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SPACE FOUNDATION

The Space Briefing Book

A Reference Guide to Modern Space Activities

Introduction

Space impacts every facet of 21st century life. Business, governance, security, education, manufacturing, healthcare, communication, and more all rely on space-based infrastructure and the technologies derived from exploring and operating in space. With rapidly expanding space access, miniaturization of technology, growing scientific knowledge, and the enduring human desire to explore our universe, there has never been a more exciting or important time in space.

This Space Briefing Book is a primer and reference guide on the organizations, laws and regulations, technologies, and factors in modern space operations. It is designed to support and inform legislators and staff, journalists, and others whose work holds a nexus to space.

The global space economy is worth hundreds of billions of dollars, and in the balance sheet of national priorities, space is a critical investment. It yields cascading dividends for job creation, technology transfer, expanded entrepreneurship, international partnerships, shared research and development, and much more. Indeed, space exploration and operation delivers wider opportunity than any effort on the planet—or beyond it.

Ad astra!

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Space Sectors

Space endeavors are grouped into sectors: civil, national security (i.e., defense and intelligence), and commercial. Each sector operates with its own goals and assets, although they all rely on a common space industrial base, workforce, and infrastructure.

Civil

Non-defense-related government space activities, including launching and managing satellites, conducting research, and exploring the solar system. In the United States, nearly all civil space missions are managed or run by NASA and NOAA.

National Security

The defense and intelligence sectors are commonly considered together as a "national security" sector. The U.S. Department of Defense oversees space missions in support of military operations, and several agencies in the U.S. intelligence community are involved in operating space assets for intelligence purposes to support military and law enforcement operations.

Commercial

All space-related endeavors—including goods, services and activities—provided by private sector enterprises with the legal capacity to offer their products to nongovernmental customers. Commercial space efforts range from satellite communication to space tourism.

U.S. Government Role In Space Activities

While NASA is the leader of American efforts in space, there are dozens of agencies, departments, and organizations throughout the U.S. government with a role in space operation, policy, funding, and other matters.

Civil Agencies

National Aeronautics and Space Administration (NASA)
Founded in 1958, NASA is the primary space agency for the U.S. government. With its headquarters in Washington, DC, NASA's research, development and operations are spread across centers around the country.

National Oceanic and Atmospheric Administration (NOAA)
NOAA is charged with studying Earth's climate, weather and oceans, as well as how solar phenomena affect Earth. Among its space-related functions, NOAA manages the National Weather Service, remote-sensing satellite constellations and the Space Weather Prediction Center.

Federal Aviation Administration (FAA)
The FAA is a regulatory and policymaking body in commercial space activities through its Office of Commercial Space Transportation (AST). Via AST, the FAA grants licenses, permits, and approvals for launch and reentry, and it sets regulations and policies for commercial spaceflight.

Department of Energy (DOE)
Probes, satellites and rovers require long-term power sources. DOE oversees the production of nuclear-fueled radioisotope power systems (RPSs), which convert heat from the decay of radioactive material into electrical power.

Defense and Intelligence Agencies

Department of Defense (DOD)
Oversees and directs the missions and projects of a variety of agencies with a space nexus in support of the U.S. military and intelligence community.

Air Force Space Command (AFSPC)
The primary military launch provider for DOD agencies, AFSPC also operates the Global Positioning System, Defense Satellite Communications Systems, the Defense Meteorological Satellite Program, the Defense Support Program and the Space-Based Infrared System Program.

Army Space and Missile Defense Command (SMDC)
Broadly, SMDC conducts space and missile defense operations, using Army capabilities to support U.S. Strategic Command.

Defense Advanced Research Projects Agency (DARPA)
The agency invests in breakthrough technologies for national security needs. DARPA's work includes exploring space technologies, such as the Experimental Spaceplane program.

Defense Intelligence Agency (DIA)
DIA provides defense intelligence to the military branches and the intelligence community. As a part of this, it identifies challenges, needs, and threats in space, and it operates the Missile and Space Intelligence Center, which provides intelligence assessments on foreign weapons systems.

Missile Defense Agency
Charged with developing and fielding a ballistic missile defense system to detect and defend against enemy ballistic missiles. System components include ground-based interceptor missiles, warship-based interceptors, and the Terminal High Altitude Area Defense (THAAD) program.

National Geospatial-Intelligence Agency (NGA)
A combat support agency using satellite reconnaissance data to provide geospatial intelligence for military and other operations.

National Security Agency (NSA)
NSA is an intelligence agency that analyzes electronic signals and systems through data gathered, in part, by satellite reconnaissance, producing signals intelligence (SIGINT) regarding international terrorists and foreign powers, organizations, or people.

National Reconnaissance Office (NRO)
Procures and operates U.S. reconnaissance satellites in support of intelligence-related activities. It operates four primary types of satellite constellations: SIGINT (signals intelligence); GEOINT (geospatial intelligence); Communications Relay; and Reconnaissance.

U.S. Space Command (USSPACECOM)
The Unified Combatant Command with warfighting responsibilities as they relate to space, including operational command and control of U.S. space forces and space-based assets.

Policy

Executive Office of the President
The U.S. President, informed by Executive Office advisors, committees, and councils, develops space policy that sets government priorities and goals and guides legislative action to fund the policy objectives.

Office of Science and Technology Policy (OSTP)
As part of the Executive Branch, OSTP advises the President on matters relating to science and technology, including development and innovation, impact on the nation and the economy, and how the federal government sets science and technology-related policies.

National Security Council
Advises the President on developing policies related to national security and foreign affairs. As it can concern military and intelligence matters, projecting and protecting a national presence in space is within the Council's purview.

National Space Council
Chaired by the Vice President, the Council includes the participation of departments with a space nexus (e.g., NASA, State, Commerce) to develop and advise on policies that impact U.S. space innovation, exploration, and dominance.

Office of Space Commerce, Department of Commerce
The office is the primary agency responsible for space commerce policy activities in the Department of Commerce, fostering the growth and success of the U.S. commercial space industry.

Office of Space and Advanced Technology (OES/SAT), Department of State
OES/SAT advances American space leadership by pursing and maintaining a rules-based international framework for space commercialization and use. It also leads the U.S. delegation to the United Nations Committee on the Peaceful Uses of Outer Space.

Office of Commercial Space Transportation (AST), FAA
An office within the FAA, AST grants licenses and permits for launch/reentry vehicles and spaceports, sets insurance requirements for launch providers, and regulates commercial spacecraft design and operation to ensure the health and safety of humans onboard.

Oversight, Funding and Regulatory Bodies

Executive

Bureau of Industry and Security, U.S. Department of Commerce
Manages Commercial Control List

Office of Commercial Space Transportation, Federal Aviation Administration, U.S. Department of Transportation
Regulates commercial spaceflight

Federal Communications Commission
Regulates radio frequencies for satellites

Directorate of Defense Trade Controls, Bureau of Political-Military Affairs, U.S. State Department
Directs ITAR restrictions and licensing

Office of the Deputy Assistant Secretary of Defense for Space Policy, U.S. Department of Defense
Implements DoD strategic guidance and national security space strategy

House

U.S. House Committee on Appropriations
House Subcommittee on Commerce, Justice, Science and Related Agencies
Appropriates budgets for space and science programs, including NASA, NOAA and the NSF

U.S. House Committee on Science, Space and Technology
House Subcommittee on Space and Aeronautics
Oversees programs and policies relating to space exploration and national space policy, including NASA and NOAA

U.S. House Committee on Transportation and Infrastructure
House Subcommittee on Aviation
Oversees programs and policies relating to all aspects of civil aviation, including the FAA

U.S. House Armed Services Committee
House Subcommittee on Strategic Forces
Oversees programs and policies relating to strategic deterrence, missile defense and space

U.S. House Permanent Select Committee on Intelligence
Oversees programs and policies relating to the U.S. intelligence community

Senate

U.S. Senate Committee on Appropriations
Senate Subcommittee on Commerce, Justice, Science and Related Agencies
Appropriates budgets for space and science programs, including NASA, NOAA and the NSF

U.S. Senate Committee on Commerce, Science and Transportation
Senate Subcommittee on Aviation and Space
Oversees programs and policies relating to aerospace research and development, national space policy, and civil aviation

U.S. Senate Armed Services Committee

Senate Subcommittee on Emerging Threats and Capabilities
Oversees programs and policies relating to science and technology, intelligence, strategic and information operations, and homeland defense

Senate Subcommittee on Strategic Forces
Oversees programs and policies relating to nuclear and strategic forces, space programs and ballistic missile defense

U.S. Senate Select Committee on Intelligence
Oversees programs and policies relating to the U.S. Intelligence Community

U.S. Space Policy, Legislation & Regulation

The efforts of U.S. space agencies, organizations, and businesses across all space sectors are guided, empowered, and sometimes restricted through federal law, presidential directives, executive orders, and regulations.

Notable U.S. Space-Related Legislation

Title 51 of the United States Code (USC) is a compilation of existing space-related laws organized into a topical space-specific section of the USC.

Communications Act of 1934

Passed long before the first spaceflight, the Communications Act has been amended over time to govern requirements for commercial satellite operations, licensing, and coordination in the use of the radio spectrum.

National Aeronautics & Space Act of 1958

President Dwight Eisenhower signed the act in 1958, which established NASA as well as U.S. objectives in space: expanding space knowledge; creating and improving space vehicles; studies of benefits from space operation; preserving the United States as a space leader; and sharing discoveries with defense agencies.

The Commercial Space Launch Act

Originally passed in 1984 and since amended, the law grants the U.S. Department of Transportation regulatory oversight of commercial spaceflight, it indemnifies companies for large third-party damages and it informs regulations for commercial human spaceflight.

Land Remote-Sensing Commercialization Act

Passed in 1984, the law principally concerned transferring the U.S. government-owned Landsat satellite program to private industry, allowing companies to take over operation of the Earth-imaging satellite constellation.

Land Remote-Sensing Policy Act

The 1992 law repealed the Land Remote-Sensing Commercialization Act, as transfer to the private sector of the U.S. government-owned Landsat proved problematic. The new law gave the Department of Commerce the power to license and regulate a U.S. commercial remote-sensing industry and to outsource the development of new Landsat components to the private sector.

U.S. Commercial Space Launch Competitiveness Act of 2015

The law was designed to encourage commercial spaceflight and innovation by: postponing significant regulatory oversight of private spaceflight companies until 2023; extending the period during which the government indemnifies commercial spaceflight companies for third-party damages beyond the company's required liability insurance; and granting private companies the right to own resources collected in space, such as materials from asteroid mining.

Weather Research and Forecasting Innovation Act of 2017

The law permits commercial weather satellites and allows NOAA to purchase weather data from commercial weather satellite constellations.

Executive Orders (EO)

EO on Coordinating Efforts to Prepare the Nation for Space Weather Events (2016)
Establishes U.S. policy to prepare for space weather events to minimize the potential impact on the economy and society.

EO on Reviving the National Space Council (2017)
The National Space Council stopped operating in 1993. The executive order revives the Council and articulates its duties related to advising and assisting the President on space policy and strategy.

EO on the Establishment of the United States Space Command (2018)
Establishes a U.S. Space Command as a functional Unified Combatant Command with general responsibilities of a Unified Combatant Command, space-related responsibilities previously assigned to U.S. Strategic Command, and responsibilities of Joint Force Provider and Joint Force Trainer for Space Operations Forces.

EO on Coordinating National Resilience to Electromagnetic Pulses (2019)
Directs the Federal government to develop "sustainable, efficient and cost-effective approaches" to building national resilience to the impact from an electromagnetic pulse (EMP), including those caused by solar eruptions.

Notable U.S. Space-Related Regulations

Radio Frequency Regulation
The Federal Communications Commission (FCC) grants licenses for commercial satellite communication, dictating which band of the electromagnetic spectrum a satellite can use. Spectrum assignments are co-managed with the National Telecommunications and Information Administration.

CFR Title 14, Chapter III
The FAA's regulations on commercial spaceflight cover the "authorization and supervision" of any U.S. organization or citizen conducting space endeavors. It requires commercial missions to receive a license to launch (and re-enter), and it also requires licenses for commercial spaceports. It does not apply to government agencies, like NASA.

International Traffic in Arms Regulations (ITAR)
ITAR restricts the export of technology and data related to national security. In 2014, ITAR export restrictions were loosened for 36 countries and satellite components were largely moved to the Commercial Control List. The U.S. State Department's Directorate of Defense Trade Controls, Bureau of Political-Military Affairs, directs ITAR restrictions and licensing.

Export Administration Regulations (EAR)
The Department of Commerce's EAR regulate technologies and data whose commercial export could lead to military applications by other nations. The Commerce Control List details the types of technologies that require a license to be exported, which includes components related to spacecraft, satellites, launch systems and other space-focused technologies.

National Space Policy Directives (SPDs)

SPD-1 Reinvigorating America's Human Space Exploration Program (2017)
Amends Presidential Policy Directive-4 (2010), articulating a direct call for space missions beyond LEO, specifically to the Moon and eventually to Mars and other celestial bodies.

SPD-2 Streamlining Regulations on Commercial Use of Space (2018)
Calls on Executive Branch agencies to review existing regulations and ensure rules are not duplicative while also promoting economic growth, advancing national security and foreign policy goals, and encouraging U.S. space commerce leadership.

SPD-3 National Space Traffic Management Policy (2018)
Calls for a new method of space traffic management (STM) that: meets current and future risks; sets priorities for space situational awareness and STM innovation; aligns with national security priorities; and encourages U.S. commercial space growth.

SPD-4 Establishment of the United States Space Force (2019)
Directs the Defense Department to develop a legislative proposal establishing a sixth branch of the U.S. Armed Forces, as well as establishing a U.S. Space Command.

U.S. Space Policies

National Space Policy (2010)
The National Space Policy directive is a comprehensive guide for all government space activities and sets out six goals for U.S. space programs: energize the domestic space-related industries; expand international cooperation; ensure stability in space; increase the assurance and resilience of mission-essential functions against all threats; pursue human and robotic initiatives for innovation, inspiration and exploration; and improve space-based Earth and sun observation. The policy also includes detailed Commercial Space Guidelines to guide government interaction with the commercial space sector.

NOAA Commercial Space Policy (2016)
Establishes the framework for the agency to use commercial space-based approaches and engage the commercial space sector.

National Space Weather Strategy and Action Plan (2019)
Articulates the objectives and activities that will improve U.S. preparedness for space weather over 10 years. Specific objectives include: guarding against space weather events, developing and sharing space weather information, and establishing plans and procedures for responding to and recovering from events.

Space Programs Around the World

There are dozens of countries around the world developing and expanding their national space programs. Some of these space programs include:

Canadian Space Agency (CSA)
Canada's space agency, CSA was established in 1990 to foster the development and study of space. Its space operations include producing the International Space Station's robotic arm and operating communication and remote sensing satellites.

China National Space Administration (CNSA)
Established in 1993, CNSA coordinates China's space activities, employing the country's indigenous launch systems for space endeavors including lunar exploration, space station development and operation of China's satellite navigation system.

European Space Agency (ESA)
An organization of 22 member states, ESA coordinates the programs and funding for the space missions of participating countries.

Indian Space Research Organization (ISRO)
Founded in 1969, ISRO controls India's constellations of communication and remote sensing satellites and leads the country's space exploration missions.

Australian Space Agency
Founded in 2018, the Australian Space Agency is responsible for coordinating the country's domestic civil space endeavors, providing space policy and strategic advice, leading international engagements on civil space matters, and supporting the development of Australia's space industry.

Brazilian Space Agency
The successor to the Brazilian space program started in 1960, the agency is responsible for the country's space ambitions, including operating the Alcântara and Barreira do Inferno Launch Centers.

National Centre for Space Studies (CNES)
The French space agency CNES was established in 1961, leading the nation to become the third country to achieve indigenous orbital launch capability. Today, CNES conducts space missions in conjunction with the ESA and boasts one of the largest budgets of any national space program.

EU Agency for the Space Programme
The European Union's space program is responsible for operating the EU's satellite navigation systems (Galileo and EGNOS) and the EU's Earth observation program (Copernicus), in addition to the EU's Space Situational Awareness program and government satellite communication endeavors. The agency is distinct from ESA.

German Aerospace Center (DLR)
Responsible for planning and implementing the German space program, the center's work includes solar system exploration, basic research, and representing Germany's national interests in the ESA.

Israel Space Agency
Founded in 1983, the agency leads and coordinates Israel's civilian space program.

Japan Aerospace Exploration Agency (JAXA)
Founded in 2003, JAXA's mandate stretches from basic research to space operations, including the Japanese Experiment Module on the International Space Station and exploration missions to the Moon and a near-Earth asteroid.

Korea Aerospace Research Institute (KARI)
The South Korean space agency first reached orbit in 2013 with a two-stage rocket and is developing an indigenous successor launch system, with ambitions to explore orbit and the Moon.

Roscosmos State Corporation for Space Activities
The Russian state-run space corporation includes the country's nationalized space industry, as well as its mission control, cosmonaut training, launch facilities and other space-focused operations.

Iranian Space Agency
Founded in 2004, ISA has successfully placed satellites in Earth orbit since 2009. The Iranian space program is currently condemned by the United States and Europe because of concerns over its military potential.

Italian Space Agency (ASI)
Founded in 1988, the agency coordinates Italy's space sector efforts and investments, serving as the lead organization for Italian space research agencies.

Swedish National Space Agency (SNSA)
The agency is responsible for Sweden's space and remote sensing activities, and its mission is to distribute government funding for space research, initiate R&D in space and remote sensing areas, and cooperate with the ESA and other agencies.

United Arab Emirates Space Agency
Created in 2014, the agency is responsible for the UAE's space endeavors, programs and partnerships, and space industry.

UK Space Agency
Established in 2010, the UKSA holds responsibility for civil space exploration, government policy and budgets, and represents the UK in space-related matters with the international community.

International Space Law

There are five international treaties underpinning space law, overseen by the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS).

The Outer Space Treaty

"Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies"

The treaty is the foundation of international space law for signatory nations (108 in 2019). The treaty presents principles for space exploration and operation: Space activities are for the benefit of all nations, and any country is free to explore orbit and beyond.

- **There is no claim for sovereignty in space; no nation can "own" space, the Moon or any other body.**
- **Weapons of mass destruction are forbidden in orbit and beyond, and the Moon, the planets, and other celestial bodies can only be used for peaceful purposes.**
- **Any astronaut from any nation is an "envoy of mankind," and signatory states must provide all possible help to astronauts when needed, including emergency landing in a foreign country or at sea.**
- **Signatory states are each responsible for their space activities, including private commercial endeavors, and must provide authorization and continuing supervision.**
- **Nations are responsible for damage caused by their space objects and must avoid contaminating space and celestial bodies.**

The Rescue Agreement

"The Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space"

Formally "The Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space," signatories agree to take all possible actions to help or rescue astronauts in need, and if applicable, return them to the nation from which they launched. Additionally, signatories agree to help return to the sponsoring nation any space objects that land on Earth outside of the country from which they were launched.

The Moon Agreement

"The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies"

"The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies" states that celestial bodies can only be used for peaceful purposes, that they should not be contaminated, that the UN should always be made aware of any station on a non-Earth body, and that if resource mining on the Moon becomes feasible, an international regime must be established to govern how those resources are obtained and used. The United States is not a signatory of the Moon Agreement.

The Liability Convention

"The Convention on International Liability for Damage Caused by Space Objects"

Signatories to "The Convention on International Liability for Damage Caused by Space Objects" take full liability for any damage caused by their space objects and agree to standard procedures for adjudicating damage claims.

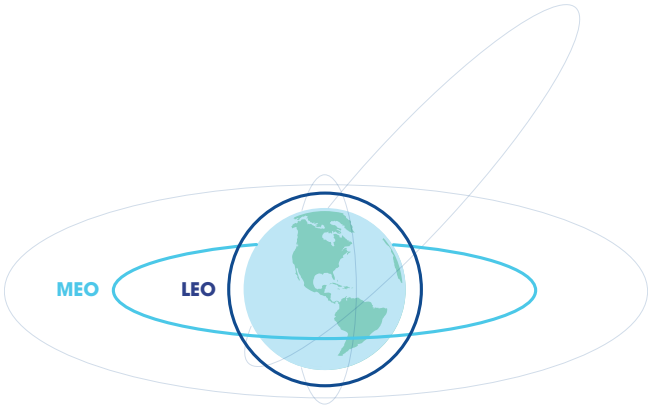
The Registration Convention

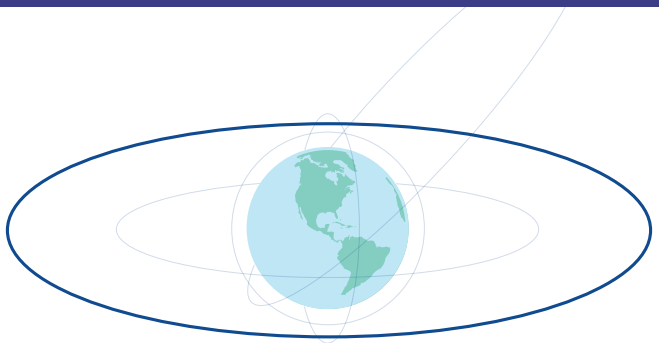
"The Convention on Registration of Objects Launched into Outer Space"

Expanding a space object register, "The Convention on Registration of Objects Launched into Outer Space" empowers the UN Secretary-General to maintain a register of all space objects.

Types of Orbits

There are several types of Earth orbit, and each offers certain advantages and capabilities.





Low Earth Orbit (LEO)

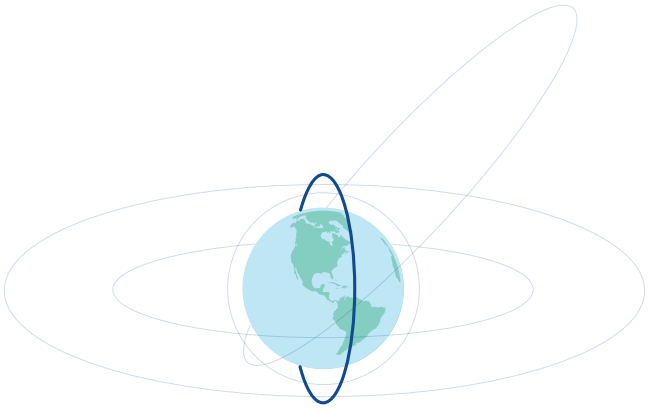
LEO is commonly used for communication and remote sensing satellite systems, as well as the International Space Station (ISS) and Hubble Space Telescope.

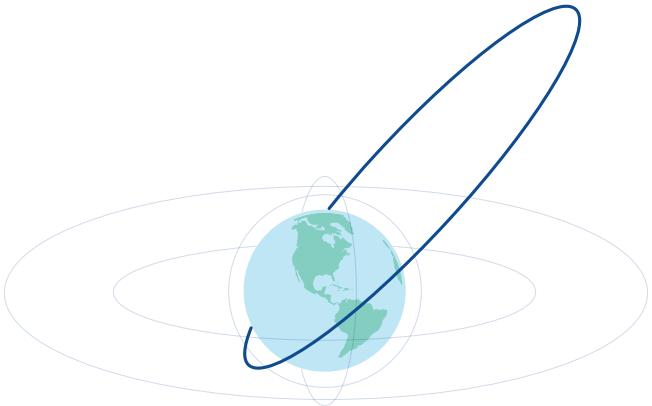
Medium Earth Orbit (MEO)

MEO is commonly used for navigation systems, including the U.S. Global Positioning System (GPS).

Geosynchronous Orbit (GSO) & Geostationary Orbit (GEO)

Objects in GSO have an orbital speed that matches the Earth's rotation, yielding a consistent position over a single longitude. GEO is a kind of GSO. It matches the planet's rotation, but GEO objects only orbit Earth's equator, and from the ground perspective, they appear in a fixed position in the sky. GSO and GEO are used for telecommunications and Earth observation.





Polar Orbit and Sun-Synchronous Orbit (SSO)

Within 30 degrees of the Earth's poles, the polar orbit is used for satellites providing reconnaissance, weather tracking, measuring atmospheric conditions, and long-term Earth observation.

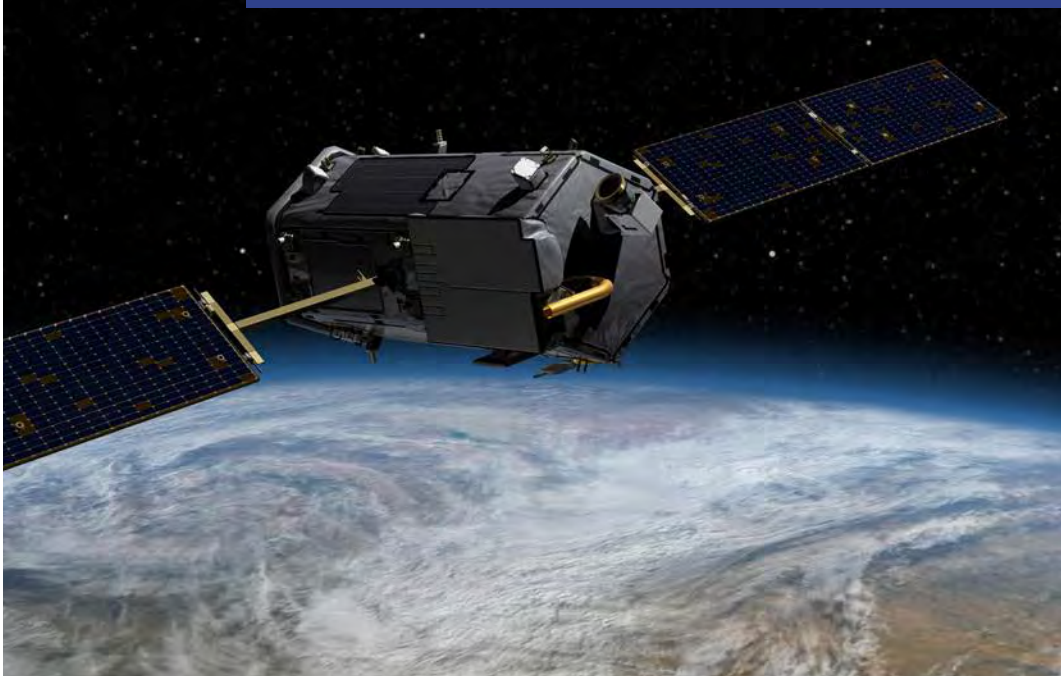
A type of polar orbit, SSO objects are synchronous with the sun, such that they pass over an Earth region at the same local time every day.

Highly Elliptical Orbit (HEO)

An HEO is oblong, with one end nearer the Earth and other more distant. Satellites in HEO are suited for communications, satellite radio, remote sensing and other applications.

Satellites

Satellites are foundational components of modern society, permitting communications, global positioning, Earth and solar system study, and a range of other activities.



Satellite Applications

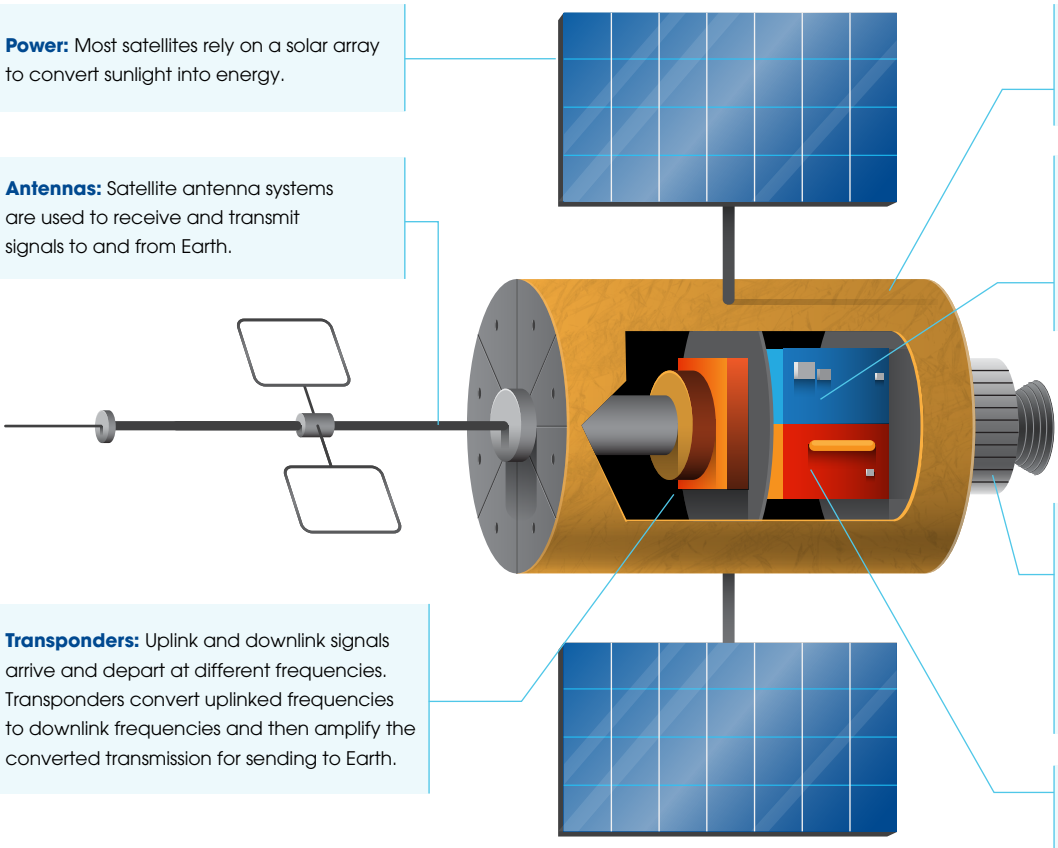
Earth Science
Remote sensing satellites are used to study the Earth, including things like weather events, ecological trends and ocean temperatures.

Solar System Study
Satellites are used to study the many celestial bodies in the solar system. To date, artificial satellites have orbited many significant planets and moons in our solar system, as well as numerous smaller objects like dwarf planets, asteroids and comets.

Reconnaissance
Similar to Earth science uses, reconnaissance or intelligence satellites employ a suite of sensors and communications tools, deployed and used by government agencies for defense or intelligence purposes, including early missile detection and emergency broadcasts.

Communications
Most of the satellites in orbit are used for relaying communications around the Earth's curve.

Position, Navigation and Timing (PNT)
Navigation satellites deliver geospatial positioning, identifying a single point on the ground by its latitude, longitude and altitude.



Power: Most satellites rely on a solar array to convert sunlight into energy.

Antennas: Satellite antenna systems are used to receive and transmit signals to and from Earth.

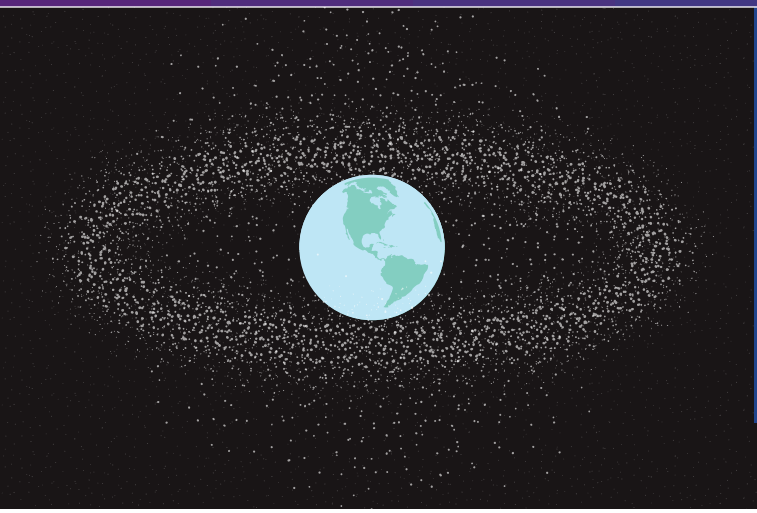
Transponders: Uplink and downlink signals arrive and depart at different frequencies. Transponders convert uplinked frequencies to downlink frequencies and then amplify the converted transmission for sending to Earth.

Housing: Housing is constructed from strong materials that can withstand the harsh space environment.

Command and Data Handling: The operational heart of a satellite, command and control systems monitor every aspect of the satellite and receive commands from Earth for operation.

Guidance and Stabilization: Sensors monitor the satellite's position to ensure it remains in the correct orbit and is oriented toward the correct target. If necessary, thrusters and other maneuvers allow a satellite to fine-tune its position and orientation.

Thermal Control: Guards satellite equipment against extreme changes in temperature.



Space Situational Awareness

There are tens of thousands of objects in Earth orbit that pose a potential threat to satellites and launches. Space Situational Awareness (SSA) refers to keeping track of objects in orbit and predicting where they will be at any given time.

SSA Organizations

U.S. Strategic Command (USSTRATCOM) Space Surveillance Network:
A global network of ground-based sensors and tracking systems that inform an up-to-date catalog of satellites, dubbed the Space Object Catalog.

USSTRATCOM SSA Sharing Program:
Promotes data exchange with other organizations tracking space debris.

ESA SSA Programme:
Develops capabilities to track objects in orbit that could disrupt other satellites or impact ground-based infrastructure.

Russian Military Space Surveillance Network (SKKP):
Russia's equivalent of the USSTRATCOM Space Surveillance Network, the SKKP catalogues space objects and tracks and predicts their location in orbit.

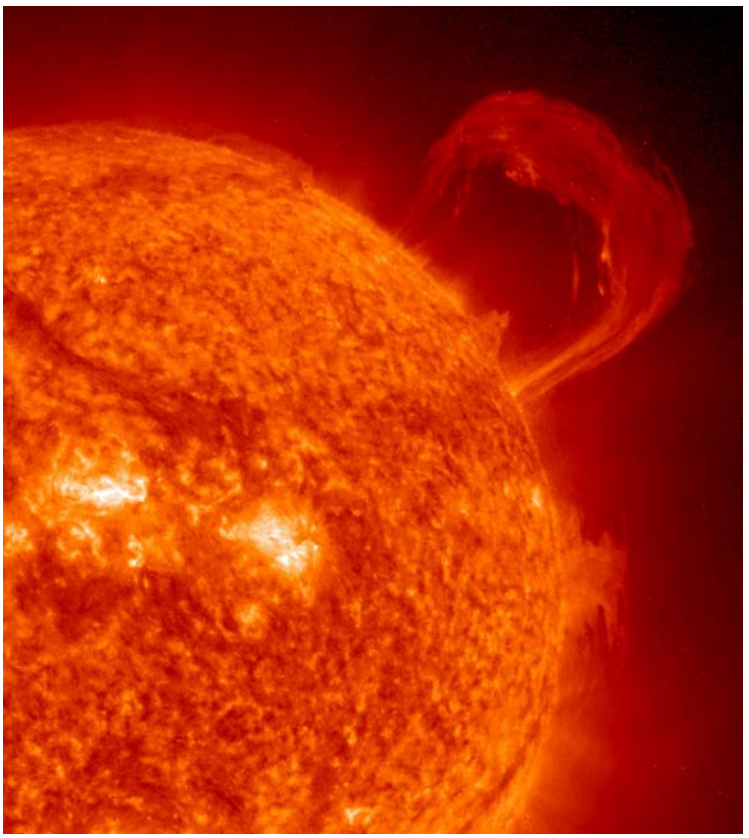
Space Data Association (SDA):
An international organization of satellite operators working to, in part, enhance the "accuracy and timeliness of collision warning notifications."

Space Weather

A sun cycle lasts about 11 years, and it is marked by the frequency of sunspots. During the "solar minimum," sunspots and solar flares are fewer and smaller, while during the "solar maximum," sunspots are larger and more frequent. Solar flares and sunspots can impact Earth's space- and ground-based infrastructure and technology. The sun is currently near its solar minimum.

Organizations Tracking Solar Activity

- **NOAA Space Weather Prediction Center:**
  The U.S. NOAA's Space Weather Prediction Center monitors for and predicts solar activity to forecast space weather's impact on Earth infrastructure.
- **ESA Space Weather Coordination Centre:**
  The European monitoring organization develops and distributes up-to-date space weather analysis, primarily catering to owners and operators of ground- and space-based infrastructure.
- **International Space Environment Service (ISES):**
  A network of space weather organizations collaborating to coordinate and deliver space weather services. It draws data from 16 regional warning centers to provide forecasts, alerts, long-term solar cycle predictions and other data on the space environment.
- **Solar and Heliospheric Observatory (SOHO):**
  Operated by the ESA and NASA, SOHO has been used to study the sun for two decades, observing the sun's composition and delivering information about it to inform analysis of space weather.

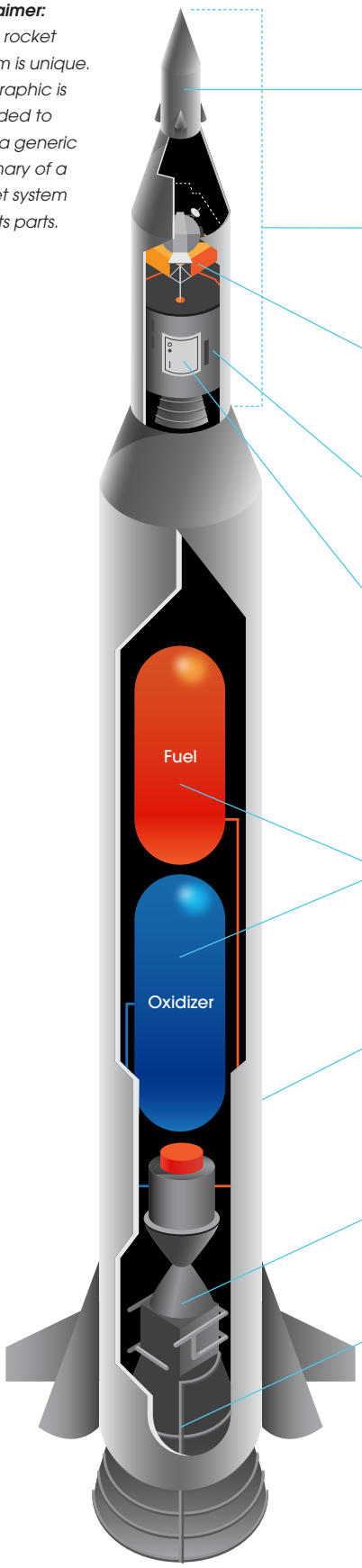


Launch Systems

Reaching Earth orbit and beyond requires a careful combination of rocket engines, spacecraft, fuels and other systems.

Components of a Launch System

Disclaimer: *Every rocket system is unique. This graphic is intended to offer a generic summary of a rocket system and its parts.*



Launch Abort System (LAS): The LAS sits atop the payload, and if launch conditions threaten the crew, it fires a solid-fuel rocket that carries the payload away from the system.

Payload Fairing: The payload experiences extreme pressure and heat as it climbs and is covered with a protective nose cone.

Crew or Cargo Module: The section containing whatever is being delivered to space, be it supplies for a space station, a satellite, or crew and passengers.

Service Module: The payload's propulsion and power systems provide thrust in space and allow the payload to maneuver.

Guidance System: Sensors, computers, radars, and communication equipment coordinated with exhaust nozzles for rocket stability during launch, ascent, and maneuvers.

Liquid Fuel: Most main engines mix a fuel (e.g., liquid hydrogen) and an oxidizer (e.g., liquid oxygen) in a combustion chamber.

Structural System: All of the parts constituting the frame of the launch system.

Rocket Engine: Engines burn fuel in a chamber, which causes the resulting gas to expand at supersonic speed.

Nozzle: Accelerates the flow of gas from the combustion chamber to produce thrust.

Launch System Families

These are some of the most common launch system families flying today. For more information, visit the company websites and **SpaceFoundation.org/BriefingBook**.

United States

Atlas V

Delta IV Heavy

Antares

Minotaur

Pegasus

New Shepard

United Launch Alliance
ulalaunch.com

Northrop Grumman
northropgrumman.com

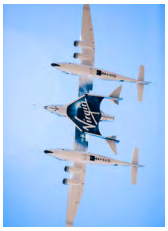
Blue Origin
blueorigin.com

Beta

Electron

Falcon 9

Falcon Heavy



SpaceShipTwo

Firefly
firefly.com

Rocket Lab
rocketlabusa.com

SpaceX
spacex.com

Virgin Galactic
virgingalactic.com

NASA's Space Launch System

NASA is developing a new heavy-lift rocket, the Space Launch System (SLS). It is designed for space missions beyond Low Earth Orbit, and when complete, SLS will be the most powerful rocket system ever built. Its Orion Multi-Purpose Crew Vehicle is designed to carry crewed missions to the Moon, Mars and beyond. The first SLS mission will be Artemis 1, which will be an integrated test of the new SLS, Orion and ground systems at Kennedy Space Center.

Russia

Angara

Proton

Soyuz

International Launch Services
ilslaunch.com

RSC Energia
energia.ru

Europe

Ariane 5

Vega

Soyuz

Arianespace
arianespace.com

Avio
avio.com

RSC Energia
energia.ru

China

CNSA cnsa.gov.cn

Kuaizhou

Long March

India

ISRO isro.gov.in

GSLV

PSLV

Israel

ISA space.gov.il

Shavit

Japan

JAXA global.jaxa.jp

Epsilon

H-2

Spacecraft

There are a variety of spacecraft already reaching space or under development to do so. Many of these are designed for crewed flight. For more information, visit the company websites and **SpaceFoundation.org/BriefingBook**.

New Shepherd

Blue Origin
blueorigin.com

CST-100 Starliner

Boeing
boeing.com

Orion

NASA
nasa.gov

Cygnus

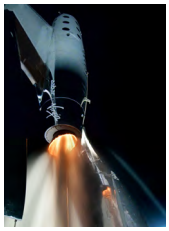
Northrop Grumman
northropgrumman.com

Dream Chaser

Sierra Nevada Corp
sncorp.com

Dragon

SpaceX
spacex.com



VSS Unity

Virgin Galactic
virgingalactic.com

Soyuz

Docking at the ISS

Acronyms

U.S. Government Agencies

AFSPC	Air Force Space Command
AST	Office of Commercial Space Transportation
DARPA	U.S. Defense Advanced Research Projects Agency
DIA	Defense Intelligence Agency
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
NASA	National Aeronautics and Space Administration
NGA	National Geospatial-Intelligence Agency
NOAA	National Oceanic and Atmospheric Administration
NRO	National Reconnaissance Office
NSF	National Science Foundation
SMDC	Army Space and Missile Defense Command
USSPACECOM	U.S. Space Command
USSTRATCOM	U.S. Strategic Command

Other Terms

EAR	Export Administration Regulations
GEO	Geostationary Orbit
GPS	Global Positioning System
GSO	Geosynchronous Orbit
HEO	Highly Elliptical Orbit
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
LAS	Launch Abort System
LEO	Low Earth Orbit
MEO	Medium Earth Orbit
SATCOM	Satellite Communications
SLS	Space Launch System
SSA	Space Situational Awareness
SSO	Sun-Synchronous Orbit
STM	Space Traffic Management

About the Space Foundation

Since 1983, the Space Foundation has been dedicated to inspiring, educating, advocating, and connecting on behalf of the space community. As a charitable organization, we are committed to engaging the public, private, nonprofit, academic, and other sectors pursuing world-changing endeavors that benefit the public interest. In this, we bring together a diverse, international space community united by its aspiration to reach for the stars and bring the rewards back to Earth. The space community has entered a new era, and the Space Foundation's work is contributing to the collaboration and growth that will take us places we have never ventured before.

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SPACE FOUNDATION