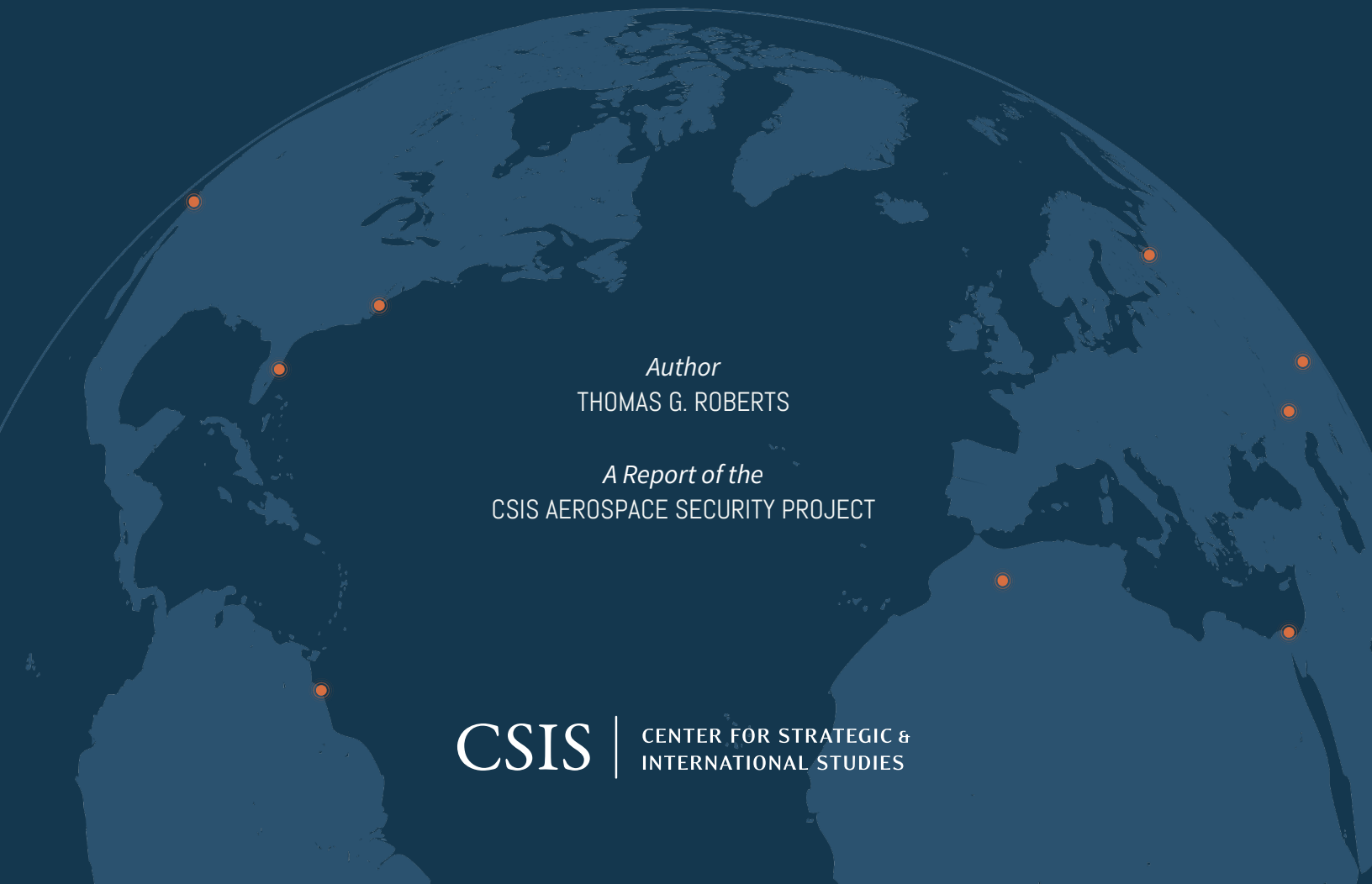
MARCH 2019

SPACEPORTS OF THE WORLD



Author
THOMAS G. ROBERTS

A Report of the
CSIS AEROSPACE SECURITY PROJECT

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

MARCH 2019

SPACEPORTS OF THE WORLD

Author
THOMAS G. ROBERTS

A Report of the
CSIS AEROSPACE SECURITY PROJECT

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

ABOUT CSIS

Established in Washington, D.C., over 50 years ago, the Center for Strategic and International Studies (CSIS) is a bipartisan, nonprofit policy research organization dedicated to providing strategic insights and policy solutions to help decisionmakers chart a course toward a better world.

In late 2015, Thomas J. Pritzker was named chairman of the CSIS Board of Trustees. Mr. Pritzker succeeded former U.S. senator Sam Nunn (D-GA), who chaired the CSIS Board of Trustees from 1999 to 2015. CSIS is led by John J. Hamre, who has served as president and chief executive officer since 2000.

Founded in 1962 by David M. Abshire and Admiral Arleigh Burke, CSIS is one of the world's preeminent international policy institutions focused on defense and security; regional study; and transnational challenges ranging from energy and trade to global development and economic integration. For eight consecutive years, CSIS has been named the world's number one think tank for international security by the University of Pennsylvania's "Go To Think Tank Index."

The Center's over 220 full-time staff and large network of affiliated scholars conduct research and analysis and develop policy initiatives that look to the future and anticipate change. CSIS is regularly called upon by Congress, the executive branch, the media, and others to explain the day's events and offer bipartisan recommendations to improve U.S. strategy.

CSIS does not take specific policy positions; accordingly, all views expressed herein should be understood to be solely those of the author(s).

ACKNOWLEDGMENTS

This report is made possible by general support to CSIS. No direct sponsorship contributed to this work. The author would like to thank Jacque Schrag, Emily Tiemeyer, Todd Harrison, and Kaitlyn Johnson from CSIS, Brian Weeden and Victoria Samson from the Secure World Foundation, and James Dean from Florida Today for their support on this project.

Center for Strategic & International Studies
1616 Rhode Island Avenue, NW
Washington, DC 20036
202-887-0200 | www.csis.org

TABLE OF CONTENTS

INTRODUCTION

OVER 60 YEARS AGO, the Soviet Union used a derivative of its R-7 rocket—often called the world's first intercontinental ballistic missile (ICBM)—to launch an artificial satellite into orbit, marking the first orbital space launch from the spaceport now known as the **Baikonur Cosmodrome**.[1] Since then, launch vehicles have reached orbit from 27 spaceports around the world. With the rate of space launches projected to grow exponentially in the coming years, spaceports will become an increasingly important and potentially limiting factor in the global space industry. This report analyzes ground-based space launches from 1957 to 2018, including brief histories of all active and inactive orbital spaceports, 10-year launch records for the 22 spaceports still in use today, and the current status of several proposals to create new facilities capable of supporting orbital space launches.

This report is accompanied by an interactive data repository available at online at **cs.is/spaceports**, which houses the launch data referenced in the following chapters. In both the online data repository and this report, only successful orbital launches from ground-based platforms are considered. Therefore, all launches from air- or mobile sea-based platforms—including those using all variants of the air-launched Pegasus vehicle, those from the mobile sea-platform provided by Sea Launch, and those from Russian submarines in the Barents Sea—are excluded. Ground-based platforms account for approximately 99 percent of all orbital space launches to date.[2]

Ground-based spaceports are typically built in geopolitically favorable locations. Many spaceports are located in the most physically optimal regions available to operators, with geographic characteristics that include close proximity to the equator, opportunities for eastward or near-eastward launch, and favorable environmental factors. Historically, orbital space launch operations have been closely tied with ballistic missile research, leading several ICBM development and testing centers to later become spaceports. Due to the political risk associated with both missile development and orbital space launch testing, several spaceports were originally created such that their precise positions could remain ambiguous. In at least one case, a spaceport was created with the intention of being entirely secret—with its operator denying its existence for more than 15 years.

– GEOGRAPHIC CONSIDERATIONS

To place a satellite into orbit, it must be delivered to a high altitude (at least 125 km for a circular orbit)[3] with sufficient horizontal velocity[4] (approximately 7 km/s for low Earth orbit).[5] Payloads launched to lower altitudes—depicted in Trajectory A in Figure 1—face too much drag from the atmosphere to maintain the velocity required for orbit without expending more fuel. Those launched to a sufficient altitude but too little horizontal velocity—like Trajectory B in Figure 1—also fail to reach orbit, instead falling back towards the Earth on a ballistic, sub-orbital trajectory.

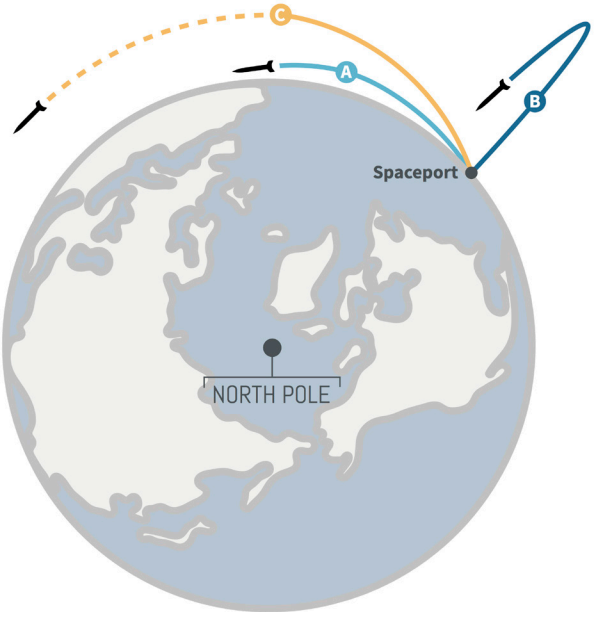


Figure 1: Comparing Sub-Orbital and Orbital Trajectories. *Reaching orbit requires both a sufficient altitude and horizontal velocity. Launches that follow a flight path similar to Trajectory A have sufficient horizontal velocity but insufficient altitude. Those that resemble Trajectory B have sufficient altitude but insufficient horizontal velocity. Both Trajectory A and B represent sub-orbital trajectories. A launch that resembles Trajectory C has both sufficient altitude and horizontal velocity and, therefore, reaches orbit.*

Due to one of the requirements for reaching orbit—sufficient horizontal velocity—some positions on the Earth's surface are more optimal than others for launching payloads to certain orbits.

Lower Latitudes

Because the Earth is rotating around its center axis—the imaginary line that passes through the north and south poles—all points on the planet's surface naturally have some horizontal velocity.[6] Therefore, some space missions can leverage this rotation to reduce the total energy required for launch.

"To take full advantage of the Earth's rotation for space launch, an object must be launched due eastward from a spaceport located precisely on the equator."

Due to the Earth's shape, the magnitude of its natural horizontal surface velocity is dependent on latitude. Points at lower latitudes have higher velocities (with a maximum of 465 m/s or 1,040 mph at the equator), and those at higher latitudes have lower velocities (about 232 m/s or 520 mph at 60° both north and south of the equator and 0 m/s at the north and south poles). Since the Earth rotates west to east, the horizontal velocity at the planet's surface—no matter its magnitude—is always eastward.

For some space missions, a velocity of a few hundred meters per second eastward can serve as a head start, lowering the energy required to accelerate an object to orbital speeds. This velocity is most helpful for missions that require a direct launch into prograde orbit—a category of orbits where satellites move around the Earth in the same direction the planet rotates.[7] For other missions, horizontal surface velocity is less helpful. Launching directly to polar or near-polar orbits—where satellites travel over both the north and south poles—requires a southward or northward launch. Since the Earth's horizontal velocity is entirely eastward, launches to polar orbits do not benefit from low latitude spaceports. Launching directly into retrograde orbits (where satellites move in the opposite direction of Earth's rotation), however, requires a westward launch, where the launch vehicle must both overcome the spaceport's natural eastward velocity and reach the horizontal velocity necessary to stay in orbit. Therefore, to take full advantage of the Earth's rotation for space launch, an object must be launched due eastward from a spaceport located precisely on the equator.

Since lower-latitude launches often require less energy (and therefore less propellant) than those from higher latitudes, the same launch vehicle could be used to launch more mass from the **Guiana Space Centre** in French Guiana than from the **Plesetsk Cosmodrome** in Russia. Similarly, a satellite launched from northern Scotland would require more propellant to reach some orbits than the same satellite launched to the same orbit from northern Brazil. Figure 2 shows the Earth's surface velocity at the five most utilized spaceports in the world.

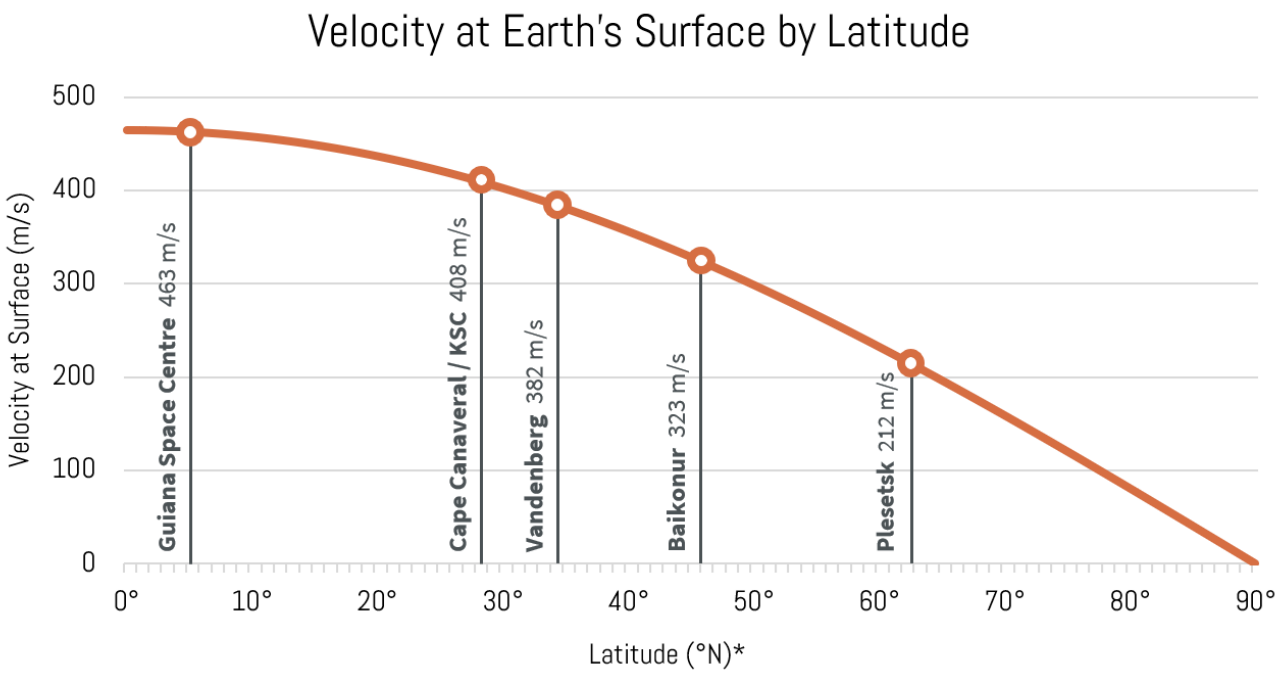


Figure 2: Velocity at Earth's Surface by Latitude. *The five most utilized spaceports are located between 5°N and 63°N. *Note: Although these five spaceports are all in the northern hemisphere, southern spaceports also benefit from the Earth's rotation with the same relationship between latitude and surface velocity.*

Lower latitudes are also helpful when trying to reach low-inclination orbits, like the geostationary belt (GEO), which has 0°-inclination. Without orbital maneuvers after launch, a spaceport can only directly launch to orbits with inclinations greater than or equal to its latitude on the Earth's surface. Thus, all payloads launches to GEO from the **Baikonur Cosmodrome**—the world's highest-latitude spaceport that has placed an object into that orbital regime—must perform costly plane change maneuvers (and burn more propellant) than the same object launched to GEO from a lower latitude spaceport. In the past 10 years, two thirds of all global GEO launches have been supported by spaceports at latitudes 30° and lower.[8]

Azimuth Limitations

All spaceports are associated with corresponding drop zones, or regions where rocket stages fall back to the Earth's surface during a successful launch and where aborted missions are likely to crash land. The toxicity of some rocket propellants and the inherent threat of falling debris lead most launch operators to avoid creating drop zones that include populated areas or include foreign territory or airspace.

The **Cape Canaveral** spaceport in Florida is restricted by the populated east coast of the United States to its north and southern Florida and several Caribbean island nations to its south. To prevent these regions from falling within the spaceport's drop zones, all launches out of Cape Canaveral face azimuth limitations. A rocket's launch azimuth is the direction it travels in the horizontal plane after leaving the launch pad, measured in degrees clockwise from due north. Historically, Cape Canaveral's allowable azimuths lie between 35° and 120°—as depicted in Figure 3—meaning orbital space launches from this spaceport are to the east.[9]

Some spaceports, however, face azimuth limitations that prevent them from launching eastward, meaning they cannot take advantage of the Earth's rotation as described in the previous subsection. For example, **Vandenberg Air Force Base**—the United States' main spaceport on its continental West Coast—is restricted to its north and east by the densely populated Bay Area and Los Angeles County regions respectively. When the spaceport was planning to host Space Shuttle launches in the mid-1980s, Vandenberg was allowed to use launch azimuths between 158° and 201°.[10] As shown in Figure 3, this restriction only allows for southward launches, making the spaceport suitable for supporting direct launches to polar and near-polar orbits, which require satellites to travel north and south when viewed from the ground.[11]

> "Most launch operators avoid creating drop zones that include populated areas foreign territory."

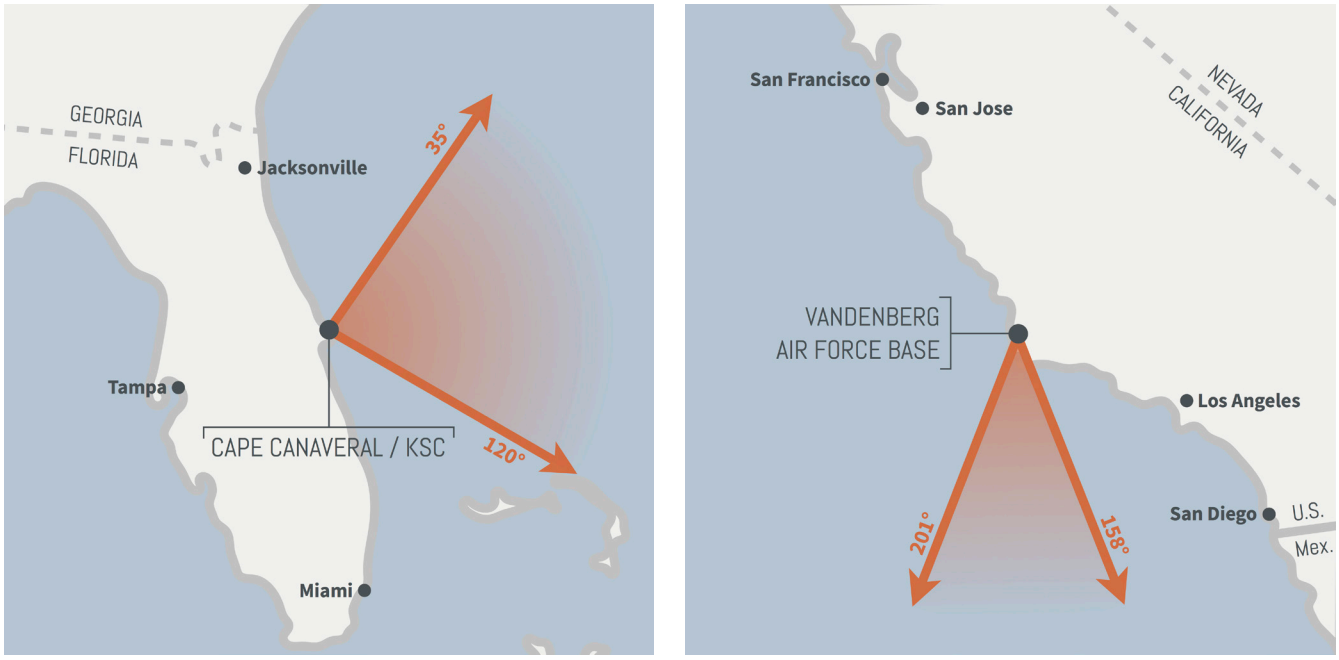


Figure 3: Azimuth Limitations at Cape Canaveral and Vandenberg. *Launches from Cape Canaveral and the Kennedy Space Center (left) are limited to azimuths near due east. The azimuth limitations at Vandenberg Air Force Base (right) only allow for southward launches.*[12]

Natural Factors

An orbital space launch out of any spaceport requires favorable weather conditions. Environmental factors such as the risk of natural disasters or protection from harsh weather conditions may make some spaceport locations more attractive to launch operators than others.

As a result, countries that face a particularly high risk of natural disasters must build their spaceports to account for that. For example, while Japan is regularly threatened by earthquakes, its two spaceports—the **Tanegashima** and **Uchinoura Space Centers**—are both located in the country's

southernmost region, where earthquakes are not as common.[13] In 2010, when a 8.9-magnitude earthquake damaged the Tsukuba Space Center—Japan's primary space center, but not a launch facility—the southern spaceports faced no damage. A spokesperson for the Japan Aerospace Exploration Agency (JAXA) confirmed that the Tanegashima spaceport "is relatively far from the [2010] earthquake's main destruction zones."[14] Situated at a relatively high altitude, the spaceport is also well protected from tsunami waves created in the aftermath of an earthquake.

In 2004, a devastating tsunami developed in the Indian Ocean after a magnitude 9.1 undersea earthquake struck the ocean floor off the coast of Indonesia.[15] Although the eastern coast of India was greatly affected by that particular disaster, launches from the **Satish Dhawan Space Centre** may have escaped delays due to the Indian Space Research Organisation's (ISRO) relatively slow launch rate at the time. In general, destructive tsunami events are more likely to affect the Japanese spaceports or the **Rocket Lab Launch Complex** in New Zealand than they are to affect the Indian spaceport.[16]

In 2016, a California wildfire caused a space launch to be delayed out of the spaceport at **Vandenberg**.[17] The launch facilities were not damaged, but the region surrounding the spaceport suffers from a perennial wildfire risk.[18]

The Florida coast, home of the spaceport at **Cape Canaveral and the Kennedy Space Center** (KSC), is prone to powerful hurricanes. In September 2017, nonessential personnel were evacuated from Cape Canaveral in advance of Hurricane Irma.[19] Additionally, a launch from the spaceport at Vandenberg was delayed to allow the support personnel on-site to return home to their families in Florida and prepare for the hurricane.[20] Later, NASA announced that the Kennedy Space Center "sustained a variety of damage" from the storm.[21]

In 2017 and 2018, launches from the **Guiana Space Centre**,[22] the spaceport at Vandenberg,[23] and the Rocket Lab Launch Complex in New Zealand[24] all faced delays due to threatening high-altitude winds. High-altitude wind speeds have been measured to be relatively high over French Guiana at mid-range altitudes (1,000 m).[25] At higher altitudes (10,000 m), wind speeds are relatively high over the spaceports in New Zealand, Japan, northern China, southern Russia, and Kazakhstan.[26] High-altitude wind shear—or abrupt variations in wind speeds at high altitudes—exert unexpected forces on launch systems during flight, which could prevent them from reaching their orbital destinations efficiently.[27]

Some space agencies enforce weather requirements for launch. For example, NASA's Space Shuttle would not begin loading its external tank with propellant if the 24-hour average temperature was 5°C (41°F) or lower, which effectively delayed all launches on cold days.[28] If launches from the **Plesetsk Cosmodrome** adhered to a similar guideline, the spaceport would likely be out of commission 7 months out of the year.[29]

– POLITICAL CONSIDERATIONS

If spaceports were placed with only geographic factors in mind, they would all be based on the equator with safe drop zones to their east and in regions protected from unfavorable weather conditions. The list of potential launch sites shrinks further when considering the need for polar launch capabilities—launching directly into an orbit that passes over both the north and south poles—which requires drop zones to the north or south. But of course, spaceports are located all over the world, suggesting that geographic factors are only one part of the process for determining where a spaceport will be located. Perhaps the greatest driving forces behind choosing where to build a spaceport are political considerations.

Accessibility

For state-sponsored space programs, one of the most important factors when choosing where to build a spaceport is accessibility. Almost all spaceports have been built in a region entirely controlled by the operating country, ensuring unfettered access to the launch site at all times.

The greatest exception to this concept is the Russian-operated **Baikonur Cosmodrome** in southern Kazakhstan. Although the Soviet spaceport was in its operator's homeland when it was established in 1955, Kazakhstan gained independence in 1991, and Russia began paying to lease the launch facilities soon thereafter. Today, Russia pays Kazakhstan approximately $115 million annually in order to maintain access to the spaceport.[30]

Another exception is the **Broglio Space Centre**, which operated in the Formosa Bay off the coast of Kenya under an agreement between NASA and the Aerospace Research Centre at the Sapienza University of Rome.[31] Although the launch platform was located off of Kenya's shores (but still in the country's exclusive economic zone), support facilities were built on a small piece of Kenyan land.[32] Neither the United States nor Italy could access the spaceport without entering Kenyan territory.

Some space programs have taken advantage of overseas territories to build spaceports in more geographically optimal locations. The **Hammaguir Test Centre** was built by the French military in French-controlled Algeria in the 1960s, but only supported space launches for two years—a period cut short by the removal of French forces when Algeria was granted sovereignty in 1967.[33] Later, the French space agency selected another site for space launch at a lower latitude: the coast of French Guiana, a French-administered territory in South America, which now hosts the **Guiana Space Centre**, one of the world's most active spaceports.[34] Both sites are more geographically favorable for orbital space launch than metropolitan France.

Neighboring Airspace

Some spaceport capabilities are limited due to the political relationships between the operating country and its neighboring states. For example, to avoid its adversaries to the east, the Israeli spaceport on the **Palmachim Airbase** exclusively launches westward into retrograde orbits, sacrificing launch effi-

ciency for regional political stability. Other space agencies have successfully established agreements with their neighbors to allow for efficient launch trajectories. The Russian Space Agency has reached an agreement with Kazakhstan to launch Russian rockets through Kazakh airspace—from both the **Baikonur Cosmodrome** and to a lesser extent the **Kapustin Yar Cosmodrome**. Other agreements are more extensive. For example, the United Kingdom has allowed both NASA and the U.S. Air Force to build ground stations on British territory in the Caribbean and southern Atlantic Oceans in order to support eastward launches out of Florida.

Political Stability

When choosing where to construct the **Broglio Space Centre** in the 1960s, the American and Italian space programs acknowledged the undesirable "political adjustments" happening in several equatorial countries in South America and Africa at the time. In the end, the two programs chose to place the most valuable assets of the launch facility—the launch platform—off the coast of Kenya, with extendable legs resting on the ocean floor.[35]

In 2017, thousands of protesters blocked the entry to the spaceport in French Guiana, threatening the European Space Agency's access to its own facility, despite France's jurisdiction over the territory.[36] Protestors told reporters that the last-minute protest—which lasted more than three weeks—was organized to bring attention to social and economic issues affecting French Guiana.

Public Awareness

In the first space age, from 1957 to 1990, some space programs made efforts to keep the exact locations of their spaceports hidden. The Baikonur Cosmodrome in Kazakhstan—made famous by supporting both the world's first satellite launch and the world's first human launch—was purposely named to mislead the public.[37] Although there really is a town in Kazakhstan named Baikonur, it is nowhere near the spaceport of the same name. The Soviet space agency chose to not publicly acknowledge the **Plesetsk Cosmodrome**—the county's second most active spaceport, which is almost 1,500 km northwest of the spaceport at Baikonur—until 1983, 17 years after the spaceport's first orbital launch.[38]

Some spaceport operators, on the other hand, hope that launches may draw public attention, perhaps generating national support for space programming or to advance in the international competition between space-faring nations. For example, the **Wenchang Satellite Launch Center**—China's newest spaceport—was built on Hainan Island, a popular tourist destination that is accessible by car and open to the public for tours and launch events.[39]

– COMPARING SPACEPORTS

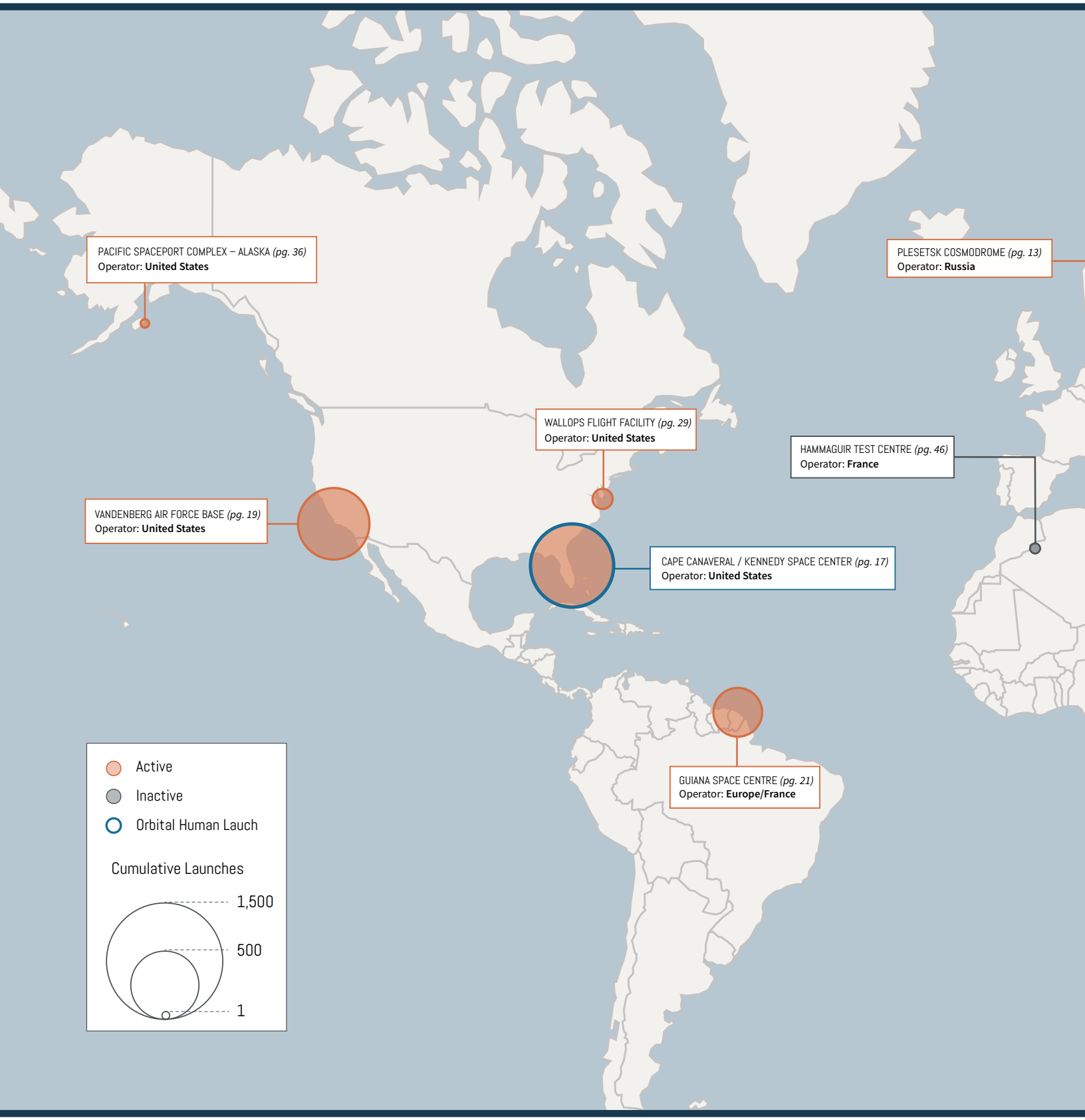
In the following chapters and the online interactive data repository, active and inactive spaceports are compared by using their total number of launches per year and the orbital destinations for each launch, including the orbital regime and inclination for each launch's primary payload.

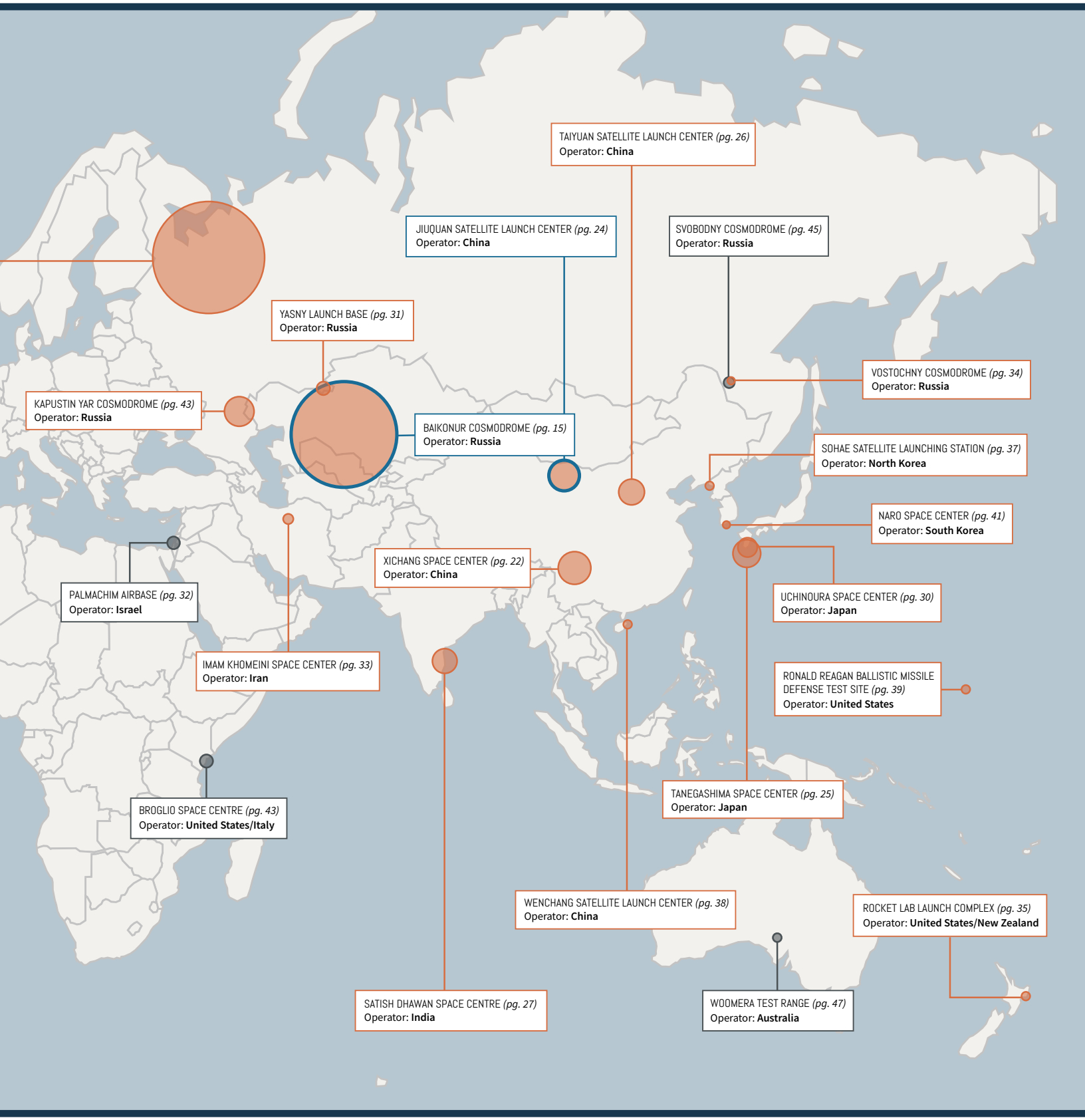
The term “primary payload” is defined as either the only payload onboard a particular launch or the payload labeled with the “A” letter code in its international designator according to the Combined Space Operations Center's (CSpOC) orbital object catalog.[40]

Primary payloads are divided into five orbital regime categories: low Earth orbit ("LEO"), geosynchronous Earth orbit ("GEO"), medium Earth orbit ("MEO"), "Other", and "Missing Elements." The LEO orbital regime includes primary payloads with apogees that do not exceed 2,000 km. The GEO regime includes primary payloads with apogees and perigees that fall within 2,000 km of the geosynchronous altitude (35,786 km). For this report, those primary payloads with altitudes that place them between LEO and GEO are sorted into the MEO category. Primary payloads with orbital parameters that do not place them within the LEO, GEO, or MEO regimes—such as those in lunar, heliocentric, or barycentric orbit—are labeled “Other.” Those primary payloads with no initial elements included in the CSpOC catalog are labeled "Missing."[41]

Orbital elements in the CSpOC catalog also include each launch's initial orbital inclination. Although an initial orbital inclination may be indicative of a launch's original azimuth out of its home spaceport, the inclination itself should not be confused with launch azimuth. An object launched from any spaceport—including those facing severe azimuth limitations—could have a different initial orbital inclination if it performs orbital maneuvers before the object is cataloged.[42]

Due to insufficient data, this report does not characterize spaceports by more detailed figures of merit, such as launch capacity, throughput, carbon footprint, or turnaround time.[43]


PACIFIC SPACEPORT COMPLEX – ALASKA (pg. 36)
Operator: United States
PLESETSK COSMODROME (pg. 13)
Operator: Russia
WALLOPS FLIGHT FACILITY (pg. 29)
Operator: United States
HAMMAGUIR TEST CENTRE (pg. 46)
Operator: France
VANDENBERG AIR FORCE BASE (pg. 19)
Operator: United States
CAPE CANAVERAL / KENNEDY SPACE CENTER (pg. 17)
Operator: United States
GUIANA SPACE CENTRE (pg. 21)
Operator: Europe/France
Active
Inactive
Orbital Human Lauch
Cumulative Launches
1,500
500
1



Explore the interactive map online at cs.is/spaceports

ACTIVE SPACEPORTS

In this report, the term "active" describes spaceports that have both supported at least one orbital space launch over the past 10 years and have not been declared inactive by its operator. There are currently 22 active spaceports around the world: 5 on U.S. territory, 4 in China, 3 in Russia, 2 in Japan, and 1 each in Kazakhstan, Israel, India, French Guiana, Iran, North Korea, South Korea, and New Zealand. Spaceports in this chapter are listed in descending order from the most to least orbital launches from 1957 to 2018.

– PLESETSK COSMODROME

LOCATION: 62.9°N, 40.6°E
OPERATOR: Russian Aerospace Forces (Russia)
FIRST ORBITAL LAUNCH: March 17, 1966
ORBITAL LAUNCHES FROM 1957 TO 2018: 1,569

With over 1,500 total launches, the Plesetsk Cosmodrome—also known as Scientific Research Facility No. 53, First State Research Cosmodrome Plesetsk (GIK-1), and the Plesetsk Missile and Space Complex—has supported more orbital launches than any other spaceport in the world.[44] Founded in 1957 as the Soviet Union's first ICBM launch base, the spaceport's location was selected for its latitude: close enough to the Soviet industrial base in the south to be accessible by rail, but far enough north to keep the continental United States within reach of the country's earliest ICBM system.[45]

From 1966 to 1983, the Plesetsk Cosmodrome was not formally acknowledged by the Soviet government.[46] Its coordinates were first announced by a group of students from the United Kingdom who tracked the signals of early satellites. After noticing that two Soviet satellites—Kosmos 112 and 129—could not have originated from Baikonur or Kapustin Yar, the students deduced the approximate location of the new spaceport and presented their findings at a British Interplanetary Society meeting in 1966.[47]

As the world's northernmost spaceport, located at 62.9° north of the equator, the Plesetsk Cosmodrome is both incapable of launching a satellite directly to equatorial orbit and inefficient at launching a satellite to GEO. No primary payload originating from Plesetsk has ever been placed in GEO.

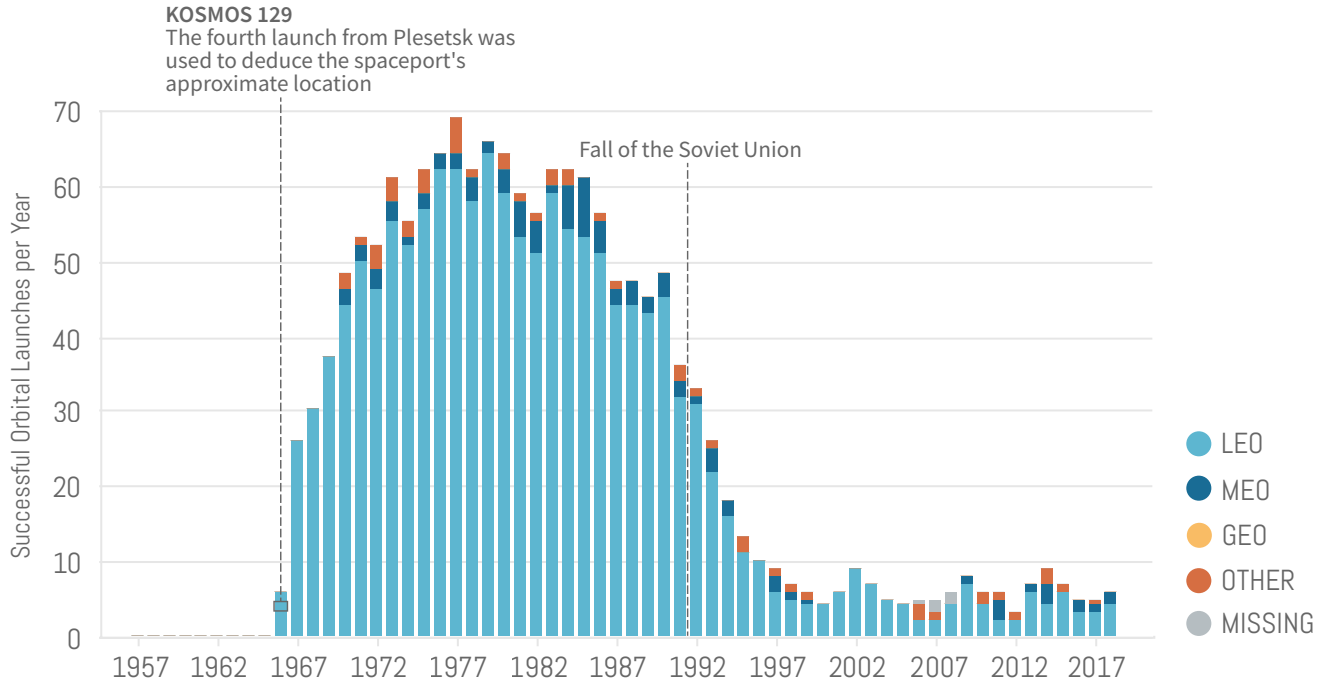


Figure 4: *Successful Orbital Launches from the Plesetsk Cosmodrome (1957-2018). Source: Space-Track.org / Gunter's Space Page*

***A Soyuz rocket launches from the Plesetsk Cosmodrome in June 2015**. The spaceport at Plesetsk is responsible for more orbital space launches than any other spaceport in the world. Source: Ministry of Defence of the Russian Federation*

Like other spaceports in landlocked Russia, orbital launches from Plesetsk are only permitted to follow a select number of predetermined flight paths such that the first and second rocket stages can be jettisoned into restricted areas within Russian territory on the ground below.[48] Despite these restrictions, the toxic debris from rocket launches out of the spaceport have posed environmental concerns for the region, threatening both the wildlife population in the Kanin Peninsula and the more human-populated areas of Arkhangelsk Oblast.[49]

VEHICLE FAMILY	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Soyuz (R-Z)	3	3	3	5	2	3	6	5	3	4	4
Rokot	1	3	2	1	1	4	2	2	2	1	2
R-12	2	1	1	-	-	-	-	-	-	-	-
R-16	-	1	-	-	-	-	-	-	-	-	-
Angara	-	-	-	-	-	-	1	-	-	-	-

***Table 1:** Launches from the Plesetsk Cosmodrome by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– BAIKONUR COSMODROME

LOCATION: 46.0°N, 63.3°E
OPERATOR: Russian Aerospace Forces / Roscosmos (Russia)
FIRST ORBITAL LAUNCH: October 4, 1957
ORBITAL LAUNCHES FROM 1957 TO 2018: 1,396

The Baikonur Cosmodrome—also known as Scientific-Research and Testing Range No. 5 (NIIP-5), GIK-5, and Tyuratam—is a Russian-operated spaceport located in southern Kazakhstan.[50] Founded in 1955, when Kazakhstan was the Kazakh Soviet Socialist Republic within the Soviet Union, the spaceport at Baikonur was created to support the development of the R-7 rocket.[51] The Baikonur Cosmodrome was also used to launch the world's first artificial satellite, Sputnik 1, in 1957 and the world's first human in space, Yuri Gagarin, in 1961.

Due to both the size of the R-7 and the sensitivity surrounding its development, the USSR Council of Ministers elected to build a new, larger facility deeper within the country's territory, as opposed to using its **Kapustin Yar** test site (the Soviet Union's first missile test site).[52] A remote area near the village of Tyuratam was selected for its proximity to the Moscow-Tashkent railway, openness to the east, and relatively low latitude compared to other Soviet test sites.[53]

As mentioned previously, since the fall of the Soviet Union, Russia has leased the space launch facilities at Baikonur Cosmodrome for $115 million per year.[54] Because rockets from the spaceport must fly over Kazakh territory, strict launch azimuth limitations are enforced to ensure rocket stages land in their designated drop zones.[55]

Baikonur is currently the only spaceport that supports human space launches to the International Space Station, since the Space Shuttle no longer operates out of the **Kennedy Space Center**,

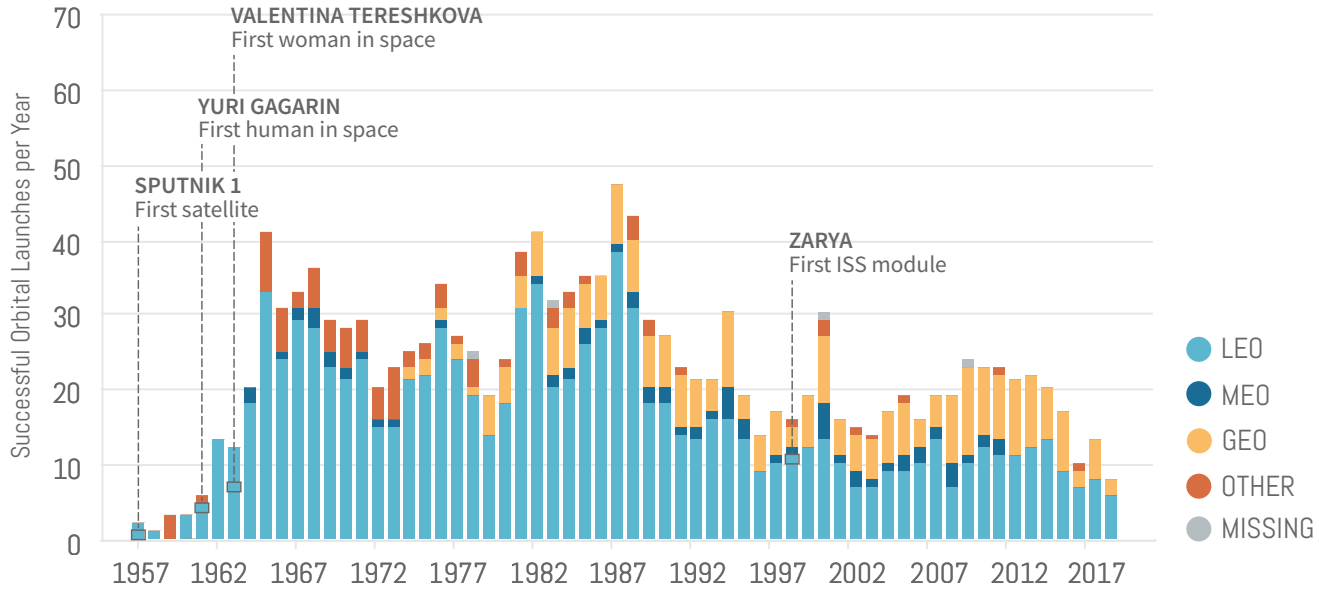


Figure 5: *Successful Orbital Launches from the Baikonur Cosmodrome (1957-2018). Source: Space-Track.org / Gunter's Space Page*

A Soyuz-FG launches from the Baikonur Cosmodrome on July 22, 2012. *This launch site became the world's first spaceport on October 4, 1957. Photo: Roscosmos*

and the China National Space Administration (CNSA)—which supports human launches out of the Jiuquan Satellite Launch Center—is not an ISS partner.

In 2013, Russian president Vladimir Putin noted the poor conditions of the spaceport complex in Baikonur, including bumpy roads and out-of-date equipment.[56] The Russian space agency intends to shift investment away from Baikonur and towards the **Vostochny Cosmodrome** in the coming years as part of its strategy to lessen its dependence on a spaceport outside of Russia's borders.

The spaceport at Baiknonur has launched payloads to every major orbital regime at a wide variety of inclinations, spanning 0° to 134°.

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Soyuz (R-Z)	10	10	10	10	11	12	9	7	8	6
Proton	10	11	9	11	9	7	7	3	4	2
Zenit	3	-	4	-	1	-	1	-	1	-
R-36M	1	2	-	-	-	-	-	-	-	-
Strela	-	-	-	-	1	1	-	-	-	-

Table 2: *Launches from the Baikonur Cosmodrome by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– CAPE CANAVERAL / KENNEDY SPACE CENTER

LOCATION: 28.6°N, 80.6°W
OPERATOR: U.S. Air Force / NASA (United States)
FIRST ORBITAL LAUNCH: February 1, 1958
ORBITAL LAUNCHES FROM 1957 TO 2018: 858

The launch facilities at Cape Canaveral and the Kennedy Space Center—operated by the U.S. Air Force 45th Space Wing and NASA, respectively—both lie at the head of the United States' Eastern Range, a missile and rocket range that stretches more than 10,000 miles from Florida to the Indian Ocean.[57] Founded as the Joint Long Range Proving Ground in 1949, the spaceports in the Eastern Range have been supporting orbital launches since 1958, when the United States' launched its first satellite.[58] The spaceports in the Eastern Range are responsible for all of NASA's crewed space missions to orbit.[59]

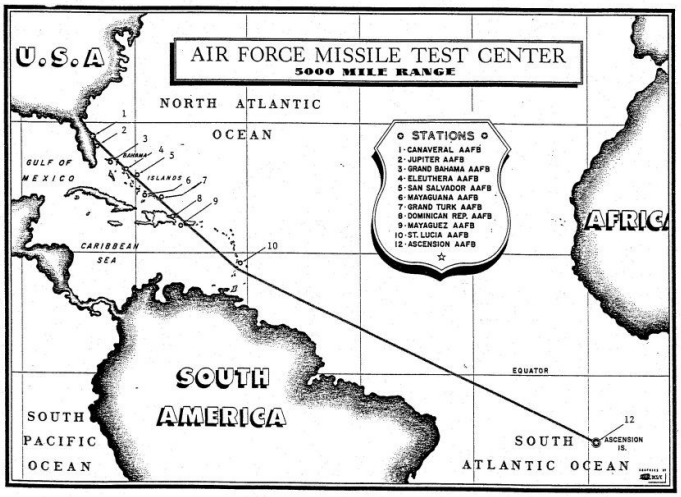


Figure 6: U.S. Air Force Eastern Range Map (1957). *As the United States Air Force continued to launch from Cape Canaveral, the Eastern Range grew to stretch to the Indian Ocean by the early 1960s.*[62] *Image: U.S. Air Force*

The Cape Canaveral region of Florida was selected for missile testing due to its accessibility by sea, the nearby military support from the Banana River Naval Air Station—now known as Patrick Air Force Base—and the opportunity to fly in an eastward direction by building support stations across islands in the Caribbean Sea and Atlantic Ocean.[60] The United Kingdom agreed to allow American tracking stations in the Bahamas to complete the chain of facilities featured in Figure 6.[61]

After U.S. president John F. Kennedy announced the Apollo Program in May 1961, it became clear that a new spaceport would need to be built,

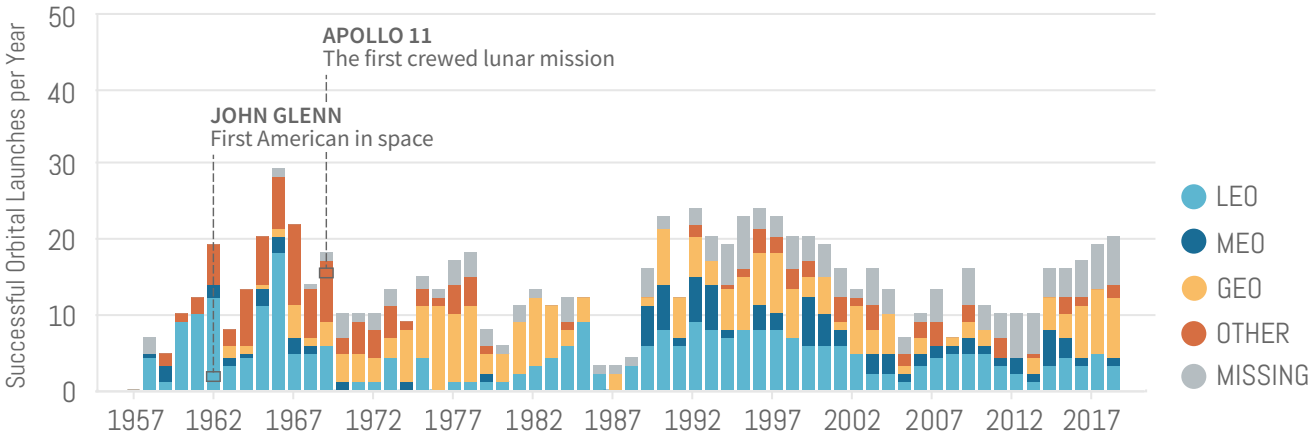


Figure 7: *Successful Orbital Launches from the Cape Canaveral/KSC (1957-2018). Source: Space-Track.org / Gunter's Space Page*

The Vehicle Assembly Building (VAB) at the Kennedy Space Center. *One of the largest buildings in the world by volume, the VAB was designed to assemble the Saturn V rocket in its vertical orientation. Photo: NASA*

since the launch pads at Cape Canaveral would not be able to support a launch system as large as the one required to carry astronauts to the Moon.[63] In a joint study between NASA and the U.S. Department of Defense, several options were considered for a new NASA-operated spaceport, including Hawaii, Texas, California, Georgia, and Merritt Island, Florida (mere miles from the spaceport at Cape Canaveral).[64] Although a previous spaceport selection study at NASA noted the value of low-latitude launch sites, the space agency selected Merritt Island for its closeness to Cape Canaveral's resources in combination with those features that made the region attractive to the Air Force a decade earlier.[65]

After the assassination of President Kennedy, the NASA launch facilities on Merritt Island were renamed the Kennedy Space Center (KSC). Because of their proximity to one another, NASA launches from KSC and Air Force launches from Cape Canaveral are cataloged together. Like the **Vandenberg** spaceport, the launch facilities on the Florida coast also hosts an FAA-licensed commercial launch site known as Cape Canaveral Spaceport and operated by Space Florida.[66]

Due to their location on the Florida coast—with the continental United States to the north and Caribbean island nations to the south—the spaceports in the Eastern Range have primarily supported eastward launches, which typically result in low-inclination, prograde orbits, as well as northeastward launches, which are used for reaching the International Space Station.[67] In 2018, the commander of the 45th Space Wing announced a new opportunity to launch southward from Cape Canaveral by first flying eastward and then turning south, following what has been called the "polar corridor."[68] This flight path from Cape

Canaveral would require more fuel than launching directly southward into a high-inclination orbit—an option available at the spaceports at **Vandenberg Air Force Base** and the **Pacific Spaceport Complex** in Alaska—and has yet to be pursued by any launch provider out of the Cape.[69]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Shuttle	5	3	3	-	-	-	-	-	-	-
Delta II	4	-	1	-	-	-	-	-	-	-
Atlas	4	3	4	5	6	6	8	7	4	4
Delta-4	3	3	2	3	2	4	2	3	1	1
Falcon	-	2	-	2	2	6	6	7	13	14
Peacekeeper	-	-	-	-	-	-	-	-	1	-
Falcon Heavy	-	-	-	-	-	-	-	-	-	1

Table 3: *Launches from Cape Canaveral / KSC by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– VANDENBERG AIR FORCE BASE

LOCATION: 34.6°N, 120.6°W
OPERATOR: U.S. Air Force (United States)
FIRST ORBITAL LAUNCH: February 28, 1959
ORBITAL LAUNCHES FROM 1957 TO 2018: 615

The United States' second most trafficked spaceport, located at Vandenberg Air Force Base (VAFB) in southern California, was first selected for intermediate range and intercontinental ballistic missile testing due to its remote location.[70] Missiles launched westward from VAFB over the Pacific Ocean could safely be tested without flying over nearby inhabited areas up and down the California coast.

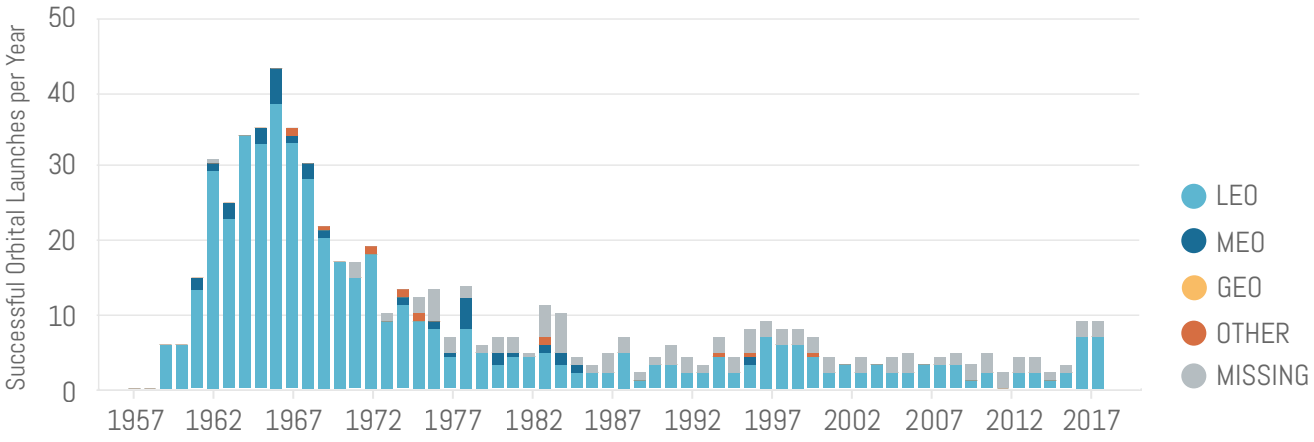


Figure 8: *Successful Orbital Launches from Vandenberg Air Force Base (1957-2018). Source: Space-Track.org / Gunter's Space Page*

After the Soviet space program launched Sputnik from the **Baikonur Cosmodrome** in 1957, VAFB was recognized for its suitability to launch satellites into very high inclinations—a useful orbital regime for imagery satellites—since payloads launched in the southward or south eastward direction could achieve orbital altitude without passing over populated areas in the United States and Mexico.[71]

Although the spaceport at VAFB is deeply rooted in the U.S. military services from its origins as a U.S. Army camp to its operation by the U.S. Air Force 30th Space Wing, it has supported a significant number of commercial space launches since the 1990s.[72] In 1996, the U.S. Federal Aviation Administration issued a site operator license to the Harris Corporation, allowing the company to lease the commercial launch pad facilities at Vandenberg known collectively as the California Spaceport.[73] The vast majority of the Iridium and Iridium NEXT satellites—which make up a polar orbit network of communication satellites—were launched from Vandenberg.[74]

Vandenberg's location in the southwestern corner of the United States severely limits the orbital destination of space launches. While VAFB has launched more polar-orbiting satellites than any other spaceport in the world, orbital destinations with lower inclinations, closer to the spaceport's 34.6° latitude, require orbital maneuvers after launch.[75] Perhaps because other spaceports can launch more directly into lower inclination orbits, two thirds of all VAFB launches have final inclinations of 80° to 100°.[76] Without being able to launch eastward, the spaceport at VAFB also cannot take advantage of the Earth's rotation to efficiently pursue high-energy geosynchronous orbit. According to the CSPoC catalog, VAFB has never launched a satellite to GEO.[77]

In the 1960s, Vandenberg launched almost 30 payloads per year; many more than the mere five launches per year it maintained from 1980 to 2016.[78] Increased commercial launch activity is contributing to a small uptick in total launches over the past two years, with nine successful orbital launches in both 2017 and 2018.[79]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Delta II	4	1	2	-	-	1	1	-	1	1
Atlas	1	1	1	1	2	3	1	1	2	1
Peacekeeper	-	1	1	-	-	-	-	-	1	-
Delta-4	-	-	1	1	1	-	-	1	-	1
Falcon	-	-	-	-	1	-	-	1	5	6

Table 4: *Launches from the Vandenberg Air Force Base by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– GUIANA SPACE CENTRE

LOCATION: 5.2°N, 52.8°W
OPERATOR: European Space Agency / National Centre for Space Studies (Europe / France)
FIRST ORBITAL LAUNCH: March 10, 1970
ORBITAL LAUNCHES FROM 1957 TO 2018: 275

On March 18, 1962, France signed the Évian Accords, granting sovereignty to Algeria and calling for the removal of French military forces from the region. When it became clear that France could no longer access its military-controlled **Hammaguir Test Centre** in Algeria after 1967, the French space agency was burdened with selecting a new spaceport location.[80] Although ballistic missile testing activities could be moved to the Landes Test Center on the western coast of France, where missiles could be launched westward over the Atlantic Ocean, such a location would not be ideal for space launch.[81]

The Ground Facilities Division of the French space agency's Scientific and Technical Directorate studied fourteen new locations for spaceports in the French territories outside of metropolitan France. The new locations were scattered around the globe, including options in Africa (Djibouti, Somalia, and Mauritania), in the Indian Ocean (the Seychelles, Sri Lanka, Madagascar), in the Pacific Ocean (French Polynesia and Northern Australia), the Caribbean (Trinidad and the French West Indies), and South America (Brazil and French Guiana).[82]

On April 14, 1964, the French prime minister announced the selection of French Guiana for its proximity to the equator, openness to the east and north, and sparse population.[83] The region's landscape was also well-situated to remain protected from earthquakes and hurricanes.[84]

Due to its proximity to the equator and its ability to launch due eastward, the Guiana Space Centre is ideally situated to take advantage of the Earth's rotation and launch satellites directly into geosynchronous orbit with minimal inclination change required once on orbit. Over three quarters of all satellites launched from the spaceport have been placed in GEO.[85]

The Guiana Space Centre is the only spaceport in the world to support orbital launch using vehicles from two different national space agencies. The facility has launched Ariane 5 and Vega rockets—the only active European launch vehicles—as well as the Russian Soyuz rocket as of 2011.[86] The spaceport has never launched a human into space.

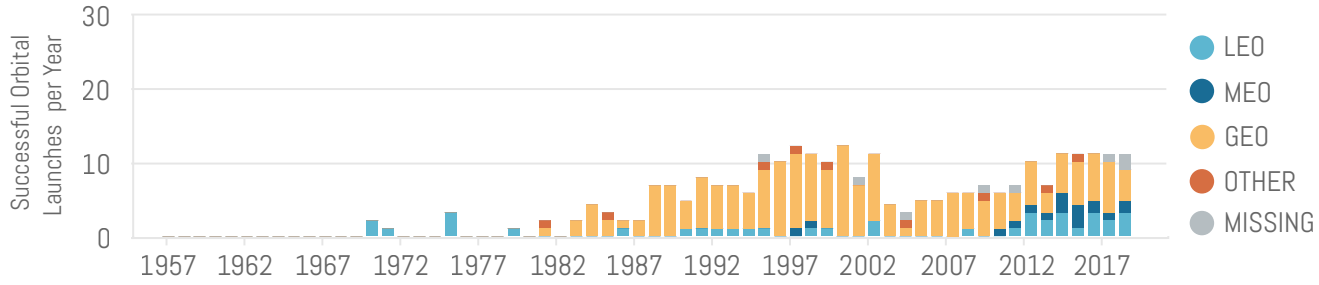


Figure 9: *Successful Orbital Launches from the Guiana Space Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

The Ariane 5 launch pad *at the Guiana Space Centre in French Guiana. Photo: Arianespace*

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ariane 5	7	6	5	7	4	6	6	7	6	6
Soyuz (R-Z)	-	-	2	2	2	4	3	2	2	3
Vega	-	-	-	1	1	1	2	2	3	2

Table 5: *Launches from the Guiana Space Centre by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– XICHANG SATELLITE LAUNCH CENTER

LOCATION: 28.3°N, 102.0°E
OPERATOR: People's Liberation Army (China)
FIRST ORBITAL LAUNCH: January 29, 1984
ORBITAL LAUNCHES FROM 1957 TO 2018: 123

The Xichang Satellite Launch Center (XSLC)—also known as the Xichang Space Center—is China's most-utilized spaceport. Situated in the south-central Sichuan Province, the XSLC was constructed in the 1970s and first used to launch a payload into orbit in January 1984.[87] Prior to the recent construction

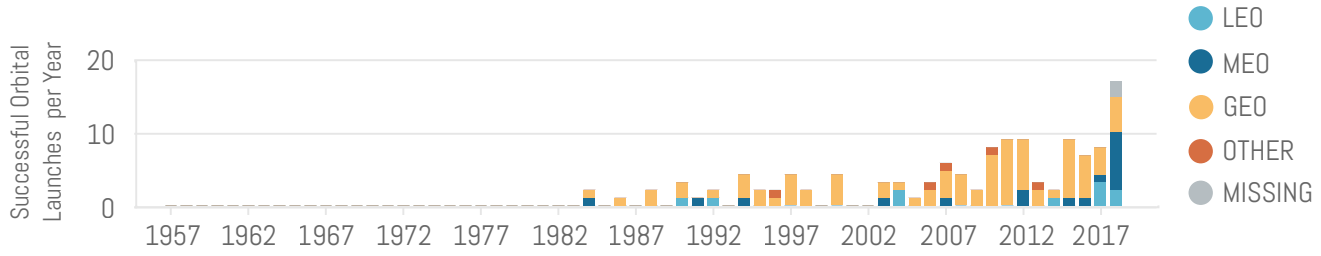


Figure 10: *Successful Orbital Launches from the Xichang Satellite Launch Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

On February 14, 1996, a Long March 3B failed to reach orbit *from the Xichang Satellite Launch Center. The rocket veered off course and crashed into a nearby hillside. Video: China Global Television Network*

of the **Wenchang Satellite Launch Center**, the spaceport at Xichang was the only Chinese spaceport used to launch payloads to GEO.[88]

The spaceport at Xichang is located within a People's Liberation Army (PLA) military base.[89] In addition to supporting orbital space launches, the facility is also used for Chinese missile testing, including the successful direct-ascent anti-satellite weapon test in 2007.[90]

In February 1996, the spaceport at Xichang experienced a catastrophic failure. A Long March 3B rocket that was carrying an American commercial satellite veered off its course after liftoff, traveled parallel to the ground for 22 seconds, and then crashed into a hillside, erupting in toxic flames.[91] Video of the launch taken from a sparsely populated village in the remote Xichang area shows the magnitude of the explosion.[92] While the official Chinese announcement following the disaster claimed only 6 people were killed, first-person western accounts and video footage of the devastation suggest that the death toll may have been much higher.[93]

Xichang's landlocked location and proximity to populated areas is problematic even when its launches are successful. Towns and villages regularly lie within the spaceport's designated drop zones and are often at risk of being struck by a jettisoned rocket body more than five times per year. In early 2018, two launches out of Xichang led to rocket bodies landing in Guizhou province and the Guangxi Zhuang Autonomous Region: one landing just outside of a populated town and the other striking the top of a building.[94] Those living in the area were given prior notice of the launch and the damaged building had been evacuated.[95]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DF-5	2	8	9	9	3	2	9	7	8	17

Table 6: *Launches from the Xichang Satellite Launch Center by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– JIUQUAN SATELLITE LAUNCH CENTER

LOCATION: 41.0°N, 100.3°E
OPERATOR: People's Liberation Army (China)
FIRST ORBITAL LAUNCH: April 24, 1970
ORBITAL LAUNCHES FROM 1957 TO 2018: 106

The Jiuquan Satellite Launch Center (JSLC) in the northern Gansu province of China—also known as the Shuangchengzi Missile Test Center within the U.S. intelligence community—supported China's first orbital launch in April 1970. Located in the Gobi Desert, approximately 200 km (125 miles) from the Mongolian border, JSLC was established in 1958 with support from the Soviet Union.[96]

Although the Jiuquan Satellite Launch Center is one of China's largest space launch facilities, the spaceport was responsible for fewer than three orbital launches per year from its first launch in 1970 to the early 2000s, perhaps due to its principal use as a ballistic missile development and testing center. In April 2000, the China News Service reported that the spaceport at Jiuquan had been selected for the nation's budding human spaceflight program.[97] Three years later, in October 2003, China launched its first taikonaut—a Chinese astronaut—on board a Long March 2F.[98] This achievement made China the third country to launch an astronaut into outer space. The spaceport at Jiuquan is the only Chinese spaceport to launch humans, supporting the Shenzhou program, which has had six crewed missions.[99] In 2011 and 2016, Jiuquan launched Tiangong-1 and Tiangong-2, China's two space stations.[100]

The Shenzhou 9 Crew at the Jiuquan Satellite Launch Center. *Shenzhou 9 was the fourth human space mission supported by the Chinese space agency and the first to dock with the first Chinese space station, Tiangong-1. Photo: STR / AFP / Getty Images*

Operated by the Chinese military, Jiuquan is hidden from public view and accessible only by a single dedicated railway.[101] In 2010, the Chinese government confirmed that JSLC has participated in at least one anti-missile inter-

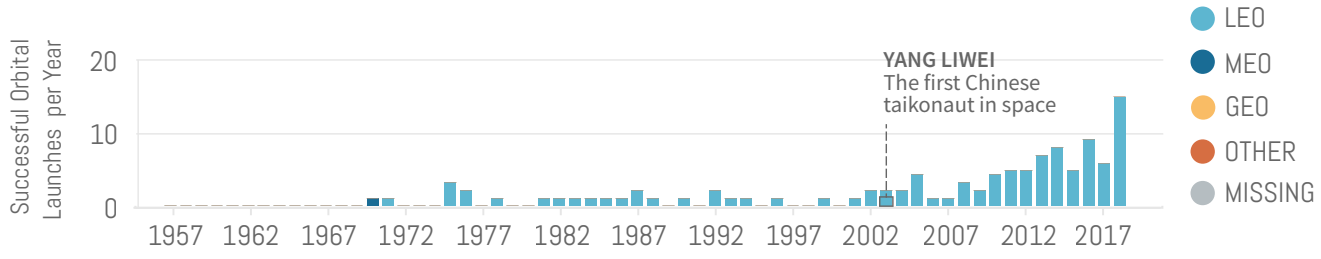


Figure 11: *Successful Orbital Launches from the Jiuquan Satellite Launch Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

ception test, launching the target object for a SC-19 missile—the same weapon system used for a destructive anti-satellite test in 2007 that destroyed a Chinese satellite.[102]

The spaceport at Jiuquan has been used exclusively for satellite launches to low altitudes. No primary payloads launched from JSLC have orbital inclinations lower than the latitude of the spaceport: 41.0°N.[103]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DF-5	2	4	5	5	6	7	4	8	4	11
JL-1	-	-	-	-	1	1	-	-	1	1
JL-2	-	-	-	-	-	-	1	1	1	2
DF-31	-	-	-	-	-	-	-	-	-	1

Table 7: *Launches from the Jiuquan Satellite Launch Center by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– TANEGASHIMA SPACE CENTER

LOCATION: 30.4°N, 131.0°E
OPERATOR: Japan Aerospace Exploration Agency (Japan)
FIRST ORBITAL LAUNCH: September 9, 1975
ORBITAL LAUNCHES FROM 1957 TO 2018: 76

First constructed in 1966, the Tanegashima Space Center (TNSC) is Japan's second spaceport after the **Uchinoura Space Center**.[104] Located on Tanegashima Island in Japan's southernmost Kagoshima Prefecture, TNSC is responsible for all of Japan's heavy-lift space launches, including all those launching to GEO.[105]

The spaceport first achieved an orbital launch in September 1975, with the successful launch of the N-1 rocket on its first attempt.[106] More recently, TNSC has used Japan's H-II launch system to support cargo resupply missions to the International Space Station; one of only five spaceports around the world that has sent a capsule to the station.[107]

Operated by JAXA, the spaceport at Tanegashima has been used to launch primary payloads with a wide variety of orbital regimes, including LEO, GEO, and missions to the Moon.[108]

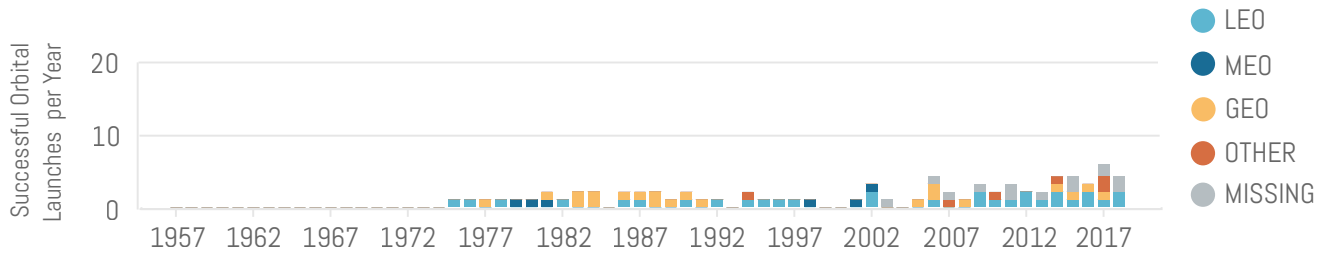


Figure 12: *Successful Orbital Launches from the Tanegashima Space Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

An H-IIA rocket sitting on the launchpad at the Tanegashima Space Center February 27, 2014. *This spaceport is located on the cliffs of Tanegashima island, south of Kyushu. Photo: NASA*

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
H-II	3	2	3	2	2	4	4	3	6	4

Table 8: *Launches from the Tanegashima Space Center by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– TAIYUAN SATELLITE LAUNCH CENTER

LOCATION: 38.9°N, 111.6°E
OPERATOR: People's Liberation Army (China)
FIRST ORBITAL LAUNCH: September 6, 1988
ORBITAL LAUNCHES FROM 1957 TO 2018: 66

The Taiyuan Satellite Launch Center—known as the Wuzhai Missile and Space Center in the U.S. intelligence community—is China's second-oldest spaceport. Established in 1966, the spaceport at Taiyuan first launched a payload into orbit successfully in September 1988.[109]

The Taiyuan Satellite Launch Center is used primarily to place satellites in polar and near-polar orbits.[110] From 1988 to 2018, all primary payloads from the spaceport were placed into LEO with

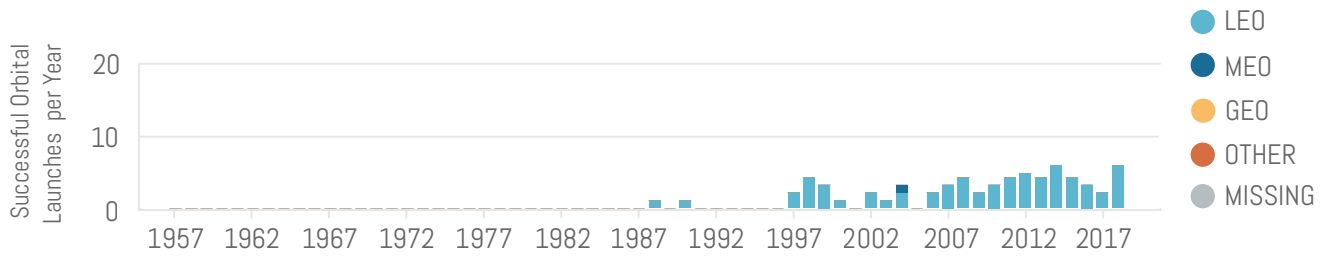


Figure 13: *Successful Orbital Launches from the Taiyuan Satellite Launch Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

inclinations between 86° and 101°.[111] The launch facilities are also used to test intercontinental ballistic missiles and overland submarine-launched ballistic missiles.[112]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DF-5	2	3	4	5	4	6	4	3	1	6
JL-2	-	-	-	-	-	-	-	-	1	-

Table 9: *Launches from the Taiyuan Satellite Launch Center by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– SATISH DHAWAN SPACE CENTRE

LOCATION: 13.7°N, 80.2°E
OPERATOR: Indian Space Research Organisation (India)
FIRST ORBITAL LAUNCH: July 18, 1980
ORBITAL LAUNCHES FROM 1957 TO 2018: 61

The Satish Dhawan Space Centre—also known as the Sriharikota Range—is India's only orbital launch facility.[113] Located on the country's eastern coast, about 70 km (43 miles) north of Chennai, the spaceport at Sriharikota supports the Indian Space Research Organisation's (ISRO) steadily increasing number of Polar Satellite Launch Vehicle (PSLV) and Geosynchronous Satellite Launch Vehicle (GSLV) launches.

Operated by ISRO, the Satish Dhawan Space Centre was first used for sub-orbital flight tests in the early 1970s.[114] In July 1980, the site supported India's first successful orbital space launch on the Satellite Launch Vehicle's (SLV) second launch attempt.[115] India's second native space launch vehicle, the more powerful Augmented Satellite Launch Vehicle (ASLV), was less successful. Two failures in 1987 and 1988—including a catastrophic nose-dive into the Bay of Bengal less than three minutes into the first launch attempt—led to a four year pause in Indian space launch until 1992.[116]

Over the past 10 years, the spaceport at Sriharikota has supported heavier-lift PSLV and GSLV launches at an average rate of three launches per year.[117] In 2017, the spaceport was used to break the record

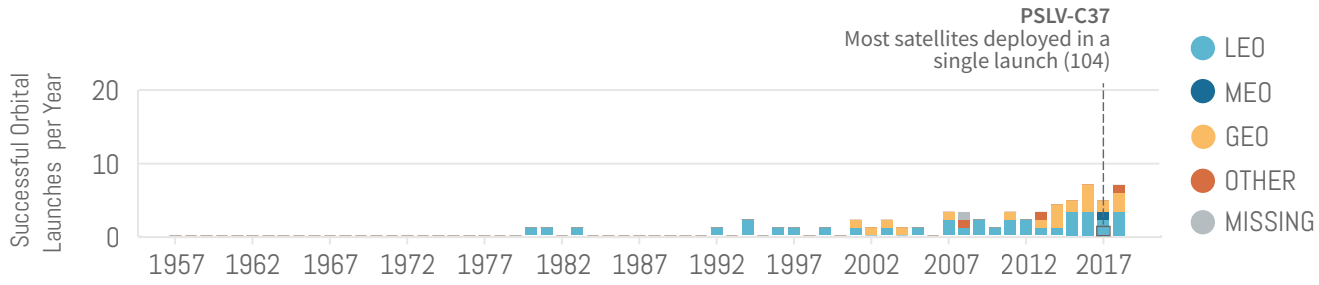


Figure 14: *Successful Orbital Launches from the Satish Dhawan Space Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

A crowd gathered to watch a PSLV launch on February 15, 2017. *This particular launch broke the world record for the most satellites launched using a single vehicle. Photo: ARUN SANKAR / AFP / Getty Images*

for the greatest number of payloads orbited via a singular space launch, launching 104 satellites using the PSLV.[118] In 2018, the Indian government announced the Indian Human Space Flight Initiative, which plans to make the Satish Dhawan Space Centre the world's fourth spaceport to support human space launch by 2022.[119]

The Satish Dhawan Space Centre has been used to launch objects to all major orbital regimes, including LEO, MEO, GEO, and orbits around the Moon and Mars.

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PSLV	2	1	3	2	3	3	4	6	3	4
GSLV	-	-	-	-	-	1	1	1	2	3

Table 10: *Launches from the Satish Dhawan Space Centre by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– WALLOPS FLIGHT FACILITY

LOCATION: 37.9°N, 75.5°W
OPERATOR: NASA / Virginia Space (United States)
FIRST ORBITAL LAUNCH: February 16, 1961
ORBITAL LAUNCHES FROM 1957 TO 2018: 34

The Wallops Flight Facility on Wallops Island, Virginia—which now features the FAA-licensed Mid-Atlantic Regional Spaceport (MARS)—was founded in 1945 and is the longest-running operational rocket launch range in the United States.[120] The space launch facility is operated by the United States' Virginia Commercial Space Flight Authority, or "Virginia Space."[121]

After almost two decades of sub-orbital rocket testing, the spaceport on Wallops Island supported its first orbital launch in February 1961 using a solid-fueled Scout rocket. Since then, the facility has been used for over 30 space launches, including the first U.S. lunar probe to be launched from outside of **Cape Canaveral**.[122]

The spaceport at Wallops Flight Facility on October 17, 2016, *featuring an Antares rocket in preparation for a cargo resupply mission to the International Space Station. Photo: Bill Ingalls / NASA*

At a higher latitude than Cape Canaveral or **Vandenberg**, the Wallops Flight Facility is ideal for launching payloads directly to the International Space Station. In October 2014, an Orbital ATK Antares rocket en route to the International Space Station exploded on the launch pad a few seconds after launch. The failure caused over $15 million in damage to one of the island's two launch pads, making the spaceport inactive for one year.[123]

In 2018, the Wallops spaceport was selected by commercial space company Rocket Lab—the site operator for the **Rocket Lab Launch Complex** in New Zealand—to host the company's second launch pad.[124] Rocket Lab is planning its first launch from the new pad for summer or fall 2019.

No primary payloads from Wallops have been placed in GEO or at inclinations higher than 70°.[125]

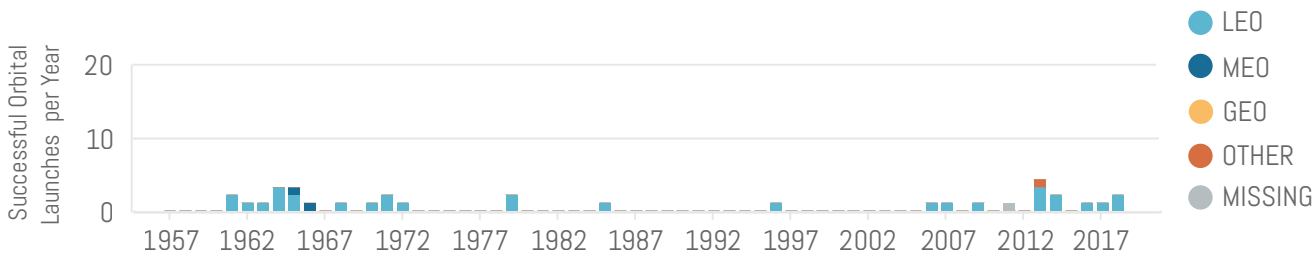


Figure 15: *Successful Orbital Launches from the Wallops Flight Facility (1957-2018). Source: Space-Track.org / Gunter's Space Page*

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Peacekeeper	1	-	1	-	2	-	-	-	-	-
Antares	-	-	-	-	2	2	-	1	1	2

Table 11: *Launches from the Wallops Flight Facility by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– UCHINOURA SPACE CENTER

LOCATION: 31.3°N, 131.1°E
OPERATOR: Japan Aerospace Exploration Agency (Japan)
FIRST ORBITAL LAUNCH: February 11, 1970
ORBITAL LAUNCHES FROM 1957 TO 2018: 31

A test of the SS-520 rocket from the Uchinoura Space Center. *The SS-520, a small sounding rocket, is the smallest launch vehicle to every carry an object to orbit. Photo: JAXA*

The Uchinoura Space Center (USC)—formerly known as Kagoshima Space Center at the University of Tokyo—is one of Japan's two spaceports. After four consecutive rocket failures, Uchinoura successfully launched its first orbital payload in February 1970.[126]

Located in the southern Kagoshima region, the Uchinoura Space Center is operated by the Institute of Space and Astronautical Science, JAXA's space science research center.[127] The spaceport at Uchinoura is less-utilized than Japan's **Tanegashima Space Center**, located 70 miles south of USC, with no more than two successful orbital launches per year since its founding. Both spaceports are ideally situated for polar or 30°-inclined orbits with open ocean to the east and south.

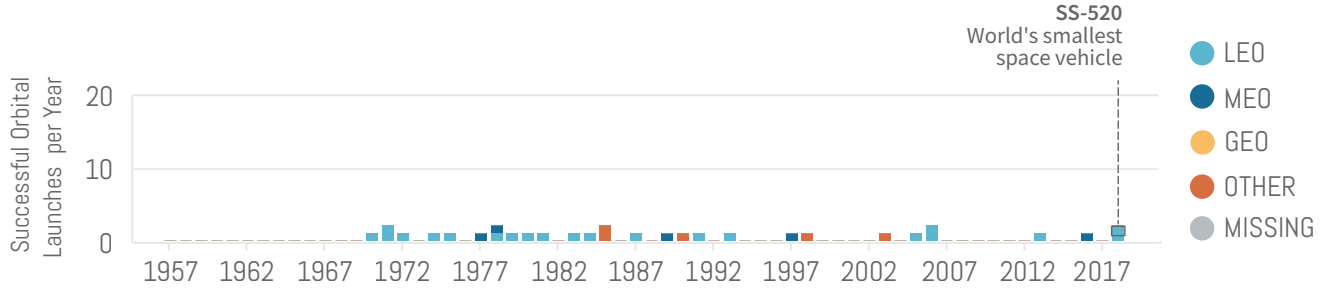


Figure 16: *Successful Orbital Launches from the Uchinoura Space Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

In 2018, the Uchinoura Space Center was used to support a satellite launch using a modified SS-520 sounding rocket, the smallest vehicle to ever place an object into orbit.[128]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
SRB-A	-	-	-	-	1	-	-	1	-	1
SS-520	-	-	-	-	-	-	-	-	-	1

Table 12: *Launches from the Uchinoura Space Center by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– YASNY LAUNCH BASE

LOCATION: 51.1°N, 59.8°E
OPERATOR: Russian Aerospace Forces (Russia)
FIRST ORBITAL LAUNCH: August 12, 2006
ORBITAL LAUNCHES FROM 1957 TO 2018: 10

Yasny Launch Base—located on the Dombarovsky Air Base—is a Russian spaceport in the southern Orenburg Oblast, about 40 km (25 miles) north of the country's border with Kazakhstan. The spaceport was upgraded in the 2000s to support launches using the Dnepr launch vehicle.[129] Since its first orbital launch in 2006, Yasny has been used exclusively for placing satellites in low Earth orbit.[130]

A majority of launches from Yasny Launch Base are destined for polar orbits, requiring a launch in the northern or southern direction. Notably, launches using the Dnepr in the southern direction result in the first stage dropping in Turkmenistan and the second stage in the Indian Ocean.[131]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
R-36M	-	1	1	-	2	2	1	-	-	-

Table 13: *Launches from the Yasny Launch Base by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

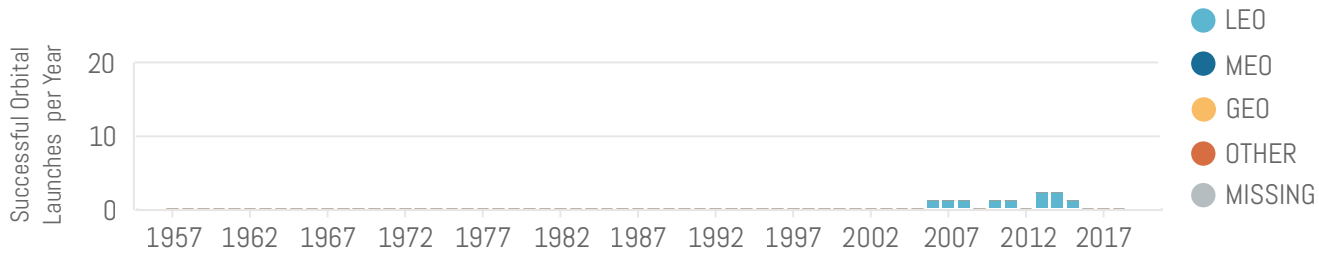


Figure 17: *Successful Orbital Launches from the Yasny Launch Base (1957-2018). Source: Space-Track.org / Gunter's Space Page*

– PALMACHIM AIRBASE

LOCATION: 31.9°N, 34.7°E
OPERATOR: Israeli Air Force / Israel Space Agency (Israel)
FIRST ORBITAL LAUNCH: September 19, 1988
ORBITAL LAUNCHES FROM 1957 TO 2018: 8

The Palmachim Airbase—also known as the Yavne Launch Facility due to its close proximity to the town of Yavne—is Israel's only spaceport.[132] Operated by the Israeli Air Force, the Israeli spaceport supported its first orbital space launch in September 1988.[133]

Due to the small size of the country, the Israeli spaceport is closer to metropolitan areas than most space launch facilities worldwide.[134] Space-bound Shavit rockets from the Palmachim Airbase are launched westward, making it the only spaceport in the world that exclusively supports retrograde orbits.[135] Westward launches also allow the Israeli Defense Forces to avoid flying over neighboring countries to Israel's east.[136] Due to the launch limitations at Palmachim, Israel has pursued prograde orbits for its satellites by placing payloads on Russian, Chinese, Indian, and European launch systems.[137]

Most of the orbital elements for Israeli satellites that were launched from the Palmachim Airbase are missing from the CSpOC catalog.

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Jericho-2	-	1	-	-	-	1	-	1	-	-

Table 14: *Launches from the Palmachim Airbase by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

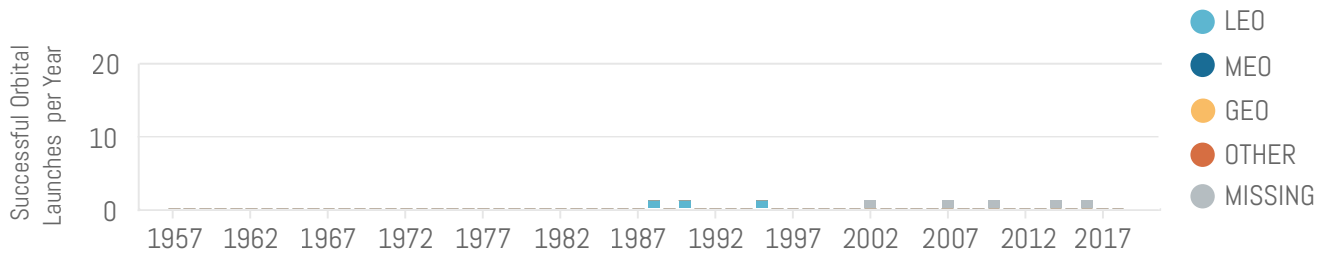


Figure 18: *Successful Orbital Launches from the Palmachim Airbase (1957-2018). Source: Space-Track.org / Gunter's Space Page*

– IMAM KHOMEINI SPACE CENTER

LOCATION: 35.2°N, 54.0°E
OPERATOR: Iranian Space Agency (Iran)
FIRST ORBITAL LAUNCH: February 2, 2009
ORBITAL LAUNCHES FROM 1957 TO 2018: 4

The Imam Khomeini Space Center—formerly known as the Semnan Spaceport—is Iran's only orbital space launch facility.[138] The spaceport began construction in 2003, a year before the Iranian Space Agency was founded.[139]

In February 2009, the spaceport was used for Iran's first successful orbital launch—the Iranian Space Agency's second attempt using the Safir space launch vehicle.[140] The Safir launch system used the Nodong engine, technology originally transferred from North Korea to Iran as part of the substantial history of missile cooperation between the two countries in the 1980s and 1990s.[141] Since then, the Imam Komeini Space Center has supported three more successful orbital launches in 2011, 2012, and 2015.[142] All four successful orbital launches from the Imam Khomeini Space Center have been to low Earth orbit at approximately the same inclination: between 55° and 56°.

The Safir's follow-on launch system, the Simorgh, has yet to have a successful orbital launch.[143] Most recently, the Simorgh failed to reach orbit on a launch attempt on January 15, 2019.[144]

On February 5, 2019, the Iranian Space Agency appeared to attempt another orbital launch using a variant of the original Safir vehicle.[145] Although satellite imagery suggests that the rocket did indeed leave the launch pad, the vehicle did not reach orbit.[146]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Nodong	1	-	1	1	-	-	1	-	-	-

Table 15: *Launches from the Imam Khomeini Space Center by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

Figure 19: *Successful Orbital Launches from the Imam Khomeini Space Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

– VOSTOCHNY COSMODROME

LOCATION: 51.9°N, 128.3°E
OPERATOR: Roscosmos (Russia)
FIRST ORBITAL LAUNCH: April 28, 2016
ORBITAL LAUNCHES FROM 1957 TO 2018: 3

The Vostochny Cosmodrome, built in close proximity to the **Svbodny Cosmodrome**, is Russia's newest spaceport. The Russian space agency announced its decision to build the new spaceport in 2007, the same year the Svobodny Cosmodrome saw its final launch.

The decision to rebuild the Svobodny Cosmodrome may be tied to the development of a new human-rated launch vehicle to replace the aging Soyuz rocket.[147] Currently, due to the emergency escape requirements of the Soyuz (which rely on vast stretches of uninhabited land to the east of the spaceport to recover parachuted cosmonauts) and the dense forest to Vostochny's east, no crewed missions will launch from the spaceport until a new vehicle is developed.[148]

A Russian Soyuz 2.1a rocket carrying Lomonosov, Aist-2D and SamSat-218 satellites lifts off from the launch pad at the new Vostochny cosmodrome outside the city of Uglegorsk, *about 200 kms from the city of Blagoveshchensk in the far eastern Amur region on April 28, 2016. . Photo: Kirill Kudryavtsev / AFP/ Getty Images*

In April 2016, the Vostochny Cosmodrome supported its first successful orbital launch.[149] Thus far, the spaceport has only supported launches to LEO using variants of the Soyuz launch vehicle. Reports suggest that Vostochny will host at least one Rokot launch before that vehicle retires after 2019.[150]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Soyuz (R-Z)	-	-	-	-	-	-	-	1	-	2

Table 16: *Launches from the Vostochny Cosmodrome by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

Figure 20: *Successful Orbital Launches from the Vostochny Cosmodrome (1957-2018). Source: Space-Track.org / Gunter's Space Page*

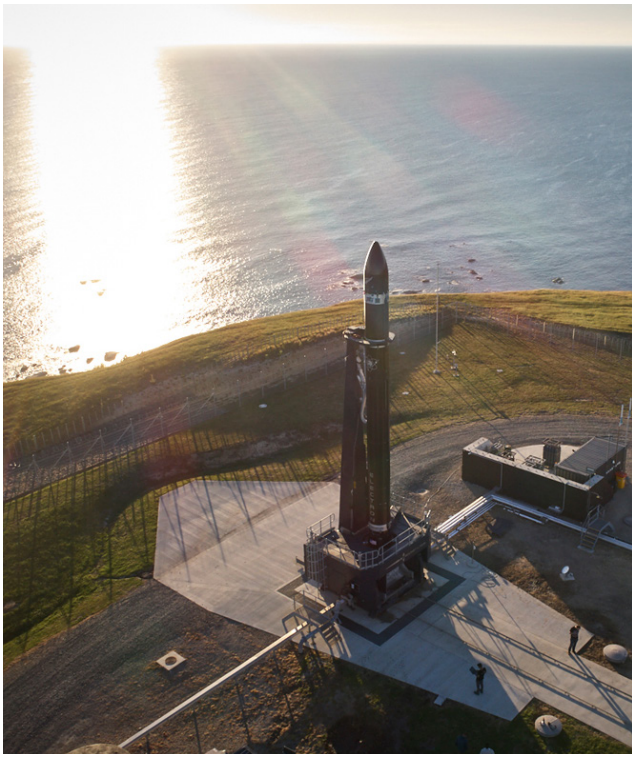
– ROCKET LAB LAUNCH COMPLEX

LOCATION: 39.3°S, 177.9°E
OPERATOR: Rocket Lab (United States / New Zealand)
FIRST ORBITAL LAUNCH: January 21, 2018
ORBITAL LAUNCHES FROM 1957 TO 2018: 3

The Rocket Lab Launch Complex on New Zealand's North Island is the world's newest active spaceport. Constructed over nine months in 2016, the spaceport—also known as Launch Complex 1—is operated by Rocket Lab, an American aerospace company.[151]

The New Zealand spaceport only supports orbital launches of Rocket Lab's Electron rocket. In a 2015 statement, the company's CEO Peter Beck claimed that the facility was built to accommodate the launch frequency Rocket Labs plans to achieve.[152] According to the company's website, Launch Complex 1 could support up to 120 flights per year, which is six times the current launch rate of **Baikonur** and **Cape Canaveral**.[153]

The spaceport's first orbital launch attempt in May 2017—called "It's a Test"—was unsuccessful. In January 2018, an Electron rocket—named "Still Testing"—successfully achieved orbit.[154]



Rocket Lab's Electron rocket at the Rocket Lab Launch Complex in Mahia, New Zealand. *The Rocket Lab Launch Complex is the world's southernmost spaceport. Photo: Rocket Lab*

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Electron	-	-	-	-	-	-	-	-	-	3

Table 17: *Launches from the Rocket Lab Launch Complex by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

Figure 21: *Successful Orbital Launches from the Rocket Lab Launch Complex (1957-2018). Source: Space-Track.org / Gunter's Space Page*

– PACIFIC SPACEPORT COMPLEX - ALASKA

LOCATION: 57.4°N, 152.3°W
OPERATOR: Alaska Aerospace Corporation (United States)
FIRST ORBITAL LAUNCH: November 20, 2010
ORBITAL LAUNCHES FROM 1957 TO 2018: 2

Constructed in January 1998, the Pacific Spaceport Complex in Alaska (PSCA)—formerly known as the Kodiak Launch Complex—was the United States' first FAA-licensed commercial spaceport to be built outside of a federal test range.[155] Operated by the Alaska Aerospace Development Corporation, a public corporation created by the state government in 1991, the Pacific Spaceport Complex has completed just two orbital launches (one in 2010 and one in 2011).[156]

The commercial launch pad at PSCA is suitable for launching small solid-propellant rockets, including those derived from intercontinental ballistic missiles.[157] Situated at 57° north of the equator on Kodiak Island in the Gulf of Alaska, the facility is the United States' northernmost spaceport. While such a location is not ideal for launches to low inclinations or high altitudes, open waters to the south and southeast allow the spaceport to efficiently launch payloads to polar and sun-synchronous orbits.[158]

In 2014, a failed missile test resulted in significant damage to the spaceport's launch facilities, delaying all launches for two years.[159] Although no orbital space launches have been recorded since the 2014 failure, reports suggest that several commercial space companies are considering the spaceport on Kodiak Island for launches in 2018 and 2019.[160]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Peacekeeper	-	1	1	-	-	-	-	-	-	-

Table 18: *Launches from the Pacific Spaceport Complex by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

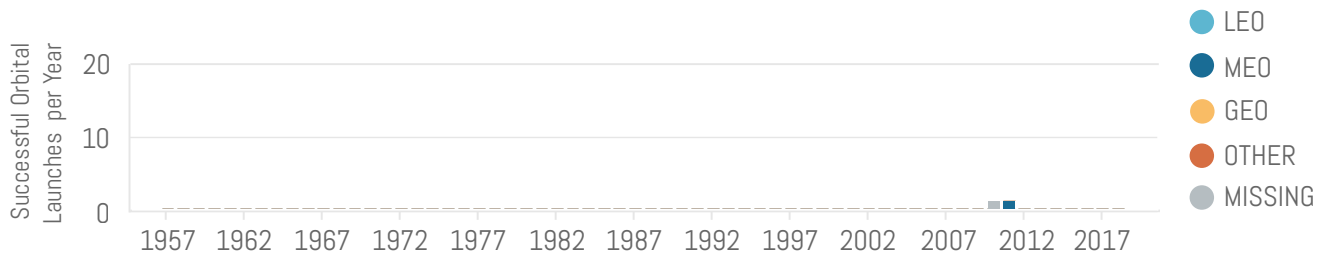


Figure 22: *Successful Orbital Launches from the Pacific Spaceport Complex (1957-2018). Source: Space-Track.org / Gunter's Space Page*

– SOHAE SATELLITE LAUNCHING STATION

LOCATION: 39.7°N, 124.7°E
OPERATOR: North Korea
FIRST ORBITAL LAUNCH: December 12, 2012
ORBITAL LAUNCHES FROM 1957 TO 2018: 2

The Sohae Satellite Launching Station—also known as Tongch'ang-dong Space Launch Center, Tongchang-ri, and Pongdong-ri—is a spaceport on the western coast of North Korea. First constructed in 2001, Sohae is the only spaceport in North Korea to have achieved orbital launch.[161]

After a failed attempt to launch a payload to orbit in April 2012, the Sohae Satellite Launching Station successfully launched its first satellite in December 2012.[162] A third attempt in February 2016 placed North Korea's second satellite into orbit.

Unlike the Tonghae Satellite Launching Ground—another North Korean launch facility known for at least two failed orbital launch attempts—the spaceport at Sohae is well-positioned to launch its rockets southward, largely avoiding Japan and South Korea during its earliest flight stages.[163] Both payloads launched from Sohae are in polar, low Earth orbit.[164]

Satellite imagery of the Sohae Satellite Launching Station, January 20, 2019. *Although disassembly appeared to be underway in July 2018, the vertical engine test stand (right) appears to have been untouched since August 2018. Photos: Airbus/CSIS Beyond Parallel*

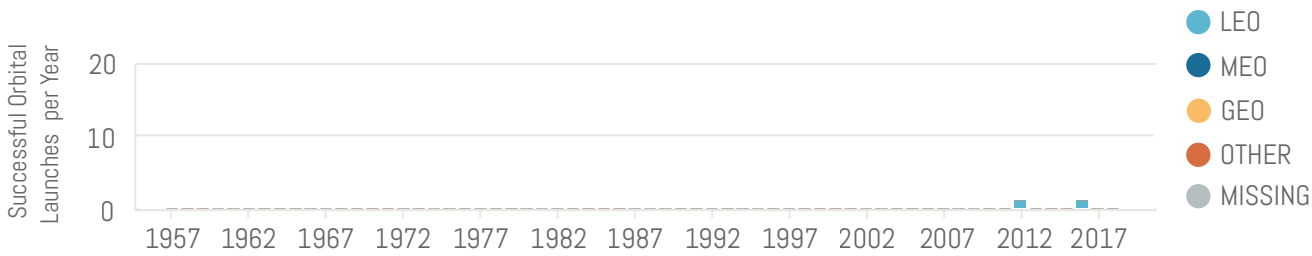


Figure 23: *Successful Orbital Launches from the Sohae Satellite Launching Station (1957-2018). Source: Space-Track.org / Gunter's Space Page*

Commercial satellite images of the spaceport at Sohae from March 2018 suggest a decrease in testing activities at the facility.[165] Although newer satellite images from July 2018 indicated that Sohae was being disassembled at that time—presumably as part of North Korea's commitment to the United States to dismantle its rocket launching facilities—a January 2019 report from CSIS Beyond Parallel stated that "no new dismantling activity has occurred at the vertical engine test stand or rail-mounted processing building since August 2018."[166]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Unha	-	-	-	1	-	-	-	1	-	-

Table 19: *Launches from the Sohae Satellite Launching Station by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– WENCHANG SATELLITE LAUNCH CENTER

LOCATION: 19.6°N, 111.0°E
OPERATOR: People's Liberation Army (China)
FIRST ORBITAL LAUNCH: November 3, 2016
ORBITAL LAUNCHES FROM 1957 TO 2018: 2

The Wenchang Satellite Launch Center (WSLC) on Hainan Island is China's newest spaceport. Located in the country's southernmost province, the spaceport at Wenchang is the only Chinese spaceport capable of supporting the Long March 5, the country's largest and most powerful launch system.[167]

The Wenchang Satellite Launch Center is China's most accessible spaceport. The country's three other spaceports were built decades earlier on mainland China and depend on railroads for transporting rockets from the country's industrial base. Long March 5 rockets are too large to fit through traditional railway tunnels, so they must travel by sea to Wenchang using specialized cargo ships.[168] Unlike the older spaceports, China's newest spaceport is also accessible to tourists who are traveling by car from nearby cities.[169]

In November 2016, the spaceport supported its first successful orbital launch, marking the first flight of the Long March 5.[170] As China's southernmost spaceport, located at 19.6° north of the equa-

Figure 24: *Successful Orbital Launches from the Wenchang Satellite Launch Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

The first flight of the Long March 5 launch vehicle. *Due to the rocket's size, the Wenchang Satellite Launch Center is the only Chinese spaceport that can support its launches. Photo: Stringer / AFP / Getty Images.*

tor, the Wenchang Satellite Launch Center is best positioned among the country's four spaceports for launching payloads to GEO.[171]

Although the first two Chinese space stations launched from the **Juiquan Satellite Launch Center**, the Chinese space agency plans to launch modules for the follow-on space station from Wenchang.[172]

In July 2017, on the Long March 5's second launch, a malfunction occurred before the payload reached orbit.[173] Future launches at Wenchang have been postponed, with a return-to-flight mission planned for 2019.[174]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
JL-2	-	-	-	-	-	-	-	2	1	-

Table 20: *Launches from the Wenchang Satellite Launch Center by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– RONALD REAGAN BALLISTIC MISSILE DEFENSE TEST SITE

LOCATION: 9.1°N, 167.7°E
OPERATOR: U.S. Army (United States)
FIRST ORBITAL LAUNCH: September 29, 2008
ORBITAL LAUNCHES FROM 1957 TO 2018: 2

The Ronald Reagan Ballistic Missile Defense (BMD) Test Site—also known as the Kwajalein Missile Range—is a U.S. Army-operated spaceport on the Kwajalein Atoll in the Marshall Islands.[175] With

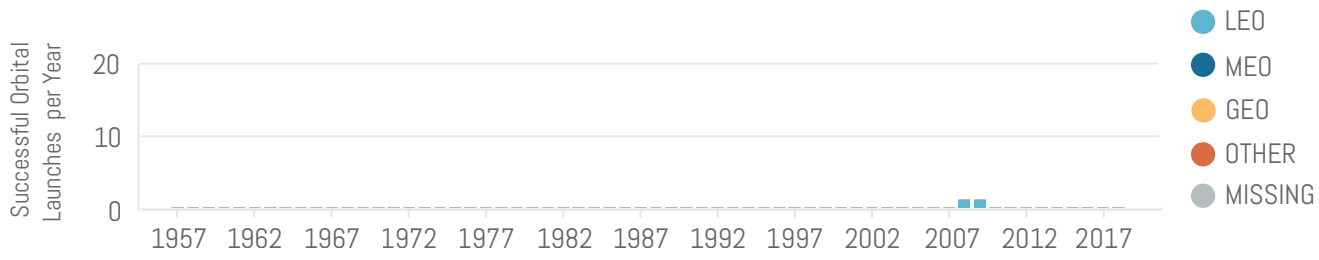


Figure 25: *Successful Orbital Launches from the Ronald Reagan BMD Test Site (1957-2018). Source: Space-Track.org / Gunter's Space Page*

The second successful orbital launch of the Falcon 1 from the Ronald Reagan BMD Test Site. *Photo: SpaceX*

only 1,400 residents on the isolated island, the test site at Kwajalein is extremely remote.[176] Located just 9° north of the equator, this spaceport is further south than any other U.S.-operated space launch facility.[177]

The spaceport's two ground-based orbital launches were both destined for equatorial low Earth orbit. Additionally, the launch facilities at Kwajalein supported two successful air-launches to LEO in 2000 and 2012.[178]

After three failed attempts at Kwajalein, the Falcon 1—built by the Space Exploration Technologies Corporation (SpaceX)—successfully reached low Earth orbit, marking the first time a commercial company used a liquid-fueled rocket to bring a satellite to orbit.[179]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Falcon	1	-	-	-	-	-	-	-	-	-

Table 21: *Launches from the Ronald Reagan BMD Test Site by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

– NARO SPACE CENTER

LOCATION: 34.4°N, 127.5°E
OPERATOR: Korea Aerospace Research Institute (South Korea)
FIRST ORBITAL LAUNCH: January 30, 2013
ORBITAL LAUNCHES FROM 1957 TO 2018: 1

The Naro Space Center in South Jeolla Province, South Korea—the country's only spaceport—was established in June 2009.[180]

After pursuing financial support from Ukraine and the United States with no success, the Korea Aerospace Research Institute (KARI) partnered with Russia's Khrunichev State Research and Production Space Center in 2004 for both the use of a Russian rocket engine and the establishment of a Korean spaceport.[181]

After two unsuccessful attempts in 2009 and 2010, the Naro Space Center became an active spaceport on January 30, 2013, with the launch of the nation's Naro-1 launch vehicle, a Korean rocket built using a Russian first stage.[182] Although the development of native launch technologies was once a cornerstone of the Korean administration, KARI has not received the government funds it would need to meet its stated mission goals, which included lunar missions by 2020.[183]

VEHICLE FAMILY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Naro	-	-	-	-	1	-	-	-	-	-

Table 22: *Launches from the Naro Space Center by Vehicle Family (2009-2018). Source: Space-Track.org / planet4589.org*

Figure 26: *Successful Orbital Launches from the Naro Space Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

INACTIVE SPACEPORTS

THERE ARE FIVE SPACEPORTS AROUND THE WORLD that have previously supported orbital launch but have not done so for at least 10 years. These spaceports are located in Russia, Kenya, Algeria, and Australia. Spaceports in this chapter are listed in descending order from the most orbital launches to the least.

– KAPUSTIN YAR COSMODROME

LOCATION: 48.6°N, 45.7°E
OPERATOR: Russian Aerospace Forces (Russia)
FIRST ORBITAL LAUNCH: March 16, 1962
ORBITAL LAUNCHES FROM 1957 TO 2018: 84

The Kapustin Yar Cosmodrome—one of three Soviet spaceports in operation before the country's collapse—is located in the southwestern Astrakhan Oblast, about 50 km (30 miles) from the Kazakh border. [184] With 82 total launches during the Soviet-era, Kapustin Yar's utilization rate paled in comparison to both the **Plesetsk Cosmodrome** to the north and the **Baikonur Cosmodrome** to the east.[185]

Before the spaceport's first launch in March 1962, Kapustin Yar was the Soviet Union's first missile test range.[186] Its selection—by the request of the chief designer of the Soviet space program—appears to be more conducive to missile tests than space launches. Secluded from high-density populations, but still accessible to the Soviet industrial base in Volgograd via discrete railway, Kapustin Yar was selected in 1947 to develop and test the earliest Soviet-built rocket systems.[187]

All of Kapustin Yar's orbital launches have been to low Earth orbit at inclinations near the spaceport's latitude on Earth. Due to Kapustin Yar's proximity to Kazakhstan, the Kazakh government must approve all eastward launches from the spaceport.[188] Kapustin Yar has supported just two orbital space launches since 1988 and none since 2008.

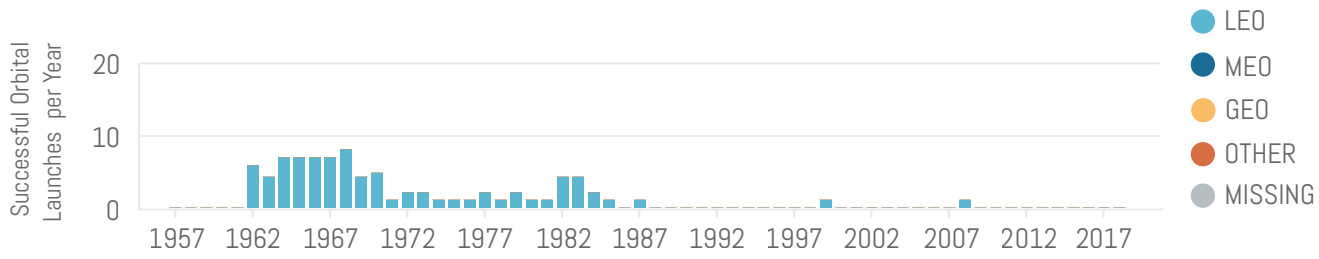


Figure 27: *Successful Orbital Launches from the Kapustin Yar Cosmodrome (1957-2018). Source: Space-Track.org / Gunter's Space Page*

– LUIGI BROGLIO SPACE CENTRE

LOCATION: 2.9°S, 40.2°E
OPERATOR: NASA / Sapienza University Rome (United States / Italy)
FIRST ORBITAL LAUNCH: April 26, 1967
ORBITAL LAUNCHES FROM 1957 TO 2018: 9

The Luigi Broglio Space Center—also known as the San Marco Equatorial Mobile Range—is an inactive, American-Italian spaceport in the Formosa Bay off the coast of Kenya. Through a 1962 agreement between NASA and the Aerospace Research Centre at the Sapienza University of Rome,

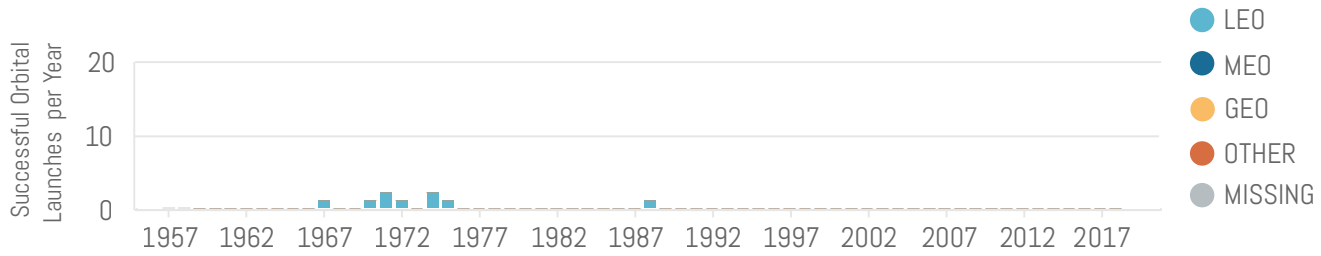


Figure 28: *Successful Orbital Launches from the Luigi Broglio Space Centre (1957-2018). Source: Space-Track.org / Gunter's Space Page*

the spaceport was used to launch American-made, solid-fueled Scout launch vehicles from 1967 to 1988.[189]

Because of the spaceport's mission to launch satellites into low Earth, equatorial orbits, Italy's Space Commission chose Broglio Space Center's location primarily for its latitude, just 2.9° south of the equator, and its openness to the east. The Space Commission elected to use a platform off the African continent due to the political instability of the equatorial regions of east Africa and east South America at the time.[190]

Although the Broglio Space Centre is located in Kenya's exclusive economic zone, the facility was managed by NASA and the Aerospace Research Centre from its establishment in the early 1960s until 2003. Since then, the Italian Space Agency has managed both the now-inactive launch platform and other supporting infrastructure both at sea and on the Kenyan mainland.[191]

A solid-fueled Scout rocket on the San Marco launch platform at the Broglio Space Centre in October 1974. *Photo: NASA*

– SVOBODNY COSMODROME

LOCATION: 51.7°N, 128.0°E
OPERATOR: Russian Aerospace Forces (Russia)
FIRST ORBITAL LAUNCH: March 4, 1997
ORBITAL LAUNCHES FROM 1957 TO 2018: 5

The Svobodny Cosmodrome is an inactive Russian spaceport located in the country's Amur oblast, about 84 km (52 miles) from the Chinese border.

After the fall of the Soviet Union, the Russian Space Forces directed the Russian Military of Defense to build a new spaceport at a latitude comparable to **Baikonur**, but at a more secluded location within Russia's new borders.[192] In 1996, Russian authorities selected an active strategic military missile site in the far east, likely for its accessibility by rail, seclusion, pre-existing rocket launch infrastructure, and the strong technical workforce already in place.[193]

A town was built near the launch facilities to accommodate the influx of skilled workers required to build and maintain the new Svobodny Cosmodrome (named after the local district).[194] To not attract attention to the spaceport, the town was misleadingly named "Oglegorsk," meaning “coal town.”[195] No coal was produced in the construction of the spaceport.

The spaceport was shuttered due to lack of funds in 2007 after just five successful orbital launches since its inaugural launch in 1997.[196] That same year—in what appears to be an effective reversal of the earlier decision—the region was selected to build the **Vostochny Cosmodrome**, a newer, larger facility that could support more frequent launches.[197]

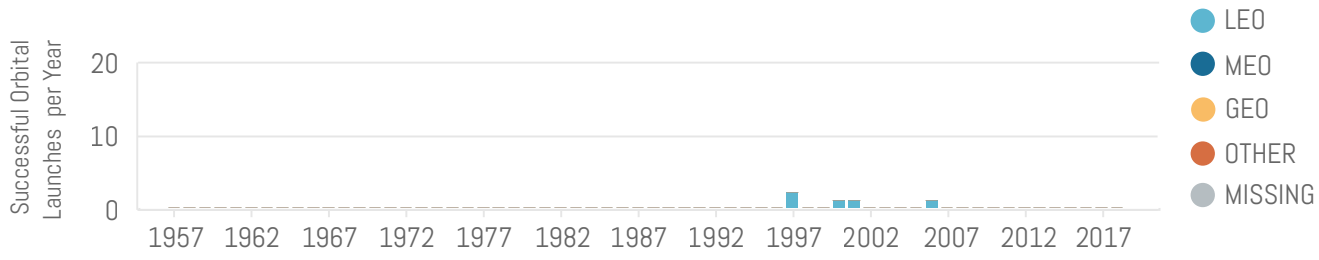


Figure 29: *Successful Orbital Launches from the Svobodny Cosmodrome (1957-2018). Source: Space-Track.org / Gunter’s Space Page*

– HAMMAGUIR TEST CENTRE

LOCATION: 31.1°N, 2.8°W
OPERATOR: Interarmy Special Weapons Test Centre (France)
FIRST ORBITAL LAUNCH: November 26, 1965
ORBITAL LAUNCHES FROM 1957 TO 2018: 4

The Hammaguir Test Centre was a French launch facility in western Algeria, near the disputed border with Morocco, operated by the French Interarmy Special Weapons Test Center (CIEES) from 1952 to 1967.[198] On November 26, 1965, the spaceport launched Asterix, the first French satellite, marking the first successful orbital launch from outside the Soviet Union or the United States.[199]

The first launch from the Hammaguir Test Centre on November 26, 1965. *This launch, the inaugural orbital flight for the Asterix vehicle, marked the first time an object had reached orbit from outside of the Soviet Union and the United States. Photo: CNES*

The spaceport at Hammaguir launched only four satellites into orbit during a brief period between 1965 and 1967.[200] In each case, the satellites were placed in low-altitude orbits at inclinations similar to the latitude of the spaceport itself: 31.1°. These orbital regimes are accessible without any orbital maneuvers.

The facility was abandoned on July 1, 1967, in accordance with the Évian Accords, granting sovereignty to Algeria and the removal of French military forces from the region, including Hammaguir.[201] Although NASA announced plans in 1963 for U.S. payloads to be launched from the Hammaguir spaceport, no launches have occurred since last French launch in 1967.[202]

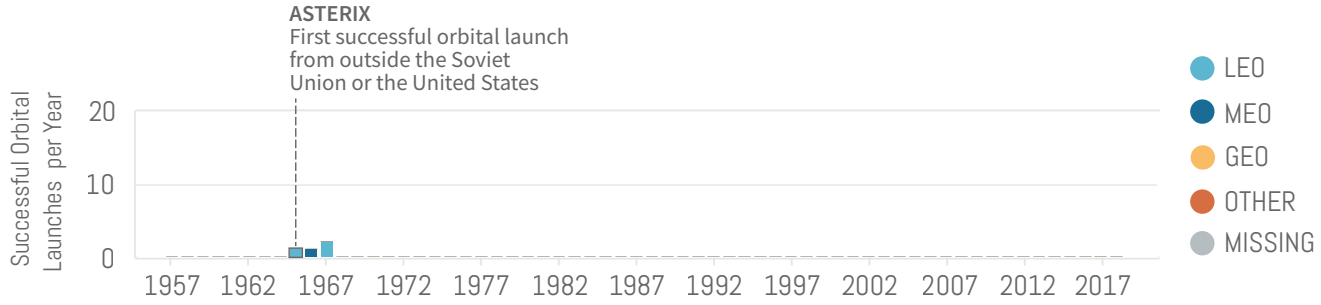


Figure 30: *Successful Orbital Launches from the Hammaguir Test Center (1957-2018). Source: Space-Track.org / Gunter's Space Page*

– WOOMERA TEST RANGE

LOCATION: 31.0°S, 136.1°E
OPERATOR: Royal Australian Air Force (Australia)
FIRST ORBITAL LAUNCH: November 29, 1967
ORBITAL LAUNCHES FROM 1957 TO 2018: 2

The Woomera Test Range is an inactive spaceport in central South Australia. The test range, covering a land area of over 120,000 square km (almost 50,000 square miles), was first constructed in 1947 as a military weapons testing center for Australia and the United Kingdom.[203] The location was likely chosen due to its remoteness and low population density: 1 person per 1000 square km.[204]

In 1960, the United States and Australia selected the Woomera region for the construction of Deep Space Station 41, a satellite tracking station to be used in NASA's Gemini and Apollo programs.[205] Later, the European Launcher Development Organisation (ELDO) selected Woomera to test the Europa multi-stage orbital launch vehicle.[206] After none of the Europa tests successfully entered orbit, ELDO transferred its launch facilities to the **Guiana Space Centre**.[207]

The test range at Woomera achieved its first orbital launch on November 29, 1967, making Australia the fourth nation to launch a satellite from its own spaceport. The payload, known as WRESAT, flew aboard a Redstone rocket purchased from the United States.[208] Four years later, the United Kingdom used the spaceport for the only successful orbital launch of its Black Arrow vehicle. Both launches were to LEO, at polar inclinations.

Although Woomera no longer supports space launches, the complex is still operated by the Royal Australian Air Force.

Several reports have suggested that private space companies—including Kistler Aerospace, SpaceX, and Virgin Galactic—have considered using the Woomera Test Range for commercial space launch.[209] No company has yet to reconfigure any portion of Woomera for space launch.

Figure 31: *Successful Orbital Launches from the Woomera Test Range (1957-2018). Source: Space-Track.org / Gunter's Space Page*

FUTURE SPACEPORTS

IN THIS REPORT, a spaceport is not considered "active" until it has achieved at least one successful orbital space launch. This chapter describes space launch facilities that may one day become active. The first section includes launch facilities that have been given commercial spaceport site licenses by the United States' Federal Aviation Administration (FAA). The second section includes those that do not hold FAA licenses, but have achieved sub-orbital spaceflight, with plans to pursue or continue pursuing orbital spaceflight. The last section includes proposals for new spaceports that have yet to be constructed. These lists are not exhaustive and do not evaluate the likelihood that any of the following facilities will actually achieve orbital spaceflight.

– FAA-LICENSED LAUNCH SITES

The Federal Aviation Administration's Office of Commercial Space Transportation is responsible for issuing launch site licenses to commercial launch operators in the United States. Licenses are granted to proposed sites when its operations "will not jeopardize public health and safety, property, U.S. national security or foreign policy interests, or international obligations of the United States."[210]

Since its establishment in 1984, the Office of Commercial Space Transportation has issued 11 launch site licenses. Four of the 11 commercial space launch sites have achieved successful orbital launch: the California Spaceport at the **Vandenberg Air Force Base,** the Mid-Atlantic Regional Spaceport at the **Wallops Flight Facility, Pacific Spaceport Complex - Alaska**, and Space Florida within the **Cape Canaveral / Kennedy Space Center** spaceport. The remaining 7 launch sites are listed below in alphabetical order.

Cecil Spaceport

LOCATION: 30.2°N, 81.9°W
OPERATOR: Jacksonville Aviation Authority (United States)
CURRENT STATUS: No launches

The Cecil Spaceport is an FAA-licensed commercial spaceport located at the Cecil Airport in southwest Jacksonville, Florida. Although no launches have been supported from the Cecil Spaceport, Generation Orbit—a Georgia-based aerospace company—has announced plans to utilize the facilities at Cecil to launch its air-launched X-60A vehicle in 2019.[211]

In 2010, the spacecraft company Rocketplane announced its plans to use the Cecil Spaceport as soon as 2013.[212] The company has since filed for bankruptcy.

Colorado Air and Space Port

LOCATION: 39.8°N, 104.5°W
OPERATOR: Adams County, Colorado (United States)
CURRENT STATUS: No launches

The Colorado Air and Space Port—also known as Front Range—is an FAA-approved commercial launch site approximately 10 km (6 miles) southeast of the Denver International Airport, on the outskirts of Denver, Colorado.[213]

No commercial space companies have plans to test or develop space vehicles at the Colorado spaceport.[214] The facility is only licensed for "Concept X" vehicles—horizontally launched space planes that take off and land on a runway—meaning it cannot be used to support air-launched systems.[215]

Houston Spaceport

LOCATION: 29.6°N, 95.2°W
OPERATOR: Houston Airport System (United States)
CURRENT STATUS: No launches

The Houston Spaceport, located at the Ellington Airport in southeast Houston, Texas, is an FAA-licensed spaceport operated by the Houston Airport System.[216] The facility is approved for horizontal take-offs and landings.[217]

In 2015, the aerospace company Sierra Nevada agreed to use the Houston Spaceport to land its Dream Chaser space plane.[218] The Dream Chaser is designed for vertical launch, perhaps onboard an Atlas V launched from either **Cape Canaveral** or **Vandenberg**.[219]

In 2018, the Houston City Council allocated almost $19 million to begin construction of support facilities at the Houston Spaceport.[220] Prior to that commitment, there was little physical development of the facility since it was first granted its spaceport license in 2015.

Midland Air and Space Port

LOCATION: 31.9°N, 102.2°W
OPERATOR: City of Midland, Texas (United States)
CURRENT STATUS: No launches

On September 17, 2014, the FAA issued a commercial launch site operator license to the Midland International Airport near Midland, Texas, making it the first FAA-licensed spaceport that also supports regularly scheduled commercial passenger flights.[221] The facility—now known as the Midland Air and Space Port—is located approximately 400 km (250 miles) east of El Paso, Texas.

In 2012, two years before the Midland Airport received its launch site operator license, private spaceflight company XCOR Aerospace responded to a $10 million incentive deal from Midland by announcing its plans to relocate its testing and development facilities from the Mojave Air and Space Port to Texas.[222] The company's plans included a reusable sub-orbital space plane, called Lynx, that would horizontally take off and land at Midland.[223] After laying off a significant portion of its employees in 2016, XCOR Aerospace filed for bankruptcy in November 2017.[224]

Like the Houston Spaceport, Sierra Nevada has named the Midland Air and Space Port as a landing site for its Dream Chaser spaceplane.[225]

The Midland Air and Space Port's online brochure lists Orbital Outfitters—a spacesuit company—as a second commercial space tenant at the facility.[226] Documentation from XCOR's 2017 bankruptcy filings show Orbital Outfitters is no longer in business.[227]

Mojave Air and Space Port

LOCATION: 35.1°N, 118.2°W
OPERATOR: East Kern Airport District, California (United States)
CURRENT STATUS: Sub-orbital

Located about 108 km (67 miles) north of Los Angeles, the Mojave Air and Space Port is a sub-orbital launch and re-entry facility in Kern County, California.[228]

On June 17, 2004, the FAA issued the Mojave spaceport a launch operator's license, making the facility the first inland spaceport in the United States.[229] Just four days later, the spaceport supported the inaugural launch of SpaceShipOne, the first non-government launch vehicle to carry a human to outer space on a sub-orbital trajectory.[230] Four months later, on October 4, 2004, the same vehicle won the Ansari X Prize—a $10 million award from the X Prize Foundation—for becoming the first privately funded space vehicle to travel to space twice in the span of two weeks.[231]

On October 31, 2014, the SpaceShipOne's follow-on vehicle—SpaceShipTwo, built by the Spaceship Company—suffered an accident, killing one of the pilots on board.[232] SpaceShipTwo did not fly from Mojave again for almost four years.[233]

More recently, other companies are hoping to earn FAA certifications to use their vehicles at Mojave. Stratolaunch—an air-launch system company founded by the late Paul Allen—expects to test its launch vehicles over the next two years, launching payloads to LEO as soon as 2020.[234]

Oklahoma Spaceport

LOCATION: 35.3°N, 99.2°W
OPERATOR: Oklahoma Space Industry Development Authority (United States)
CURRENT STATUS: Sub-orbital

The Oklahoma Spaceport—also known as the Clinton-Sherman Industrial Airpark—is an FAA-approved sub-orbital launch facility approximately 156 km (97 miles) west of Oklahoma City.

Although conditions at the Oklahoma Spaceport are favorable—the facility is both inland and does not intersect with any restricted or military airspace—no horizontal space launch vehicle companies have used the site to test their designs.[235] One company, Armadillo Aerospace—known for its plans to design a vertically-launched lunar lander—used the Oklahoma Spaceport for a small number of test-flights under an experimental permit in 2007 before it stopped operating.[236] Another company that chose to operate at the Oklahoma Spaceport, Rocketplane, went bankrupt in 2010.[237]

According to the FAA's Office of Commercial Space Transportation, no vehicles currently have an active launch license to operate out of Oklahoma.[238]

Spaceport America

LOCATION: 33.0°N, 107.0°W
OPERATOR: New Mexico Spaceport Authority (United States)
CURRENT STATUS: Sub-orbital

Located adjacent to the U.S. Army-operated White Sands Missile Range, Spaceport America is a state-owned launch facility in southern New Mexico. The facility is primarily leased by Virgin Galactic, a space tourism company, but also holds partnerships with SpaceX, Boeing, and other aerospace companies.[239]

The state of New Mexico has invested over $200 million constructing Spaceport America and its support facilities.[240] Although the spaceport has supported several sub-orbital space launches since it opened in 2011, all SpaceShipTwo test flights have used runways at the Mojave Air and Space Port.[241] The FAA Office of Commercial Space Transportation first issued Spaceport America's launch site operator's license in 2008.[242]

– SUB-ORBITAL TEST SITES

The following spaceports have achieved sub-orbital spaceflight, but do not hold an FAA site license. These facilities are either located outside the United States or launch on a permit-by-permit basis with the Commercial Space Transportation Office. Spaceports often achieve sub-orbital flight before attempting or achieving orbital spaceflight. Some of the space launch facilities listed below have attempted orbital launch unsuccessfully. Launch sites in this section are ordered alphabetically.

Alcântara Launch Center

LOCATION: 2.4°S, 44.4°W
OPERATOR: Brazilian Air Force / Brazilian Space Agency (Brazil)
CURRENT STATUS: Sub-orbital

Constructed in the 1980s, the Brazilian Air Force's Alcântara Launch Center is the only spaceport in Brazil designated for orbital launch.[243] Although the facility has been responsible for several sounding rocket launches, the Alcântara Launch Center has yet to successfully launch a satellite into orbit.

Located in the northwestern state of Maranhão, Alcântara Launch Center is ideally situated for launch to geosynchronous orbit. Situated only 2.4° south of the equator, the spaceport at Alcântara is the lowest latitude of any space launch facility anywhere in the world. Besides its latitude, the Brazilian government also chose the region for its low population density and accessibility by air and sea.[244]

The Brazilian Space Agency has attempted to establish several international agreements to attract foreign launch providers to Alcântara. The earliest plans for the spaceport included tests of a Brazilian-French liquid-fueled launch system, but the two governments failed to agree on a Technology Safeguards Agreements (TSA), which would prevent Brazil from accessing French technologies that

could aid in the proliferation of nuclear weapons.[245] Despite repeated rounds of attempted negotiations, the United States and Brazil have also yet to agree on a TSA, and no American launches have taken place at the Brazilian facility.[246]

Although Brazil and Russia agreed to allow the Russian space agency to use the facilities in 2002, no Russian space launches have been attempted from Alcântara.[247]

In 2003, Brazil and Ukraine signed an agreement to allow for Alcântara to launch the Ukrainian Cyclone rocket.[248] The Brazilian government terminated the partnership in 2015 before any test launches had been administered, citing a lack of confidence in Ukraine's ability to provide the launch system in a timely manner.[249] In one attempt at orbital launch, in August 2003, a fire on the launch pad killed over 20 people.[250]

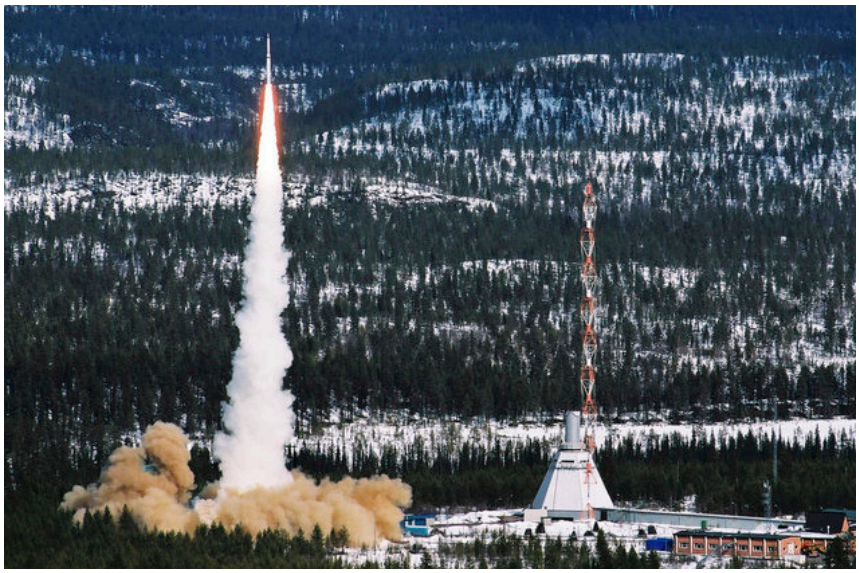
Esrange Space Center

LOCATION: 67.8°N, 20.3°E
OPERATOR: Swedish Space Corporation (Sweden)
CURRENT STATUS: Sub-orbital

The Esrange Space Center is a sub-orbital launch facility near Kiruna, Sweden. First founded by the European Space Research Organisation in the early 1960s, Esrange has been used to launch sounding rockets and high-altitude balloons dedicated to atmospheric science research.[251]

In 2017, the Swedish government funded a study to determine the feasibility of supporting orbital launches at Esrange.[252] The following year, researchers concluded that the site could indeed be used to launch low-Earth orbiting satellites, most efficiently to polar orbits.[253]

Although no launch dates have been announced, a satellite launched from the Esrange Space Centre could potentially be the first object placed into orbit from mainland Europe.



A sub-orbital sounding rocket launches from the Esrange Space Center in northern Sweden on July 3, 2002. *No object has ever reached orbit from mainland Europe. Photo: ESA*

Nearby, at the Kiruna Airport, a company called Spaceport Sweden hosts aircraft flights for tourists wishing to experience the sensations of low gravity and see the northern lights.[254] In 2007, the Swedish government signed an agreement with Virgin Galactic, committing to building a regulatory environment such that Spaceport Sweden or perhaps the Esrange Space Center could become the company's first European launch facility.[255]

Spaceport Camden

LOCATION: 30.9°N, 81.5°W
OPERATOR: Camden County, Georgia (United States)
CURRENT STATUS: Sub-orbital; proposed for FAA-licensing

Spaceport Camden is a launch site in the southeast corner of Georgia, near Cumberland Island. Although Camden has yet to receive a launch site license from the FAA, the site has supported one FAA-approved, sub-orbital, vertical launch of the Vector-R vehicle.[256]

According to its website, Spaceport Camden is proposing a substantial site license from the FAA, including a vertical launch facility and landing zone.[257] The Camden County Commission formally submitted their application to the FAA on January 29, 2019.[258]

In January 2019, a community activism group—called *Protect Cumberland Island*—began an awareness campaign about the environmental risks associated with space launch from the proposed Spaceport Camden launch site.[259] The group specifically opposes the site's vertical launch proposal, which it argues poses a "risk to people and property."[260] The Camden County administrator largely dismissed the concerns raised by the group, stating that many of its members are "non-Camden County residents and many are from out of state."[261]

Tonghae Satellite Launching Ground

LOCATION: 40.9°N, 129.7°E
OPERATOR: North Korea
CURRENT STATUS: Sub-orbital

The Tonghae Satellite Launching Ground—also known as Musudan-ri and the Hwadae-kun Missile Test Site—is a launch facility in northeastern North Korea known for several unsuccessful attempts at placing North Korean satellites in orbit.

First built in the early 1980s, Tonghae supported three orbital launch attempts: one in 1998 using the Taepodong-1 launch system and two more in 2006 and 2009 using the Taepodong-2 launch system.[262] Despite verification of the third launch's failure, a report from North Korea claimed success, suggesting that the satellite could be heard broadcasting North Korean national music.[263]

Due to the launch facility's position on the coast of North Korea and its proximity to Japanese airspace, most launch tests were constrained to altitudes below 400 km, possibly limiting the nation's ability to test the full extent of its launch systems.[264]

Commercial satellite images of the Tonghae Satellite Launching Ground suggest that the facility could not be used for another space launch attempt without significant repairs, due to long periods of underuse.[265] Work on the site appeared to slow to a halt after the success of North Korea's newer facility, the **Sohae Satellite Launching Station**.[266]

West Texas Launch Site

LOCATION: 31.4°N, 104.8°W
OPERATOR: Blue Origin, LLC (United States)
CURRENT STATUS: Sub-orbital

Located approximately 161 km (100 miles) east of El Paso, Texas, the West Texas Launch Site (WTLS)—also known as Corn Ranch—is Blue Origin's primary test facility for the company's New Shepard launch system.[267] Although the FAA issued Blue Origin a launch license for the New Shepard System in 2017—meaning that particular vehicle is permitted to test launch from WTLS—the company does not hold an active site operator license for WTLS, and the spaceport is not formally FAA-certified.[268]

Blue Origin's New Shepard crew capsule was recovered after a successful launch test at the West Texas Launch Site on December 12, 2017. *The flight was the first for New Shepard Crew Capsule #2. Photo: NASA*

Recently, the New Shepard launch vehicle was effectively declared the world's first fully reusable, vertically-launched space vehicle after being recovered from five sub-orbital launches out of WTLS.[269]

– PROPOSED SPACEPORTS

This section includes proposals to build spaceports in the future. These facilities range from perennial, nonmaterial spaceport plans to funded projects awaiting construction. Proposals in this section are listed alphabetically.

Antonio B. Won Pat International Airport

LOCATION: 13.5°N, 144.8°E
OPERATOR: A.B. Won Pat International Airport Authority, Guam (United States)
CURRENT STATUS: Proposed for FAA-licensing

In 2018, Virgin Orbit—a launch company owned by Richard Branson and focused on small satellite launches—proposed using the Antonio B. Won Pat International Airport in Guam to support its air-launched LauncherOne vehicle.[270] The airport has not yet applied for a site license from the FAA.[271]

Christmas Island, Australia

LOCATION: 10.4°S, 105.7°E
OPERATOR: Asia Pacific Space Centre (Australia)
CURRENT STATUS: Proposed

Christmas Island, an Australian island territory about 500 km (305 miles) south of Jakarta, Indonesia, is the site of a proposed commercial spaceport. Although the island was noted as a potentially favorable location for orbital space launch as early as the 1960s, the territory was more recently proposed as a space launch site in 1998 by the Australian company Asia Pacific Space Centre.[272] Prior to 1998, the company proposed to launch from Cape York in northeastern mainland Australia.[273]

In 2004, the Russian State Duma ratified an agreement with the Australian government to build a launch facility on Christmas Island.[274] Earlier, the two governments planned on the site being used for the proposed Aurora vehicle, a Russian-Australian rocket derived from the Soyuz launch system and built by Asia Pacific.[275] Initial plans of the spaceport suggested it would be called the "Aurora Rocket Space Complex" and support its first commercial launch in 2004.[276]

The Aurora vehicle was never tested for launch. In 2009, the Australian government withdrew its support for Asia Pacific and its launch complex.[277]

Hawaii Air and Space Port

LOCATION: 19.7°N, 156.0°W
OPERATOR: Hawaii Department of Transportation (United States)
CURRENT STATUS: Proposed for FAA-licensing

The state of Hawaii has proposed the Kona International Airport at Keahole to become an FAA-licensed spaceport.[278] Located on the western coast of the state's Big Island, the proposed spaceport would only support horizontally-launched reusable vehicles.

Although the Hawaii state government is interested in attracting new tourists to the state with space-themed attractions, a pair of spaceports within the state could be used for sub-orbital passenger flights between the islands, improving travel times for commuters.[279]

Pacific Spaceport Complex - Hawaii

LOCATION: 19.7°N, 155.0°W
OPERATOR: Alaska Aerospace Corporation (United States)
CURRENT STATUS: Proposed

The Alaska Aerospace Corporation, the state-owned corporation responsible for operating the **Pacific Space Port Complex** in Alaska, is developing plans to construct a second launch site closer to the equator and capable of more efficient launches to low-inclination orbits. One of the two proposed locations is in Hawaii on the eastern coast of the state's Big Island.[280]

The corporation says that the Hawaiian site would support only small payloads, between 50 and 100 kg (110 and 220 lbs).[281] Currently, Alaska Aerospace is supporting an environmental assessment of the site, a traditional early step for any spaceport proposal.[282]

On January 25, 2019, protestors gathered at a Hawaiian community center to express their disapproval of Alaska Aerospace's proposal and remarks made by the Corporation's CEO earlier that day.[283] Some community members cited concerns that building a spaceport in the proposed region would further threaten the homestead communities that have already been displaced by other regional development projects.

Pacific Spaceport Complex - Saipan

LOCATION: 15.3°N, 145.8°E
OPERATOR: Alaska Aerospace Corporation (United States)
CURRENT STATUS: Proposed

In addition to **Pacific Spaceport Complex - Hawaii**, the Alaska Aerospace Corporation is concurrently considering another low-latitude launch site, on the northeast tip of Saipan, in the Northern Mariana Islands.[284] The preferred location is on the Formerly Used Defense Site clean-up list, meaning the U.S. Army Corps of Engineers has yet to clean up any contamination of munitions that could be there from both American and Japanese forces during World War II.[285]

In the case that the preferred site is not cleaned up in a timely manner—per Alaska Aerospace's request—the corporation will proceed with one of two other identified locations in the Northern Mariana Islands.[286]

Santa Maria Island, Portugal

LOCATION: 37.0°N, 25.1°W
OPERATOR: Portuguese Science and Technology Foundation / ESA (Portugal / Europe)
CURRENT STATUS: Proposed

In 2018, the Portuguese government announced its plans to build a spaceport on Santa Maria Island in the Azores archipelago.[287] The Azores, an autonomous region of Portugal, is located approximately approximately 1,400 km (870 miles) off the Portuguese coast in the Atlantic Ocean.

The project—called the Atlantic International Satellite Launch Programme—accepted proposals from commercial space companies interested in developing vehicles to launch from Santa Maria Island.[288] Of the 14 companies that expressed interest—including 11 from Europe, two from both the United States and Roscosmos, the Russian space agency—the Programme has selected five companies to develop more detailed proposals for the spaceport.[289] ArianeGroup, the European company that developed the Ariane 5 rocket that launches from the **Guiana Space Centre**, is interested in managing the new spaceport on Santa Maria.[290] The Portuguese government also plans to start commercial space launch from the island in 2021.[291]

Southerland County, Scotland

LOCATION: ~58.5°N, ~4.5°W
OPERATOR: United Kingdom Space Agency (United Kingdom)
CURRENT STATUS: Proposed

In July 2014, the United Kingdom's Minister of State for Transport announced plans to identify a location to construct a new vertical-launch spaceport in Scotland, England, or Wales.[292] In July 2018, the UK Space Agency announced its selection: the northern coast of Scotland's Southerland County.[293] Once operational, the spaceport will likely support small payload launches using vertical launch vehicles from Lockheed Martin and Orbex.[294]

Only one British launch vehicle has ever been used for orbital space flight—Black Arrow, tested at the **Woomera Test Range** in 1971. A spaceport in Scotland would likely return British-built space launches to the United Kingdom and bring space launch to continental Europe for the first time.

SpaceX South Texas Launch Site

LOCATION: 26.0°N, 97.2°W
OPERATOR: Space Exploration Technologies Corp. (United States)
CURRENT STATUS: Under Construction

The SpaceX South Texas Launch Site—also known as the Boca Chica Launch Site—is located on the southern tip of the state, near Boca Chica State Park, less than 8 km (5 miles) from the U.S.-Mexico border. The launch site is still under construction.[295]

On August 4, 2014, the Texas state government announced that SpaceX would build a commercial spaceport in southern Texas.[296] Previously, the company had considered launch site locations in Georgia, Florida, and Puerto Rico. To attract SpaceX, the Texas state government agreed to contribute $15 million towards the construction of the spaceport.[297]

The SpaceX South Texas Launch Site does not currently hold an FAA site license.[298] Although SpaceX holds no launch licenses for any of its vehicles to be test launched from South Texas, the company reportedly plans to complete low- and high altitude test flights—500 m (1600 feet) and 5 km (3 miles) respectively—in late 2019.[299]

In January and February 2019, several members of the U.S. House of Representatives expressed concern after noticing that a map from the U.S. Department of Homeland Security suggested plans to build a barrier running through the SpaceX property in southern Texas.[300] The barrier would be part of the Trump administration's proposal to build a wall along the U.S.-Mexico border.

CONCLUSION

ALTHOUGH SEVERAL NEW LAUNCH PROVIDERS are developing air-launched vehicles to deliver payloads to orbit—including Virgin Orbit, Stratolaunch, and Generation Orbit—the vast majority of satellites are launched from ground-based spaceports. As private companies continue to test and operate their launch vehicles from spaceports around the world, launch site operators may attract more customers by demonstrating their ability to support timely, successful launches.

"Hosting a space launch from a remote facility—such as the Plesetsk Cosmodrome or the Imam Khomeini Space Center—no longer keeps a space launch a secret."

Unfortunately for launch operators choosing between several spaceports to support their launches, there are several challenges to evaluating a spaceport's capabilities given publicly-available data. Currently, only some launch providers publish their launch manifest— a list of upcoming and past launches, describing a mission's purpose, spaceport, and vehicle—making it difficult to compare a spaceport's record of actual launch attempts with its projections. Additionally, independently-managed launch records often show the success or failure of an orbital launch attempt without including the accuracy with which a spaceport supported an orbital launch. Once an object is in orbit and registered in the CSpOC's online catalog—corresponding to a successful orbital launch in the CSIS dataset—it is not noted whether the recorded orbit is indeed the payload's intended orbit. Therefore, it is difficult to assess a spaceport's record of supporting launches to the appropriate orbital destination. Lastly, when a space launch is delayed due to weather, launch operators rarely publish detailed information on the delay decision. What may appear to be a streak of unluckiness due to uncontrollable weather may actually be a spaceport reaching its launch capacity.

The Modern Spaceport

Unlike the earliest days of spaceflight, space launches are known to the public almost immediately due to the ability to track satellites from the ground, purchase high-resolution satellite imagery from remote sensing companies to monitor spaceport activity, and access the official CSpOC catalog from the U.S. government. Hosting a space launch from a remote facility—such as the **Plesetsk Cosmodrome** or the **Imam Khomeini Space Center**—no longer keeps a space launch a secret.

As the geosynchronous belt remains a key orbital regime for space-faring nations' national security, Russia and China have invested in lower latitude launch opportunities to launch their state-sponsored vehicles. After it abandoned a bid to launch a Soyuz-derived vehicle from the low-latitude **Christmas Island, Australia** launch site, the Russian government turned its focus to the **Guiana Space Centre** in South America, where it began construction of a Soyuz-compatible launch pad in 2005 and first launched in 2011.[301] In 2018, China became the world's most active space launch country despite its newest spaceport, the low-latitude **Wenchang Satellite Launch Center**, still facing mission delays and not hosting a single launch in 2018.

Azimuth limitations may be a decreasingly important factor for spaceport location selection. Developments in automated flight—such as an automated abort feature—will likely allow flight paths over regions previously disallowed by the United States' Federal Aviation Administration,

including a southward corridor from the **Cape Canaveral / Kennedy Space Center** spaceport and, perhaps, a Caribbean island corridor from the **SpaceX South Texas Launch Site**.

Although seven of the launch sites listed in the fourth chapter of this report hold licenses from the FAA, the majority of them are only allowed to support *horizontal* launches. At many of these sites, orbital spaceflight—which is most often achieved via *vertical* launch—is only one of two goals; the other being sub-orbital spaceflight tourism. So far, receiving a site operator license from the FAA is not a strong indicator of achieving orbital spaceflight.

ABOUT THE AUTHOR

Thomas G. Roberts is a research associate and program manager with the CSIS Aerospace Security Project. His research interests include satellite system architecture analysis, civil and commercial space operations, and international collaboration in science research. Previously, Mr. Roberts has written on space-based missile defense, threats against space-based assets, and human spaceflight programs. His work has appeared in *The Atlantic, War on the Rocks, The Bulletin of the Atomic Scientists*, and other publications. Mr. Roberts is the host and executive producer of *Moonstruck*, a podcast about the history of human spaceflight. He holds a B.A. in astrophysical sciences with honors and an undergraduate certificate in Russian studies from Princeton University. In 2015, he was named a Harry S. Truman Scholar.

ENDNOTES

INTRODUCTION

1 Anatoly Zak, "The Rocket That Launched Sputnik and Started the Space Race," *Popular Mechanics*, October 4, 2017, https://www.popularmechanics.com/space/moon-mars/a28491/r-7-rocket-sputnik/.

2 Space-Track.org, accessed January 2, 2019, https://www.space-track.org/.

3 Jonathan C. McDowell, "The Edge of Space: Revisiting the Karman Line," *Acta Astronautica* 151 (October 2018): 671, doi:10.1016/j.actaastro.2018.07.003.

4 The "horizontal velocity" of an object is the component of its velocity parallel to the Earth's surface.

5 David Wright, Laura Grego, and Lisbeth Gronlund, *The Physics of Space Security: A Reference Manual* (Cambridge, MA: American Academy of Arts and Sciences, 2005), 20.

6 The horizontal velocity at the Earth's surface is also known as the "tangential velocity."

7 Satellites in prograde orbit have an orbital inclination between 0° and 90°. The vast majority of space objects are in prograde orbit.

8 All of the active, sub-30° spaceports happen to be in the northern hemisphere: Cape Canaveral / Kennedy Space Center (28.6°N), the Xichang Satellite Launch Center (28.3°N), the Wenchang Satellite Launch Center (19.6°N), the Satish Dhawan Space Centre (13.7°N), the Ronald Reagan Ballistic Missile Defense Test Site (9.1°N), and the Guiana Space Centre (5.2°N); Thomas G. Roberts and Jacque Schrag, "Spaceports of the World," CSIS Aerospace Security, accessed February 13, 2019, https://aerospace.csis.org/data/spaceports-of-the-world/.

9 Kim Dismukes, "Launch Sites," NASA, April 7, 2002, https://spaceflight.nasa.gov/shuttle/reference/shutref/sts/launch.html.

10 David Middlecamp, "Vandenberg Was Poised to Be a Space Shuttle Launch Site - Then Tragedy Struck," *Tribune*, November 16, 2018, https://www.sanluisobispo.com/news/local/news-columns-blogs/photos-from-the-vault/article221603735.html.; Ibid.

11 Note: These azimuth restrictions at Vandenberg only apply to orbital space launches. Sub-orbital missile tests have been conducted from this site with more westward azimuths outside the limits shown in Figure 3; See: Brian Webb, "Viewing Vandenberg Rocket and Missile Launches," Space Archive, November 4, 2018, http://www.spacearchive.info/vafbview.htm.

12 Some sources suggest azimuths as great as 300° can be supported at Vandenberg, see Charles D. Brown, *Spacecraft Mission Design* (Reston, VA: American Institute of Aeronautics and Astronautics, 1998), 56.

13 "What Are the National Seismic Hazard Maps for Japan?," Japan Seismic Hazard Information Station, 2012, http://www.j-shis.bosai.go.jp/en/shm.

14 Tariq Malik, "Earthquake Forces Closure of Japan's Space Station Control Center," Space.com, March 11, 2011, https://www.space.com/11110-japan-earthquake-tsunami-space-station.html.

15 Alan Taylor, "Ten Years Since the 2004 Indian Ocean Tsunami," *Atlantic*, December 26, 2014, https://www.theatlantic.com/photo/2014/12/ten-years-since-the-2004-indian-ocean-tsunami/100878/.

16 "Sketch of Global Tsunami Hazard," PreventionWeb, May 2009, https://www.preventionweb.net/english/professional/maps/v.php?id=10602.

17 "Wildfire At California Air Force Base Explodes In Size, Delays Satellite Launch," CBS San Francisco, September 19, 2016, https://sanfrancisco.cbslocal.com/2016/09/19/wildfire-at-california-air-force-base-explodes-in-size-delays-satellite-launch/.

18 Umair Irfan, "The West Is on Fire ... Again," Vox.com, August 14, 2018, https://www.vox.com/2018/7/20/17582890/wildfires-2018-carr-fire-california-cranston-ferguson-colorado.

19 Jeff Foust, "Cape Canaveral Facilities Prepare for Hurricane Irma," SpaceNews.com, September 8, 2017, https://spacenews.com/cape-canaveral-facilities-prepare-for-hurricane-irma/.

20 Ibid.

21 Brian Dunbar, "Kennedy Sustains Damage from Hurricane Irma," NASA Blogs (blog), September 12, 2017, https://blogs.nasa.gov/kennedy/2017/09/12/kennedy-sustains-damage-from-hurricane-irma/.

22 "Flight VS20: Soyuz with CSO-1: 24-hour delay due to weather conditions," Arianespace, December 18. 2018, http://www.arianespace.com/press-release/flight-vs20-soyuz-with-cso-1-24-hour-delay-due-to-weather-conditions/.

23 Tariq Malik, "SpaceX Delays Falcon 9 Rocket Launch Due to High-altitude Winds," Fox News, February 21, 2018, https://www.foxnews.com/science/spacex-delays-falcon-9-rocket-launch-due-to-high-altitude-winds.

24 Jeff Foust, "Rocket Lab Waits out Weather Delays," SpaceNews.com, May 24, 2017, https://spacenews.com/rocket-lab-waits-out-weather-delays/.

25 Cristina Archer and Ken Caldeira, "Global Assessment of High-Altitude Wind Power," *Energies* 2, no. 2 (2009): 311.

26 Ibid., 312.

27 Brian Lada, "3 Weather Obstacles That SpaceX Faces When Launching Rockets into Space," Accuweather, April 9, 2016, https://www.accuweather.com/en/weather-news/3-weather-obstacles-that-spacex-faces-when-launching-rockets-into-space/57121215.

28 George Diller, "Space Shuttle Weather Launch Commit Criteria and KSC End of Mission Weather Landing Criteria," NASA, January 2003, https://www.nasa.gov/centers/kennedy/news/releases/2003/release-20030128.html.

29 "Climate & Weather Averages in Arkhangelsk, Russia," timeanddate.com, accessed February 13, 2019, https://www.timeanddate.com/weather/russia/arkhangelsk/climate.

30 "Kazakhstan Finally Ratifies Baikonur Rental Deal With Russia," Space Daily, April 12, 2010, http://www.spacedaily.com/reports/Kazakhstan_Finally_Ratifies_Baikonur_Rental_Deal_With_Russia_999.html.

31 H.N. Nesbitt, *History of the Italian San Marco Equatorial Mobile Range* (NASA, 1971), https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19720007316.pdf.

32 Ibid.

33 John Pike, "Hammaguir / Hamaguir," Global Security, accessed June 27, 2018, https://www.globalsecurity.org/wmd/world/france/hammaguir.htm; "Algeria: France-Algeria Independence Agreements (Evian Agreements)," *International Legal Materials* 1, no. 2 (1962): 214-30, http://www.jstor.org/stable/20689578.

34 "CSG at 50: Half a Century of Europe's Spaceport," European Space Agency, April 5, 2018, http://m.esa.int/About_Us/Welcome_to_ESA/ESA_history/CSG_at_50_half_a_century_of_Europe_s_Spaceport.

35 H.N. Nesbitt, *History of the Italian San Marco Equatorial Mobile Range*.

36 Peter D'Auria and Tim Fernholz, "How a Handful of South American Protestors Took Europe's Space Program Hostage," Quartz, April 17, 2017, https://qz.com/960817/how-a-handful-of-south-american-protestors-in-french-guiana-took-ariane-space-and-europes-space-program-hostage/.

37 Amiko Kauderer, "Baikonur Cosmodrome," NASA, October 23, 2010, https://www.nasa.gov/mission_pages/station/structure/elements/baikonur.html?r=1&l=ri&fst=0.

38 Steven J. Isakowitz, et al., *International Reference Guide to Space Launch Systems*.

39 Andrew Jones, "Wenchang Launch Centre Opens Space Program for Tourism," GBTIMES, February 1, 2017, https://gbtimes.com/chinas-wenchang-launch-centre-opens-space-program-tourism.

40 Space-Track.org, accessed January 2, 2019.

41 For more information on orbital regimes, see: aerospace.csis.org/aerospace101/popular-orbits-101/.

42 For both this report and the accompanying online database, the data was provided by the JsPOC catalog on January 2, 2019.

43 George Finger and Carey McClesky, "Spaceport Performance Measures," SpaceOps 2010 Conference, April 2010, https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20100039456.pdf.

ACTIVE SPACEPORTS

44 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

45 Pavel L. Podvig, *Russian Strategic Nuclear Forces* (MIT Press, 2001), 122.

46 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

47 Ibid.

48 Ibid.

49 GS, "Russian Space Junk Pummels the Arctic," *Earth Island Journal* 8, no. 2 (1993): 16.

50 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

51 Asif A. Siddiqi, *Challenge to Apollo: The Soviet Union and the Space Race*, 1945-1974 (Washington, DC: NASA History Div., Off. of Policy and Plans, 2000), 133.

52 Ibid.

53 Ibid., 134.

54 Elizabeth Howell, "Baikonur Cosmodrome: Russian Launch Complex," Space.com, June 16, 2018, https://www.space.com/33947-baikonur-cosmodrome.html.

55 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

56 Andrew E. Kramer, "Russian Space Center in Kazakhstan Counts Down Its Days of Glory," *New York Times*, June 18, 2013, https://www.nytimes.com/2013/06/19/world/asia/kazakh-town-fades-its-days-of-space-glory-numbered.html.

57 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

58 Ibid.

59 Roberts and Schrag, “Spaceports of the World.”

60 "Moonport: The Making of 'the Cape'," NASA, https://www.hq.nasa.gov/pao/History/SP-4204/ch1-3.html.

61 This report's accompanying online database denotes spaceports that have supported orbital human space launch with a blue outline.

62 Barrett, “What Is the ‘Range?’.”

63 Kennedy Space Center, NASA, *America’s Spaceport* (NASA, 2005), https://www.nasa.gov/centers/kennedy/pdf/284959main_AmSpaceport08.pdf.

64 Ibid.

65 Kennedy Space Center, NASA, *America’s Spaceport.*

66 Stella Tkatchova, *Emerging Space Markets* (Berlin: Springer, 2018), 124.

67 Roberts and Schrag, “Spaceports of the World.”

68 James Dean, "Southbound? Cape Rockets May Fly New Path toward Poles," *Florida Today*, April 7, 2018, https://www.floridatoday.com/story/tech/science/space/2017/12/31/southbound-cape-rockets-may-fly-new-path-toward-poles/975027001/.

69 Anthony Colangelo, "T 70: Polar Launches from Cape Canaveral," Main Engine Cut Off (audio blog), January 17, 2018.

70 "Vandenberg Air Force Base," Holloman Air Force Base, 2017, accessed June 27, 2018, http://afspacemuseum.org/vandenberg/.

71 "The History and Heritage of Vandenberg Air Force Base and the 30th Space Wing," Vandenberg Air Force Base, August 2016, http://www.vandenberg.af.mil/Portals/18/documents/AboutUs/2016_Heritage_Pamphlet_B.pdf?ver=2016-08-11-140448-493.

72 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

73 "Spaceport Operations," Harris Corporation, accessed January 30, 2019, https://www.harris.com/what-we-do/spaceport-operations.

74 “Iridium,” *Gunter's Space Page*, 2018, http://space.skyrocket.de/doc_sdat/iridium.htm; “Iridium Next,” Gunter's Space Page, 2018, http://space.skyrocket.de/doc_sdat/iridium-next.htm.

75 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

76 Roberts and Schrag, “Spaceports of the World.”

77 Space-Track.org, accessed May 24, 2018.

78 Roberts and Schrag, “Spaceports of the World.”

79 Ibid.

80 European Space Agency, “CSG at 50: Half a Century of Europe’s Spaceport.”

81 Anatoly Zak, "History of the Launch Site in Kourou, French Guiana," Russian Space Web, May 25, 2008, http://www.russianspaceweb.com/kourou_origin.html.

82 Ibid.

83 Ibid.

84 "Spaceport Operations," Arianespace, accessed June 27, 2018, http://www.arianespace.com/spaceport-facility/operations/.

85 Roberts and Schrag, “Spaceports of the World.”

86 Robin McKie, "Soyuz Rocket Prepares for First Launch from French Guiana," *Guardian*, October 19, 2011, https://www.theguardian.com/science/2011/oct/19/soyuz-first-launch-french-guiana.

87 "Xichang Space Launch Center," Nuclear Threat Initiative, June 7, 2018, http://www.nti.org/learn/facilities/883/.

88 David J. Thompson and William R. Morris, *China in Space: Civilian and Military Developments* (Air University Press, 2001).

89 John Pike, "Base 27 Xichang Satellite Launch Center," Global Security, accessed July 31, 2018, https://www.globalsecurity.org/space/world/china/xichang.htm.

90 "Anti-satellite Test Generates Dangerous Space Debris," *New Scientis*t, January 20, 2007, https://www.newscientist.com/article/dn10999-anti-satellite-test-generates-dangerous-space-debris/.

91 Anatoly Zak, "Disaster at Xichang," *Air & Space Magazine*, February 1, 2013, https://www.airspacemag.com/history-of-flight/disaster-at-xichang-2873673/.

92 Footage shows launch failure of China's rocket 20 years ago, CGTN, YouTube, November 24, 2016, https://www.youtube.com/watch?v=p_Q6azI6Ocs.

93 Anatoly Zak, "Disaster at Xichang," *Air & Space Magazine*, February 1, 2013, https://www.airspacemag.com/history-of-flight/disaster-at-xichang-2873673/.

94 Andrew Jones, "China's Xichang Prepares for Hectic 2018 Launch Plans," GBTIMES, February 23, 2018, https://gbtimes.com/xichang-space-centre-set-for-17-launches-in-2018-including-beidou-satellite-and-moon-missions; 另外一段视频, ChinaSpaceflight, Twitter post, January 12, 2018, 1:21 a.m., https://twitter.com/cnspaceflight/status/951700575015419904?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E951700575015419904&.

95 Andrew Jones, "Rocket Booster Drops from Sky and Explodes near Town after Chinese Space Launch," GBTIMES, January 12, 2018, https://gbtimes.com/rocket-booster-drops-from-sky-and-explodes-near-town-after-chinese-space-launch.

96 PA Patil, "China's Space Launch Facilities," Centre for Air Power Studies (CAPS), October 29, 2015, http://capsindia.org/files/documents/CAPS_Infocus_PP_16.pdf.

97 Wei Long, "Jiuquan Will Be Gateway For Chinese Manned Flights," Space Daily, April 12, 2000, http://www.spacedaily.com/news/china-00r.html.

98 Jayan Panthamakkada Acuthan, "China's Outer Space Programme: Diplomacy of Competition or Co-operation?" *China Perspectives*, no. 63 (2006): 35.

99 Wendy Whitman Cobb, "What Will the Success of China's Space Program Mean for NASA?" *Pacific Standard*, January 4, 2019, https://psmag.com/news/is-china-spurring-a-new-space-race.

100 "Tiangong 1 (TG 1)," Gunter's Space Page, 2019, https://space.skyrocket.de/doc_sdat/tg-1.htm.

101 PA Patil, "China's Space Launch Facilities," Centre for Air Power Studies (CAPS), October 29, 2015, http://capsindia.org/files/documents/CAPS_Infocus_PP_16.pdf.

102 "Jiuquan Space Launch Center," Nuclear Threat Initiative, November 17, 2011, http://www.nti.org/learn/facilities/71/.

103 Roberts and Schrag, "Spaceports of the World."

104 Elizabeth Howell, "Tanegashima: Japan's Largest Space Center," Space.com, September 30, 2016, https://www.space.com/34270-tanegashima-space-center.html.

105 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

106 "N-class," *Gunter's Space Page*, 2018, https://space.skyrocket.de/doc_lau/n-class.htm.

107 Howell, "Tanegashima: Japan's Largest Space Center."

108 "Lunar Exploration Satellite 'LUNAR-A'," Japan Aerospace Exploration Agency, accessed September 5, 2018, http://global.jaxa.jp/projects/sat/lunar_a/index.html.

109 Lawrence R. Sullivan, *Historical Dictionary of the People's Republic of China* (Lanham: Roman & Littlefield, 2016), 530.

110 Mark A Stokes and Dean Cheng, *China's Evolving Space Capabilities: Implications for U.S. Interests* (Project 2049 Institute, 2012), https://www.uscc.gov/sites/default/files/Research/USCC_China-Space-Program-Report_April-2012.pdf.

111 Roberts and Schrag, "Spaceports of the World."

112 Thompson and Morris, *China in Space: Civilian and Military Developments.*

113 "GSLV Launched Successfully," *Current Science* 80, no. 10 (2001): 1254.

114 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

115 Thomas G. Roberts and Jacque Schrag, "Spaceports of the World"; "SLV-3 / ASLV," *Gunter's Space Page*, 2018, https://space.skyrocket.de/doc_lau/slv_aslv.htm.

116 Brian Frank, "Satellites and Plowshares: The Potential Demise of the Indian Space Program," *Harvard International Review* 15, no. 3 (1993): 69.

117 Misty, "India's Emerging Space Program."

118 Jay Bennett, "India Plans to Launch 104 Satellites With Just One Rocket," *Popular Mechanics*, November 14, 2017, https://www.popularmechanics.com/space/rockets/a24983/india-space-agency-launch-104-satellites/.

119 Zeenat Saberin, "India Approves Budget for First Manned Space Mission in 2022," Al Jazeera, December 28, 2018, https://www.aljazeera.com/news/2018/12/india-approves-budget-manned-space-mission-2022-181228194441300.html.

120 Joe Pappalardo, "Wallops Island: The Little Spaceport That Could," *Popular Mechanics*, February 15, 2018, https://www.popu-

larmechanics.com/space/a9438/wallops-island-the-little-spaceport-that-could-15892294/.

121 "Virginia Commercial Space Flight Authority," Commonwealth of Virginia, accessed August 27, 2018, https://www.virginia.gov/agencies/virginia-commercial-space-flight-authority/.

122 Elizabeth Howell, "Wallops Flight Facility: NASA Spaceport in Virginia," Space.com, September 21, 2016, https://www.space.com/34132-wallops-flight-facility.html.

123 Joe Pappalardo, "How NASA Got Bullied Into Rebuilding a Spaceport," *Popular Mechanics*, February 15, 2018, https://www.popularmechanics.com/space/rockets/a17619/nasa-wallops-island-spaceport-repairs/.

124 Jeff Foust, "Rocket Lab Selects Wallops for U.S. Launch Site," SpaceNews.com, October 17, 2018, accessed January 30, 2019, https://spacenews.com/breaking-rocket-lab-chooses-wallops-as-its-u-s-launch-site/.

125 Roberts and Schrag, “Spaceports of the World.”

126 Stuart Griffin, "Letter from Tokyo: In Space at Last," *Science News* 97, no. 9 (1970): 232.

127 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

128 Jon Fingas, "Japan Launches Smallest Rocket Ever to Carry Satellite into Orbit," Engadget, February 3, 2018, https://www.engadget.com/2018/02/03/japan-launches-smallest-rocket-ever-to-carry-satellite-into-orbit/.

129 Anatoly Zak, "Dombarovskiy (Yasny) ICBM Site," Russian Space Web, April 4, 2015, http://www.russianspaceweb.com/dombarovskiy.html.

130 “Dnepr,” *Gunter's Space Page*, 2018, http://space.skyrocket.de/doc_lau_det/dnepr-1.htm.

131 Zak, “Dombarovskiy (Yasny) ICBM Site.”

132 "Palmachim," Nuclear Threat Initiative, January 1, 2011, http://www.nti.org/learn/facilities/440/.

133 John Pike, "Palmachim / Palmikhim / Yavne," Global Security, accessed July 31, 2018, https://www.globalsecurity.org/military/world/israel/palmachim.htm.

134 Mike Gruntman, *Blazing the Trail: The Early History of Spacecraft and Rocketry* (Reston, VA: American Institute of Aeronautics and Astronautics, 2004), 453.

135 “Shavit,” Gunter's Space Page, 2018, https://space.skyrocket.de/doc_lau/shavit.htm.

136 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed

137 Space-Track.org, accessed May 24, 2018, https://www.space-track.org/.

138 "Imam Khomeini Space Center," Nuclear Threat Initiative, November 2, 2017, http://www.nti.org/learn/facilities/313/.

139 "Safir," Missile Threat, Center for Strategic and International Studies, October 16, 2017, https://missilethreat.csis.org/missile/safir/.

140 Peter Crail, "Iran Makes First Successful Space Launch," *Arms Control Today* 39, no. 2 (2009): 43.

141 Michael Elleman, "North Korea-Iran Missile Cooperation," 38 North, September 22, 2016, https://www.38north.org/2016/09/melleman092216/.

142 “Safir,” Gunter's Space Page, 2018, https://space.skyrocket.de/doc_lau/safir.htm.

143 Farzin Dadimi, "Iran's Space Program Emerges from Dormancy," Chemical Weapons in the Middle East, August 1, 2017, https://www.washingtoninstitute.org/policy-analysis/view/irans-space-program-emerges-from-dormancy.

144 Nasser Karimi, "Iran Says It's Launched a Satellite That Didn't Reach Orbit," AP News, January 15, 2019, https://apnews.com/a8c2f77cc86747f68c8ca3e05a52536a.

145 Gunter’s Space Page, “Safir,” 2018, https://space.skyrocket.de/doc_lau/safir.htm.

146 Geoff Brumfiel, "Satellite Imagery Suggests 2nd Iranian Space Launch Has Failed," NPR, February 6, 2019, https://www.npr.org/2019/02/06/692071812/satellite-imagery-suggests-second-iranian-space-launch-has-failed.

147 Anatoly Zak, "The Spaceport in Siberia," *Air & Space Magazine*, May 21, 2014, https://www.airspacemag.com/space/spaceport-siberia-180951416/.

148 Ibid.

149 Igor Ageyenko, "Russia's Vostochny Cosmodrome Transforms the Far Eastern Region," Russia Beyond, April 26, 2016, https://www.rbth.com/science_and_tech/2016/04/26/russias-vostochny-cosmodrome-transforms-the-far-eastern-region_588331.

150 John Sheldon, "Russia To Decommission Rokot SLV And Make Only One Launch From Vostochny in 2019," SpaceWatch.Global, December 20, 2018, https://spacewatch.global/2018/12/russia-to-decommission-rokot-slv-and-make-only-one-launch-from-vostochny-in-2019/.

151 David Rogers, "First Ever Private Spaceport Opens for New Zealand 'Space Bus'," Global Construction Review, September 28, 2016, http://www.globalconstructionreview.com/innovation/first-ever-private-spaceport-op7ens-ne7w-zealan7d/.

152 Jeff Foust, "Rocket Lab Selects New Zealand Launch Site," SpaceNews.com, July 1, 2015, https://spacenews.com/rocket-lab-selects-new-zealand-launch-site/.

153 "Our Launch Sites," Rocket Lab, accessed July 13, 2018, https://www.rocketlabusa.com/launch/launch-sites/.

154 “Electron,” Gunter's Space Page, 2018, https://space.skyrocket.de/doc_lau/electron.htm.

155 United States, Department of Transportation, Federal Aviation Administration, *Special Report: An Overview of the U.S. Commercial Space Launch Infrastructure* (Washington, DC: Department of Transportation, 1998); "From the Last Frontier," Comprehensive Launch Capabilities, accessed July 9, 2018, http://akaerospace.com/comprehensive-launch-capabilities.

156 Alaska Aerospace Corporation, *A Diversified, Sustainable Aerospace Industry for Alaska* (2011), 7.

157 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

158 "Pacific Spaceport Complex - Alaska (PSCA)," Alaska Aerospace, accessed July 6, 2018, http://akaerospace.com/capabilities/pacific-spaceport-complex-alaska-psca.

159 Jeff Foust, "Senator Targets Alaska Launch Site in Wasteful Spending Report," SpaceNews.com, January 17, 2017, http://spacenews.com/senator-targets-alaska-launch-site-in-wasteful-spending-report/.

160 Jeff Foust, "Vector Planning First Orbital Launch This Summer," SpaceNews.com, February 20, 2018, http://spacenews.com/vector-planning-first-orbital-launch-this-summer/; Jeff Foust, "Rocket Lab Selects Four Finalists for U.S. Launch Site," SpaceNews, July 12, 2018, https://spacenews.com/rocket-lab-selects-four-finalists-for-u-s-launch-site/.

161 "Sohae Satellite Launching Station," Nuclear Threat Initiative, April 24, 2014, http://www.nti.org/learn/facilities/202/.

162 “Unha,” *Gunter's Space Page*, 2018, https://space.skyrocket.de/doc_lau/unha.htm.

163 "Sohae Satellite Launching Station," Nuclear Threat Initiative, April 24, 2014, http://www.nti.org/learn/facilities/202/.

164 Roberts and Schrag, “Spaceports of the World.”

165 Joseph S. Bermudez Jr., "Quick Takes: Sohae Satellite Launching Station Remains Quiet," 38 North, March 22, 2018, https://www.38north.org/2018/03/sohae032018/.

166 Joseph Bermudez and Victor Cha, "North Korea Reportedly Renews Commitment to Dismantle the Sohae Launch Facility," CSIS Beyond Parallel, January 30, 2019, https://beyondparallel.csis.org/north-korea-reportedly-renews-commitment-dismantle-sohae-launch-facility/; Joseph S. Bermudez Jr., "North Korea Begins Dismantling Key Facilities at the Sohae Satellite Launching Station," 38 North, July 24, 2018, https://www.38north.org/2018/07/sohae072318/; Matt Spetalnick, "U.S. Identifies North Korea Missile Test Site It Says Kim Committed to Destroy," Reuters, June 20, 2018, https://www.reuters.com/article/us-northkorea-usa-site/u-s-identifies-north-korea-missile-test-site-it-says-kim-committed-to-destroy-idUSKBN1JH02B.

167 Jessica Meyers, "Aerospace Peppers and Astronaut Robots: A Town's Transformation Reveals China's Ambitions in Space," *Los Angeles Times*, May 11, 2017, http://www.latimes.com/world/asia/la-fg-china-hainan-space-2017-story.html#.

168 "China's Ambitions in Space Are Growing," *Economist*, January 20, 2018, https://www.economist.com/china/2018/01/20/chinas-ambitions-in-space-are-growing.

169 Meyers, “Aerospace Peppers and Astronaut Robots: A Town’s Transformation Reveals China’s Ambitions in Space.”

170 “CZ-5/YZ2 (Chang Zheng-5/YZ2)” *Gunter's Space Page*, 2018, https://space.skyrocket.de/doc_lau_det/cz-5_yz2.htm.

171 Economist, “China’s Ambitions in Space Are Growing.”

172 Andrew Jones, "What We Know about China's Space Station: Modules, Crew, Launch Plans and More," GBTIMES, May 31, 2018, https://gbtimes.com/what-we-know-about-chinas-space-station-modules-crew-launch-plans-and-more.

173 "China's New Heavy-lift Rocket Launch Fails in Flight," Reuters, July 2, 2017, https://www.reuters.com/article/us-china-space-idUSKBN19N0KZ.

174 Andrew Jones, "China Reveals Cause of Long March 5 Failure; Lunar Sample Mission to Follow Return-to-flight," SpaceNews, April 16, 2018, https://spacenews.com/china-reveals-cause-of-long-march-5-failure-lunar-sample-mission-to-follow-return-to-flight/.

175 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems*, 4th ed.

176 Jordan M. Vinson, "The Kwaj Current - Television Show," U.S. Army, April 21, 2018, https://www.army.mil/article/204197/the_kwaj_current_television_show.

177 Michael C. Sirak, "Army Nears Decision on Using Kwajalein for Commercial Space Launches," *Inside Missile Defense* 4, no. 25 (1998): 3, http://www.jstor.org/stable/43971795.

178 Space-Track.org, accessed May 24, 2018.

179 Aaron Rowe, "SpaceX Did It - Falcon 1 Made It to Space," *Wired*, September 28, 2008, https://www.wired.com/2008/09/space-x-did-it/; “Falcon-1,” Gunter's Space Page, 2019, https://space.skyrocket.de/doc_lau/falcon-1.htm; "SpaceX Successfully Launches Falcon 1 to Orbit," NASA, September 28, 2008, https://www.nasa.gov/offices/c3po/home/spacex_falcon1_flight_4.html.

180 "Korea Starts Construction for Space Center," Space Daily, August 12, 2003, http://www.spacedaily.com/news/korea-03b.html; "Naro Space Center, Space Science Museum," Visit Korea, http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_1_1_1.jsp?cid=813942.

181 Stephanie Wan, *U.S.-South Korean Space Cooperation* (Secure World Foundation, 2010), 6.

182 Miriam Kramer, "South Korea Launches Rocket in 1st Space Success," Space.com, January 30, 2013, https://www.space.com/19553-south-korea-launches-naro-rocket-satellite.html.

183 Harry Kim, "South Korea's Race to Space Is Lagging Behind," The Diplomat, November 21, 2017, https://thediplomat.com/2017/11/south-koreas-race-to-space-is-lagging-behind/.

INACTIVE SPACEPORTS

184 *Air University Space Primer* (Maxwell AFB, AL: Air University, 2003), 20-2.

185 Roberts and Schrag, “Spaceports of the World.”

186 "The Soviet Land-Based Ballistic Missile Program, 1945-1972", National Security Agency, https://www.archives.gov/files/declassification/iscap/pdf/2010-005-doc2.pdf, 27.

187 Siddiqi, *Challenge to Apollo: The Soviet Union and the Space Race,* 1945-1974, 53-54;

188 *Air University Space Primer*, 20-2.

189 H.N. Nesbitt, *History of the Italian San Marco Equatorial Mobile Range.*

190 Ibid.

191 "'Luigi Broglio' Space Center," A.S.I. - Agenzia Spaziale Italiana, June 8, 2015, https://www.asi.it/en/agency/bases/broglio.

192 Anatoly Zak, "Vostochny (formerly Svobodny) Cosmodrome," Russian Space Web, April 15, 2016, http://www.russianspaceweb.com/svobodny.html.

193 "ESA Permanent Mission in Russia," European Space Agency, accessed July 24, 2018, http://m.esa.int/About_Us/ESA_Permanent_Mission_in_Russia/Svobodny.

194 Ageyenko, “Russia’s Vostochny Cosmodrome Transforms the Far Eastern Region.”

195 Ageyenko, “Russia’s Vostochny Cosmodrome Transforms the Far Eastern Region.”

196 Zak, “Vostochny (formerly Svobodny) Cosmodrome.”

197 Ageyenko, “Russia’s Vostochny Cosmodrome Transforms the Far Eastern Region.”

198 National Photographic Interpretation Center, *Hammaguir Missile Test Centre, North Africa, Photographic Interpretation Report* (1964), https://www.cia.gov/library/readingroom/docs/CIA-RDP78T05439A000300300009-0.pdf.; Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems,* 4th ed.

199 Attila Nagy, "Fifty Years Ago Today France Launched Its First Satellite, Astérix," Gizmodo, November 26, 2015, https://gizmodo.com/fifty-years-ago-today-france-launched-its-first-satelli-1744774915.

200 Roberts and Schrag, “Spaceports of the World.”

201 Pike, “Hammaguir / Hamaguir.” *International Legal Materials,* “Algeria: France-Algeria Independence Agreements (Evian Agreements).”

202 J. Krige and A. Russo*, A History of the European Space Agency: 1958 - 1987* (European Space Agency, 2000), 10.

203 Isakowitz, Hopkins, and Hopkins, *International Reference Guide to Space Launch Systems,* 4th ed.

204 Campbell, “Woomera Rebooted - Building Our Next-Generation National Test Range Capability.”

205 Chad J. R. Ohlandt, "Competition and Collaboration in Space between the U.S., China, and Australia: Woomera to WGS and the Impact of Changing U.S. National Space Security Policy," *Asian Survey* 54, no. 2 (2014): 408.

206 "Fifty Years since First ELDO Launch," European Space Agency, June 5, 2014, https://m.esa.int/About_Us/Welcome_to_ESA/ESA_history/Fifty_years_since_first_ELDO_launch.

207 Malcom J. Phillips, "How It Started—Australia's Early Days in Space at Woomera," The Strategist, May 2, 2018, https://www.aspistrategist.org.au/started-australias-early-days-space-woomera/.

208 "WRESAT – Australia's First Satellite," International Astronautical Federation, accessed July 6, 2018, http://www.iafastro.org/wresat-australias-first-satellite/.

209 "Woomera Chosen as Rocket Launch Site for Space Station," ABC News, August 20, 2006, http://www.abc.net.au/news/2006-08-21/woomera-chosen-as-rocket-launch-site-for-space/1243418; Peter Hackett, "Woomera May Get Virgin Spaceport," *The Advertiser*, November 3, 2006, https://www.adelaidenow.com.au/news/woomera-may-get-virgin-spaceport/news-story/5f33c-c4f9d20fb9dde0c75602d2c9299.

FUTURE SPACEPORTS

210 "Licenses, Permits & Approvals," Office of Commercial Space Transportation, October 10, 2018, https://www.faa.gov/about/office_org/headquarters_offices/ast/licenses_permits/.

211 Melissa Ross, "First Launch At Jacksonville's Cecil Spaceport Could Come Before Year's End," WJCT News, February 14, 2018, http://news.wjct.org/post/first-launch-jacksonville-s-cecil-spaceport-could-come-year-s-end; "GOLauncher," Gunter's Space Page, 2019, https://space.skyrocket.de/doc_lau/golauncher.htm.

212 Jeff Foust, "Waiting for Liftoff," *SpaceNews Magazine*, July 18, 2016, http://www.spacenewsmag.com/feature/waiting-for-liftoff/.

213 "Colorado Blasts Off To The Future With Space Travel Plans," CBS Denver, March 2, 2012, https://denver.cbslocal.com/2012/03/02/colorado-blasts-off-to-the-future-with-space-travel-plans/.

214 Jeff Foust, "Colorado Airport Receives FAA Spaceport License," SpaceNews.com, August 21, 2018, https://spacenews.com/colorado-airport-receives-faa-spaceport-license/.

215 Ibid.

216 "Active Licenses," Federal Aviation Administration, accessed January 12, 2019, https://www.faa.gov/data_research/commercial_space_data/licenses/.

217 Jake Magee, "An Out-of-this-world Concept: Houston Spaceport Will Take Bay Area to New Heights," Community Impact Newspaper, October 5, 2018, https://communityimpact.com/houston/technology/2018/10/05/an-out-of-this-world-concept-houston-spaceport-will-take-bay-area-to-new-heights/.

218 Sierra Nevada Corporation, "Sierra Nevada Corporation and Houston Airport System Announce New Agreement," news release, March 24, 2015, https://www.sncorp.com/press-releases/snc-dc-houston-airport/.

219 Mike Wall, "Private Dream Chaser Space Plane Will Launch on Atlas V Rockets," Space.com, July 27, 2017, https://www.space.com/37636-dream-chaser-space-plane-on-atlas-v-rockets.html.

220 Doug Delony, "$18.8M for Phase 1 of Houston Spaceport Project Approved," KHOU, October 17, 2018, https://www.khou.com/article/tech/188m-for-phase-1-of-houston-spaceport-project-approved/285-605258095.

221 Joseph Basco, "FAA Approves Spaceport License for Midland International," Midland Reporter-Telegram, September 17, 2014, https://www.mrt.com/business/article/FAA-approves-spaceport-license-for-Midland-7415553.php; Jeff Foust, "FAA Awards Spaceport License to Texas Airport," SpaceNews.com, September 17, 2014, https://spacenews.com/41902faa-awards-spaceport-license-to-texas-airport/.

222 Mark Harris, "The Short Life and Death of a Space Tourism Company," Air & Space Magazine, December 2017, https://www.airspacemag.com/space/fate-of-the-lynx-180967118/.

223 Mark Carreau, "XCOR Selects West Texas For Suborbital, Orbital R&D Hub," Aviation Week, July 10, 2012, http://aviationweek.com/awin/xcor-selects-west-texas-suborbital-orbital-rd-hub.

224 Jeff Foust, "XCOR Aerospace Files for Bankruptcy," SpaceNews.com, November 9, 2017, https://spacenews.com/xcor-aerospace-files-for-bankruptcy/.

225 Sierra Nevada Corporation, "Midland International Air and Space Port Receives Dream Chaser Spacecraft Compatible Landing Site Designation," news release, November 3, 2016, https://www.sncorp.com/press-releases/snc-midland-spaceport/.

226 *Midland Air and Space Port, Spaceport Business Park*, accessed January 21, 2019, http://www.flymaf.com/DocumentCenter/View/188/Air-and-Space-Port-and-Spaceport-Business-Park-Brochure?bidId=.

227 Doug Messier, "XCOR Owes $27.5 Million to Creditors, Orbital Outfitters Out of Business," Parabolic Arc, November 21, 2017, http://www.parabolicarc.com/2017/11/21/xcor-owes-275-million-orbital-outfitters-business/.

228 Leonard David, "Spaceport to Rise in California Desert," *CNN*, May 25, 2004, http://www.cnn.com/2004/TECH/space/05/24/mojave.spaceport/index.html.

229 "Fact Sheet – Commercial Space Transportation," Federal Aviation Administration, June 28, 2010, https://www.faa.gov/News/Fact_Sheets/News_Story.cfm?newsId=11559.

230 Tony Long, "June 21, 2004: SpaceShipOne Reaches Space," *Wired*, June 21, 2011, https://www.wired.com/2011/06/0621space-shipone-first-private-spacecraft/.

231 "Launching a New Space Industry," Ansari XPRIZE, accessed January 17, 2019, https://ansari.xprize.org/prizes/ansari.

232 "Virgin Galactic Crash: Mojave Investigation under Way," *BBC News*, November 2, 2014, https://www.bbc.com/news/world-us-canada-29864533.

233 "SpaceShipTwo (SS2)," *Gunter's Space Page*, 2019, https://space.skyrocket.de/doc_lau/spaceshiptwo.htm.

234 Alan Boyle, "Stratolaunch Gets World's Biggest Airplane Ready for Takeoff with 136 Mph Taxi Test," GeekWire, January 9, 2019, https://www.geekwire.com/2019/stratolaunch-gets-worlds-biggest-airplane-ready-takeoff-136-mph-taxi-test/.

235 Jesse Pound, "The Space Wait Continues for Oklahoma Town," NewsOK.com, August 1, 2016, https://newsok.com/article/5511901/the-space-wait-continues-for-oklahoma-town.

236 Cyrus Farivar, "John Carmack's $8M Pipe Dream Meets Reality: Armadillo Aerospace on Life Support," Ars Technica, August 2, 2013, https://arstechnica.com/science/2013/08/john-carmacks-8m-pipe-dream-meets-reality-armadillo-aerospace-on-life-support/; Jeff Foust, "Armadillo Aerospace Suspends Vehicle Development Work," SpaceNews.com, August 2, 2013, https://spacenews.com/36590armadillo-aerospace-suspends-vehicle-development-work/.

237 Jesse Pound, "The Space Wait Continues for Oklahoma Town."

238 "Active Licenses," Federal Aviation Administration, accessed January 18, 2019, https://www.faa.gov/data_research/commercial_space_data/licenses/.

239 "Spaceport America FAQs," Spaceport America, accessed September 11, 2018, https://spaceportamerica.com/faqs/.

240 Tkatchova, *Emerging Space Market.*

241 "SpaceShip Two (SS2)," Gunter's Space Page, 2019, https://space.skyrocket.de/doc_lau/spaceshiptwo.htm.

242 Stella Tkatchova, *Emerging Space Markets*, 123.

243 Anthony Faiola, "Brazil's Spaceport Displaces Villagers," *Washington Post*, October 6, 2001, https://www.washingtonpost.com/archive/politics/2001/10/06/brazils-spaceport-displaces-villagers/8de27ae3-620b-434c-9ad5-ff0af77090bd/?utm_term=.16d90cffab21.

244 John Pike, "Alcantara Launch Center," Global Security, accessed July 11, 2018, https://www.globalsecurity.org/space/world/brazil/alcantara.htm.

245 National Photographic Interpretation Center *Brazilian Space Launch Vehicle Program* (S) (National Photographic Interpretation Center, 1982), http://www.thespacereview.com/archive/2050.pdf.

246 Frank Braun, "Brazil Exercises the Option to Say 'No,'" *The Brown Journal of World Affairs* 15, no. 2 (2009): 242; David Logsdon and Reeve Wolford, "U.S., Brazil Should Act Now to Forge a Partnership in Space," SpaceNews, February 28, 2018, https://spacenews.com/op-ed-u-s-brazil-should-act-now-to-forge-a-partnership-in-space/.

247 John Pike, "Alcantara Launch Center," Global Security, accessed July 11, 2018, https://www.globalsecurity.org/space/world/brazil/alcantara.htm.

248 Ibid.

249 Peter B. De Selding, "Brazil Pulling Out of Ukrainian Cyclone-4 Launcher Project," SpaceNews, April 17, 2015, http://spacenews.com/brazil-pulling-out-of-ukrainian-launcher-project/.

250 Jon Jeter, "At Least 21 Die In Rocket Blast At Brazil Base," *Washington Post*, August 23, 2003, https://www.washingtonpost.com/archive/politics/2003/08/23/at-least-21-die-in-rocket-blast-at-brazil-base/19541506-60f4-4ec4-aa8a-b6f2754203e4/?utm_term=.943e741e3539.

251 "Esrange Space Center," Swedish Space Corporation, accessed January 17, 2019, https://www.sscspace.com/ssc-worldwide/esrange-space-center/.

252 Jaroslaw Adamowski, "Sweden Eyes Small Satellite Market with Expanded Space Center," SpaceNews.com, November 21, 2017, https://spacenews.com/sweden-eyes-small-satellite-market-with-expanded-space-center/.

253 Anne Ytterskog et al., "One Step Further towards a European Launch Capability for Small Satellites – SmallSat Express," *15th International Conference on Space Operations*, May 2018, 1, https://arc.aiaa.org/doi/pdf/10.2514/6.2018-2491.

254 Miriam Kramer, "Spaceport Sweden Launches Aerial Northern Lights Tours, Aims for Space," Space.com, February 14, 2014, https://www.space.com/24697-spaceport-sweden-auroras-commercial-spaceflight.html.

255 "Swedish City Gears Up For Virgin Galactic Spaceport," *Wired*, April 25, 2008, https://www.wired.com/2008/04/swedish-city-ge/.

256 Michael Sheetz, "This Founder Split from Elon Musk and Is Now Launching Rockets for One-twentieth the Cost of SpaceX,"

CNBC, August 3, 2017, https://www.cnbc.com/2017/08/03/vector-space-systems-former-spacex-founder-launching-rockets-for-3m.html.

257 "Why Camden," Spaceport Camden, accessed January 18, 2019, https://spaceportcamden.us/why.php.

258 Dave Williams, "Camden County Submits License Application for Spaceport," *Atlanta Business Chronicles*, January 29, 2019, https://www.bizjournals.com/atlanta/news/2019/01/29/camden-county-submits-license-application-for.html.

259 "About Us," Protect Cumberland Island, accessed February 14, 2019, http://protectcumberlandisland.org/about-us/.

260 Protect Cumberland Island, "LCI Statement," press release, January 31, 2019, https://www.politico.com/f/?id=00000168-a57d-d2f5-a7eb-a77d64510002.

261 Jacqueline Klimas, "2 Japanese Space Companies Growing U.S. Operations," POLITICO Space, February 4, 2019, https://www.politico.com/newsletters/politico-space/2019/02/04/2-japanese-space-companies-growing-us-operations-385281.

262 "Tonghae Satellite Launching Ground," Nuclear Threat Initiative, June 7, 2013, http://www.nti.org/learn/facilities/201/.

263 William J. Broad, "North Korean Missile Launch Was a Failure, Experts Say," *New York Times*, April 6, 2009, https://archive.nytimes.com/www.nytimes.com/learning/students/pop/articles/06korea.html.

264 John Schilling, "The Musudan Could Be Operational Sooner Than Expected," 38 North, February 23, 2017, https://www.38north.org/2016/10/jschilling101716/.

265 38 North, "North Korea's Tonghae Satellite Launching Ground: Caretaker Status," 38 North, October 28, 2016, https://www.38north.org/2016/10/tonghae102816/.

266 Choe Sang-Hun, "North Korea Said to Stop Construction at Rocket Site," *New York Times,* July 23, 2013, https://www.nytimes.com/2013/07/24/world/asia/north-korea-is-said-to-halt-upgrades-at-rocket-launching-site.html.

267 Michael Graczyk, "Space Dreams Boost Tiny Texas Town," NBCNews.com, March 13, 2005, http://www.nbcnews.com/id/7151863/ns/technology_and_science-space/t/space-dreams-boost-tiny-texas-town/#.XEX84c9Kjrk.

268 United States, Department of Transportation, Federal Aviation Administration, *Commercial Space Transportation License: LRLO 17-105* (Washington, DC: FAA, 2017).

269 "New Shepard," Blue Origin, accessed January 17, 2019, https://www.blueorigin.com/new-shepard/.

270 Haidee V. Eugenio, "A.B. Won Pat Guam International Airport Moving Forward with Plans for Spaceport," Pacific Daily News, January 11, 2019, https://www.guampdn.com/story/news/2019/01/11/guam-international-airport-moves-forward-plans-spaceport/2534716002/.

271 Kevin Kerrigan, "Guam Airport May Host Launch of Satellites," *The Guam Daily Post*, December 19, 2018, https://www.postguam.com/news/local/guam-airport-may-host-launch-of-satellites/article_74e277fc-0274-11e9-aa56-13b3dc2f289f.html.

272 David S. F. Portree, "An Ideal Home in Space (1960)," *Wired*, June 4, 2017, https://www.wired.com/2013/03/the-ideal-home-in-space-1960/.

273 "APSC Dumps Queensland For Christmas Island," Space Daily, July 13, 1998, http://www.spacedaily.com/reports/APSC_Dumps_Queensland_For_Christmas_Island.html.

274 European Union, European Space Agency, *Duma Ratifies Space Agreements with ESA, Other Countries* (2004), http://www.esa.int/About_Us/ESA_Permanent_Mission_in_Russia/Duma_ratifies_space_agreements_with_ESA_other_countries/(print).

275 "Russian Approves New Australian Launch Project," Space Daily, March 26, 2001, http://www.spacedaily.com/news/apsc-01a.html.

276 Jos Heyman, "A Tale Of Two Spaceports," *SatMagazine,* May 2011, http://www.satmagazine.com/story.php?number=131406989.

277 Australia, *Territory of Christmas Island, Christmas Island Space Centre (APSC Proposal) Repeal Ordinance 2009*, by Quentin Bryce (2009), https://www.legislation.gov.au/Details/F2009L01469.

278 "Project Overview" Hawaii Air and Spaceport, accessed January 18, 2019, http://hawaiiairandspaceport.com/.

279 Sean Hao, "Hawaii May Apply for Spaceport License to Alleviate Tourism Slump," *Honolulu Advertiser,* July 14, 2009, http://the.honoluluadvertiser.com/article/2009/Jul/14/ln/hawaii907140334.html.

280 Tom Callis, "Alaska Company Proposes Satellite Launch Facility on Shipman Land," Hawaii Tribune-Herald, December 28, 2018, https://www.hawaiitribune-herald.com/2018/12/28/hawaii-news/alaska-company-proposes-satellite-launch-facility-on-shipman-land/.

281 Eric Berger, "Rocket Report: Blue Nears Flight, India to Double Up, Musk's Starship Love," Ars Technica, January 11, 2019, https://arstechnica.com/science/2019/01/rocket-report-blue-nears-flight-india-to-double-up-musks-starship-love/.

282 Alaska Aerospace Corporation, *2017 Annual Report* (Anchorage: Alaska Aerospace Corporation), https://akaerospace.com/sites/default/files/reports/AAC Annual Report 2017.pdf.

283 Tom Callis, "Spaceport Meeting Gets Heated," *West Hawaii Today,* January 26, 2019, https://www.westhawaiitoday.com/2019/01/26/hawaii-news/spaceport-meeting-gets-heated/.

284 Alaska Aerospace Corporation, *2017 Annual Report.*

285 Alaska Aerospace Corporation, *2017 Annual Report*; "Formerly Used Defense Sites Program," U.S. Army Corps of Engineers, accessed January 21, 2019, https://www.usace.army.mil/missions/environmental/formerly-used-defense-sites/.

286 Alaska Aerospace Corporation, *2017 Annual Report.*

287 MIT Portugal, "Atlantic International Satellite Launch Programme," news release, September 28, 2018, https://www.mitportugal.org/news/2319-atlantic-international-satellite-launch-programme

288 "Results 1st Stage," Atlantic International Satellite Launch Programme, accessed January 16, 2019, http://www.atlanticsatelliteprogramme.org/ISLP.html.

289 Berger, “Rocket Report: Blue Nears Flight, India to Double Up, Musk’s Starship Love.”

290 MIT Portugal, "Atlantic International Satellite Launch Programme."

291 Fundação Para a Ciência e a Tecnologia, "Atlantic International Satellite Launch Programme," news release, September 24, 2018, https://www.fct.pt/noticias/index.phtml.en?id=368&/2018/9/Atlantic_International_Satellite_launch_Programme.

292 Robert Goodwill, "Shortlist of locations for UK's first spaceport: Press conference" (speech, Farnborough, United Kingdom, July 15, 2014), https://www.gov.uk/government/speeches/spaceport-uk.

293 United Kingdom, *UK Government funding for vertical launch spaceport in Sutherland* (UK Space Agency, 2018), https://www.gov.uk/government/news/uk-government-funding-for-vertical-launch-spaceport-in-sutherland.

294 Jeff Foust, "Lockheed Martin, Orbex to Launch from New British Spaceport," SpaceNews.com, July 16, 2018, https://spacenews.com/lockheed-martin-orbex-to-launch-from-new-british-spaceport/.

295 Rye Druzin, "Blue Origin Completes 9th Successful Test in West Texas," ExpressNews.com, July 19, 2018, https://www.expressnews.com/business/local/article/Blue-Origin-completes-9th-successful-test-in-West-13089301.php#photo-15891653.

296 Eric Berger, "Texas, SpaceX Announce Spaceport Deal near Brownsville," *Houston Chronicle,* August 4, 2014, https://blog.chron.com/sciguy/2014/08/texas-spacex-announce-spaceport-deal-near-brownsville/.

297 Jeff Foust, "SpaceX Breaks Ground on Texas Spaceport," SpaceNews.com, September 22, 2014, https://spacenews.com/41957spacex-breaks-ground-on-texas-spaceport/.

298 Federal Aviation Administration, “Active Licenses.”

299 Jeff Foust, "Musk Teases New Details about Redesigned Next-generation Launch System," SpaceNews.com, December 24, 2018, https://spacenews.com/musk-teases-new-details-about-redesigned-next-generation-launch-system/.

300 Erik Wasson, "SpaceX Texas Launch Site Risks Being Split in Two by Border Wall," Bloomberg.com, February 8, 2019, https://www.bloomberg.com/news/articles/2019-02-08/musk-s-spacex-has-big-stake-in-outcome-of-border-security-talks.

CONCLUSION

301 "Soyuz Launch Site Ready for First Flight," European Space Agency, April 1, 2011, http://www.esa.int/Our_Activities/Space_Transportation/Soyuz_launch_site_ready_for_first_flight.

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

1616 Rhode Island Avenue, NW
Washington, DC 20036