Commercial Space Transportation

QUARTERLY LAUNCH REPORT

Special Report:

An Overview of the U.S. Commercial Space Launch Infrastructure

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Special Report

AN OVERVIEW OF THE U.S. COMMERCIAL SPACE LAUNCH INFRASTRUCTURE

Unprecedented Growth Seen for U.S. Commercial Space Launch Infrastructure

The commercial space transportation industry has witnessed unparalleled growth in the number of commercial launches over the past few years. Last year witnessed the largest number yet, 35 commercial launches worldwide, nearly twice the 21 commercial launches of the previous year. The United States, in particular, has experienced dramatic growth in commercial launch activity, with a record 17 commercial launches taking place in 1997 (up from 11 commercial launches in 1996). This growth trend is likely to continue, with a very ambitious 29 commercial launches planned for U.S. launch sites this year and at least another 25 such launches for 1999.

The United States government has, since the 1950s, built, operated, and maintained a space launch infrastructure for launching satellites into space. Most notably, Cape Canaveral Air Station and Vandenberg Air Force Base have been the backbone of the U.S. orbital launch infrastructure. Much of the demand for and use of these launch sites has traditionally come from U.S. military and civil government agencies. Beginning in the early 1980s, a number of the government-operated launch sites began providing support for commercial launch activities as well, with NASA acting as the primary intermediary for providing launch services to satellite operators. Following the Challenger accident, a White House decision in August 1986 ruled that launch customers could solicit bids directly from the launch vehicle builders who would, in turn, lease launch facilities

Figure 1. U.S. Commercial Space Launch Infrastructure

from NASA or the U.S. Air Force. This decision, coupled with the 1984 U.S. Commercial Space Launch Act and its 1988 amendments, did much to foster a true commercial launch business, which continues to grow to this day.

Today, even further commercialization of the U.S. launch infrastructure is evident, with two trends taking place in the launch industry. First, true commercially operated launch facilities have made significant progress toward realization. Earlier this year, the very first launch from a U.S. commercial launch site took place at Spaceport Florida. Second, the U.S. Air Force is taking steps to accommodate a much greater number of commercial launches from the federal ranges as well. A range modernization and upgrade program has been established to help reduce launch site costs and turn around times as well as to improve range flexibility and responsiveness. Some range organizations are also making business process improvements in a concerted effort to improve service quality for commercial and government users of the eastern and western ranges.

CURRENT COMMERCIAL LAUNCH SITES

Since September 1996, three organizations have been awarded a commercial Launch Site Operator License by the FAA Associate Administrator for Commercial Space Transportation. These licenses support three sites – Spaceport Florida, California Spaceport, and the Virginia Space Flight Center – which are co-located with federal launch facilities but are run by non-federal organizations at these sites.

Up until January 1998, the majority of U.S. commercial launch activity had taken place at the federal launch ranges. Spaceport Florida's launch of Lunar Prospector on an Athena 2 on January 6, 1998 marked the first ever launch from a commercial site. Sea Launch, a commercial partnership headed by Boeing Commercial Space Company, will begin operation of its own mobile launch facility off shore, in international waters, later this year. Sea Launch's mobility is similar to that of Orbital Sciences Corporation's Pegasus, an air-launched small launch vehicle deployed from an L-1011 aircraft. Other organizations examining the possibility of commercial launch sites include the Alaska Aerospace Development Corporation, the New Mexico Office of Space Commercialization, Beal Aerospace Technology, Inc., and the Texas Aerospace Commission. A discussion of each of the current and proposed commercial launch sites follows.

Spaceport Florida

The Spaceport Florida Authority (SFA) was established in 1989 by the state of Florida to facilitate the development of the state's space related industry. A commercial license from the FAA Associate Administrator for Commercial Space Transportation was awarded to the Spaceport Florida Authority on May 22, 1997. The SFA facility consists of about 70 acres of land owned by the U.S. Air Force and operated by the U.S. Navy's Strategic Systems Program Office. The Spaceport Florida Authority charges approximately $300,000 per use of the facility.

The cornerstone of SFA's efforts was refurbishing Launch Complex 46, an old Trident missile launch site at Cape Canaveral Air Station, to accommodate small commercial launch vehicles. The philosophy behind developing Launch Complex 46 was not to tailor a facility for a single launch system, but rather to build a public transportation infrastructure for several competing launch systems. SFA's Launch Complex 46 can accommodate a variety of launch vehicle configurations, and payload lift

capabilities up to 4,000 pounds to LEO are possible. In the future, the complex could even accommodate lift capabilities in excess of 4,900 pounds to LEO. From its position on Cape Canaveral, Launch Complex 46 can accommodate mission profiles with launch azimuths ranging from 47° NE to 110° SE (and any other azimuths that the Air Force would approve), and orbital inclinations from 28.5° to 58°. Launches to LEO, GEO, and interplanetary trajectories can be conducted from this site.

As Spaceport Florida is located on the Cape Canaveral Air Station, the commercial launch site can offer all necessary support services by relying on existing range infrastructure. Payload processing facilities, including cleanroom environments are available from off-site commercial providers, in addition to range tracking and telemetry equipment required to conduct launch operations.

Currently, the launch complex is configured to launch vehicles that use the Castor 120 or similar solid motor as a first stage. Examples include Lockheed Martin's Athena launch vehicle and Orbital Sciences Corporation's Taurus vehicle. Infrastructure can support launch vehicles with a maximum height of 120 feet and diameters ranging from 50 to 120 inches. The first launch from Launch Complex 46 was of the Lockheed Martin Athena 2 launch vehicle, which deployed the Lunar Prospector mission for NASA in January, 1998. The next launch planned from Spaceport Florida will be of the Athena 1 vehicle this December, when it will deploy the Rocsat satellite for Taiwan.

The next major effort by the SFA is to convert former Titan 1, Titan 2, and suborbital pads to service a variety of small launch vehicles for both orbital and suborbital launches. In September 1997, the SFA announced plans to develop Launch Complex 20, which includes three launch pads, a launch control blockhouse, and an on-site facility for small payload preparation and storage. The SFA hopes to take advantage of these facilities to provide a rapid response capability for the LEO communications satellite replacement market or for scientific payloads. By refurbishing the blockhouse, the SFA hopes to offer a multi-user launch control and data monitoring system that will serve several types of vehicle and payload systems. Development of Launch Complex 20 is expected to cost about $3 million. The Air Force will provide about $2.5 million in funding, and the State of Florida has appropriated $125,000 for the project, according to the Spaceport Florida Authority.

Other current SFA activities include the development of a new $16 million Space Operations Support Complex to provide a single operations facility for visiting launch and payload teams.

The Spaceport Florida Authority has also attracted several launch industry support providers to the state, including a $27 million liquid hydrogen rocket fuel production facility, a $27 million rocket motor storage facility, and a $5 million university-based satellite technology development center.

SPACEPORT FLORIDA
Cape Canaveral Air Station, Florida

Location.....28.5° N, 81° W
Launch Azimuths.....47° NE to 110° SE
Operator.....Florida Spaceport Authority
First Launch.....1998
Orbital Launches to Date.....1
First Commercial Launch.....1998
Orbits Addressed.....All Orbits
Most Launches in One Year.....1 (1998)
Most Commercial Launches.....1 (1998)
Vehicles Currently Serviced.....Athena
Vehicles Proposed for Site.....Taurus, various RLVs

California Spaceport

While the Spaceport Florida is operated by a public transportation authority, the California Spaceport is a commercially operated launch services company, utilizing leased property on Vandenberg Air Force Base. The California Spaceport is operated and managed by Spaceport Systems International, L.P. (SSI), a limited partnership between ITT Federal Services Corporation and California Commercial Spaceport, Inc.

The California Spaceport was the first commercial launch site to be licensed by the Associate Administrator for Commercial Space Transportation (September 19, 1996). From its position on Vandenberg, the launch site is situated to support a variety of mission profiles to low polar orbit inclinations, with possible launch azimuths ranging from 220° to 150°.

The focus of the California Spaceport's payload processing services was originally on the refurbishment of the Payload Preparation Room, which was a cleanroom facility designed to process three Space Shuttle payloads simultaneously. The Payload Preparation Room, located near Space Launch Complex 6 (SLC-6), is now leased by SSI as their Integrated Processing Facility (IPF). SSI will be a provider of payload processing services and orbital launch support services for both commercial and government users. California Spaceport provided payload processing services for the NASA Lewis satellite and has contracts to provide payload processing for two Earth Observation System (EOS) satellites.

California Spaceport's new launch complex, when complete, will be equipped to accommodate several configurations of small launch vehicles, based on either Castor 120 or Minuteman solid motor first stages. SSI also has plans to provide facilities to service launch vehicles using a variety of liquid and cryogenic fuels. Additionally, the completed launch complex will provide two Stack & Checkout Facilities for preparing launch vehicles. Rail-mounted Mobile Launch Platforms (MLP's) will transport the stacked vehicle and payload to the launch site.

Phase I construction at California Spaceport's launch complex began in 1995. Currently in place are the concrete flame ducts, communication, electrical, and water infrastructure. Phase II construction in preparation for the Minotaur launch will commence in the fall of 1998, to be completed by May 1999. Further construction will depend on requirements provided by the California Spaceport's next orbital launch customer.

In September 1999, California Spaceport will support the launch of an orbital payload under the Air Force's Orbital/Sub-orbital Program (OSP) intended to use surplus ballistic missile assets to deploy government payloads. The launch will be carried out by the new Minotaur launch vehicle, which consists of a modified Minuteman II first stage and second stage, with an Orbital Sciences Corporation Pegasus upper stage. The Minotaur will deploy JAWSAT, a

CALIFORNIA SPACEPORT
Vandenberg Air Force Base, Lompoc, California

Location	34.4° N, 120.35° W
Launch Azimuths	150° SE to 220° SW
Operator	Spaceport Systems International
First Launch	1999 (projected)
Orbital Launches to Date	None
First Commercial Launch	1999 (projected)
Orbits Addressed	LEO
Most Launches in One Year	N/A
Most Commercial Launches	N/A
Vehicles Currently Serviced	N/A
Vehicles Proposed for Site	Athena, Taurus, Minotaur, Various RLVs

joint project by the Air Force Academy and Weber State University.

Virginia Space Flight Center

The Virginia Space Flight Center (VSFC) is operated by the Virginia Commercial Space Flight Authority in cooperation with NASA at the Wallops Flight Facility on Wallops Island, Virginia.

The origins of this commercial launch site began at Virginia's Old Dominion University in 1992. That year, the Center for Commercial Space Infrastructure was created to establish commercial space research and operations facilities in the state of Virginia. The Center worked in cooperation with Wallops Flight Facility to develop a commercial launch infrastructure there. Three years later, Virginia Governor George Allen signed a bill into law creating the Virginia Commercial Space Flight Authority (VCSFA) as a public organization specifically to develop a Virginia commercial launch capability. The Center for Commercial Space Infrastructure is currently the Executive Directorate for the VCSFA.

From its position on Virginia's southeastern Atlantic coast, Wallops Island can accommodate orbital inclinations between 38° and 60°. Launch azimuths available from VSFC range between 90° east and 160° southeast (or any other azimuth approved by NASA Goddard Space Flight Center, Wallops Flight Facility, and the FAA). Facilities exist to service a variety of solid-fueled vehicles. The Virginia Commercial Space Flight Authority was awarded a commercial launch site operator license by the FAA on December 19, 1997.

In 1997, the VCSFA signed an agreement with NASA to use NASA facilities at Wallops in support of commercial launches under what is known as the NASA/Virginia Commercial Space Flight Authority Reimbursement Space Act Agreement. The 30-year agreement allows the Authority access to the NASA facilities on a cost reimbursement basis.

VIRGINIA SPACE FLIGHT CENTER
Wallops Flight Facility, Virginia

Location	37.8° N, 75.5° W
Launch Azimuths	90° E to 160° SE
Operator	Virginia Commercial Space Flight Authority
First Launch	1999 (projected)
Orbital Launches to Date	None
First Commercial Launch	1999 (projected)
Orbits Addressed	LEO
Most Launches in One Year	N/A
Most Commercial Launches	N/A
Vehicles Currently Serviced	N/A
Vehicles Proposed for Site	Athena, Taurus, various RLVs

The Virginia Space Flight Center is not the first commercial venture at Wallops Flight Facility. In 1994, EER Systems of Seabrook, Maryland, built and operated pad LP 0-A, to be used by EER's Conestoga launch vehicle. The Conestoga's first and only attempted launch from this location took place in fall 1995. The launch pad is still commercially owned by EER Systems.

Development of the commercial facilities include completion of launch pad LP 0-B, which will consist of a 19,000-square foot pad and a 182-foot service tower, equipped with a 75-ton crane for vehicle and payload handing. Phase I construction of the pad began in early 1998 and is planned to be completed by the end of the year. Phase I includes the pad, launch mount, and some additional supporting infrastructure. The service tower will be included in subsequent phases. The new pad is designed as a "Universal Launch Pad," capable of supporting a variety of small and medium launch vehicles. The most likely vehicles

for the facility are the Lockheed Martin Athena or the Orbital Sciences Corporation Taurus.

A new payload processing and integration facility with a class-100,000 cleanroom[1] is also planned. Other available facilities include downrange tracking equipment, including a ground station on Antigua and the mobile ground equipment based out of Wallops.

Sea Launch

In April 1995 it was announced that a new venture called Sea Launch planned to loft Ukrainian-built Zenit rockets from a mobile, floating launch platform in international waters in the east-central equatorial Pacific Ocean. The Sea Launch partnership is led by Boeing Commercial Space Company and includes Norwegian ship building company Kvaerner Maritime a.s., the Ukrainian rocket builder KB Yuzhnoye, and the Russian space company RKK Energia, which produces the vehicle's upper stage.

The Sea Launch system consists of three main parts: the Assembly & Command Ship (ACS), the launch platform, and the Zenit 3SL vehicle. The ACS houses the vehicle integration facilities and is where the vehicle stages are assembled while docked at the Sea Launch home port in Long Beach, CA. Ground breaking began at the home port in August 1996 and was completed in March 1998. Construction of the ACS began in December 1995. The ship was later outfitted with launch systems hardware at St. Petersburg, Russia. The command ship departed Russia in June 1998 and arrived in Long Beach in mid-July.

The launch platform is a self-propelled semi-submersible ocean vessel converted from an oil-drilling platform. Installation of the launch support hardware began in Russia in April 1997 before the platform departed for Long Beach in June 1998. The launch hardware included the transporter erector system, fueling systems, and control systems for the highly automated Zenit vehicle.

The Zenit, on which the Sea Launch vehicle is based, is built by Yuzhnoye of Dnepropetrovsk, Ukraine. Unlike other Soviet heritage launch vehicles, Zenit was not derived from a ballistic missile. Rather, it was built as a next generation space launch vehicle in the early 1980's and has been primarily used to loft heavy LEO satellites for the Soviet and Russian military.

Payload processing for Sea Launch is conducted at Astrotech's new Payload Processing Facility located at the Long Beach home port. The integrated vehicle is rolled off onto the launch platform, where an environmentally controlled hanger stores the vehicle until launch. The command ship and the launch platform then depart for the launch site, located along the equator about 1,400 miles from Hawaii. The vehicle is rolled out of the hanger and erected on the launch platform, while launch operations are conducted from the control ship.

SEA LAUNCH
Pacific Ocean

Location .....Mobile (first launch from 0° N, 154° W)
Launch Azimuths .....N/A
Operator.....Sea Launch
First Launch.....Projected 1998
Orbital Launches to Date.....None
First Commercial Launch.....None
Orbits Addressed.....GEO, MEO
Most Launches in One Year.....N/A
Most Commercial Launches.....N/A
Vehicles Currently Serviced.....None
Vehicles Proposed for Site.....Zenit Sea Launch

[1] A class-100,000 cleanroom is a facility inside which each cubic foot of air contains no more than 100,000 particles greater than or equal to 0.5 microns in size.

Sea Launch has firm commitments for 18 launches: thirteen for Hughes and five for Loral. The first launch of the Zenit Sea Launch is planned for early 1999 and will loft the Galaxy 11 satellite for PanAmSat.

Pegasus

A report on the U.S. commercial launch infrastructure would not be complete without some mention of the Pegasus launch vehicle manufactured by Orbital Sciences Corporation. Because this vehicle is air-launched from underneath an aircraft, the Pegasus launch system is considered unique from "fixed' launch systems in that its launch site is mobile (not unlike the Sea Launch platform, which can change its ocean-based location to accommodate a variety of launch requirements).

The Pegasus is primarily used to launch small payloads to LEO for U.S. government and commercial customers. A B-52 aircraft and, now, an L-1011 aircraft have departed from numerous locations carrying the Pegasus launch vehicle, demonstrating the mobility offered by its air-launched configuration. Pegasus launch sites, from which the aircraft have flown, have included Vandenberg Air Force Base, Edwards Air Force Base, Kennedy Space Center, Wallops Flight Facility, Cape Canaveral Air Station, as well as one launch from the Spanish Canary Islands (the only Pegasus launch from a location outside of the United States).

PEGASUS
Various Launch Locations

Location ..... Mobile
Launch Azimuths ..... N/A
Operator ..... Orbital Sciences Corporation
First Launch 1990
Orbital Launches to Date 22
First Commercial Launch 1993
Orbits Addressed ..... LEO, ELI
Most Launches in One Year 5 (1996, 1997)
Most Commercial Launches 3 (1997)
Vehicles Currently Serviced ..... Pegasus
Vehicles Proposed for Site ..... N/A

The launch from Spain successfully deployed the Minisat 01 satellite for the Spanish National Institute of Aerospace Technology (INTA) on April 21, 1997. Officials at Orbital Sciences Corporation have indicated that they would like to conduct additional launches from satellite owners' home countries in the future.

PROPOSED COMMERCIAL LAUNCH SITES

Southwest Regional Spaceport

The Southwest Regional Spaceport (SRS) is a proposed commercial launch site that would be located adjacent to the White Sands Missile Range in New Mexico.

The Southwest Regional Spaceport has been promoted by the New Mexico Office of Space Commercialization (NMOSC), a division of the Economic Development Department of the State of New Mexico. Support for developing a spaceport comes from the U.S. Air Force and the New Mexico State government. The Environmental Impact Study for this site was funded with $1.3 million in state funds.

Unlike the other commercial launch sites, the Southwest Regional Spaceport would be able to service the next generation of reusable launch vehicles (RLVs) due to its inland location. Previously McDonnell Douglas had used White Sands for testing and development of the Clipper Graham (or DC-XA), a precursor to a vertical take-off and landing reusable launch vehicle. The New Mexico site was a strong contender as a site for continued DC-XA development under the NASA X-33 program, as well as the further development of an operational RLV based on that

SOUTHWEST REGIONAL SPACEPORT
White Sands, New Mexico

Location .....33° N, 106.5° W
Launch Azimuths .....N/A
Operator.....New Mexico Office of Space Commercialization
First Launch.....N/A
Orbital Launches to Date.....None
First Commercial Launch .....N/A
Orbits Addressed .....Planned suborbital, LEO
Most Launches in One Year .....N/A
Most Commercial Launches.....N/A
Vehicles Currently Serviced.....None
Vehicles Proposed for Site .....Various RLVs

design. Lockheed Martin's lifting body configuration was chosen for the X-33 program over the McDonnell Douglas proposal. Nevertheless, attracting an RLV launch provider remains a priority for the New Mexico site.

Several studies related to building a commercial launch site in New Mexico have been conducted. In April 1995, an 18-month study was completed by New Mexico State University's Physical Sciences Lab and McDonnell Douglas outlining requirements for a site to conduct commercial and government launches. Environmental impact studies are also progressing. A commercial launch facility at the New Mexico site would initially use tracking facilities from neighboring White Sands. Plans also call for construction of launch pads, an aircraft runway, and payload processing facilities. The cost of establishing a commercial launch site at the New Mexico site has been estimated to be between $80 and $120 million.

Kodiak Launch Complex

Narrow Cape, on Kodiak Island off the southern coast of Alaska, is the Alaska Aerospace Development Corporation's site for the state's first commercial launch site. From this location, the launch site can accommodate a variety of orbital and sub-orbital mission profiles. The location's wide launch-azimuth range allows for launches between 64° posigrade and 64° retrograde. This feature would allow a variety of remote sensing, communication, and scientific payloads to be launched into LEO and highly elliptical orbits.

The Alaska Aerospace Development Corporation (AADC) is a public corporation founded by the Alaskan state government in 1991 to support the development of the aerospace industry in Alaska. In 1993, the agency was awarded $1.1 million from the U.S. Air Force to develop plans for a launch complex in Alaska that would be capable of launching payloads of about 3,500 pounds to a high inclination orbit. In 1994, the AADC rejected a proposal to build a launch site at the Poker Flat Research Range, a university-owned facility for launching sounding rockets near the city of Fairbanks, in favor of the Kodiak facility. In 1996, the Air Force awarded the AADC $6 million to support launches of Minuteman II derivative vehicles, with launches commencing in 1998 under the Orbital/Sub-orbital Program (OSP).

A commercial launch site license application was filed by AADC with the FAA on January 22, 1997 for the Kodiak Launch Complex.

Construction of the new launch site began in

KODIAK LAUNCH COMPLEX
Narrow Cape, Kodiak Island, Alaska

Location .....57.5° N, 153° W
Launch Azimuths .....116° SE to 244° SW
Operator.....Alaska Aerospace Development Corp.
First Launch.....Projected 1998
Orbital Launches to Date.....None
First Commercial Launch .....None
Orbits Addressed .....Planned suborbital, LEO, highly elliptical
Most Launches in One Year .....N/A
Most Commercial Launches.....N/A
Vehicles Currently Serviced.....None
Vehicles Proposed for Site .....Athena, Taurus, various RLVs

January 1998, and AADC plans to conduct its first launch from Kodiak Launch Complex in September 1998. The first launch will be a suborbital launch for the U.S. Air Force Space and Missile Systems Center, Launch Test Programs Division (SMC/TEB) at Kirtland AFB, NM. The primary goal of the flight will be to simulate a ballistic missile attack profile and evaluate the performance of early warning radar systems. The ait-1 (atmospheric interceptor technology) mission will use a vehicle supplied by Orbital Sciences Corporation.

The vehicle's first and second stages will be a modified second and third stage Minuteman II, without the Minuteman II first stage.

The fully operational commercial launch site would include facilities for payload processing, including a class-100,000 cleanroom. The payload processing facility will include a 40-foot by 60-foot airlock and a 40-foot by 60-foot processing bay, each with 2,400 sq. ft. of floor space. Detailed designs have also been completed for the pad service structure and a facility for transporting the completed vehicle to the pad. No firm orbital launch customers have yet been found for the Kodiak site.

The AADC is also supporting the development of ground station facilities near Fairbanks, Alaska in cooperation with several commercial remote sensing companies. The high latitude location makes the Fairbanks site favorable for polar orbiting satellites, which typically pass above Fairbanks several times daily. Also under consideration is the use of Wallops Flight Facility's mobile tracking stations.

Other Proposed Commercial Launch Sites

Beal Aerospace Technology, Inc. has selected Sombrero Island in the Caribbean to be the launch site for its BA-2 launch vehicle. From this location, the BA-2 will be able to address a variety of orbital destinations, and the low latitude of the site will allow the BA-2 to deliver more than 11,000 pounds to geosynchronous transfer orbit. The Caribbean nation of Anguilla has leased Sombrero Island to Beal Aerospace under a 98-year exclusive use agreement. The island is a dependent territory of the United Kingdom and is located about 35 miles northwest of Anguilla. Sombrero Island is approximately one mile long and three-eighths of a mile across, comprising 100 acres. Sombrero Island is uninhabited, except for a lighthouse located at one end of the island. Beal Aerospace plans to construct a launch pad for its BA-2 vehicle at one end of the island and a horizontal vehicle integration building at the other. Additional planned infrastructure includes an aircraft runway, a heavy-load roadway between the vehicle integration building and the launch pad, and a port area near the vehicle integration building to allow barge access for vehicle stages and other equipment. Beal Aerospace Technology, Inc. is unique in that it is developing a new vehicle and launch site as a wholly commercial venture.

The Texas Aerospace Commission, an agency established by the Texas state government to promote development of aerospace industries in Texas, has been investigating the possibility of establishing a commercial launch site in that state. Currently up to seven sites including five along the Texas gulf coast and two in west Texas are being evaluated as potential locations for the commercial launch site. Texas Aerospace Commission officials are continuing discussions with various government and launch industry representatives concerning Texas as a host for a new launch site.

COMMERCIAL DEVELOPMENTS AT THE FEDERAL RANGES

The U.S. federal ranges have supported commercial launch activity since the mid 1980s. The Eastern range at Cape Canaveral and the Western range at Vandenberg Air Force Base are where the bulk of the nation's government and commercial launches are conducted today. Additional orbital launch activities are conducted at the Kennedy Space Center, Wallops Flight Facility, and Edwards Air Force Base. Wallops has also supported commercial launches of Pegasus from other locations, such as Spain. A number of government-operated missile and scientific research sites (e.g., White Sands, the Pacific Missile Range Facility) have also been home to FAA-licensed suborbital launch activity. Other suborbital facilities, such as Kwajalein and Poker Flat, have considered expanding their launch sites to full-fledged orbital launch facilities as well.

The U.S. government, primarily the Air Force, is preparing to accommodate the continuing increase in the number of commercial launches from the federal launch sites. This will be accomplished through range modernization programs that will upgrade much of the range's support and communications systems. The U.S. Air Force began a complete range modernization program in 1987 and in July 1993. The Range Standardization and Automation (RSA) program is a key effort to modernize and upgrade the Eastern range at Cape Canaveral and portions of the Western range at Vandenberg.

The RSA program will replace obsolete 1960s and 1970s vintage telemetry, tracking, command and control, weather, area surveillance, and communications systems with modern and efficient systems. The program is intended to help reduce range costs and turn around times, and improve range flexibility and responsiveness.

One of the key RSA proposals is the change from ground-based radar tracking to GPS-based tracking. This will provide highly accurate launch vehicle time, space, and position information. However, it will also require upgrades to both U.S. range systems and launch vehicles. Once these conversions are complete, the U.S. Air Force projects that it will be able to close 12 range radars, saving over $300M in operations and sustainment costs.[2]

Launch pad modifications are also underway to accommodate the next generation of the Delta and Atlas launch systems, the Delta 3 and the Atlas 3. Work is also progressing to support the new EELV family of launch vehicles, each being separately developed by Boeing and Lockheed Martin. A more complete discussion on each of the federal launch sites and their individual efforts at modernization and upgrades is provided below.

Cape Canaveral Air Station

The two launch complexes at Cape Canaveral Air Station (CCAS) most frequently used for commercial launch activity are launch complexes 17 and 36, used for Delta and Atlas vehicles respectively. CCAS also currently supports launches of Athena, Titan, and Pegasus vehicles.

The Boeing Delta 2 launch vehicle family has deployed a wide variety of commercial and government payloads from CCAS. The Globalstar system of LEO communication satellites have been launched on Delta 2 vehicles.

[2] Speech by Lt Gen Lord at the Federal Aviation Administration's conference on *Commercial Space Transportation in the 21st Century: Technology and Environment, 2001-2025*, 10 February 1998, at the Key Bridge Marriott Hotel, Arlington, VA

The Delta 2 is also used to launch medium-weight class satellites to GEO from Launch Complex 17 pads A and B. Pad B has been modified to accommodate the larger Delta 3, which will be used to launch intermediate-weight class GEO communications satellites. Improvements include new flame ducts and additional umbilical connectors. The first Delta 3 launch will deploy the Galaxy 10 satellite for PanAmSat in August of this year.

The Lockheed Martin Atlas 2 launch vehicle family primarily uses CCAS to launch intermediate-weight class communications satellites to GEO from Launch Complex 36 pads A and B. Pad B is undergoing modifications for the Atlas 3, which is expected to launch its first payload in early 1999. Modifications include improvements to the Mobile Service Tower, Umbilical Tower, and Launch Support Building. New flame ducts are also being installed, along with a variety of equipment related to fueling vehicles with liquid propellants. Work on both the Atlas and Delta pads is being conducted concurrently on a non-interference basis with existing Atlas 2 and Delta 2 operations from these pads.

CAPE CANAVERAL AIR STATION
Merritt Island, Florida

Location	28.5° N 81° W
Launch Azimuths	93° SE to 105° SE
Operator	U.S. Air Force / 45th Space Wing
First Launch	1950
Orbital Launches to Date	508
First Commercial Launch	1982
Orbits Addressed	All orbits
Most Launches in One Year	30 (1966)
Most Commercial Launches	9 (1990, 1995, 1996)
Vehicles Currently Serviced	Atlas 2, Athena 1 & 2, Delta 2, Titan 4, Pegasus
Vehicles Proposed for Site	Atlas 3, Delta 3, Delta 4, Lockheed Martin EELV, various RLVs

Modernization of range support equipment, including radar and telemetry facilities, play a vital part in the commercial launch providers' ability to conduct launch operations efficiently and cost effectively. The Range Operations Control Center (ROCC) began initial services in 1995, after an eight-year effort to modernize and consolidate range safety assets at Cape Canaveral Air Station. Improvements at CCAS allowed for better handling of information related to range communications, range safety control systems, scheduling, weather forecasting at the range, and other data processing functions.

Vandenberg Air Force Base

Almost all launch activity to date from Vandenberg Air Force Base (VAFB) has been for missions to low Earth orbit, the majority for government customers. Vandenberg Air Force Base has supported commercial activity since 1989. To date, all 18 commercial launches from VAFB have been LEO launches.

The Boeing Delta 2 launch vehicle has carried out commercial missions from Vandenberg as well as from Cape Canaveral. The Vandenberg launch site is situated to accommodate mission profiles to polar LEO orbits and has been used to deploy the Iridium constellation of communication satellites. Work was completed on the pad at Space Launch Complex 2 West (SLC 2W) in 1995 to accommodate Delta 2 launches, and can handle up to six launches annually.

The Lockheed Martin Atlas 2 has not flown commercial missions from Vandenberg, but Space Launch Complex 3 East (SLC 3E) has been modified to handle future launches of the Atlas 2. The first mission for the Atlas 2 at Vandenberg will be to deploy the Earth Observation System (EOS) AM-1 mission for NASA on an Atlas 2AS, now set for early 1999. Extensive work at

VANDENBERG AIR FORCE BASE
Lompoc, California

Location ..... 34.4° N 120.35° W
Launch Azimuths ..... 147° SE to 286° NW
Operator ..... U.S. Air Force / 33rd Space Wing
First Launch 1958
Orbital Launches to Date 591
First Commercial Launch 1989
Orbits Addressed ..... LEO
Most Launches in One Year 46 (1966)
Most Commercial Launches 9 (1997)
Vehicles Currently Serviced ..... Atlas 2, Athena 1 & 2, Delta 2, Titan 2, Titan 4, Pegasus
Vehicles Proposed for Site ..... Athena, Taurus, various RLVs

this facility included a new mobile service tower and umbilical tower, for a total project cost of about $300 million. At least three additional classified launches for the Department of Defense have been identified for polar Atlas 2 launches through 2002. The Atlas 2 can be used to launch to a variety of polar LEO orbits from this location, but no commercial customers are known to have purchased a polar Atlas 2 launch at this time.

Kennedy Space Center

The Kennedy Space Center (KSC) is located on Merritt Island adjacent to the U.S. Air Force launch facilities at the Cape Canaveral Air Station. It was originally created to support the Apollo lunar landing program, and all of the crewed Apollo flights took place from KSC. Following the last Saturn launches from this site it was modified to support the Space Shuttle program. In addition to ongoing non-commercial Shuttle flights, between 1982 and 1986, 11 Shuttles were launched from the KSC with commercial payloads. Since that time there have been no commercial shuttle flights, although United Space Alliance has proposed a return to commercial shuttle operations.

KENNEDY SPACE CENTER
Merritt Island, Florida

Location ..... 28.5° N, 81° W
Launch Azimuths ..... 39° NE to 120° SE
Operator ..... NASA
First Launch 1964
Orbital Launches to Date 119
First Commercial Launch 1982
Orbits Addressed ..... All Orbits
Most Launches in One Year 9 (1985)
Most Commercial Launches 4 (1985)
Vehicles Currently Serviced ..... Space Shuttle
Vehicles Proposed for Site ..... N/A

In 1985, a commercial Pegasus launch was made from the KSC. There have been no Pegasus launches from this site since.

Wallops Flight Facility

Wallops Island has operated as a sounding rocket range since 1945 and conducted its first orbital launch in 1961, when a Scout launch vehicle deployed the Explorer 9 balloon that was used to study atmospheric density. Since that time, several orbital and suborbital missions have been conducted at Wallops for NASA. In 1994, EER Systems completed launch pad LP 0-A, which was built to support its Conestoga launch vehicle. The first and only flight of Conestoga failed to deploy the METEOR recoverable satellite, designed for microgravity experiments, in 1995.

Other orbital launches from Wallops have included flights of Orbital Sciences Corporation's Pegasus air-launched vehicle, the first of which deployed the MSTI 3 satellite in 1996 on a commercially licensed launch. The next two Pegasus flights will deploy 16 Orbcomm LEO communication satellites this year. In April 1996, the Air Force designated Wallops Flight Facility as one of the sites to conduct launches of converted Minuteman II missiles under the Orbital/Sub-orbital Program (OSP), along with Kodiak Launch Complex and the California Spaceport.

WALLOPS FLIGHT FACILITY
Wallops Island, Virginia

Location .....37.8° N 75.5° W
Launch Azimuths .....90° E to 109° SE and 126° SE to 129° SE
Operator.....NASA
First Launch.....1945
Orbital Launches to Date.....26*
First Commercial Launch 1995
Orbits Addressed .....LEO
Most Launches in One Year.....3 (1961, 1964, 1965)
Most Commercial Launches.....3 (1961, 1964, 1965)
Vehicles Currently Serviced.....Pegasus
Vehicles Proposed for Site .....N/A
* Includes Pegasus launches.

At present, a Wallops tracking station located on the island of Bermuda has not been appropriated funds for continued operation. Plans call for using the TDRS satellites for tracking purposes.

Other Federal Launch Facilities

Several military ranges have also entered the commercial space market, either launching commercial missions or using commercially-available launch vehicles. In one example, two licensed commercial suborbital flights of a Talos Castor were launched from Barking Sands, Hawaii, in September 1994. These launches carried the Zest 1 and Zest 2 experiments for the Ballistic Missile Defense Organization (BMDO). Between 1989 and 1996, eight commercial suborbital missions launched from New Mexico's White Sands Missile Range. One of these launches lofted a Black Brant 9 for EER Systems while the remaining seven launches were of Starfire vehicles. Edwards Air Force Base was the site of six non-commercial flights of the commercially-available Pegasus rocket between 1990 and 1994.

In 1997, the Department of Energy granted the Nevada Test Site (NTS) Development Corporation access to the Nevada Test Site for commercial development. Original plans called in part for Kistler Aerospace to use the test site as the development and launch site for its K-1 reusable two-stage launch vehicle. Kistler must first obtain approval from the Federal Aviation Administration before beginning operations in Nevada. Kistler has also invested $32 million in the development of a launch site in Woomera, Australia. Construction in Woomera began in May 1998 and the first test launch is scheduled to take place in the second half of 1998.

The Army first considered offering the Kwajalein Missile Range, located about 2500 miles southwest of Honolulu, as a commercial space launch site in 1997. According to the U.S. Army Space and Missile Defense Command, Kwajalein's near-equatorial position makes it an ideal site for launching larger payloads into a geostationary orbit. As of early July 1998, it is unknown whether plans to develop Kwajalein as a commercial launch site will proceed.

OTHER FEDERAL LAUNCH SITES:

EDWARDS AIR FORCE BASE
California

Location .....35° N 117° W
Launch Azimuths .....N/A
Operator.....U.S. Air Force
First Launch.....1990
Orbital Launches to Date.....6
First Commercial Launch .....None
Orbits Addressed .....LEO
Most Launches in One Year 3 (1994)
Most Commercial Launches.....N/A
Vehicles Currently Serviced.....Pegasus
Vehicles Proposed for Site .....Various RLVs

PACIFIC MISSLE RANGE FACILITY
Barking Sands, Kauai, Hawaii

Location .....22.7° N 157.40° W
Launch Azimuths .....N/A
Operator.....U.S. Navy
First Launch.....1962
Orbital Launches to Date.....None
First Commercial Launch 1991
Orbits Addressed .....Suborbital only
Most Launches in One Year .....N/A
Most Commercial Launches.....2 (1991)
Vehicles Currently Serviced.....None
Vehicles Proposed for Site .....None

KWAJALEIN MISSILE RANGE
Kwajalein Atoll, Marshall Islands

Location .....9.15° N 166.12° W
Launch Azimuths .....N/A
Operator.....U.S. Army
First Launch.....N/A
Orbital Launches to Date.....None
First Commercial Launch .....None
Orbits Addressed .....Suborbital only, proposed all orbits
Most Launches in One Year .....N/A
Most Commercial Launches.....N/A
Vehicles Currently Serviced.....None
Vehicles Proposed for Site .....Various ELVs & RLVs

OTHER FEDERAL LAUNCH SITES (CONTINUED)...

POKER FLAT RESEARCH RANGE
University of Alaska Fairbanks, Alaska

Location .....65.07° N 147.29° W
Launch Azimuths .....N/A
Operator.....Geophysical Institute, NASA
First Launch.....1968
Orbital Launches to Date.....None
First Commercial Launch .....None
Orbits Addressed .....Suborbital only
Most Launches in One Year .....N/A
Most Commercial Launches.....N/A
Vehicles Currently Serviced.....None
Vehicles Proposed for Site .....Various RLVs

WHITE SANDS MISSILE RANGE
Tularosa Basin, New Mexico

Location .....33° N 106.5° W
Launch Azimuths .....N/A
Operator.....Department of Defense
First Launch.....1945
Orbital Launches to Date.....None
First Commercial Launch 1989
Orbits Addressed .....Suborbital only
Most Launches in One Year .....N/A
Most Commercial Launches.....2 (1989)
Vehicles Currently Serviced.....None
Vehicles Proposed for Site .....Various RLVs