Developments in Outer Space: Asia Pacific and Singapore

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Executive Summary

The history of outer space has been defined by three major periods. The Cold War's superpower rivalry between the United States and the Soviet Union set new precedents for space exploration and shaped today's international norms. The 1990s saw the privitization and commercialization of space as well as the first major use of space assets in combat. Finally, the 21st century has been marked by a proliferation of spacefaring nations, complicating the realm of space with many different national interests of both peaceful and military purposes.

4 major space treaties define the rules of international space activity. The 1967 Outer Space treaty, the 1967 Astronaut Rescue Agreement the 1972 Liability Convention and the 1974 Registration Convention. They have established outer space as a realm of peaceful international cooperation, though this realm is not free from state competition.

Existing outer space weapons typically target satellites and may consist of interceptor satellites, ground based anti-satellite weapons of kinetic or directed energy, fighter-jet launched interceptors and satellite jammers. There is also the threat of high altitude nuclear explosion. All present threats to satellites in low-earth, mid-earth and geosynchronous orbit. Trends for the future of space weapon development point to major power competition over sub-orbital hypersonic missiles and infantry space transportation.

The major powers of the United States, China and Russia all have vested interest in controlling outer space. The US' heightened vulnerability from its heavy dependence on satellite systems has made it anxious to project space superiority. China's status as a rising space power makes it want to seek parity with the US in terms of space capability and is developing anti-satellite weapons as an asymmetric counter to US space dominance. Russia as a weakened space power has relied more on the international legal regime to project its will.

In Southeast Asia, Indonesia and Malaysia appear in the lead in terms of space development. Both have dedicated space agencies, with the former researching rocket technology and the latter having achieved manned spaceflight. Thailand, Singapore and Vietnam follow behind, more focused on developing remote sensing capabilities and the ability to take high resolution imagery. The Phillipines interest in space is more scientific, while Laos has become totally dependent on China to fund its satellite program. Cambodia, East Timor and Myanmar do not appear to be conducting space development.

It is in the national interest to ensure that Singapore remains relevant in a world increasingly engaged in outer space. It must catch up with the region in space development and should engage in bilateral and multilateral cooperation to develop its independent space capabilities. Leveraging economic comparative advantages, Singapore should be able to carve out a niche in the outer space community.

Background: From the Cold War to the 21st Century

Understanding geopolitical developments in outer space requires some knowledge of the history of space affairs from the 20th century. It was the Cold War that started the original space race between the United States (US) and the Soviet Union. However, outer space becomes much more complicated in the 21st century with a sharp increase in spacefaring nations with interests in space ranging from science and commerce to defence.

The precedent for law governing outer space, aka "space law" is laid out in the outer space treaties of the 1960s. These treaties explain why space has developed into a realm of international cooperation as opposed to one of state competition, though state competition is still evident.

Historical Context

The Cold War

The Soviet launch of Sputnik in 1957 started an intense rivalry between the United States and USSR for outer space superiority.[1] Early on, both superpowers agreed to use space 'only for peaceful purposes' and not for the 'testing of military missiles', presumably having a common interest in avoid military conflict and competition in space. Secretly however, both were developing and launching a great number of military satellites.

A major function of military satellites was satellite reconnaissance. At the time, the limited capabilities of of anti-satellite weaponry of the time and the common desire to be able to early-detect nuclear missile launches lead to both superpowers' mutual acceptance of satellite reconnaissance on each other.

Over time, military satellites developed three basic functions throughout the Cold War: technical intelligence collection, targeting, and arms control monitoring and verification. Other military uses of satellites (like communications and navigation, weather monitoring) also came to be seen as lawful and useful by both sides.

Anti-satellite (ASAT) weaponry also saw development. As technology progressed, development moved from traditional ground based ASAT weapons to space-based kinetic energy and directed energy orbital weapon platforms. Despite development, space weaponry was never achieved, with the discontinuation of the US 'Star Wars' program and the Soviet Union's unilateral moratorium on ASAT testing in 1983 as part of Soviet premier Yuri Andropov's effort to ban space weaponry.

The 1990s

The US Persian Gulf War marked the first 'space war', where satellites were providing surveillance, improving targeting, reconnaissance, communications, navigation, and missile warning capabilities. Control of outer space became essential for modern military operations.[2] The 1990s also brought a revolution in computers and telecommunications, which was supported by the increased commercial utilization of satellites by the private sector. Notably, satellites became dual-use assets, shared by military and commercial users (as this arrangement was more economical for militaries).

The 21st Century

Since the turn of the century, the privatization of space has only gotten stronger. It has been estimated that there are 1,700 commercial satellites in orbit, 70% of which are privately owned and operated. Through this civilian imagery services have become increasingly available. There have also been marked increases in access to satellite

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[1] Institute of Air and Space Law, Background Paper "Peaceful" and Military Uses of Outer Space: Law and Policy. McGill University Faculty of Law, Montreal, Canada. (2005).

[2] Weiss, Leonard. "Historic Growth of Space Activities: Services Provided by Space Assets" in Ensuring America's Space Security - Report of the FAS Panel on Weapons in Space. (2004).

technologies by states, who use them to develop indepdendent space capabilities. Even more nations today are able to launch satellites (such as Israel, Brazil, Pakistan, North Korea, South Korea and Iran).

The major powers have reacted in kind, with the US pushing for for full military-technological dominance of outer space to offset the vulnerability of its assets in space. Russia has become too weak for space competition, choosing to rely on the international legal regime to counter space weaponization. Finally, China has continued its rise as a strong space power, viewing US space supremacy as a threat.

Legal & Treaty Considerations

Unlike the Earth, outer space is an area governed exclusively by international law. We may trace the Space Law's roots to the Space Race of the 1950s-60s. With US and Russia both becoming space-faring nations, there became a need for a legal framework governing state activities in space.

In 1962, the United Nations General Assembly adopted the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space[3]. 9 principles were laid out (in brief):

1. The exploration & use of outer space is for the benefit of mankind.
2. Outer space is free for use & exploration by all states.
3. Outer space is not subject to national appropriation and sovereignty claims.
4. Outer space activities are to be conducted according to international law for peaceful purposes.
5. States bear ultimate responsibility for any space activity.
6. Outer space activity should be guided by cooperation.
7. States retain jurisdiction and control of space objects they launch
8. States are liable for damage caused by their space object
9. Astronauts are envoys of mankind in outer space.

These principles established Outer space as a peaceful civilian realm to be governed by international law. There was a formalization of these principles with the 1967 Outer Space Treaty and the (Astronaut) Rescue Agreement of 1967.

The 1967 Outer Space Treaty's 17 articles further enshrined space as a peaceful realm[4]. The key articles include (in brief):

1. The freedom of outer space for scientific exploration.
2. Outer Space and celestial bodies being not subject to claims of sovereignty.
3. The conduct of space exploration in accordance with international law.
4. The prohibition of weapons of mass destruction (including nuclear) in space.
5. The prohibition of military bases, weapons testing and military maneuvers on any celestial bodies.
6. Recognition of astronauts as envoys of mankind in space.
7. States bearing responsibility for national activities in outer space (including NGO).
8. States retain ownership of the space objects they launch into space.
9. States to abide by the principle of cooperation and mutual assistance in space.

The agreements also consider a basis for interstate conflict and dispute settlement. If a state has reason to believe that another state's outer space activity would be harmful to them, it must undertake international consultation before proceeding with a response.

[3] UN General Assembly resolution 18/62, Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space. (1962).
[4] United Nations Office for Outer Space Affairs, 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies. (1967).

Giving weight to the Outer Space Treaty, the United States, United Kingdom and Soviet Union were the first few to accede to and ratify, establishing an understanding between Cold War powers about their conduct in space. The subsequent 1967 Rescue Agreement also created a legal basis for states to return astronauts to their country of origin and to make all effort to rescue stranded astronauts.

The Partial Nuclear Test Ban of 1963 further reinforced the prevention of WMD proliferation in space. Primarily between the United States, United Kingdom and Soviet Union in the wake of increasingly more destructive nuclear tests and preceding tests already conducted in space and underwater, the treaty banned the testing of nuclear weapons in space[5]. With these developments, while nuclear weapons were banned from space, there was no actual prohibition of orbital conventional weapons in space.

Further treaties governing the use of space appeared in the 1970s, with the 1972 Convention on International Liability for Damage Caused by Space Objects (aka the Liability Convention) and the 1974 Convention of Registration of Objects Launched into Outer Space (aka the Registration Convention). The Liability Convention settled issues regarding liability, charging states with the liability for damage caused from launching its objects.
The Registration Convention ensured that objects in space were properly registered, with all launches recorded in a central register maintained by the UN and necessary information provided, also making it hard for states to launch conventional weapons into space secretly.

So far, international legal cooperation for peaceful space exploration had gone with no major disputes. But this progress was checked when the 1979 Agreement of States on the Moon & Celestial Bodies (aka the Moon Treaty)[6] was not signed and ratified by many countries. It contents included (briefly):

1. All activities carried out on the moon (or celestial bodies) to be in accordance with international law
2. the moon to be used exclusively for peaceful purposes (prohibition of orbital WMDs, military bases, weapons tests and military maneuvers)
3. The need for states to update the UN on its activities on the moon
4. The freedom of scientific investigation of the moon
5. The environmental protection of the moon
6. The freedom to land and launch, place objects and traverse the moon
7. The freedom to establish a moon base after informing the UN secretary general
8. The recognition of the moon and its natural resources as the heritage of mankind not subject to claims of sovereignty or discrimination.
9. The establishment of an international regime governing moon natural resource exploitation

Objections over treaty provisions on the moon's natural resources lead to its rejection by all spacefaring nations who have not ratified the agreement. Since then, there have been few major legal additions to space law.

Since then the UN General Assembly has passed a few more resolutions on space; namely the Principles Relevant to the Use of Nuclear Power Sources in Outer Space in 1992 and the Declaration of International Cooperation in the Exploration and Use of Outer Space (…) in 1996. The former gives permission for the use of nuclear reactors to further space exploration, the latter reinforces the principles enshrined in the Outer Space Treaty and Legal Principle Declaration.

The conduct of states in space is laid out in the various treaties and UN principles listed earlier, but space's commercial use has also not been neglected. The International Mobile Satellite Organization (IMSO) coordinates long range identification and tracking for maritime, aeronautical and land purposes by satellite, acting exclusively for

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[5] United Nations Office for Disarmanent Affairs, Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water. (1963).
[6] United Nations Office for Outer Space Affairs, 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies. (1979).

peaceful purposes[7]. The International Telecommunications Satellite Organization (ITSO) ensures private telecommunication companies adhere to maintaining global coverage and connectivity and provide non-discriminatory access to the satellite system[8]. Finally the International Telecommunication Constitution and Convention (ITU) maintains and extends cooperation amongst member states for telecommunications, allocating radio frequencies for space services and standardizing telecommunications[9]. Simply, there is an existing civilian infrastructure for the coordination of telecommunication satellites.

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[7] International Mobile Satellite Organization, Text of the Convention on the International Mobile Satellite Organization. (2007).

[8] International Telecommunications Satellite Organization, Agreement Relating To the International Telecommunications Union. (1971).

[9] International Telecommunication Union, Collection of the Basic Texts of the International Telecommunication Union Adopted by the Plenipotentiary Conference. (2011).

Weapons of Outer Space

Satellites are of strategic military importance to modern military warfighting. As such, states have been developing weaponry to strike key targets in outer space, crippling their adversaries. In addition, although orbital weapons platforms have never been deployed, their development is within the reach of spacefaring nations. By understanding the actual vulnerabilities and capabilities of space faring nations may we understand the geopolitics of outer space.

Existing Space-Related Weaponry

States have already developed some forms of weaponry to target objects in space. It may be safely assumed that states have ability to develop the following space or ASAT weapons:

Small Satellites	A recent trend is the miniaturization of satellites. For visualization, a small satellite is one that is under 500kg. Smaller satellites are cheaper, easier to build and launch.[10] These advances essentially allow for the proliferation of satellite capabilities amongst a wider array of nations, ie: more interests, motivations and rivalries in Outer Space. Satellite weaponisation can be accomplished through a variety of means. The smaller size allows it an element of stealth in approaching other satellites. It may also function as a 'space mine', disabling specific satellites it chooses to intercept through explosives or other means. For example, the Chinese have reportedly developed a parasitic satellite able intercept and to disable a target satellite.
Ground Based Anti-Satellite Weapons (Kinetic)	Kinetic ASAT weapons would seek to launch themselves into orbit and destroy space assets through direct collision. This usually requires the launch state to have the necessary launch capability, and to have a precise enough tracking capability. For example, the North Korean Scud-C missile can reach 300km while the Nodong missile can reach 500km, all within low-earth orbit.
Ground Based Anti-Satellite Weapons (Direct Energy)	More technologically advanced states have been making investments into direct energy aka laser weapons. Direct energy ASAT weapons attack space assets through heat damage. They can explode external pressurized fuel tanks and destroy satellite optics (disabling reconnaissance). They may also disrupt through overheating a satellite's solar cells, disabling it. The destructiveness of laser weapons are measured in megawatts per square meter. Given enough power, laser weapons could ostensibly reach targets in geosynchronous earth orbit (GEO). As an example of direct energy weapons application at sea, the US Navy has already field tested the AN/SEQ-3 laser on the USS Ponce. It has been shown to disable boat engines and shoot down drones in flight.
Low Earth Orbit (LEO) Launched Interceptors	In order to kinetically attack GEO satellites, interceptors would need to be launched from LEO, perhaps out of a fighter jet. In theory, it is feasible because the interception velocity is manageable, homing can be done through optical systems. The interceptor would still require enough energy to enter orbit.
High Altitude Nuclear Explosion (HANE)	The detonation of nuclear bomb in high altitude has 2 effects: Firstly, there would be an electromagnetic pulse affecting all electrical systems within line-of-sight of the explosion. Secondly, there would be the 'Christofilos' effect. A HANE would create artificial radiation belts, supercharging the natural Van Allen belts, causing LEO satellites to degrade much faster due to bombardment by excess radiation.[11]

[10] Weiss, Leonard. "United States Space Systems Vulnerabilities and Threats - Introduction" in Ensuring America's Space Security - Report of the FAS Panel on Weapons in Space. (2004).

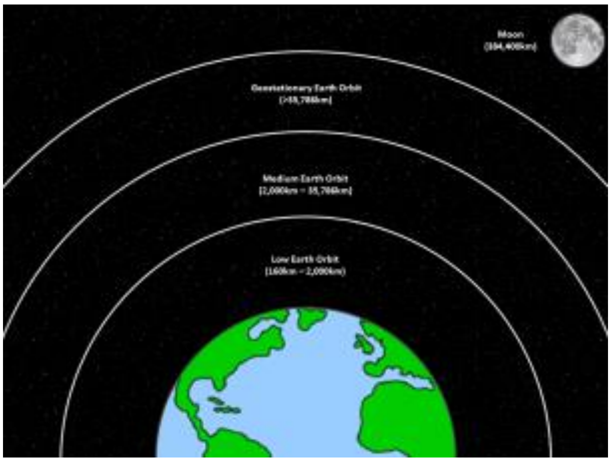
[11] Papadopoulos, Dennis. "Satellite Threat Due to High-Altitude Nuclear Detonation" in Ensuring America's Space Security - Report of the FAS Panel on Weapons in Space. (2004).

	The US Starfish high-altitude nuclear test of 1962 is the most well known example of a HANE. EMP effects were seen in Hawaii while man-made radiation belts eventually cripped one third of all satellites in LEO. Further HANE tets have been curbed by the nuclear test-ban treaty.
GEO satellite jamming	It has also been suggested that a method to attack GEO satellites is to overwhelm it with incoming signals, so that data it returns to the ground station is incomprehensible. For example, the 2003 jamming of the Telestar-12 by Cuba to foil the broadcasting of US Persian-language propaganda into Iran is an example.
Orbital debris	The use of kinetic weapons is curtailed by the effects of creating more orbital debris. Kinetically destroying a satellite would create orbital debris that could impact other satellites, creating a chain reaction of orbital debris strikes. Therefore, kinetic strikes are less desirables for nations with space assets.

Diagrams of Space Weaponry

The following diagrams help us to understand the capabilities of space weaponry (to scale).

Explanation of Earth Orbits



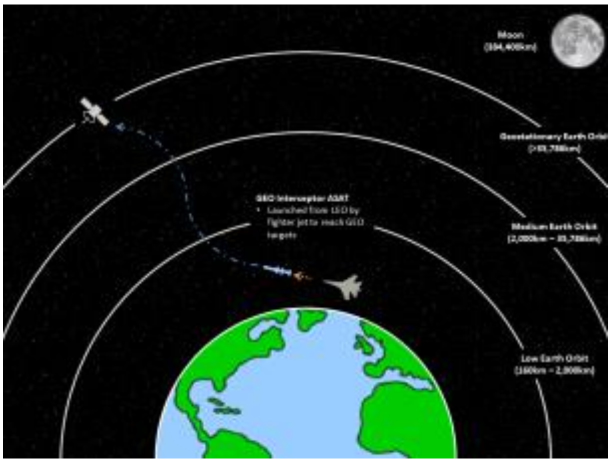
An orbit is determined by the distance of the space object to earth.

Low Earth Orbit (LEO) is anywhere between 160km to 2000km away from earth.

Medium Earth Orbit (MEO) is between 2000 to 35,786km from earth.

Geostationary (or Geosynchronous) Earth Orbit (GEO) is a distance of more than 35,786km away from earth.

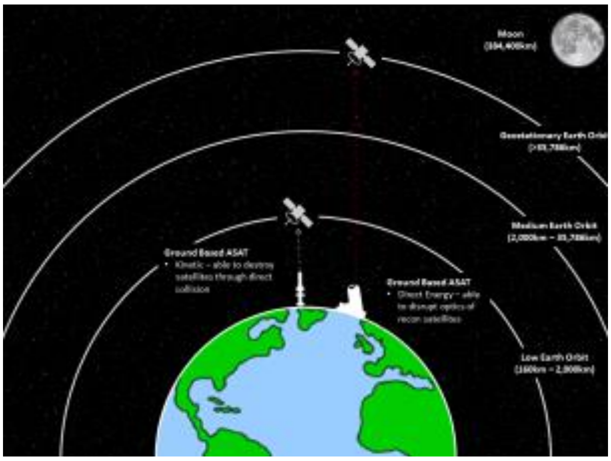
Diagram of LEO Interceptors



LEO interceptors are missiles launched from a F-16 in earth's atmosphere. Upon release, they use their own propellant to break free of earth's gravity to reach LEO, MEO or GEO depending on how much propellant is used.

Air-launched satellites use a similar technique to achieve orbit.

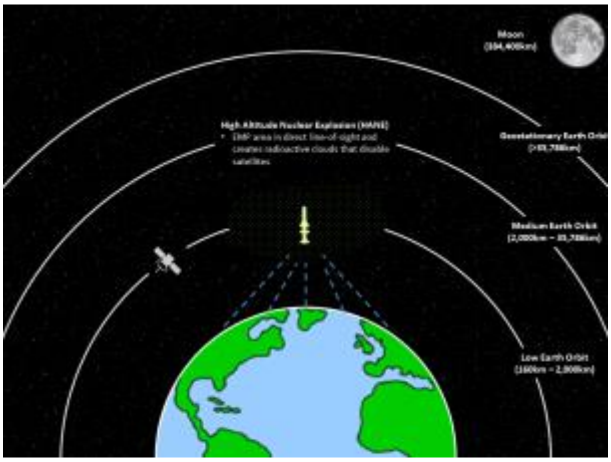
Diagram of ground based ASAT weapons



Ground based ASAT weapons are the easiest way to attack satellites. Kinetic weapons crash into satellites to disable them, but so far are only able to reach satellites in LEO.

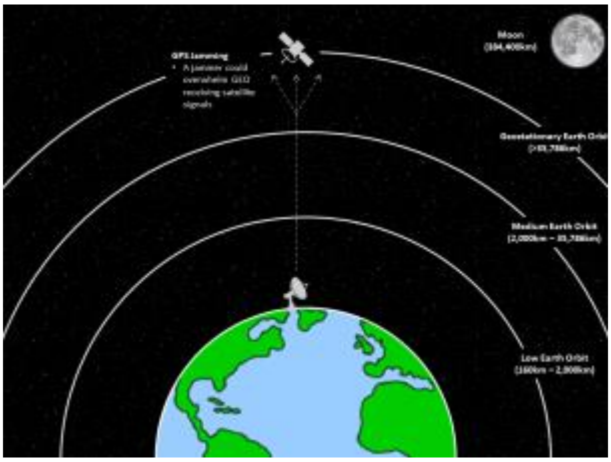
Directed energy weapons use lasers to damage satellites at any orbit and are constricted by power consumption.

Diagram of High Altitude Nuclear Explosion (HANE)



HANE presents a significant risk to all nations with assets in space. Besides all visible territory being affected by EMP, the 'Christofilos' effect aka the supercharging of the Van Allen belts would disable large numbers of LEO satellites passing through dangerous radioactive clouds.

Diagram of GEO Satellite Jamming



Probably the easiest way to attack a satellite in GEO would be through satellite jamming, given the difficulty of all other methods.

A ground station jamming the signals that satellites receive could render the data that the satellite transmits back down to earth useless.

Future Space Capabilities

There are also space weapons that had undergone development but were not completed or are still undergoing development. Studying the weapons listed below will help in understanding the trends for space weaponry in the future:

Prompt Global Strike	The Prompt Global Strike capability, harnesses the sub-orbital realm to conduct precision missile strikes. It allows a state to conduct a missile strike from space (or at space objects). The Prompt Global Strike capability aims to give the US the ability to conduct a conventional precision strike from the United States to anywhere in the world within a matter of hours. It is a missile travelling at hypersonic speed (about 5793km/h, Mach 6) at sub-orbital altitude (21km above sea level) travelling at a much flatter trajectory than a inter-continental ballistic missile. The name Prompt Global Strike refers to the specific US program, however Russia and China are also competing to develop this capacity. The US X-51A Waverider, Chinese WU-14 and Russian Yu-71 are all hypersonic sub-orbital missiles undergoing testing or have completed testing.[12] [13] Their development has implications for both strategic and conventional warfare. Conventionally, this would allow for air strikes or rather 'space' strikes from much further away, shortening conflict response times. Strategically, nuclear-tipped hypersonic sub-orbital missiles could bypass current anti-ballistic missile defenses, changing the strategic balance of nuclear powers around the world.[14] This is important because current legal and treaty considerations are unclear as to whether to consider sub-orbital weapons as 'space weapons'. It is likely major powers will seek to exclude weapons as this from space weapon bans.
The Small Unit Space Transport and Insertion (SUSTAIN)	The Small Unit Space Transport and Insertion (SUSTAIN) concept seeks to give the US the capability to conduct infantry deployment via spaceflight.[15] Proposed by the US Marine Corps, it would be able to deliver a squad of 13 marines to touch-down anywhere in the world in under two hours. A sub-orbital lander would be carried up to the atmosphere by a carrier aircraft, whereupon it would detach, accelerate and climb to 304km using scramjet engines. It would use rockets to reach 804km, before re-entering into the designated area of operations. It is believed to still be in development. In 2009, the US National Security Space Office and Air Force Security Centre Headquarters co-hosted a technology forum for the SUSTAIN concept. It is understood that a large obstacle is the extraction of troops post-insertion.
Kinetic Orbital Strike	Although this capability remains science fiction, it provides an illustration of what orbital weapons may look like should PAROS fail. The basic concept is simple, a satellite with tungsten rods is placed in orbit. The rods are directed to release over ground targets, allowing gravity to accelerate it to a point where the kinetic energy released would decimate the target.[16]

[12] Lee, Sui-Wei. China Confirms Hypersonic Missile Carrier Test. Reuters, (2014).
[13] Bora, Kukil. Russie's Secret Hypersonic Nuclear Missile Yu-71 Can Breach Existing Missile Defense Systems: Experts. International Business Times, (2015)
[14] Woolf, Amy F. Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues. (2016).
[15] Axe, David. Semper Fly: Marines in Space. Popular Science, (2006).
[16] Adams, Eric. Rods from God. Popular Science, (2004).

Strategic Defence Initiative	The Strategic Defence Initiative (SDI) was announced by Ronald Reagan in 1983 with the intended objective of protecting the US from ballistic strategic nuclear weapons. The program earned the nickname 'Star Wars' due to its proposal of conventional orbital weapons platforms. For space weapons, the X-ray laser program was to harness controlled nuclear explosion to power laser emitters, destroying incoming nuclear warheads.[17] A more promising weapon was the Brilliant Pebbles system. They were non-nuclear satellite based interceptors using watermelon sized tungsten projectiles to intercept incoming warheads. This too was canceled in 1994. Though ultimately unsuccessful in weaponizing space, the SDI continues to live on under a different name. The SDI was renamed the Ballistic Missile Defence Organization (BMDO) by Bill Clinton in 1993.

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[17] Sherman, Robert. Ballistic Missile Defence. Federation of American Scientists, (2015).

Key Developments in Asia Pacific

Singapore will need to pay attention to trends in the region in order to take advantage of outer space in the future. Internationally, space norms will be shaped by the major powers of the world, namely the US, China and Russia. Regionally, ASEAN nations are becoming increasingly interested in outer space developmen t. While Indonesia and Malaysia lead, Thailand, Vietnam and Singapore are catching up ahead of Brunei, Laos and Cambodia.

Major Power Considerations

United States

The United States views outer space as a being crucial to their military interests. As mentioned earlier, the Persian Gulf War was an example of the extremely effective military usage of space assets. Subsequently, 2001 Rumsfeld report painted a picture of a US heavily reliant on space for telecommunications, navigation and reconnaissance.[18] According to the report, this overreliance presented a vulnerability that the US' enemies would seek to e xploit.

Under the Bush administration, the 2006 National Space Policy broadly sought to achieve space superiority. To the administration, the "the freedom of action in space is as important to the United States as air power and sea power."[19] The subsequent policy principles thus included the evergreen objective of being committed to the exploration and use of outer space for peaceful purposes but also expressed belligerence through rejecting limitations on the rights of the US to operate in space and opposing the development of new legal regimes to limit US access to space. The more practical guidelines to achieve US space goals were to develop space professionals, improve space system development, increase interagency partnerships and strengthen the US spa ce industry.

Under the Obama administration, this approach has been characteristically softened with the 2010 National Space policy. Obama's policy emphasized international cooperation in the exploration of space. Six goals were presented including to energize domestic space industries, to expand international cooperation, to strengthen space stability, to increase US space resilience, to pursue innovation and to improve space observation capabilities.[20] The 2010 policy suggests a closer observance of inte rnational law, but preserves space as a strategic area "vital to its national interest".

This approach has been tested in recent times given China and the US have intensified their space competition. This can be seen through displays of anti-satellite capabilities. In 2007, China conducted an anti-satellite missile test against an aging FY-1C weather satellite, shooting it down with a kinetic kill vehicle.[21] This test became internationally criticized for worsening the creation of orbital debris. In 2008, the US displayed ASAT capability through its destruction of the malfunctioned USA-193 military reconnaissance satellite. A SM-3 missile launched from the USS Lake Erie destroyed the satellite, before it burned up on re-entry.[22]

A number of agencies look after the US' interests in space. While the National Aeronautics and Space Administration (NASA) conducts the civilian space program, military capabilities are handled by the United States Space Command (USSPACECOM). Under USSPACECOM, the Air Force Space Command (AFSPC) takes a leading role. They provide the US military with the ability to launch satellites, conduct space surveillance and support ground troops through satellite communications and intelligence. It is telling the way they view air, space and cyb erspace as interdependent.[23]

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[18] Weiss, Leonard. "Protecting U.S. Space Systems – The Case for Weaponization" in Ensuring America's Space Security - Report of the FAS Panel on Weapons in Space. (2004).
[19] U.S. National Space Policy. National Security Presidential Directives (2006).
[20] National Space Policy of the United States of America. The White House, (2010).
[21] BBC News. Concern over China's Missile Test. (2007).
[22] Shanker, Thom. Missile Strikes a Spy Satellite Falling From Orbit. The New York Times, (2008).
[23] Kehler, Robert. 2009-2010 Air Force Space Command Strategic Plan. Air Force Space Command, (2009)

The US concerns over its overreliance on outer space for its modern warfighting are justified. As much as it can the US will seek to preserve military dominance in the area until it can no more. This explains US resistance to the Prevention of Arms Race in Outer Space (PAROS) treaty despite its overwhelming international support. Because of its many vulnerabilities in space, the US is forced to project superiority over a vast space to defend its interests.

China

China views its space program with great pride. It had to survive the 'Great Leap Forward' in 1958-61, Soviet withdrawal of science and technology support, the Cultural Revolution of 1966-77, before space had its 'heyday' becoming a cornerstone of the national science and technology development effort in 1986.[24]

Three key factors play into the development of the Chinese space program. Politics, economics and technology. Vast political will was required in order to marshal the vast resources to develop a space program, that 'at the time' could be viewed as an exotic endeavour. Economically, the Chinese view their developments in space technology as a sign of economic progress. Technologically, the basis for spacefaring rockets is built on the foundation of Chinese ballistic missile development, meaning the space race has a strategic military purpose as well.[25]

Policy-wise, China's stated objectives for its outer space activities are the exploration of outer space, to understand earth better, to benefit mankind, to meet the demands of economic construction, scientific and technological development and to protect China's national interests and rights.

Its principles are much more conservative, seeking to use space development to serve the country's overall development strategy. It also wishes to be self-reliant and independent in the field, making 'leapfrogging' development. China also views space as an area to connect with the outside world, actively engaging in space exchanges and cooperation. Like its economic development, China's space development has been making rapid progress. It is known to already possess the capability to build satellites and launching vehicles, construct launching sites, conduct telemetry, tracking and command operations, conduct manned spaceflight and engage in deep-space exploration.[26]

The Chinese National Space Administration is the civilian face of the Chinese space program, conducting most of its activities. While there has been no official announcement, there has been rumour that China has created a fifth military service dedicated to aerospace operations. Similar to the AFSPC, the 'Space Force' will conduct outer space and cyberspace operations.

China is co-sponsoring the PAROS treaty with Russia, largely to limit US space capabilities. It views US unilateralism in space with great suspicion, fearing that US anti-ballistic missile space weapons would have a destabilizing effect on China's ability to conduct strategic nuclear deterrence. It is likely that China will continue to develop ASAT weapons as an asymmetric counter against US space weapon systems.

China feels highly threatened by the US' space superiority. Its actions with regard to militarizing space or attempting to regulate space weaponry stem from this fear. It is likely this fear will not be allayed until it is able to reach equity with the US in terms of space capability, making it a potentially dangerous actor in starting a new 'space race'.

[24] Smith, Marcia S. China's Space Program: An Overview. Congressional Research Service Report for Congress, (2003).
[25] Handberg, Roger, and Zhen Li. Chinese space policy: A Study in Domestic and International Politics. Routledge, (2006).
[26] Information Office of the State Council of the People's Republic of China. China's Space Activities in 2006. Chinese National Space Administration, (2006).

Russia

Post-Cold War Russia is a far more diminished space power compared to the Soviet Union. Without the political will or economic ability to compete with the US, it has sought to project its will through international cooperation and legal regimes in the pursuit of peace. The modern Russian space program is fueled by sales of oil.[27]

Space development under the Soviet Union was decentralized under a number of design bureaus. Post-Cold War, they were consolidated into a federal space agency known as Roscosmos.[28] Roscosmos has a distinctly commercial flavour, having financed itself through the collapse of the Soviet Union by engaging in commercial satellite launches and space tourism.

As the Russian economy boomed in 2005 thanks to high prices for oil and gas exports, so too did the funding for Russian space activities increase. Under Putin, a long-term strategy for space for 2005 to 2010 was laid under decree No. 635. This directed Roscosmos to pursue manned spaceflight and lunar landing, heavy-lift rocket development and importantly the construction of a new spaceport inside of Russian territory, the Vostochny launch center as opposed to the Baikonur Cosmodrome in Kazakhstan. Unfortunately between 2010 and 2013, it also appears that Roscosmos has been grossly mismanaged with multiple launch failures and a organizational activities in disarray. In response, the Russian government has undertaken a significant reorganization and renationalization of the Russian space industry.[29]

Russian space policy appears to be a balance of peaceful pursuit of outer space exploration with the moderate pursuit of defence activity in outer space. It is notable that the language of its legal documents suggests the pre-emptive prohibition of space weaponization, not wanting to be the first to weaponize space. A Russian moratorium against ASAT testing from 1983 still stands, meaning that there would be a number of legal hurdles for Russia to cross before it could begin to engage in space weaponization activities again.

While Roscosmos conducts the civillian space activities of Russia, the Russian Space Forces, a branch of the Russian Aerospace Defence forces conducts military space activities such as satellite deployment and early warning of ballistic missiles. Russia has not been isolated from the pressures of space competition, flight testing a Nudol direct ascent anti-satellite missile and a 'satellite catcher' which was a small satellite that separated from the upper stage of its rocket and chased it down.[30] It has been suggested to have surveillance or anti-satellite capabilities.

Russia is a weakened space power. Its aging infrastructure and personnel from its time as the superpower is waning. In the short term, it will pursue international cooperation and legal regimes to further its interests in space. Its activities in outer space will continue to be largely commercial, unless it feels threatened by the deployment of US anti-ballistic missile defense systems.

ASEAN Regional Considerations

Thailand

Thailand is beginning moderate space development. It's only known space-related agency is the Geo Informatics and Space Technology Development Agency (GITSDA) but it is also a member of APRSAF, APSCO, COSPAR and UNCOPOUS.

The Thai space-related agency is the Geo Informatics and Space Technology Development Agency (GITSDA) under the Ministry of Science and Technology. It's functions include providing private and public entities with satellite remote sensing and Geographic Information System (GIS) data. This data has a number of uses including agriculture,

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[27] Zak, Anatoly. Russian Space Program: A Decade Review (2000-2010). Russian Space Web, (2016).
[28] Howell, Elizabeth. Roscosmos: Russia's Space Agency. Space.com, (2016).
[29] Zak, Anatoly. Russian Space Program: A Decadal Review (2010-2019). Russian Space Web, (2016).
[30] Rincon, Paul. Russia Tests 'Satellite Catcher'. BBC News, (2014).

natural resources, land and urban planning, disaster monitoring and national security uses. For example, the GITSDA coastal radar system provides early warning for tsunami disaster events.[31]

The most widely-known satellite Thailand owns is the THEOS, also known as Thaichote, an earth observation satellite. It was built by France and launched by Russia on a converted ICBM in 2008.[32] With a mass of 750kg it is classified as a small satellite. In addition, Thailand has launched a number of communication satellites, designated Thaicom-1 to Thaicom-7.

Thailand has yet to implement an official space policy, though there is an awareness of the need to do so and a sense of growing impetus around the initiative. At present, Thai space activities are regulated by the National Committee on Space Policy (NCSP) and the Ministry of Information and Communications Technology (MICT).

Thailand's interest in space is more civilian than military. Their experience with the 2004 tsunami disaster has made them realise the importance having a domestic satellite imagery capability. Their interest will turn economic as they build a space industry.

Indonesia

Indonesia is an established space power in this region. Their spearhead space agency is the National Institute of Aeronautics and Space (LAPAN) and they are a member of APRSAF, APSCO, COSPAR and UNCOUPOUS. Through their agreement with the Ukrainian National Space Agency they are able to access rocket and satellite technologies.

Established in 1963 by Indonesian president Sukarno, LAPAN has conducted research on rocket, remote sensing, satellites and space science.[33] Having already sent up a number of satellites, LAPAN is moving into research for micro-satellites. Their LAPAN-TUBSAT weighs only 57kg, housing a color video camera, communications equipment and a altitude control system. This has number of remote sensing and surveillance capabilities. Notably, it launches its satellites from India. It currently has a number of satellite assets, namely LAPAN A-1 to A-3 conducting remote sensing.

Indonesia has made efforts to develop a domestic spaceport capable of launching objects into space. This is especially advantageous to Southeast Asia as any vehicle launched closer to the equator has greater initial velocity, making heavier payloads possible. Two of its attempts have failed, though it's most recent efforts show promise. Indonesia's plan for Biak spaceport since 2006 was to air-launch satellites in cooperation with Russia, but has since stalled due to Russian treaty obligations to the Missile Technology Control Regime. It's other plan for the Enggano satellite launchpad in 2011 was rejected due to conservation concerns. The latest attempt is the Morotai spaceport, starting planning in 2012 and expected to be completed by 2025. A rocket test-flight from the island is to be expected at some point.[34]

Alarmingly, LAPAN has ventured into rocket development since the 1980s. Classified as RX "Roket Eksperimental", the program has experienced rejuvenation since the Indonesian military began cooperation in 2005. It is believed that the LAPAN is currently focused on developing satellite launch vehicle.

An established program, LAPAN's most recent strategic plan for 2016 - 2019 clearly states its vision, mission objectives and policy direction, strategy and regulatory framework. LAPAN has a number of overall goals including achieving competence in space & atmospheric science, remote sensing and aeronautics & space technology. The policy directions taken subsequently are to develop a capacity in science and technology, ability to conduct space

[31] Geo-informatics and Space Technology Development Agency Profile. Geo-informatics and Space Technology Development Agency Website.

[32] RIA Novosti. Russia Launches Thai Satellite on Converted Missile. Sputnik International, (2008).

[33] National Institute of Aeronautics and Space (LAPAN). Wikipedia, (2016).

[34] Utomo, Yunanto Wiji. Bandar Space Will be Built in Morotai. Kompas.com, (2012).

flight, mitigate natural disasters and climate change through space science, advance Indonesia's international interests through effective policy and reforming the agency.[35]

Indonesia may be regarded as an established space power in the region. It has moderate advancement into micro-satellite and rocket technology. It has ambitious plans to be the first regional spaceport. It may be assumed that through its remote sensing capabilities, it is already able to conduct extensive satellite surveillance of Singapore.

Vietnam

Vietnam is a relatively new entrant into the space community. It's interest in space technology appears to be targeted to mitigate the effects of climate change. The 'Strategy for Space Research and Applications until 2020' has guided Vietnam's space development since 2006, coordinating the Ministry of Science & Technology, the Ministry of Natural Resource & Environment and the Ministry of Information & Telecommunication. Its space agency is the Space Technology Insitute.[36]

The Space Technology Insitute has a number of responsibilities. It is tasked with developing a legal framework for Vietnamese space technology research by studying existing international laws and regulations. It also seeks to develop the national space infrastructure by building ground receiving stations, establishing a science laboratory for space technology, developing small satellite technology and employing high-tech applications such as optical observation and satellite radar technology. Finally, it is attempting to promote space technology applications such as telecommunications, broadcasting, hydrometeorology, environmental science, agriculture, transportation and defence.[37]

An example of Vietnam's satellite development is the VINASAT-1. Launched in 2008 from the French Guiana Space Centre, it was manufactured by Lockheed Martin. It is a telecommunications satellite able to bring telecommunication, internet and television services to Vietnam's isolated, mountainous and island areas. The next most significant satellite launch is the VNREDSAT-1, launched in 2013. It is an earth observation satellite for natural resources, environment and disaster monitoring. Weighing in at 120kg, it is considered a small satellite and possesses an considerable remote sensing equipment.[38]

Vietnam is also making progress on the Hoa Lac Space Centre. It's purpose is to conduct space science and technology research and application. It also seeks to transfer space technology to advance socio-economic development. It has the added objective of promoting international space cooperation projects. Interestingly, Vietnam is one of two countries in Southeast Asia to have ventured into manned spaceflight, sending a cosmonaut into space in 1980 under the Soviet space program.

Vietnam's interest in space is primarily to mitigate the effects of climate change. It has a heavy focus on space science and technology, and likely will seek to use this to advance its economic development when suitable.

Brunei

Brunei is partnering with India for space development. Thanks to (or as a result of) strong bilateral ties with India, Brunei has played a major role in India's space programme. It is home to one of the Indian space agency's Telemetry

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[35] National Institute of Aeronautics and Space (LAPAN). Rencana Strategis Lembaga Penerbangan Dan Antariksa Nasional 2015-2019 (translated as Space Agency Strategic Plan 2015-2019), (2015).
[36] Pike, John. Vietnamese Space Agencies and Plans. GlobalSecurity.org, (2011).
[37] Space Technology Institute. Introduction to Space Technology Institute. Vietnamese Academy of Science and Technology (VAST), (2009).
[38] Chung, Doan Min. Satellite Technology Development in Vietnam. Vietnamese Academy of Science and Technology (VAST), United Nations/Turkey/European Space Agency Workshop on Space Technology Applications for Socio-Economic Benefits, (2010).

Tracking and Command Centre, aiding India in it's mars mission launch of 2013.[39] Thus, Brunei has found its own small role in advancing space development in the region.

Malaysia

Malaysia's Angkasawan Space Program began as a offset agreement between Malaysia and Russia through the purchase of Sukhoi-300MKM fighter jets. The Russian government agreed to bear the cost of training and sending a Malaysian astronaut to the International Space Station. Thus on 10 October 2007, Muszaphar Shukor became the first Malaysian in Space. The Malaysian National Space Agency (ANGKASA) was established in 2002 to coordinate the Angkasawan program and Malaysia's future space endeavours.[40]

ANGKASA's stated mission is to develop the country's potential in the space sector to support the development of the new economy as well as to generate knowledge and strengthen the national security infrastructure. Besides conducting the manned spaceflight missions, ANGKASA has also ventured into satellite development.

Three known satellite programmes are the TiungSAT, MEASAT and the RAZAKSAT. TiungSAT-1 was a space science satellite developed for earth imaging and meteorology observation, launched from Baikonur Cosmodrome in 2000. MEASAT-1 to 2 and MEASAT-3 were launched in 1996 and 2006 respectively, providing telecommunication services like Astro. The latest satellite is the RAZAKSAT, launched in 2008 with a focus on remote sensing. The RAZAKSAT failed in 2011 when it was revealed to be unable to accurately photograph the earth's surface.[41]

Policy-wise, the Malaysian Outer Space Act is still in its drafting stage. The act's objectives include for space activities to build up a space industry, to use innovative space technology to aid society, to further scientific advancement and to create a critical mass of space development talent.[42] An interesting thing to note is that Malaysian astrophysicist Mazlan Othman served as the director of UNOOSA from 2010 to 2014, providing an able academic mind to the Malaysian space program.

Manned spaceflight for Malaysia may not have immediate economic returns, but signals its progress to the international community as a developing nation. Malaysia's foray into satellites has been mostly for telecommunication, but its recent efforts at remote sensing provide an idea of the programs new direction.

Laos

Laos' foray into space has been very recent and only with China's aid. The LAOSAT-1 telecommunications satellite launched from Xichang launch centre in 2015. Laos financed the USD $259 million dollar launch through a loan from the export-import bank of China, but experienced legal difficulties in negotiating the lending conditions.[43]

Laotian space activities are coordinated under the Department of Space Technology, whose job it is to draft space policy and operate Laotian satellites. The government appears enthusiastic about the benefits of space technology, citing dependence on space from every ministry from information and culture to education to natural resources and environment.[44] In conclusion, Laos will for the foreseeable future be heavily dependent on China for any space related developments.

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[39] Sadikin, Syazwan. Brunei Helps India’s Space Programme. Brunei Times, (2016).
[40] National Space Agency (ANGKASA). About Angkasawan – Background, National Space Agency (ANGKASA) Website, (2016).
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[42] Subari, Mustafa Din. Malaysia Space Related Activities (2011). The National Space Agency (ANGKASA), (2012).
[43] Selding, Peter B. Laos, with China’s Aid, Enters Crowded Satellite Telecom Field. Spacenews.com, (2015).
[44] Khamone, Singthong. The Current Status of Space Technology Activities in Laos PDR. APRSAF-18, Communication Satellite Application Working Group, (2011).

Phillipines

The Phillipines foray into space actually begins in the 1960s, when it first built a earth satellite receiving station. In the 1970s, the Phillipines began considering satellite applications but only launched the Agila-2 in 1997 from Xichang launch centre, China. Space development experienced a renaissance in 2010 when the Department of Science and Technology (DOST) took charge.

Besides the DOST, Phillipines also has the Committee on Space Technology Applications (COSTA), an intra-governmental committee pooling their respective space interests. Recently, Filipino space activity has seen the successful launch of the PHL-1 microsatellite from Cape Canaveral, Florida in 2016. It's purpose is largely scientific, possessing various scientific imaging equipment.[45]

It is recognized in the Philippines that a space policy would be necessary to develop, but it appears it has not found any political will yet.

The Phillipines appears to recognize the importance of space, having conducted two studies such as the Space Science and Technology Initiatives 10-Year Baseline Research Outcomes and the National Space Development and Utilization Policy.[46] Its interests are identified as national security, environmental monitoring and industry building. However, the actual actions taken in space development do not match its rhetoric.

Cambodia

Cambodia has no known space development.

Singapore

Singaporean space development began with the creation of the Singapore Space & Technology Association in 2006, a non-profit association focusing on developing Singapore's space industry. The Economic Development Board followed close behind, establishing a dedicated 'space team' in 2009.

Singapore's satellite activities in space have been largely attributed to commercial and scientific interests. Its first satellite, ST-1 was launched in 1998 by Singtel for telecommunications purposes.[47] In December 2015, 6 locally-made satellites launched off from India by NUS, with functions ranging from the scientific to earth observation.[48]

The NUS Centre for Remote Imaging and Sensor Processing (CRISP) remote sensing satellite ground station conducts research into remote sensing in the region pulling information from a bevy of international satellites open for public use.

Recently, the government has also set up the Office for Space Technology and Industry (OSTIn) in 2013 to research and develop the future space industry, particularly in the manufacture and launch of satellites.[49]

Singapore is slowly developing a nascent space industry, spearheaded largely by the private sector and universities. As its interests continue to grow in space, it will undoubtedly begin to formalize its efforts into policy encompassing industry, science and national security.

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[45] Verzosa, Cez. Diwata Ascending: The Benefits of a Fillipino Space Program. GMA News Online, (2016).
[46] Sese, Rogel Mari. Space Research and Development in the Phillipines. National SPACE Development Program, (2016).
[47] Chua, Alvin. Singapore's first satellite (ST-1). National Library Board Singapore Infopedia,(2012).
[48] Chow, Jermyn. Milestone for Singapore as Six Satellites Launch in Orbit. The Straits Times, (2015).
[49] Chua, Grace. Singapore's Leap Into The Space Industry. Asiaone, (2013).

The National Interest

Singapore's national interest must be to remain relevant in a world increasingly engaging in outer space. It must take steps to catch up with the ASEAN region in terms of outer space development. Singapore should also engage both bilaterally and multilaterally with relevant nations in order to move towards developing independent space capabilities. By leveraging existing economic comparative advantages, Singapore can carve out a niche in the space industry of the future.

Singapore's Existing Space Assets

Since 2006, Singapore has become more and more interested in the commercial applications of outer space. Singaporean organizations dealing with outer space were initially non-profit, though in recent times the government has begun to actively take a role in industry development. Singapore already has 12 satellites in orbit for mostly commercial and scientific purposes, though ST Engineering's TELEOS-1 provides Singapore with the ability conduct satellite surveillance.

Singapore's Space-related Organizations

Singapore has three formal organizations that conduct space activities. The Space Science and Technology Assocation (SSTA), Centre for Remote Imaging, Sensing and Processing (CRISP) and Office for Space Technology and Industry (OSTIn). The SSTA and OSTIn focus on the commercial and industrial aspects of space, while CRISP conducts scientific remote sensing for private and public organizations alike.

Space Science and Technology Assocation (SSTA)

Established in 2006, the SSTA is Singapore's lead, non-profit space association focused on developing Singapore's space technology industry. It also acts as a neutral platform to facilitate information and communication for government, industry and academia.[50]

The SSTA spearheads major initiatives that advance Singapore's space ecosystem, like the Global Space Technology Convention. It also drives educational and outreach programs to encourage careers in the expanding aerospace/space industry.

The SSTA's birth was out of an EDB officer's recognition of the lack of official organization dealing with space. Thus far it has served an important purpose in rallying the civil space industry, though with the arrival of OSTIn it's new objectives remain to be seen.

Centre for Remote Imaging, Sensing and Processing (CRISP)

Established in 2001, CRISP is a research centre of the National University of Singapore established with funding from the Agency of Science & Technology & Research (A*STAR) of Singapore. Its mission is to develop an advanced capability in remote sensing to meet the scientific, operational and business requirements of Singapore and the region.[51]

It receives data from international satellites of all nationalities from the French SPOT series to the Chinese Fengyun 1C. It processes the received data through a satellite ground station into a standard or value added form for distribution and research. CRISP also conducts research in ocean and coastal studies, tropical vegetation studies and remote sensing data processing techniques.

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[50] Tan, Lynette. Presentation on Singapore Space and Technology Association (SSTA), (2016).
[51] Overview. Centre for Remote Imaging, Sensing and Processing Website, (2015).

CRISP interests are largely commercial and academic and appear untapped for the purposes of defence. Their research into remote sensing however is an untapped opportunity should defence policymakers properly take the time to understand. Potential applications include high resolution imaging, highly accurate weather prediction and various detection capabilities.

Office for Space Technology and Industry (OSTIn)

OSTIn was established by the Singapore government in Feburary 2013 with the mandate as the designated office to develop Singapore's space industry. It's objectives are to plan and execute economic strategies to grow Singapore's space industry in a sustainable manner, to forge collaborations within Singapore as well as between Singapore and the international community and to champion the growth of Singapore's pool of human capital for the space industry.

Chaired by EDB's chairman Dr Beh Swan Gin, OSTIn's steering committee is made up of ministries and agencies consisting of the Agency for Science, Technology and Research (A*STAR), Singapore Economic Development Board (EDB), Ministry of Communication and Information (MCI), Ministry of Defence (MINDEF), Ministry of Education (MOE), Ministry of Foreign Affairs (MFA), Ministry of Trade and Industry (MTI), Ministry of Transport (MOT) and the National Research Foundation (NRF)[52]

OSTIn may be seen as the official arm of the government in the space sector so far with a distinctly commercial/industrial focus. This is admirable and a logical step in terms of Singapore's space development, but lacks a focus developing legislation, managing space-related foreign affairs and defence considerations that other regional space agencies may provide.

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[52] Satellite & Space, National Research Foundation Website, (2016).

Known Singaporean Satellites in Orbit*

Singapore's current space assets consist of only satellites of varying size, ranging from 1kg nanosatellites to 5090kg satellites. They are listed below:

No.	Name	Date of Launch	Operator	Classification	Purpose	Altitude	Launch Location	Size
1	KENT RIDGE 1	16/12/2015	NUS	University	Disaster Monitoring through hyperspectral imaging	LEO - 550km	Satish Dhawan Space Centre, India	Microsatellite - 78kg
2	ATHENOXAT 1	16/12/2015	Microspace Rapid Pte Ltd	Commercial	Demonstrate night-vision optical payload	LEO - 550km	Satish Dhawan Space Centre, India	
3	VELOX C1	16/12/2015	NTU/DSO	University	Tropical Weather Monitoring - GPS Radio Occultation	LEO - 550km	Satish Dhawan Space Centre, India	Minisatellite - 123kg
4	TELEOS 1	16/12/2015	ST Electronics (Satellite Systems) Pte Ltd	Commercial/Military	High-resolution imagery	LEO - 550km	Satish Dhawan Space Centre, India	Mnisatellite - 400kg
5	VELOX 2	16/12/2015	NTU/Addvalue Innovation Pte Ltd	University	Nanosatellite & precision navigation demonstration	LEO - 550km	Satish Dhawan Space Centre, India	Nanosatellite - 13kg
6	GALASSIA	16/12/2015	NUS	University	Scientific measurement of ionosphere & quantum communication research	LEO - 550km	Satish Dhawan Space Centre, India	Nanosatellite - 2kg
7	VELOX 1	30/06/2014	NTU	University	Education & High resolution imagery	LEO - 650km	Satish Dhawan Space Centre, India	Nanosatellite - 4kg
8	POPSAT HIP1	19/06/2014	Microspace Rapid Pte Ltd	Commercial	Micropropulsion experimentation	LEO - 630km	Yasny Cosmodrome, Russia	Nanosatellite - 3kg
9	VELOX PII	21/11/2013	NTU	University	Technology demonstration platform	LEO - 600km	Yasny Cosmodrome, Russia	Nanosatellite - 1kg
10	ST 2	20/05/2011	Singtel/Chunghwa	Commercial	Telecommunications	GEO - 36,000km	Guiana Space Centre, French Guiana	Satellite - 5090kg
11	X-SAT	20/04/2011	NTU/CRISP/DSO	University	Demonstrate high-resolution imaging	LEO - 817km	Satish Dhawan Space Centre, India	Minisatellite - 105kg
12	ST 1	25/08/1998	Singtel/Chunghwa	Commercial	Telecommunications	GEO - 36,000km	Guiana Space Centre, French Guiana	Satellite - 3200kg

*Data from United Nations of Outer Space Affairs [53]

2011 saw renewed Singaporean interest in space lead mainly by universities and commercial interests. However, ST Engineering's TELEOS 1 is Singapore's most visible **military** asset in space, with its express purpose being access to satellite imagery for time-sensitive events such as homeland security and border control, maritime situational awareness and disaster monitoring and management.

[53] United Nations Office of Outer Space Affairs. Online Index of Objects Launched into Outer Space, (2016).

Navigating the Geopolitics of Outer Space

Regional Considerations

I make the following recommendations for Singapore's development for outer space in a regional ASEAN context. It would be wise not to attempt to portray ourselves as a regional space power yet, given our nascent space capabilities. Moving forward, we should explore opportunities for cooperation within the region, balancing security concerns against the risk complete dependency on external powers for outer space services. Vietnam, Malaysia and Indonesia are countries with space programs worth learning from.

Although behind in terms of regional space development, Singapore will be able to leverage upon existing economic comparative advantages. Our geographical location close to the equator puts us in a prime location as a spaceport should we find a way to overcome the space constraints. A Singapore an space program would not be as budgetarily restricted given our strong financial standing and ability to attract investment. Singapore has a strong potential to develop human capital for a space industry, especially given a renewed focus on engineering. In addition, Singapore's efficiency, process and discipline should prove to be highly effective completing space programs, unlike some of our neighbors.

There are immediate security concerns in outer space for Singapore to consider. Indonesia has displayed an existing ability to conduct satellite surveillance on Singapore likely for military purposes. In addition, the RX missile program should cause Singapore great concern given the TNI's direct cooperation with LAPAN on this front. Dependency on external power's space technology must also be taken into account. For example, should Singapore become heavily dependent on India for launching satellites and ties sour, we could be forced to turn to China as the next nearest regional spaceport.

Encouragingly, there are more opportunities than threats before us. We should acknowledge that space has genuinely useful applications for neighboring developing countries in environmental protection, resource management and disaster relief. Particularly for the Singapore Armed Forces (SAF), there is a opportunity for to use satellite imagery to augment humanitarian aid and disaster relief (HADR) efforts to great effect.

I would also advise consultation with Malaysia on international outer space affairs, given Malaysia's UNOOSA ex-director Mazlan Othman's expertise in the area. We may view Thailand as an equal in terms of space development and perhaps seek partnership. There also exist opportunities to provide satellite services to East Timor, Myanmar, Brunei and Cambodia who may be more amenable to a regional partner than towards the giants of India or China.

To conclude, becoming a space power should be Singapore's ambition in order to remain relevant within the region. However, the development of increased space capabilities will be necessary before we are able to use it as an effective foreign policy tool.

International Considerations

Singapore should become more actively involved in the international space community. It would be in our interest to join norm-setting organizations for outer space such an the UN Committee for the Peaceful Uses of Outer Space, the Committee on Space Research, the UN General Assembly Disarmament Committee and the Prevention of Arms Race in Outer Space (PAROS) negotiations, if not as a participant then as a observer. The purpose of this move would be to properly discern country positions on the international issues governing outer space and to predict the future trends in space development.

The PAROS treaty is currently the most heated topic in discussion at present. Determining the correct position for Singapore to take relies on correctly predicting the halt or inevitability of the weaponization of outer space. This position may only be determined by superior intelligence of the true intentions and actions of the major powers of US, Russia and China in the area of space weaponization.

There are potential arguments for and against Singapore's support for the PAROS treaty. I start with the argument in support of the PAROS treaty. Given the substantial dependence of the international community and the world economy on outer space technologies (thanks to globalization) it is in all states interests to preserve peace in outer space. The PAROS treaty would not compromise any nation's existing military capabilities, but rather prohibit the future placement of conventional weapons in space, which there are none at present. Reflecting this, there is near overwhelming international support for PAROS.

The argument against Singapore's support for PAROS is that the legal text does not prohibit the research and development of space weapons or anti-satellite weapons, which are the US' primary concerns. If we predict the prospect of weaponization of outer space incorrectly, we may allow China and Russia to reach parity with the US in terms of space weapon development. Under this tripolar system, we will likely be required to conduct space activities subject to China's approval.

Besides our actions at the UN General Assembly, there are additional opportunities for Singapore in the international space community. Our progress in space development can be advanced through bilateral cooperation with other countries. Our existing launches from India, Russia and French Guinea should be treated with as much importance as any bilateral issue. In addition, Japan is a untapped partner for space science and development.

In determining Singapore's role in the international space community, it is in our interest to carve out a niche sector in the space industry. The actions of major powers will shape the international norms regarding space development and Singapore must be prepared to position itself correctly and adapt to the changing environment.

Enhancing Singapore's Space Capabilities

In approaching space development, there is a risk of being too quick to pour resources into capabilities that do not serve our interests. Malaysia's ANGKASA manned spaceflight program has been criticized as such, with its director's defence being that it has purpose as 'political mileage'. It is also important to recognize that space development requires innovation and risk of failure, thus concentrating efforts into a few state-run enterprises may not be wise (akin to putting all our eggs into one basket).

In order to avoid the first problem, we must first identify the functions of outer space development and satellite applications.

Useful Applications of Outer Space Development[54]

Geodesy	The mathematical measurement of the earth
Astronomy	The study of celestial objects
Navigation*	Monitoring and controlling movement
Surveillance*	The monitoring of behaviour and activity
Meteorology*	The study of the atmosphere
Space Stations	Spacecraft that are designed to remain in space
Communications*	The act of conveying meaning to others
Lunar Exploration	Exploration of the moon

[54] Weiss, Leonard. "Historic Growth of Space Activities: Services Provided by Space Assets" in Ensuring America's Space Security - Report of the FAS Panel on Weapons in Space. (2004).

Earth Observation*	The gathering of information about earth's physical, chemical and biological systems
Search & Rescue	Search and provision of aid to those in distress
Manned Orbital Stations	Reusable spacecraft for space travel
Space physics research	The study of space plasma (superheated gas)
Interplanetary Exploration	Travel between planets
Microgravity experimentation	Research on weightlessness

*space applications of interest to Singapore

There are useful applications of outer space that impact Singapore's national interests directly, ranging from the access to satellite surveillance of our neighbours to the ability to control our own telecommunication. Hence, we should be aware that the space capabilities here we do not develop ourselves will make us dependent on other nations. Developing independent space capabilities in the areas highlighted in green would make sense.

Besides catching up to the region's existing space capabilities, it would be in Singapore's interest to pursue potential space capabilities for the near future (arranged in order of potential benefit):

Potential Space Capabilities for Singapore

Air-launch spaceport	Given Singapore's geographical location close to the equator, we are a prime location for a spaceport. Traditional spaceports are restrained by space, however air-launching satellites may be a way to overcome this. Becoming a spaceport would simultaneously reduce our launch dependency on other nations and elevate our profile as a regional space power.
Remote sensing for HADR	Remote sensing has a number of applications for humanitarian aid and disaster relief operations. Satellites in geostationary orbit over Southeast Asia would allow us to monitor the extent of disasters in real-time and advise affected nations on how to deploy both our resources and theirs.
Maritime telecommunications for SEA	Singtel has already ventured into the realm of providing maritime telecommunications. By leaning on this advantage through more investment and satellite deployment, we may be able to carve out a niche in maritime satellite communications in the Southeast Asian waters.
Maritime Satellite Navigation	With the advent of small satellite technologies, a global navigation system for Southeast Asia could become very attractive. Geostationary satellites would allow for a much more precise calculation of location, which has various commercial, research and military applications.
Improved Haze Sensing Capabilities	Current imaging satellites are limited by a window of opportunity in which the satellite passes directly over its intended target (estimated to be every 12 hours). By increasing the number of imaging satellites in orbit, we will be able to cut this time down significantly. This newfound capability may be used to both advise Indonesia on occurrences of forest fires and as a tool to apply diplomatic pressure.
Superior Military Surveillance	Our current reliance on the THEOS-1 will prove useful in providing surveillance. It would be wise to further develop our capacity in this area as an early-warning system.
Aircraft Tracking and Search and Rescue	MH370 was an example of the difficulty of tracking and conducting maritime search and rescue of aircraft. If real-time satellite tracking and imaging were possible, it is

	conceivable that Singapore could play a leading role in aircraft search and rescue.
Robotics: Lunar Exporation, Mars Exploration, Deep Space Exploration	Should Singapore develop a capacity in robotics, we may carve out a niche in celestial exploration developing build-to-order robotics for various commercial and state interests. To do so quickly and cost-efficiently would be the objective.
Space-Based Radar	Instead of catching up to existing technology, a area of space development that is just developing is space-based radar technology.
Space-Based Solar Power	Instead of catching up to existing technology, Singapore may wish to look into space-based solar power. Already pursued by Japan, China and the US, should Singapore develop this capability we will be a leader in a revolutionary form of energy production.

Singapore will be able to use its inherent comparative advantages to carve out a niche in the growing space industry, but in order to lead it will be required to make bold decisions of calculated risk.

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Appendix

Asia Pacific Space Agencies

Country	Region	Agency	Initials	ASTR	SAT	RCKT
Brunei	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
Cambodia	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
Indonesia	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	ASEAN	Asia-Pacific Space Cooperation Organization	APSCO	No	Yes	No
	ASEAN	Committee on Space Research	COSPAR	No	No	No
	ASEAN	National Institute of Aeronautics and Space	LAPAN	No	No	No
	ASEAN	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Laos	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
Malaysia	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	ASEAN	Malaysian National Space Agency	ANGKASA	Yes	Yes	No
	ASEAN	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Myanmar	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
Philippines	ASEAN	-	-	-	-	-
Singapore	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	ASEAN	Centre for Remote Imaging, Sensing and Processing	CRISP	No	Yes	No
Thailand	ASEAN	APAC Multilateral Cooperation in Space Technology and Applications	AP-MCSTA	No	Yes	No
	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	ASEAN	Asia-Pacific Space Cooperation Organization	APSCO	No	Yes	No
	ASEAN	Committee on Space Research	COSPAR	No	No	No
	ASEAN	Geo-Informatics and Space Technology Development Agency	GISTDA	No	Yes	No
	ASEAN	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Timor-Leste	ASEAN	-	-	-	-	-
Vietnam	ASEAN	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
Vietnam	ASEAN	Space Technology Institute (Vietnam)	VAST-STI	Yes	Yes	No
China	East Asia	APAC Multilateral Cooperation in Space Technology and Applications	AP-MCSTA	No	Yes	No
	East Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	East Asia	Asia-Pacific Space Cooperation Organization	APSCO	No	Yes	No
	East Asia	China National Space Administration	CNSA	Yes	Yes	Yes
	East Asia	Committee on Space Research	COSPAR	No	No	No
	East Asia	Consultative Committee for Space Data Systems	CCDS	No	No	No
	East Asia	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Hong Kong	East Asia	-	-	-	-	-
Japan	East Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	East Asia	Committee on Space Research	COSPAR	No	No	No
	East Asia	Consultative Committee for Space Data Systems	CCDS	No	No	No
	East Asia	Japan Aerospace Exploration Agency	JAXA	Yes	Yes	Yes
	East Asia	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
North Korea	East Asia	National Aerospace Development Administration	NADA	No	Yes	Yes
South Korea	East Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	East Asia	Korea Aerospace Research Institute	KARI	Yes	Yes	Yes
	East Asia	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Taiwan	East Asia	Committee on Space Research	COSPAR	No	No	No

	East Asia	National Space Organization	NSPO	No	Yes	Yes
Mongolia	Others	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	Others	Asia-Pacific Space Cooperation Organization	APSCO	No	Yes	No
	Others	National Remote Sensing Centre of Mongolia	NRSC	No	No	No
	Others	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Australia	Pacific Islands	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	Pacific Islands	Committee on Space Research	COSPAR	No	No	No
	Pacific Islands	Commonwealth Scientific and Industrial Research Organisation	CSIRO	No	Yes	No
	Pacific Islands	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Maldives	Pacific Islands	-	-	-	-	-
New Zealand	Pacific Islands	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
Papua New Guinea	Pacific Islands	-	-	-	-	-
Samoa	Pacific Islands	-	-	-	-	-
Bangladesh	South Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	South Asia	Asia-Pacific Space Cooperation Organization	APSCO	No	Yes	No
	South Asia	Space Research and Remote Sensing Organization	SPARRSO	No	No	No
Bhutan	South Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
India	South Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	South Asia	Committee on Space Research	COSPAR	No	No	No
	South Asia	Indian Space Research Organisation	ISRO	Yes	Yes	Yes
	South Asia	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Nepal	South Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
Pakistan	South Asia	APAC Multilateral Cooperation in Space Technology and Applications	AP-MCSTA	No	Yes	No
	South Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	South Asia	Asia-Pacific Space Cooperation Organization	APSCO	No	Yes	No
	South Asia	Committee on Space Research	COSPAR	-	-	-
	South Asia	Pakistan Space and Upper Atmosphere Research Comission	SUPARCO	No	Yes	Yes
	South Asia	United Nations Committee on the Peaceful Uses of Outer Space	UNCOPOUS	-	-	-
Sri Lanka	South Asia	Asia-Pacific Regional Space Agency Forum	APRSAF	No	Yes	No
	South Asia	Sri Lanka Space Agency	SLSA	No	Yes	No

Legend
ASTR - Astronauts
SAT - Satellites
RCKT - Sounding Rockets Capable

Asia Pacific Spacefaring Capabilities

				Launch Capabilities				
Country	Region	Agency	Initials	Launch Capable	Multiple Satellites Launch Capable	Cryogenic Rocket Engines	Operates ET Probe	Recoverable Satellites
China	East Asia	China National Space Administration	CNSA	Yes	Yes	Yes	Yes	Yes
North Korea	East Asia	Korean Committee of Space Technology	KCST	Yes	No	No	No	No
South Korea	East Asia	Korea Aerospace Research Institute	KARI	Yes	No	No	No	No
India	South Asia	Indian Space Research Organisation	ISRO	Yes	Yes	Yes	Yes	Yes
Japan	East Asia	Japan Exploration Agency	JAXA	Yes	Yes	Yes	Yes	Yes

				Spaceflight Capabilities				
Country	Region	Agency	Initials	Manned Spaceflight	Manned Space Launch	Spacewalk Capable	Space Rendezvous and Docking Capable	Operates Space Station
China	East Asia	China National Space Administration	CNSA	Yes	Yes	Yes	Yes	Yes
North Korea	East Asia	Korean Committee of Space Technology	KCST	-	-	-	-	-
South Korea	East Asia	Korea Aerospace Research Institute	KARI	-	-	-	-	-
India	South Asia	Indian Space Research Organisation	ISRO	-	-	-	-	-
Japan	East Asia	Japan Exploration Agency	JAXA	-	-	-	-	-

				Lunar Soft-Landing Capabilities				
Country	Region	Agency	Initials	Circumlunar Manned Spaceflight	Unmanned Moon Soft Landing	Rover Operation	Lunar Sample Return	Manned Moon Landing
China	East Asia	China National Space Administration	CNSA	No	Yes	Yes	No	No
North Korea	East Asia	Korean Committee of Space Technology	KCST	-	-	-	-	-
South Korea	East Asia	Korea Aerospace Research Institute	KARI	-	-	-	-	-
India	South Asia	Indian Space Research Organisation	ISRO	-	-	-	-	-
Japan	East Asia	Japan Exploration Agency	JAXA	-	-	-	-	-

Asia Pacific Space Agreements

Country	Region	1967 OST	1968 ARRA	1972 LIAB	1975 REG	1979 MOON	1963 NTB
Brunei	ASEAN						
Cambodia				S			
Indonesia		R	R	R	R		R
Laos		R	R	R			R
Malaysia		S	S				R
Myanmar		R	S				R
Philippines		S	S	S		R	R
Singapore		R	R	R	S		R
Thailand		R	R				R
Timor-Leste							
Vietnam		R	S				S
China	East Asia	R	R	R	R		R
Hong Kong							
Japan		R	R	R	R		R
Macau							
North Korea							
South Korea		R	R	R	R		R
Taiwan							
Mongolia	Others	R	R	R	R		R
Australia	Pacific Islands	R	R	R	R	R	R
Maldives			R				
New Zealand		R	R	R			R
Papua New Guinea		R	R	R			R
Samoa							R
Bangladesh	South Asia	R					R
Bhutan							R
India		R	R	R	R	S	R
Nepal		R	R	S			R
Pakistan		R	R	R	R	R	R
Sri Lanka		R		R			R

Country	Region	1974 BRS	1971 ITSO	1971 INTR	1976 INTC	1976 IMSO	1992 ITU
Brunei	ASEAN		R			R	R
Cambodia							R
Indonesia			R			R	R
Laos				R			R
Malaysia			R			R	R
Myanmar							R
Philippines			R			R	R
Singapore		R	R			R	R
Thailand		R				R	R
Timor-Leste							R
Vietnam		R	R	R	R	R	R
China	East Asia		R			R	R

Hong Kong							
Japan			R			R	R
Macau							
North Korea							
South Korea		R	R			R	R
Taiwan							
Mongolia	Others		R	R	R	R	R
Australia	Pacific Islands	R	R			R	R
Maldives							R
New Zealand			R			R	R
Papua New Guinea			R				R
Samoa							R
Bangladesh	South Asia		R			R	R
Bhutan			R				R
India			R	R		R	R
Nepal			R				R
Pakistan			R			R	R
Sri Lanka			R			R	R

R for ratified, S for signed

Legend

Abbreviation	Working Title	Full Title
1967 OST	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
1968 ARRA	Rescue Agreement	Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space
1972 LIAB	Liability Convention	Convention on International Liability for Damage Caused by Space Objects
1975 REG	Registration Convention	Convention on Registration of Objects Launched into Outer Space
1979 MOON	Moon Agreement	Agreement Governing the Activities of States on the Moon and Other Celestial Bodies
1963 NTB	Test Ban	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water
1974 BRS	BRS	Convention Relating to the Distribution of Programme-Carrying Signals Transmitted by Satellite
1971 ITSO	ITSO	Agreement Relating to the International Telecommunications Satellite Organization
1971 INTR	INTR	Agreement on the Establishment of the INTERSPUTNIK International System and Organization of Space Communications
1976 INTC	INTERCOSMOS	Agreement on Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes (INTERCOSMOS)
1976 IMSO	IMSO	Convention on the International Mobile Satellite Organization
1992 ITU	ITU	International Telecommunication Constitution and Convention

Spaceports with Achieved Manned Spaceflight

Spaceport	Location	Launch Complex	Launcher	Spacecraft	Flights	Years
Baikonur Cosmodrome	Kazakhstan	Site 1	Vostok (r)	Vostok 1–6	6 Orbital	1961–1963
Baikonur Cosmodrome	Kazakhstan	Site 1	Voskhod (r)	Voskhod 1–2	2 Orbital	1964–1965
Baikonur Cosmodrome	Kazakhstan	Site 1, 31	Soyuz, Soyuz-U	Soyuz 1–40 †	37 Orbital	1967–1981
Baikonur Cosmodrome	Kazakhstan	Site 1, 31	Soyuz-U, Soyuz-U2	Soyuz-T 2–15	14 Orbital	1980–1986
Baikonur Cosmodrome	Kazakhstan	Site 1	Soyuz-U, Soyuz-U2	Soyuz-TM 2–34	33 Orbital	1987–2002
Baikonur Cosmodrome	Kazakhstan	Site 1	Soyuz-FG	Soyuz-TMA 1–22	22 Orbital	2002–2011
Baikonur Cosmodrome	Kazakhstan	Site 1, 31	Soyuz-FG	Soyuz TMA-M 1–20	20 Orbital	2010–2016
Baikonur Cosmodrome	Kazakhstan	Site 1	Soyuz-FG	Soyuz MS	0 Orbital	(Planned) 2016–
Cape Canaveral AFS	USA, Florida	LC5	Redstone	Mercury 3–4	2 Sub-O	1961–1961
Cape Canaveral AFS	USA, Florida	LC14	Atlas	Mercury 6–9	4 Orbital	1962–1963
Cape Canaveral AFS	USA, Florida	LC19	Titan II	Gemini 3–12	10 Orbital	1965–1966
Cape Canaveral AFS	USA, Florida	LC34	Saturn IB	Apollo 7	1 Orbital	1968–1968
Kennedy Space Center	USA, Florida	LC39	Saturn V	Apollo 8–17	10 Lun/Or	1968–1970
Kennedy Space Center	USA, Florida	LC39	Saturn IB	Skylab 2–4	3 Orbital	1973–1974
Kennedy Space Center	USA, Florida	LC39	Saturn IB	Apollo-Soyuz	1 Orbital	1975–1975
Kennedy Space Center	USA, Florida	LC39	STS 1–135 ‡	Space Shuttle	134 Orbital	1981–2011
Jiuquan SLC	China	Area 4	Long March 2F	Shenzhou 5–7, 9-10	5 Orbital	2003–

Spaceports with Achieved Satellite Launches

Spaceport	Location	Years (Orbital)	Launches to orbit or interplanetary	Launch vehicles (operators)
Baikonur Cosmodrome, Baikonur/Tyuratam	Kazakhstan	1957-	>1,000	R7/Soyuz, Kosmos, Proton, Tsyklon, Zenit, Energia
Cape Canaveral Air Force Station	Florida, USA	1958-	>400	Delta, Scout, Atlas, Titan, Saturn, Athena, Falcon 9
Delta class submarine	Barents Sea	1998-	2	Shtil', Volna (Russia)
Guiana Space Centre	Kourou, French Guiana	1970-	225	7 Diamant, 207 Ariane, 8 Soyuz-2, 3 Vega
Hammaguir French Special Weapons Test Centre	Algeria	1965–1967	4	Diamant A (France)
Jiuquan Satellite Launch Center	China	1970-	58	Long March
Kapustin Yar Cosmodrome	Astrakhan Oblast, Russia	1962-2008	85	Kosmos
Kennedy Space Center	Florida, USA	1967-	151	17 Saturn, 134 Space Shuttle
Kodiak Launch Complex, Alaska, USA	Alaska, USA	2001-	3	1 Athena, 2 Minotaur IV
Mid-Atlantic Regional Spaceport (MARS), Virginia, USA	USA, Virginia	2006-	8	5 Minotaur I, 2 Antares, 1 Minotaur V
Naro Space Center, South Jeolla, South Korea	South Korea	2013-	1	Naro-1
Odyssey mobile platform, Pacific Ocean	Pacific Ocean	1999–	32	Zenit-3SL (Sea Launch)
Omelek, Kwajalein Atoll, Marshall Islands	Marshall Islands	2008-	2	Falcon 1 (USA)
Palmachim Air Force Base, Israel	Israel	1988-	6	Shavit

Plesetsk Cosmodrome	Arkhangelsk Oblast, Russia	1966-	>1,500	R-7/Soyuz, Kosmos, Tsyklon-3, Rokot, Angara
San Marco platform, Broglio Space Centre	Malindi, Kenya	1967–1988	9	Scout (ASI and Sapienza, Italy)
Satish Dhawan Space Centre (SHAR)	Andhra Pradesh, India	1979-	41	3 SLV, 2 ASLV, 30 PSLV, 5 GSLV, 1 GSLV Mk III
Semnan, Iran	Iran	2009-	3	Safir
Sohae, North Korea	North Korea	2012-	1	Unha-3
Svobodny Cosmodrome, Amur Oblast, Russia	Russia	1997–2006	5	Start-1
Taiyuan Satellite Launch Center, China	China	1988-	46	Long March
Tanegashima Space Center, Japan	Japan	1975-	50	6 N-I, 8 N-II, 9 H-I, 6 H-II, 21 H-IIA
Uchinoura Space Center (Kagoshima), Japan	Japan	1970–	28	27 Mu, 1 Epsilon
Vandenberg Air Force Base, California, USA	USA, California	1959-	>500	Delta, Scout, Atlas, Titan, Taurus, Athena, Minotaur, Falcon 9
Various airport runways (B-52, Stargazer)		1990-	39	Pegasus (Orbital Sciences Corporation)
Vostochny Cosmodrome, Amur Oblast, Russia	Russia	2016-	1	Soyuz-2
Wallops Flight Facility	USA, Virginia	1961-1985	19	Scout
Woomera Prohibited Area	South Australia	1967, 1971	2	Redstone (WRESAT), Black Arrow (UK Prospero X-3)
Xichang Satellite Launch Center	China	1984-	79	Long March
Yasny Cosmodrome (Dombarovsky)	Orenburg Oblast, Russia	2006-	7	Dnepr-1