advanced phases of terrestrial and space communications.

National Geospatial-Intelligence Agency (NGA) – Headquartered in Springfield, VA

The National Geospatial-Intelligence Agency (NGA) is a combat support agency for the DoD and a member of the intelligence community. The NGA has been the nation’s primary source of geospatial intelligence (GEOINT) for the DoD and the U.S. Intelligence Community since 2003. The NGA uses imagery from space-based, national intelligence reconnaissance systems, as well as commercial satellites and other sources, to develop imagery and map-based intelligence solutions and provide geospatial intelligence support for global world events, disasters and military actions.

National Reconnaissance Office (NRO)
Headquartered in Chantilly, VA

The National Reconnaissance Office (NRO) designs, builds and operates U.S. reconnaissance satellites. The NRO’s mission is to develop and operate unique and innovative overhead reconnaissance systems and conduct intelligence-related activities essential for U.S. security.
U.S. Strategic Command (USSTRATCOM)
Headquartered at Offutt Air Force Base, NE
Established in 2002, U.S. Strategic Command is one of nine U.S. unified commands under the DoD. It is charged with multiple missions, including full-spectrum global strike, space operations, integrated missile defense and global C4ISR (command, control, communications, computers, intelligence, surveillance and reconnaissance). Under USSTRATCOM are Joint Functional Component Commands (JFCCs), responsible for day-to-day planning and execution for the primary mission areas. JFCC-Space is involved with coordinating, planning and conducting space operations. It even monitors orbiting satellites and space debris, allowing high-value spacecraft including the International Space Station to maneuver and avoid collision.

Army Space and Missile Defense Command (SMDC) – Headquartered at Redstone Arsenal, AL
Established in 1997, the Army Space and Missile Defense Command’s (SMDC) mission is to provide dominant space and missile defense capabilities for the Army and to plan for and integrate those capabilities in support of combatant commanders. SMDC serves as the Army-specific proponent for space, high-altitude and ground based midcourse defense.

SMDC conducts space and missile defense operations and provides planning, integration, control and coordination of Army forces and capabilities in support of strategic deterrence, integrated missile defense, and space operations. SMDC also serves as the Army force modernization proponent for space, high altitude and global missile defense and as the Army operational integrator for global missile defense.

Air Force Space Command (AFSPC)
Headquartered at Peterson Air Force Base, CO
Activated in 1982, Air Force Space Command is the primary space force for the US Armed Forces. AFSPC is a major military command that organizes, trains and equips forces to supply combatant commanders with the space and intercontinental ballistic missile capabilities necessary to defend the U.S. and its national interests. AFSPC supports U.S. military operations worldwide through the use of many different types of satellite, launch and cyber operations. AFSPC’s mission is to defend the United States through the control and exploitation of space and to provide resilient and affordable space and cyberspace capabilities for the Joint Force and the Nation.

Defense Space Council (DSC)
Headquartered in Washington, D.C.
Created in 2010, the Defense Space Council (DSC) is chaired by the Principal DoD Space Advisor (PDSA), currently the Secretary of the Air Force. The DSC is the principal advisory forum to inform, coordinate and resolve space issues for DoD. The DSC is charged with aligning requirements, acquisition and budget planning and execution of strategy and policy.
GLOBAL SPACE PROGRAMS

Image Credit: NASA
Introduction
Most space activities are inherently dual-use. In the U.S., government space programs are separated as either civil or national security; however, space programs in other nations rarely have such distinctions. Many countries carry out military space activities in conjunction with civilian space activities. The information in this segment is focused on the publicly recognized space activities of other nations.

While many countries have different means of collaborating with others, when it comes to international concerns, regulations, and laws in outer space, most turn to the United Nations for guidance. The UN has its own body for deliberation and cooperation on space issues and activities. The UN Committee on the Peaceful Uses of Outer Space (COPUOS) has met regularly since its establishment in 1959 to govern uses of outer space and ensure compliance with basic principles of peace, security, and development. It has two sub-committees; the Scientific and Technical Subcommittee and the Legal Subcommittee.

Algeria
The Algerian Space Agency (ASAL) consists of a central structure and four operational entities that are: Center of Space Techniques (CTS), Space Applications Center (SAC), Satellite Development Center (SDC), and Telecommunications Systems Operating Center (TSOC). ASAL promotes development of space activities intended to contribute to Algeria's economic, social, and cultural development. ASAL implements the Algerian National Space Program for 2006-2020, which is reviewed and updated every five years.

In 2010, the Algerian remote sensing satellite Alsat-2A was successfully placed into orbit. Alsat-2A was the second remote sensing satellite launched by Algeria; Alsat-1 launched in 2002. In 2016, satellites, Alsat-1B (a satellite designed for agricultural and disaster monitoring) and Alsat-1N (containing amateur radio payloads) were launched. Alcomsat-1 is a communications satellite scheduled to launch before 2018.

Brazil
Government programs include the Agência Espacial Brasileira (AEB) and the Alcântara Space Centre. Brazil's strategy for space is outlined in its 2005 National Program of Space Activities (PNAE) 9-year plan. Brazil's stated aim is to develop and use space technology to address its national needs, while contributing to the improvement of its citizens’ quality of life. Brazil also actively participates in international space programs. Beginning in 1988, Brazil and China established an ongoing space relationship centered on the joint China-Brazil Earth Resources Satellite (CBERS) program.

Canada
Canada became the fourth nation to operate a satellite in space with the launch of Alouette 1 in 1962. Government programs include the Canadian Space Agency (CSA), the Canadian Center for Remote Sensing and the Canadian Forces. Canada employs a niche strategy, focusing on expertise in three areas: space robotics, radar technology for Earth observation and advanced satellite communications. Budgets focus heavily on space science and Earth observations, as well as human spaceflight. Canada’s space program is uniquely tied to the European Space Agency (ESA) and U.S. civilian and military programs. Canada has a cooperation agreement with ESA, collaborates on many NASA missions and is a contributor to the International Space Station (ISS). Many CSA astronauts have served on board the ISS, and in 2017 Canada unveiled its most recent astronaut class selection, the fourth in its space program's history.
Government spending on space programs and activities in Europe comes from three distinct sources: activities funded by the European Union (EU), executed by the European Commission (EC) and implemented by the European Space Agency (ESA); activities funded by the member states of the ESA; and national activities funded and carried out by the European countries themselves. The EC focuses its resources on three primary areas: space research, the Earth observation program Copernicus, and the satellite navigation program Galileo. ESA is the primary space actor in Europe, with 22 member states that contribute a set amount, based on gross domestic product, for space science and some mandatory technology programs. Voluntary contributions from countries can also be made to other optional programs, such as human spaceflight, Earth observation, launchers, or telecommunications. The biggest contributors are France, Germany, Italy, and the UK, with a collective contribution of 68.0% of the total 2017 contributions. ESA has focused its efforts on upgrading and developing its launch vehicles, Earth observation activities, and space science missions.

France

The French space program is the third oldest institutional space program in history, and France became the third nation to launch a satellite to orbit on its own domestically produced rocket in 1965. France is the top contributor to the ESA budget. France’s national space agency is the Centre National d’Études Spatiales (CNES), with main facilities in Paris, Toulouse, and ‘Europe’s Spaceport’ Kourou (French Guiana). The activity of CNES is focused on five main fields: Ariane (launchers), sciences, observation, telecommunications, and defense.

In 2018, CNES and CNSA (China) will launch the CfoSat mission to study ocean surface winds and waves. CNES is overseeing development of the SEIS instrument, a major component of the InSight (Interior exploration using Seismic Investigations, Geodesy and Heat Transport) satellite from NASA, also to be launched in 2018. Ten French astronauts have flown aboard the International Space Station.

Germany

The German Aerospace Center (DLR) is Germany’s largest research and development center in aeronautics, space, transportation, energy, and security research. It is also the German national space agency. DLR focuses on planetary science and Earth observation, and is conducting applied research for protecting the environment and development of environmentally friendly technologies to promote NextGen aviation, autonomous mobility, communication, navigation, and security. Major German space programs have continued to emphasize applied Earth observation and space robotics. This includes the merging of optoelectronics and Synthetic Aperture Radar (SAR) to generate extremely high-resolution remote sensing imagery, such as on the TerraSAR-X / TanDEM mission which launched in 2007 and 2010. In the realm of human spaceflight, Germany has sent many astronauts into space with the Space Shuttle and Soyuz, including three astronauts who worked onboard the ISS.

Italy

Established in 1988, Italy’s national space agency is the Agenzia Spaziale Italiana (ASI), which promotes, coordinates, and conducts space activities in Italy, including developing space technology. ASI plays a key role at the European level, where Italy is the third largest contributor country to ESA. In 2010, Italy launched the fourth and final satellite in the COSMO-SkyMed Earth-observation satellite constellation. COSMO-SkyMed provides dual use radar Earth observation data intended to meet civilian and military needs. ASI led Europe’s development of the Vega small-class launcher, which now complements the larger Ariane V launcher. Multiple Italian astronauts have flown on the ISS over its lifetime.
China

China owns the second largest fleet of spacecraft in orbit. China’s space agency has two parts, the China National Space Administration (CNSA), which is an internal structure of the State Administration for Science, Technology and Industry for National Defense (SASTIND), and the China Aerospace Science and Technology Corporation (CASC), which consists of multiple, smaller, state owned companies. The manned spaceflight program is operated by the Chinese Manned Space Engineering Office (CMSEO), which is within the General Armaments Department (GAD) of the People’s Liberation Army (PLA). Funding for space is part of military budgets, which are only partially disclosed. China’s goals include facilitating economic development, ensuring self reliance, promoting national prestige, and projecting power. Programs focus on manned spaceflight and space applications, such as remote sensing, communications, navigation, and space science and technology. In parallel, China has developed capabilities to limit or prevent the use of space-based assets by potential adversaries during times of crisis or conflict.

The country launched its first astronaut (taikonaut) into Earth orbit in 2003, performed its first spacewalk in 2008, and made a successful soft landing on the Moon with its lander, Chang’e-3, in 2013. It was the first soft landing on the Moon since 1976, making China the third country to land on the Moon. CNSA announced it would conduct 30 launches in 2017, a new record. CNSA plans to be the first to land on the far side of the Moon with Chang’e-4 and to land a rover on Mars in 2018 and 2020 respectively. CNSA has its own small space station, with plans to launch another station, Tiangong 3, in the 2020s. China is not involved with the International Space Station.

India

India’s government space program is structured around the Indian Space Research Organisation (ISRO), which manages civil space programs. ISRO’s vision is to “harness space technology for national development while pursuing space science research and planetary exploration.” India’s space program has generally focused on technological, scientific, and social development through space capabilities. Only recently has the country migrated toward programs such as space exploration and military applications. India often emphasizes its strategy of international collaboration with leading space powers and has strengthened its relationships with Europe in its efforts to commercialize its launch capability. India’s first satellite was launched by the Soviet Union in 1975. India has also worked with Russia to develop its own geostationary launch vehicle, and successfully launched its own spacecraft to the Moon in 2008.

ISRO developed and operates the Polar Satellite Launch Vehicle (PSLV) and the Geostationary Satellite Launch Vehicle (GSLV), both of which have successfully launched numerous satellites and payloads. In 2013, ISRO launched its Mars Orbiter Mission (MOM) aboard a PSLV. The MOM probe reached orbit around Mars in 2014 and began carrying out scientific observations, making ISRO the fourth space agency to reach Mars behind NASA, Roscosmos, and the European Space Agency.
Israel

The Israel Space Agency (ISA) coordinates government space activities and focuses on satellite development for communication and remote sensing. ISA partners with a number of nations on various space activities, including technology development and human spaceflight. ISA developed and operates its own launch vehicle, Shavit. The Earth observing satellite EROS-C was set to launch in 2008, but has been postponed several times to 2019. A joint American-Israeli proposal for ULTRASAT was submitted to NASA by a team from Caltech. The Israeli contribution will be funded by the Israel Space Agency and launch is expected before 2021. Today, Israel is the smallest country with indigenous launch capabilities.

Japan

Japan became the fourth nation to launch its own satellite with a domestically produced launcher in 1970. In 2008, Japan enacted a new Basic Law of Space, allowing the country to use space for national security purposes. In addition, the law established the Strategic Headquarters for Space Policy (SHSP), chaired by the prime minister, to formulate Japan’s “Basic Plan for Space Policy.”

In a continued effort to consolidate its space programs, Japan has merged three air and space research organizations into a single integrated institution named the Japan Aerospace Exploration Agency (JAXA), which focuses on launchers, space science, human space activities, space applications, and aeronautics. Its space science program includes successful missions to asteroids and the Moon, with follow-on return missions planned. For human space activities, along with contributing the Japanese Experimental Module (JEM) to the ISS, 10 Japanese Astronauts have flown into space, including multiple long-duration missions on ISS since 1992. Some of the most important new developments among JAXA programs are the new H3 launcher aimed to launch in 2020, and development of the upgraded HTV cargo spacecraft. Due to increased regional security concerns, Japan has been increasing its focus on a national security satellite system that will improve its information gathering capabilities. This direction was reconfirmed by updates to the Basic Plan for Space Policy in 2016.

Luxembourg

In the 1980’s, Luxembourg, a small and wealthy country originally known for its iron and steel industry, recognized potential value in the space industry, recognized potential value in the space industry, and began to provide financial support and pro-industry regulations for its domestic satellite industry. Luxembourg now has one of the largest commercial satellite industries, second only to the U.S. military.

In recent years, Luxembourg has also taken interest in the asteroid mining industry. Luxembourg is providing numerous benefits to budding private mining companies willing to locate their headquarters in Luxembourg (including tax cuts, R&D grants, direct investments, and purchasing equity). In 2016, the Ministry of Economy announced the Space Resources initiative, which “will be the development of a legal and regulatory framework confirming certainty about the future ownership of minerals extracted in space from Near Earth Objects such as asteroids.” A law on space resources was adopted on July 20, 2017, to provide this legal and regulatory framework. Also in 2017, the Deputy Prime Minister of Luxembourg announced that to become a leading nation in asteroid mining, Luxembourg will soon be introducing a national space agency, as well as a new national space law.

Mexico

The Mexican Space Agency (AEM) was founded in 2010 to pursue further education and development in the space industry in Mexico. While Mexico has yet to create a space infrastructure, it is well on its way.

In 2015, the Mexican Space Agency and ProMéxico released a plan for Mexico’s space involvement called Orbit Plan 2.0. This plan lays out a detailed timeline that includes plans to increase communications connectivity in Latin America by 25% by 2026, and for Mexico to be in the top three leaders of the global space market and have assured space access by 2036. This plan will establish Mexico’s space sector and engage the country in the global space economy.
The Netherlands

Established in 2009, the Netherlands Space Office (NSO) was created to administer all space programs for the Netherlands and to educate its general population on matters of space. Even though the Netherlands established the NSO, they are a member of the European Space Agency (ESA), and roughly 70% of the Dutch space budget goes directly to ESA.

The Netherlands has always shown a strong interest in space. In August 1974, they launched the Netherlands Astronomy Satellite (ANS) from the U.S., more than 30 years before the creation of the NSO. This was the first Dutch satellite in Earth’s orbit, and its purpose was to record ultraviolet and x-ray data. From this mission, three new types of x-ray sources were identified. In 1993, with some commercial help, the Netherlands launched the Infrared Astronomy Satellite (IRAS) from the U.S. The goal of this satellite was to survey the sky for sources of infrared radiation, particularly from the Milky Way. In more recent years, the Netherlands’ space activity has been centered on ESA efforts. Two Dutch astronauts have flown into space, one of whom stayed onboard the International Space Station.

Nigeria

Established in 2001, Nigeria’s space program is administered through its National Space Research and Development Agency (NASRDA), which consists of six geographically distributed centers that include the Center for Basic Space Science, the Center for Satellite Technology Development, the Center for Geodesy and Geodynamics, the Center for Space Transport and Propulsion, the National Center for Remote Sensing, and the Center for Space Science and Technology Education. In recent years, Nigeria worked with China to develop and launch an Earth-observation satellite in 2003, Nigeriasat-1, as part of the international Disaster Monitoring Constellation (DMC). Nigeriasat-2 is the follow-on Earth-observation satellite and launched in 2011.

Russia

Russia’s space program is organized around the State Corporation Roscosmos, which was established in 2015 on the basis of the now-defunct Federal Space Agency, and before that, the Soviet Space program (1957-1991). A branch of Russia’s armed forces (Russian Aerospace Forces or VKS) is dedicated to all military satellites, launch facilities, and space situational awareness (SSA) programs. Russia owns one of the largest fleets of spacecraft in orbit. The agency focuses on human spaceflight, space sciences, communications, remote sensing, and navigation. The Soviet/Russian Space Program was responsible for many firsts in space, including the first satellite, Sputnik 1, the first animal, first man, and first woman in space and in Earth orbit, and the first spacewalk, as well as records for the longest flight and amount of time in space.

Russia remains a world leader in space and continues to make investments in launch infrastructure and systems. Russia still allocates funds to support the ISS, including crew and cargo transportation. With the retirement of the U.S. Space Shuttle in 2011, Russia became solely responsible for the transport of all crew to and from the ISS.
The Korea Aerospace Research Institute (KARI) is South Korea’s space agency. KARI’s objective is to contribute to the development of the national economy and improvement of the public life through aerospace science and technology. In addition to continued development of scientific and remote sensing satellites, Korea’s national space plans include further work on its new Korea Space Launch Vehicle (KSLV) rocket, participation in international space exploration initiatives including the ISS, a continued astronaut training program, and long-term plans for lunar orbiter and lander spacecraft.

A Korean Space Launch Vehicle 1 rocket, called Naro-1, was launched from South Korea’s Naro Space Center in 2013, successfully carrying the science satellite STSAT-2C into orbit. In 2015, The Korea Multipurpose Satellite-3A (Arirang-3A) was launched from the Yasny launch base in Russia. In 2016, South Korea and the U.S. reached an agreement for bilateral cooperation between their space programs on the use of space technology.

The State Space Agency of Ukraine (SSAU) is a government body coordinated by the Cabinet of Ministers of Ukraine and is responsible for the formation and implementation of state policy in space activities.

SSAU, through 5-year National Space Programs, (today in the Fifth National Space Program for the period 2013-2017) ensures the exploration and use of outer space for peaceful purposes, coordinates research and development work on design, production and testing of space technologies, including interests of national security and defense, and ensures the application, support, and improvement of objects of space activities. SSAU also carries out international space activities in accordance with international treaties signed by the state and performs other functions in space activities pursuant to Ukrainian legislation.

The space projects of Ukraine include production and launching of the ERS satellites Sich-2-1, Sich-2M, Sich-3R, Sich-3O and scientific satellite Microsat-M, creation of the National Satellite Communication System, participation in the space projects Antares (USA), Vega (ESA), and in EU projects via Horizon – 2020.

The United Arab Emirates established its national space agency in 2014, with the goals of promoting research and innovation in the Emirates’ scientific community, encouraging younger generations to get involved, and strengthening international relations. It is the first space agency in the Gulf Cooperation Council (GCC) region, and is committed to advancing the space sector in the Middle East and beyond. Although the UAE has launched satellites prior to the establishment of their space agency, launches are not yet a primary focus. One of the main initiatives for the agency was to establish a degree program for advanced sciences in the Middle East, which has been implemented at the Masdar Institute of Science and Technology. The Mars Hope Mission is another large initiative of the UAE Space Agency, which will put the Hope probe into orbit around Mars by 2021.

The UAE also plans to launch KhalifaSat in 2018. This is the first satellite that will have been completely developed by Emirates engineers at the Mohammed bin Rashid Space Centre. This Earth observing mission will focus on taking high-resolution imagery for environmental measures, urban planning, and area classification.
In 1962, the United Kingdom launched its first satellite into space in partnership with the U.S., making it the third nation to operate a satellite on orbit. Then in 1971, the UK launched a British-built satellite into orbit on a British-built rocket, research from which went on to inform the European Launcher Development Organisation (later part of the European Space Agency).

The UK Space Agency (UKSA) was created in 2010 to replace the British National Space Centre and bring all UK civil space activities under one single management. Currently, the UK is one of the four largest contributors to ESA and actively participates in its many scientific and exploratory missions. In 2017, the UKSA announced plans to enable commercial operations of small satellite launch vehicles and sub-orbital flights out of UK spaceports by 2020.

72 Nations Have Space Interests

Many nations now recognize the strategic value and practical benefits of space assets and are pursuing space capabilities. By the end of 2017, government, commercial, or academic organizations in at least 72 nations - including 19 member states of ESA – were operating one or more satellites, or planning to launch a satellite before the end of 2020. Some of those nations include: Algeria, Argentina, Australia, Austria, Azerbaijan, Bahrain, Bangladesh, Belarus, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cuba, Czech Republic, Denmark, Egypt, France, Germany, Greece, Indonesia, Iran, Iraq, Israel, Italy, Japan, Kazakhstan, Kenya, Laos, Lithuania, Luxembourg, New Zealand, North Korea, Malaysia, Mexico, Mongolia, Morocco, the Netherlands, Nigeria, Norway, Pakistan, Peru, Poland, Portugal, Romania, Russia, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Thailand, Tunisia, Turkey, Turkmenistan, United Kingdom, United Arab Emirates, United States of America, Uruguay, Uzbekistan, Ukraine, Venezuela and Vietnam. Only three nations currently have human spaceflight capabilities, the U.S. (NASA), Russia (Roscosmos), and China (CMEO – China Manned Space Engineering office).
ORBITS OF THE EARTH

Image Credit: NASA
**Perigee** – the closest point to the Earth that an object makes while orbiting Earth.

**Apogee** – the farthest point from the Earth that an object makes while orbiting Earth.

**Constellation** – a group of coordinated and synchronized satellites with shared operational control.
Low Earth Orbit (LEO) is commonly accepted as between 124 and 1,240 miles above the Earth’s surface. Spacecraft in LEO make one complete revolution of the Earth in about 90 minutes (the “orbital period”). The International Space Station (ISS) orbits between 198.6 and 215.5 miles above the Earth’s surface. The Hubble Space Telescope operates in this region, as did the Space Shuttles. Proximity to the Earth’s surface provides a high level of detail and the ability to detect distinct objects (known as “spatial resolution”). Most remote sensing satellites, as well as national security assets and some communication satellites, are placed in LEO. Satellites are subject to the risk of collisions posed by the high volume of space debris currently orbiting Earth.

Medium Earth Orbit (MEO) is the region of space around the Earth above LEO (1,240 miles) and below geosynchronous orbit (22,240 miles). In MEO, orbital periods range from about two to twelve hours. The most common use for satellites in this region is navigation, such as the United States’ Global Positioning System (GPS) (12,550 miles), Chinese BeiDou Navigation Satellite System (scattered throughout MEO), the Russian GLONASS (11,870 miles), and the European Galileo (14,430 miles) constellations. Communication satellites that cover the North and South Poles are also put in MEO.

Highly Elliptical Orbits (HEO) are characterized by a relatively low-altitude perigee and an extremely high-altitude apogee. A satellite moves fastest when it’s in perigee, and much slower when it’s in apogee. These extremely elongated orbits are useful for communication satellites because of the long duration they’re able to spend in apogee; visibility in HEO can exceed 12 hours. Some satellite radio providers use HEO orbits to keep two satellites positioned above North America, while another satellite quickly sweeps through the southern part of its 24-hour orbit to maintain permanent coverage.

Geosynchronous/Geostationary Orbit (GEO) is the region in which satellites orbit at approximately 22,240 miles above the Earth’s surface. At this altitude, the orbital period is equal to the period of rotation of the Earth, so the satellite appears to move neither east nor west. The orbital path of a satellite in geosynchronous orbit always remains above the equator, and therefore appears completely stationary relative to the surface of the Earth. This positioning is convenient for communication satellites. In addition, geostationary satellites provide a “big picture” view that enables coverage of weather events, which is especially useful for monitoring large, severe storms and tropical cyclones. However, instruments and sensors on satellites in GEO have poor spatial resolution due to their distance from Earth.
Polar Orbit refers to near-polar inclination and an altitude of 435 to 500 miles. Satellites in polar orbit pass over the equator and every latitude on the Earth’s surface at the same local time each day, meaning the satellite passes overhead any location at essentially the same time throughout all seasons of the year. This orbit enables regular data collection at consistent times and is useful for long-term comparisons. Weather and environmental monitoring satellites are often placed in polar orbits. Many national security assets also follow polar orbits.

GEO Transfer Orbit (GTO) is an elliptical orbit of the Earth, with the perigee in LEO and the apogee in GEO. This orbit is a transfer path after launch to LEO for launch vehicles carrying a payload to GEO. To enter GTO, an object must increase its velocity. To exit GTO, a satellite usually produces thrust in a direction tangent to the current GTO orbit while at its apogee.

Sun-Synchronous Orbit (SSO) rely on a constant quantity of sunlight, and are in polar orbit around 400 to 500 miles above the Earth’s surface. Satellites in SSO cross the equator at the same time every day and every night. They have a very restricted path, and require regular corrections and maintenance. They are best utilized for assessing change over time, such as Canada’s Radarsat-2, which monitors climate change via remote sensing.
SPACE SITUATIONAL AWARENESS/
SPACE TRAFFIC MANAGEMENT
The terms Space Situational Awareness (SSA) and Space Traffic Management (STM) refer to the ability to view, understand and predict the physical location of natural and manmade objects in orbit around the Earth, with the objective of avoiding collisions.

One longtime global concern is the amount of space debris surrounding our planet, and its danger to satellites that are currently active in orbit as well as to those which will eventually launch into orbit. Therefore, it’s been made a priority to try to preserve the space environment.

The U.S. Air Force made an upgrade to its Joint Space Operations Center (JSpOC) to improve space surveillance, collision avoidance, launch support, and the ability to provide more precise and timely orbital information. Another space surveillance system is currently being built by the U.S. Air Force known as the Space Fence. As a second-generation system, it will be able to detect space debris the size of a marble, as well as improve the precision and timing of tracking potential threats in space. Space Fence is expected to be operational by 2019.

Current SSA policy is looking to establish standards that would better enable the integration of data from multiple sources; different countries, as well as commercial and civilian providers. There is broad agreement that it would be ideal if there were a more active space traffic management system, and more open access to data.

Commercial operators established the Space Data Association (SDA) in 2009 to provide satellite operators with a way to share controlled, reliable and efficient data for increased safety of satellite operations. As the commercial space sector continues to grow, private organizations could play a larger role in developing standards and practices in areas such as limiting debris, satellite servicing, and the tracking of small satellites.

Unfortunately, space debris is not the only component in space situational awareness. Ground-based electronic and cyber threats are issues on the rise, especially with current Chinese and Russian advancements in anti-satellite weaponry. They have the potential to disrupt satellite activity in space, and thus directly affect military efforts by interfering with ground-based communications and surveillance. It’s anticipated that any future conflict will involve space warfare.
Minor flare and coronal mass ejection (CME) in profile. Image Credit: NASA
Space Weather refers to any anomalies caused by the Sun that affect near-Earth space as well as Earth’s upper atmosphere.

Geomagnetic storms are a type of space weather that temporarily disturb Earth’s magnetosphere. A geomagnetic storm can be initiated by either solar coronal mass ejections (CME) or solar flares. These produce solar winds, which travel across the expanse of space, and usually hit Earth’s magnetic field 24 to 36 hours later.

Solar wind is another variation of space weather, and is associated with what we classify as auroral lights. They are the most visible effects of the Sun’s activity on Earth’s atmosphere, and can be seen at the northern and southern poles. Electrically charged particles from the Sun make contact with Earth’s magnetic field, and collide with atoms and molecules in our atmosphere, resulting in a release of energy that produces what we know as auroral lights.

Solar storms can last anywhere from a few short minutes to several hours. However, the effects of geomagnetic storms can lurk even longer in the Earth’s magnetosphere and atmosphere for days or even weeks.

Unfortunately, space weather isn’t preventable, so our technology is susceptible to these strong electrical currents. However, risk can be mitigated if preventative action is taken. NOAA is tasked with this responsibility. It can predict the severity of geomagnetic activity within a few minutes, and with the one to three-day delay of space weather, warn assets in space to adjust accordingly.

Space weather has the power to disrupt electric power grids, contribute to the corrosion of oil and gas pipelines, and interfere with high-frequency radio communications and Global Positioning System (GPS) navigation. Objects in space during one of these space weather events, such as satellites, are subject to temporary operational aberrations, damage to electronics, and the degradation of solar arrays.

A prime example of the effects of space weather is an event that took place on March 13, 1989, due to geomagnetically induced currents (GICs). The Hydro-Québec power network collapsed because of a CME ejected from the Sun four days earlier. This caused a blackout that lasted for more than nine hours, and affected over 6 million people.
COMMUNICATIONS: RADIO FREQUENCIES
Satellites use a small portion of the radio frequency band to receive signals and relay them back to Earth. Interference with a satellite’s radio signal can be the result of solar weather, conflicting satellite signals, or terrestrial commercial technologies. Radio Frequency Interference (RFI) is characterized as any unwanted signal received by a device that prevents clear or best signal reception.

No nation owns the radio frequency spectrum, but all nations depend on keeping it free from interference. Space-based services can be particularly vulnerable to interference because satellites in space cannot easily increase their transmitted power when faced with increased noise. Many space services are not traditional two-way communications, but include passive monitoring (weather), active sensing (remote sensing) and/or one-way broadcasting (GPS). As a result, critical frequency bands require special international protection.

There is growing pressure on all frequencies from terrestrial commercial technologies, making regulatory protection more important than ever. International management of the use of the radio-frequency spectrum and satellite orbits is regulated by the International Telecommunication Union. In the U.S., the Federal Communications Commission, in partnership with the National Telecommunications and Information Agency, is entrusted with protecting national security, public safety requirements and scientific federal agencies relying on space systems.

### Frequency Bands Allocated to Satellite Transmission

<table>
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<tr>
<th>Letter Designation for Satellite Frequency Band</th>
<th>Frequency Range</th>
<th>Examples of Satellite Services at Different Frequency Bands</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>L</td>
<td>1-2 GHz</td>
<td>Mobile satellite services and GPS</td>
<td>Moderate antennas about 2 ft or less; Negligible atmospheric effects; Popular in terrestrial communications</td>
<td>Moderate to low capacity; Susceptible to jamming</td>
</tr>
<tr>
<td>S</td>
<td>2-4 GHz</td>
<td>Maritime radio navigation; deep space research and radiolocation</td>
<td>Minimal disturbance from rain fade</td>
<td>Moderate to low capacity</td>
</tr>
<tr>
<td>C</td>
<td>4-8 GHz</td>
<td>Fixed satellite services and VSAT</td>
<td>Less susceptible to disturbance from heavy rain fade</td>
<td>Requires a large satellite dish; Interference from terrestrial microwave systems</td>
</tr>
<tr>
<td>X</td>
<td>8-12 GHz</td>
<td>Military and satellite imagery</td>
<td>Enable sharp, high-resolution radar images; Provides a communication option to the heavily populated C and Ku bands</td>
<td>Sensitive to heavy rain fade</td>
</tr>
<tr>
<td>Ku</td>
<td>12-18 GHz</td>
<td>Fixed satellite services and VSAT</td>
<td>More bandwidth; No interference from terrestrial microwave links and other technologies; Operates with a smaller satellite dish</td>
<td>Sensitive to heavy rain fade</td>
</tr>
<tr>
<td>Ka</td>
<td>18-40 GHz</td>
<td>Fixed satellite services and broadcasting satellite services</td>
<td>Greater bandwidth; Increased data throughput; Smaller receive antenna</td>
<td>Severe sensitivity to heavy rain fade</td>
</tr>
</tbody>
</table>

*Rain fade refers primarily to the absorption of a microwave radio frequency (RF) signal by atmospheric rain, snow or ice; losses are especially prevalent at frequencies above 11 GHz.

**Information Sources:**
According to the Federal Aviation Administration (FAA), small launch vehicles are defined as those with a payload capacity of less than 2,268 kilograms (5,000 pounds) at 185 kilometers (100 nautical miles) altitude and in a 28.5-degree inclination orbit. Medium to heavy launch vehicles are capable of carrying more than 5,000 pounds at 100 nautical miles altitude and in a 28.5-degree inclination orbit.

A launch vehicle’s main goal, whether sub-orbital or orbital in nature, is to achieve the needed velocity to propel a spacecraft or payload out of Earth’s gravity and into a desired course or orbit. With technological advancements, and a constant quest for cost efficiency, commercial companies are now investing in launch vehicles that can be recycled and reused. Although a completely reusable orbital vehicle has yet to be developed since the Space Shuttle, multiple private companies have developed, or are working on, reusable rocket systems that utilize vertical take-off and vertical landing. Others are developing more shuttle-like systems that would utilize vertical take-off and horizontal landing.

Any launch vehicle with no recoverable components after its mission is complete is an expendable launch vehicle (ELV). These systems are only used once and then discarded. ELV’s are used frequently in practice launches or for launching satellites due to their lower risk of mission failures.

For a detailed review of various commercial launch vehicles, the FAA provides a compendium of commercial space transportation each year:

https://www.faa.gov/about/office_org/headquarters_offices/ast/media/2017_AST_Compendium.pdf
For more information on the global space economy, various sectors, players, and trends, please visit *The Space Report: The Authoritative Guide to Global Space Activity*. For over a decade, the Space Foundation Research and Analysis team has gathered an ever-expanding collection of information about the global space industry, government policies and priorities, and the evolving trends in the space workforce and in education that influence space activity. In addition to the existing information contained within the report, subscribers also have access to the Space Foundation’s analysts, who can assist with finding the answers to support data-driven decision making. For more information, please contact thespacereport@spacefoundation.org.