Federal Aviation Administration

The Annual Compendium of Commercial Space Transportation: 2014

February 2015

About the FAA Office of Commercial Space Transportation

The Federal Aviation Administration's Office of Commercial Space Transportation (FAA AST) licenses and regulates U.S. commercial space launch and reentry activity, as well as the operation of non-federal launch and reentry sites, as authorized by Executive Order 12465 and Title 51 United States Code, Subtitle V, Chapter 509 (formerly the Commercial Space Launch Act). FAA AST's mission is to ensure public health and safety and the safety of property while protecting the national security and foreign policy interests of the United States during commercial launch and reentry operations. In addition, FAA AST is directed to encourage, facilitate, and promote commercial space launches and reentries. Additional information concerning commercial space transportation can be found on FAA AST's website:

http://www.faa.gov/go/ast

Cover art: Phil Smith, The Tauri Group (2015)

NOTICE

TABLE OF CONTENTS

LIST OF FIGURES

COMMERCIAL SPACE TRANSPORTATION YEAR IN REVIEW

LAUNCH SITES

2013 COMMERCIAL SPACE TRANSPORTATION FORECASTS

LIST OF TABLES

INTRODUCTION

The Commercial Space Transportation Compendium by the Federal Aviation Administration's Office of Commercial Space Transportation (FAA AST) provides an overview of the industry's activities from the past year, including:

- review of all orbital launches in 2014;
- orbital launch vehicles, suborbital reusable vehicles, and on-orbit vehicles and platforms that launched in 2014 or reached advanced stages of development;
- commercial and government launch sites;
- other commercial ventures, including companies investing in opportunities beyond low Earth orbit;
- regulations related to commercial space transportation; and
- a forecast of global launch demand.

In addition, throughout each of these sections are brief highlights of significant events from 2014.

See the appendices for other resources, including:

- the 2014 manifest of worldwide orbital launches;
- definitions of terminology; and
- a list of acronyms and abbreviations.

2014 BUSY YEAR IN U.S. COMMERCIAL SPACEFLIGHT

- Highest estimated U.S. launch revenues in 16 years: $1.1B
- Highest number of licensed orbital launches since 2004
- Busiest year for development of safety regulations and environmental reviews
- Highest number of active and proposed commercial launch sites ever

TOTAL LICENSED ORBITAL LAUNCHES 12 (71% ↑ from 2013)

TOTAL PERMITTED LAUNCHES 7 (same as 2013)

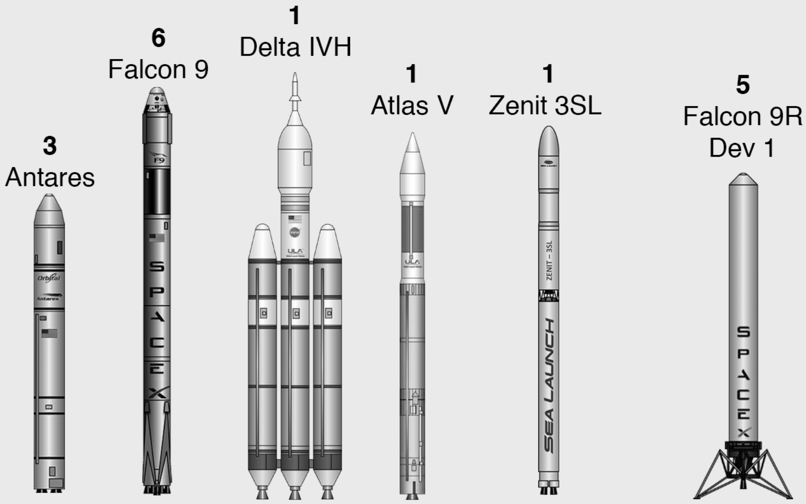
$1.1B 2014 estimated FAA-licensed launch revenues

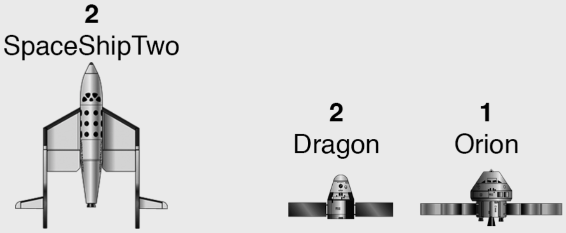
Five FAA-licensed cargo missions to ISS were conducted in 2014, with one launch failure experienced by Antares

NASA’s EFT 1 flew on an FAA-licensed United Launch Alliance Delta IV Heavy

SpaceX concluded five Falcon 9R flights from its site in McGregor, Texas

Scaled Composites conducted two powered flights of SpaceShipTwo in 2014. One flight ended in failure, resulting in two crew casualties





Licensed Launch Activity **Permitted Launch Activity** **Reentry Activity**

FAA AST 2014 ACTIVITIES

LICENSES AND PERMITS

- 25% increase in launch licenses, reentry licenses, and experimental permits from previous year (20 in 2014, 16 in 2013)
- Issued launch site license for Midland International Air and Space Port in Midland, Texas
- Issued safety approval for Waypoint 2 Space and Black Sky Training for spaceflight participant training
- Working with Florida, New Mexico, and Texas on new launch support facilities and launch sites
- FAA AST working with National Transportation Safety Board on the October 31, 2014 accident involving SpaceShipTwo

ENVIRONMENTAL IMPACT ASSESSMENTS

- FAA AST hosted two public hearings in Florida seeking input on the proposed Shiloh Spaceport on Merritt Island.
- The office published the final environmental impact assessment for the SpaceX launch site in Brownsville, Texas.

INFORMING REGULATIONS

- Issued “Recommended Practices for Human Space Flight Occupant Safety” designed to enable discussion on safety practices.

STUDIES

- Monitors all worldwide launches - provides U.S. Government and industry with data
- Develops with industry input the only 10-year commercial launch forecast
- Studying radiation propagation medical effects that may impact spaceflight participants
- Studying with NASTAR Center how spaceflight participants with common chronic illnesses will respond to spaceflight

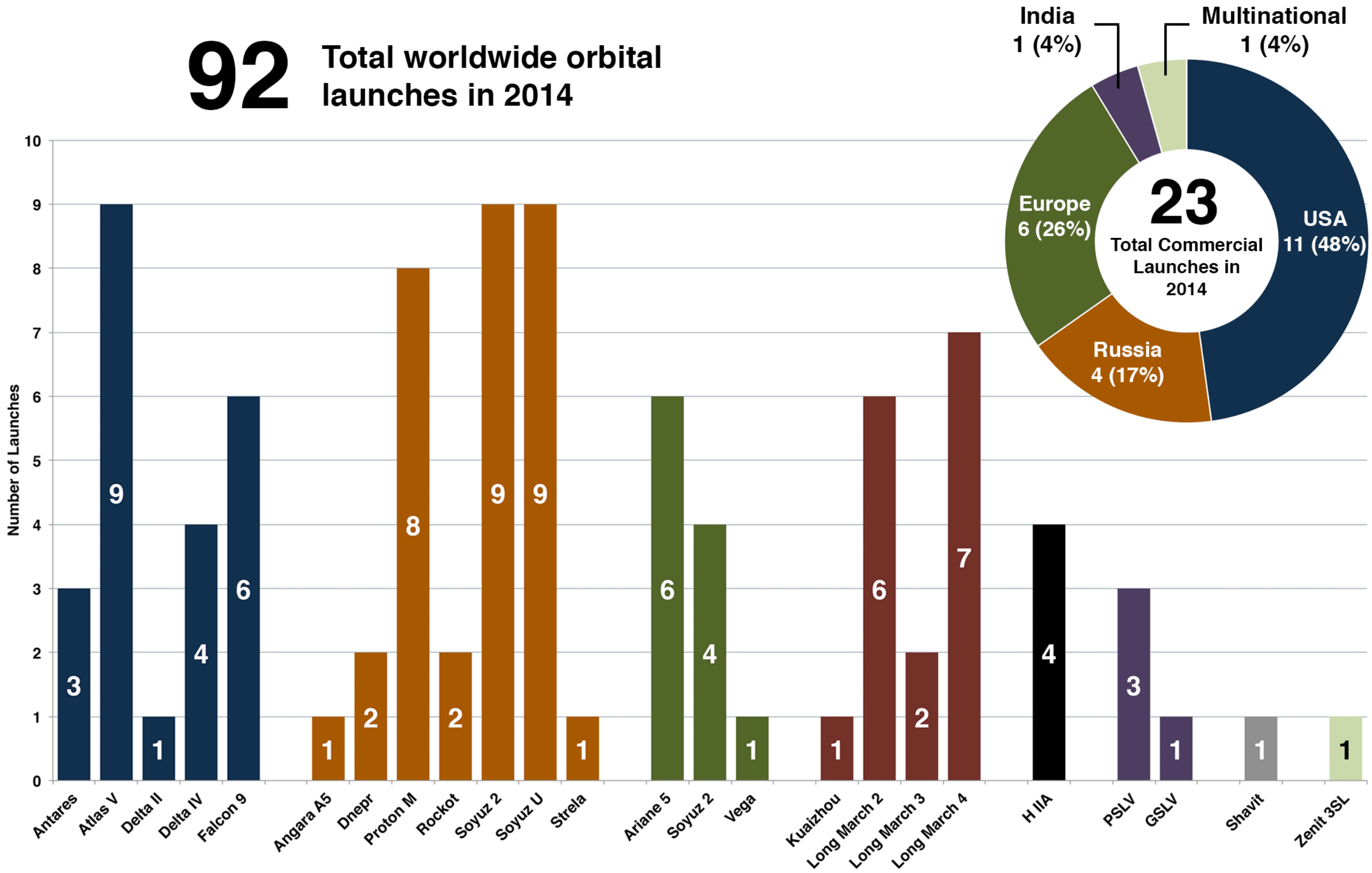
ACTIVE LICENSES, PERMITS, AND APPROVALS

(December 31, 2014)

26 Licenses **3** Experimental Permits **7** Safety Approvals

2014 Orbital Launches by Vehicle

92 Total worldwide orbital launches in 2014



2014: Highest Number of Active and Proposed Commercial Orbital and Suborbital Launch Sites

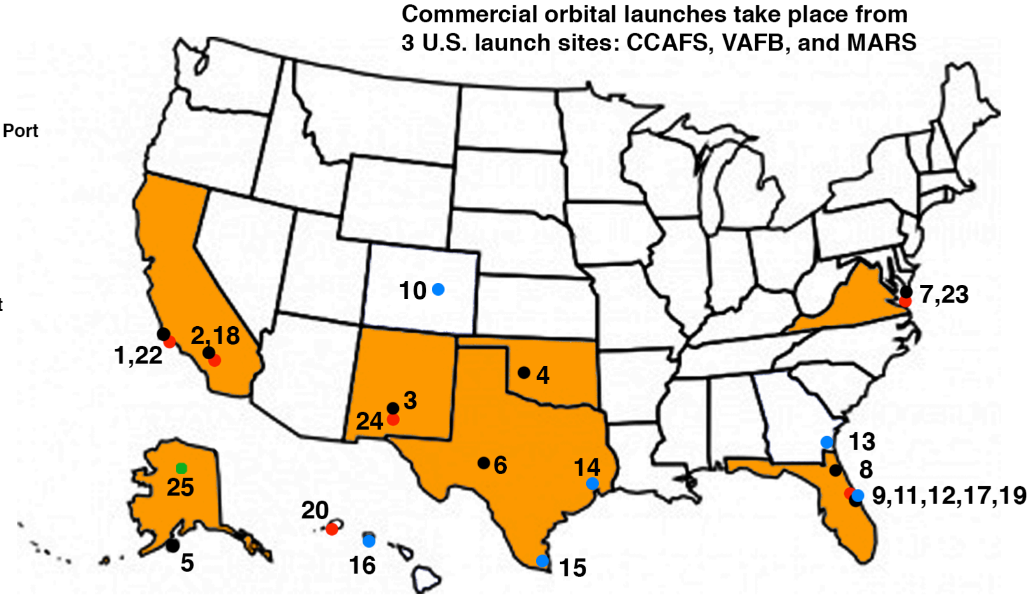
STATES WITH FAA-LICENSED SITES
1 - California Spaceport
2 - Mojave Air and Space Port
3 - Spaceport America
4 - Oklahoma Spaceport
5 - Kodiak Launch Complex
6 - Midland International Air & Space Port
7 - Mid-Atlantic Regional Spaceport
8 - Cecil Field Spaceport
9 - Cape Canaveral Spaceport

PROPOSED SITES
10 - Front Range Spaceport
11 - Shiloh
12 - Space Coast Regional Spaceport
13 - Camden County
14 - Houston Spaceport
15 - Brownsville (sole site operator)
16 - Hawaii Air and Space Port

FEDERAL SITES
17 - CCAFS
18 - EAFB
19 - KSC
20 - PMRF
21 - RRBMDTS (Kwajelein)
22 - VAFB
23 - WFF
24 - WSMR

UNIVERSITY SITES
25 - Poker Flat

Commercial orbital launches take place from 3 U.S. launch sites: CCAFS, VAFB, and MARS



This page intentionally left blank.

COMMERCIAL SPACE TRANSPORTATION 2014 YEAR IN REVIEW

This section summarizes U.S. and international orbital launch activities for calendar year 2014. This section is also available separately as the *Commercial Space Transportation: 2014 Year in Review*.

Cover Art: John Sloan, FAA AST (2015)

EXECUTIVE SUMMARY

The Commercial Space Transportation: 2014 Year in Review summarizes U.S. and international orbital launch activities for calendar year 2014, including launches licensed by the Federal Aviation Administration's Office of Commercial Space Transportation (FAA AST).

In 2014, the United States, Russia, Europe, China, Japan, India, Israel, and multinational provider Sea Launch conducted a total of 92 orbital launches, 23 of which were commercial (See Figure 1). In 2013 there were 81 launches, including 23 commercial launches. Three of the 92 launches failed; two government launches, Russia's Proton M launch of the Express AM4R communications satellite and Europe's Soyuz 2.1b launch of two Galileo navigation satellites, and one commercial launch, United States' Antares 120 launch of the Cygnus commercial cargo capsule to the International Space Station (ISS).

Highlights of 2014 in the orbital space launch industry:

- The United States performed 11 commercial orbital launches, making 2014 the most active year since the late 1990s.
- NASA continued its ISS Commercial Resupply Services (CRS) program, with the launch of five resupply missions. One CRS mission of a Cygnus cargo spacecraft launched by an Antares vehicle resulted in a launch failure;
- SpaceX continued to successfully launch payloads for commercial clients, including three commercial launches to geosynchronous transfer orbit (GTO) and one to low earth orbit (LEO);
- The U.S. launch provider United Launch Alliance (ULA) exceeded its own record number of 11 launches last year with 14 missions, launching 9 Atlas V, 4 Delta IV, and one Delta II;
- One of these ULA vehicles, a Delta IV Heavy, successfully launched NASA's Orion Multi-Purpose Crew Vehicle on Exploration Flight Test 1 (EFT 1). The launch was licensed by FAA AST;
- Two new orbital launch vehicles were successfully tested. The Russian Angara launch vehicle family was introduced by a suborbital test of Angara 1.1PP in July and a GEO insertion of a dummy payload by Angara A5 in December. India successfully performed a suborbital test of its LVM3 launch vehicle (formerly known as GSLV Mk 3); and
- Orbital launch vehicles deployed 46 CubeSat class satellites launched as piggyback payloads. Sixty seven more CubeSats were delivered to the ISS by the Cygnus, Dragon, and Progress spacecraft and then released into orbit from the ISS. Twenty nine more CubeSats were lost during a failed launch attempt of a Cygnus cargo spacecraft to the ISS.

Revenues from the 23 commercial orbital launches in 2014 were estimated to be about $2.36 billion. These revenues are nearly a half billion dollars higher than in 2013 while consistent with commercial launch revenue in 2009, 2010, and 2012. The estimated commercial orbital launch revenues of $1.1 billion for U.S. providers was the highest in five years (See Figure 2). This is the highest since 1998, when the total was $1.12 billion.

FAA AST licensed 12 commercial orbital launches in 2014, compared to seven licensed launches in 2013. SpaceX's Falcon 9 vehicle had six licensed launches: two in April and September, under NASA's CRS program, and four for commercial satellite operators AsiaSat, ORBCOMM, and Thaicom. Orbital's Antares was used for three FAA-licensed ISS resupply missions in January, July, and October. The October launch attempt of Antares resulted in a failure; its cause is currently being investigated. Atlas V provided by United Launch Alliance (ULA) successfully launched commercial Earth observation satellite WorldView 3 in August. Another ULA successful FAA-licensed mission was that of Delta IV Heavy launching NASA's Orion EFT 1. Sea Launch's Zenit 3SL successful launch of Eutelsat 3B was also an FAA-licensed launch.

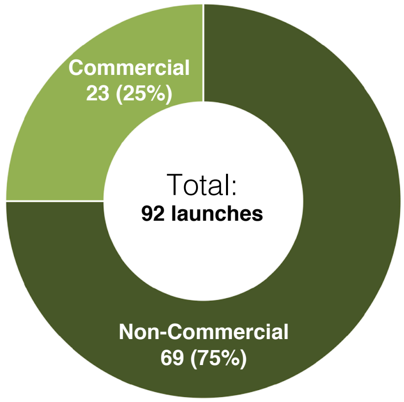


Figure 1. 2014 Total Worldwide Launch Activity

2014 LAUNCH ACTIVITY

WORLDWIDE ORBITAL LAUNCH ACTIVITY

Launch providers from the United States, Russia, Europe, China, Japan, India, Israel, and one multinational provider conducted a total of 92 launches in 2014, 23 of which were commercial (see Figures 2 and 3, Tables 1 and 2). This is higher than the previous five-year average of 79 total launches and 22 commercial launches per year. The following is a summary of worldwide orbital commercial launches in 2014, by country.

- The United States conducted 23 launches in 2014, four more launches than in 2013. Eleven of the 23 launches were commercial, five more than in 2013.
- Russia had the most total launches (32) in 2014, same as in 2013. It performed four commercial launches, down from 12 in 2013. Russia experienced one failure of a Proton M launch vehicle while attempting to launch the Express AM4R GEO communications satellite for the Russian Satellite Communications Company (RSCC).
- Europe conducted 11 launches in 2014, six of which were commercial, rebounding from the low number of seven launches in 2013, including four commercial ones.
- China had 16 orbital launches, all non-commercial, one launch more than in 2013. This is the second year in a row with no commercial launch activity in China.
- India had four successful launches, including one commercial launch in 2014, compared to three non-commercial launches in 2013.
- Israel successfully launched its Shavit vehicle carrying Ofeq 10 reconnaissance satellite, a non-commercial launch. It was the first orbital launch in Israel since 2010.
- Japan performed a total of four non-commercial launches in 2014, up one launch from 2013.
- The multinational Sea Launch Zenit 3SL launch vehicle performed one successful launch in 2014. In 2013, there was one failed commercial launch attempt by Sea Launch.
- There were 10 commercial launches of GEO satellites in 2014, one launch less than in 2013. This year continued the downward trend in commercial launches to GEO with the new lowest number since 2007.

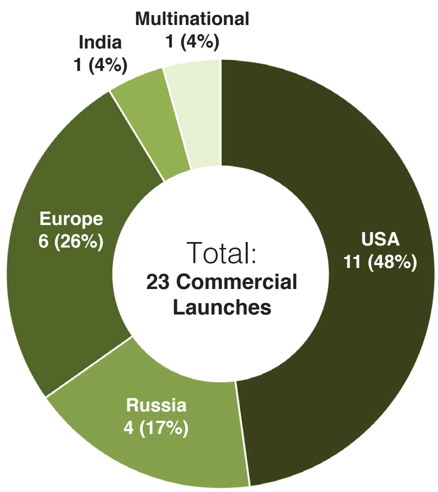


Figure 2. 2014 Worldwide Commercial Launch Activity

Country/Region	Commercial Launches	Non-Commercial Launches	Launches
United States	11	12	23
Russia	4	28	32
Europe	6	5	11
China	0	16	16
Japan	0	4	4
India	1	3	4
Israel	0	1	1
Multinational	1	0	1
TOTAL	***23***	***69***	***92***

Table 1. 2014 Worldwide Orbital Launch Events

Date	Launch Vehicle	Launching Country/ Region	Primary Payload Name	Orbit	Launch Outcome
1/6/14	Falcon 9	USA	Thaicom 6	GEO	Success
1/9/14	Antares 120	USA	Orb 1	LEO	Success
2/14/14	Proton M	Russia	Turksat 4A	GEO	Success
3/22/14	Ariane 5 ECA	Europe	Astra 5B	GEO	Success
4/18/14	Falcon 9	USA	Spx 3	LEO	Success
5/26/14	Zenit 3SL	Multinational	Eutelsat 3B	GEO	Success
6/19/14	Dnepr	Russia	KazEOSat 2	GEO	Success
6/30/14	PSLV CA	India	SPOT 7	SSO	Success
7/10/14	Soyuz 2.1b	Europe	O3b 05-08	MEO	Success
7/13/14	Antares 120	USA	Orb 2	LEO	Success
7/14/14	Falcon 9	USA	ORBCOMM FM103, 104, 106, 107, 109, 111	LEO	Success
8/5/14	Falcon 9	USA	AsiaSat 8	GEO	Success
8/13/14	Atlas V 401	USA	WorldView 3	SSO	Success
9/7/14	Falcon 9	USA	AsiaSat 6	GEO	Success
9/11/14	Ariane 5 ECA	Europe	MEASAT 3B	GEO	Success
9/21/14	Falcon 9	USA	Spx 4	LEO	Success
10/16/14	Ariane 5 ECA	Europe	Intelsat 30	GEO	Success
10/28/14	Antares 120	USA	Orb 3	LEO	Failure
11/6/14	Dnepr	Russia	ASNARO 1	SSO	Success
12/5/14	Delta IV Heavy	USA	EFT 1	LEO	Success
12/6/14	Ariane 5 ECA	Europe	DirecTV 14	GEO	Success
12/18/14	Soyuz 2.1b	Europe	O3b 09-12	MEO	Success
12/27/14	Proton M	Russia	Astra 2G	GEO	Success

Table 2. 2014 Worldwide Commercial Launch Events

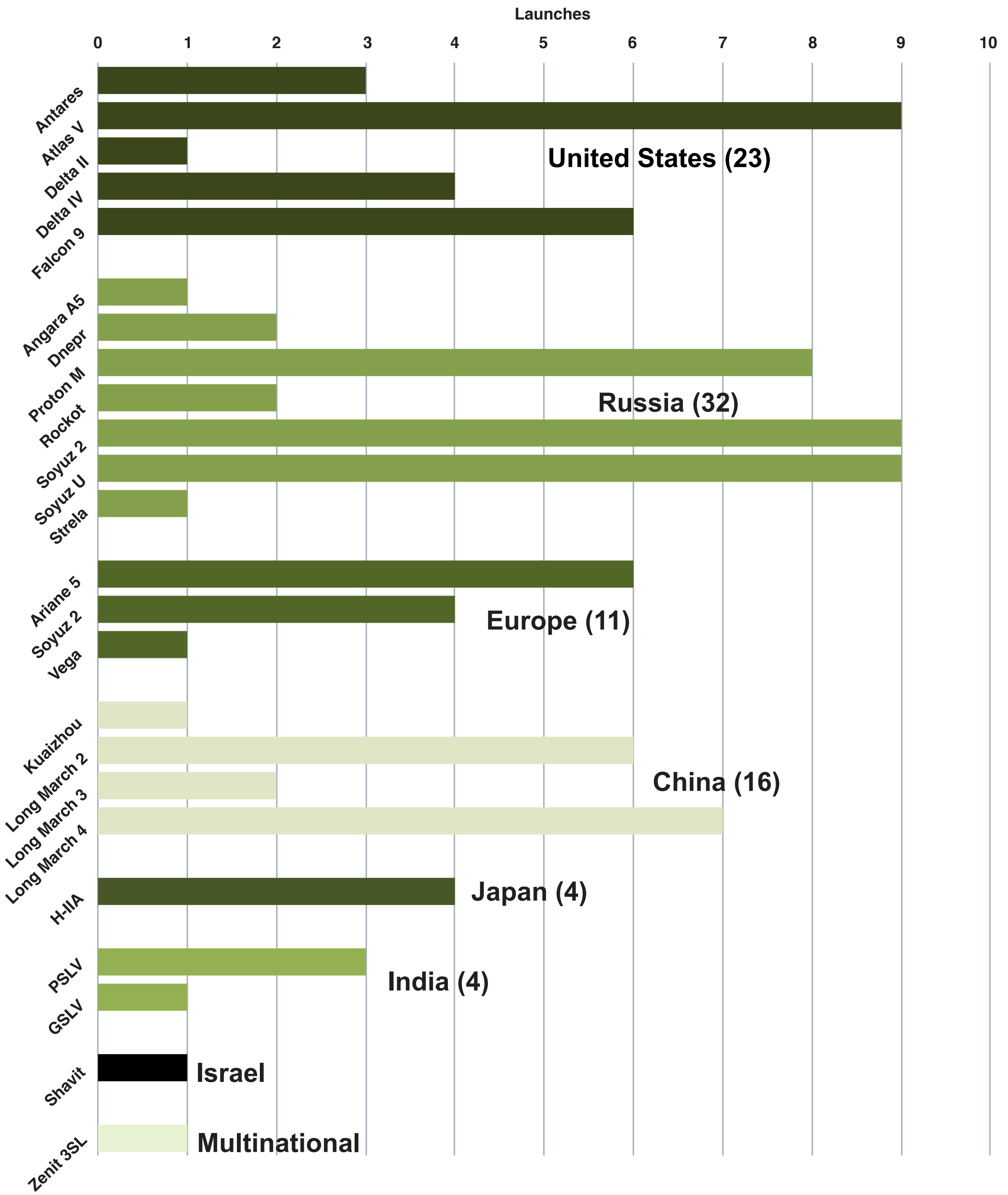


Figure 3. 2014 Launch Vehicle Use

Worldwide Launch Revenues

Estimated revenues from the 23 commercial launch events in 2014 amounted to approximately $2.36 billion (Figure 4). These revenues are nearly a half billion dollars higher than in 2013 while consistent with commercial launch revenue in 2009, 2010, and 2012. The following are 2014 revenues by country:

- Commercial launch revenues in the United States amounted to $1.1 billion, the highest since 1998. Estimated commercial launch revenue for 2013 was $339.5 million.
- Russian commercial launch revenues were approximately $218 million, 30 percent of the last year's $759 million. The delay caused by a civil government Proton failure in May resulted in only two commercial Proton launches in 2014. The other two Russian commercial launches this year were performed by the low cost Dnepr vehicle.
- European commercial launch revenues were approximately $920 million, a 30 percent increase from 2013.
- China did not perform any commercial launches in 2014, same as in 2013. It earned an estimated total of $90 million for two commercial launches in 2012.
- Multinational (Sea Launch) revenues from the single 2014 launch were estimated at $95 million, on par with the 2013 results.

Payments for launch services are typically spread over one to two years before the launch, but for the purposes of this report, revenue is counted in the year a customer's payload launches. Launch revenues are attributed to the country or region where the primary vehicle manufacturer is based. These revenues are assessed based on commercial launch price estimates for each launch vehicle using publically available information.

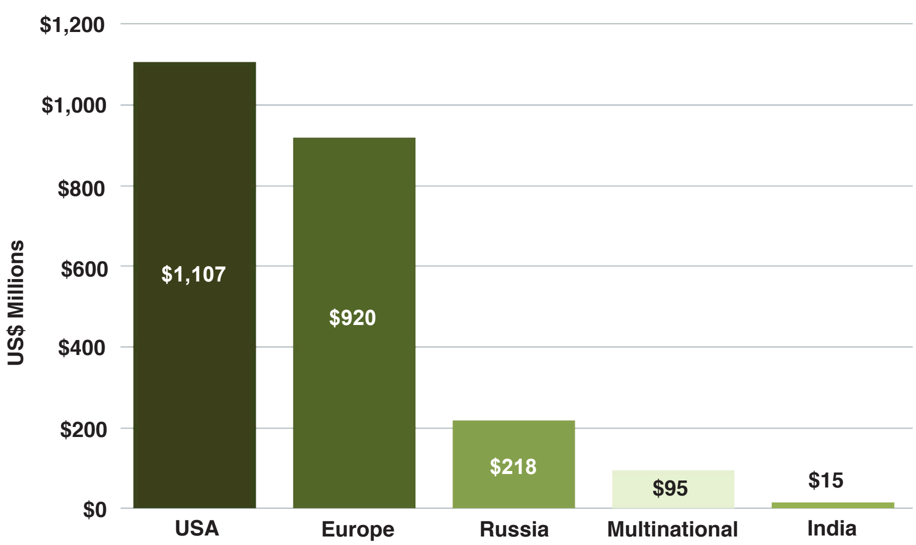


Figure 4. Estimated 2014 Commercial Launch Revenues

[1] International Launch Services (ILS) and Arianespace constitute an exception. ILS is a Russian-owned company incorporated in the United States and selling launches of the Russian Proton vehicles. Arianespace markets launches of a Russian-manufactured Soyuz 2 vehicle from the Kourou launch site in French Guiana.

U.S. AND FAA-LICENSED ORBITAL LAUNCH AND REENTRY ACTIVITY

FAA-Licensed Orbital Launch Summary

There were 12 FAA-licensed orbital launches in 2014 (see Table 3) from four different launch sites.

SpaceX's Falcon 9 vehicle made six licensed launches: two CRS missions to the ISS and four launches for commercial communications satellite operators, all from Cape Canaveral Air Force Station (CCAFS).

Orbital's Antares had three FAA-licensed launch attempts, two successful CRS missions to the ISS and one failed CRS launch attempt, from the Mid-Atlantic Regional Spaceport (MARS) in Virginia. ULA performed two FAA-licensed launches, one by Atlas V of the WorldView 3 commercial remote sensing satellite from Vandenberg Air Force Base (VAFB) and the other by Delta IV Heavy of NASA's EFT 1 from CCAFS.

Date	Vehicle	Primary Payload	Orbit	Launch Outcome
1/6/14	Falcon 9	Thaicom 6	GEO	Success
1/9/14	Antares 120	Orb 1	LEO	Success
4/18/14	Falcon 9	Spx 3	LEO	Success
5/26/14	Zenit 3SL	Eutelsat 3B	GEO	Success
7/13/14	Antares 120	Orb 2	LEO	Success
7/14/14	Falcon 9	ORBCOMM FM103, 104, 106, 107, 109, 111	LEO	Success
8/5/14	Falcon 9	AsiaSat 8	GEO	Success
8/13/14	Atlas V 401	WorldView 3	SSO	Success
9/7/14	Falcon 9	AsiaSat 6	GEO	Success
9/21/14	Falcon 9	Spx 4	LEO	Success
10/28/14	Antares 120	Orb 3	LEO	Failure
12/5/14	Delta IV Heavy	EFT 1	LEO	Success

Table 3. 2014 FAA-Licensed Orbital Launch Events

Sea Launch's Zenit 3SL vehicle performed one FAA-licensed launch of a commercial telecommunications satellite Eutelsat 3B.

Over the past five years (in 2010–2014), FAA has on average licensed about six launches per year. However, in 2014 the number of FAA-licensed launches exceeded the 11 launches FAA licensed in 2008. At that time, five of the 11 FAA-licensed launches were Sea Launch's Zenit 3SL carrying commercial GEO communications satellites. With the Zenit 3SL launches effectively put on hold after this year's single launch, the increase in licensed orbital launches is predominantly driven by U.S. launch organizations. SpaceX and Orbital (teamed with ULA) plan 10 to 15 licensed launches in 2015. Figures 5 and 6 summarize the number of FAA-licensed orbital launches and revenue in 2010-2014.

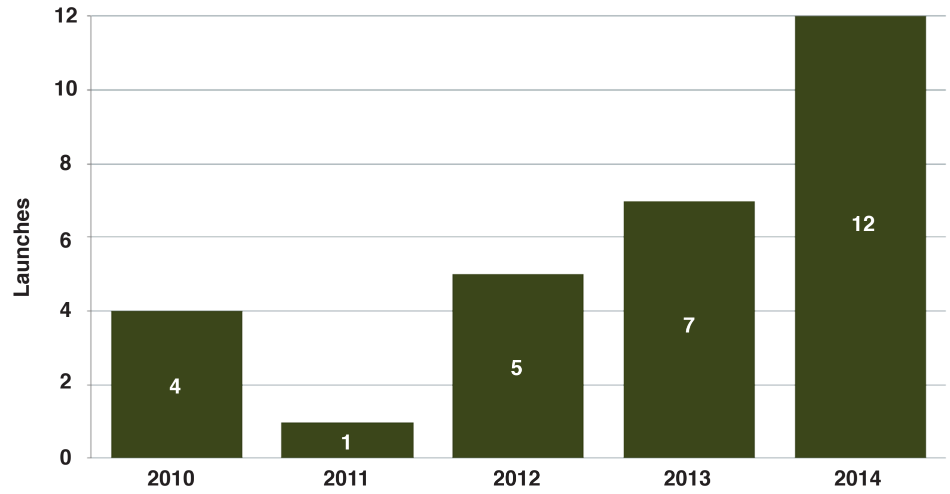


Figure 5. FAA-licensed Orbital Launch Events, 2010-2014

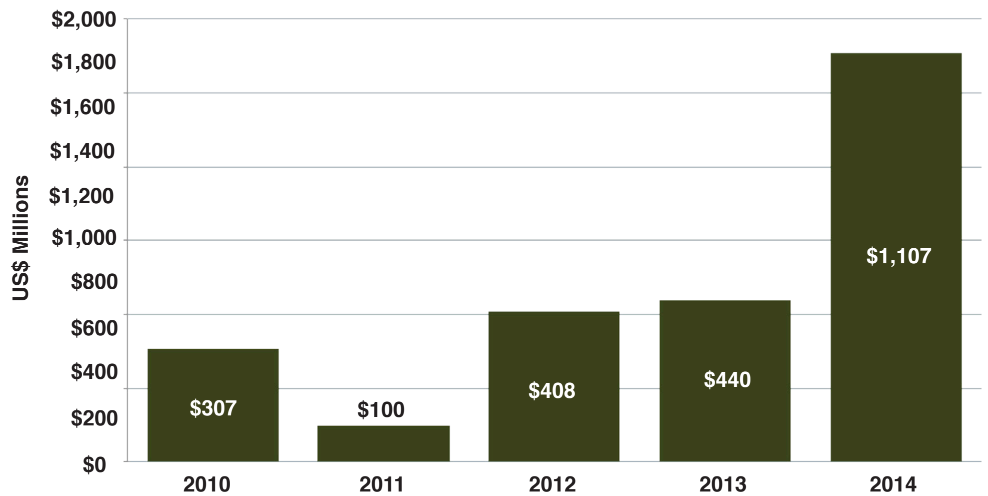


Figure 6. Estimated Revenue for FAA-licensed Orbital Launch Events, 2010-2014

United States

U.S. launch vehicles provided 12 U.S. government launches and 11 commercial launches in 2014. Of the 12 government launches, two were for NASA and 10 were for the Department of Defense (DoD), including the Air Force. Six launches for NASA, including five SpaceX and Orbital launches to the ISS and the ULA launch of EFT 1 were all licensed by the FAA and therefore counted as commercial launches. Table 4 on page 16 summarizes U.S. and FAA-licensed launch vehicles active in 2014.

The following is a list of U.S.-based launch service providers, highlighting their launch activity in 2014. It includes all companies that launch from the United States or under the regulatory oversight of the FAA AST.

Orbital Sciences Corporation

Orbital provides the Antares, Minotaur, and Pegasus vehicles for orbital launch.

Orbital launched two successful Cygnus resupply missions to the ISS in January and July. The third launch attempt of Antares in October resulted in a failure and the loss of the Cygnus spacecraft and the cargo it was carrying to the ISS; its cause is currently being investigated.

Space Exploration Technologies Corporation

SpaceX performed six commercial Falcon 9 launches in 2014. In April and September, two Falcon 9 v1.1 rockets launched the Dragon capsules carrying supplies to the ISS. These vehicles were performed under NASA's CRS program. In January, Falcon 9 deployed a commercial telecommunications satellite Thaicom 6 to GTO. In July, six second generation ORBCOMM commercial telecommunications satellites were launched into LEO by one Falcon 9 vehicle, and in August and September two more Falcon 9 launches delivered two AsiaSat commercial satellites to GTO: AsiaSat 8 and AsiaSat 6.

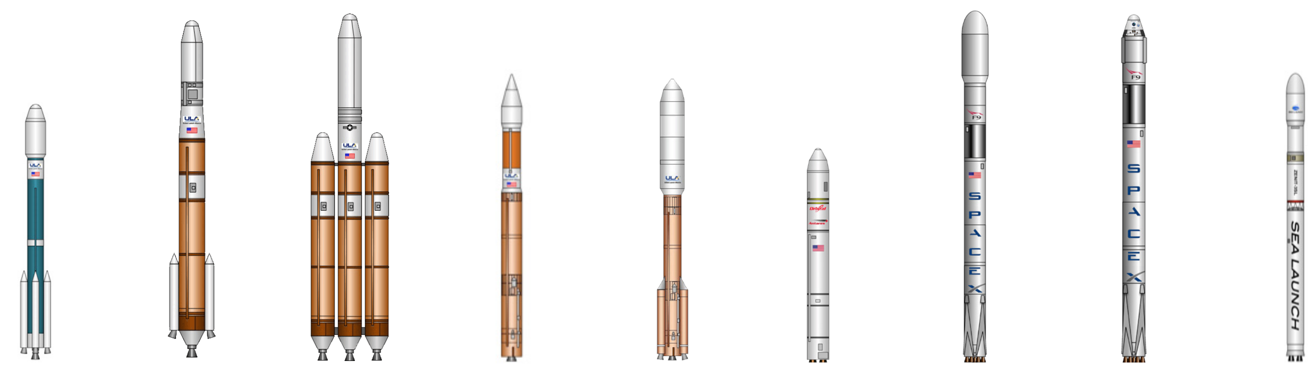
United Launch Alliance

ULA, a joint company between Boeing and Lockheed Martin, manufactures and operates Boeing-heritage Delta vehicles and Lockheed Martin-heritage Atlas vehicles. In 2014, ULA conducted a record number of 14 launches, two of them commercial.

A Delta II 7320-10 deployed Orbiting Carbon Observatory (OCO 2) for NASA. Delta IV vehicles placed three Air Force payloads into orbit: Navstar GPS 2F-05, Navstar GPS 2F-06, and GSSAP 1. A Delta IV Heavy commercial FAA-licensed launch deployed NASA's EFT 1. Atlas V vehicles performed eight non-commercial missions, seven for the DoD, Air Force, and one for NASA: DMSP 19, NRO L-67, NRO L-33, Navstar GPS 2F-07, CLIO, Navstar GPS 2F-08, NRO L-35, and TDRS L. A commercial FAA-licensed Atlas V launch deployed WorldView 3, a commercial remote sensing satellite for DigitalGlobe.

FAA-Licensed Multinational Launches: Sea Launch AG

Zenit 3SL, a launch vehicle operated by multinational commercial launch provider Sea Launch AG, deployed one commercial GEO communications satellite for commercial operator Eutelsat.



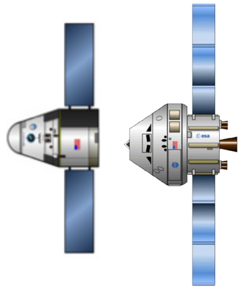
Vehicle	Delta II 7320-10	Delta IV Medium+ (4,2)	Delta IV Heavy	Atlas V 401	Atlas V 541	Antares 120	Falcon 9	Falcon 9 (Dragon)	Zenit 3SL
2014 Total Launches	1	3	1	7	2	3	4	2	1
2014 Licensed Launches	0	0	0	1	0	3	4	2	1
Launch Reliability (2014)	1/1 100%	3/3 100%	1/1 100%	7/7 100%	2/2 100%	2/3 67%	4/4 100%	2/2 100%	0/1 0%
Launch Reliability (Last 10 Years)	6/6 100%	12/12 100%	7/8 88%	25/25 100%	3/3 100%	4/5 80%	6/6 100%	7/7 100%	24/26 92%
Year of First Launch*	1999	2002	2004	2002	2011	2013	2013	2010	1999
Active Launch Sites	CCAFS, VAFB	CCAFS, VAFB	CCAFS, VAFB	CCAFS, VAFB	CCAFS, VAFB	MARS	CCAFS, VAFB	CCAFS	Odyssey Pacific Ocean Platform
LEO kg (lbs)	2,703 (5,958)	12.240 (26,980)	22,560 (49,740)	9,797 (21,598)	17,443 (38,476)	4,900 (10,780)	13,150 (28,991)	9,000 (19,842)	--
GTO kg (lbs)	--	6,267 (13,817)	14,420 (31,791)	4,750 (10,470)	8,290 (18,270)	--	4,850 (10,692)	--	6,160 (13,580)

** The year the respective variant of a launch vehicle was launched for the first time.*

Table 4. U.S. and FAA-Licensed Launch Vehicles Active in 2014

FAA Reentry License Summary

There were three reentries conducted under an FAA reentry license in 2014. Two SpaceX's Dragon spacecraft performed the licensed reentries, in May and October 2014, completing its third and fourth CRS missions to the ISS. A test version of Lockheed Martin's Orion multi-purpose crew vehicle was successfully recovered in the Pacific Ocean following an FAA-licensed reentry (See Table 5 for details.)



Vehicle	SpaceX Dragon	Orion (EFT 1)
2014 Total Reentries	2	1
2014 Licensed Reentries	2	1
Reentry Reliability (2014)	2/2 100%	1/1 100%
Reentry Reliability (Last 10 Years)	6/6 100%	1/1 100%
Year of First Reentry	2010	2014
Reentry Sites	Pacific Ocean	Pacific Ocean
Payload to LEO, kg (lbs)	6,000 (13,228)	N/A
Payload from LEO, kg (lbs)	3,000 (6,614)	N/A

Table 5. FAA-Licensed Reentry Vehicles Active in 2014

FAA Suborbital Launch Summary

Suborbital launches carried out under FAA licenses or experimental permits are listed in Table 6.

- SpaceX performed five suborbital launches of its Falcon 9R Dev 1 experimental rocket from SpaceX's McGregor Test Site authorized under an FAA Experimental Permit. Four flights were successful and the fifth launch conducted on August 22 resulted in an on-board anomaly and vehicle self-destruction commanded by flight control. These flights were part of the development program of a reusable first stage for the Falcon 9 orbital launch vehicle.
- Virgin Galactic's SpaceShipTwo performed two powered flight tests from Mojave Air and Space Port authorized under an FAA experimental permit issued to Scaled Composites, the vehicle manufacturer. The second flight on October 31st resulted in a catastrophic failure and death of one of the pilots. The second pilot survived but suffered injuries. The cause of the crash is currently being investigated.

Operator	Type of FAA Authorization	Launch Date	Vehicle
Scaled Composites	Experimental Permit (EP 12-007)	1/10/14	SpaceShipTwo
SpaceX	Experimental Permit (EP 14-010)	4/18/14	Falcon 9R Dev 1
SpaceX	Experimental Permit (EP 14-010)	5/2/14	Falcon 9R Dev 1
SpaceX	Experimental Permit (EP 14-010)	6/17/14	Falcon 9R Dev 1
SpaceX	Experimental Permit (EP 14-010)	8/1/14	Falcon 9R Dev 1
SpaceX	Experimental Permit (EP 14-010)	8/22/14	Falcon 9R Dev 1
Scaled Composites	Experimental Permit (EP 12-007)	10/31/14	SpaceShipTwo

Table 6. FAA 2014 Suborbital License and Permit Flight Summary

NON-U.S. ORBITAL LAUNCH ACTIVITY

The following section of the report highlights non-U.S. launch activity on a country-by-country basis.

Russia

In 2014, there were 32 Russian launches. Thirty-one of these were successful, one Proton M failed. Eight launches were with Proton vehicles and 18 with Soyuz vehicles. Dnepr and Rockot performed two launches each. One mission was launched with Strela. The new Angara A5 heavy class launch vehicle performed a successful test launch of a dummy payload to GEO from a northern Russia launch site Plesetsk; this test flight was preceded by a suborbital test launch of a lighter Angara version. Twenty-one of the missions launched from Baikonur Cosmodrome, and nine missions launched from Plesetek. Two Dnepr launches were condicted from Dombarovskiy Air Base. Four launches were commercial and 28 were non-commercial. The non-commercial missions are detailed below.

- Eight Soyuz launches were dedicated ISS missions, involving four Progress M cargo missions and four Soyuz spacecraft crew exchange missions.
- Nine launches were performed in the interest of the Russian military. A Proton vehicle launched a GEO communications satellite Olymp K. Six Soyuz vehicles launched three Glonass series navigation satellites and three intelligence satellites. A Rockot vehicle launched three Cosmos series store-and-forward communications satellites. One Strela launch vehicle launched Kondor E1, an imagery intelligence satellite.
- Russia conducted 10 launches for civil purposes, that were not related to the ISS. Four Proton vehicles launched six GEO communications satellites (two of the launches were dual manifest), one launch, intended to deploy Express AM4R, resulted in a failure. Four Soyuz vehicles launched four primary payloads, including two remote sensing satellites, a weather, and a science payload. The launch of the Meteor 3M N2 weather satellite also carried five microsats as piggyback payloads. Rockot launched three Gonets series store-and-forward communications satellites. The new Angara A5 heavy class launch vehicle performed a successful test launch of a dummy payload to GEO
- International Launch Services (ILS) facilitated two commercial launches of Proton M. Both missions were telecommunications satellites to GEO, Turksat 4A for Turk Telekom and Astra 2G for SES.
- Two Dnepr commercial vehicles provided by JSC Kosmotras launched primary payloads KazEoSat 2 for Kazakhstan and ASNARO 1 for the Japanese Government. KazEoSat 2 was launched with 36 secondary payloads, including Deimos 2 remote sensing satellite for Spain and 35 microsatellites, most of them cubesats. ASNARO 1 was launched with four Japanese university microsatellites.

Europe

Europe conducted 11 launches in 2014 from its spaceport in French Guiana. Six were with Ariane 5 vehicles, four with Soyuz vehicles, and one with the Vega rocket. Four of the Ariane 5 and two of the Soyuz launches were commercial. The other five European launches were non-commercial, carrying payloads for the European Space Agency (ESA), European Commission, Italian Space Agency, and government of Kazakhstan. More details on European launches are below:

- Five Ariane 5 ECA launch vehicles placed 10 satellites in GEO, including seven commercial telecommunications satellites, one military communications satellite, and two civil government communications satellites. All Ariane 5 ECA launches were dual manifests of GEO satellites.
- An Ariane 5 ES launched the fifth and the last Automated Transfer Vehicle (ATV) bringing cargo to the ISS.
- Two Soyuz 2 launches were commercial launching a total of eight satellites to medium earth orbit (MEO) for the O3b commercial communications constellation.
- Two more Soyuz 2 launches launched Sentinel 1A for ESA and two Galileo navigation satellites for the European Commission. The Galileo satellites were deployed in a useless orbit due to an in-flight anomaly in the Fregat upper stage; the launch was declared a failure.
- Vega launched KazEOSat 1 for Kazakhstan.

China

China conducted 16 orbital launches, all of them for the Chinese government. Two launches were conducted from the Xichang Satellite Launch Center, eight from the Jiuquan Satellite Launch Center, and six from the Taiyuan Satellite Launch Center. More details on Chinese launches are below.

- Eleven launches were for China’s military. These launches deployed a total of 16 satellites, all to low earth (LEO) and sun-synchronous (SSO) orbits. Twelve of these satellites are believed to be for signal and image intelligence purposes, three for remote sensing, one for early warning, and one development payload.

- Five launches were for China’s civil government agencies and a university. They deployed seven satellites, including two remote sensing, two development and test payloads, one meteorological satellite, one communications satellite, and one science payload.

India

The Indian Space Research Organization (ISRO) performed four orbital launches in 2014. GSLV Mk II launched GSAT 14 geostationary communications satellite, and two PSLV launches deployed two navigation satellites for ISRO.

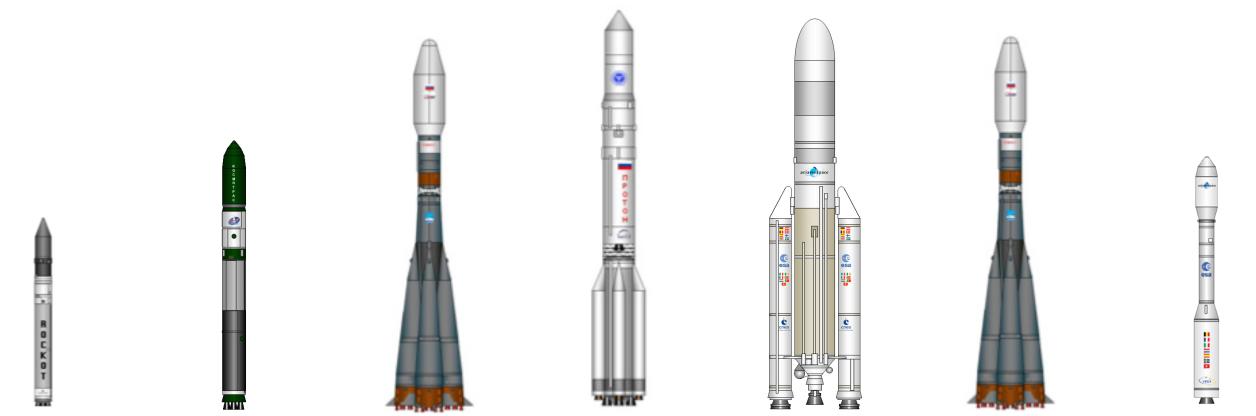
One PSLV launch was a commercial deployment of SPOT 7 for SPOT Image (since sold to Azercosmos), accompanied by four civil and university microsatellites.

Israel

Israel launched Ofeq 10 military observation satellite using Shavit 1 vehicle.

Japan

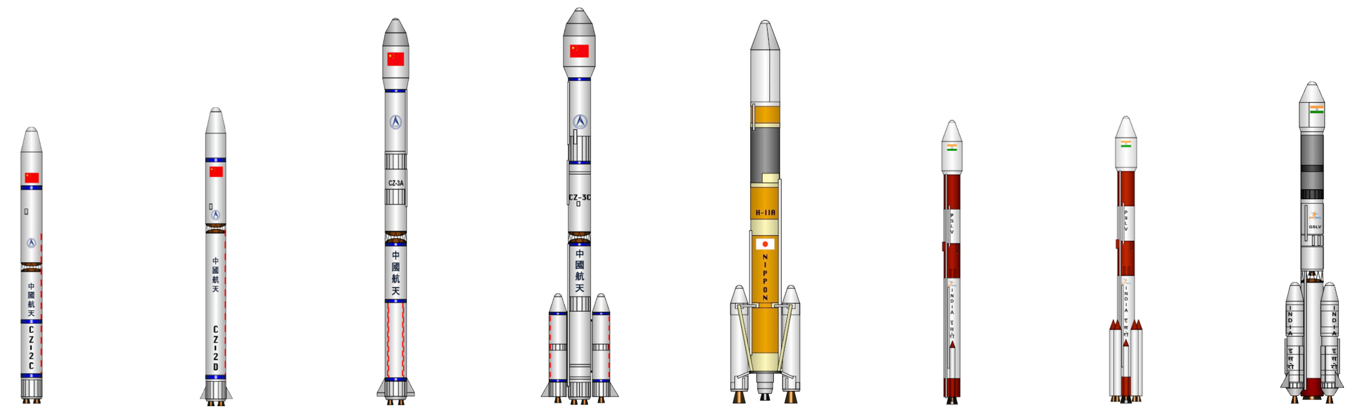
Japan had four H-IIA launches this year, launching GPM-Core remote sensing payload built by NASA Goddard Space Flight Center, Himawari 8 meteorological satellite, Hayabusa 2 scientific probe, and ALOS 2 remote sensing payload. ALOS 2 was launched with four microsatellites as secondary payloads.



Vehicle	Rockot	Dnepr	Soyuz 2	Proton M	Ariane 5 ECA	Soyuz 2	Vega
Country/Region	Russia	Russia	Russia	Russia	Europe	Europe	Europe
2014 Total Launches	2	2	9	8	5	4	1
Launch Reliability (2014)	2/2 100%	2/2 100%	9/9 100%	7/8 88%	5/5 100%	3/4 75%	1/1 100%
Launch Reliability (Last 10 Years)	19/20 95%	8/8 100%	26/28 92%	72/81 89%	43/44 98%	9/10 90%	3/3 100%
Year of First Launch*	1994	2010	2004	2001	2002	2011	2012
Active Launch Sites	Baikonur, Plesetsk	Baikonur, Dombarovsky	Baikonur, Plesetsk	Baikonur	Kourou	Kourou	Kourou
LEO kg (lbs)	2,150 (4,740)	3,700 (8,157)	4,850 (10,692)	23,000 (50,706)	21,000 (46,297)	4,850 (10,692)	2,300 (5,071)
GTO kg (lbs)	--	--	1,700 (3,800)	6,920 (15,256)	9,500 (20,944)	3,250 (7,165)	--

** The year the respective variant of a launch vehicle was launched for the first time.*

Table 7. Non-U.S. Commercially Available Launch Vehicles Active in 2014



Vehicle	Long March 2C	Long March 2D	Long March 3A	Long March 3C	H-IIA	PSLV CA	PSLV XL	GSLV Mk. II
Country/Region	China	China	China	China	Japan	India	India	India
2014 Total Launches	4	2	1	1	4	1	1	1
Launch Reliability (2014)	4/4 100%	2/2 100%	1/1 100%	1/1 100%	4/4 100%	1/1 100%	1/1 100%	1/1 100%
Launch Reliability (Last 10 Years)	17/18 94%	17/17 100%	15/15 100%	11/11 100%	24/25 96%	4/4 100%	4/4 100%	1/2 50%
Year of First Launch*	1975	1992	1994	2008	2001	2009	2012	2010
Active Launch Sites	Jiuquan, Taiyuan, Xichang	Jiuquan	Xichang	Xichang	Tanegashima	Satish Dhawan	Satish Dhawan	Satish Dhawan
LEO kg (lbs)	3,850 (8,488)	1,300 (2,866)	--	--	10,000 (23,046)	2,100 (4,630)	1,800 (3,968)	5,000 (11,023)
GTO kg (lbs)	1,250 (2,756)	--	2,600 (5,732)	3,800 (8,378)	6,000 (13,228)	--	1,140 (2,513)	2,500 (5,516)

** The year the respective variant of a launch vehicle was launched for the first time.*

Table 7. Non-U.S. Commercially Available Launch Vehicles Active in 2014 (continued)

This page intentionally left blank.

ORBITAL LAUNCH VEHICLES

Orbital launch vehicles send payloads into orbit around the Earth or Sun, including LEO, GTO, SSO, and to other destinations. All of the currently offered orbital vehicles in the world are expendable rockets.

A Falcon 9 vehicle, manufactured and operated by SpaceX, is launched from Cape Canaveral Air Force Station in July 2014 carrying six ORBCOMM satellites.

Image credit: SpaceX

This section describes expendable launch vehicles in detail, beginning with U.S. vehicles and concluding with non-U.S. vehicles. Individual factsheets provide technical detail for each vehicle system.

In 2014 there were 92 orbital launches, 23 of which were commercial. There were 12 FAA AST-licensed launches conducted in 2014, the highest since 2004. The following are 2014 highlights of the commercial launch industry:

Eleven of the 23 U.S. launches this year were commercial orbital launches. The European company Arainespace conducted six commercial launches. The multinational company Sea Launch AG and Antrix of India each conducted a single commercial launch. Russian providers only conducted three commercial launches, the lowest since 2001.

- Orbital Sciences' new launch vehicle Antares performed two successful launches, both from Virginia's Mid-Atlantic Regional Spaceport (MARS):
  - Orb 1 and Orb 2 cargo flights to the International Space Station (ISS) were successfully carried out.
- SpaceX successfully launched its Falcon 9 vehicle six times from Cape Canaveral Air Force Station (CCAFS).
  - Spx 3 and Spx 4 cargo flights carried 4,300 kilograms to ISS.
  - Three telecommunications satellites were deployed to geosynchronous orbits (GEO), including Thaicom 6, AsiaSat 6, and AsiaSat 8.
  - A cluster of six ORBCOMM satellites was deployed to low Earth orbit (LEO).
- A record number of CubeSats were launched during 2014 (133). Twenty-nine were lost due to a launch failure (Orb 3).
  - Sixty-seven Planet Labs 3U CubeSats were successfully deployed into LEO in three separate launch events. Most of the satellites (56) were carried aboard Cygnus cargo modules launched by the Antares, for later orbital deployment from the Kibo module on ISS.
- Though not commercial launches, there were a number of significant launches by foreign governments.
  - In July, Russian company Khrunichev successfully launched the first test version of the Angara 1.2PP vehicle, the smallest variant in the Angara family. This was a suborbital launch. In December, Khrunichev successfully launched the much larger Angara A5 vehicle.
  - The Indian Space Research Organization (ISRO) successfully launched its LVM3 (formerly called GSLV Mark III) for the first time. The suborbital flight was designed to test the vehicle as well as a reentry capsule expected to be used to send astronauts into orbit.
  - China successfully launched a new, small-class vehicle called Kuaizhou for a second time since its inaugural flight in 2013.
- There were three failed orbital launch attempts in 2014:
  - A Russian Proton M vehicle was destroyed during a launch failure on May 15. The vehicle was carrying an Express communications satellite.
  - The Fregat upper stage for a Soyuz 2.1b failed on orbit shortly after launch on August 22, placing two Galileo navigation satellites into the wrong orbit.
  - An Antares vehicle was destroyed during a launch failure from MARS on October 28. The vehicle was carrying Orb 3, the third cargo mission under a Commercial Resupply Services (CRS) contract between NASA and Orbital Sciences Corp.

These and other 2014 orbital launch events are discussed in detail in the Year in Review Section.

U.S. COMMERCIAL ORBITAL LAUNCH VEHICLES

There are six expendable launch vehicle types available for commercial use in the United States: Antares, Atlas V, Delta IV, Falcon 9, Minotaur C, and Pegasus XL. Another new U.S. vehicle, the Super Strypi, developed and built by the University of Hawaii (UH), Sandia, and Aerojet Rocketdyne, and originally expected to fly in 2013, is scheduled to make inaugural launch in 2015; however, the availability of Super Strypi for commercial use remains uncertain. Another launch vehicle provided by Orbital, the Minotaur C, is essentially an improved version of the company's Taurus XL vehicle, which first flew in 1994. A Minotaur C contract for the launch of six satellites was signed between Orbital and Skybox Imaging in 2014. Currently available orbital launch vehicles are listed in Table 1.

Other U.S. vehicles are under various stages of development, including the air-launched Thunderbolt from Stratolaunch Systems, and several small systems like Alpha from Firefly Space Systems, Electron from Rocket Labs USA, GOLauncher-2 from Generation Orbit, the Lynx Mark III from XCOR Aerospace, the NEPTUNE from InterOrbital Systems, and others. The Defense Advanced Research Projects Agency (DARPA) is also sponsoring development of vehicles that may be available for commercial use, including the XS-1 and Airborne Launch Assist Space Access (ALASA).

All of these vehicles are described in greater detail in the following pages.

Operator	Vehicle	Year of First Launch	Total/2014 Launches	Active Launch Sites	Mass to GTO kg (lb)	Mass to LEO kg (lb)	Mass to SSO kg (lb)
Orbital Sciences Corp.	Antares	2013	5/3	MARS	--	6,120 (13,492)	4,500 (9,920)
United Launch Alliance (ULA)/ Lockheed Martin Commercial Launch Services	Atlas V	2002	51/9	CCAFS, VAFB	2,690-6,860 (5,930-15,120)	8,123-18,814 (17,908-41,478)	6,424-15,179 (14,163-33,464)
ULA/Boeing Launch Services	Delta IV	2002	28/4	CCAFS, VAFB	4,541-13,399 (10,012-29,540)	9,390-22,977 (20,702-50,656)	7,746-21,556 (17,078-47,522)
SpaceX*	Falcon 9 v1.1	2013	8/6	CCAFS	4,850 (10,692)	13,150 (28,991)	--
Orbital Sciences Corp.	Pegasus XL	1994	32/0	CCAFS, Kwajalein, VAFB, WFF	--	475 (1,045)	325 (715)
Orbital Sciences Corp.	Minotaur C	2015	0/0	CCAFS, Kwajalein, VAFB, WFF	--	1,458 (3,214)	1,054 (2,3214)
UH, Sandia, Aerojet Rocketdyne	Super Strypi	2015	0/0	Barking Sands	--	200 (441)	--

** The Falcon 9 v1.0 was launched 5 times between 2010 and 2013. The numbers in this Compendium reflect the Falcon 9 v1.1, introduced in September 2013.*

Table 1. Currently Available U.S. Commercial Launch Vehicles

NON-U.S COMMERCIAL ORBITAL LAUNCH VEHICLES

There are 13 expendable launch vehicle types available for commercial use outside the United States: Ariane 5, Dnepr, Epsilon, GSLV, H-IIA/B, Long March 2D, Long March 3A, Proton M, PSLV, Rockot, Soyuz 2, Vega, and Zenit 3SL/SLB.

Operator	Vehicle	Year of First Launch	Total/2014 Launches	Active Launch Sites	Mass to GTO kg (lb)	Mass to LEO kg (lb)	Mass to SSO kg (lb)
Antrix/ISRO	GSLV	2001	8/1	Satish Dhawan	2,500 (5,516)	5,000 (11,023)	--
Antrix/ISRO	PSLV	1993	26/3	Satish Dhawan	1,425 (3,142)	3,250 (7,165)	1,750 (3,850)
Arianespace	Ariane 5	1996	77/6	Guiana Space Center	9,500 (20,944)	21,000 (46,297)	10,000 (22,046)
Arianespace	Soyuz 2	2004	38/10	Baikonur, Guiana Space Center, Plesetsk	3,250 (7,165)	4,850 (10,692)	4,400 (9,700)
Arianespace	Vega	2012	3/1	Guiana Space Center	--	1,500 (3,307)	--
CGWIC	Long March 2	2C: 1975 2D: 1992	2C: 38/4 2D:15/2	Jiuquan, Taiyuan, Xichang	2C: 1,250 (2,756)	2C: 3,850 (8,488)	2C: 1,900 (4,189) 2D: 1,300 (2,866)
CGWIC	Long March 3A	A: 1994 B: 1996 BE: 2007 C: 2008	A: 23/0 B: 13/0 BE:13/0 C: 11/1	Xichang	A: 2,600 (5,732) B: 5,100 (11,244) BE: 5,500 (12,125) C: 3,800 (8,378)	--	--
Eurockot	Rockot	1990	22/2	Baikonur, Plesetsk	--	2,140 (4,718)	--
ILS	Proton M	2001	86/8	Baikonur	6,920 (15,256)	23,000 (50,706)	--
ISC Kosmotras	Dnepr	1999	21/2	Baikonur, Dombarovsky	--	3,700 (8,157)	2,300 (5,071)
JAXA	Epsilon	2013	1/0	Uchinoura	--	1,200 (2,646)	700 (1,543)
Mitsubishi	H-IIA/B	A: 2001 B: 2009	A: 26/4 B: 4/0	Tanegashima	A: 4,100-6,000 (9,039-13,228) B: 8,000 (17,637)	A: 10,000-15,000 (22,046-33,069) B: 19,000 (41,888)	--
Sea Launch/ Land Launch	Zenit 3	3SL: 1999 3SLB: 2008	3SL: 36/1 3SLB: 6/0	Baikonur, Sea Launch	3SL: 6,000 (13,228) 3SLB: 3,500 (7,716)	--	--

Table 2. Currently Available Non-U.S. Commercial Launch Vehicles

ANTARES

Orbital Sciences Corp.

Antares 120

Antares 130

Antares 121

Antares 131

Antares 122

Antares 132

In 2013, Orbital Sciences Corporation began offering its Antares, a two-stage vehicle designed to launch government and commercial satellites to low Earth orbit (LEO), Cygnus cargo modules to the International Space Station (ISS), and missions requiring Earth escape trajectories. The Antares is also available under the NASA Launch Services (NLS) II contract for future science missions.

The Antares is the first cryogenically fueled vehicle produced by Orbital. The Antares 100 series consists of a first stage produced by Ukrainian Yuzhnoye Design Office (Yuzhnoye) powered by twin Aerojet AJ26-62 engines derived from the Russian NK-33. A customer can select from two different second stages, the Castor-30XL or the Castor-30B, both from Alliant TechSystems (ATK). Orbital also offers an optional Bi-Propellant Third Stage (BTS) for high-energy performance needs. The vehicle is topped off with a payload adapter and a 4-meter (13-foot) diameter fairing. In 2008, NASA selected the Antares (originally named Taurus II) to receive funding under the COTS program. NASA ultimately selected Orbital and its competitor SpaceX to provide cargo transportation to the ISS under a CRS contract.

The fifth launch of Antares, which took place in October 2014, ended in a launch failure. Orbital is redesigning the vehicle by replacing the engines (from AJ26 to the RD-181) and making other modifications. This version will be introduced in 2016.

Launch service provider
Orbital Sciences Corp.
Company headquarters
USA
Manufacturer
Orbital Sciences Corp.

Mass, kg (lb)
530,000 (1,168,450)
Length, m (ft)
40.5 (132.9)
Diameter, m (ft)
3.9 (12.8)

Year of first launch
2013
Number of launches
5
Reliability
80%
Launch site
MARS (Pad 0-A)

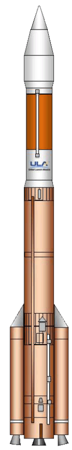
LEO capacity, kg (lb)
4,550-5,700 (10,031-12,566)
SSO capacity, kg (lb)
3,350-4,500 (7,385-9,921)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	9.9 (32.5)	3.9 (12.8)

	1st Stage	2nd Stage	3rd Stage Option	3rd Stage Option
Stage designation	N/A	Castor-30B/30XL	STAR-48V	Bi-Propellant Third Stage (BTS)
Length, m (ft)	25 (82)	30B: 4.17 (13.7) 30XL: 5.99 (19.7)	2 (6.6)	1.8 (5.9)
Diameter, m (ft)	3.9 (12.8)	2.34 (7.7)	1.2 (3.9)	1.7 (5.6)
Manufacturer	KB Yuzhnoye	ATK	ATK	Orbital
Propellant	LOX/Kerosene	Solid	Solid	N_2O_4/UDMH
Propellant mass, kg (lb)	240,000 (529,109)	30B: 12,887 (28,411) 30XL: 24,196 (53,343)	2,010 (4,431)	--
Total thrust, kN (lbf)	3,630 (816,000)	396.3 (89,092)	77.8 (17,490)	--
Engine(s)	2 x AJ26-62	--	--	--
Engine manufacturer	Aerojet Rocketdyne	--	--	Orbital
Engine thrust, kN (lbf)	1,815 (408,000)	396.3 (89,092)	77.8 (17.490)	--

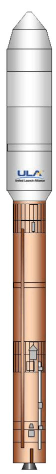
ATLAS V

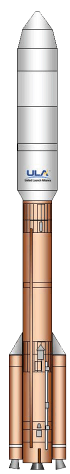
United Launch Alliance



Atlas V 401/402 411/412

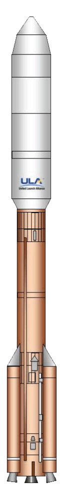
Atlas V 422/421 431/432

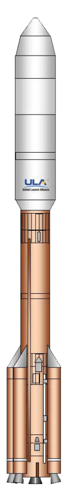




Atlas V 501/502 511/512

Atlas V 521/522 531/532





Atlas V 541/542

Atlas V 551/552

The Atlas V family is a product of the U.S. Air Force's Evolved Expendable Launch Vehicle Program (EELV), begun in 1995. Lockheed Martin originally developed the Atlas V, but manufacturing and operations are now conducted by United Launch Alliance (ULA), a joint company between Lockheed Martin and Boeing. ULA markets the vehicle to the U.S. Government and Lockheed Martin Commercial Launch Services markets to commercial clients worldwide. In 2010, ULA began the process of certifying Atlas V for human missions, to launch NASA astronauts to low Earth orbit (LEO). ULA has agreements with Boeing and Sierra Nevada Corporation (SNC) to launch their crewed orbital vehicles on an Atlas V.

Atlas V consists of the Common Core Booster (CCB) powered by a Russian RD-180 engine, a Centaur upper stage powered by either one or two Pratt & Whitney Rocketdyne (PWR) RL10A-4-2 engines, a payload adapter, and a payload fairing. The vehicle variants are described in two groups: Atlas V 400 series and Atlas V 500 series. The first number of the three-digit designator indicates the diameter of the fairing in meters, the second number indicates the number of Aerojet solid rocket boosters used (zero to five), and the third number indicates the number of RL10A-4-2 engines employed by the Centaur upper stage (one or two).

The Atlas V family debuted in 2002 with the successful launch of an Atlas V 401 from Cape Canaveral Air Force Station (CCAFS) and can launch payloads to any desired orbit.

Launch service provider	United Launch Alliance LMCLS
Company headquarters	USA
Manufacturer	United Launch Alliance
Mass, kg (lb)	401: 333,731 (734,208) 551: 568,878 (1,251,532)
Length, m (ft)	60.6-75.5 (198.7-247.5)
Diameter, m (ft)	3.8 (12.5)
Year of first launch	2002
Number of launches	51
Reliability	100%
Launch sites	CCAFS (SLC-41) VAFB (SLC-3E)
GTO capacity, kg (lb)	4,750-8,900 (10,472-19,621)
LEO capacity, kg (lb)	9,370-18,510 (20,657-40,510)
SSO capacity, kg (lb)	7,724-15,179 (17,029-33,464)

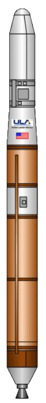
Fairing	Length, m (ft)	Diameter, m (ft)
Large Payload Fairing	12 (39.4)	4.2 (13.8)
Extended Payload Fairing	12.9 (42.3)	4.2 (13.8)
Extra Extended Payload Fairing	13.8 (45.3)	4.2 (13.8)

	1st Stage	SRB*	2nd Stage Option	2nd Stage Option
Stage designation	Common Core Booster	SolidRocketBoosters	Single Engine Centaur	Dual Engine Centaur
Length, m (ft)	32.5 (106.6)	20 (65.6)	12.7 (41.7)	12.7 (41.7)
Diameter, m (ft)	3.8 (12.5)	1.6 (5.2)	3.1 (10.2)	3.1 (10.2)
Manufacturer	ULA	Aerojet Rocketdyne	ULA	ULA
Propellant	LOX/Kerosene	Solid	LOX/LH_2	LOX/LH_2
Propellant mass, kg (lb)	284,089 (626,309)	46,697 (102,949)	20,830 (45,922)	20,830 (45,922)
Total thrust, kN (lbf)	3,827 (860,309)	1,688 (379,550)	99.2 (22,300)	198.4 (44,600)
Engine(s)	1 x RD-180	--	1 x RL10A-4-2	2 x RL10A-4-2
Engine manufacturer	RD AMROSS	--	Aerojet Rocketdyne	Aerojet Rocketdyne
Engine thrust, kN (lbf)	3,827 (860,309)	1,688 (379,550)	99.2 (22,300)	99.2 (22,300)

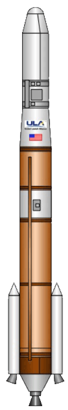
Figures are for each booster.

DELTA IV

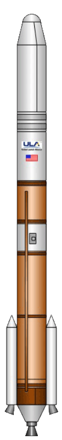
United Launch Alliance



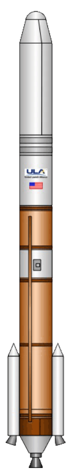
Delta IV Medium



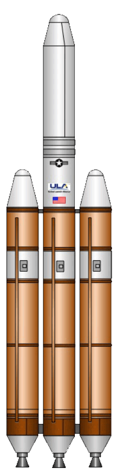
Delta IV Medium+ (4,2)



Delta IV Medium+ (5,2)



Delta IV Medium+ (5,4)



Delta IV Heavy

The Delta IV family is a product of the U.S. Air Force's Evolved Expendable Launch Vehicle Program (EELV), begun in 1995. Boeing originally developed the Delta IV, but manufacturing and operations are now conducted by United Launch Alliance (ULA), a joint company between Lockheed Martin and Boeing. ULA markets the vehicle to the U.S. Government and Boeing Launch Services markets to commercial clients worldwide. The vehicles can launch payloads to any desired orbit.

The Delta IV is composed of a Common Booster Core (CBC) powered by a PWR RS-68A main engine, one of two cryogenic upper stages (varying in propellant tank volume and diameter) powered by a PWR RL10B-2 engine, a payload adapter, and a payload fairing. The vehicle may also feature between two and four ATK GEM-60 motors. The Delta IV is available in five variants.

The Delta IV family debuted in 2002 with the successful launch of a Delta IV Medium+ (4,2) from Cape Canaveral Air Force Station (CCAFS).

A Delta IV Heavy was launched in early December 2014 carrying NASA's prototype Orion Multi-Purpose Crew Vehicle on Exploration Test Flight 1 (EFT 1). The successful mission marked the first time the vehicle was launched under an FAA AST license.

Launch service provider
United Launch Alliance
Boeing Launch Services

Company headquarters
USA

Manufacturer
United Launch Alliance

Mass, kg (lb)
D-IVM: 249,500 (549,559)
D-IVH: 733,000 (1,615,416)

Length, m (ft)
62.8-71.6 (206-234.9)

Diameter, m (ft)
5 (16.4)

Year of first launch
2002

Number of launches
28

Reliability
100%

Launch sites
CCAFS (SLC-37)
VAFB (SLC-6)

GTO capacity, kg (lb)
4,300-14,420 (9,480-31,791)

LEO capacity, kg (lb)
9,150-22,560 (20,172-49,736)

SSO capacity, kg (lb)
7,500-21,000 (16,535-46,300)

Fairing	Length, m (ft)	Diameter, m (ft)
11.7-Meter Fairing	11.7 (38.5)	4 (13)
14.3-Meter Fairing	14.3 (47)	5 (16.4)
19.1-Meter Fairing	19.1 (62.7)	5 (16.4)
Metallic Fairing	19.8 (65)	5 (16.4)

	1st Stage	SRB*	2nd Stage Option	2nd Stage Option
Stage designation	Common Booster Core	GEM-60	4-Meter Cryogenic Upper Stage	5-Meter Cryogenic Upper Stage
Length, m (ft)	46.7 (153.2)	15. 8 (52)	10.4 (34)	12.2 (40)
Diameter, m (ft)	5 (16.4)	1.6 (5.3)	4 (13.1)	5 (16.4)
Manufacturer	ULA	ATK	ULA	ULA
Propellant	LOX/LH_2	Solid	LOX/LH_2	LOX/LH_2
Propellant mass, kg (lb)	199,640 (439,735)	59,520 (130,944)	20,410 (45,000)	27,200 (60,000)
Total thrust, kN (lbf)	2,891 (650,000)	1,245.5 (280,000)	110 (24,750)	110 (24,750)
Engine(s)	1 x RS-68A	--	1 x RL10B-2	1 x RL10B-2
Engine manufacturer	Aerojet Rocketdyne	--	Aerojet Rocketdyne	Aerojet Rocketdyne
Engine thrust, kN (lbf)	2,891 (650,000)	1,245.5 (280,000)	110 (24,750)	110 (24,750)

**Figures are for each booster.*

FALCON 9 v1.1

SpaceX

Falcon 9 v1.1
(with Dragon)

Falcon 9 v1.1
(with fairing)

Space Exploration Technologies (SpaceX), founded in 2002, first launched its Falcon 9 in 2010 from Cape Canaveral Air Force Station (CCAFS). The vehicle is designed to launch government and commercial payloads to low Earth orbits, geosynchronous transfer orbits, and Earth escape trajectories. It is also used to transport the Dragon cargo module to the International Space Station (ISS), and in 2017 will begin transporting crewed versions of the Dragon. SpaceX will also provide Falcon 9 launches under the Air Force's Orbital/Suborbital Program-3 (OSP-3).

The vehicle consists of a first stage powered by nine SpaceX Merlin engines, a second stage powered by a single Merlin Vacuum engine, a payload adapter, and a large payload fairing. The Falcon 9 is also designed to launch the company's Dragon capsule, which does not require a fairing. The first version of the Falcon 9 (v1.0) launched successfully five times since its introduction in 2010.

An upgraded version of the Falcon 9 was introduced in September 2013. Falcon 9 v1.1, the upgraded vehicle, features a longer first stage, new higher thrust engines (the Merlin 1D instead of the Merlin 1C), and an octagonal arrangement of engines on the first stage (instead of a "tic-tac-toe" pattern) to relieve loads on the vehicle during launch. The figures in this fact sheet reflect the upgraded Falcon 9.

SpaceX developed the Grasshopper and Falcon 9R vehicles to test reusable technologies designed for the Falcon 9 first stage. This allows the company to offer launches on Falcon 9 while concurrently developing a reusable system.

Launch service provider SpaceX
Company headquarters USA
Manufacturer SpaceX

Mass, kg (lb) 505,846 (1,155,200)
Length, m (ft) 68.4 (224.4)
Diameter, m (ft) 3.7 (12)

Year of first launch 2010
Number of launches 8
Reliability 100%
Launch sites CCAFS (SLC-40) VAFB (SLC-3E)

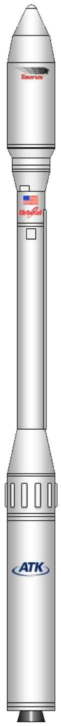
GTO capacity, kg (lb) 4,850 (10,692)
LEO capacity, kg (lb) 13,150 (28,991)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	13.2 (43.3)	5.2 (17.1)

	1st Stage	2nd Stage
Stage designation	1st Stage	2nd Stage
Length, m (ft)	42.6 (139.8)	12.6 (41.3)
Diameter, m (ft)	3.7 (12)	3.7 (12)
Manufacturer	SpaceX	SpaceX
Propellant	LOX/Kerosene	LOX/Kerosene
Propellant mass, kg (lb)	411,000 (906,010)	73,400 (161,819)
Total thrust, kN (lbf)	5,885 (1,323,000)	801 (180,000)
Engine(s)	9 x Merlin-1D	1 x Merlin-1D
Engine manufacturer	SpaceX	SpaceX
Engine thrust, kN (lbf)	653.8 (147,000)	801 (180,000)

MINOTAUR C

Orbital Sciences Corp.



3210
Minotaur C

Orbital Sciences Corporation offers the four-stage small-class vehicle, Minotaur C, as an option for satellite customers. The Minotaur C, an upgraded version of the Taurus first introduced in 1994, was developed under sponsorship of the Defense Advance Research Projects Agency (DARPA). Several variants of the Minotaur-C are available, allowing Orbital to mix and match different stages and fairings to address customer needs.

The Minotaur C launches from SLC-376E at Vandenberg Air Force Base (VAFB), though it may also be launched from SLC-46 at Cape Canaveral Air Force Station (CCAFS) and Pad 0-B at Virginia's Mid-Atlantic Regional Spaceport (MARS).

Skybox Imaging signed a contract with Orbital Sciences Corp. in 2014 for the launch of six SkySat satellites on a single Minotaur C. The launch is planned for 2015.

Orbital Sciences Corp. and ATK Systems initiated a merger in 2014, and this merger will be finalized in 2015 with the establishment of Orbital ATK, Inc.

Launch service provider Orbital Sciences Corp.
Company headquarters USA
Manufacturer Orbital Sciences Corp.

Mass, kg (lb) 70,000 (154,324)
Length, m (ft) 24.6 (80.7)
Diameter, m (ft) 2.4 (7.9)

Year of first launch 2015
Launch sites CCAFS (SLC-46) MARS (Pad 0-B) VAFB (SLC-376E)

3110, 3112
Minotaur C

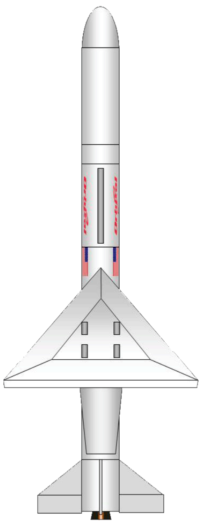
Fairing	Length, m (ft)	Diameter, m (ft)
2.3-Meter Fairing	1.6 (5.2)	2.3 (7.5)
1.6-Meter Fairing	2.2 (7.2)	1.6 (5.2)

LEO capacity, kg (lb) 1,160 (2,552)
SSO capacity, kg (lb) 1,600 (3,520)

	1st Stage	2nd Stage	3rd Stage	4th Stage Option	4th Stage Option
Stage designation	Castor-120	Orion-50SXLG	Orion-50XL	Orion-38	STAR-37
Length, m (ft)	9.1 (29.9)	8.9 (29.2)	3.1 (10.2)	1.3 (4.3)	2.3 (7.5)
Diameter, m (ft)	2.4 (7.9)	1.3 (4.3)	1.3 (4.3)	1 (3.3)	0.7 (2.3)
Manufacturer	ATK	ATK	ATK	ATK	ATK
Propellant	Solid	Solid	Solid	Solid	Solid
Propellant mass, kg (lb)	48,960 (107,939)	15,023 (33,120)	3,925 (8,655)	770 (1,697)	1,066 (2,350)
Total thrust, kN (lbf)	1,904 (428,120)	704 (157,729)	196 (44,171)	36 (8,062)	47.3 (10,625)
Engine thrust, kN (lbf)	1,904 (428,120)	704 (157,729)	196 (44,171)	36 (8,062)	47.3 (10,625)

Pegasus XL

Orbital Sciences Corp.



Pegasus XL

Orbital's Pegasus XL is a small-class, air-launched vehicle. Orbital Science Corporation offers the Pegasus XL as a means to launch small satellites to low Earth orbits (LEO).

The vehicle is derived from the first generation Standard Pegasus first launched in 1990. It is normally composed of three solid propellant stages manufactured by ATK, but it may also include an Orbital-built Hydrazine Auxiliary Propulsion System (HAPS) as a fourth stage. The vehicle uses a 1.2-meter (3.9-foot) payload fairing. The first, second, and third stages are manufactured by ATK and include Orion-50SXL, Orion-50XL, and Orion-38 motors, respectively. The Orion-50SXL is also integrated with a wing, enabling aerodynamic flight during the launch phase. The vehicle is air-launched from a Lockheed-built L-1011 aircraft.

The Pegasus XL has flown 26 consecutive successful missions since 1997, but did not fly in 2014.

LEO capacity figures are for the Pegasus XL without a HAPS fourth stage from Cape Canaveral Air Force Station (CCAFS). Sun-synchronous orbit (SSO) figures are for the same vehicle configuration launched from Vandenberg Air Force Base (VAFB).

Orbital Sciences Corp. and ATK Systems initiated a merger in 2014, and this merger will be finalized in 2015 with the establishment of Orbital ATK, Inc.

Launch service provider	Orbital Sciences Corp.
Company headquarters	USA
Manufacturer	Orbital Sciences Corp.

Mass, kg (lb)	23,130 (50,993)
Length, m (ft)	16.9 (55.4)
Diameter, m (ft)	1.3 (4.2)

Year of first launch	1994
Number of launches	32
Reliability	91%
Launch sites	Canary Islands, CCAFS, Kwajalein, VAFB, WFF

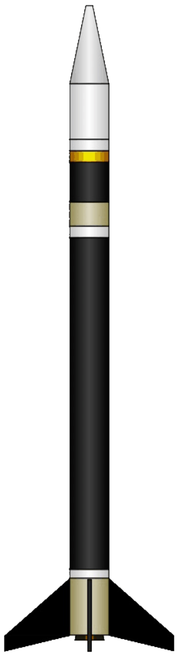
LEO capacity, kg (lb)	450 (992)
SSO capacity, kg (lb)	325 (717)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	2.1 (6.9)	1.2 (3.9)

	1st Stage	2nd Stage	3rd Stage	4th Stage
Stage designation	Orion-50SXL	Orion-50XL	Orion-38	HAPS
Length, m (ft)	10.27 (33.7)	3.1 (10.2)	1.3 (4.3)	0.7 (2.3)
Diameter, m (ft)	1.3 (4.3)	1.3 (4.3)	1 (3.3)	1 (3.3)
Manufacturer	ATK	ATK	ATK	Orbital
Propellant	Solid	Solid	Solid	Hydrazine
Propellant mass, kg (lb)	15,014 (33,105)	3,925 (8,655)	770 (1,697)	73 (161)
Total thrust, kN (lbf)	726 (163,247)	196 (44,171)	36 (8,062)	0.6 (135)
Engine(s)	--	--	--	3 x Rocket Engine Assemblies
Engine manufacturer	--	--	--	Orbital
Engine thrust, kN (bf)	726 (163,247)	196 (44,171)	36 (8,062)	0.2 (45)

SUPER STRYPI

ORS Office
Sandia National Labs



Super Strypi

The Department of Defence's Operationally Responsive Space (ORS) Office, with support from Sandia National Laboratories (SNL), Aerojet Rocketdyne, the University of Hawaii, and NASA's Ames Research Center, is developing a small launch vehicle known as Super Strypi. The goal is to deliver payloads in the range of 300 kilograms (661 pounds) to low Earth orbit (LEO). This vehicle may be available commercially following test flights to provide launch services to the Government, both Civil and Department of Defense (DoD), as well as commercial programs.

The three-stage all-solid vehicle is based on the 1960s-era Strypi test missile. Aerojet Rocketdyne is developing the three new solid rocket motors that support the Super Strypi launch system. The first stage is the LEO-46, second stage is the LEO-7 and the third stage is the LEO-1.

The rail-launched Super Strypi, also called the Spaceborne Payload Assist Rocket Kauai (SPARK), is scheduled to make its inaugural flight in 2015 from the Pacific Missile Range Facility (PMRF) at Barking Sands in Hawaii. The vehicle is also compatible with other launch sites, such as, but not limited to, Space Florida's Cape Canaveral Spaceport, Kodiak Launch Complex in Alaska, and NASA's WFF.

Launch service provider ORS Office Sandia National Laboratory
Company headquarters USA
Manufacturer ORS Office Sandia National Laboratory Aerojet Rocketdyne

Mass, kg (lb) 28,240 (62,260)
Length, m (ft) 16.8 (55)
Diameter, m (ft) 1.5 (5)

Year of first launch 2015
Launch site PMRF (Pad 41)

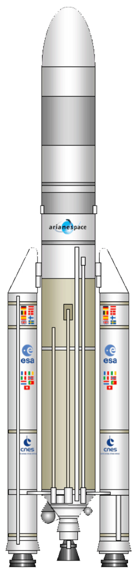
LEO capacity, kg (lb) 320 (705)
SSO capacity, kg (lb) 275 (606)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	1.5 (5)	1.5 (5)

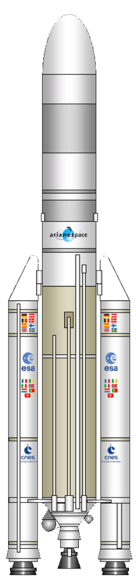
	1st Stage	2nd Stage	3rd Stage
Stage designation	LEO-46	LEO-7	LEO-1
Length, m (ft)	11.3 (37)	2.7 (9)	1.5 (5)
Diameter, m (ft)	1.5 (5)	1.5 (5)	1.5 (5)
Manufacturer	Aerojet Rocketdyne	Aerojet Rocketdyne	Aerojet Rocketdyne
Propellant	ANB-3745 solid	ANB-3790 solid	ANB-3790 solid
Propellant mass, kg (lb)	20,582 (45,376)	3,232 (7,125)	651 (1,435)
Total thrust, kN (lbf)	729.5 (164,000)	TBD	TBD
Engine thrust, kN (lbf)	729.5 (164,000)	TBD	TBD

Ariane 5

Arianespace



Ariane 5 ECA



Ariane 5 ES

The Ariane 5, technically the Ariane 5 ECA, is the workhorse of France-based Arianespace, a European launch consortium. With direct technical heritage to the Ariane 4 series, the Ariane 5 consists of an Airbus liquid-fueled core stage powered by the Snecma Vulcain 2 engine, two Europropulsion strap-on solid boosters, a Snecma cryogenic upper stage powered by an HM7B engine direct heritage from Ariane 4, an Airbus payload adapter that can accommodate two satellites (called SYLDA), and a Ruag-built payload fairing. The Ariane 5 ECA is optimized for launches of two geosynchronous communications satellites.

Arianespace also provides the Ariane 5 ES version with a storable propellant upper stage engine used to launch the Automated Transfer Vehicle (ATV) to the International Space Station (ISS) and very large satellites like Envisat.

Arianespace oversees the procurement, quality control, launch operations, and marketing of the Ariane 5. A new joint venture, called Airbus Safran Launchers and established in late 2014, is the prime contractor for Ariane 5 manufacturing. The Ariane 5 has launched 77 times since its introduction in 1996, with 63 consecutive successes since 2003. The Ariane 5 ECA variant has flown 47 times.

In December 2014, the European Space Agency (ESA) authorized development of the Ariane 6 vehicle as an eventual replacement for the Ariane 5. The new vehicle will be offered in two variants beginning in 2020.

Launch service provider Arianespace
Company headquarters France
Manufacturer Airbus Safran Launchers

Mass, kg (lb) 777,000 (1,712,992)
Length, m (ft) 46-52 (151-171)
Diameter, m (ft) 5.4 (17.7)

Year of first launch 2002 (ECA version)
Number of launches 47 (ECA version)
Reliability 98%
Launch site Guiana Space Center (ELA-3)

GTO capacity, kg (lb) 9,500 (20,944)
LEO capacity, kg (lb) 21,000 (46,297)
SSO capacity, kg (lb) 10,000 (22,046)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	17 (55.8)	5.4 (17.7)

	1st Stage	SRB*	2nd Stage
Stage designation	EPC	EAP	ESC-A
Length, m (ft)	30.5 (100.1)	31.6 (103.7)	4.7 (15.4)
Diameter, m (ft)	5.4 (17.7)	3.1 (10.2)	5.4 (17.7)
Manufacturer	Airbus	Europropulsion	Airbus
Propellant	LOX/LH_2	Solid	LOX/LH_2
Propellant mass, kg (lb)	170,000 (374,786)	240,000 (529,109)	14,900 (32,849)
Total thrust, kN (lbf)	960 (215,817)	7,000 (1,573,663)	67 (15,062)
Engine(s)	1 x Vulcain 2	--	1 x HM7B
Engine manufacturer	Snecma	--	Snecma
Engine thrust, kN (lbf)	960 (215,817)	7,000 (1,573,663)	67 (15,062)

**Figures are for each booster.*

DNEPR

ISC Kosmotras

Dnepr

The Dnepr, introduced in 1999, is developed from surplus Soviet R-36 (SS-18) intercontinental ballistic missiles (ICBM). About 150 missiles were made available for conversion into launch vehicles. The missiles, with components built during the Soviet era, are refurbished by PA Yuzhmash located in Ukraine. The three-stage, liquid fueled vehicle is designed to address medium-class payloads or clusters of small- and micro-class satellites. It is marketed by the Russian-based company ISC Kosmotras.

The Dnepr has launched 21 times, with one failure. The Dnepr is launched from Pad 109 and Pad 95 at the Baikonur Kosmodrome in Kazakhstan and the Dombarovsky missile base in Western Russia.

Due to increasing political tensions between Russia and Ukraine during 2014, and the resulting international sanctions against Russia, PA Yushmash, a key supplier of missiles and other hardware to the Russian military, has experienced considerable financial difficulties that may impact its product line.

Launch service provider ISC Kosmotras
Company headquarters Russia
Manufacturer PA Yuzhmash

Mass, kg (lb) 260,546 (574,406)
Length, m (ft) 34.3 (112.5)
Diameter, m (ft) 3 (9.8)

Year of first launch 1999
Number of launches 21
Reliability 97%
Launch sites Baikonur (LC-109, LC-95) Dombarovsky (LC-13)

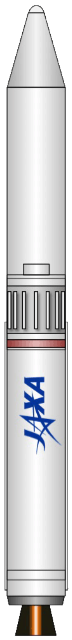
LEO capacity, kg (lb) 3,700 (8,157)
SSO capacity, kg (lb) 2,300 (5,071)

Fairing	Length, m (ft)	Diameter, m (ft)
Sandard Fairing	5.3 (17.4)	3 (9.8)
Extended Fairing	6.1 (20)	3 (9.8)

	1st Stage	2nd Stage	3rd Stage
Stage designation	1st Stage	2nd Stage	3rd Stage
Length, m (ft)	22 (72.2)	6 (19.7)	1.5 (4.9)
Diameter, m (ft)	3 (9.8)	3 (9.8)	3 (9.8)
Manufacturer	PA Yuzhmash	PA Yuzhmash	PA Yuzhmash
Propellant	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH
Propellant mass, kg (lb)	147,900 (326,064)	36,740 (80,998)	1,910 (4,211)
Total thrust, kN (lbf)	4,520 (1,016,136)	755 (169,731)	18.6 (4,181)
Engine(s)	4 x RD-264	1 x RD-0255	1 x RD-869
Engine manufacturer	OKB-456 (NPO Energomash)	OKB-154 (KB Khimavtomatika)	OKB-586 (Yuzhnoye)
Engine thrust, kN (lbf)	1,130 (254,034)	755 (169,731)	18.6 (4,181)

Epsilon

Japan Aerospace Exploration Agency



Epsilon

The Epsilon is a vehicle under development by the Japan Aerospace Exploration Agency (JAXA), derived from the Nissan-built M-V discontinued in 2006. The vehicle will be used to send small payloads to low Earth orbits and polar orbits. The first launch of Epsilon took place during 2013, successfully placing a small payload into low Earth orbit (LEO).

The Epsilon comes in both a Standard Configuration and an Optional Configuration. The first stage of the Standard Configuration Epsilon is a solid motor similar to those on the H-IIA. An M-34c solid motor constitutes the second stage, and a KM-2Vb represents the third stage. A payload adapter and fairing complete the system. The Optional Configuration features an additional compact Post Boost Stage integrated with the third stage for Sun-synchronous orbits (SSO).

The vehicle is launched from Uchinoura Space Center, formerly called Kagoshima Space Center.

Launch service provider	JAXA
Company headquarters	Japan
Manufacturer	IHI

Mass, kg (lb)	90,800 (200,180)
Length, m (ft)	24.4 (80.1)
Diameter, m (ft)	2.5 (8.2)

Year of first launch	2013
Number of launches	1
Reliability	100%
Launch site	Uchinoura Space Center

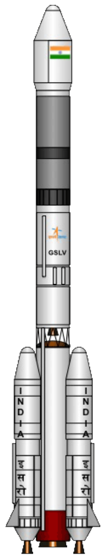
LEO capacity, kg (lb)	700 -1,200 (1,543-2,646)
SSO capacity, kg (lb)	450 (992)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	10 (32.8)	2.5 (8.2)

	1st Stage	2nd Stage	3rd Stage	4th Stage
Stage designation	SRB-A3	M-34c	KM-V2b	Post Boost Stage
Length, m (ft)	15 (49.2)	5 (16.4)	3 (9.8)	0.5 (1.6)
Diameter, m (ft)	2.5 (8.2)	2.5 (8.2)	2.5 (8.2)	2 (6.6)
Manufacturer	Nissan	Nissan	Nissan	Nissan
Propellant	Solid	Solid	Solid	Hydrazine
Propellant mass, kg (lb)	66,000 (145,505)	10,800 (23,800)	2,500 (5,512)	100 (220)
Total thrust, kN (lbf)	1,580 (355,198)	377.2 (84,798)	81.3 (18,277)	< 1 (225)
Engine(s)	--	--	--	3 units
Engine manufacturer	--	--	--	Nissan
Engine thrust, kN (lbf)	1,580 (355,198)	377.2 (84,798)	81.3 (18,277)	<0.33 (74)

GSLV

Antrix



GSLV
Mk. I

GSLV
Mk. II

The Geosynchronous Satellite Launch Vehicle (GSLV) project began in 1990 with the objective of achieving an Indian indigenous satellite launch capability to geosynchronous orbit (GEO).

GSLV uses major components that are already proven in the PSLV vehicles in the form of the S125/S139 solid booster and the liquid-fueled Vikas engine.

The current variant, GSLV Mk.II was introduced in 2010 and uses an indigenous cryogenic engine, the CE-7.5 in the third stage instead of the Russian cryogenic engine used by the vehicle's older version, GSLV Mk. I. The 49.1 meter (161 ft) tall GSLV, with a lift-off mass of 414.8 metric tons, is a three-stage vehicle that employs solid, liquid and cryogenic propulsion technologies. The payload fairing is 7.8 meter (26 ft) long and 3.4 meters (11.2 ft) in diameter. The GSLV can place approximately 5,000 kg (11,023 lb) into low earth orbit (LEO). GSLV can place 2,500 kg (5,516 lb) into geosynchronous transfer orbit (GTO).

In 2014, India successfully performed a suborbital test of its LVM3 launch vehicle (formerly known as GSLV Mk III).

Launch service provider Antrix
Company headquarters India
Manufacturer ISRO

Mass, kg (lb) 414,750 (914,637)
Length, m (ft) 49.13 (161.2
Diameter, m (ft) 2.8 (9.2)

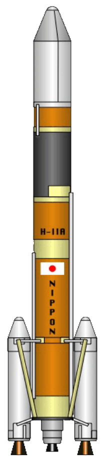
Year of first launch 2001
Number of launches (A/B) 8
Reliability (A/B) 63%
Launch site Satish Dhawan

GTO capacity, kg (lb) 2,500 (5,516)
LEO capacity, kg (lb) 5,000 (11,023)

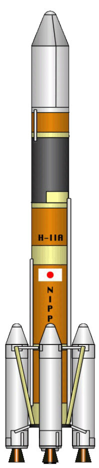
Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing		3.4 (11.2)

	Liquid Boosters	1^{st} Stage	2^{nd} Stage	3^{rd} Stage
Stage designation	Strap-on Motors	GS1	GS2	CUS
Length, m (ft)	19.7 (64.6)	20.3 (66.7)	11.6 (38)	8.7 (28.6)
Diameter, m (ft)	2.1 (6.8)	2.8 (9.1)	2.8 (9.1)	2.8 (9.1)
Manufacturer	ISRO	ISRO	ISRO	ISRO
Propellant	N_2O_4/UDMH	Solid	N_2O_4/UDMH	LOX/H_2
Propellant mass, kg (lb)	40,000 (88,200)	129,000 (284,400)	37,500 (82,600)	12,400 (27,300)
Total thrust, kN (lbf)	680 (152,870)	4,700 (1,056,602)	800 (179,847)	75 (16,861)
Engine(s)	L40H Vikas 2	S139	Vikas	CE-7.5
Engine manufacturer	ISRO	ISRO	ISRO	ISRO
Engine thrust, kN (lbf)	170 (38,218)	4,700 (1,056,602)	800 (179,847)	75 (16,861)

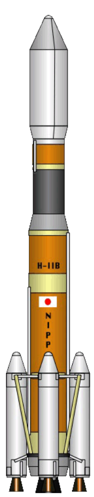
H-IIA/B



H-IIA
202



H-IIA
204



H-IIB

The two-stage H-IIA and H-IIB, designed and built by Mitsubishi Heavy Industries (MHI), are Japan's primary launch vehicles.

The H-IIA vehicle features a cryogenic core stage powered by a single LE-7A engine, two large liquid rocket boosters, an upper stage, a payload adapter, and a payload fairing. The vehicle may also employ a combination of solid boosters to supplement thrust. The H-IIA 202 uses two solid rocket boosters, and the H-IIA 204 uses four solid rocket boosters. The H-IIB features a large first stage powered by two LE-7A engines and supplemented by four liquid rocket boosters and a second stage powered by an LE-5B engine.

There are currently two versions of the H-IIA and one version of the H-IIB available. The H-IIA (with two or four solid boosters) is used to launch a variety of satellites to low Earth orbit, geosynchronous transfer orbits, and beyond. The H-IIB (with four upgraded solid boosters) is currently used to launch the H-II Transfer Vehicle (HTV) to the International Space Station (ISS), and has recently been offered as an option for commercial satellite customers.

The H-II vehicle family can trace its lineage through the H-I, the N-1, and ultimately the U.S. Thor intermediate range ballistic missile.

In 2014, the Japan Aerospace Exploration Agency (JAXA) requested the MHI begin development of the H-III, a replacement for the H-IIA/B expected by 2020.

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	12 (39.4)	4.07 (13.4)

Launch service provider
MHI Launch Services

Company headquarters
Japan

Manufacturer
Mitsubishi Heavy Industries

Mass, kg (lb)
289,000-530,000
(637,136-1,168,450)

Length, m (ft)
53-57 (173.9-187)

Diameter, m (ft)
4 (13.1)

Year of first launch
2001

Number of launches (A/B)
30

Reliability (A/B)
98%

Launch site
Tanegashima

GTO capacity, kg (lb)
4,000-6,000 (8,818-13,228)

LEO capacity, kg (lb)
10,000-16,500 (22,046-36,376)

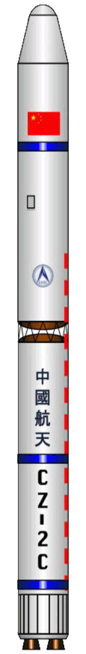
SSO capacity, kg (lb)
3,600-4,400 (7,937-9,700)

	1st Stage	Solid Booster (H-IIA)*	Solid Booster (H-IIB)*	2nd Stage
Stage designation	1st Stage	SRB-A	SRB-A3	2nd Stage
Length, m (ft)	37 (121.4)	15 (49.2)	15.1 (49.5)	11 (36.1)
Diameter, m (ft)	4 (13.1)	2.5 (8.2)	2.5 (8.2)	4 (13.1)
Manufacturer	Mitsubishi	Nissan	Nissan	Mitsubishi
Propellant	LOX/LH_2	Solid	Solid	LOX/LH_2
Propellant mass, kg (lb)	101,000 (222,667)	60,500 (133,380)	66,000 (145,505)	17,000 (37,479)
Total thrust, kN (lbf)	1,098 (246,840)	2,260 (508,068)	1,580 (355,198)	137 (30,799)
Engine(s)	LE-7A	--	--	LE-5B
Engine manufacturer	Mitsubishi	--	--	Mitsubishi
Engine thrust, kN (lbf)	1,098 (246,840)	2,260 (508,068)	1,580 (355,198)	137 (30,799)

**Figures are for each booster.*

LONG MARCH 2

China Great Wall Industry Corporation



Long March 2C

The Long March 2, which comes in two versions, is a small-class vehicle designed to address missions to low Earth orbit. The vehicle is built by the Shanghai Academy of Spaceflight Technology (SAST) and marketed by China Great Wall Industry Corporation (CGWIC). Both organizations are subsidiaries of the China Aerospace Science and Technology Corporation (CASC).

The Long March 2D, used mainly for Sun-synchronous orbits (SSO) missions, consists of two stages and is only launched from Jiuquan Satellite Launch Center (JSLC). The Long March 2C features a solid motor upper stage and is launched from JSLC, Taiyuan Satellite Launch Center (TSLC) and Xichang Satellite Launch Center (XSLC).

Launch service provider CGWIC
Company headquarters China
Manufacturer SAST

Mass, kg (lb) 233,000 (513,677)
Length, m (ft) 41-42 (134.5-137.8)
Diameter, m (ft) 3.4 (11.2)

Year of first launch LM-2C: 1975, LM-2D: 1992
Number of launches LM-2C: 38, LM-2D: 15
Reliability LM-2C: 100%, LM-2D: 100%
Launch sites JSLC, TSLC, XSLC

GTO capacity, kg (lb) 1,250 (2,756)
LEO capacity, kg (lb) 3,850 (8,488)
SSO capacity, kg (lb) 1,300-1,900 (2,866-4,189)

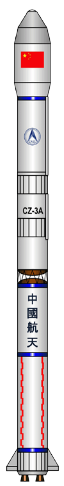
Long March 2D

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	7 (22.9)	3.4 (11.2)

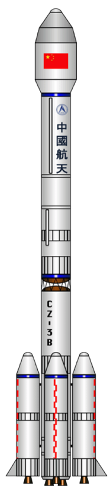
	1st Stage (LM-2C)	1st Stage (LM-2D)	2nd Stage (LM-2C)	2nd Stage (LM-2D)	3rd Stage (LM-2C)
Stage designation	1st Stage	1st Stage	2nd Stage	2nd Stage	2804
Length, m (ft)	25.7 (84.3)	27.9 (91.5)	7.8 (25.6)	10.9 (35.8)	1.5 (4.9)
Diameter, m (ft)	3.4 (11.2)	3.4 (11.2)	3.4 (11.2)	3.4 (11.2)	2.7 (8.9)
Manufacturer	SAST	SAST	SAST	SAST	SAST
Propellant	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH	Solid
Propellant mass, kg (lb)	162,706 (358,705)	182,000 (401,241)	54,667 (120,520)	52,700 (116,184)	125 (275.6)
Total thrust, kN (lbf)	2,961.6 (665,794)	2,961.6 (665,794)	741.3 (166,651)	742 (166,808)	10.8 (2,428)
Engine(s)	4 x YF-21C	4 x YF-21C	1 x YF-24E	1 x YF-24C	--
Engine manufacturer	CALT	CALT	CALT	CALT	--
Engine thrust, kN (lbf)	740.4 (166,449)	740.4 (166,449)	741.3 (166,651)	742 (166,808)	10.8 (2,428)

Long March 3A

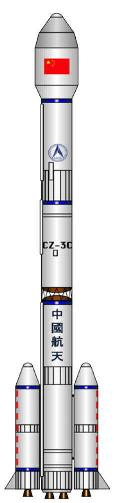
China Great Wall Industry Corporation



Long March 3A



Long March 3B



Long March 3C

China Great Wall Industry Corporation (CGWIC) markets the Long March 3A vehicle family for customers seeking launches of satellites to geosynchronous orbit. It is derived from the discontinued Long March 3, and is the basis for the Long March 3B, enhanced 3BE, and C versions. The Long March 3B features four liquid boosters and the 3C features two. All variants are launched from Xichang Satellite Launch Center (XSLC).

There are four versions of the three-stage Long March 3A. The Long March 3A consists of a core stage powered by four YF-21C engines, a second stage powered by a YF-24E engine, and a third stage powered by a YF-75 engine. The vehicle is topped with a payload adapter and fairing. The Long March 3B and Long March 3BE have the same core stage powered by four YF-21C engines, the same second stage powered by a YF-24E engine, and the same third stage powered by a YF-75 engine. The difference between the two is the type of liquid rocket boosters they use. The Long March 3C is the same as the Long March 3B, but with two liquid rocket boosters instead of four. A selection of four payload fairings is offered for all variants.

Development and manufacturing of the Long March 3A vehicles are shared between the China Academy of Launch Vehicles (CALT) and SAST. The Long March 3A can trace its lineage to the DF-5 intercontinental ballistic missile (ICBM) first deployed in 1981.

Fairing	Length, m (ft)	Diameter, m (ft)
Fairing Option A	8.9 (29)	3.4 (11)
Fairing Option B	8.9 (29)	3.7 (12)
Fairing Option C	8.9 (29)	4 (13)
Fairing Option D	8.9 (29)	4.2 (13.8)

Launch service provider
CGWIC

Company headquarters
China

Manufacturer
CALT

Mass, kg (lb)
242,000-456,000 (533,519-1,005,308)

Length, m (ft)
52.5-57 (172-187)

Diameter, m (ft)
3.4 (11)

Year of first launch
LM-3A: 1994, LM-3B: 1996, LM-3C: 2008

Number of launches
LM-3A: 23, LM-3B/E: 26, LM-3C: 11

Reliability
LM-3A: 100%, LM-3B: 92%, LM-3C: 100%

Launch site
XSLC

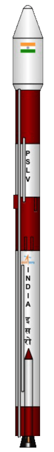
GTO capacity, kg (lb)
2,600-5,500 (5,732-12,125)

	1st Stage (LM-3A)	1st Stage (LM-3BE)	Booster (LM-3B/C)*	Booster (LM-3BE)*	2nd Stage (LM-3A)	2nd Stage (LM-3B/BE)	3rd Stage (ALL)
Stage designation	1st Stage	1st Stage	Booster	Booster	2nd Stage	2nd Stage	3rd Stage
Length, m (ft)	23.3 (76.4)	24.8 (81.4)	15.3 (50.2)	16.1 (52.8)	11.3 (37.1)	12.9 (42.3)	12.4 (40.7)
Diameter, m (ft)	3.4 (11.2)	3.4 (11.2)	2.3 (7.5)	2.3 (7.5)	3.4 (11.2)	3.4 (11.2)	3 (9.8)
Manufacturer	CALT	CALT	CALT	CALT	CALT	CALT	CALT
Propellant	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH	LOX/LH_2
Propellant mass, kg (lb)	171,800 (378,754)	186,200 (410,501)	37,700 (83,114)	41,100 (90,610)	32,600 (71,871)	49,400 (108,908)	18,200 (40,124)
Total thrust, kN (lbf)	2,961.6 (665,794)	2,961.6 (665,794)	740.4 (166,449)	740.4 (166,449)	742 (166,808)	742 (166,808)	167.2 (37,588)
Engine(s)	4 x YF-21C	4 x YF-21C	1 x YF-25	1 x YF-25	1 x YF-24E	1 x YF-24E	1 x YF-75
Engine manufacturer	CALT	CALT	CALT	CALT	CALT	CALT	CALT
Engine thrust, kN (lbf)	740.4 (166,449)	740.4 (166,449)	740.4 (166,449)	740.4 (166,449)	742 (166,808)	742 (166,808)	167.2 (37,588)

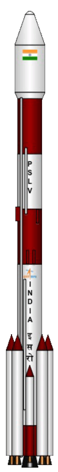
**Figures are for each booster.*

PSLV

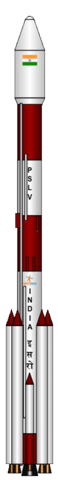
Antrix



PSLV-CA



PSLV-G



PSLV-XL

The Indian Space Research Organization (ISRO) has offered the Polar Satellite Launch Vehicle (PSLV) since 1993. The vehicle is used to launch small and medium payloads to low Earth orbit and, on occasion, to send small satellites to geosynchronous orbit. For missions to LEO, it is not uncommon for the PSLV to launch several satellites at a time.

The PSLV is available in three variants. The basic version is known as the PSLV-CA, for “Core Alone.” The PSLV-G, or standard PSLV, is teh more common variant and features six solid strap-on motors attached to the first stage core. The PSLV-XL is similar to the standard PSLV, but the six solid boosters are longer to accomodate greater propellant mass and thus increasing buring time.

The PSLV has been used for four commercial launches. The latest was a 2014 launch that carried payloads for France (SPOT 7), Canada (Can-X4 and X5), Germany (AISAT), and Singapore (VELOX-1). SPOT 7 was sold to the government of Azerbaijan several moths later.

Launch service provider
ISRO

Company headquarters
India

Manufacturer
ISRO

Mass, kg (lb)
320,000 (705,479)

Length, m (ft)
44 (144)

Diameter, m (ft)
2.8 (9.2)

Year of first launch
1993

Number of launches
28

Reliability
96%

Launch sites
Satish Dhawan Space Center

GTO capacity, kg (lb)
1,425 (3,142)

LEO capacity, kg (lb)
3,250 (7,165)

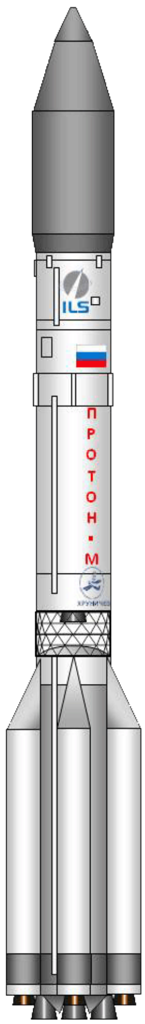
SSO capacity, kg (lb)
1,750 (3,850)

Fairing	Length, m (ft)	Diameter, m (ft)
PSLV Fairing	8.3 (27.2)	3.2 (10.5)

	Solid Boosters	1st Stage	2nd Stage	3rd Stage	4th Stage
Stage designation	PSOM	PS1	PS2	PS3	PS4
Length, m (ft)	G: 10 (32.8) XL: 13.5 (44.3)	20.34 (66.7)	12.8 (42)	3.54 (11.6)	2.6 (8.5)
Diameter, m (ft)	1 (3.3)	2.8 (9.2)	2.8 (9.2)	2.02 (6.6)	2.02 (6.6)
Manufacturer	ISRO	ISRO	ISRO	ISRO	ISRO
Propellant	Solid	Solid	N_2O_4/UDMH	Solid	Solid
Propellant mass, kg (lb)	G: 9,000 (19,842) XL: 12,000 (26,455)	138,000 (304,238)	40,700 (89,728)	6,700 (14,771)	2,000 (4,409)
Total thrust, kN (lbf)	4,314 (969,828)	4,800 (1,079,082)	799 (179,622)	240 (53,954)	14.6 (3,282)
Engine(s)	--	--	1 x Vikas	--	2 x PS-4
Engine manufacturer	--	--	ISRO	--	ISRO
Engine thrust, kN (lbf)	719 (161,638)	4,800 (1,079,082)	799 (179,622)	240 (53,954)	7.3 (1,641)

Proton M

International Launch Services



Proton M

The Proton M is provided by International Launch Services (ILS) as a launch option for government and commercial operators of satellites in geosynchronous orbit. It is typically not used for missions to low Earth orbit (LEO).

The Proton M is built by the Khrunichev State Research and Production Space Center. The vehicle traces its lineage to the UR500 system developed by Vladimir Chelomei's OKB-52 design bureau in 1965. The Proton was originally intended to send cosmonauts to the Moon until Soviet leadership selected Sergei Korolov's N-1 vehicle instead. The Proton launched the Soviet Union's Almaz (Salyut) and Mir space stations, and two modules of the International Space Station (ISS).

Until December 2012, the Russian government used an earlier version of the Proton, often called the Proton K. It now uses the Proton M with either versions of the Block DM or the Breeze-M as the fourth stage or as a three-stage vehicle for LEO missions.

When introduced in 2001, the Proton M maintained a flawless record of 13 launches before a failure was encountered in 2006. Since then, there has been a Proton M failure each year except in 2009. The 2014 failure in May resulted in the loss of the Express AM4R satellite.

The Khrunichev-designed and built Angara series of vehicles is expected to gradually replace the Proton M beginning in 2015.

Launch service provider International Launch Services
Company headquarters USA
Manufacturer Khrunichev

Mass, kg (lb) 712,800 (1,571,400)
Length, m (ft) 53 (173)
Diameter, m (ft) 7.4 (24)

Year of first launch 2001
Number of launches 86
Reliability 91%
Launch sites Baikonur (LC-8 and LC-200)

GTO capacity, kg (lb) 6,920 (15,256)
LEO capacity, kg (lb) 23,000 (50,706)

Fairing	Length, m (ft)	Diameter, m (ft)
PLF-BR-13305 Fairing	13.3 (43.6)	4.4 (14.4)
PLF-BR-15255 Fairing	15.3 (50.2)	4.4 (14.4)

	1st Stage	2nd Stage	3rd Stage	4th Stage
Stage designation	1st Stage	2nd Stage	3rd Stage	Breeze-M
Length, m (ft)	21.2 (69.6)	17.1 (56.1)	4.1 (13.5)	2.7 (8.9)
Diameter, m (ft)	7.4 (24.3)	4.1 (13.5)	4.1 (13.5)	4 (13)
Manufacturer	Khrunichev	Khrunichev	Khrunichev	Khrunichev
Propellant	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH
Propellant mass, kg (lb)	428,300 (944,239)	157,300 (346,787)	46,562 (102,651)	19,800 (43,651)
Total thrust, kN (lbf)	10,000 (2,248,089)	2,400 (539,541)	583 (131,063)	19.2 (4,411)
Engine(s)	6 x RD-276	3 x RD-0210	1 x RD-0123	1 x 14D30
Engine manufacturer	NPO Energomash	KB Khimavtomatika	KB Khimavtomatika	DB Khimmash
Engine thrust, kN (lbf)	1,667 (374,682)	800 (179,847)	583 (131,063)	19.6 (4,411)

Rockot

Eurockot

Rockot

The three-stage Rockot is developed using refurbished missile components. The missile used as the basis for the commercially available vehicle is the UR100N (SS-19) intercontinental ballistic missile (ICBM) built by Soviet-era OKB-52. Production and launch of the Rockot is managed by Eurockot Launch Services GmbH, a joint company between Russia's Khrunichev State Research and Production Space Center and EADS Astrium.

The Rockot consists of three stages. The first two stages are composed of SS-19 booster segments. The first stage is powered by an RD-244 engine and the second by an RD-235 engine. The third stage is a newly manufactured Khrunichev Breeze-KM upper stage. A payload adapter and fairing complete the vehicle system.

Since 1990, the vehicle has launched 24 times, with 2 failures. The first three launches were with the initial version, the Rockot-K. In May 2000, the vehicle was upgraded to accommodate a larger payload, it became the Rockot-KM, which has launched 21 times with 2 failures. The Rockot-KM launches from Plesetsk Kosmodrome in Russia.

The Rockot is predominantly used for scientific Earth observation and climate research missions in LEO. Eleven flights have been performed by Eurockot Launch Services for international customers. Rockot-KM currently has a backlog of commercial customers until 2015 and Russian government flights to the end of the decade.

Launch service provider
Eurockot

Company headquarters
Germany

Manufacturer
Khrunichev

Mass, kg (lb)
107,000 (235,895)

Length, m (ft)
29.2 (95.8)

Diameter, m (ft)
2.5 (8.2)

Year of first launch
2000

Number of launches
22

Reliability
91%

Launch site
Plesetsk (LC-133)

LEO capacity, kg (lb)
1,820-2,150 (4,012-4,740)

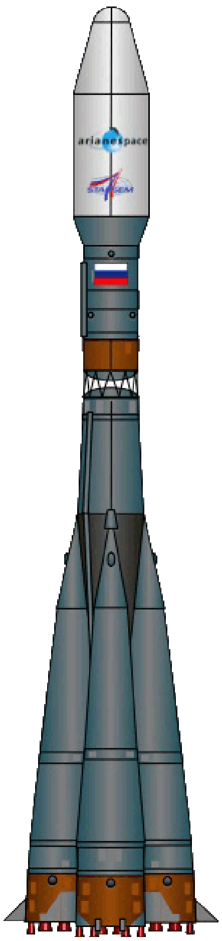
SSO capacity, kg (lb)
1,180-1,600 (2,601-3,527)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	2.6 (8.5)	2.5 (8.2)

	1st Stage	2nd Stage	3rd Stage
Stage designation	1st Stage	2nd Stage	Breeze-KM
Length, m (ft)	17.2 (56.4)	3.9 (12.8)	2.5 (8.2)
Diameter, m (ft)	2.5 (8.2)	2.5 (8.2)	2.5 (8.2)
Manufacturer	OKB-52 (Khrunichev)	OKB-52 (Khrunichev)	Khrunichev
Propellant	N_2O_4/UDMH	N_2O_4/UDMH	N_2O_4/UDMH
Propellant mass, kg (lb)	71,455 (157,531)	10,710 (23,612)	4,975 (10,968)
Total thrust, kN (lbf)	1,870 (420,393)	240 (53,954)	19.6 (4,406)
Engine(s)	3 x RD-0233 1 x RD-0234	1 x RD-235	1 x S5.98M
Engine manufacturer	OKB-154 (KB Khimavtomatika)	OKB-154 (KB Khimavtomatika)	Khrunichev
Engine thrust, kN (lbf)	520 (116,901)	240 (53,954)	19.6 (4,406)

Soyuz 2.1A/B

Arianespace
Starsem



Soyuz 2

The Soyuz 2 (also referred to as Soyuz ST) is used to launch satellites to virtually any orbit from three different launch sites. It can trace its lineage to the R-7 intercontinental ballistic missile designed by Sergei Korolov and his OKB-1 design bureau in the mid-1950s.

The Soyuz received its current name when it was selected to launch crewed Soyuz spacecraft in 1966. Since that year, the R-7-derived vehicles have launched almost 1,800 times. There have been several versions of the Soyuz, culminating with the Soyuz 2 currently providing commercial service. The older Soyuz FG version continues to launch Progress and Soyuz missions to the ISS. The Soyuz 2 is operated by Arianespace at the Guiana Space Center. Arianespace's sister company, Starsem, manages Soyuz launches from Baikonur.

The Soyuz 2 is manufactured by TsSKB-Progress at the Samara Space Center and NPO Lavotchkin (the upper stage). The vehicle consists of a core stage powered by an RD-108A, four liquid strap-on boosters powered by RD-107A engines, a second stage powered by an RD-0124 engine, and a Lavotchkin Fregat upper stage powered by an S5.92 engine. A payload adapter and standard 4-meter (13-foot) diameter fairing complete the vehicle system. TsSKB-Progress can produce about 20 Soyuz vehicles per year.

The Soyuz 2 variant has flown 38 times, with three failures. The 2014 failure, due to a fault in the Fregat upper stage, resulted in the loss of two Galileo navigation satellites.

Launch service provider
Roscosmos
Arianespace/Starsem

Company headquarters
Arianespace: France
Starsem: France

Manufacturer
TsSKB Progress

Mass, kg (lb)
334,668 (737,817)

Length, m (ft)
46.2 (151.6)

Diameter, m (ft)
10.3 (33.8)

Year of first launch
2004

Number of launches
38

Reliability
92%

Launch sites
Baikonur (LC-31 or LC-6)
Guiana Space Center (ELS)
Plestesk (LC-43)

GTO capacity, kg (lb)
3,250 (7,165)

LEO capacity, kg (lb)
4,850 (10,692)

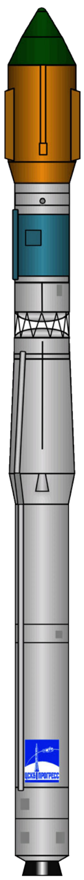
SSO capacity, kg (lb)
4,400 (9,700)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	11.4 (37.4)	4.1 (13.5)

	1st Stage	4 x Liquid Boosters	2nd Stage	3rd Stage
Stage designation	Core Stage	1st Stage	3rd Stage	Fregat
Length, m (ft)	27.1 (88.9)	19.6 (64.3)	6.7 (22)	1.5 (4.9)
Diameter, m (ft)	3 (9.8)	2.7 (8.9)	2.7 (8.9)	3.4 (11.2)
Manufacturer	TsSKB-Progress	TsSKB-Progress	TsSKB-Progress	NPO Lavotchkin
Propellant	LOX/Kerosene	LOX/Kerosene	LOX/Kerosene	N_2O_4/UDMH
Propellant mass, kg (lb)	90,100 (198,636)	39,160 (86,333)	25,400 (55,997)	6,638 (14,634)
Total thrust, kN (lbf)	838.5 (188,502)	792.5 (178,161)	297.9 (66,971)	19.9 (4,474)
Engine(s)	1 x RD-108A	1 x RD-107A	2.1a: 1 x RD-0110 2.1b: 1 x RD-0124	1 x S5.92
Engine manufacturer	AO Motorostroitel	AO Motorostroitel	Voronyezh	NPO Lavotchkin
Engine thrust, kN (lbf)	838.5 (188,502)	792.5 (178,161)	2.1a: 297.9 (66,971) 2.1b: 297.9 (66,971)	19.9 (4,474)

Soyuz 2.1v

Roscosmos



Soyuz 2.1v

The Soyuz 2.1v is similar to the Soyuz, but without the liquid strap-on boosters.

The first stage diamter is 2.7 m, compared to 2 m of a Soyuz. It is powered by a single engine, a modified version of the NK-33 once designated for use on the N-1 lunar rocket from the 1970s. In the long-term, the first stage will be powered by the RD-191 manufactured by NPO Enrgomash. The second stage is the same as that used for the Soyuz 2.1a/b.

A Volga upper stage may be employed for certain missions, such as insertion in orbits as high as 1,500 km (932 mi) in altitude.

The vehicle was originally conceived as a replacement for the small-class Rockot. It is expected to be available for launch from Russia's newest launch site, Vostochny, sometime after 2018.

Launch service provider Roscosmos
Company headquarters Russia
Manufacturer TsSKB Progress

Mass, kg (lb) 157,000 (346,126)
Length, m (ft) 44 (144)
Diameter, m (ft) 2.95 (9.7)

Year of first launch 2013
Number of launches 1
Reliability 100%
Launch sites Baikonur (LC-31 or LC-6) Plesetsk (LC-43)

LEO capacity, kg (lb) 3,000 (6,614)
SSO capacity, kg (lb) 1,400 (3,086)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	7.7 (25.3)	3.7 (12.1)

	1st Stage	2nd Stage	3rd Stage
Stage designation	1st Stage	2nd Stage	Volga
Length, m (ft)	27.8 (91.2)	6.7 (22)	1.03 (3.4)
Diameter, m (ft)	2.95 (9.7)	2.7 (8.9)	3.1 (10.2)
Manufacturer	TsSKB Progress	TsSKB Progress	TsSKB Progress
Propellant	LOX/Kerosene	LOX/Kerosene	UDMH
Propellant mass, kg (lb)	119,700 (263,893)	25,400 (55,997)	900 (1,984)
Total thrust, kN (lbf)	1,510 (339,462)	297.9 (66,971)	2.94 (661)
Engine(s)	1 x 14D15 (NK-33)	1 x RD-0124	1 x main engine
Engine manufacturer	NK Engines Company	Voronyezh	TsSKB Progress
Engine thrust, kN (lbf)	1,510 (339,462)	297.9 (66,971)	2.94 (661)

VEGA

Arianespace

Vega

The Vega launch vehicle, named after the second brightest star in the northern hemisphere, is operated by Arianespace and targets payloads to polar and low Earth orbits used by scientific and Earth observation satellites.

Development of the Vega began in 2003 led by the European Space Agency with contributions from the Italian space agency, the French space agency, and Italy-based Avio.

The Vega consists of four stages: a first stage P80 solid motor, a second stage Zefiro-23 solid motor, a third stage Zefiro-9 solid motor, and a liquid-fueled fourth stage called the Attitude and Vernier Upper Module (AVUM). The AVUM, powered by the RD-869, is produced by Yuzhnoye in the Ukraine. The payload adapter is affixed to the fourth stage and covered in a fairing during launch.

In December 2014, the European Space Agency agreed to pursue a replacement for the first stage called P120. The P120 will also serve as a strap-on booster for the Ariane 6 vehicle expected to be introduced in 2020.

Launch service provider Arianespace
Company headquarters France
Manufacturer ELV S.p.A.

Mass, kg (lb) 133,770 (294,912)
Length, m (ft) 29.9 (98.1)
Diameter, m (ft) 3 (9.8)

Year of first launch 2012
Number of launches 3
Reliability 100%
Launch site Guiana Space Center (ZLV)

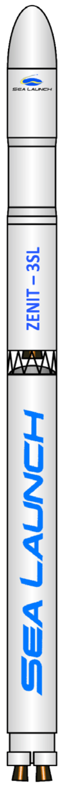
LEO capacity, kg (lb) 1,000-2,300 (2,205-5,071)
SSO capacity, kg (lb) 1,100-1,740 (2,425-3,836)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	7.9 (25.9)	2.6 (8.5)

	1st Stage	2nd Stage	3rd Stage	4th Stage
Stage designation	P80FW	Zefiro 23	Zefiro 9	AVUM
Length, m (ft)	11.2 (36.7)	8.4 (27.6)	4.1 (13.5)	2 (6.6)
Diameter, m (ft)	3 (9.8)	1.9 (6.2)	1.9 (6.2)	2.2 (7.2)
Manufacturer	Europropulsion	Avio	Avio	Avio
Propellant	Solid	Solid	Solid	N_2O_4 (UDMH)
Propellant mass, kg (lb)	88,365 (194,811)	23,906 (52,704)	10,115 (22,300)	367 (809)
Total thrust, kN (lbf)	2,261 (508,293)	1,196 (268,871)	225 (50,582)	2.5 (562)
Engine(s)	--	--	--	1 x RD-869
Engine manufacturer	--	--	--	Yuzhnoye
Engine thrust, kN (lbf)	2,261 (508,293)	1,196 (268,871)	225 (50,582)	2.5 (562)

ZENIT 3SL

Sea Launch AG



Zenit 3SL

The Zenit 3SL can be traced to the 1980s when the Soviet government pursued a system that could be used as both a booster for the Energia launch vehicle and as a stand-alone vehicle. The first-generation Zenit 2 was introduced in 1985 and has been launched 37 times. The Zenit 3SL represents a second generation vehicle. It is provided by Sea Launch, a conglomerate entity with four major component providers: RSC Energia, PA Yuzhmash/Yuzhnoye, Aker Solutions, and Boeing.

The Zenit 3SL is a three-stage vehicle. Yuzhnoye provides both the first and second stages, which are powered by the RD-171M and the RD-120 engines, respectively. A specially modified Block-DM third stage is supplied by S.P. Korolev Rocket and Space Corporation Energia (RKK Energia). Boeing provides the payload fairing.

The Zenit 3SLB is a modernized version of the earlier generation of the two-stage Zenit featuring a Block-DM third stage, but marketed by Land Launch, a subsidiary of Sea Launch. Land Launch also includes the Zenit 2SLB, which is essentially the same as the Zenit 3SLB but without a third stage.

Due to increasing political tensions between Russia and Ukraine during 2014, and the resulting international sanctions against Russia, PA Yushmash, a key supplier of missiles and other hardware to the Russian military, has experienced considerable financial difficulties that may impact its product line.

Launch service provider Sea Launch AG
Company headquarters Switzerland
Manufacturer PA Yuzhmash

Mass, kg (lb) 470,000 (1,036,173)
Length, m (ft) 59 (193.6)
Diameter, m (ft) 3.9 (12.8)

Year of first launch 1999
Number of launches 3SL: 36 3SLB: 6
Reliability 3SL: 93% 3SLB: 100%
Launch site 3SL: Pacific Ocean/*Odyssey* 3SLB: Baikonur (LC-45/1)

GTO capacity, kg (lb) 3SL: 6,160 (13,580) 3SLB: 3,750 (8,267)

Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	11.39 (37.4)	3.9 (12.8)

Zenit 3SLB

	1st Stage	2nd Stage	3rd Stage
Stage designation	1st Stage	2nd Stage	Block DM-SL
Length, m (ft)	32.9 (108)	10.4 (34)	4.9 (16.1)
Diameter, m (ft)	3.9 (12.8)	3.9 (12.8)	3.7 (12.1)
Manufacturer	Yuzhnoye	Yuzhnoye	RSC Energia
Propellant	LOX/Kerosene	LOX/Kerosene	LOX/Kerosene
Propellant mass, kg (lb)	322,280 (710,505)	81,740 (180,205)	15,850 (34,943)
Total thrust, kN (lbf)	7,256 (1,631,421)	992 (223,026)	79.5 (17,864)
Engine(s)	1 x RD-171M	1 x RD-120 1 x RD-8	1 x 11D58M
Engine manufacturer	NPO Energomash	NPO Energomash	RSC Energia
Engine thrust, kN (lbf)	7,117 (1,631,421)	RD-120: 912 (205,026) RD-8: 80 (18,000)	79.5 (17,864)

OTHER U.S. VEHICLES IN DEVELOPMENT WITH ORBITAL DEPLOYMENT CAPABILITY

Vehicle	Manufacturer	Anticipated Introduction Year	Description
ALASA	DARPA and Boeing	2015	DARPA is leading the effort to develop a small, air-launched vehicle capable of sending 45 kg (99 lb) to LEO for $1M.
Alpha	Firefly Space Systems	TBD	Firefly Space Systems is developing a small, ground-launched vehicle capable of sending 400 kg (882 lb) to LEO for $9M.
Athena	Lockheed Martin	2014	Lockheed Martin is reintroducing the Athena to address small- to medium-class payloads. The vehicle uses solid propellant stages, offered in three versions depending on customer needs. Initial flights of the vehicle are expected to launch from a new facility currently under construction at Kodiak Launch Complex.
Electron	Rocket Labs USA	2015	Rocket Labs is headquartered in New Zealand, but has a subsidiary in the U.S. It aims to develop a small vehicle capable of sending a 100 kg (220 lb) payload to LEO for $4.9M.
GOLauncher	Generation Orbit	2016	Generation Orbit is developing an air-launch capability using a conventional high-performance jet aircraft that carries either a GO1 rocket stage for suborbital missions or a GO2 rocket stage capable of sending 45 kg (44-66 lb) into LEO for about $1.75M.
LauncherOne	The Spaceship Company	2016	Virgin Galactic will offer LauncherOne, a small-class orbital launch vehicle. It will use the WhiteKnightTwo carrier aircraft as the first stage. The payload capacity will be 225 kg (500 lb) for a price of about $10M. SkyBox Imaging and GeoOptics have already signed contracts with Virgin Galactic for the launch of their satellites.
Lynx Mark III	XCOR Aerospace	2015-2016	XCOR will launch microsatellites using an upper stage rocket carried in a dorsal pod on the Lynx Mark III SRV. Maximum payload capacity will be 15 kg (33 lb) with a launch price around $550K. The Lynx Mark III will roll out after successful test flights of the prototype Lynx Mark I and operational experience with Lynx Mark II.
Nanosat Launch Vehcile	Garvey Spacecraft	TBD	Garvey Spacecraft is developing a small orbital launch vehicle based on earlier successes with suborbital rockets.
NEPTUNE	Interorbital Systems (IOS)	TBD	Mojave-based IOS is developing a line of NEPTUNE vehicles to send micro- and small-class satellites into orbit. IOS has performed engine tests during the past few years and is planning operational launches from Tonga.
Thunderbolt	Stratolaunch Systems	2017	Stratolaunch is an orbital launch services venture involving Scaled Composites, Orbital Sciences Corp., and Dynetics. The carrier aircraft is composed of a large twin-fuselage design. Development cost for the launch system is estimated to be about $300 million, with manufacturing conducted at Mojave Air and Space Port in California. A test flight is expected to launch from NASA's Kennedy Space Center Shuttle Launch Facility.
XS-1	DARPA	2018	DARPA is working with three teams to develop a vehicle capable of sending a 1,800 kg (4,000 lb) to LEO. The teams are Boeing with Blue Origin, Masten Space Systems with XCOR Aerospace, and Northrop Grumman with Virgin Galactic.

Table 3. Other U.S. Vehicles in Development with Orbital Deployment Capability

OTHER NON-U.S. ORBITAL LAUNCH VEHICLES IN DEVELOPMENT

Vehicle	Manufacturer	Anticipated Introduction Year	Description
Angara	Khrunichev State Research and Production Space Center	2014	Since 1995, the Angara has been an effort to produce modular launch vehicles using LOX and kerosene as propellants and powered by an RD-191 engine. Two small-class Angara 1 versions will use one booster module, a medium-class Angara 3 will use three, the heavy-class Angara 5 will use five. The vehicles will also use Breeze-KM and Breeze-M upper stages. An inaugural launch iof the Anagare 1.2 successfully took place in 2014, followed later by a successful test of the Angara 5.
Ariane 6	Airbus Safran Launchers	2020	In 2014, the European Space Agency (ESA) agreed to pursue development of the Ariane 6, a replacement for the Ariane 5 ECA. The cryogenic first stage will be powered by a Vulcain 2 engine, supplemented by two (Ariane 62) or four (Ariane 64) P120 solid motors (the same unit used for the first stage of an anticipated upgraded Vega). The vehicle will have dual payload capability, and have a launch price of $80M to $104M.
Long March 5, 6, and 7	China Academy of Launch Vehicle Technology (CALT) and Shanghai Academy of Spaceflight Technology (SAST)	2015	The newest generation of Long March vehicles will feature several variants based on interchangeable liquid-fueled stages. The Long March 5 is a heavy-lift version featuring a core stage and combinations of strap-on boosters based on the cores of Long March 6 or 7. It will launch from the new Wenchang Satellite Launch Center on Hainan Island. The Long March 6 is a three-stage, small-class vehicle. The first stage of this vehicle will be an optional strap-on liquid stage for the Long March 7. The Long March 7 is a three-stage, medium-class vehicle featuring a core first stage and optional strap-on liquid boosters based on the Long March 6. It will likely replace the Long March 2F for human missions.
SOAR	Swiss Space Systems	2017	Swiss Space Systems (S3) is developing a small, reusable spaceplane capable of sending 250 kg (551 lb) to LEO for about $10.5M. The spaceplane will launch from an Airbus A300 aircraft).
Tsyklon 4	Yuzhnoye Design Office	2015	The Brazilian Space Agency signed an agreement with the Ukrainian Space Agency to support development of the Tsyklon 4. It is being developed by Alcântara Cyclone Space (ACS), a joint effort between Brazil and Ukraine. It will launch from Brazil's Alcântara launch site. Due to increasing political tensions between Russia and Ukraine during 2014, and the resulting international sanctions against Russia, PA Yushmash, a key supplier of missiles and other hardware to the Russian military, has experienced considerable financial difficulties that may impact its product line.

Table 4. Other Non-U.S. Orbital Launch Vehicles in Development

This page intentionally left blank.

SUBORBITAL REUSABLE VEHICLES

Suborbital reusable vehicles carry humans, cargo, or both to the edge of space. These vehicles primarily target markets in science and technology research and space tourism.

Scaled Composites' SpaceShipTwo lands at Mojave Air and Space Port following a successful powered test flight in January 2014.

Image credit: Virgin Galacitc/Jon Griffith

Suborbital reusable vehicles (SRVs) are part of an emerging industry with the potential to support new markets. SRVs are commercially developed reusable space vehicles that travel just beyond the threshold of space, about 100 kilometers (62 miles) above the Earth. While traveling through space, the vehicles experience between one to five minutes of microgravity and provide clear views of the Earth. Currently planned vehicles can carry ~700 kilograms (~1,543 pounds) of cargo, some will carry people, and some will be able to launch very small satellites. The companies developing SRVs typically target a high flight rate and relatively low cost. Current ticket prices vary from $95,000 to $250,000 per seat. The first passengers are expected to fly in late 2015. These vehicles have been developed using predominantly private investment as well as some government support. Having gained momentum in 2012, each of the SRV companies has continued its research and development activities. 2014 Highlights include:

- Scaled Composites conducted a powered test flight of SpaceShipTwo in January. A second powered test flight in October resulted in catastrophic failure, destroying the vehicle in flight, injuring the pilot and killing the co-pilot.
- XCOR Aerospace continues to build its Lynx Mk I vehicle, having integrated the propulsions system with the fuselage in December. The company also began construction of its new headquarters and manufacturing facility at Midland International Air and Space Port.
- Masten Space Systems, which continues work on its Xombie and Xaero-B suborbital test vehicle, was selected by DARPA as on of the teams to develop the XS-1 air launched systems. By July, Masten conducted over 300 flights with its Xoie, Xombie, and Xaero reusable vehicles.

Detailed data on the SRVs are discussed in the fact sheets dedicated to individual vehicles.

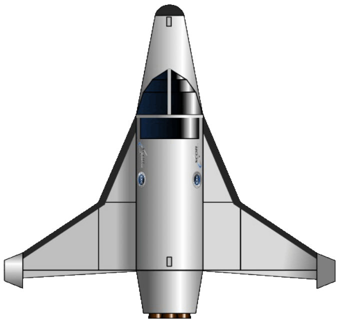
Operator	SRV	Seats*	Maximum Cargo kg (lb)	Price	Announced Operational Date
Blue Origin	New Shepard	3+	120** (265)	Not announced	Not announced
Masten Space Systems	Xaero Xombie Xogdor	-- -- --	12 (26) 20 (44) 25 (55)	Not announced Not Announced Not announced	Not announced Not announced Not Announced
UP Aerospace	SpaceLoft XL	--	36 (79)	$350,000 per launch	2006 (actual)
Virgin Galactic	SpaceShipTwo	6	600 (1,323)	$200,000 per seat	2015-2016
XCOR Aerospace	Lynx Mark I Lynx Mark II Lynx Mark III	1 1 1	120 (265) 120 (265) 770 (1,698)	$95,000/seat $95,000/seat $95,000/seat	2014 2014 2015-2016

* Passengers only; several vehicles are piloted
** Net of payload infrastructure

Table 5. SRVs and Providers

Lynx

XCOR Aerospace



Lynx

XCOR Aerospace is developing the Lynx suborbital reusable vehicle, which builds on XCOR's previously demonstrated rocket aircraft, the EZ-Rocket and X-Racer.

The Lynx family of vehicles are piloted HTHL vehicles designed to carry one pilot and one participant. The initial test vehicle will not cross the boundary of space, but the Mark II and Mark III are designed to reach over 100 kilometers altitude.

XCOR is developing the Lynx vehicle through a phased approach with a Mark I test vehicle to be tested in 2014 and a Mark II operational vehicle expected to start service in 2015. The more capable Mark III vehicle will include a dorsal pod for larger suborbital payloads, space telescopes, or for launching small satellites.

The Lynx vehicles will initially fly from the Mojave Air and Space Port; however, they can operate from any licensed spaceport with a 2,400-meter (8,000-foot) runway.

In 2014, XCOR started development of its new headquarters at Midland International Air and Space Port, Texas. Manufacturing of Lynx II and Lynx III vehicles will take place at a hangar adjacent to the Shuttle Landing Facility at Kennedy Space Center, Florida.

Operator XCOR Aerospace
Company Headquarters USA
Manufacturer XCOR Aerospace
Launch Site Mojave Air and Space Port Midland International Airport

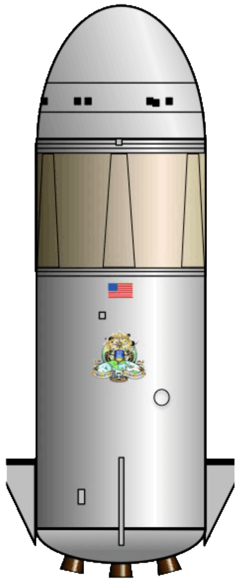
Mass, kg (lb) ~5,000 (11,023)
Length, m (ft) 10 (33)
Wingspan, m (ft) 7.3 (24)

Vehicle Type Horizontal takeoff, horizontal landing
Year Launch Operations Begin 2015
Seats Pilot: 1 Participant: 1
Price $95,000 per seat

	Lynx Mark I	Lynx Mark II	Lynx Mark III
Introduction year	2013	2014	2015-2016
Length, m (ft)	10 (33)	10 (33)	10 (33)
Wingspan, m (ft)	7.3 (24)	7.3 (24)	7.3 (24)
Mass, kg (lb)	4,850 (10,692)	5,000 (11,023)	TBD
Cargo capacity, kg (lb)	120 (265)	120 (265)	770 (1,698)
Apogee, km (mi)	61 (38)	100+ (62+)	100+ (62+)
Time in microgravity	~1 minute	~3 minutes	~3 minutes
Flight duration	25-30 minutes	25-30 minutes	25-30 minutes
Propellant	LOX/Kerosene (RP-1)	LOX/Kerosene (RP-1)	--
Total thrust, kN (lbf)	51.6 (11,600)	51.6 (11,600)	--
Engine(s)	4 x XR5K18	4 x XR5K18	--
Engine manufacturer	XCOR	XCOR	XCOR
Engine thrust, kN (lbf)	12.9 (2,900)	12.9 (2,900)	--

New Shepard

Blue Origin



New Shepard

Blue Origin, founded in 2000, is developing a vertical takeoff and vertical landing (VTVL) suborbital vehicle named the New Shepard. *New Shepard* will carry approximately 200 kilograms (441 pounds) of payload mass or three or more crew to an altitude of 100 kilometers (62 miles).

The system includes a Crew Capsule capable of carrying three or more astronauts plus a separate Propulsion Module. After accelerating for approximately two and a half minutes, the Propulsion Module will shut down and separate from the Crew Capsule. The Propulsion Module will perform an autonomous rocket-powered vertical landing. The Crew Capsule will land with the assistance of parachutes.

Blue Origin received an FAA AST Experimental Permit in 2014 authorizing flight testing of New Shephard.

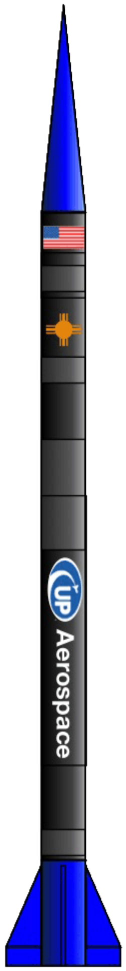
Operator Blue Origin
Company Headquarters USA
Manufacturer Blue Origin
Launch Site Van Horn, Texas

Length, m (ft) 15 (49.2)
Diameter, m (ft) ~5 (16.4)
Engine BE-3
Engine Manufacturer Blue Origin
Thrust, kN (lbf) 444.8 (100,000)
Propellant LOX/LH_2

Vehicle Type Vertical takeoff, vertical landing
Seats Participants: 3
Apogee, km (mi) 100 (62)

SpaceLoft

UP Aerospace



SpaceLoft

UP Aerospace operates the SpaceLoft launch platform. The SpaceLoft is an operational, single-stage unguided rocket; the vehicle takes off vertically and lands via parachute. The SpaceLoft can transport up to 36 kilograms (79 pounds) of payloads to a standard mission altitude of 115 kilometers (71.5 miles). Customers can select options from among a collection of standardized payload modules that provide power and command circuitry.

Since its inaugural launch in September 2006, SpaceLoft has launched a total of nine times, all successfully. UP Aerospace is headquartered in Denver, Colorado, with launch facilities at Spaceport America in New Mexico.

SpaceLoft vehicles have been successfully launched nine times from a site in New Mexico which has since become Spaceport America. In 2014, UP Aerospace launched a SpaceLoft vehicle carrying four payloads under NASA's Flight Opportunities Program.

Operator
UP Aerospace

Company Headquarters
USA

Manufacturer
UP Aerospace

Launch Site
Spaceport America

Mass, kg (lb)
354 (780)

Length, m (ft)
6.1 (20)

Diameter, m (ft)
0.26 (0.85)

Engine
1 x UPA-264-C

Engine Manufacturer
Cesaroni Technologies

Thrust, kN (lbf)
36.6 (8,228)

Propellant
Solid

Vehicle Type
Vertical takeoff, parachute recovery

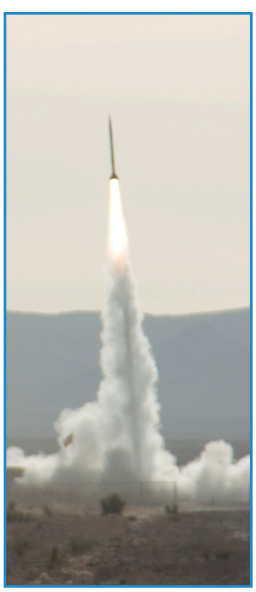
Year Launch Operations Began
2006

Cargo Capacity, kg (lb)
36 (79)

Apogee, km (mi)
160 (99)

Time in Microgravity
~4 minutes

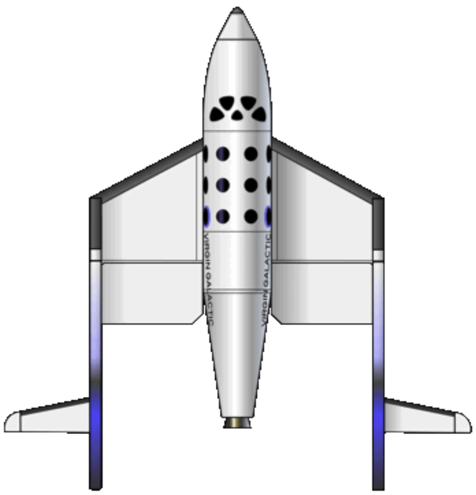
Flight Duration
~13 minutes



Payload accommodations	Length, cm (in)	Diameter, cm (in)
NC-1	35.6 (14)	8.4 (3.3)
NC-2	34.3 (13.5)	15.9 (6.3)
NC-3	21.6 (8.5)	20.3 (8)
PTS4-X	8.3 (3.3)	24.8 (9.8)
PTS10-X	23.5 (9.3)	24.8 (9.8)

SpaceShipTwo

Virgin Galactic



SpaceShipTwo

Virgin Galactic is developing the reusable suborbital vehicle SpaceShipTwo. Scaled Composites designed, built, and tested SpaceShipTwo.

The Spaceship Company will build future production vehicles. SpaceShipTwo is twice as large, but uses the same basic technology, carbon composite construction, and design as SpaceShipOne, which won the Ansari X PRIZE in 2004 and was the world's first privately built vehicle flown into space.

The vehicle is air-launched at approximately 15,240 meters (50,000 feet) from the carrier aircraft WhiteKnightTwo. Powered by a hybrid rocket motor, SpaceShipTwo will follow a typical ballistic arc. The vehicle will use a "feathering" system for reentry, followed by a glide runway landing.

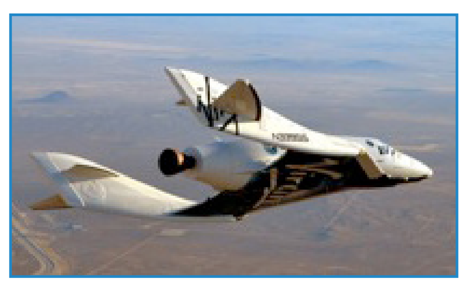
Four powered flights of SpaceShipTwo have been conducted, beginning in 2013. A flight on October 31, 2014 resulted in a catastrophic failure of the vehicle, killing co-pilot Michael Alsbury and injuring pilot Peter Siebold. The National Transportation Safety Board (NTSB) is investigating the accident witht he support of FAA AST and a report is expected in 2015.

Operator	Virgin Galactic
Company Headquarters	USA
Manufacturer	The Spaceship Company
Launch Site	Spaceport America

Mass, kg (lb)	54,431 (120,000) est.
Length, m (ft)	24 (78.7)
Wingspan, m (ft)	42.7 (140)

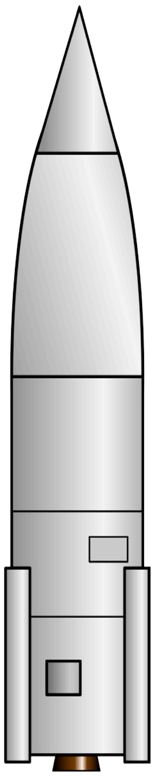
Vehicle Type	Horizontal takeoff, horizontal landing
Year Launch Operations Begin	2015-2016
Seats	Pilots: 2 Participants: 6
Price	$250,000 per seat
Cargo Capacity, kg (lb)	600 (1,323)
Apogee, km (mi)	110 (68.4)
Time in Microgravity	5 minutes
Flight Duration	~120 minutes

	1st Stage	2nd Stage
Stage designation	WhiteKnightTwo (Eve)	SpaceShipTwo
Length, m (ft)	24 (78.7)	18.3 (60)
Wingspan, m (ft)	42.7 (140)	8.2 (27)
Manufacturer	Scaled Composites	The Spaceship Company
Propellant	Jet A-1 (kerosene)	N_2O/HTPB solid
Total thrust, kN (lbf)	123.3 (27,706)	266.9 (60,000)
Engine(s)	4 x PW308A	1 x RocketMotorTwo
Engine manufacturer	Pratt & Whitney Rocketdyne	Sierra Nevada Corp.
Engine thrust, kN (lbf)	30.7 (6,904)	266.9 (60,000)



XAERO

Masten Space Systems



Xaero

Masten currently offers the Xaero suborbital vehicle for payload flights. Xogdor will be the next vehicle and is currently in development. Masten intends to later develop a reusable suborbital production vehicle called the Extreme Altitude 1.0 (XA-1.0). Masten Space Systems is located in Mojave, California.

Xaero and Xogdor are both vertical takeoff, vertical landing (VTVL), uncrewed vehicles. Unlike other VTVL vehicles, throttle-able engines will allow Xaero and Xogdor to perform soft landings via deceleration, instead of parachute landings.

Xaero is designed to reach 30-kilometer (18.6-mile) altitudes with a 10-kilogram (22-pound) payload, whereas Xogdor will be capable of reaching 100 kilometers. The company unveiled its Xearo-B vehicle in 2013.

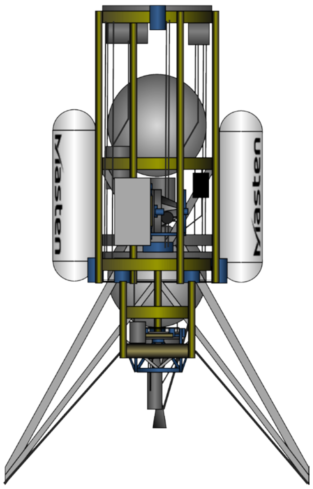
Operator Masten Space Systems
Company Headquarters USA
Manufacturer Masten Space Systems
Launch Site Mojave Air and Space Port

Length, m (ft) 3.6 (12)
Engine Manufacturer Master Space Systems
Propellant LOX/alcohol

Vehicle Type Vertical takeoff, parachute recovery
Cargo Capacity, kg (lb) 10 (22)
Apogee, km (mi) 30.5 (19)
Flight Duration 5 to 6 minutes

XOMBIE

Masten Space Systems



Xombie

Xombie is a technology demonstration vehicle developed and operated by Masten Space Systems. It is not designed to carry payloads per se; rather, it is used to test vertical lift off, vertical landing, and translational flight technologies.

XA-0.1B originally featured four engines with 4 kN (1,000 lbf) of total thrust, but was converted in early 2009 to be powered by a single engine with 3 kN (750 lbf). The vehicle was successfully flight tested (tethered) until September 2009. XA-0.1B first flew free of tether September 19, 2009 and qualified for the Lunar Lander Challenge Level One second prize of $150,000 on October 7, 2009. That day, the vehicle went on to win the $150,000 second prize in the Level One competition.

In June 2014, Xombie was flown with an autnomous landing system developed by Astrobotic Technologies. The flight was funded by the NASA's Flight Opportunities Program. The vehicle ascended to about 260 meters (853 feet) in 25 seconds. During the boost phase, the Astrobotic Autolanding System (AAS) was activated and it navigated the vehicle to a precise landing location, successfully avoiding obstacles.

The test objectives included accurately tracking Xombie's location, detecting hazards larger than 25 centimeters (10 inches) and finding an acceptable landing location. The AAS uses cameras and an inertial measurement unit for navigation, because the Global Positioning System used on Earth would not be available for a landing on another planet or the moon. Astrobotic is also developing a lunar lander called Griffin, and the AAS test will inform design decisions and mission planning.

Also in 2014, the U.S. Defense Advanced Research Projects Agency (DARPA) awarded 12-month study contracts to Masten, Boeing and Northrop Grumman for the companies to define how they would design, build, and fly their entrants in the XS-1 program, a development project aimed at producing a vehicle capable of sending 2,300 kilograms to low Earth orbit (LEO) for $5 million. Xombie flight data will help inform the research.

Operator	Masten Space Systems
Company Headquarters	USA
Manufacturer	Masten Space Systems
Launch Site	Mojave Air and Space Port

Length, m (ft)	4.9 (16)
Diameter, m (ft)	1.2 (4)
Engine Manufacturer	Masten Space Systems
Propellant	LOX/ethanol

Vehicle Type	Vertical takeoff, vertical landing
Year Launch Operations Began	2009
Cargo Capacity, kg (lb)	0
Apogee, km (mi)	30 (18.6)
Time in Microgravity	0
Flight Duration	< 5 min

OTHER SUBORBITAL VEHICLES IN DEVELOPMENT

Operator / Vehicle	Remarks	Vehicle Details
Booster Space Industries ***Sub-orbital Spacecraft*** 	Booster Space Industries is developing a "sub-orbital aircraft." Booster is planning a two-stage system; the first stage will be a conventional commercial jet aircraft, similar to an Airbus A300-600, capable of carrying the sub-orbital aircraft to an altitude of approximately 12 kilometers (7.5 miles) for launch. Booster is primarily based in Spain, with a European-United States consortium.	**Seats**: ~10 **- Pilots**: 2 **- Passengers**: ~8 **Altitude**: 115 – 150 km (71-93 mi) **Payload**: 1,200 kg (2,645 lb) **Propulsion**: 2 rocket engines, liquid hydrogen (LH_2) and LOX **Duration of microgravity**: ~4 minutes **HTHL** **Operational flights target dates**: 2016/2017
Copenhagen Suborbitals ***Tycho Brahe*** 	Copenhagen Suborbitals is developing the Tycho Brahe, a capsule that will carry one person to 100 kilometers (62 miles) altitude. The person will stand in the vehicle for the entire mission and will be able to see through a 360-degree dome at the top. The company is based in Denmark.	**Seats**: 1 **Altitude**: 100 km (62 mi) **Mass**: ~300 kg (~661 lb) **Payload**: ~70 kg (~154 lb) **Propulsion**: LOX/polyurethane **Off-shore VTVL (parachute landing)** **Operational flights target date**: 2015
Garvey Spacecraft Corp. ***P-18*** 	Garvey Spacecraft Corp. is developing the Prospector 18 (P-18) vehicle. The latest P-18 flight was on December 8, 2012 at the Friends of Amateur Rocketry (FAR) test site outside Mojave, CA. This launch was performed for NASA's Launch Services Program (LSP) High Altitude Launch Service (HALS) for Demonstration Nano-Satellites program. The company is also developing a Nanosat Launch Vehicle (NLV) for launch of up to 10 kilograms (22 pounds) payloads to LEO.	**Seats**: N/A **Altitude**: 4.6 km (2.9 mi) **Mass**: TBD **Propulsion**: LOX/ethane propellant launch vehicle using aerospike engine technology **VTVL**
S3, Swiss Space Systems ***SOAR*** 	S3 plans to launch small satellites and, at a later stage, manned suborbital spaceflights. SOAR suborbital spaceplane will be launched from an Airbus A300. The spaceplane, in turn, will release a disposable third stage with a satellite.	**Seats**: TBD **Altitude**: 80 km (50 mi) **Mass**: TBD **Payload**: ~250 kg (~550 lb) **Propulsion**: TBD **HTHL** **Operational flights**: 2017
Whittinghill Aerospace ***mCLS*** 	Whittinghill is developing the minimum Cost Launch System (mCLS) designed to send nano-satellites into LEO. The system uses a cluster of standardized propellant modules. For the Flight Opportunities Program, Whittinghill will modify one of the propellant modules for a suborbital flight. Whittinghill Aerospace is located in Camarillo, CA.	**Seats**: N/A **Altitude**: TBD **Mass**: TBD **Payload**: TBD **Propulsion**: N_2O/rubber **Vertical takeoff or rail launch, parachute landing** **Operational flights**: TBD

Table 6. Other Suborbital Vehicles in Development

Image Credits (from top to bottom) Booster Space Industries, Copenhagen Suborbitals, Garvey Spacecraft Corp., Rocketplane Global, and Whittinghill Aerospace

This page intentionally left blank.

ON-ORBIT VEHICLES AND PLATFORMS

On-orbit vehicles and platforms transport or contain cargo, crew, or both in low Earth orbit. Most of these spacecraft are developed with some funding from or partnership with NASA.

An Orbital Sciences Corporation Cygnus used for the 2014 Orb 2 mission as seen from the ISS.

Image credit: Orbital Sciences Corp.

NASA started the commercial crew and cargo program to help commercial companies develop new capabilities for transporting crew and cargo to the ISS. These services are intended to replace some of the ISS resupply services performed by the Space Shuttle. The first of these vehicles, SpaceX's Dragon, became operational in 2012, restoring NASA's ability to deliver and retrieve cargo in LEO. Crewed vehicles made many advances this year but are not expected to become operational before 2017.

In on-orbit vehicle and platform development by commercial companies conducted in 2014 included:

- Five cargo missions were conducted as part of NASA's ISS Cargo Resupply Services contracts with Orbital Sciences Corp. and SpaceX. Three were conducted by Orbital, but the Orb 3 mission was lost following a launch failure. SpaceX conducted two successful cargo missions.
- Orbital Sciences Corp. announced plans to modify the Antares vehicle, replacing the AJ26 engines with the RD-191 engine provided by NPO Energomash. In the meantime, Orbital has contracted with United Launch Alliance for an Atlas V to carry a Cygnus cargo module to ISS in 2015. The upgraded Antares is expected to enter service in 2016.
- In September, NASA selected Boeing and SpaceX for the Commercial Crew Transportation Capability (CCtCap) program. Boeing will develop the CST-100 and SpaceX will develop the Dragon V2. Sierra Nevada Corp., which is developing the Dream Chaser, is contesting the award, but vows to continue working on its winged vehicle.
- Blue Origin continues work on its Biconic Spacecraft and the Reusable Booster System. In 2014, it entered into an agreement with ULA in the development of a new vehicle to replace the Atlas V, using Blue Origin's BE-4 liguid rocket engine currently under development.

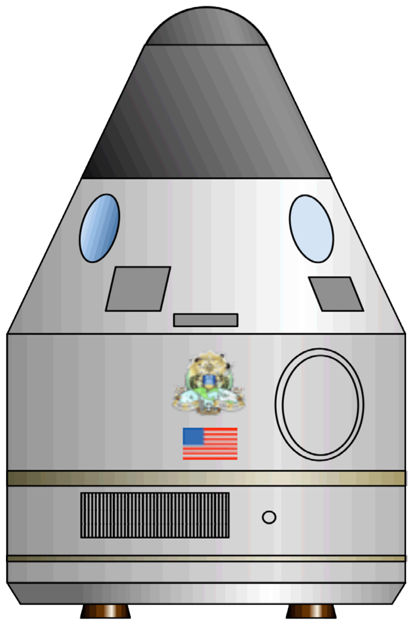
Details on on-orbit vehicle and platforms are provided in the following fact sheets.

Operator	Vehicle	Launch Vehicle	Maximum Cargo kg (lb)	Maximum Crew Size	First Flight
SpaceX	Dragon (cargo)	Falcon 9	6,000 (13,228)	0	2010
SpaceX	Dragon V2 (crew)	Falcon 9	TBD	7	2017
Orbital	Cygnus (Standard)	Antares	2,000 (4,409)	0	2013
Orbital	Cygnus (Enhanced)	Antares	2,700 (5,952)	0	2015
Boeing	CST-100	Atlas V Delta IV Falcon 9	TBD	7	2017
SNC	Dream Chaser	Atlas V	TBD	7	TBD
Blue Origin	Space Vehicle	Atlas V Blue Origin RBS	TBD	7	TBD
Operator	**Platform**	**On-Orbit Vehicle**	**Maximum Volume m^3 (ft^3)**	**Maximum Crew Size**	**First Flight**
Bigelow Aerospace	BA 330	Dragon CST-100	330 (11,653)	6	TBD
Bigelow Aerospace	BEAM	Dragon	32 (1,125)	TBD	2015

Table 7. On-Orbit Vehicles and Platforms

Biconic Spacecraft

Blue Origin



Biconic Spacecraft

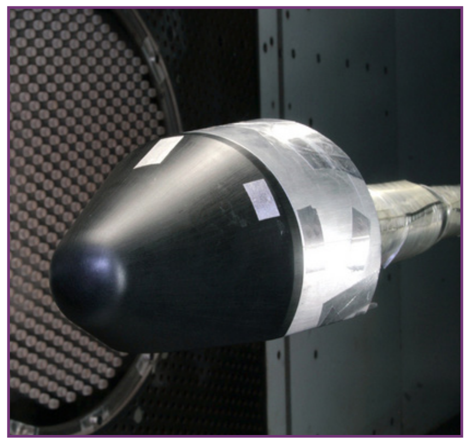
Washingon-based Blue Origin has been developing an orbital Biconic Spacecraft as part of its reusable, two-stage Orbital Transportation System to send the vehicle into orbit for several years. Development of both systems leverages lessons learned from the company's New Shephard suborbital program. Few details of this program have been released to the public.

The spacecraft is designed to carry seven crewmembers to low Earth orbit (LEO). "Biconic" refers to the use of two cone shapes merged together, forming a slight taper, providing a better lift-to-drag ratio than a single cone shape. The shape has been tested and refined 180 times in a wind tunnel (photo at right). Its mass, including crew, will be about 22,000 kg. Blue Origin was awarded $22 million in 2011 under NASA's Commercial Crew Development (CCDev) program and was awarded an unfunded Space Act Agreement to continue work under CCDev 2 in 2013. The company successfully completed a System Requirements Review of the vehicle in May 2012.

The Reusable Booster System is a two-stage launch vehicle designed to propel the Biconic Spacecraft to LEO. The RBS first stage will be powered by the company's BE-3 engine, which burns liquid oxygen (LOX) and liquid hydrogen at a thrust of about 490 kN (110,000 lbf). Successful testing of this engine took place at NASA's Stennis Space Center in 2013. Another version of this engine, called BE-3U, is also being developed for use in the RBS second stage.

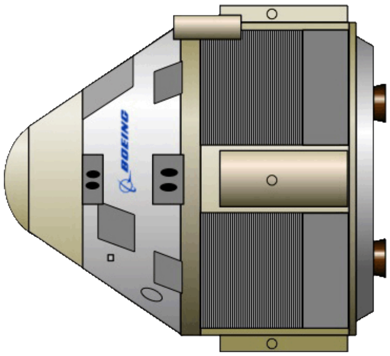
	Biconic Spacecraft
Vehicle type	Crewed, reusable
Crew	7
Length, m (ft)	15.8 (52)
Diameter, m (ft)	73.8 (24)

Operator Blue Origin	
Company Headquarters USA	
Manufacturer Blue Origin	
Launch Site TBD	
Launch Vehicle Reusable Booster System	
Landing Type Parachute splashdown	
Year Operations Begin TBD	



CST-100

Boeing



CST-100

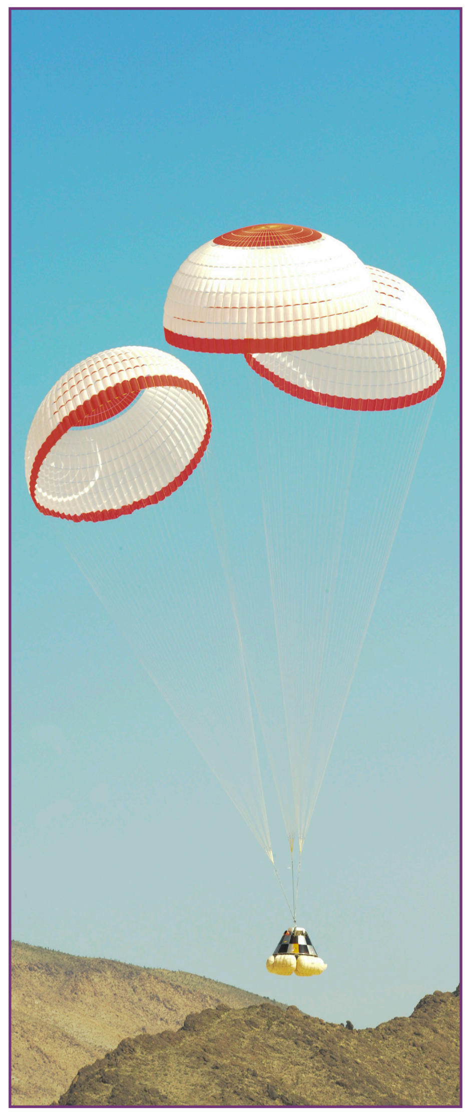
Crew Space Transportation (CST)-100 is a reusable capsule consisting of a crew module and service module. It is designed for transportation of up to seven crew or a combination of people and cargo to and from low Earth orbit. CST-100 is designed to be reused up to 10 times and includes a launch escape system.

The CST-100 design uses proven flight components from heritage systems, such as an Apollo parachute system and Orion's airbag landing system. CST-100 will launch initially on the Atlas V launch vehicle, but the design is compatible with a variety of launch vehicles. Boeing plans to have CST-100 operational in 2017.

NASA selected Boeing under the agnecy's Commercial Crew Transportation Capability (CCtCap) program, awarding the company a milestone-based contract valued at $4.2B. Later, Boeing announced that the CST-100 could be easily modified for cargo transportation services.

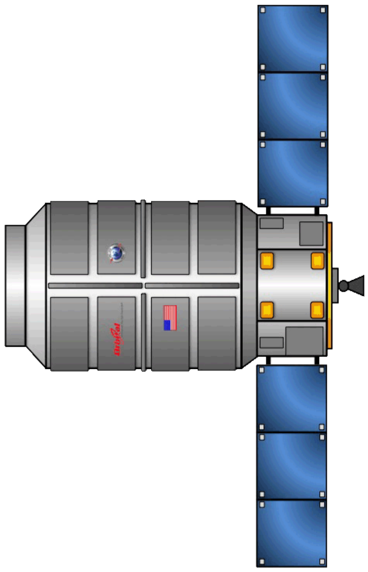
	CST-100
Vehicle type	Crewed, reusable
Crew	7
Length, m (ft)	5 (16.4)
Diameter, m (ft)	4.6 (15.1)
Propulsion	4 x thruster units (service module) 12 x thrusters (command module) 4 x RS-88 abort engines
Propellant	LOX/alcohol

Operator Boeing
Company Headquarters USA
Manufacturer Boeing
Launch Site CCAFS (SLC-41)
Launch Vehicle Atlas V
Landing Type Parachute splashdown
Year Operations Begin ~2017



CYGNUS

Orbital Sciences Corp.



Cygnus

Orbital Sciences Corporation offers the Cygnus, an advanced maneuvering spacecraft designed to transport pressurized cargo to the International Space Station.

NASA selected Orbital to develop the Cygnus under the agency's Commercial Crew and Cargo Program. In addition, NASA awarded Orbital a Commercial Resupply Services contract totalling $1.9 billion to provide at least eight cargo resupply missions to the ISS.

The Cygnus system consists of a service module based on Obital's LEOStar and GEOStar and a pressurized cargo module based on the multipurpose pressurized logistics module for the ISS developed by Thales Alenia Space.

Operator	Orbital Sciences Corp.
Company Headquarters	USA
Manufacturer	Orbital Sciences Corp. Thales Alenia Space
Launch Site	MARS (Pad 0-A)
Launch Vehicle	Antares
Landing Type	Non-recoverable
Year Operations Began	2013

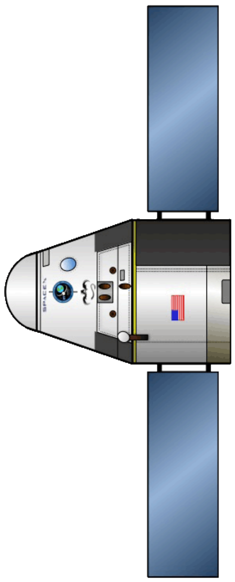
Once the Cygnus undocks from the ISS, it can stay in orbit for two years before it is programmed to reenter. According to orbital, Cygnus has hosted payload and nanosatellite (cubesat) deployment capabilities.

Following the loss of the Cygnus Orb 3 mission in October 2014, Orbital announced plans to pursue development of a newly engined Antares. In the meantime, the company has contracted with United Launch Alliance to have one, and perhaps two, Cygnus modules launched to ISS aboard Atlas V vehicles in 2015. The new Antares is expected to enter service in 2016.

	Standard Cygnus	Enhanced Cygnus
Vehicle type	Cargo, expendable	Carge, expendable
Length, m (ft)	5.7 (18.7)	6.9 (22.6)
Diameter, m (ft)	3.1 (10.2)	3.1 (10.2)
Up mass, kg (lb)	2,000 (4,409.2)	2,700 (5,952.5)
Pressurized cargo volume, m^3 (ft^3)	18.8 (663.9)	27 (953.5)
Flight duration	1 week - 2 years	1 week - 2 years
Propulsion	1 x main engine, 4 x thrusters	1 x main engine, 4 x thrusters
Propellant	N_2H_4/MON-3	N_2H_4/MON-3
Power, kW (peak)	3.5	3.5

Dragon

SpaceX



Dragon

Dragon is a free-flying reusable spacecraft designed to take pressurized cargo, unpressurized cargo, and/or a crew of seven to and from low Earth orbit.

SpaceX began developing Dragon internally in 2005. In 2006, the company received NASA funding for Dragon's development and operation under the COTS program.

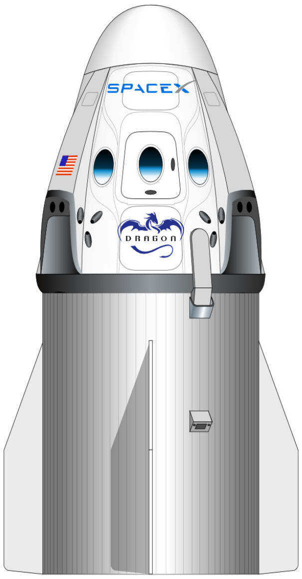
In addition, NASA awarded SpaceX a CRS contract totaling $1.6 billion to provide at least 12 cargo resupply missions to the ISS. By the end of 2014, SpaceX had successfully conducted four missions to ISS using Dragon. Also in that year, NASA extended the CRS contract to 2017. In 2015, NASA is expected to announce a second CRS request for proposals.

Operator SpaceX
Company Headquarters USA
Manufacturer SpaceX
Launch Site CCAFS (SLC-40)
Launch Vehicle Falcon 9
Landing Type Parachute splashdown
Year Operations Began 2012

	Dragon Cargo
Vehicle type	Cargo, reusable
Crew	0
Length, m (ft)	4.4 (14.4)
Diameter, m (ft)	3.6 (11.8)
Up mass, kg (lb)	6,000 (13,228)
Down mass, kg (lb)	3,000 (6,614)
Pressurized cargo volume, m^3 (ft^3)	10 (353)
Unpressurized cargo volume, m^3 (ft^3)	14 (490)
Flight duration	1 week - 2 years
Propulsion	18 x Draco thrusters
Propellant	NTO/MMH
Power, kW (peak)	4

Dragon V2

SpaceX



Dragon V2

In 2014, Space Exploration Technologies (SpaceX) unveiled a mockup of its crewed reusable Dragon V2 vehicle. It differs substantially from the cargo version of the Dragon in terms of external appearance and internal arrangement.

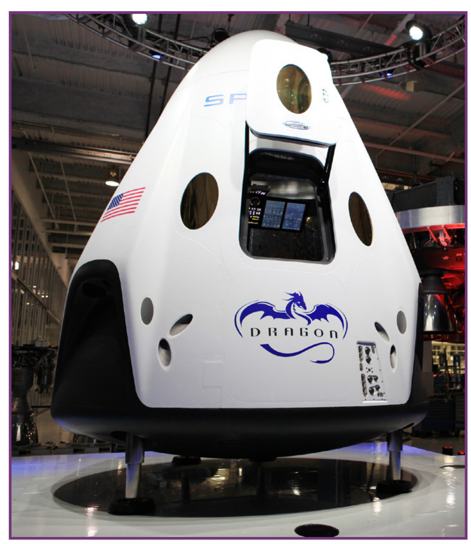
Externally, the spacecraft features eight clusters of thrusters, which serve as part of the reaction control system as well as a pusher abort system designed to separate the Dragon V2 from a booster failure. The Dragon V2 can deploy four landing struts. Also evident is a crew hatch and large windows. The spacecraft will generate power from two deployable solar panels.

Internally, the Dragon V2 contains seating for seven individuals. In addition to an environmental control and life support system provided by Paragon Space Development Corporation, the Dragon V2 uses updated computers and avionics derived from the cargo version of Dragon.

In 2012, SpaceX announced that it expects a crewed mission will cost about $160 million, or roughly $20 million per seat. The company plans to conduct a crewed flight tests of Dragon V2 beginning in 2016.

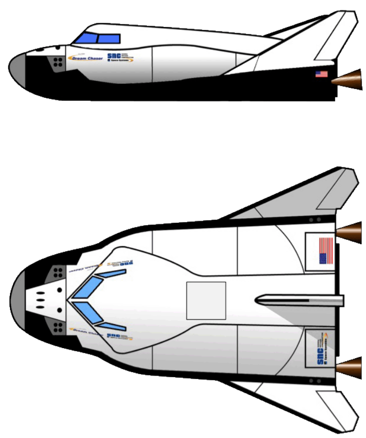
Operator SpaceX
Company Headquarters USA
Manufacturer SpaceX
Launch Site CCAFS (SLC-40)
Launch Vehicle Falcon 9
Landing Type Vertical ground landing
Year Operations Begin 2017-2018

	Dragon V2
Vehicle type	Crewed, reusable
Crew	7
Length, m (ft)	6.1 (20)
Diameter, m (ft)	3.7 (12.1)
Up mass, kg (lb)	3,310 (7,300)
Down mass, kg (lb)	2,500 (5,500)
Pressurized cargo volume, m^3 (ft^3)	10 (350)
Unpressurized cargo volume, m^3 (ft^3)	14 (490)
Flight duration	1 week to 2 years
Propulsion	8 x SuperDraco thrusters for launch abort and landing and 12 x Draco thrusters for maneuvering
Propellant	NTO/MMH
Power, kW (peak)	--



Dream Chaser

Sierra Nevada Corp.



Dream Chaser

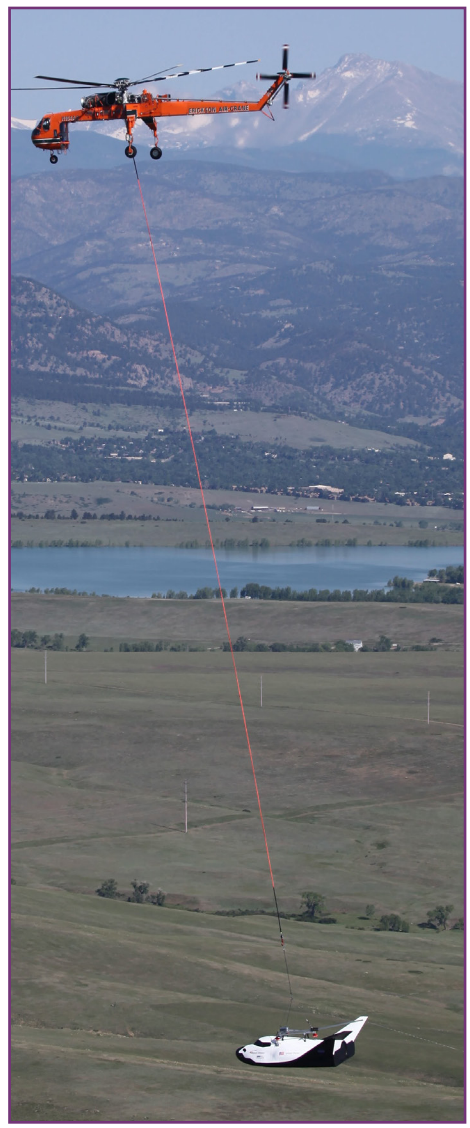
Dream Chaser is a reusable, piloted lifting-body spacecraft designed to fly up to seven crew and cargo to and from LEO using non-toxic propellant.

Dream Chaser will launch vertically on an Atlas V launch vehicle, conduct operations in low Earth orbit, and ultimately dock to the International Space Station. Following completion of its mission, Dream Chaser will deorbit, experience a low-g reentry (<1.5 g), and glide to a horizontal landing on a conventional runway.

The design of Dream Chaser derives from NASA's HL-20 experimental aircraft concept. The onboard propulsion system is derived from Sierra Nevada Corporation's SpaceShipOne and SpaceShipTwo hybrid rocket motor technology. Dream Chaser completed its first glide test and landing in late 2013.

In 2014, NASA selected Boeing and SpaceX under the agency's Commercial Crew Transportation Capability (CCtCap) program. Sierra Nevada Corp. filed a formal protest with the U.S. Court of Federal Claims, citing "serious questions and inconsistencies in the source selection process." The court ultimately lifted a temporary injunction stopping Boeing and SpaceX work under CCtCap after NASA indicated such an injunction will delay introduction of a U.S. crewed vehicle capable of servicing the ISS. A final ruling is expected in 2015. In the meantime, Sierra Nevada Corp. is continuing work on Dram Chaser, having also entered into a partnership with Stratolaunch Systems,

Operator Sierra Nevada Corp.
Company Headquarters USA
Manufacturer Sierra Nevada Corp.
Launch Site CCAFS (SLC-41)
Launch Vehicle Atlas V
Landing Type Horizontal landing
Year Operations Begin TBD



	Dream Chaser
Vehicle type	Crewed, reusable
Crew	7
Length, m (ft)	9 (29.5)
Wingspan, m (ft)	7 (23)
Pressurized cargo volume, m³ (ft³)	16 (565)
Flight duration	210 days
Propulsion	2 x hybrid motors
Propellant	HTBP/N_2O

LAUNCH SITES

Launch sites are sites dedicated to launching orbital or suborbital vehicles into space. FAA AST licenses commercial launch and reentry sites in the United States.

Texas' Midland International Air and Space Port

Image credit: Midland Convention & Visitors Bureau

Launch sites are sites dedicated to launching orbital or suborbital vehicles into space. These sites provide the capability to integrate launch vehicle components, fuel and maintain vehicles, and integrate vehicles with payloads. Launch sites can facilitate either vertical takeoff, vertical landing (VTVL) or horizontal takeoff, horizontal landing (HTHL) vehicles. From the launch site, a launch vehicle travels through an area called the launch range, which typically includes tracking and telemetry assets. These range assets monitor the vehicle's performance until it safely delivers a payload into orbit or returns to Earth. Tracking and telemetry assets may also facilitate recovery of reusable stages.

FAA AST licenses commercial launch and reentry sites in the United States. By January 2015, FAA AST issued nine launch site operator licenses. Table 8 below lists the FAA AST-licensed launch sites. Figure 1 identifies the locations of federal and non-federal launch sites in the United States.

FAA-licensed launch and reentry sites are often co-located with federal locations, including CCAFS in Florida, VAFB in California, and WFF in Virginia.

Of the 18 active launch and reentry sites (Table 9 on Page 70), the U.S. Government manages eight, state agencies manage nine FAA-licensed commercial sites in partnership with private industry, and a university manages one (Alaska's Poker Flat site). Four sites are dedicated to orbital launch activity, nine facilitate suborbital launches only, and five can host both types of operations.

In addition to these sites, there are three sites where individual companies conduct launches with FAA AST licenses or permits. Each of these sites is owned by the company that launches from it. The Odyssey Launch Platform exclusively supports Sea Launch's Zenit 3SL vehicles on the Central Pacific Ocean. SpaceX conducts flight tests of its Falcon 9R vehicle at its McGregor, Texas site. Blue Origin conducts FAA-permitted flight tests from its site near Van Horn, Texas.

Several proposed launch and reentry sites in the United States are in various stages of development, summarized in Table 10. In addition, specific details for launch and reentry sites in the U.S. are provided in the launch site fact sheets that follow.

Launch Site/State	Operator	License First Issued	Expires	2014 FAA AST-Licensed or Permitted Flights
California Spaceport, California	Spaceport Systems International	1996	9/18/16	None
Mid-Atlantic Regional Spaceport, Virginia	Virginia Commercial Space Flight Authority	1997	12/18/17	3 licensed flights
Kodiak Launch Complex, Alaska	Alaska Aerospace Corporation	1998	9/23/18	None
Cape Canaveral Spaceport, Florida	Space Florida	1999	6/30/15	None
Mojave Air and Space Port, California	East Kern Airport District	2004	6/16/14	2 permitted flights
Oklahoma Spaceport, Oklahoma	Oklahoma Space Industry Development Authority	2006	6/11/16	None
Spaceport America, New Mexico	New Mexico Spaceport Authority	2008	12/14/18	None
Cecil Field Spaceport, Florida	Jacksonville Aviation Authority	2010	1/10/15	None
Midland International Airport, Texas	Midland International Airport	2014	9/15/19	None

Table 8. FAA-licensed Commercial Launch Sites

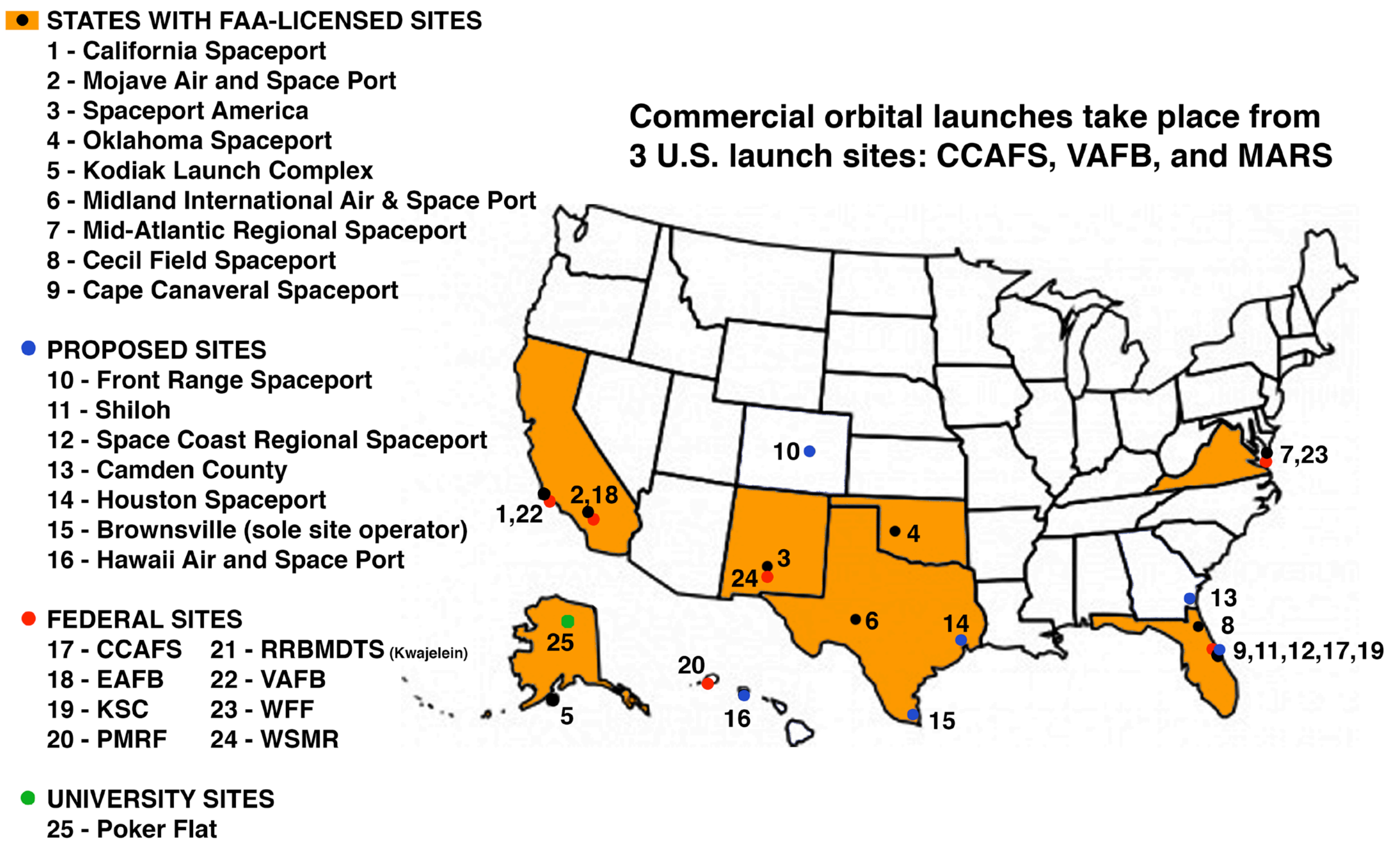


Figure 1. U.S. Federal and Non-Federal Launch Sites.

2014 Highlights

Eleven FAA AST-licensed orbital launches took place from launch sites in the U.S. Five of these were conducted to supply cargo to the ISS - two by SpaceX from CCAFS and three by Orbital from MARS. SpaceX also launched the following satellites, each on a single Falcon 9 vehicle launched from CCAFS: Thaicom 6, six ORBCOMM satellites, AsiaSat 6, AsiaSat 8. A Lockheed Martin Commercial Launch Services Atlas V 401 launched WorldView 3 from VAFB or DigitalGlobe, and ULA launched NASA's Orion Multi-Purpose Crew Vehicle from CCAFS.

Seven suborbital launches were conducted under an FAA AST Experimental Permit. Scaled Composites conducted two powered flights of SpaceShipTwo from Mojave Air and Space Port. SpaceX launched its Falcon 9R Dev 1 vehicle from its sole site located in McGregor, Texas, which is not required to be licensed by AST.

FAA AST issued its ninth license order regarding the operation of a launch site to Midland International Airport, renamed the Midland International Air and Space Port, in Texas.

SpaceX started modifying Launch Complex 39A, which it leases from NASA to support launches of its Falcon Heavy vehicle. The Falcon Heavy is expected to launch for the first time in late 2015.

At KSC, Boeing started modifying Orbiter Processing Facility 1 for the Air Force's X-37B space plane, and an MOU was signed between Space Floirda and Swiss Space Systems to operate the company's SOAR launch system frm the Shuttle Landing Facility.

FAA AST prepared an Environmental Impact Statement (EIS) to evaluate potential environmental impacts at a site near Brownsville, Texcas that may result from the FAA proposal to issue launch licenses and/or experimental permits to SpaceX. The site itself will not require a license as it will be operated by a single company, but the vehicles will require a license or permit.

Launch Site	Operator	State/ Country	Type of Launch Site	Type of Launches Supported	Currently Available for Commercial Operations
California Spaceport	Spaceport Systems International	California	Commercial	Orbital	Yes
Cape Canaveral Spaceport	Space Florida	Florida	Commercial	Orbital/Suborbital	Yes
Cape Canaveral Air Force Station	U.S. Air Force	Florida	Government	Orbital	SLC-41 (Atlas V) SLC-37B (Delta IV) SLC-40 (Falcon 9)
Cecil Field Spaceport	Jacksonville Aviation Authority	Florida	Commercial	Suborbital	Yes
Edwards Air Force Base	U.S. Air Force	California	Government	Suborbital	No
Kennedy Space Center	NASA	Florida	Government	Orbital	No
Kodiak Launch Complex	Alaska Aerospace Corporation	Alaska	Commercial	Orbital/Suborbital	Yes
Mid-Atlantic Regional Spaceport	Virginia Commercial Space Flight Authority	Virginia	Commercial	Orbital	Yes
Midland International Air and Space Port	Midland International Airport	Texas	Commercial	Suborbital	Yes
Mojave Air and Space Port	East Kern Airport District	California	Commercial	Suborbital	Yes
Oklahoma Spaceport	Oklahoma Space Industry Development Authority	Oklahoma	Commercial	Suborbital	Yes
Pacific Missile Range Facility	U.S. Navy	Hawaii	Government	Suborbital	No
Poker Flat Research Range	University of Alaska Fairbanks Geophysical Institute	Alaska	University	Suborbital	Five pads available for suborbital launches
Ronald Reagan Ballistic Missile Defense Test Site	U.S. Army	Republic of the Marshall Islands	Government	Orbital/Suborbital	Omelek Island launch pad
Spaceport America	New Mexico Spaceport Authority	New Mexico	Commercial	Suborbital	Yes
Vandenberg Air Force Base	U.S. Air Force	California	Government	Orbital/Suborbital	SLC-2 (Delta II) SLC-3E (Altas V) SLC-4E (Falcon 9 and Falcon Heavy) SLC-6 (Delta IV) SLC-8 (Minotaur) SLC-576E (Taurus)
Wallops Flight Facility	NASA	Virginia	Government	Orbital/Suborbital	Six pads available for suborbital launches
White Sands Missile Range	U.S. Army	New Mexico	Government	Suborbital	No

Table 9. U.S. Active Launch and Reentry Sites

Proposed Launch Site/ Spaceport	Operator	State	Status
Brownsville	SpaceX	Texas	SpaceX is exploring the proposed site for conducting commercial launches.
Front Range Spaceport	Front Range Airport Authority	Colorado	This proposed suborbital spaceport is located just east of the Denver metropolitan area. FAA AST awarded the State of Colorado a STIM grant for an environmental assessment in preparation for the launch site application process.
Hawaii Air and Space Port	Hawaii Department of Transportation - Airports Division	Hawaii	Currently being evaluated for placement at Kona International Airport on the Big Island.
Houston Spaceport	Houston Airport System	Texas	Houston Airport Authority began the spaceport licensing and environmental assessment activities required to become an FAA licensed spaceport. FAA license award projected for the end of 2014 or early 2015.
Roosevelt Roads Naval Station	Puerto Rico	Puerto Rico	This proposed spaceport is located at the former Roosevelt Roads Naval Station in Puerto Rico.
Space Coast Regional Airport	Titusville-Cocoa Airport Authority	Florida	Currently involved in licensing and environmental assessment activities. FAA license award projected for end of 2014 or early 2015.

Table 10. Proposed Launch and Reentry Sites in the United States

California Spaceport Vandenberg Air Force Base

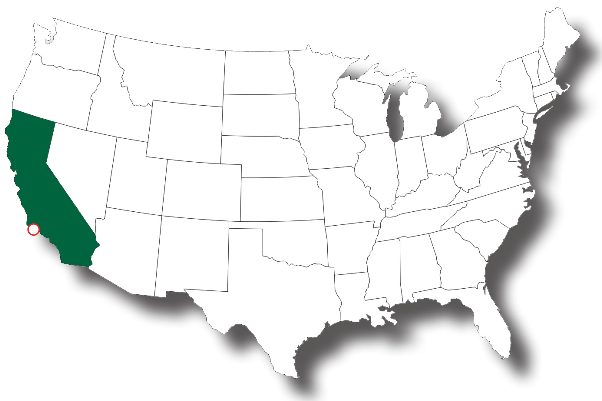
SSI

U.S. Air Force

Spaceport Systems International (SSI), established in 1993, operates California Spaceport (CSP), which is located on California's central coast. The spaceport is a commercial launch facility and satellite processing facility on Vandenberg Air Force Base (VAFB). In 1996, the FAA issued the first Commercial Space Launch Site Operator's License to the spaceport. SSI received this license one year after signing a 25-year lease with the Air Force to provide commercial launch services from a 100-acre plot on VAFB property. The lease also included a payload processing facility that was originally built for the Space Shuttle program.

VAFB is the only location in the United States where both commercial and government polar orbiting satellites are launched. The Pegasus, Taurus, Minotaur, Atlas V, and Delta IV vehicles launch polar orbiting satellites from VAFB. SpaceX plans to launch its Falcon 9 vehicle from VAFB in 2013. VAFB also launches intercontinental ballistic missiles. The base started as a U.S. Army training center, Camp Cooke, in 1941, and was officially transferred to the U.S. Air Force in 1957.

Location California
Owner/Operator CSP: SSI VAFB: USAF
Launch Site Type CSP: FAA licensed VAFB: Federal (military)
Year Established California Spaceport: 1996 VAFB: 1941
Number of Launch Events California Spaceport: 11 VAFB: 653
Description Active orbital and suborbital launch site and headquarters of the Air Force's 30th Space Wing that manages the Western Range. SLC-8 is a commercial launch site co-located at VAFB.
Key Facilities ***CSP:*** SLC-8 (Minotaur) ***VAFB:*** SLC-2E/W (Delta II) SLC-3E (Atlas V) SLC-3W (Falcon 9) SLC-6 (Delta IV) SLC-576E (Taurus) 12/30 (4,572-meter runway)



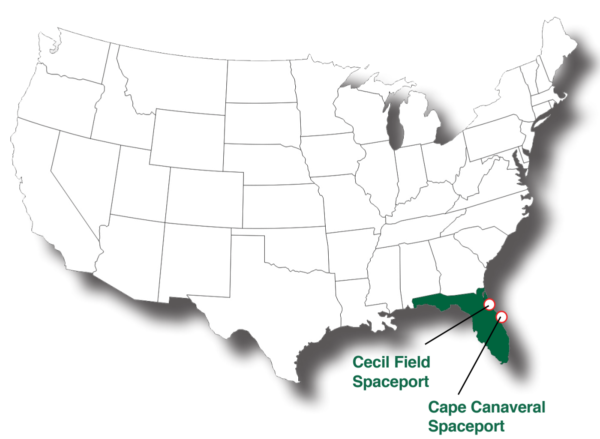
Cape Canaveral Spaceport
Cecil Field Spaceport

Space Florida

Space Florida manages two launch sites. Cape Canaveral Spaceport (CCS) is co-located at Cape Canaveral Air Force Station. It also manages a hangar at NASA's Kennedy Space Center for suborbital reusable vehicles. Cecil Field Spaceport (CFS) is co-located at Cecil Airport near Jacksonville.

Space Florida, using a $500,000 grant from the State of Florida, is refurbishing SLC-46, which has not been used for launches since 1999. The site will support launches of Lockheed Martin's new Athena III and Orbital's Minotaur and Taurus. Space Florida is also configuring SLC-36 for suborbital launches similar to SLC-47. In May 2011, Masten Space Systems and Space Florida signed a $400,000 contract for Masten to perform vertical launches from SLC-36A. Recently completed construction includes a processing facility, launch control center, and launch pad.

Location Florida
Owner/Operator Space Florida
Launch Site Type CCS: FAA licensed CFS: FAA licensed
Year established CCS: 1999 CFS: 2010
Number of Orbital Launch Events CCS: 2
Description Cape Canaveral Spaceport supports commercial orbital and suborbital launches. Cecil Field Spaceport supports commercial suborbital activity.
Key Facilities ***CCS:*** Business Incubator SLC-36 SLC-46 (Athena, Minotaur) SLC-47 (suborbital) Exploration park Operation Storage Facility RLV Hangar Space Life Sciences Lab Sea port ***CFS:*** 9L/27R (2,439-meter runway 9R/27L (2,439-meter runway) 18L/36R (3,811-meter runway) 18R/36L (2,439-meter runway)



Cape Canaveral AFS
Kennedy Space Center

U.S. Air Force
NASA

Together, the Air Force's Cape Canaveral Air Force Station (CCAFS) and NASA's Kennedy Space Center (KSC) represent the most active orbital launch location in the United States. Commercial and government launches take place from CCAFS, while human spaceflight missions managed by NASA take place from KSC's Launch Complex 39.

Both launch sites include a large variety of payload and vehicle processing facilities, hazardous materials storage, liquid fueling systems, and access to rail, air, and sea transportation.

KSC is preparing facilities, including Launch Complex 39B and the Vehicle Assembly Building, for NASA's forthcoming Space Launch System and Orion crewed capsule. SpaceX signed an agreement with NASA to lease Launch Complex 39A for the Falcon Heavy, and the company began modifying the facility in 2014. It is also working with Space Florida to lease other facilities for commercial use, including the Space Shuttle Orbiter Processing Facilities (OPF). Beginning in 2014, OPF-1 and OPF-2 started being modified to accommodate the Air Force's X-37B space plane. Boeing also signed a lease agreement with NASA in 2014 to use OPF-3 for the CST-100 crewed capsule currently in development.

Location
Florida
Owner/Operator
CCAFS: USAF KSC: NASA
Launch Site Type
CCAFS: Federal (military) KSC: Federal (civil)
Year Established
CCAFS: 1948 KSC: 1962
Number of Orbital Launch Events
CCAFS: 698 KSC: 151
Description
Main orbital launch site for the United States since 1958. Headquarters of the Air Force's 45th Space Wing that manages the Eastern Range with support from NASA WFF. KSC has been the center of NASA's human spaceflight activity since the mid-1960s.
Key Facilities
CCAFS: SLC-37 (Delta IV) SLC-40 (Falcon 9) SLC-41 (Atlas V) 13/31 (3,048-meter skid strip) Sea port ***KSC:*** LC-39A LC-39B 15/33 (4,572-meter runway) Sea port

KODIAK LAUNCH COMPLEX

Alaska Aerospace Corporation

Kodiak Launch Complex (KLC) is the first FAA-licensed launch site not co-located on a federally controlled launch site. Kodiak has one launch pad (LP-1) that can launch intermediate-class payloads to LEO or polar orbits. The complex also has a suborbital launch pad (LP-2) for missile testing.

In 2010, Lockheed Martin announced the revival of the Athena launch vehicle family and highlighted KLC as a launch site for the vehicles. Development of a new launch pad for the Athena III began in 2012. In October 2010, the FAA awarded $227,195 to the Alaska Aerospace Corporation as part of the Space Transportation Infrastructure Matching (STIM) Grants Program for construction of a rocket motor storage facility. In August 2014, LP-1 was damaged when an Air Force Advanced Hypersonic Weapons test ended in failure, the test vehicle having been destroyed by range control personnel following an anomaly. Soon afterwards, Lockheed Martin began repairing and upgrading LP-1 to accommodate the company's Athena 2S vehicle.

However, dropping oil prices led Alaska Governor Bill Walker to implement a fiscal restraint order in December 2014 directing all state agencies to "halt to the maximum extent possible" discretionary expenditures for six projects, one of which was the Kodiak Launch Complex.

Location
Alaska

Owner/Operator
Alaska Aerospace Corporation

Launch Site Type
FAA licensed

Year Established
1998

Number of Orbital Launch Events
3

Description
Kodiak Launch Complex was the first commercial launch site located outside a federal facility. Launch site for military, government, and commercial telecommunications, remote sensing, and space science payloads.

Key Facilities
- LP-1 (Athena)
- LP-2 (missile testing)
- Control and management center
- Payload processing facility
- Spacecraft transfer facility
- Solid motor storage

Mid-Atlantic Regional Spaceport VCSFA
Wallops Flight Facility NASA

The Virginia Commercial Space Flight Authority (VCSFA) was created in 1995. VCSFA began its lease at Wallops Island in 1997 and expanded the Mid-Atlantic Regional Spaceport (MARS) facilities to its present state, with two launch facilities (one mid-class and one small-class launch facility). Through agreements with NASA, VCSFA also added access to support infrastructure facilities, such as vehicle and payload processing integration facilities and instrumentation and emergency facilities. In 2011, VCSFA received an FAA AST $125,000 Space Transportation Infrastructure Grant for security and remote monitoring improvements at MARS.

NASA's WFF is the primary provider of NASA's science suborbital and small orbital flight programs. Annually, WFF conducts approximately 30 sounding rocket missions from this and other sites worldwide. It also conducts about 20 balloon missions per year and several hundred hours of piloted and unpiloted aircraft missions. WFF also manages the Wallops Research Range (WRR), consisting of the launch range, mobile range, and airport. WRR has conducted more than 16,000 launches over its 65-year history and annually supports approximately 20 suborbital launches.

MARS consists mainly of Launch Pads 0A and 0B, plus supporting facilities. Launch Pad 0A cost about $160 million to support Orbital Sciences Coproration's Antares vehicle; $90 million was provided by the State of Virginia, $60 million from NASA and $10 million from Orbital. In October 2014, damage was sustained by MARS Launch Pad 0A following the launch failure of an Antares vehicle. Initial assessments showed that the damage to facilities was not as severe as expected, and that repairs will be completed by 2016. Launch Pad 0B is used to support launches of the Minotaur series of vehicles.

Location
Virginia

Owner/Operator
MARS: VCSFA
WFF: NASA

Launch site type
MARS: FAA licensed
WFF: Federal (civil)

Year established
MARS: 1997
WFF: 1945

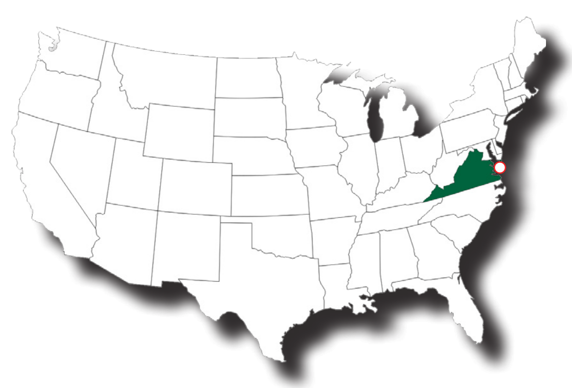
Number of orbital launch events
MARS: 11
WFF: 28

Description
WFF is a federally funded research, development, and testing facility supporting vertical launch and aircraft-based launches. MARS is a commercial spaceport co-located at WFF supporting vertical and horizontal space launch activities.

Key facilities

MARS
Launch Pad 0A
Launch Pad 0B

WFF
Three launch pads
Two launchers
Runway for unmanned aerial systems
11 assembly and processing facilities
Solid motor storage
Liquid fueling facilities

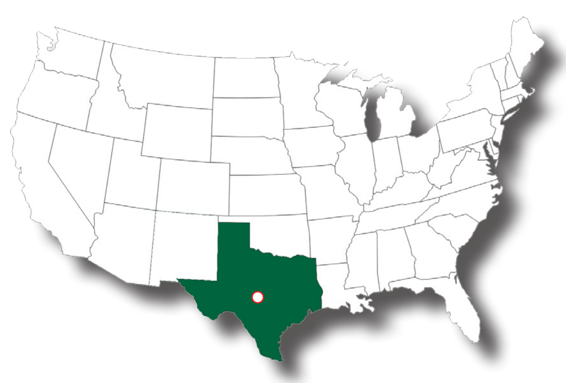


Midland International Air and Space Port

The Midland International Air and Space Port is the latest commercial launch site licensed by FAA AST, having been awarded the license in September 2014. The airport is approximately 330 miles from Dallas, Texas and 300 miles from El Paso, Texas. The air and space port is located on the same site as Sloan Field, a small airport founded in 1927. The airport was used as a training base during World War II before reverting back to commercial operations in late 1945.

In August 2014, XCOR Aerospace, which is moving its headquarters from Mojave Air and Space Port to Midland, kicked off construction of its new hangar. The XCOR hangar will become the home of the first XCOR Lynx suborbital spacecraft, XCOR's corporate headquarters, and its research and development facilities.

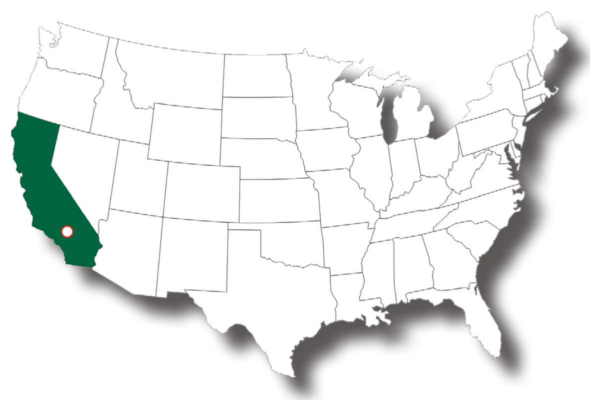
Location Texas
Owner/Operator City of Midland
Launch Site Type FAA licensed
Year Established 2014
Description Over 20 daily departures with non-stop service take place from the Midland International Air and Space Port to locations like Dallas Fort Worth, Dallas Love Field, Houston Intercontinental, Houston Hobby, Las Vegas, and Denver International. Currently, the airport is served by Southwest Airlines, Envoy Air, and United Express.
Key Facilities 4/22 (1,404-meter runway) 10/28 (2,530-meter runway) 16L/34R (1,323-meter runway) 16R/34L (2,896-meter runway)



MOJAVE AIR AND SPACE PORT

East Kern Airport District

Location
California
Owner/Operator
East Kern Airport District
Launch Site Type
FAA licensed
Year Established
2004
Description
Mojave Air and Space Port is a site used for flight testing, space industry development, and aircraft heavy maintenance and storage.
Key Facilities
12/30 (3,810-meter runway) 8/26 (2,148-meter runway) 4/22 (1,202-meter runway) Dedicated space vehicle areas



The Mojave Air and Space Port is an aerospace test center and spaceport operated by the East Kern Airport District in the Mojave Desert. High-performance aircraft were tested at Edwards Air Force Base in the Mojave desert.

Sixty companies operate out of Mojave, including Scaled Composites, XCOR Aerospace, Masten, and Interorbital Systems. Companies are currently designing, building, and testing small suborbital reusable vehicles on site.

East Kern Airport District has been awarded three FAA Space Transportation Infrastructure Matching (STIM) grants since 2010, totalling $273,750 for aquisition of an emergency rescue vehicle, development of a supplemental environmental assessment, and the purchase of specialized firefighting equipment.

In October 2014, SpaceShipTwo *VSS Enterprise*, which is tested at Mojave Air and Space Port, was destroyed shortly after it was launched from the WhiteKnightTwo carrier aircraft. The pilot survived serious injuries and the copilot was killed. The National Transportation Safety Board (NTSB) is investigating the accident witht he support of FAA AST and a report is expected in 2015.

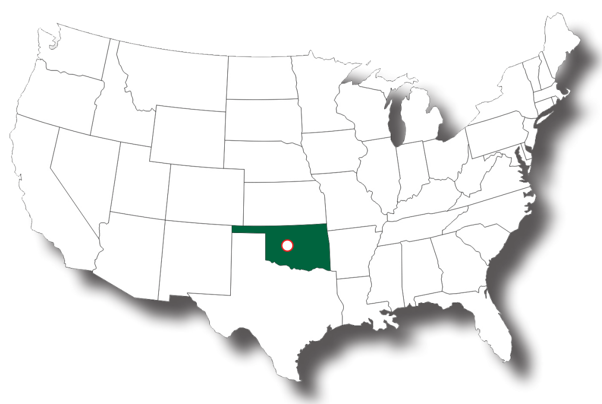
Oklahoma Spaceport

Oklahoma Space Industry Development Authority

Location
Oklahoma
Owner/Operator
OSIDA
Launch Site Type
FAA licensed
Year Established
2006
Description
OSIDA plans to use the site to provide support services for horizontally launched suborbital RLVs.
Key Facilities
17R/35L (4,116-meter runway) 17L/35R (1,583-meter runway)

Oklahoma Spaceport is managed by the Oklahoma Space Industry Development Authority (OSIDA). The site is located near the community of Burns Flat. It is part of what is also known as the Clinton-Sherman Industrial Airpark.

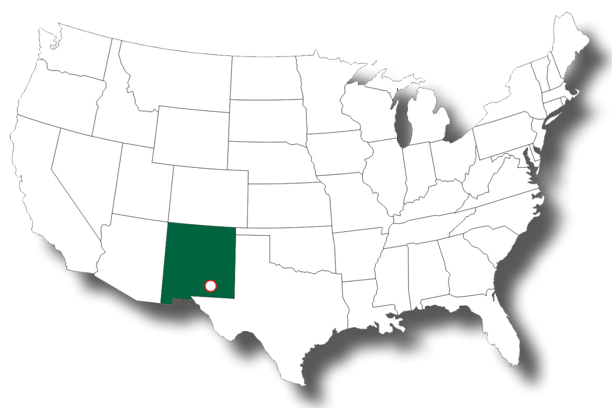
In March 2010, using $380,000 in FAA grants, OSIDA installed precision approach path indicator systems for the spaceport's two runways and replaced the old rotating airport beacon. OSIDA will install runway and taxi way signage and runway end identifier lights, using a $600,000 FAA grant received in August 2011. OSIDA plans to build a spaceport operations control center along with new perimeter fencing and security gates completely enclosing the facility.



Spaceport America

New Mexico Spaceport Authority

Location
New Mexico
Owner/Operator
NMSA
Launch Site Type
FAA licensed
Year Established
2008
Description
Spaceport America is a commercial spaceport that supports vertical and horizontal space launch activity.
Key Facilities
Main terminal building Hangar Visitor center (in development) UP Aerospace launch pad 16/34 (3,048-meter runway)



Spaceport America is the world's first purpose-built, commercial spaceport. The site is located in Sierra County, near the city of Truth or Consequences, New Mexico. The spaceport's first FAA-licensed launch took place in October 2012.

Virgin Galactic, the anchor tenant, signed a 20-year lease agreement immediately after issuance of the license. The main terminal hangar is capable of housing two WhiteKnightTwo aircraft and five Virgin Galactic SpaceShipTwo spacecraft.

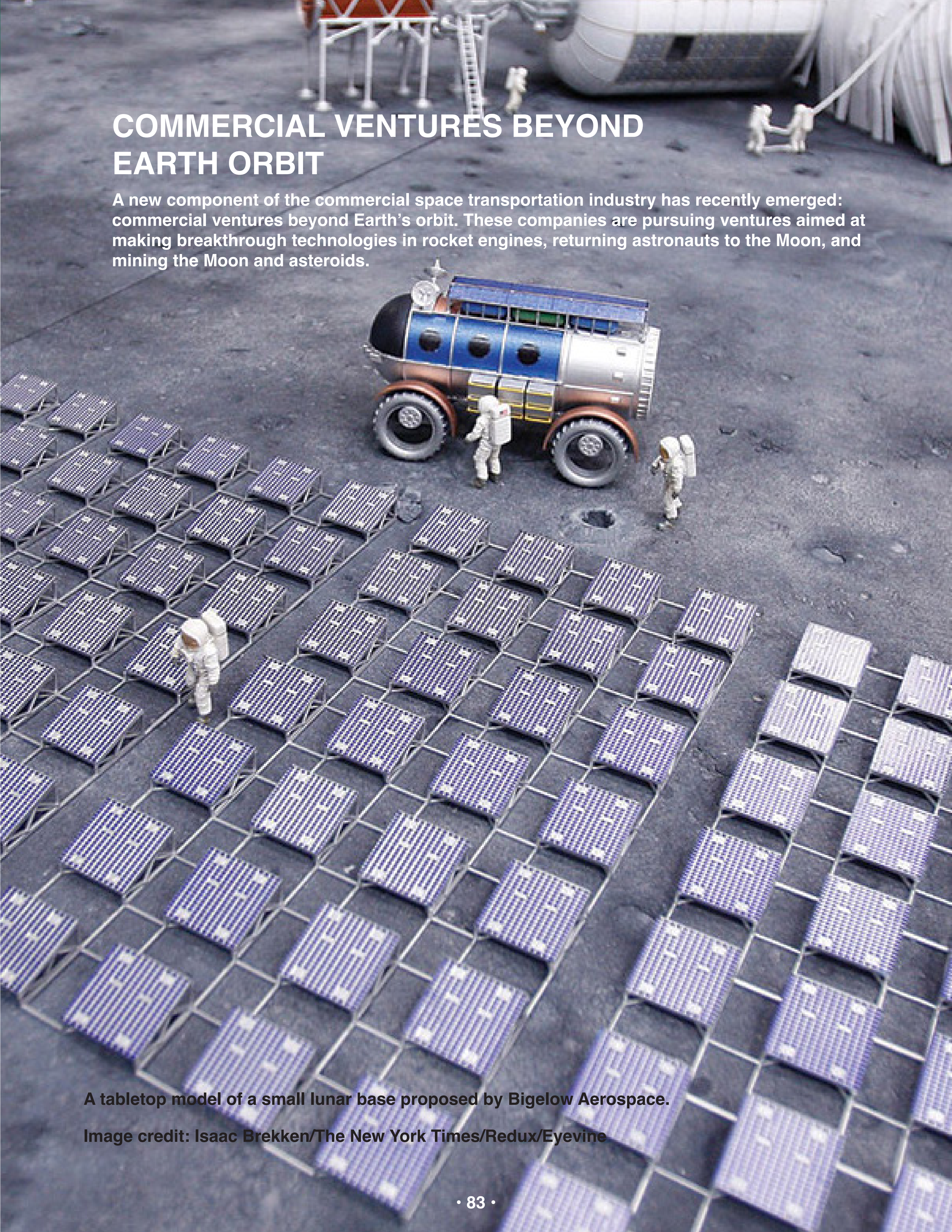
In September 2010, the FAA awarded the New Mexico Spaceport Authority (NMSA) $43,000 to provide an Automated Weather Observing System, as part of the FAA's Space Transportation Infrastructure Matching Grants Program. NMSA was also awarded an FAA grant worth nearly $250,000 in August 2011, for constructing a rollback integration building that can be used to prepare space vehicles for vertical launches. The spaceport is entirely financed by the taxpayers of New Mexico, with an estimated cost of $218.5 million.

Delays experienced by launch service providers like Virgin Galactic have inspired the New Mexico Spaceport Authority to explore alternative means of generating revenue at the spaceport until flight operations actually start. Negotiations with several potential tenants took place in 2014.

SpaceX intends to launch its Falcon 9R Dev 2 vehicle from Spaceport America instead of its McGregor, Texas test site because the New Mexico site is a licensed facility authorized to support suborbital flight trajectories. The Falcon 9R Dev 1 vehicle was a low-altitude test article flown at McGregor under an FAA AST Experimental Permit.

COMMERCIAL VENTURES BEYOND EARTH ORBIT

A new component of the commercial space transportation industry has recently emerged: commercial ventures beyond Earth's orbit. These companies are pursuing ventures aimed at making breakthrough technologies in rocket engines, returning astronauts to the Moon, and mining the Moon and asteroids.



A tabletop model of a small lunar base proposed by Bigelow Aerospace.

Image credit: Isaac Brekken/The New York Times/Redux/Eyevine

This compendium has summarized the main components of the commercial space transportation industry: orbital launch vehicles, SRVs, on-orbit space vehicles and platforms, and launch sites. Commercial space transportation activities, from launching communication satellites, resupplying the ISS, building space stations, and sending tourists to the edge of space, have all focused on activities in Earth's orbit. However, a relatively new component of the commercial space transportation industry has recently emerged: commercial ventures *beyond* Earth's orbit. These companies are pursuing ventures aimed at making breakthrough technologies in rocket engines, returning astronauts to the moon, and mining the moon and asteroids. Examples of these new ventures are highlighted below.

Lunar Efforts

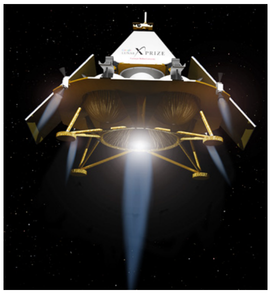
Artist's conception of Golden Spike Lunar Lander.

Image credit: Golden Spike

Golden Spike Company: Golden Spike: The Golden Spike Company formed to offer private human expeditions to the surface of the Moon by 2021. The company's president is former NASA Associate Administrator for Science Alan Stern, and its board is led by former NASA Johnson Space Center director Gerry Griffin. Golden Spike is focused on foreign national governments as their primary market and estimates the cost for a two-person lunar surface mission will be $1.55 billion. Golden Spike has contracted and partnered with multiple companies in the space industry, including Northrop Grumman and United Launch Alliance, for design of their propulsion modules, lunar lander, pressure suits and various mission analyses. Flight tests are expected around 2020.

Google Lunar X PRIZE: The X PRIZE Foundation is a nonprofit organization whose mission is to "bring about radical breakthroughs for the benefit of humanity." Google and the X PRIZE Foundation formally announced the Google Lunar X PRIZE in 2007. A total of $30 million in prizes are available to the first privately funded teams to successfully land a robot on the surface of the Moon, travel 500 meters (1,640 feet), and send video, images, and data back to Earth. The original deadline for the Prize was the end of 2012, which has since been modified to the end of 2016.

Shackleton Energy Company: Shackleton was formed in 2007 in Texas by Bill Stone, Dale Tietz, and Jim Keravala. The program is establishing first operational propellant depots in LEO and on the Moon within 10 years. Stone estimates this will take $22 billion of total investments. The plan is to mine the ice on the Moon and then use it to make LOX/LH propellants for distribution to a fleet of spacecraft. They also plan to provide life support, consumables, and services in LEO and on the Moon. A crowdfunding effort did not come close to raising the required $1.2 million in seed funding. Separately, Stone is developing robotic technologies for extreme environments, including contract work under NASA for specialized planetary exploration robots.

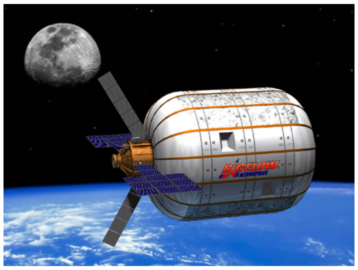


Astrobotic's Griffin Lander.

Image credit: Astrobotic

Cis-Lunar Efforts

Astrobotic: Astrobotic, founded in 2008, aims to provide robotic missions for hire to points beyond low Earth orbit, including to the Moon. In 2014, NASA selected Astrobotic as one of the three companies under the agency's Lunar CATALYST initiative, a program designed to spur commercial cargo transportation capabilities to the lunar surface. NASA is negotiating a 3-year, unfunded Space Act Agreement (SAA) with these companies. For this project, Astrobitc is expected to use its Griffin Lander currently under development.



Bigelow's BA 330 module.

Image credit: Bigelow Aerospace

Bigelow Aerospace: Bigelow Aerospace, founded by Robert Bigelow in 1999, plans to provide affordable options for people to live and work in space using an orbital platform it developed based on NASA's inflatable transit habitation technology. Bigelow, who has committed $500 million to the project, announced in 2014 that for $26 to $36 million clients will be able to spend up to 60 days on the Bigelow Alpha Station, composed of BA 330 modules. Prior to the launch of BA 330 modules, Bigelow Aerospace will test an inflatable platform on the ISS in 2015. The company is also developing module concepts for use on the lunar surface and for interplanetary transport.

Planetary Resources: In April 2012, Planetary Resources, Inc., a company formed by Space Adventures founder Eric Anderson and X PRIZE Chairman Peter Diamadis, introduced its plans to mine near-Earth asteroids for raw materials. The company believes asteroid mining will create a trillion-dollar industry. Planetary Resources plans to launch several constellations of Arkyd-100 Series LEO space telescopes on Virgin Galactic's LauncherOne. In October 2014, the company's Arkyd 3 CubeSat, designed to test key technologies, was destroyed during a launch failure of the Antares vehicle carrying Orb 3 to the ISS.

The B612 Foundation: The B612 foundation is a non-profit that intends to create the first comprehensive, dynamic map of our inner solar system and show the current and future locations and trajectories of Earth-crossing asteroids. The foundation's Chairman and CEO is former astronaut Ed Lu. The B612 Foundation expects its $450 million Sentinel mission will be the first privately funded deep space mission. This mission would launch an infrared telescope into a Venus-like orbit around the sun in 2018.

Deep Space Industries: Starting with small robotic scouts directly inspecting near Earth asteroids – called "FireFlies" because they light the way -- DSI is surveying and harvesting the riches of space to accelerate exploration and settlement. Propellants, metals and other materials will help maintain and expand Earth-orbit habitats as well as the hundreds of communications and reconnaissance satellites now operating. As expeditions head to the Moon and Mars, they will be outfitted and fueled with DSI-harvested resources for reduced costs. Founders include Rick Tumlinson, David Gump, and Chief Scientist Dr. John Lewis, author of Mining the Sky and Rain of Iron and Ice.

New Engine Technologies

The BE-3 tested at NASA's Stennis Space Center.

Image credit: NASA/ Blue Origin

Blue Origin: In addition to developing its *New Shephard* suborbital vehicle, an orbital launch vehicle, and an in-space Biconic Spacecraft, Blue Origin also develops propulsion systems. It's BE-3 engine, which burns liquid oxygen and liquid hydrogen and has a thrust of about 110 kN (1oo,ooo lbf), was successfully tested at NASA's Stennis Space Center in 2013. The company is also developing the LOX/liquid methane BE-4 engine, with a thrust of 2,400 kN (550,000 lbf). Blue Origin is working on the engine under a partnship agreement with United Launch Alliance (ULA) signed in 2014 as part of a program to develop a follow-on vehicle to the Atlas V.

Ad Astra Rocket Company: Ad Astra is developing the Variable Specific Impulse Magnetoplasma Rocket (VASIMR®), a new type of high-power electric engine designed to be more efficient than conventional chemical rockets, allowing cost-effective orbital debris mitigation, twice the payload mass for lunar delivery, half the transit time to Mars, and many other applications. In 2013, Ad Astra successfully completed the VX-200 program, accomplishing more than 10,000 reliable high-power firings of its 200 kW VASIMR® engine prototype, which measured 5.8N thrust, 5000 sec specific impulse and 72 percent thruster efficiency with argon propellant. The team also measured detailed plume characteristics. Also in 2013, Ad Astra began the VX-200SS program, a thermal steady-state version of the VX-200 system, to test flight-like components for a spaceflight ready design in 2014.

Skylon

Image credit: Reaction Engines

Reaction Engines Ltd: A British company, Reaction Engines is developing an advanced combined cycle air-breathing rocket engine called SABRE (Synergetic Air-Breathing Rocket Engine), capable of Mach 5+ atmospheric flight and transition to a pure rocket mode of operation. SABRE will enable a new generation of responsive low cost space access vehicles, such as the SABRE-optimized Skylon spaceplane, and other hypersonic vehicle applications. Following the successful testing of critical engine technologies, Reaction Engines recently attained $100 million in UK government funding towards a full engine demonstration program. First flights are expected by 2020.

Sierra Nevada Corp.: Sierra Nevada Corp. (SNC), a satellite and vehicle manufacturer, is developing the Dream Chaser in-space orbital vehicle. Dream Chaser will be powered by a new, non-toxic engine being deveoped by ORBITEC, a company SNC purchased in July 2014. Though not selected by NASA under the agency's Commercial Crew Transportation Capability, SNC is expected to continue development of Dream Chaser.

Space Propulsion Group Inc.: Established in 1999, Space Propulsion Group is developing a LOX/paraffin-based advanced hybrid rocket motor, in addition to other hybrid propulsion technologies to reduce the cost and environmental impact of access to space.

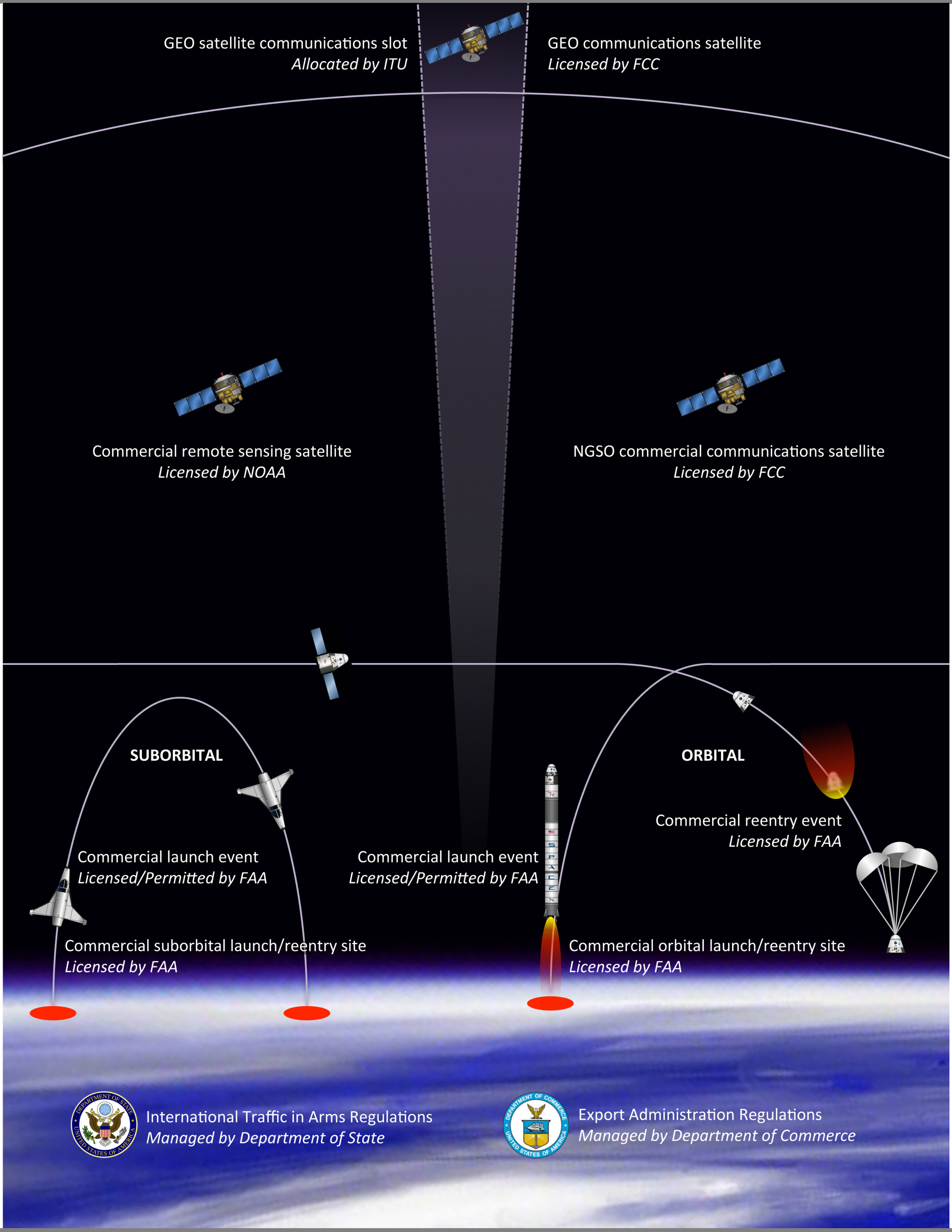
In recent years, the commercial space transportation industry has broadened its scope from delivering commercial communication satellites to orbit to launching satellites for a variety of Earth remote sensing purposes. Now the industry is set to deliver supplies, and ultimately crew, to the ISS, and it is aiming to bring tourists to the edge of space and deploy inflatable space stations in the near future. By the end of the decade, the industry seeks to extend its reach beyond Earth's orbit, with commercial missions to the surface of the Moon and asteroids.

REGULATION AND POLICY

Commercial space-related activities are regulated in the United States by several agencies, including the FAA, FCC, NOAA, the Department of State, and Department of Commerce.

The first flight of SpaceX's Falcon 9R reusable test vehicle, conducted under an FAA AST Experimental Permit, takes place from the company's McGregor site in Texas.

Image credit: SpaceX


GEO satellite communications slot
Allocated by ITU
GEO communications satellite
Licensed by FCC
Commercial remote sensing satellite
Licensed by NOAA
NGSO commercial communications satellite
Licensed by FCC
SUBORBITAL
ORBITAL
Commercial reentry event
Licensed by FAA
Commercial launch event
Licensed/Permitted by FAA
Commercial launch event
Licensed/Permitted by FAA
Commercial suborbital launch/reentry site
Licensed by FAA
Commercial orbital launch/reentry site
Licensed by FAA
International Traffic in Arms Regulations
Managed by Department of State
Export Administration Regulations
Managed by Department of Commerce

Commercial space-related activities—from launches and ground stations to satellite communications and capsule reentries—are regulated in the United States by several agencies, including the FAA, the Federal Communications Commission (FCC), the National Oceanic and Atmospheric Administration (NOAA), the Department of State, and Department of Commerce.

FEDERAL AVIATION ADMINISTRATION

FAA AST regulates all commercial launches conducted by U.S. entities in the United States or abroad. The licenses and permits issued by FAA AST include a launch- or reentry-specific license, launch or reentry operator license, launch site license, experimental permit, Class 2 or Class 3 waiver, and safety approval.

Launch- or Reentry-Specific License

This license authorizes one or more launches or reentries for a specific launch or reentry activity on a specific vehicle type operating from a specific site. The license identifies, by name or mission, each activity authorized by the license. The license expires when it reaches its expiration date or when the activities authorized by the license are completed, whichever happens first.

Launch or Reentry Operator License

This license allows an operator to perform multiple launches or reentries of the same or similar type. The license authorizes launches or reentries from a specific site, using vehicles from the same family, and transporting specific classes of payloads or performing specific activities. This license remains in effect for two to five years from the date it is issued.

Launch Site or Reentry Site Operator License

This license authorizes a site to host vehicle launches or reentries. In addition to safety concerns, FAA AST considers the environmental impact of a potential launch or reentry site before issuing this license, as required by the National Environmental Policy Act. Launch site or reentry site operator licenses are up for renewal every five years.

Operator	Type of FAA Authorization	Issue Date	Vehicle	Launch Site
SpaceX	Launch Specific License	2/28/14	Falcon 9 v1.1	CCAFS
SpaceX	Launch Specific License	3/7/14	Dragon (abort test)	CCAFS
SpaceX	Launch Specific License	5/2/14	Falcon 9 v1.1	CCAFS
SpaceX	Launch Specific License	5/21/14	Falcon 9 v1.1	CCAFS
Orbital Sciences Corp.	Launch Vehicle License	6/12/14	Antares 130	WFF
Mojave Air and Space Port	Launch Site Operator License	6/17/14	--	Mojave Air and Space Port
Orbital Sciences Corp.	Launch Vehicle License	7/17/14	Pegasus XL	Ronald Reagan Ballistic Missile Test Site
Midland International Airport	Launch Site Operator License	9/15/14	--	Midland International Air and Space Port

Table 11. FAA AST Licensed Launch and Site Activity in 2014

Figure 2. (left) Regulation of Space-Related Activities in the United States

Experimental Permit

This permit allows suborbital reusable rockets to launch or reenter while conducting research and development, showing compliance to obtain a license, or training crew. An alternative to licensing, this permit is processed faster than licenses, allows an unlimited number of launches for a particular vehicle design, and is valid for a one-year renewable term.

Safety Approval

This document determines that an identified safety element will not jeopardize the safety of public health or property when used or employed within a defined parameter or situation. FAA AST may issue a safety approval for a launch vehicle; a reentry vehicle; a safety system, process, service, or component thereof; qualified and trained personnel performing a process or function related to licensed launch activities; or any combination of the above.

Launch Indemnification

FAA AST also administers the financial responsibility and risk-sharing requirements for commercial launch and reentry operators as part of the FAA's licensing and permitting authority. The Commercial Space Launch Amendments Act of 2004 provides the government's authority to indemnify commercial launch operators against certain third party claims in the event of a launch accident. The Space Launch Liability Indemnification Extension Act (H.R. 3547) was introduced into the United States House of Representatives on November 20, 2013, and the bill was passed by the House and Senate during the 113th United States Congress. This extended the current limitation on liability of commercial space launch companies until December 31, 2014. Under the current law, a space launch company is liable for any damages up to $500 million, after which the U.S. Government will pay the damages in the range of $500 million to $2.7 billion.

Operator	Type of FAA Authorization	Date	Vehicle/Purpose
Black Sky Training, Inc.	Safety Approval	1/22/14	Spaceflight participant training program
Waypoint 2 Space, Inc.	Safety Approval	1/23/14	Spaceflight participant training program
Blue Origin	Experimental Permit	2/12/14	New Shephard
SpaceX	Experimental Permit	2/25/14	Falcon 9R
Scaled Composites	Experimental Permit Renewal	5/21/14	SpaceShipTwo

Table 12. Other FAA Commercial Space Transportation Regulatory Activity in 2014

Occupant Safety

The FAA is interested in developing guidelines for the safety of occupants of commercial suborbital and orbital spacecraft. Between 2012 and 2013, the FAA held eight teleconferences with the Commercial Space Transportation Advisory Committee (COMSTAC) regarding human occupant safety. The two organizations discussed safety measures that have historically proven valuable, from the time when occupants are exposed to vehicle hazards prior to flight through when they are no longer exposed to vehicle hazards after landing. A purpose of this continuing dialog is to ultimately gain the consensus of government, industry, and academia on established practices to encourage, facilitate, and promote the continuous improvement of the safety of launch and reentry vehicles designed to carry humans. FAA AST also worked closely with the FAA's Civil Aerospace Medical Institute to discuss medical issues. Lastly, studies related to human space flight safety were conducted by the FAA's Center of Excellence for Commercial Space Transportation, particularly the University of Colorado Boulder and the University of Texas Medical Branch.

This page intentionally left blank.

COMMERCIAL SPACE TRANSPORTATION FORECASTS

This section presents 2014 Commercial Space Transportation Forecasts, previously released by FAA AST and the Commercial Space Transportation Advisory Committee (COMSTAC).

The Orbital Sciences Corporation's Antares rocket is seen as it launches from Pad-0A of the Mid-Atlantic Regional Spaceport at the NASA Wallops Flight Facility in Virginia, Sunday, April 21, 2013.

Image credit: NASA/Bill Ingalls

This page intentionally left blank.

EXECUTIVE SUMMARY

The Federal Aviation Administration's Office of Commercial Space Transportation (FAA AST) and the Commercial Space Transportation Advisory Committee (COMSTAC) have prepared forecasts of global demand for commercial space launch services for the 10-year period from 2014 through 2023.

The 2014 Commercial Space Transportation Forecasts report is in two sections:

- *The COMSTAC 2014 Commercial Geosynchronous Orbit (GSO) Launch Demand Forecast*, which projects demand for commercial satellites that operate in GSO and the resulting commercial launch demand to GSO; and
- The FAA's *2014 Commercial Space Transportation Forecast for Non-Geosynchronous Orbits (NGSO)*, which projects commercial launch demand for satellites to NGSO, such as low Earth orbit (LEO), medium Earth orbit (MEO), elliptical (ELI) orbits, and external (EXT) trajectories beyond orbits around the Earth.

Together, the COMSTAC and FAA forecasts project an average annual demand of 30.1 commercial space launches worldwide from 2014 through 2023, down from 31.2 launches in the 2013 forecasts. The reports project an average of 16.3 commercial GSO launches and 13.8 NGSO launches for 2014 through 2023. Figure 1 shows the combined 2013 GSO and NGSO Historical Launches and Launch Forecast. Table 1 shows the number of payloads and launches projected from 2014 through 2023.

It is important to distinguish between forecast demand and the number of satellites actually launched. Launch vehicle and satellite programs are complex, and susceptible to delays, which generally makes the forecast demand for launches the upper limit of actual launches in the near-term forecast.

Figure 1. Combined 2014 GSO and NGSO Historical Launches and Launch Forecasts

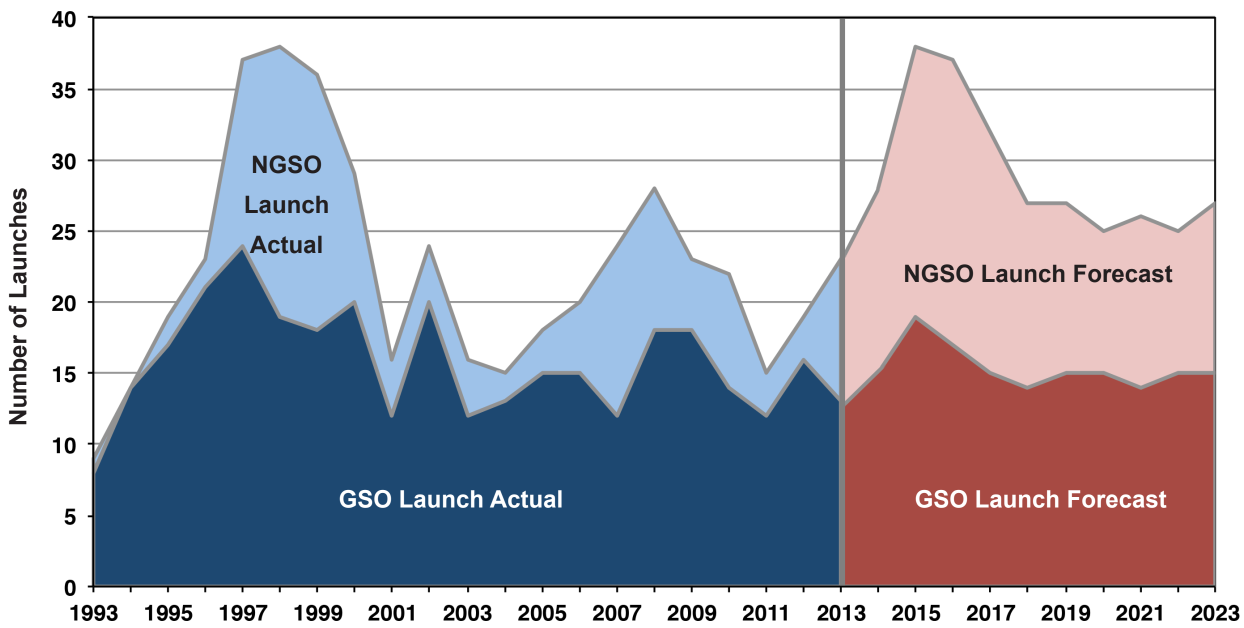


Table 1. Commercial Space Transportation Payload and Launch Forecasts

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total	Avg.
Payloads												
GSO Forecast (COMSTAC)	18	25	24	23	22	23	23	22	23	23	226	22.6
NGSO Forecast (FAA)	106	74	72	69	46	39	37	39	37	39	558	55.8
Total Satellites	**124**	**99**	**96**	**92**	**68**	**62**	**60**	**61**	**60**	**62**	**784**	**78.4**
Launches												
GSO Medium-to-Heavy	13	18	19	16	16	16	17	15	17	16	163	16.3
NGSO Medium-to-Heavy	13	18	16	14	13	10	10	10	10	10	124	12.4
NGSO Small	0	1	4	3	0	2	0	2	0	2	14	1.4
Total Launches	**26**	**37**	**39**	**33**	**29**	**28**	**27**	**27**	**27**	**28**	**301**	**30.1**

The GSO market remains stable with a projected demand of 22.6 satellites per year, virtually the same as last year. Figure 2 shows the 2014 GSO Historical Launches and Launch Forecast. Thirty-five percent of GSO satellites projected to launch from 2014 to 2023 are in the heaviest mass class (above 5,400 kilograms). At the same time, 14 percent of the satellites in the same period are in the lowest mass class (below 2,500 kilograms). In 2014, unaddressable launches remained at the comparably high level—launch contracts that were not open to international (including U.S.) competition—as Chinese and Russian government-owned aerospace companies routinely package satellites, launches, and financing together. The satellite services market is generally robust, and new launch vehicle options will affect the dynamics of the launch industry. Operators are cautious about the impact of the economy on their plans but are generally satisfied with satellite and launch vehicle offerings.

Figure 2. 2014 GSO Historical Launches and Launch Forecast

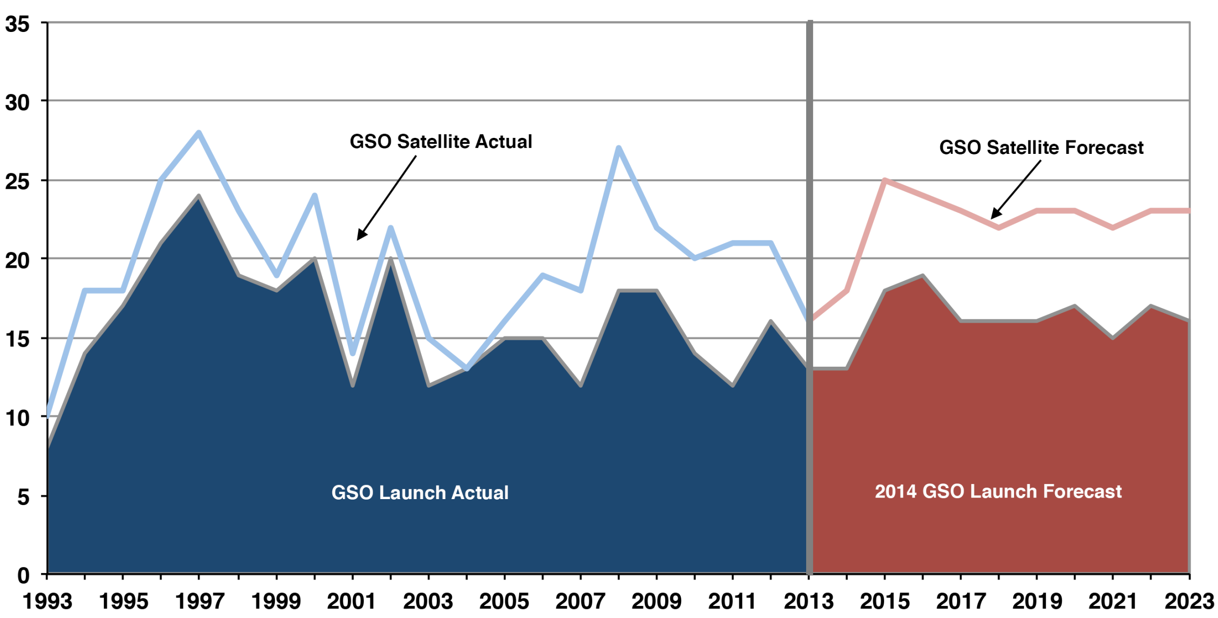
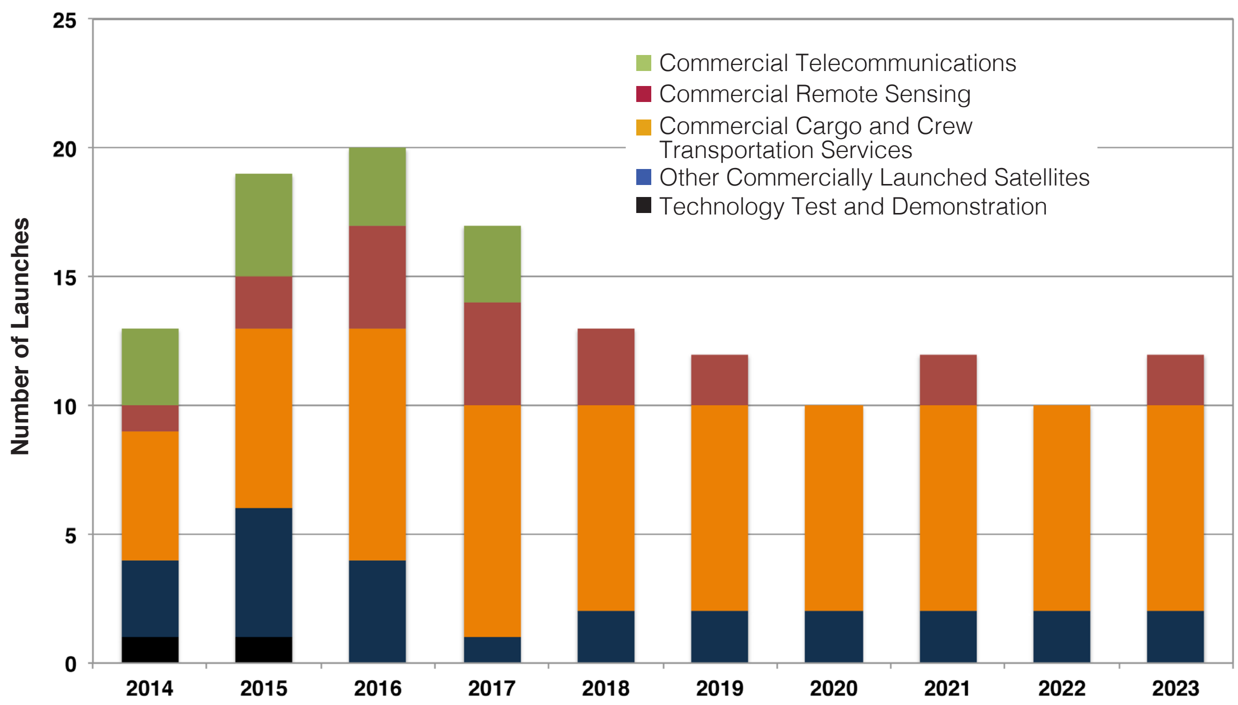


Figure 3. Projected NGSO Launches from 2014-2023



The demand for commercial NGSO launches is expected to increase relatively significantly as major NGSO telecommunication constellations are replenished and NASA ISS commercial crew and cargo resupply missions become more regular. The annual average of NGSO commercial launches is expected to grow from an annual average of 6 launches a year over the last ten years to almost 14 launches annually. From 2014 to 2023, 558 payloads are projected to launch commercially, driving 138 launches with multi-manifesting. Ten more launches over the next decade are projected compared to last year's forecast of 128 launches. This increase is driven primarily by additional flights for commercial crew and cargo and commercial remote sensing. Figure 3 shows the projected NGSO launches for the next 10 years. The launches in the next 10 years are predominantly commercial launches to the ISS, which require medium-to-heavy vehicles. Ninety percent of all commercial NGSO launches during the forecast period will launch on medium-to-heavy vehicles. Compared to last year's report, the number of small launches has increased, and the number of medium-to-heavy launches has remained constant. The increase in small launches is due to the inclusion of Skybox Imaging's plans to use Minotaur C and LauncherOne to deploy its constellation. A number of new small launchers are being planned, and a number of intermediate launch vehicles have been introduced or will be introduced in the next few years. From 2014 to 2017 the report forecasts a number of small commercial satellites to be launched as Iridium, Globalstar, ORBCOMM, O3b, Planet Labs, Skybox all deploy their constellations. The number of small multimanifested satellites drops off towards the end of the forecast, but the number of launches remain relatively steady as NASA begins its commercial crew program.

The two sections that follow—GSO and NGSO—provide detailed information on the two market segments.

This page intentionally left blank.

COMSTAC 2014 COMMERCIAL GEOSYNCHRONOUS ORBIT LAUNCH DEMAND FORECAST

EXECUTIVE SUMMARY

The Commercial Space Transportation Advisory Committee (COMSTAC) for the Office of Commercial Space Transportation of the Federal Aviation Administration (FAA AST) compiled the 2014 Commercial Geosynchronous Orbit (GSO) Launch Demand Forecast (the Report). This year's Report is the 22nd annual forecast of global demand for commercial GSO satellites and launches addressable by the U.S. space launch industry—that is, launches open to internationally competitive (including U.S.) launch service procurement—over the next ten years. The Report provides a detailed analysis of satellites scheduled for launch in the next three years and a broader forecast of launch demand for the subsequent seven years. The Report is intended to assist FAA AST in resource planning for licensing and in efforts to foster commercial space launch capability in the United States.

The Report is updated annually, using inputs from commercial satellite operators, satellite manufacturers and launch service providers. Both satellite and launch demand forecasts are included in the Report. The satellite demand is a forecast of the number of addressable commercial GSO satellites that operators expect will be launched. The launch demand is determined by the number of addressable satellites to be launched adjusted by the number of satellites projected to be launched together on a single launch vehicle, referred to in the Report as "dual-manifest" launches.

Figure 4 provides a summary of the forecast, showing annual projected satellites and launches. Table 2 provides the corresponding values, including the projected number of dual-manifested launches.

Figure 4. Forecast Commercial GSO Satellite and Launch Demand

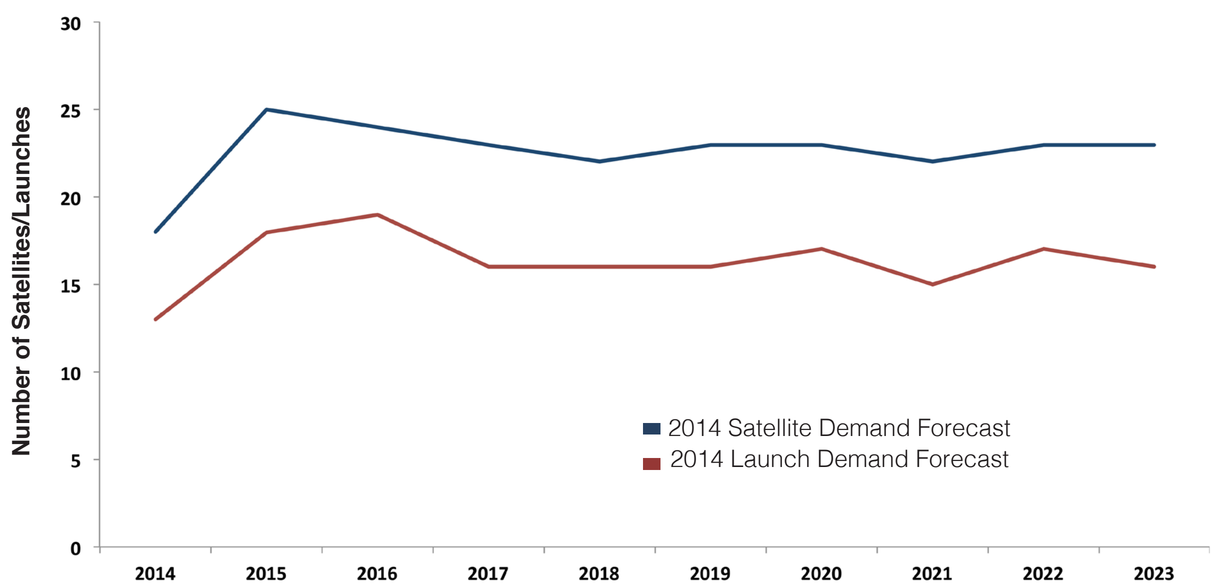


Table 2. Forecast Commercial GSO Satellite and Launch Demand

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total	Average
Satellite Demand	18	25	24	23	22	23	23	22	23	23	226	22.6
Launch Demand	13	18	19	16	16	16	17	15	17	16	163	16.3
Dual Launch Demand	5	7	5	7	6	7	6	7	6	7	63	6.3

The key findings of this report are:

- The 2014 COMSTAC GSO forecast projects 19 addressable commercial GSO satellites on 14 launches in 2014 and an annual average of 22.8 satellites on 16.5 launches for the period from 2014 through 2023.
- The number of addressable satellites launched in 2013 dropped from 2012, as a result of satellite delays and launch failures.
- While the average number of satellites to be launched in the next ten years is unchanged from last year's report, the number of launches has decreased, representing a combination of more dual-manifest launches and more unaddressable satellites.
- The satellite services market is generally robust, and new launch vehicle options have changed the dynamics of the launch industry.
- Operators are cautious about the impact of the economy on their plans but are generally satisfied with satellite and launch vehicle offerings.

It is important to distinguish between forecast demand and the number of satellites that are actually launched. Satellite programs are susceptible to delays, so the forecast demand is an upper limit on the number of satellites that may actually be launched. To account for these differences, the forecast team developed a "launch realization factor." This factor is based on historical data comparing actual satellites launched with predicted satellite demand from previous Reports. This factor is then applied to the near-term forecast to provide a range of satellites reasonably expected to be launched. For example, while 19 satellites are projected to be launched in 2014, applying the realization factor adjusts this to a range of 15 to 21 satellites.

Table 3. 2014 GSO Forecast Team

Forecast Team Member	Affiliated Company
Raymond Wong	The Boeing Company
Peter Stier	Sea Launch
Alan Keisner	SpaceX
Chitta Ratana	Space Systems Loral
Kate Maliga	The Tauri Group
Keith Karuntzos	United Launch Alliance
Chris Kunstadter	XL Insurance

HISTORY OF THE REPORT

In 1993, the U.S. Department of Transportation requested that COMSTAC annually prepare a commercial GSO satellite launch demand forecast to present the commercial space industry's view of future space launch requirements. COMSTAC works with U.S. launch service providers, satellite manufacturers, and satellite service providers to develop the forecast. A Forecast Team of COMSTAC members and industry experts, listed in Table 3, compiled this year's Report.

One of the goals of FAA AST is to foster a healthy commercial space launch capability in the United States. In order to do this, FAA AST must understand the scope and trends of global commercial spaceflight demand. In addition, FAA AST must be able to plan for and allocate resources which may be necessary to carry out its responsibilities in licensing commercial U.S. space launches. This Report provides necessary data to FAA AST for these purposes.

FORECAST METHODOLOGY

The methodology for developing the forecast has remained consistent throughout its history. The Forecast Team, through FAA AST, requests projections of satellites to be launched over the next 10 years from global satellite operators, satellite manufacturers, and launch service providers. This includes a projection of these organizations' launch plans as well as a broad, industry-wide estimate of total GSO launches. In addition, input is sought on a variety of factors that might affect satellite and launch demand.

The Forecast Team, using this input as well as public sources (e.g., satellite operator and launch provider web sites), and the team's own industry knowledge, develops the near-term forecast, covering the first three years (2014–2016) of the ten-year forecast period. The combined comprehensive inputs as well as the above sources are then used to generate the longer-term demand forecast (2017 to 2023).

Other factors that were considered in developing the forecast include:

- Publicly-announced satellite and launch contracts
- Projected planned and replenishment missions
- Growth in demand from new and existing services and applications
- Availability of financing and insurance
- Potential consolidation among operators
- New launch vehicle capabilities
- Hosted payload opportunities

The production cycle for today's satellites is typically two to three years, but it can be longer for heavier or more complex satellites. Orders within a two- to three-year horizon are thus generally reliable. Satellite orders more than three years out can be difficult to identify, as many of these programs are in early stages of planning or procurement. Beyond five years, new markets and new uses of satellite technology may emerge that are currently unanticipated.

COMSTAC COMMERCIAL GSO LAUNCH DEMAND FORECAST RESULTS

Addressable vs. Unaddressable

To clarify which launch opportunities can be "addressed" by U.S. launch providers, satellite launches are classified as either "addressable" or "unaddressable." Addressable, in the context of this Report, is defined as commercial GSO satellite launches that are open to an internationally competitive (including U.S.) launch service procurement process. Satellites and launches bundled in government-to-government deals, launches captive to particular launch service providers, and others that are not internationally competed are classified as unaddressable.

The number of unaddressable launches has increased from the 2013 forecast, as Chinese, Indian, Japanese and Russian government-owned or -supported aerospace companies continued packaging satellites, launches, financing and insurance for commercial satellites on a strategic, non-competitive basis. Figure 5 and Table 4 compare the numbers of addressable and unaddressable satellites since 1993.

Figure 5. Addressable and Unaddressable Satellites since 2005

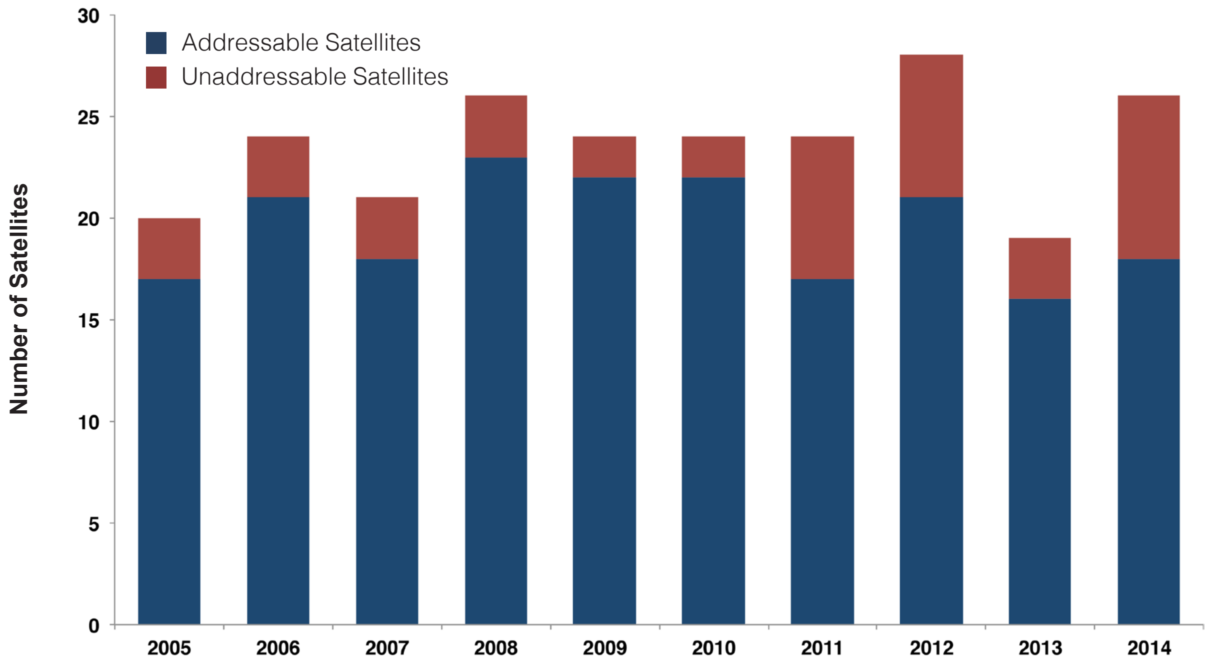


Table 4. Addressable and Unaddressable Satellites Since 2005

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Addressable	17	21	18	23	22	22	17	21	16	18
Unaddressable	3	3	3	3	2	2	7	7	3	8
Total	**20**	**24**	**21**	**26**	**24**	**24**	**24**	**28**	**19**	**26**

Mass Classes

One of the primary metrics for determining launch requirements is satellite mass. Mass classes based on ranges of satellite masses are used to analyze developments in satellite and launch demand. Four mass classes are currently used, as shown in Table 5.

Table 5. Satellite Mass Class Categorization

Class	Separated Mass	Representative Satellite Bus Models
Medium	Below 2,500 kg (<5,510 lbm)	Lockheed Martin A-2100, Orbital GEOStar, Boeing BSS-702, SSL-1300
Intermediate	2,500 - 4,200 kg (5,510 - 9,260 lbm)	A-2100, IAI Amos, MELCO DS-2000, GEOStar, SSL-1300, Thales SB-4000
Heavy	4,200 - 5,400 kg (9,260 - 11,905 lbm)	Astrium ES-3000, BSS-702, IAI Amos, A-2100, DS-2000, GEOStar, SSL-1300, SB-4000
Extra Heavy	Above 5,400 kg (>11,905 lbm)	ES-3000, BSS-702, A-2100, SSL-1300, SB-4000

The upper limit of the smallest mass class was increased in 2008 from 2,200 kg to 2,500 kg. This adjustment captured the growth in mass of the smallest commercial GSO satellites being manufactured. As an example, Orbital's GEOStar bus, which dominated the lower end of the mass scale in previous years, has recently been used for satellites in excess of 3,200 kg, which fall in the intermediate mass class range. Unaddressable launches in this smallest class abound, with one to three medium class satellites being launched in most years.

One technical development that has affected the trend towards increasing satellite mass is the development of satellites using electric propulsion rather than chemical propulsion (such as liquid apogee motors) for orbit-raising. By reducing the mass of propellant used for orbit-raising, which in many cases is greater than the dry mass of the satellite, the satellite can carry a significantly larger payload. Alternatively, by keeping the satellite mass low, two satellites, each with the payload capacity of a large satellite, can be launched together.

Using electric propulsion increases the time required for orbit-raising—months rather than days. Nonetheless, in many cases, the benefits of the mass and launch cost savings outweigh the delay in achieving final orbital position.

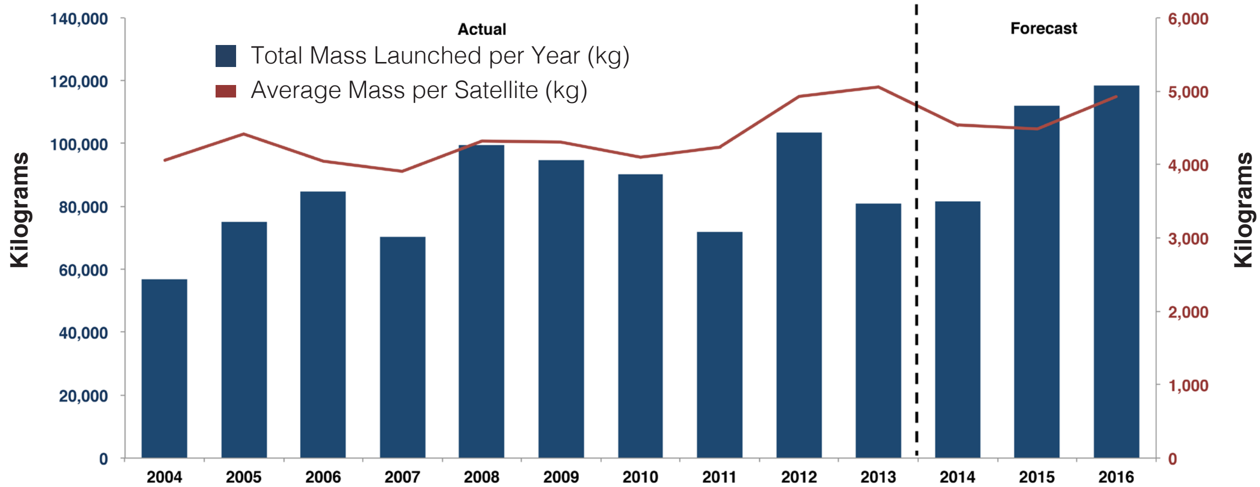
In 2012, Boeing signed a contract with Asia Broadcast Satellite (ABS) and Satmex for four all-electric design 702SP satellites. Since then, most other manufacturers of commercial communications satellites have indicated they already have—or will offer—that technology to their customers in the near future.

With the advent of all-electric propulsion satellites, this smaller mass class is expected to grow in the next three years.

Table 6. Total Satellite Mass Launched per Year and Average Mass per Satellite

	Actual									Forecast		
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total Mass Launched per Year (kg)	75,166	84,881	70,314	99,479	94,670	90,171	72,057	103,499	80,916	81,601	112,070	118,311
Average Mass per Satellite (kg)	4,422	4,042	3,906	4,325	4,303	4,099	4,239	4,929	5,057	4,533	4,483	4,930

Figure 6. Total Satellite Mass Launched per Year and Average Mass per Satellite



Likewise, the heaviest mass class continues to dominate, with 56 percent of satellites launched in 2013 falling into this mass class. As the smallest mass class grows, the extra-heavy mass class is expected to decrease to 38 percent of the satellites projected for launch from 2014 through 2016.

Figure 6 and Table 6 show the total mass launched per year and the average mass per satellite launched. The total mass launched per year correlates with the number of satellites launched per year. The average mass of satellites launched in the past nine years was over 4,000 kg, reaching a new high of over 5,000 kg in 2013. The average mass in 2014 is expected to reduce slightly. The 20 satellites scheduled for launch in 2014 have a mass of 89,968 kg, for an expected average satellite mass of 4,498 kg.

Figure 7 and Table 7 show the trends in satellite mass class distribution.

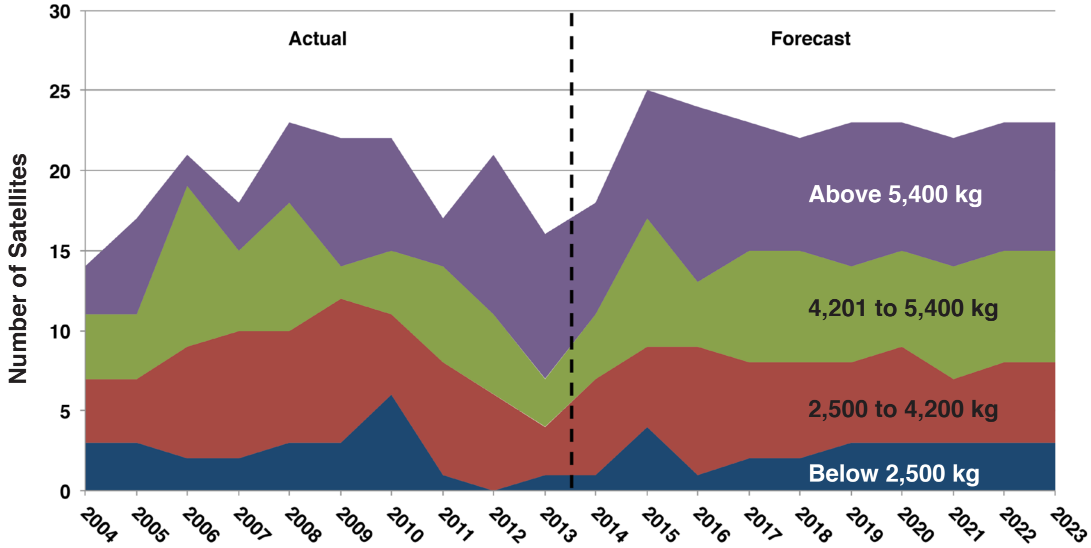
Table 7. Trends in Satellite Mass Class Distribution

	Actual									Forecast										Total 2014 to 2023	Avg. 2014 to 2023	% of Total 2014 to 2023
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023			
Above 5,400 kg	6	2	3	5	8	7	3	10	9	7	8	11	8	7	9	8	8	8	8	82	8.2	36%
4,201 - 5,400 kg	4	10	5	8	2	4	6	5	3	4	8	4	7	7	6	6	7	7	7	63	6.3	28%
2,500 - 4,200 kg	4	7	8	7	9	5	7	6	3	6	5	8	6	6	5	6	4	5	5	56	5.6	25%
Below 2,500 kg	3	2	2	3	3	6	1	0	1	1	4	1	2	2	3	3	3	3	3	25	2.5	11%
Total	**17**	**21**	**18**	**23**	**22**	**22**	**17**	**21**	**16**	**18**	**25**	**24**	**23**	**22**	**23**	**23**	**22**	**23**	**23**	**226**	**23**	**100%**

Dual-Manifesting

Several launch services providers are capable of lofting two satellites simultaneously into geosynchronous transfer orbit (GTO), and these capabilities are factored into the launch demand forecast. The demand analysis for launch vehicles must take into consideration this capability. Care must be taken in that inclusion into the forecast must be based upon the addressability of each of the

Figure 7. Trends in Satellite Mass Class Distribution



satellites flown. A launch vehicle which has the launch services competitively procured for both satellites is included in the forecast and counted as dual launch. A vehicle which has only one of the two satellite launch services contracts competitively procured is also included in the forecast but counted as a single launch. A vehicle which has the launch services of both satellites directed to a specific launch service provider is not counted in the forecast as such services are not competitively procured.

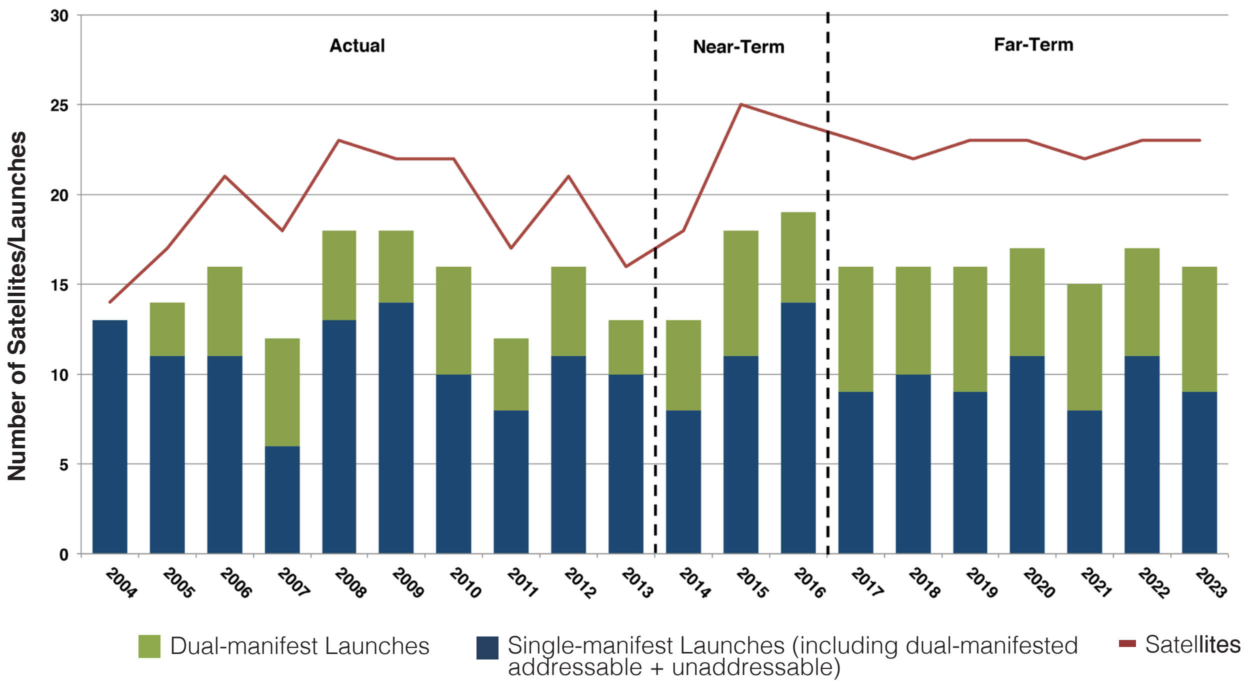
Arianespace's Ariane 5 vehicle has been launching dual-manifested, competitively-procured, commercial launch services missions for over ten years. The Forecast Team determined the near-term number of dual manifest launches on Ariane 5 by assessing the existing backlog of satellites through 2016. International Launch Services' Proton M vehicle has flown several dual-manifested missions, typically with at least one Russian-built (unaddressable) satellite. SpaceX's Falcon 9 has two orders to fly in dual configuration, pairing Boeing-built electric propulsion satellites for Asia Broadcast Satellite and SatMex.

Dual-manifesting for two satellites in the Heavy and/or Extra Heavy mass classes is not yet possible. Arianespace typically attempts to match satellites that together have a total mass approaching 10,000 kg. As Europe considers a follow-on vehicle for the Ariane 5, one option is the Ariane 5ME (Mid-life Evolution) which would raise the operational capability by 10 percent or more by 2018, thus enabling Ariane 5ME to carry two large-class satellites.

The debut of SpaceX's Falcon Heavy launch vehicle will also permit dual manifesting of larger satellites. The introduction of electric propulsion technology over time however may partially reverse the trend of growth in overall satellite mass, allowing more dual manifesting on existing launch vehicles.

Figure 8 presents the 2014 single- and dual-manifest satellite and launch demand forecast from 2014 through 2023, and the actual launch statistics from 2004 through 2013. The Forecasting Team projects that after the next three years, the number of dual manifest launches within the addressable market area will stabilize at seven per year, despite the European Space Agency (ESA) developing the single-manifest Ariane 6, which will supercede the Ariane 5 in the next decade. While the retirement of the Ariane 5 would preclude Arianespace from contracting for larger dual manifest missions, the other launch service providers will have already developed and launched their own dual manifest solutions. However, this capability transition to other launch vehicles is not expected to impact the number of dual manifest launches over the rest of the decade. Figure 8 shows the satellite and launch demand forecast from 2014 to 2023 as well as actual launch statistics for 2004 through 2013.

Figure 8. Dual Manifesting and Launch Demand



Near-Term Demand Forecast

Table 8 shows the satellites projected to be launched in the next three years. The projections for 2014 to 2016 show an increase in the number of satellites to be launched over the previous three years (2011-2013).

Table 8. Commercial GSO Satellite Near-Term Manifest

	2014			2015			2016		
Total	18			25			24		
Below 2,500 kg	1			4			1		
		GSAT 14	GSLV	DM	ABS 2A	Falcon 9		PSN 6	TBD
				DM	ABS 3A	Falcon 9			
				DM	Satmex 7	Falcon 9			
				DM	Satmex 9	Falcon 9			
2,500 - 4,200 kg	6			5			8		
	DM	Athena-Fidus	Ariane 5	DM	ARSAT 2	Ariane 5	DM	Amazonas 4B	Ariane 5
	DM	Amazonas 4A	Ariane 5	DM	GSAT 16	Ariane 5	DM	Brisat	Ariane 5
	DM	Optus 10	Ariane 5	DM	Hispasat AG1	Ariane 5		BulgariaSat	Falcon 9
	DM	ARSAT 1	Ariane 5	DM	Intelsat 34	Ariane 5		Thaicom 8	Falcon 9
	DM	GSAT 15	Ariane 5	DM	Sky Mexico 1	Ariane 5		JCSAT 15	TBD
		Thaicom 6	Falcon 9					JCSAT 16	TBD
								Palapa E	TBD
								Intelsat 36	TBD
4,201 - 5,400 kg	4			8			4		
		Turksat 4A	Proton M	DM	Sicral 2	Ariane 5	DM	DSN 1	Ariane 5
		Asiasat 8	Falcon 9	DM	Thor 7	Ariane 5		Mexsat 2	Ariane 5
		Asiasat 6	Falcon 9		Amos 6	Falcon 9		SES 10	Falcon 9
		Turkmen 1	Falcon 9		JCSAT 14	Falcon 9		Telstar 12V	H-IIA
					SES 9	Falcon 9			
					Eutelsat 9B	Proton M			
					Mexsat 1	Proton M			
					Turksat 4B	Proton M			
Above 5,400 kg	7			8			11		
	DM	ABS 2	Ariane 5	DM	BADR 7	Ariane 5	DM	Echostar XVIII	Ariane 5
	DM	Astra 5B	Ariane 5	DM	DirecTV 15	Ariane 5	DM	Echostar XIX	Ariane 5
	DM	MEASAT 3B	Ariane 5	DM	Eutelsat 8WB	Ariane 5	DM	Intelsat 29E	Ariane 5
	DM	Intelsat 30	Ariane 5	DM	NBN 1A	Ariane 5	DM	Intelsat 33E	Ariane 5
	DM	DirecTV 14	Ariane 5	DM	Star One C4	Ariane 5	DM	Jabiru 1	Ariane 5
		Eutelsat 3B	Zenit 3SL		Inmarsat 5F2	Proton M	DM	NBN 1B	Ariane 5
		Astra 2G	Proton M		Inmarsat 5F3	Proton M	DM	Sky Brasil 1	Ariane 5
					Intelsat 31	Proton M	DM	Star One D1	Ariane 5
								Viasat 2	TBD
								Eutelsat 65WA	TBD
								Inmarsat 5F4	

DM = Potential Dual-Manifested Satellites

* = Satellite proposed, not yet identified publicly

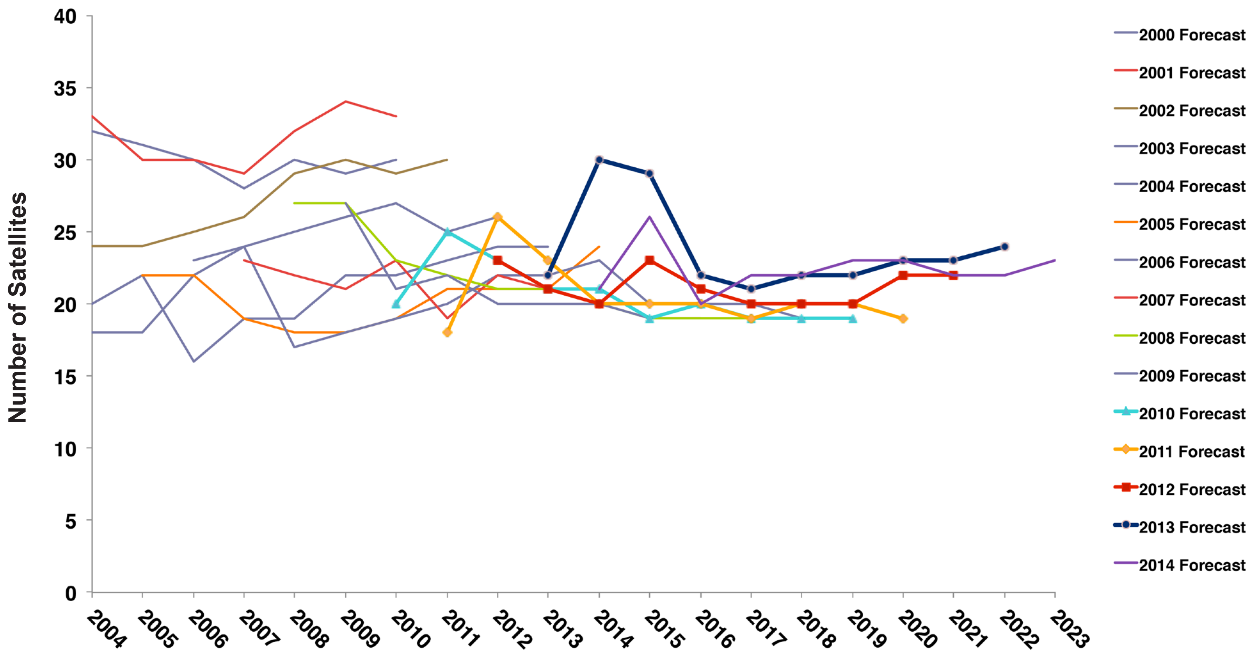
Comparison with Previous COMSTAC Forecasts

The current forecast continues the slight increase in average annual launches for the next ten years as seen in the 2013 Report. The average number of satellites from the 2004 to 2013 Reports was in a narrow range—between 20.5 and 21.8 satellites. The 2014 Report shows an average of 22.8 satellites to be launched each year, unchanged from the 2013 Report.

The 2013 Report projected 21 satellites to be launched in 2013. The reduction to 16 satellites actually launched in 2013 reflects:

- Satellite and launch vehicle technical issues,
- Changing business climate for several operators who encountered financial issues, and
- Reclassification of several launches as unaddressable

Figure 9. Comparison of Annual Forecasts: 2004-2023



COMSTAC DEMAND PROJECTION VS. ACTUAL LAUNCHES REALIZED

Factors That Affect Satellite Launch Realization

- The demand for satellite launches is typically larger than the number of satellites that will actually be launched in a year. Some factors that contribute to the difference between forecast and realized launches are:
- Satellite technical issues: Satellite manufacturers may have manufacturing, supplier, or component issues that delay the delivery of a satellite. On-ground and in-orbit anomalies can affect the delivery of satellites under construction until fleet-wide issues (such as commonality of parts, processes, and systems) are resolved. Delays in delivery of spacecraft to the launch site then impact the scheduling of launches.
- Launch vehicle technical issues: Launch vehicle manufacturers and launch service providers may have manufacturing, supplier, or component issues that cause launch delays. Recovery from launch anomalies and failures can also significantly affect launch schedules. Delays have a cascading effect on subsequent launches, and some science missions have specific launch windows that, if missed, may result in lengthy delays and manifest issues.
- Weather: Inclement weather, including ground winds, flight winds, cloud cover, lightning, and ocean currents often cause launch delays, though these are typically short-term (on the order of days).
- Range availability issues: The lack of launch range availability due to prioritized government missions, schedule conflicts with other launch providers, launch site maintenance, and other range-related issues can cause launch delays.
- Dual-manifesting: Dual-manifesting requires that two satellites are delivered to the launch site on time. A delay on one satellite results in a launch delay for the other satellite and subsequent satellites. Payload compatibility issues (such as mass mismatch, technical differences, and differing orbit insertion requirements) can also cause delays.
- Business issues: Corporate reprioritization, changing strategies and markets, and inability to obtain financing may delay or cancel satellite programs; however, this can free up launch slots for other customers.
- Regulatory issues: Export compliance, FCC or international licensing, and frequency coordination can cause delays, launch vehicle shifts, and satellite program cancellations. U.S. government policy regarding satellite and launch vehicle export control can make it difficult for U.S. satellite manufacturers and launch vehicle operators to work with international customers.

Projecting Actual Satellites Launched Using a Realization Factor

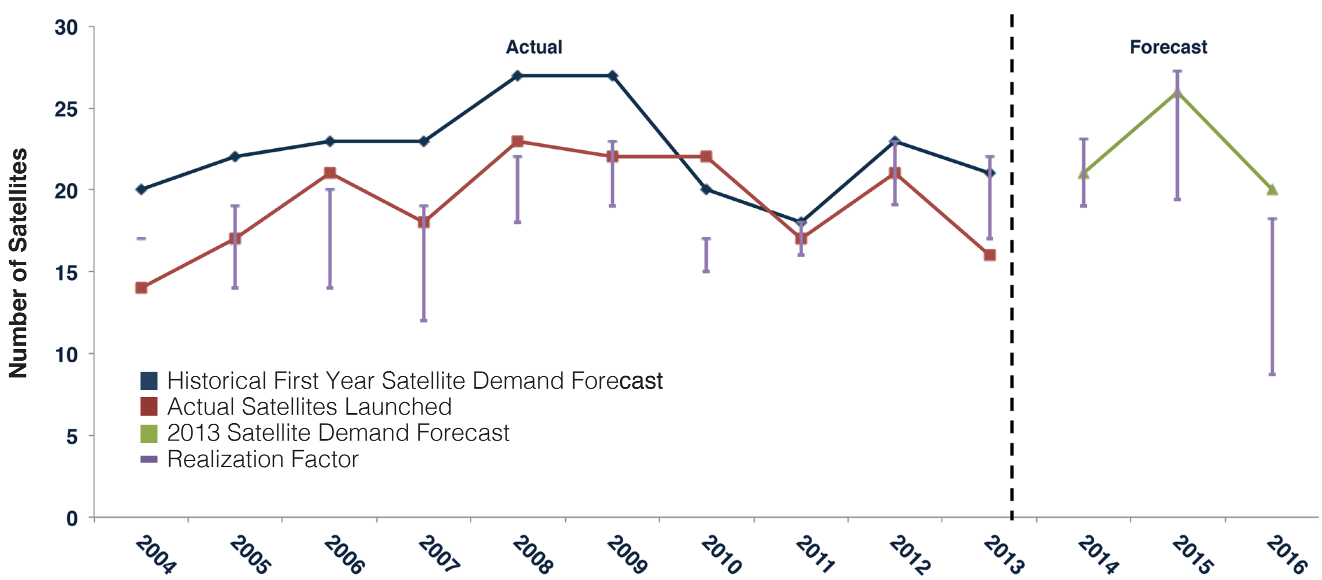
Over the history of this Report, the forecast demand for satellites and launches has almost always exceeded the number of satellites and launches actually accomplished in each of the first three years of a forecast period. To better estimate the number of near-term satellites that will be launched, the near-term demand is adjusted by a "realization factor." This factor is derived by comparing forecast satellite launches with actual satellites launched in the five years prior to the current Report.

The range of satellite launches expected to be realized is calculated by multiplying the near-term forecast by the highest and lowest variations of forecast versus actual over the preceding five years. Since 1993, the actual number of satellites launched in the first year of the forecast was 58 percent to 110 percent of the forecast number, with an average of 80 percent. For the past five years, the range was 80 percent to 110 percent, with an average of 91 percent. Based on this methodology, while 20 satellites are forecast for launch in 2014, the expected realization for 2014 is 16 to 22 satellites.

The consistent overestimation illustrates the "bow-wave" effect of the forecast: survey respondents list satellites that were planned to be launched the previous year but slipped into the subsequent year, without compensating for the subsequent year's satellite launches concurrently slipping forward.

The calculation becomes less precise for the second out-year. The forecast has almost always overestimated the actual launches two years hence. Since 1993, the actual realization for the second out-year ranged from 48 percent to 105 percent, with an average of 77 percent. For the past five years, the range was 68 percent to 105 percent, with an average of 82 percent. Using the same methodology, while 27 satellites are forecast to be launched in 2015, the expected realization for 2015 is 18 to 28 satellites.

Figure 10. Realization Factor



Since the launch realization factor was added to the Report in 2002, the actual number of satellites launched has usually fallen within the launch realization range, demonstrating the robustness of the realization factor methodology.

As shown in Figure 10, the 2013 report forecast 20 satellites for launch in 2013, with a realization range of 14 to 22 satellites. 16 satellites were actually launched in 2013.

FACTORS THAT MAY AFFECT FUTURE DEMAND

Many market, regulatory, and financial factors affect current and future demand for commercial GSO satellite launches, such as:

Demand for Satellite Services

Demand for satellite services continues to be strong in certain regions, led by substantial growth in Asia and solid growth in the Middle East, Central Asia, and South America, despite uncertain economic environments in the United States and Europe. This growth can be attributed to:

- increased globalization and interconnectivity of modern enterprise communications, especially the expansion into emerging markets that lack a fiber-based infrastructure;
- improved economic standards creating an expanded middle class with available discretionary incomes;
- adoption of common practices and standards;
- increased deregulation of the telecommunications sector and the use of new frequencies;
- development of cost-effective personal mobile voice, data, and broadband devices;
- consumer demand for data-rich content, such as UltraHD and 3D TV, that will require more bandwidth;
- demand for aeronautical broadband (e.g., WiFi on commercial aircraft)
- increased travel and cultural integration;
- adoption of commercial solutions by governments to supplement defense and military capabilities;
- revolution in software applications, creating new information portals for consumer.

Globalization

Growth in telecommunications and broadcasting markets is being driven by an increasing number of multi-national companies with office hubs and distribution networks spread across the world. This enables companies to operate globally while being perceived as an integral part of the local economy. Companies recruit and train personnel to use modern communications tools such as social media, internet marketing, and wireless devices, overcoming the limits of national borders and cultural boundaries.

Content is more accessible and less expensive, enabling consumers and enterprises to fully integrate, share similar experiences, and improve productivity and responsiveness to customer needs and orders on a global basis. The rapid growth of affordable information delivery to end-consumers, through satellite dishes, cable head-ends, fiber-to-the-curb, and wireless broadband, enabled a significant expansion of content choices while permitting two-way interactivity on an unprecedented scale. This drives significant demand for more bandwidth availability, increasing the need for satellite-based and ground-based delivery systems.

Mobility

The global demand from enterprises and consumers for mobile communications has expande over the past decade. The development of low-cost mobile equipment unleashed significant growth best met by the ubiquity only satellite delivery can provide. From global communications to direct-to-consumer services such as mobile television, Internet and broadband services, and satellite radio, and enterprise capabilities such as mobile broadcasting, satellite news gathering, and transportation fleet management, the demand for mobile connectivity appears insatiable. Transportation systems are rapidly incorporating mobile communications technologies, such as airline operators JetBlue and United Airlines with DirecTV service for their passengers, rental car fleets featuring Sirius Satellite Radio, and emergency services such as OnStar expanding beyond General Motors vehicles. Mobile connectivity will be a major driver for market growth in the next decade, particularly in Asia, where countries such as South Korea, Japan, Taiwan, and Singapore typically adopt new technologies early.

Market Segments

Fixed Satellite Services (FSS)

The FSS market continues to perform well. Major global operators such as Intelsat, SES, and Eutelsat and regional operators such as Telesat, AsiaSat, and SkyPerfect report high transponder utilization rates and stable transponder lease pricing. The market is driven by demand for larger replacement spacecraft, with additional expansion in new orbital slots for new satellites. Asia continues to lead growth due to increasing demand for enterprise VSAT services, expansion of high definition television services (HDTV), and Internet connectivity. Demand in Western Europe remains solid, but growth is focused in Central and Eastern Europe and Russia. The Middle East and Africa are experiencing moderate growth in transponder demand, due to deregulation, increased competition, and the availability of more local content from broadcasters. Due to the prolonged impact of the economic recession, the North American market has experienced some transponder pricing weakness, but this has not substantially affected operator financial performance. South America continues to rise with the emergence of a larger consumer class, improved regulatory climate, and several nations seeking ITAR-free low-cost satellites to exercise their rights to ITU-assigned orbital slots and frequencies. Another positive sign is increased demand by governments for capacity to support civil applications and military communications. The U.S. Department of Defense has decreased its demand for commercially procured bandwidth with the drawdown of troops in Iraq and Afghanistan. However, satellite operators have been able to find other customers to make up for this drop. Intelsat, Eutelsat, Hispasat, and other operators expect to derive significant revenues from national governments for the provision of transponder capacity.

Direct Broadcasting Services (DBS)

The lethargic U.S. economy has pressured the DBS market, increasing consumer churn rates, competition from low-cost fiber-to-the-curb in urban areas, and cost pressures from cable operators trying to protect market share. Satellites have even reached saturation in selected metropolitan areas. This accounts for EchoStar's motivation to expand its consumer and enterprise presence by providing broadband and mobile services with the acquisition of Hughes Communications and its Jupiter 1 (now EchoStar 17) satellite. Both EchoStar and DirecTV have strong capital investment programs and expect to launch several satellites each in the next few years to replace and add to current capacity. Telesat will also meet increasing demand with the launch of new satellites, in regions where the cost of laying fiber or cable is prohibitive. Demand for direct-to-home services in Europe is increasing, but many consumers receive HDTV via cable head-end distribution channels from FSS operators such as SES, Eutelsat, and Telenor. As with FSS, growth will be driven by demand for HDTV in Asia from operators such as Japan's SkyPerfect, South Korea's KT, and Singapore's SingTel/Optus.

Broadband Services

The broadband market continues to spread globally, as enterprise and consumer needs for mobile connectivity drive investments in high-capacity systems such as Hughes Communications (now EchoStar), INMARSAT, ViaSat, and newcomers such as Avanti in the UK and NewSat and NBN in Australia. INMARSAT is deploying its Global Express system to provide broadband connectivity in land mobile, aeronautical, and maritime market segments. The U.S.'s LightSquared 4G wireless hybrid terrestrial/satellite system encountered a major hurdle with the FCC, which stated the system's transmissions cause interference with signals from the GPS constellation. As with the FSS and DBS markets, demand from Asia, led by South Korea, Japan, China, Taiwan, and Singapore, will drive the market for broadband satellite services. Government-funded initiatives and mandates to provide broadband services and Internet connectivity will help drive the market, particularly where those demands cannot be met by laying fiber, such as in remote and rural locations.

Mobile Satellite Systems (MSS)

The MSS market remains in flux. MSS requires significant investment to expand the ground network, including the ancillary terrestrial network in urban areas, to attract enterprise and consumer users. Both LightSquared and TerreStar entered bankruptcy in an attempt to rearrange financing and acquire new investors, but for now, their SkyTerra 2 and TerreStar 2 satellites, respectively, remain unlaunched. EchoStar's Dish Network recently acquired all the assets of TerreStar, and plans to rejuvenate that system.

INMARSAT continues to perform strongly with steady demand in its vertical enterprise markets as it deploys its advanced INMARSAT 5 satellites. Mexico's Mexsat constellation will provide mobile services for civil administration and emergency communications. In the Middle East, Thuraya remains successful and is considering system expansion to meet demand. Europe and Japan have been contemplating dedicated MSS services to build on capabilities currently provided through FSS systems, but coordination across European nations remains an issue.

Digital Audio Radio Service (DARS)

DARS remains an exclusively North American product since the merger of XM Satellite Radio and Sirius Satellite Radio. DARS revenue grew six percent this year, satellite radio growth tracks with car sales. In 2013, car sales in the United States were up 11 percent. This service has yet to attract global attention, although South Korea and Japan cooperated on the MBSAT system. DARS will likely expand to Asia first, followed by Western Europe.

In summary, enterprise and consumer demand for connectivity via satellite is expected to increase over the next decade. The outlook for satellite services from GSO remains strong, driven by replacement and modest expansion in FSS and DBS systems and by new broadband systems. Economic recovery in North America, Europe, and Asia will enable a return to growth, with robust pent-up demand from enterprise, consumer, and government markets from existing and emerging satellite operators.

Satellite Technologies

All-Electric Satellites

Advances in satellite propulsion technology are gaining traction in the market. Hybrid systems utilizing electric propulsion for north-south stationkeeping reduce fuel loads, resulting in lower separated mass than satellites with traditional all-chemical systems. These solutions have been in the market for almost two decades but are finding increased commercial appeal as payloads become larger and more complex. Hybrid systems capable of electric orbit raising offer even greater separated mass saving by augmenting a portion of the traditional chemical orbit raising with higher efficiency electric propulsion.

The all electric satellite technology, offered from major manufacturers like Boeing and SSL, is compelling for an operator looking to lower their capital expenditures (CAPEX) needed to build and launch a GEO commercial satellite. Because all electric satellites have significantly lower mass than traditional bi-propellant systems, two of these satellites can be launched on the same launch vehicle in a stacked configuration. Dual launches offer a potential savings of 20-50% from the launch costs alone and can help operators close business cases that did not seem feasible before.

A drawback to all electric satellites is orbit raising schedules of six months longer than conventional all-chemical satellites, but their lighter mass allows all-electric satellites to carry larger payloads on a smaller platform. Operators will need to evaluate the financial and schedule impacts between all-electric and traditional satellite offerings.

The impact from all-electric offerings for the launch market is still unclear. All-electric satellites are often designed for a stacked dual-launch configuration, which, in theory, would halve the number of launches for these satellites. However, some of the all-electric awards could be for new business opportunities that moved forward with help from the dual launch savings. As more all-electric satellites are ordered, this will provide clues on how operators plan to incorporate the satellites into their fleets.

Laser Communications

In the future, operators will have the capability to connect their GEO commercial satellites to terrestrial ground stations via laser links. As shown in tests by NASA and other space agencies, laser communications offers orders of magnitude higher data rates than traditional radio frequency communication and may prove useful for deep space exploration. Implementing a laser communication system will also save mass and reduce power on the satellite. For higher bandwidth applications like High Throughput Satellites (HTS), laser communications will help provide higher throughput, especially where spectrum is limited. However, because laser links can be attenuated by cloud cover, several ground terminals in diverse regions would be needed to guarantee the quality of service to the end-user.

The impact of laser communications on the launch vehicle market is probably minimal. Laser communications is not applicable to all satellite missions, and thus will be limited to applications involving large data transfers. Lasers will be enhancements to the existing payloads or add-ons to provide links for certain functions, rather than creating an entirely new market for laser communication satellites.

Spectrum Limitations and Orbital Slot Limitations

The lack of available spectrum at the commonly-used C- and Ku-band frequencies and orbital slots makes it challenging for new satellite operators to enter the market and for existing operators to expand their business unless they consider acquiring a competitor or developing alternative spectrum (such as Ka-band). This was demonstrated by Eutelsat's recent acquisition of Satmex, that allowed the company to control new orbital slots with access to fast-growing Latin American markets. In other instances, operators have co-operated on developing or preserving an orbital slot. In 2014, AsiaSat will place a satellite in Thaicom's 120°E longitude orbital position. In return, Thaicom will have access to the C-band transponders on the satellite. This agreement allowed Thaicom to preserve its orbital slot and provided expansion opportunities for AsiaSat.

Additional spectrum is available in the FSS (Fixed Satellite Services) Planned Bands, which were established by the ITU to create equitable access to spectrum and orbital slots especially for smaller, relatively-undeveloped countries. The Broadcasting Satellite Service (BSS) Planned Bands are widely used for one-way, direct-to-home television services (DirecTV and Dish in the US, and SES and Eutelsat in Europe), but the FSS Planned Bands have hardly been exploited. Through the exercise of the ITU Plan in the ITU Radio Regulations (Appendix 30B), these smaller countries can gain access to C- and Ku-band frequencies that are distinctly different from the commonly used ("unplanned") C- and Ku-band frequency sets.

With the launch of the Vinasat 1 and 2 satellites, Vietnam has become one of the early adopters of Planned C- and Ku-band. The Vinasat 1 and 2 spacecraft are located at 132° east longitude, which enables Vietnam’s access to satellite communications without causing or receiving harmful interference from neighboring satellites.

Leveraging existing orbital locations and using Planned Bands can play an important role in the expansion of satellite communications. An orbital slot that is fully utilized for conventional unplanned C- and Ku-bands in the Northern Hemisphere can also be developed for the same unplanned bands in the Southern Hemisphere. In addition, the same slot can be developed for the Planned C- and Ku-bands. These strategies may provide a modest, medium-term stimulus in the launch market as new satellites are built for these areas. However, as spectrum and slots get increasingly congested, launcher demand is likely to shift to replacement satellites.

New Applications

4K and 8K UltraHD

The 4K version of UltraHD (UHD) TV provides four times the resolution of Full HD 1080p TV channels, and, as a result, transmission of 4K UHD will require a substantial increase in bandwidth (in comparison to HD TV), with some experts reporting that 50% more bandwidth will be required for UHD. Video compression techniques being developed as part of the latest video encoding and transmission standard (High Efficiency Video Coding or HEVC) are playing a key role in setting the bandwidth and data rates that will be required for reasonably reliable transmission of UHD. The 8K version of UltraHD TV provides 16 times the resolution of Full HD 1080p TV channels. While many are working on 4K programming and hardware, NHK of Japan is skipping 4K altogether and working on 8K technologies, with the goal of broadcasting the 2020 Tokyo Olympic Games in 8K.

The rollout of 4K video could cause an increase in the number of transponders that are required to deliver DTH video and broadcast and cable channel distribution. It is not yet clear if the DTH operators are actively planning to support 4K video. If cable operators decide to support 4K video, the broadcast and cable networks are likely to require additional C-band capacity, along with the use of HEVC and higher-order modulation schemes. How this will drive overall demand for satellites is uncertain. It remains to be seen if compression and modulation can keep pace with the 8K video rollout in the long term.

In-Flight Connectivity

There are many players in the in-flight WiFi market space. Whereas Panasonic, OnAir, Row 44, and others use satellites links, GOGO mainly uses an air-to-ground (ATG) network to connect its planes. Though the number of connected aircraft has increased, the take rates for in-flight connectivity are currently below expectations. This is forecasted to change as more passengers have smartphones or tablets and as rules are relaxed for the use of personal electronic devices during all phases of flight.

As the demand for in-flight connectivity increases, the service providers will have to choose between an ATG, satellite or hybrid ATG/satellite network. For satellites, they also must choose between L-band, Ku-band and Ka-band systems. INMARSAT's Global Express satellites, along with Viasat 2, may provide some of this required additional capacity. However, as the market increases, there will be more satellite orders to meet bandwidth demands for in-flight connectivity.

High-Throughput Satellites (HTS)

High-throughput satellites employ frequency re-use and spot beams to increase the satellite bandwidth over traditional, bent-pipe payloads. In recent years, the HTS market was driven by Ka-band, broadband applications to the consumer market, led by satellite orders from Hughes Network Systems and Viasat. Intelsat is replacing some of its FSS satellites with its high-throughput Epic satellites starting in 2015. Intelsat's goal is to reduce the price per megabit charged to the customer, while at the same time, increasing the revenue generating capacity of the Epic satellites over conventional ones at some of its prime orbital locations.

HTS systems are very compelling for providing additional bandwidth to customers at a lower price point than traditional offerings. As demand for data increases, such as for in-flight connectivity or cellular backhaul, HTS orders are likely to grow. These dedicated HTS systems would be similar to the Jupiter-2 and Viasat-2 satellites. For operators like Intelsat, a HTS system could reduce their fleet count by providing double or triple the capacity on-orbit over traditional FSS satellites. Other operators could add a high-throughput payload on a replacement satellite. Though orders for high-throughput payloads and satellites will increase, the net effect of this surge on the launch vehicle market is unclear.

On-Orbit Servicing

There have been several commercial forays into the satellite servicing market in recent years. In March 2014, ViviSat announced the booking of three missions to use its Mission Extension Vehicles (MEV), a platform that will connect to a GEO commercial satellite and take over attitude and control functions while the host satellite continues to operate its functional payload. ViviSat hopes to start the construction of these specialized vehicles by the end of 2014 pending completion of financing. In 2011, Canada's MacDonald Dettwiler and Associates (MDA) Corporation also announced plans for an in-orbit servicing vehicle with hopes of demonstrating the capabilities on Intelsat satellites. However, MDA changed its plans in 2012 in order to support government-sponsored satellite servicing initiatives.

Government agencies have also been active in this area. NASA launched its Robotic Refueling Mission in 2011, with the first phase demonstration successfully completed in 2013. Phase 2 demonstrations are expected to be carried out in 2014, and build upon the previous tests of robotic arms, tools and sensors. In 2012, the DLR Space Administration (Germany) announced plans to demonstrate in-orbit servicing and related technologies with the construction of a client and servicer vehicle as part of its DEOS project, to be launched in 2018.

The U.S. Defense Advanced Research Projects Agency (DARPA) Phoenix project is also focused on satellite servicing and new ways to access space. Phoenix's goal is to develop and demonstrate technologies that make it possible to inspect and robotically service co-operative space systems in GEO, and to validate new satellite assembly architectures. Phoenix has achieved promising Phase 1 results, and in 2013 it awarded prime contracts to eight companies for its Phase 2 efforts.

If successful, the start of on-orbit servicing and life extension missions may push out replacement orders for some GEO commercial satellites. Eventually, however, many of these satellites will still need to be replaced, and thus the overall launch vehicle demand may not change.

Competition from LEO Systems

The GSO market is seeing competition emerging from constellation systems deployed in LEO, particularly in the market for enterprise and consumer broadband services. Major GEO broadband service providers include:

- Intelsat with its open architecture Epic series of high throughput satellites for C-, Ku-, and Ka-band overlay for fixed and wireless broadband, media customized solutions, mobility sectors, and government applications on thick and thin route traffic;
- INMARSAT’s Global Xpress Ka-band system as the first worldwide mobile satellite system providing broadband services to the maritime and aeronautical sectors;
- ViaSat with its series of high throughput satellites based on a new satellite architecture and innovative ground system that maximizes total bandwidth throughput to transform satellite broadband economics and the quality of the user experience for coverage of rural and remote areas in North America; and
- Echostar with its Jupiter platforms also providing broadband services coverage to North America.

Arabsat, Eutelsat, Avanti, Hispasat, SES, NBN, and Telesat also have or plan to have broadband Ka-band packages on FSS satellites or dedicated Ka-band spacecraft offering broadband services within their operating regions.

These GSO operators are being challenged by MEO operator O3b, which touts its next-generation global network as combining the reach of satellite with the speed of fiber, providing enterprise mobile backhaul, consumer and government customers with affordable, low-latency, high-bandwidth connectivity. O3b believes its competitive advantage lies in the low latency experienced with its MEO satellite system compared to that from GEO, which can be up to 4 times greater to improve the quality of the end user’s experience. O3b notes that certain classes of services are more susceptible to the effects of network latency, including real time video and voice and voice messaging, and real time data uplink and downlink and transactional data. O3b notes that latency has a major impact on web commerce, with significant loss of e-commerce sales lost due to poor website performance when the purchaser experiences signal disruptions and loss of interactive connectivity.

End users perceive latency increases of a few hundred milliseconds in a negative way which can translate into loss of business for providers and advertisers. O3b also notes that major providers of web video streaming now using TCP transport, so the latency impact on the degraded user experience will be the same for Internet video streaming as it is for data file transfer. O3b believes the quality of the user experience from its MEO system will enable measurably improved voice quality, dramatically improving the response of interactive applications enabling such as interactive gaming, and reducing file download times by 60 percent.

O3b is beginning service with eight satellites from MEO but intends to ultimately operate 20 satellites to backhaul broadband traffic to connect underserved and poorly served populations between 45 degrees north and 45 degrees south latitude. Competition will therefore be quite strong for consumers and government broadband users for applications such as web browsing, file sharing, VOIP, video on demand, video conferencing, internet television, and real time internet gaming and other services. Global capacity requirements are expected to reach 480 Gbps by 2021 with over 10 million consumer broadband via satellite subscribers. The race is on between GEO and LEO providers for end-users and revenues.

Hosted Payloads

Hosted payloads are payloads that are typically too small to justify a dedicated mission due to payload size, budget, or potential revenues. Hosted payloads are often paired with a commercial satellite mission, where the satellite operator accommodates the payload to offset its costs or to add to a revenue stream to close a business case. The current U.S. National Space Policy directs the use of hosted payload solutions to maximize reliability, affordability, and responsiveness.

There are a variety of potential hosted payload types, including experimental payloads, technology demonstrations, scientific missions, remote sensing, weather and climate monitoring, GPS and WAAS (Wide-Area Augmentation System), and national security missions. Payload hosting benefits both parties. The total price of the satellite and launch service is shared, offsetting the primary payload's costs while providing affordable space access for the hosted payload. In addition, the hosted payload gains the efficiency of using a commercial launch system that provides access to more orbital locations. Furthermore, the schedule from the start of a program to launch is relatively short (two to three years) and fairly predictable compared to a shared launch with other government missions.

Commercial satellite operators regularly formulate their satellite procurement contracts to address their needs and take advantage of opportunities, like hosted payloads, to improve return on investment. There is a ready supply of commercial satellite launches willing and eager to accommodate hosted payloads, and the number of hosted payload launches and awards continues to increase.

Examples of hosted payloads include:

- In 2011, SES Government Solutions launched the Commercially Hosted Infrared Payload Flight Demonstration Program (CHIRP) on the SES-2 satellite (built by Orbital Sciences Corporation). This Third-Generation Infrared Surveillance (3GIRS) program will be used to validate missile-warning technologies.

- The Australian Defense Force (ADF) purchased a specialized UHF communications payload from Intelsat. This payload is hosted aboard the Intelsat 22 satellite (built by Boeing Space & Intelligence Systems) and was launched in March 2012.
- Avanti Communications is placing a Ka-band broadband payload, designated HYLAS 3, aboard a European Space Agency (ESA) European Data Relay System (EDRS) satellite due to be launched in late 2015.
- NASA contracted with SSL to host a Laser Communications Relay Demonstration terminal, to test laser optical communications between a geostationary-orbiting satellite and a NASA ground terminal, aboard a commercial satellite yet to be selected. Launch is planned for 2016.
- Inmarsat added hosted payloads to its three Boeing-built Inmarsat 5 Ka-band satellites.
- ESA, the European Commission, and Eurocontrol (the European analog to the FAA's air traffic control organization) contracted with SES to host two Satellite-Based Augmentation Systems (SBAS) for the European Geostationary Navigation Overlay Service (EGNOS). EGNOS will supplement GPS, GLONASS, and the Galileo satellite navigation systems by measuring the accuracy of satellite navigation signals. The first payload is hosted aboard SES 5 (built by SSL) and the second on Astra 5B (built by EADS Astrium).

There are limitations to widespread use of hosted payloads. The contractual relationships are complex, because there are typically three or more parties involved in the mission, rather than two (satellite manufacturer and operator). In some cases, a hosted payload is added after a contract is signed between the satellite manufacturer and operator. In such cases, the manufacturer and operator do not want to impact their program schedule and require firm deadlines for delivery of the hosted payload, as well as clearly defined interfaces at the start of satellite integration. If the hosted payload fails to arrive on time, the satellite operator or the hosted payload operator may be liable for any impacts to satellite cost and schedule. In such cases, the satellite manufacturer may seek "off-ramps" to offset the possibility of late delivery penalties if the hosted payload causes a delay in delivery of the satellite.

There is a broad and growing interest in developing, launching, and operating hosted payloads. Industry collaboration or other co-operative leadership is necessary to bring together clients, financing sources, satellite operators, and launch vehicle providers to standardize the hosted payload process. When this is accomplished, hosted payloads will be a routine part of the commercial satellite business.

Seven satellite manufacturers and operators recently agreed to form an industry alliance to increase awareness of the benefits of hosted government payloads on commercial satellites. The Hosted Payload Alliance (HPA) will serve as a bridge between government and industry to foster open communication between potential users and providers of hosted payload capabilities. HPA Steering Committee members include Boeing, Intelsat, Iridium, Lockheed Martin, Orbital, SES, and SSL.

Launch Service Providers

Competition has increased in the GEO communications satellite launch services market with new entrants debuting capabilities, existing providers investing to improve their product and service offerings, and others waiting in the wings to enter the marketplace. Communications satellite launch service awards will be based more than before on overall best value as perceived by satellite operators, with key factors being proven reliability, schedule assurance, manifest availability, available scheduling, and a compelling value proposition.

In the past twelve months, SpaceX has launched several satellites into GTO for commercial satellite operators. Falcon 9 can deliver ~4,850 kg into GTO from CCAFS. The company is developing the Falcon Heavy launch vehicle which will be capable of lofting ~21,200 kg into GTO from CCAFS when operational in 2015 to address the intermediate and heavy mass segments of the commercial satellite market.

Arianespace is seeking to improve its competitiveness in the commercial GTO marketplace with investments in Ariane 5ME (Mid-life Extension) program, which will increase capacity from ~9,400 kg today to ~11,300 kg by 2018. This will enable Ariane 5 to carry two large satellites simultaneously as opposed to pairing one small/medium and one large satellite today. Additionally, ESA is funding development of Ariane 6 to be operational in 2021 to provide single satellite launch capability across the payload mass spectrum to be more price-competitive. Although capable of placing a medium mass payload into GTO from Kourou, the Soyuz vehicle appears to be dedicated to flying missions to LEO for now.

International Launch Services (ILS) continues to upgrade its Proton M/Breeze M vehicle to eventually be capable of lofting >6,900 kg into GTO from Baikonur. Introduction of a 5 meter payload fairing in 2016 will allow deployments of satellites with mass up to 5,850 kg. ILS has demonstrated dual payload capability several times. The company has recently instituted a series of quality management reforms, streamlined production at its Khrunichev facilities, and reduced payload processing times at Baikonur. The company hopes to increase its launch rate to 12-14 per year from its current rate of 6-8 per year. Proton M is to be phased out by 2020 as is Baikonur launch complex and replaced by the modular and less-costly Angara family of boosters launched from Russia's Far East. The Russian government recently announced a ~$50 billion investment in the space sector through 2020 to regain world class capabilities, including in affordable launch vehicles.

Sea Launch recently completed a return-to-flight mission following a failure in 2013. Sea Launch's parent organization, RSC Energia, has pledged its support for Sea Launch and, in cooperation with the Russian Space Agency, is in the process of creating a strategy that will expand the addressable market for the Zenit-3SLby increasing the Zenit-3SL's lift capacity to 6,700 kg and introducing fairing modifications. The Land Launch Zenit-3SLB/F remains in the market for lofting small/medium satellites to GTO from Baikonur.

Japan recently contracted with Canada's Telesat for a commercial launch of a GEO communications satellite, Telstar 12V, and India is considering launching commercial satellites to GTO. In September 2012, Mitsubishi Heavy Industries, Ltd (MHI) took responsibility for H-IIA’s launch service operations. The H-IIA vehicle can loft up to 5800 kg to GTO. India’s Space Research Organization (ISRO) plans to debut its new GSLV Mark III vehicle which is capable of lofting ~4,000 kg to GTO.

China remains very active in launching domestic and foreign satellites, with unaddressable launches for operators in countries such as Sri Lanka, Pakistan, and Laos. One satellite manufacturer in Europe has developed “ITAR-free” satellites to appeal to satellite operators to take advantage of the lower cost of Chinese launchers.

Lockheed Martin has begun to pursue reentry into the commercial GTO market using the Atlas V launch vehicle from its 50 percent-owned subsidiary, United Launch Alliance. Lockheed Martin hopes to leverage the large U.S. government backlog of ULA to offer the Atlas V at a competitive price, while touting the vehicle’s reliability.

Others, including South Korea with its KSLV launch vehicle and Brazil and Ukraine with their Tsyklon-4 launch vehicle, have considered eventually entering the commercial GSO market.

Multilaunch Services Agreements

Larger commercial GSO satellite operators have used multi-launch agreements to secure favorable price discounts and launch slots. Some reservations may be options in that either no down payment is paid, or are placeholders without specifically-named satellites. Multi-launch services agreements will not have an impact on driving demand for launch services but will simply change the mix of launch services providers.

Cooperation and Partnerships

Satellite operators continue to pursue satellite and orbital slot sharing strategies to realize their business objectives. Partnerships provide access to orbital slots otherwise unavailable to some operators as well as local market access and relationships. Partnerships can also allow operators to share satellite infrastructure costs and close business plans that they might not be able to independently. There have been numerous examples of satellite/orbital slot partnerships, including Measat/Azercosmos, Measat/Newsat, Asiasat/Thaicom, Eutelsat/Nilesat, SES/Gazprom, and Intelsat/JSAT.

Several European and Russian satellite manufacturers recently announced the formation of joint-ventures to target the Russian and international satellite markets. Thales and ISS-Reshetnev formed a new company, Universum Space Technologies, to manufacture hardware in Russia that could match the exacting standards set by U.S. and European companies. The other joint venture, Energia Satellite Technologies, is a partnership between RSC Energia and Astrium. Energia SAT will focus on satellite services and the exchange of technologies and know-how in the manufacturing, assembly and test of equipment and satellite systems. The new companies will target several Russian government telecommunications programs in the near term, while raising their own technical and quality standards to compete in the future against U.S. and European builders.

Geopolitical Influences on Launch Vehicle Demand

Geopolitical factors may influence the U.S. licensed launch demand during the forecast period. At the time of this document, the Russo-Ukrainian conflict had escalated to the point whereby the United States and the European Union have imposed additional sanctions against Russia.

The impact to U.S. licensed launch demand of these sanctions may be a delay of satellite projects, or a realignment or change of commercial customers' launch providers.

Impact of International "Government to Government" Satellite Delivery in Orbit Sales

One of the factors influencing market demand for U.S. licensed launch activity is that of international governments brokering turnkey space solutions involving the purchase and financing of the manufacture, launch and insurance coverage of satellite programs.

Countries such as China, India and Russia have sold GEO communications and remote sensing satellites under "Delivery-In-Orbit" contracts with developing countries such as Angola, Belarus, Bolivia, Brazil, Egypt, Nigeria, Pakistan, Turkmenistan and Venezuela. These sales are often politically-driven, with satellites sometimes provided on a strategic, non-competitive basis in exchange for access, or for the direct barter of natural resources.

Characteristically targeted towards countries that do not have their own satellites in orbit, these procurements are approximately fifteen percent of global commercial GEO launches, thereby decreasing the overall addressable market of available launches for U.S. licensed launch vehicles.

This trend is expected to grow as the quality, reliability and heritage of these exporting countries' satellites and launch vehicles continue to develop and other commercial benefits such as technology transfer and engineer training programs continue to appeal to governments.

Regulatory Environment

A multi-year export control reform initiative to reform the nation's export control regime by the Departments of State, Commerce and Defense achieved an important milestone in April 2014 with publication in the Federal Register of the first in a series of final rules revising the U.S. Munitions List (USML) and the Commerce Control List (CCL).

In early 2013, the Department of Commerce's Bureau of Industry and Security (BIS) announced a proposed rule transferring certain commercial satellite, spacecraft and related items may now return to the Commerce Control List (CCL), rather than the Department of State's United States Munitions List (USML).

Currently, additional category revisions are working their way through the interagency review process, and Category XV (satellites) is likely next in the queue, with a final rule on reforms to controls and on satellite and space items may be issued in the summer of 2014.

While it is estimated that up to 90 percent of existing space items presently on the USML will be transferred to CCL, the inclusion of commercial hosted payloads under ITAR could go into effect for Department of Defense-funded secondary or hosted payloads. Additionally, certain additions to the CCL have been satellite components previously not covered.

Prior to this proposed ruling, several international spacecraft manufacturers had developed commercial satellite offerings that are not subject to U.S. export control regulations, without using ITAR-restricted components. The introduction of this and other "ITAR-free" satellites (Western-built satellites containing no ITAR-restricted components) has affected Western launch providers as well as U.S. satellite manufacturers.

Eight ITAR-free commercial GSO satellites were launched between 2005 and 2012, mostly on Long March launch vehicles. Table x lists the ITAR-free satellites that have been launched since 2005.

In perhaps what is the first sign of the impact of this proposed ruling, in June of 2013, Thales Alenia switched launch providers from Long March to Space Exploration's Falcon-9 for the launch of Turkmenistan's first telecommunications satellite after the likelihood of potentially being blocked by U.S. export rules from shipping the satellite to China for launch became more evident.

Table 9 lists the ITAR-free satellites that have been launched since 2005.

Table 9. ITAR-free Satellites

Satellite	Operator	Launch Vehicle	Launch Date	Satellite Model
Apstar 6	APT	Long March	4/12/2005	TAS Spacebus 4000
Chinasat 6B	China Satcom	Long March	7/5/2007	TAS Spacebus 4000
Chinasat 9	China Satcom	Long March	6/9/2008	TAS Spacebus 4000
Palapa D1	Indosat	Long March	8/31/2009	TAS Spacebus 4000
Express AM4	RSCC	Proton	8/17/2011	Astrium Eurostar 3000
Eutelsat W3C	Eutelsat	Long March	10/7/2011	TAS Spacebus 4000
Apstar 7	APT	Long March	3/31/2012	TAS Spacebus 4000
Chinasat 12	China Satcom	Long March	11/27/2012	TAS Spacebus 4000

The European Union pressed ahead with its "EU Space Code of Conduct" to encourage satellite operators, launch agencies, and other users of space to recognize and respond to the growing threat from space debris. While the GSO population has not yet suffered catastrophic losses due to debris, the issue is being studied closely. All users of space, including providers of insurance and financing, can be affected by the loss of a satellite in geosynchronous orbit. Because of the potential cascading effect of a single debris event across the geosynchronous orbit, launch activity may be affected as operators consider their response.

Financial Markets

Uncertainty still impacts global financial markets, creating mixed results for financing satellite programs. Stock markets have exhibited recent volatility with investors nervous about the slowing growth of the Chinese economy, the continuing gridlock in economic policy in the U.S., and the impacts to the U.S. economy of budget sequestration, and the overall lower growth rates in satellite company earnings and revenue streams. Traditional equity investors remain hesitant towards commercial space startups. Debt markets for satellite financing remain strong as traditional investors remain risk averse.

Even established companies with strong balance sheets are experiencing difficulty securing new debt and equity financing. The pricing of Intelsat's IPO was reduced by 22 percent, from $23 per share to $18 per share, with share volume offered reduced by 11 percent. Proceeds will be used to pay down sizeable debt which may have kept some prospective investors on the sidelines. However, general reaction by institutional investors in the run-up to the IPO was positive. This attitude was driven by the fact that the investor community has a good understanding of the company's business model and of the FSS business in general, as the company's bonds have long been traded on public market exchanges. Also aiding investors is good insight into the company's strong backlog for earnings growth now that it is entering a period of substantially lower capital investment in new satellites, where free cash flow can be directed to reduce outstanding debt. Increased exposure through public equity stock trading on global exchanges will help with investor awareness.

Export credit agency (ECA) financing continued to play a strong role in contributing to satellite business sector growth. The U.S.-based Ex-Im Bank has financed 60% of U.S. commercial satellite exports over the past two years and is expected to maintain that level. Ex-Im Bank is ramping up its support for U.S. industry to meet aggressive competition from its European counterpart, Coface, which provides significant funding and guarantees for European satellite industry export sales worldwide. The loss of financing support for Iridium's next generation satellite system secured by a $1.8 billion loan guarantee from Coface was a watershed moment for Ex-Im Bank, which saw jobs and economic growth migrate to vendors in France and Italy as opposed to Lockheed in the U.S. Ex-Im Bank raised its participation in the satellite financing sector from $50 million per year through 2009 to $1.4 billion in 2012. As an example of its renewed effort to support U.S. job creation, Ex-Im Bank provided a low-interest loan of $471 million to ABS to cover construction of its two Boeing all-electric satellites, a large spacecraft from SSL, and launches on SpaceX Falcon 9 vehicles. This action in turn permitted ABS to securing bank financing as lenders were more comfortable knowing there was backing by the U.S. export credit agency. Additionally, the cost-competitiveness of the all-electric platform made the project risk more palatable to lenders, turning it from a classic equity risk into an acceptable debt risk. Ex-Im Bank also recently provided an $87 million loan guarantee to Hispasat to purchase a satellite from Orbital Sciences Corp even as Coface supports the satellite's launch on the European Ariane launch vehicle. New ECAs are emerging in China and Russia, to win business for domestic contractors and to provide jobs and build technological capabilities.

Given the long lead-times associated with deploying GSO spacecraft, continued access to affordable capital will remain crucial for operators. Assuming a continued steady global economic recovery, certainty in the financial markets will provide confidence for investors to move forward in offering financing for satellite operators and services providers for business recapitalization and expansion.

Space Insurance

Space insurance is typically the third largest cost component of a commercial satellite system, after the cost of the satellite and launch services. The space insurance market is characterized by low frequency and high severity of losses, a small number of insured events, highly complex technical underwriting and claims handling, unique risks and exposures, manuscript policy wordings, and volatile underwriting results. As a result, the number of insurance companies willing to commit capital to space insurance has always been limited – there are currently about 40 companies worldwide providing such insurance. The business cycle of space insurance – and of insurance companies in general – is influenced by worldwide catastrophe losses and investment returns, among other factors. Due to good experience in space insurance over the past decade, as well as a recovery in financial markets, there is currently an abundance of available capacity for insuring satellite launches. This has pushed pricing to historically low levels, facilitating the placement of insurance for satellite programs. Nonetheless, adverse experience in space insurance in the past year has tempered the growth of capacity, and certain technologies have experienced increased pricing and constrained insurance. Although this can affect the scheduling of launches, there is generally sufficient time between insurance policy placement and launch to allow for such contingencies.

SUPPLEMENTARY QUESTIONNAIRE RESULTS

As part of the COMSTAC request for input from industry participants, a supplementary questionnaire was provided to satellite service providers. The questionnaire focuses on factors that may impact service providers' plans to purchase and launch satellites. A summary of the responses to this questionnaire is provided in Table 10. The last column is a comparison to the survey responses received for the 2013 Report.

This year, the following organizations responded with data used to develop the Report:

Satellite Operators:

- SES
- NewSat

Satellite Manufacturers:

- Boeing
- SSL
- Thales Alenia Space

Launch Service Providers:

- Arianespace
- Sea Launch
- United Space Alliance
- SpaceX

The basis of the questionnaire is the single question: “To what extent have your company’s plans to purchase or launch satellites been positively or negatively impacted by the following variables in the past year?”

The variables fall into three main categories: financial, technical, and regulatory. The 2014 survey does not reflect any major changes in respondents’ perception of the industry. In the financial category, there was a slight increase in the percentage of respondents who felt global economic conditions were having a negative impact on their business plans but operators were more optimistic regarding the impact of industry consolidation and the ability to compete with terrestrial services. Technical concerns showed improvement in some areas including the availability of launch vehicles that meet requirements and the reliability of satellite systems and launch vehicles.

Slight increases are reported in terms of the impact of competition with terrestrial services, regional or global economic conditions, and the consolidation of satellite service providers. Demand for satellite services is less of an issue than in 2013, though at 71 percent this remains a concern when it comes to planning and launching satellites. Introduction of new or upgraded launch vehicles also represents a continuing issue. Reflecting continuing global economic woes, the responses to financial concerns remained somewhat negative, though less of a concern than in 2013.

Operators continue to be satisfied with the variety of satellite systems available to them. However, there are concerns that the introduction of new satellite technologies is having a negative impact on plans. Operators also had mixed opinions about launch vehicles, with the introduction of new and upgraded vehicles having some negative impact. In addition, the availability of launch vehicle continues to be an issue. The dissatisfaction with launch vehicle reliability has increased dramatically since the 2011 survey when none of the operators expressed any concerns about launch vehicle reliability, but 2014 inputs do indicate that impressions are improving. This can likely be attributed to the recent string of Proton failures and the 2012 Sea Launch failure. All of the respondents responded either neutrally or favorably to the introduction of new/upgraded launch vehicles.

This page intentionally left blank.

Table 10. Survey Questionnaire Summary

Question: "To what extent have your company's plans to purchase or launch satellites been positively or negatively impacted by the following variables in the past year?"	Significant Negative Impact	Some Negative Impact	No Effect	Some Positive Impact	Significant Positive Impact	2014 vs. 2013
Ability to compete with terrestrial services	0%	14%	57%	29%	0%	**Increase**
Availability of affordable insurance	0%	33%	17%	50%	0%	**Decrease**
Availability of financing	0%	29%	71%	0%	0%	**Decrease**
Demand for satellite services	0%	71%	14%	14%	22%	**Decrease**
Regional or global economic conditions	0%	43%	14%	43%	0%	**Increase**
Consolidation of satellite service providers	0%	0%	57%	43%	0%	**Increase**
Availability of required operating licenses	29%	43%	29%	0%	0%	**Decrease**
Availability of export licenses	14%	43%	29%	14%	0%	**Decrease**
Availability of launch vehicles that meet your requirements	0%	43%	29%	29%	0%	**Decrease**
Availability of satellite systems that meet your requirements	0%	0%	75%	25%	0%	**Decrease**
Reliability of launch systems	0%	43%	57%	0%	0%	**Decrease**
Reliability of satellite systems	0%	43%	29%	29%	0%	**Decrease**
Introduction of new satellite technologies	29%	29%	29%	0%	14%	**Decrease**
Introduction of new or upgraded launch vehicles	29%	57%	0%	0%	14%	**Decrease**

2014 COMMERCIAL SPACE TRANSPORTATION FORECAST FOR NON-GEOSYNCHRONOUS ORBITS

INTRODUCTION

The 2014 Commercial Space Transportation Forecast for Non-Geosynchronous Orbits (NGSO) is developed by the Federal Aviation Administration’s Office of Commercial Space Transportation (FAA AST). This report projects commercial launch demand for all space systems deployed to NGSO, including low Earth orbit (LEO), medium Earth orbit (MEO), elliptical orbits (ELI), and external trajectories (EXT) to the Moon or other solar system destinations. First compiled in 1994, the forecast assesses payloads most likely to seek commercial launch services during the next 10 years. Commercial launches, as defined for this report, include those whose services are sought on the international market. It also includes U.S. domestic commercial launch services licensed by the FAA, such as commercial launches to the International Space Station (ISS).

The 2014 report helps U.S. industry, as well as the U.S. Government, understand the scope and trends of global commercial spaceflight demand. It also assists FAA AST in licensing and planning.

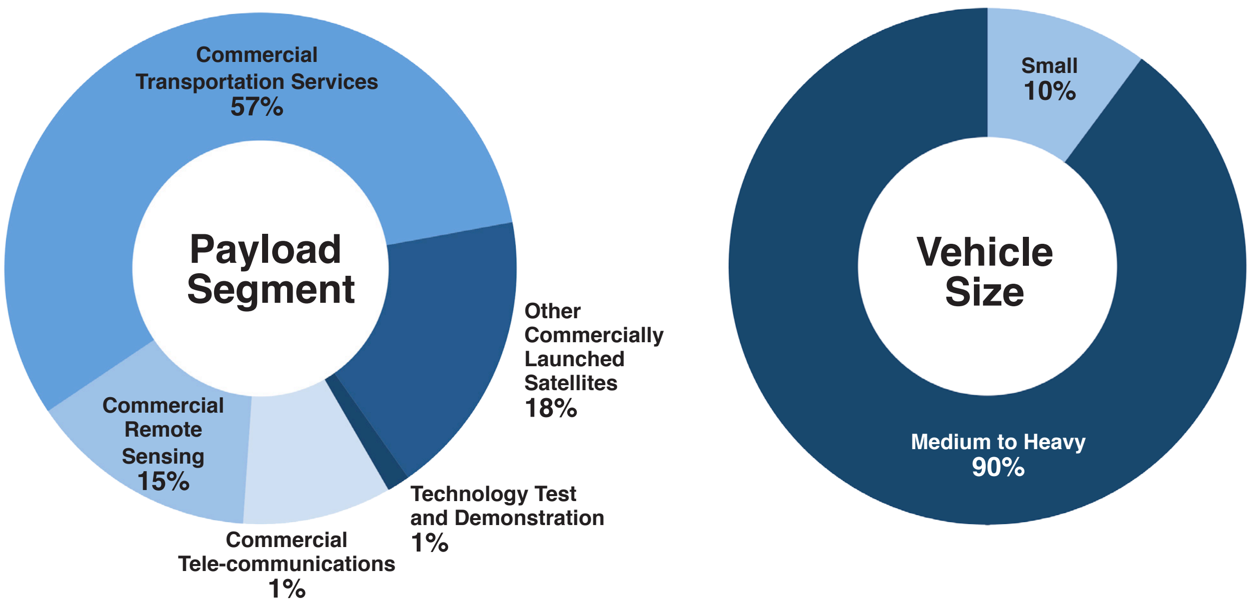
SUMMARY

The report projects an average demand of 13.8 launches per year worldwide during the period 2014 through 2023. The launch demand peaks in 2016, with 20 launches, due to the continued deployment of Iridium constellation, Skybox Imaging planning for 3 flights on Vigin Galactic’s LauncherOne; 9 commercial crew and cargo launches to the ISS; and 4 launches for other payloads launched commercially. For the telecommunications sector, a drop in launch demand is expected in 2018, when telecommunication constellations, including Iridium, finish deployment. From 2014 to 2017 the report forecasts a number of small commercial satellites to be launched as Iridium, O3b, Planet Labs, Skybox all deploy their constellations. The number of small multimanifested satellites drops off towards the end of the forecast, but the number of launches remain relatively steady as NASA begins its commercial crew program.

The average of 13.8 launches a year is an increase of little less than a launch a year compared to last year’s forecast. This increase in forecasted launches is driven primarily by the inclusion of Skybox’s plans and additional test flights for NASA’s commercial crew program. The number of NGSO commercial launches is relatively small compared to the total number of NGSO launches per year. For the last 10 years, there has been an average of 46 NGSO launchers per year. Only 13 percent of these launches (approximately 6 launches per year) were commercial. The forecast predicts the annual commercial NGSO launch numbers will more than double the historical annual averages.

Launch demand is divided into 2 vehicle size classes, with an average of 12.4 medium-to-heavy vehicle launches per year and 1.4 small vehicle launches per year for 2014 to 2023. The launches in the next 10 years are predominantly commercial launches to the ISS which require medium-to-heavy vehicles. Ninety percent of all commercial NGSO launches during the forecast period will launch on medium-to-heavy vehicles. Compared to last year's report, the number of small launches has increased, and the number of medium-to-heavy launches has remained constant. The increase in small launches is due to the inclusion of Skybox Imaging's plans to use Minotaur C and LauncherOne to deploy its constellation. A number of new small launchers are being planned, and a number of intermediate launch vehicles have been introduced or will be introduced in the next few years. Historically, the relatively higher price of small vehicle launches, availability of multiple-manifest launch services and commercial payload brokerage and integration services for secondary payloads, as well as other factors discussed in the Satellite and Launch Forecast Trends section have resulted in the use of fewer small vehicle launches. If these dynamics change, there could be a bifurcation in launch demand between the demand for heavy vehicles for commercial crew and cargo and large satellites and a demand for smaller vehicles for the smaller (>100kg) remote sensing and telecommunication satellites. Figure 11 depicts the launch distribution by payload segment type and vehicle size.

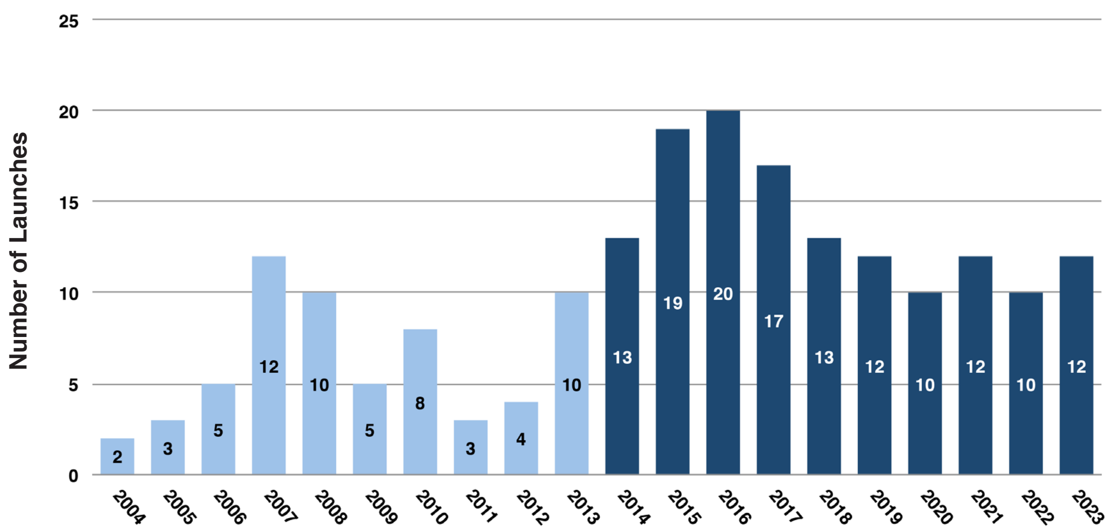
Figure 11. Distribution of Forecasted Launches by Payload Segment and Vehicle Size



Fifty-eight percent of the NGSO launches projected for the next 10 years are for commercial crew and cargo to the ISS. This marks a slight increase from a 57 percent share projected for this segment in the 2013 report, due to the inclusion of additional test flights for new spacecraft in NASA's commercial crew program. The commercial crew launches to the ISS are scheduled for spacecraft still in development, and all of these launches partly rely on government funding subject to annual appropriations; therefore, technical or financial issues could delay ISS crew launches further. After commercial crew and cargo flights to the ISS, Other Commercially Launched Satellites, which is predominantly government satellites launched commercially, is the second largest market, comprising 18 percent of the launch market. Commercial remote sensing market comprise 14 percent of the market with 20 predicted launches, 14 of the twenty launches are planned for small launch vehicles. Telecommunications satellites comprise 9 percent of the launch market, launching 27 percent of the forecasted payloads, all of them multi-manifested or launched as secondary payloads. Telecommunications market it is expected to significantly drop off in 2018 when the major NGSO telecommunications constellations, Iridium, Globalstar, ORBCOMM, and O3b, are deployed.

The annual launch rate during the next 10 years is considerably higher than in the previous decade (see Figure 12). Commercial space transportation; emerging commercial remote sensing; and telecommunications constellation replenishments drive this increase. Last year's report predicted 16 launches for 2013. Ten launches occurred, which was within our realization factor, but less than forecasted number. However, 10 commercial NGSO flights is almost double the 10-year historical average of 6 commercial NGSO flights annually.

Figure 12. Commercial NGSO Launch History and Projected Launch Plans



The near-term launch projection (2014-2017) is based on publicly announced launch demand. Table 1 identifies all NGSO satellites manifested for 2014 through 2017 that drive a launch. The report projects 13 NGSO launches for 2014 and 19 launches for 2015. However, applying a realization factor, the actual NGSO launches are more likely to be between six and eight in 2014 and 8 and 10 in 2015. This factor is based on the difference between projected launches and actual launches in the five years before the year of the report and is only applied to 2014 and 2015. The mid- and far-term launch projections (2018-2023) are based on publically available information from satellite service providers, correspondence with service providers, and estimates of when the existing satellites will reach end of life and require replacement.

METHODOLOGY

This report is based on FAA AST research and discussions with the U.S. commercial space industry, including satellite service providers, spacecraft manufacturers, launch service providers, system operators, government offices, and independent analysts. The report examines progress for publicly announced payloads (satellites, space vehicles, and other spacecraft) and considers the following factors:

- Financing;
- Regulatory developments;
- Spacecraft manufacturing and launch services contracts;
- Investor confidence;
- Competition from space and terrestrial sectors; and
- Overall economic conditions.

This report includes five payload segments, defined by the type of service the spacecraft offer:

- Commercial Telecommunications;
- Commercial Remote Sensing;
- Commercial Cargo and Crew Transportation Services, including cargo and human spaceflight;
- Other Commercially Launched Satellites; and
- Technology Test and Demonstration.

Future deployments of payloads that have not yet been announced are projected based on market trends, the status of payloads currently on orbit, and the economic conditions of potential payload developers and operators. Follow-on systems and replacement satellites for existing systems are evaluated on a case-by-case basis. In some cases, expected future activity is beyond the timeframe of the report or is not known with enough certainty to merit inclusion in the NGSO forecast model. For the Other Commercially Launched Satellites market, the forecast used near-term primary payloads generating individual commercial launches in the model and estimated future years based on historical and near-term activity. The projected launches for commercial cargo and crew transportation services were based on the National Aeronautics and Space Administration (NASA) 2015 ISS traffic model and manifested launches for cargo and human spaceflight.

Table 11. Near-Term NGSO Manifest of Identified Primary Payloads[2]

Service Type	2014	2015	2016	2017
Commercial Telecommunications Satellites	O3b (4) - Soyuz 2	Globalstar (6) - Soyuz 2	Iridium (10) - Falcon 9	Iridium (10) - Falcon 9
	O3b (4) - Soyuz 2	Iridium (2) - Dnepr	Iridium (10) - Falcon 9	Iridium (10) - Falcon 9
	ORBCOMM (8) - Falcon 9	Iridium (10) - Falcon 9	Iridium (10) - Falcon 9	Iridium (10) - Falcon 9
		ORBCOMM (8) - Falcon 9		
Commercial Remote Sensing Satellites	Worldview-3 - Atlas V 401	DMC3 (3) - PSLV	EROS C - Small TBD	TSX-NG - Medium TBD
		SkySat 4-9 - Minotaur C	SkySat-10 - LauncherOne	SkySat-13 - LauncherOne
			SkySat-11 - LauncherOne	SkySat-14 - LauncherOne
			SkySat-12 - LauncherOne	SkySat-15 - LauncherOne
Commercial Cargo and Crew Transportation Services[3]	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares
	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares
	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9
	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9
	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9
		Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9
		Crew Test Flight - TBD	Crew Test Flight (Dream Chaser) - Atlas V	ISS Crew - TBD
			Crew Test Flight - TBD	ISS Crew - TBD
			Crew Test Flight - TBD	ISS Crew - TBD
Other Commercially Launched Satellites	ASNARO - Dnepr	SAOCOM 1A - Falcon 9	DragonLab 1 - Falcon 9	DragonLab - Falcon 9
	PAZ - Dnepr	Formosat 5 - Falcon 9	DubaiSat-3 - Dnepr	
	Google X PRIZE - LM 2C	Göktürk 1 - Vega	EnMAP - PSLV	
		Kompsat 3A - Dnepr	SAOCOM 1B - Falcon 9	
		Deimos - Dnepr		
Technology Test and Demonstration Launches	Orion MPCV Demo - Delta IV Heavy	Test Package - Falcon 9 Heavy		
Total Payloads (includes secondary)	**106**	**74**	**72**	**69**
Total Launches	**13**	**19**	**20**	**17**
Launch Realization Factor Applied	**6-8**	**8-10**		

[2] Near-term NGSO payloads and launches are based on information obtained from discussions with launch providers, satellite manufacturers, system operators, government offices, and independent analysts. Launch dates could vary between publicly available information and information gathered from other sources.

[3] The Commercial Cargo and Crew Transportation Services near-term NGSO manifest is based on the NASA 2014 ISS traffic model.

NGSO PAYLOAD MARKET SEGMENTS

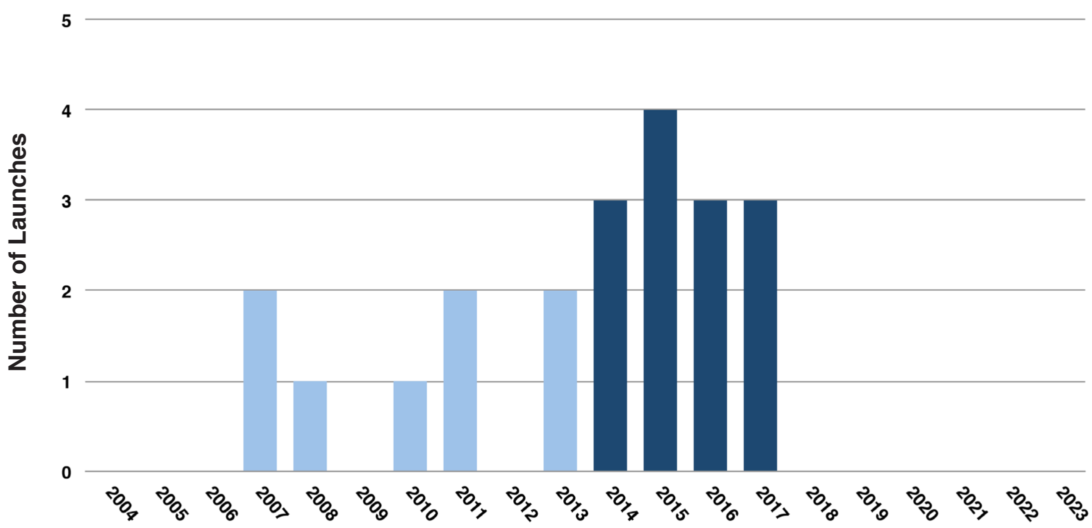
Commercial Telecommunication Satellites

The NGSO telecommunications satellite market is based on large constellations of small-to-medium-sized satellites that provide global or near-global communications coverage. The constellations can be divided into three major categories based on the frequencies the satellites use: narrowband (also known as Little LEO), wideband (also known as Big LEO), and broadband.

Telecommunications Launch Demand Summary

From 2014 through 2017, between three and four launches of NGSO telecommunications satellites will occur each year. There will be three launches in 2014, as ORBCOMM and the emerging MEO Ka-band broadband operator O3b launch their satellites, and there will be four launches in 2015 and three launches a year in 2016 and 2017, as Iridium replaces its satellites and Globalstar launches additional satellites. Globalstar and O3b are planning to launch on Soyuz 2 vehicles from Baikonur, Kazakhstan and French Guiana, respectively. The first two Iridium NEXT satellites are currently planned to launch on a Dnepr rocket in 2015. Two ORBCOMM and seven Iridium NEXT launches are planned for the Falcon 9 vehicle. Operators intend to finish the replacement of their constellations before 2018, so no telecommunications launches are projected for the subsequent years. Figure 13 provides a representation of telecommunications launch history and projected launch plans.

Figure 13. Commercial Telecommunications Launch History and Projected Launch Plans



2014	2015	2016	2017
O3b (4) - Soyuz 2	Globalstar (6) - Soyuz 2	Iridium (10) - Falcon 9	Iridium (10) - Falcon 9
O3b (4) - Soyuz 2	Iridium (2) - Dnepr	Iridium (10) - Falcon 9	Iridium (10) - Falcon 9
ORBCOMM (8) - Falcon 9	Iridium (10) - Falcon 9	Iridium (10) - Falcon 9	Iridium (10) - Falcon 9
	ORBCOMM (8) - Falcon 9		

Narrowband NGSO Telecommunications Systems

Narrowband LEO systems (see Table 12) operate at freqencies below 1GHz. These systems provide narrowband data communications, such as email, two way paging, and simple messaging for automated meter reading, vehicle fleet tracking, and other remote data monitoring applications. ORBCOMM is the only fully operational narrowband system. Another system, AprizeStar, is partially operational with eight satellites on orbit five of which are operational, will reach its capacity when the full constellation is deployed. The AprizeStar deployment schedule is dependent on the availability of funding and revenue generated by the satellites currently on orbit.

Table 12. Narrowband Systems

<table>
<tr><th rowspan="2">System/ Operator</th><th rowspan="2">Prime Contractor</th><th colspan="2">Satellites</th><th rowspan="2">Orbit Type</th><th rowspan="2">First Launch</th><th rowspan="2">Status</th></tr>
<tr><th>Number (on orbit/ operational)</th><th>Mass kg (lb)</th></tr>
<tr><td colspan="7">Operational</td></tr>
<tr><td>ORBCOMM/ ORBCOMM Inc.</td><td>Orbital Sciences Corp. (1st Gen.);

SNC (2nd Gen.)</td><td>41/27</td><td>43 (95) (1st Gen.)

142 (313) (2nd Gen.)</td><td>LEO</td><td>1997</td><td>System operational with 41 satellites on orbit. In 2012, a prototype second generation satellite was launched to orbit as a secondary payload on a Falcon 9/Dragon ISS mission. In accordance with ISS safety requirements, the satellite was deployed at a lower altitude than initially planned in an effort to optimize the safety of the ISS and its crewmembers.</td></tr>
<tr><td colspan="7">Under Development</td></tr>
<tr><td>AprizeStar (LatinSat)/ Aprize Satellite</td><td>SpaceQuest</td><td>8/5</td><td>10 (22)</td><td>LEO</td><td>2002</td><td>Planned 12- to 30-satellite system, with intermittent launches based on availability of funding. Two satellites are planned for launch in 2014. The company expects to continue launching two AprizeSat satellites every year or two for as long as Dnepr cluster launches are available.</td></tr>
</table>

Wideband NGSO Telecommunications Systems

Wideband LEO systems (see Table 13) use frequencies in the range of 1.6–2.5 GHz (L- and S-band frequencies). Wideband systems provide mobile voice telephony and data services. The two wideband systems Globalstar and Iridium are on orbit and operational.

Table 13. Wideband Systems

System/ Operator	Prime Contractor	Satellites: Number (on orbit/ operational)	Satellites: Mass kg (lb)	Orbit Type	First Launch	Status
Operational						
Globalstar/ Globalstar, Inc.	SS/Loral (1st Gen.) Thales Alenia Space (2nd Gen.)	68/54	447 (985) (1st Gen.) 700 (1,543) (2nd Gen.)	LEO	1998	Constellation on orbit and operational. Eight replacement satellites launched in 2007. Eighteen second generation satellites launched on three Soyuz rockets in 2010 and 2011. Six more second generation satellites were launched aboard a Soyuz vehicle in 2013. Six additional satellites ordered from Thales Alenia Space in September 2012, to launch in 2015.
Iridium/ Iridium Communications Inc.	Motorola (Iridium) Thales Alenia Space (Iridium NEXT)	90/72	680 (1,500) Iridium 800 (1,763) Iridium NEXT	LEO	1997	Constellation on orbit and operational. Five spare satellites launched in February 2002; two additional spares launched June 2002. Next generation system under development by Thales Alenia Space. Multiple launches of Iridium NEXT constellation are projected to begin in 2015.

Broadband NGSO Telecommunications Systems

Broadband systems (see Table 14) reside in NGSO and provide high-speed data services at Ka- and Ku-band frequencies. O3b Networks Ltd. accomplished an initial deployment of its first four satellites in 2013.

Table 14. Broadband Systems

System/ Operator	Prime Contractor	Satellites: Number (on orbit/ operational)	Satellites: Mass kg (lb)	Orbit Type	First Launch	Status
Under Development						
O3b/O3b Networks Ltd.	Thales Alenia Space	4/4	700 (1,540)	MEO	2013	The first four satellites of the constellation launched in 2013. Eight more are scheduled for deployment in 2014.

Federal Communications Commission Telecommunication Licenses

Table 15 shows Federal Communications Commission (FCC) telecommunications licenses issued to the commercial NGSO telecommunications satellite operators. The three systems originally deployed in the 1990s, ORBCOMM, Globalstar, and Iridium, are in different stages of planning, development, and deployment of their new generation of satellites.

Table 15. FCC Telecommunication Licenses

Licensee	Year of Filing	Remarks
ORBCOMM	1998	Authorized Orbital Communications Corporation to modify its non-voice, non-geostationary mobile-satellite service system, initially licensed and authorized in 1994.
Iridium Satellite LLC	2001	Authorized Iridium to operate feeder uplinks in the 29.1-29.25 Mobile-Satellite Service (MSS).
Iridium Satellite LLC	2002	Granted assignment of licenses and authorizations pertaining to the operation of the Iridium Mobile Satellite Service System.
ORBCOMM	2008	FCC authorization for the ORBOMM second generation satellites to operate within the United States
Globalstar	2011	FCC authorization to operate its second-generation satellites within the United States
AprizeStar	2012	FCC authorization to operate satellites Aprizesat 1 through 10.
Skybox Imaging	2012	FCC authorization for Skysat 1 and Skysat 2 to transmit telemetry signals and remote-sensing data in the 8025-8400 MHz frequency band and to receive command signals on center frequencies of 2081 MHz and 2083 MHz.
O3b	2012	License to operate a gateway in Haleiwa, Hawaii.
Planet Labs	2013	FCC authorization for Planet Labs to transmit image and telemetry data to fixed earth stations using the 8025-8400 MHz frequency band, and receive command signals in the 2025-2110 MHz band.
O3b	2013	License to operate a gateway in Vernon, Texas.

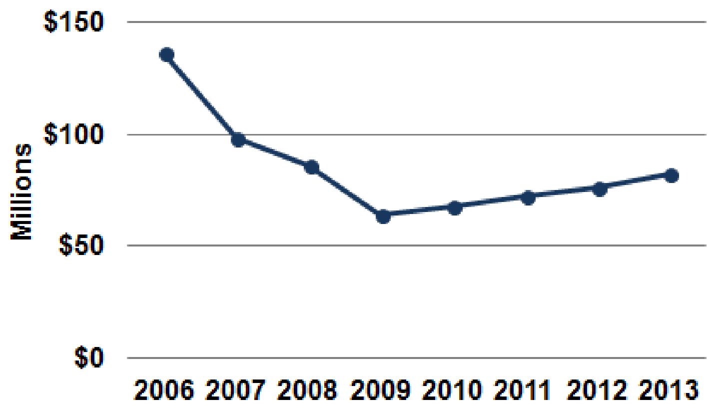
Globalstar

Globalstar, Inc. is a publicly traded wideband system operator primarily serving the commercial global satellite voice and data markets. Their full service offering began in 2000. The company is currently in the process of augmenting its on-orbit satellite constellation.

Globalstar's first generation satellite constellation consisted of 52 satellites: 48 operational satellites plus 4 on-orbit spares. Globalstar's original constellation began experiencing problems with its S-band amplifier in 2001. In 2007, the S-band problem began affecting the company's voice and two-way data services. The constellation's simplex one-way L-band data services were not affected by these problems. To mitigate the S-band problems and begin updating the on-orbit constellation, Globalstar launched its final eight first generation replacement satellites on two Soyuz vehicles in May and October 2007. The addition of these satellites to the constellation did not restore sufficient capacity for full voice and two-way data service.

As a result of the S-band problems, Globalstar's revenues started to slip in 2006. In response to these declining revenues, Globalstar lowered prices for its customers and developed a simplex service product called the Satellite Pour l'Observation de la Terra (SPOT) Satellite Global Positioning System (GPS) Messenger. In July 2009, Globalstar uploaded a second generation SPOT Satellite GPS Messenger software upgrade to the existing constellation.

Figure 14. Publicly Reported Globalstar Annual Revenue



Arianespace, through its Starsem affiliate, launched 24 Globalstar second generation satellites. The first 6 satellites were launched into orbit in 2010, the next 12 launched in 2011, and the remaining 6 in February 2013. All launches were from Baikonur, Kazakhstan on Soyuz rockets carrying six satellites per launch. Globalstar reported significant improvement in service availability and quality after the new generation satellites came online following on-orbit testing.

Thales Alenia Space (TAS) developed and built the 25 second generation satellites (including one ground spare) for Globalstar. Together with the 8 replacement satellites launched in 2007, Globalstar has a 32-satellite system since the initial deployment of its new constellation concluded.

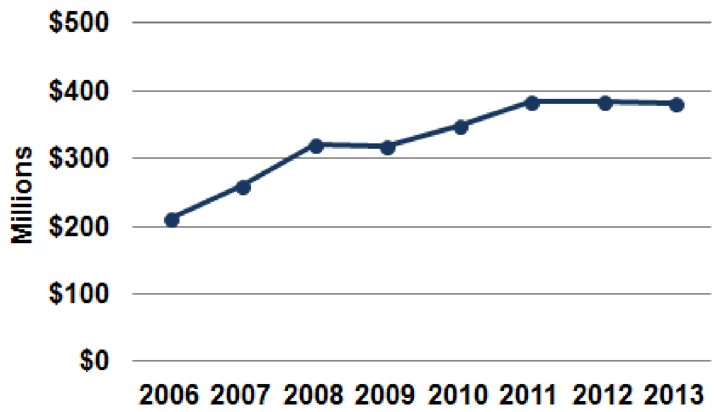
Globalstar reported it is in negotiations with TAS for an option of manufacturing 23 additional satellites in the coming years. The spacecraft would be spares for the existing fleet and launch as needed. An order for manufacturing of the first six was placed with TAS in September 2012, tentatively to launch in 2015. Currently, there is no launch contract for these additional satellites, and any launch would be contingent on the health of the satellites on orbit. Therefore, this report does not project additional launches beyond 2015.

Figure 14 shows the decline in Globalstar's revenues from 2006 to 2009 and a rise beginning in 2010, due to higher revenues from the SPOT Satellite GPS Messenger service and simplex data services and improvements in duplex and simplex services after second generation satellite deployment. Because of the commercial success of the SPOT Satellite GPS Messenger service, Globalstar plans to introduce additional duplex and simplex products and services through its renewed constellation.

Iridium

Iridium Communications Inc. is the successor to the original Iridium LLC that built and launched the Iridium satellite constellation in the late 1990s. Iridium Communications Inc. owns and operates a constellation of 72 operational commercial communications satellites: 66 active spacecraft and 6 orbiting functional spares. These satellites comprise a fully operational system to provide service until at least 2015. In 2010, Iridium selected TAS as the prime contractor for the system development of a second generation satellite constellation, named Iridium NEXT. Each satellite in the new constellation can carry a hosted payload in addition to the primary communications payload. Iridium is marketing this opportunity to potential customers while the satellites are under construction.

Figure 15. Publicly Reported Iridium Annual Revenue



Iridium announced that SpaceX will be the primary launch provider for Iridium NEXT. Iridium also signed a contract with International Space Company Kosmotras (provider of the Dnepr launch vehicle) to be a supplemental provider of launch services for Iridium NEXT. The company reportedly plans to launch 72 satellites (66 to enter active service and 6 to serve as on-orbit spares) during a 3-year period scheduled to begin in 2015. The first two Iridium NEXT satellites are currently planned to launch on a Dnepr rocket in 2015. The rest of the Iridium NEXT constellation will launch on approximately 7 Falcon 9 launches carrying 10 satellites each. Nine Iridium NEXT satellites will remain ground spares. Iridium revenues are presented in Figure 15.

ORBCOMM

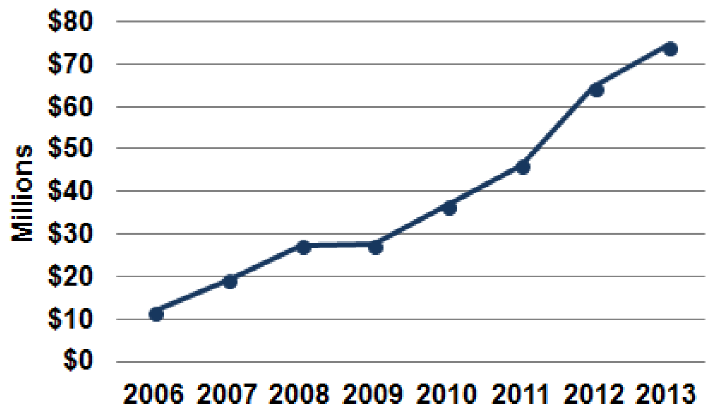
Between 1995 and 1999, ORBCOMM deployed a narrowband constellation of 35 satellites, 27 of which are operational today. It is the only company to have fully deployed a system that provides low-bandwidth packet data services worldwide. ORBCOMM focuses on providing data services for machine-to-machine applications.

In 2008, six ORBCOMM satellites launched on a Russian Cosmos 3M vehicle to begin replacing the legacy constellation deployed in 1999. One of the planned upgrades to the constellation was the addition of the Automatic Identification System (AIS), a sea vessel identification and tracking system. Shortly after deployment, all six satellites failed, leaving ORBCOMM with no AIS capability for its subscribed customers.

To remediate the service shortfall, Luxspace, a subsidiary of the prime satellite manufacturer OHB System, developed Vesselsat 1 and Vesselsat 2. Vesselsat 1 launched into equatorial orbit on a Polar Satellite Launch Vehicle (PSLV) rocket in December 2011, and Vesselsat 2 launched into polar orbit on a Long March rocket in January 2012. Both satellites launched as piggyback payloads. ORBCOMM is the exclusive licensee for the AIS data collected by VesselSat 1 and VesselSat 2. These two AIS-only satellites will not be integrated into ORBCOMM's current or second generation (OG2) constellation. Instead they will serve as a supplement to these constellations.

ORBCOMM's plans for replacing its current constellation are underway. Seventeen satellites of the 18-satellite second generation constellation are either under construction or awaiting launch. All satellites in the constellation include AIS payloads. ORBCOMM ordered the satellites in 2008 from Sierra Nevada Corporation (SNC), with subcontractors Boeing and ITT Corporation. In 2011, ORBCOMM announced its plan to use SpaceX's Falcon 9 vehicle to launch the onstellation.

Figure 16. Publicly Reported ORBCOMM Annual Revenue



A prototype ORBCOMM OG2 satellite was carried by the SpaceX Falcon 9 vehicle as a secondary payload on a cargo resupply mission to the ISS in October 2012. The launch met its primary objective of sending the Dragon spacecraft to the ISS, but did not deploy the ORBCOMM satellite into the desired orbit due to an anomaly on one of the Falcon 9's first stage engines. To remain fully compliant with the safety plan approved for Dragon delivery to the ISS, SpaceX did not have the Falcon 9 execute the second burn necessary to deliver the ORBCOMM satellite into a higher orbit.

In 2014, the remaining OG2 satellites will begin to launch aboard Falcon 9 vehicles in 2014. Between 8 and 12 satellites will be launched in 2014, and the remainder of the 18-satellite constellation are likely to launch in 2015.

ORBCOMM revenues are presented in Figure 16.

Aprize Satellite

Aprize Satellite, Inc. plans to deploy a 12-satellite system, depending on funding opportunities and customer demand for data communication and AIS data service. A total of eight AprizeStar satellites weighing 10 kilograms (22 pounds) each, launched as secondary payloads on Russian Dnepr vehicles: two satellites a year in 2002, 2004, 2009, 2011, and 2013. The 2 original satellites launched in 2002 are no longer in orbit. Two more satellites are expected to be deployed by another Dnepr multi-manifest launch in 2014. Three of the eight satellites on orbit are not operational. The company needs to launch 5 more satellites to complete the constellation, as well as any replacement satellites needed. In the years following 2014, the company expects to continue launching two AprizeSat satellites every year or two for as long as Dnepr cluster launches are available. Any additional satellites are likely to launch as secondary payloads and not generate demand for a launch.

O3b

O3b Networks, headquartered in St. John, Jersey, Channel Islands, plans to provide broadband connectivity to underserved parts of the world with support and funding from high profile investors, including major GEO commercial satellite operator SES, Google, Liberty Global, and HSBC.

The O3b constellation will operate in the Ka-band in an equatorial orbit with a minimum of five satellites to cover +/- 45 degrees of latitude around the Equator. More satellites can be added as needed to meet demand.

Offering to bridge the gap between current satellites and fiber optic cables, O3b Networks plans to provide fiber-like trunking capacity to telecommunications operators and backhaul directly to 3G Cellular and WiMAX towers. Prior to the launch of its first four satellites in 2013, O3b had been successful in having its capacity booked by regional telecommunications companies and Internet service providers. O3b Networks teamed with VSAT satellite services provider Harris CapRock to deliver connectivity solutions to maritime clients, including Royal Caribbean Cruises.

TAS is under contract to build 16 communications satellites for O3b. O3b has a launch services agreement with Arianespace for two more Soyuz launches from French Guiana. Each Soyuz will deploy four O3b satellites in MEO in the equatorial plane.

Telecommunications Satellite Fleet Replacement after 2022

NGSO telecommunications satellites launched in the 1990s and early 2000s had an estimated design life of four (ORBCOMM) to seven and a half (Globalstar) years (see Table 16). However, the majority of these satellites are still on orbit and continue to provide telecommunications services; most of the first generation Globalstar, Iridium, and ORBCOMM constellations have exceeded their design life by two to three times. For financial reasons, many of the satellites were not replaced when their estimated design life ended. Operators were able to continue providing services until second generation spacecraft were ready.

Now most of the satellites launched or prepared for launch by NGSO communications satellite operators have an estimated design life of 10 to 15 years, which places the estimated replacement dates beyond 2022. The exception is ORBCOMM, with a minimum design life estimate of a conservative five years. If any of these satellites need to be replaced within the 2014 - 2023 period, they will likely be launched as piggyback payloads, unlikely to generate demand for a dedicated launch.

Table 16. Commercial Telecommunications Satellite Systems' Design Life

Satellite System	1st Generation Satellite Design Life	Current Status	2nd or Current Generation Satellite Design Life
Globalstar	7.5 years	Most of the satellites on orbit, partially operational	15 years
Iridium	5 years	Most of the satellites on orbit, operational	10 years (design), 15 years (projected)
ORBCOMM	4 years	Most of the satellites on orbit, operational	More than 5 years
Aprize Satellite	N/A	8 on orbit, 6 in service, launching more to complete system	10 years
O3b Network	N/A	4 satellites in orbit, partially operational. Launching 8 more to complete system	10 years

COMMERCIAL REMOTE SENSING SATELLITES

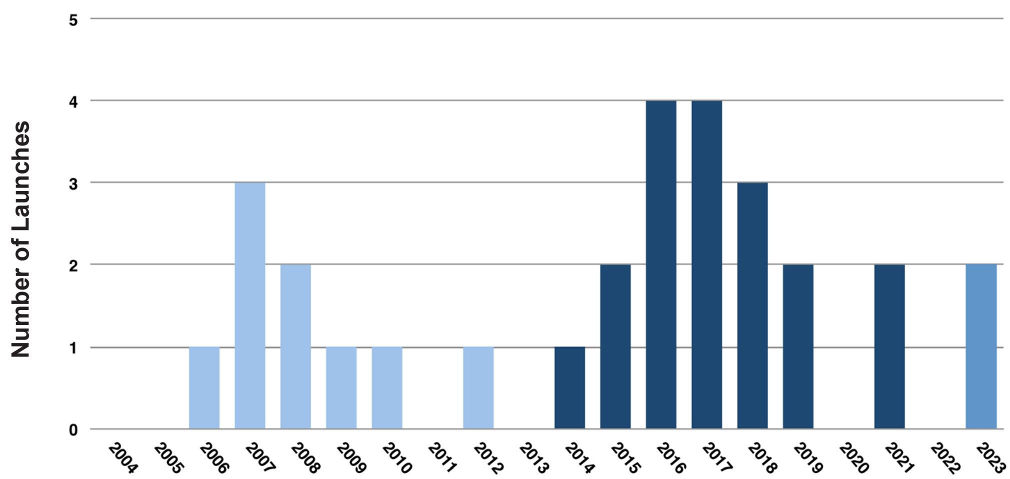
Remote sensing refers to any orbital platform with sensors trained on Earth to gather data across the electromagnetic spectrum for geographic analysis, military use, meteorology, climatology, or other uses. The remote sensing industry generally comprises three markets:

- Aerial imagery
- Satellite imagery
- Value-added services, including geographic information systems (GIS)

GIS consists of images obtained from aircraft or satellites integrated with layers of information, usually customized according to user needs. It constitutes the largest part of the industry both in terms of demand and revenue generation.

The satellite imagery market is composed of companies that acquire and operate their own remote sensing satellites. These include Airbus Defense and Space, BlackBridge, DigitalGlobe, DMC International Imaging, ImageSat, MDA Geospatial Services, Planet Labs, and Skybox Imaging. New companies like BlackSky Global and PlanetiQ are entering the market. For all of these companies, GIS products and services are the main generator of revenue. In some cases, imagery obtained from government satellites is made available to customers through a GIS company. For example, imagery from two Pleiades satellites operated by the French government is made available through Airbus Defense and Space. In other cases, the operation of remote sensing satellites, the imagery obtained from them, and the sales of GIS products and services is managed through a public-

Figure 17. Commercial Remote Sensing Launch History and Projected Launch Plans



2014	2015	2016	2017
Worldview-3 - Atlas V	DMC3 (3) - PSLV	EROS C - Small TBD	TSX-NG - Medium TBD
	SkySat 4-9 - Minotaur C	SkySat-10 - LauncherOne	SkySat-13 - LauncherOne
		SkySat-11 - LauncherOne	SkySat-14 - LauncherOne
		SkySat-12 - LauncherOne	SkySat-15 - LauncherOne

private partnership (PPP). The TerraSAR-X and TanDEM-X satellites are managed by a PPP that includes the German Space Agency (DLR) and Airbus Defense and Space.

This forecast captures only commercial remote sensing satellite companies that procure internationally competed launches and FAA licensed launches. It does not include organizations that depend on a particular launch provider, either because of a commitment to a national industrial base or through a previously established agreement with the launch provider. In those instances, the launch is not considered internationally competed.

Table 17. Commercial Remote Sensing Systems

System	Operator	Manufacturer	Satellites	Mass kg (lb)	Highest Resolution (m)	Revisit Time (hrs.)	Launch Year
CICERO	GeoOptics	TBD	CICERO 1-12	TBD	TBD	TBD	2017
Deimos Perseus	Dauria Aerospace and Elecnor Deimos	Dauria Aerospace	Perseus O 1-8	<10 (22)	22	24	2015
DMC3	DMC International Imaging Ltd.	SSTL	DMC3 1-3	350 (771)	1	24	2014
Dove	Planet Labs	Planet Labs	Dove 1-100	<10 (22)	3-5	24	2014
EROS	ImageSat International	Israel Aircraft Industries	EROS A EROS B EROS C	280 (617) 350 (771) 350 (771)	1.5 0.7 0.7	24-288	2000 2006 2016
GeoEye	DigitalGlobe	General Dynamics Lockheed Martin	GeoEye-1 GeoEye-2	907 (2,000) 2,087 (4,601)	0.41 0.34	50-199 50-199	2008 2016
IKONOS	DigitalGlobe	Lockheed Martin	IKONOS	816 (1,800)	1	<72	1999
PlanetIQ	PlanetIQ	TBD	PlanetIQ 1-12	75 (165)	N/A	N/A	TBD
OmniEarth	OmniEarth	Draper Labs/ Dynetics/ Harris	OmniEarth 1-18	500 (1,102)	TBD	24	TBD
QuickBird	DigitalGlobe	Ball Aerospace	QuickBird	909 (2,004)	0.6	60-134	2001
RADARSAT	MDA	MDA	RADARSAT-1 RADARSAT-2 RCM	2,750 (6,050) 2,195 (4,840) 1,200 (2,645)	8 3 TBD	48-72 48-72 TBD	1995 2007 2018
RapidEye	RapidEye AG	MDA	RapidEye 1-5	150 (330)	6.5	24	2008
SkySat	SkyBox Imaging	SkyBox Imaging	SkySat-1 SkySat-2	91 (200) 91 (200)	<1 <1	<24	2013 2014
TerraSAR-X and TanDEM-X	BMBF/DLR/ Astrium	Astrium	TerraSAR-X TanDEM-X TerraSAR-NG	1,023 (2,255) 1,023 (2,255) TBD	3 0.5 TBD	264 264 TBD	2007 2010 2015
WorldView	DigitalGlobe	Ball Aerospace	WorldView-1 WorldView-2 WorldView-3	2,500 (5,510) 2,800 (6,175) 2,800 (6,175)	0.5 0.5 0.5	41-130 26-89 TBD	2007 2009 2014

The major companies operating or actively developing remote sensing satellites across the globe are profiled in Table 17. These satellites have been or are likely to be launched commercially.

Licenses issued by the U.S. National Oceanic and Atmospheric Administration

The U.S. National Oceanic and Atmospheric Administration (NOAA) licenses U.S. commercial remote sensing systems in accordance with the Land Remote Sensing Policy Act of 1992. There have been 35 remote sensing licenses issued or amended since 1993 (see Appendix). Seven licenses were issued in 2013 and two in early 2014 (see Table 18).

Table 18. NOAA Remote Sensing Licenses Issued in 2013

Licensee	Date License Granted or Updated	Remarks
Southern Stars	2/18/2013	License issued for operation of cubesat SkyCube.
Saint Louis University	6/20/2013	License issued for operation of cubesat COPPER.
Nanosatisfi	TBD	License issued for operation of cubesat Ardusat 1.
University of Alabama Huntsville	9/17/2013	License issued for operation of cubesat ChargerSat-1.
Teledyne Brown Engineering	11/5/2013	License issued for MUSES.
University of Hawai`i at Mānoa	TBD	License issued for Hawai'iSat-1.
Planet Labs, Inc.	9/26/2013	License issued for Flock-1 constellation, consisting of 28 3U cubesat satellites.

Remote Sensing Launch Demand Summary

The commercial remote sensing industry is characterized by relatively stable satellite replacement schedules. Launches of commercial remote sensing satellites will take place at an average of two per year through the forecast period. The significant increase in the average from last year's projection of less than a launch a year reflects the inclusion of Skybox Imaging launches in this year's forecast. Skybox acquired funding to support its initial constellation of 12 satellites, and the successful launch of its first satellite late in 2013. Peaks in the number of launches can be seen during 2016 and 2018, reflecting projected deployment of satellites operated by Airbus Defense and Space, ImageSat, and Skybox. Figure 17 provides a launch history and projected launch plans for commercial remote sensing satellites.

Commercial remote sensing satellites in the near-term portion of this report (2014-2017) have been announced by their respective companies, are under construction, and are scheduled for a launch. Satellites projected for the latter portion of the report (2018-2023) are based on published statements regarding the service lives of satellites currently operating on orbit.

DigitalGlobe

Established in 1992, DigitalGlobe is a commercial high-resolution remote sensing satellite operator and GIS provider headquartered in Longmont, Colorado. The company operates imaging satellites and provides GIS products using satellite and aerial imagery. Following a merger with GeoEye, Inc. on January 31, 2013, DigitalGlobe currently operates five remote sensing satellites: IKONOS, GeoEye-1, QuickBird, WorldView-1, and WorldView-2. WorldView-3 will launch in 2014 aboard an Atlas V 401 vehicle. Another satellite, GeoEye-2, is currently under construction and will be stored as a ground spare.

DigitalGlobe's first satellite, QuickBird, was launched in 2001 and is projected to continue operating until late 2013. WorldView-3 is expected to have a service life of up to 12 years. DigitalGlobe's two other satellites, WorldView-1 and WorldView-2, are expected to reach end of operational life in the second quarter of 2018 and the first quarter of 2021, respectively.

The U.S. National Geospatial-Intelligence Agency (NGA) partially funded the development of the current generation of DigitalGlobe (including the former GeoEye) satellites. In 2010, NGA awarded both DigitalGlobe and GeoEye 10-year contracts worth up to $7.35 billion as part of the EnhancedView program. These contracts intended to extend NGA's ability to tap imagery from the private sector and help guarantee the availability of commercial remote sensing products into the decade. In July 2012, due to planned cuts to the EnhancedView budget, DigitalGlobe and GeoEye announced plans to merge, a process completed in January 2013.

DMC International Imaging

DMC International Imaging, Ltd. (DMCii), based in the United Kingdom, operates the Disaster Monitoring Constellation (DMC) on behalf of governments that provide the satellites. DMCii is a wholly owned subsidiary of Surrey Satellite Technology Ltd. (SSTL). The constellation's primary purpose is to distribute imagery for commercial and humanitarian purposes.

The original DMC constellation (Alsat-1, Beijing-1, BilSat, Nigeriasat-1, and UK-DMC1) became fully operational in 2006, with satellites evenly distributed in a single sun-synchronous orbit (SSO). Four additional satellites were launched between 2009 and 2011, and the current retinue of operating satellites include China's Beijing-1, Nigeria's Nigeriasat-2 and NX, Spain's DEIMOS-1, and the United Kingdom's UK-DMC2. The satellites orbit at an altitude of 700 kilometers (435 miles). Nigeria's satellites Nigeriasat-2 and NX were launched in 2011 and represent the latest members of the DMC constellation.

In June 2011, DMCii signed a seven-year deal with China-based Twenty First Century Aerospace Technology Company Ltd. (21AT) to lease the imaging capacity aboard a three-satellite constellation called DMC3. The lease allows 21AT to obtain timely imagery without procuring and operating a constellation themselves. The constellation, designed and manufactured by SSTL, will be owned and operated by DMCii and is projected to launch in 2015 aboard an Indian PSLV-XL vehicle. Each DMC3 satellite will provide one-meter panchromatic and four-meter multispectral imaging.

Airbus Defense and Space

Airbus Defense and Space (Airbus) operates the French remote sensing constellation, Satellite Pour l'Observation de la Terre (SPOT) and the German synthetic aperture radar (SAR) remote sensing missions TerraSAR-X and TanDEM-X. It also handles sales of imagery obtained by two Pléiades satellites operated by CNES, the DEIMOS-1 satellite operated by DMC International Imaging on behalf of the Spanish government, and Formosat-2 operated by the government of Taiwan.

The TerraSAR-X and TanDEM-X missions are public private partnerships between the German Aerospace Centre (DLR), the German Federal Ministry of Education and Research and Airbus. DLR operates the two identical satellites and is responsible for the scientific use of the data. Airbus holds the exclusive commercial exploitation rights for imagery acquired by TerraSAR-X and TanDEM-X.

The TerraSAR-X Mission is performed by two satellites, TerraSAR-X and TanDEM-X, each contributing a part of the imaging resources. The TanDEM-X Mission uses the same two satellites to perform close formation flight with distances of 200m. The two satellites will fly in this formation until 2015. The goal of the TanDEM-X Mission is to generate a homogeneous, high-quality global Digital Elevation Model.

The first TerraSAR-X satellite launched aboard a Russian Dnepr vehicle in 2007. The second TerraSAR-X satellite was launched in 2010, also aboard a Dnepr. Airbus expects these satellites to function five years beyond 2018.

Work is currently underway for a second generation of SAR satellites called TerraSAR-X Next Generation. The launch is planned for launch in 2018. No launch vehicle has been been selected. DLR and Airbus are also discussing a next generation of satellites beyond the 2018 timeframe to replace the first generation TerraSAR-X satellites. These are not included in the report because system definition has not started. As with TerraSAR-X and TanDEM-X, imagery from these future satellites is expected to be available for scientific and commercial purposes.

The Centre National d'Etudes Spatiales (CNES), France's space agency, was majority shareholder of SPOT Image until 2009, when responsibility for the system transferred to EADS Astrium; in 2011 the company formed the Geo Information Division to specifically manage the SPOT satellites and data sales. EADS Astrium has since acquired and built SPOT-6 and SPOT-7, the former launched in 2013 and the latter planned for a 2014 launch. In 2014, through mergers, EADS Astrium became part of Airbus Group. The SPOT constellation consists of three satellites, SPOT-4, launched in 1998, SPOT-5, launched in 2002, and SPOT-6, launched in 2012. SPOT-7 is planned for launch in 2014 aboard an Indian PSLV vehicle. The launch of SPOT-7 is not included in the forecast because it was not internationally competed; like SPOT-6, SPOT-7 will be launched aboard a PSLV as a result of a partnership between CNES and the Indian Space Research Organization (ISRO).

BlackBridge

Berlin-based BlackBridge operates the RapidEye constellation of five satellites, and GIS imagery. RapidEye AG changed its name to BlackBridge in November 2013.

The company has additional offices in Luxembourg, Canada, and the United States.

The RapidEye satellites provide wide-area, repetitive coverage and 5-meter-pixel-size multi-spectral imagery. MacDonald, Dettwiler and Associates (MDA) was the prime contractor for the development of the satellites, responsible for design and implementation. MDA subcontracted Surrey Satellite Ltd (SSTL) in the UK to supply the bus and integrate the satellites whereas Jena-Optronik from Germany provided the camera payloads. All five satellites were launched aboard a Dnepr launch vehicle from Baikonur, Kazakhstan on August 29, 2008. The constellation is expected to remain in service until at least 2019, four years beyond the designed service life.

Though planning for the next generation of satellites is underway, BlackBridge has not released details publicly. During 2014, the company expects to provide details about its future satellite development plans. The forecast assumes that BlackBridge will secure funding for a replacement constellation with a launch projected in 2018, a year before the anticipated end of life of the original satellites.

BlackSky Global, LLC

U.S.-based BlackSky Global was issued a NOAA license authorizing deployment of an "Earth observation satellite system." The system, which is planned for launch in 2015, will feature one or more satellites in a polar orbit with an altitude of between 450 km and 600 km. Because no technical details are public, the BlackSky system is not included in the forecast.

Dauria Aerospace/Elecnor Deimos

In October 2013, Dauria Aerospace and Elecnor Deimos announced a joint partnership to build and operate a constellation of 8 satellites capable of frequently capturing multispectral imagery of the same area, supplemented by onboard automated identification of ground features. The highest resolution possible is expected to be about 22 meters. Each member of the constellation, called Perseus-O, will consist of a 6U cubesat arrangement. Perseus-O satellites will be launched as secondary payloads during 2015, though no launch vehicle has been selected yet. Dauria Aerospace has also built Perseus-M1, Perseus-M2, and DX-1, and these non-commercial remote sensing satellites will be launched as secondary payloads aboard Dnepr vehicles in 2014. Eleconor Deimos also operates the Deimos-1 cubesat currently on orbit, and will operate the much larger Deimos-2 (300 kg), which will be launched in 2014 aboard a Dnepr as the primary payload.

GeoOptics

GeoOptics is an environmental and weather data services company that will launch small satellites into polar orbit caryrying the data sensor technology called GPS-Radio Occultation (RO). RO technology measures temperature, air pressure and water vapor with near-perfect accuracy—and unlike any other data form in orbit today—for use in operational weather forecasting and space weather applications, as well as climate monitoring. With this in-orbit sensor infrastructure GeoOptics will be collecting mass amounts of atmospheric and environmental data for use in computational models in Numeric Weather Prediction (NWP) forecasting and climatological models. These models will ultimately feed data analytics for clean tech, financial, insurance, agribusiness and defense and many other industries, as well as science and research organizations, worldwide.

The company plans to launch satellites beginning in 2015 toward a full operational constellation of 24 satellites over the next few years. Launches will be conducted through a combination of available secondary launch vehicles. Because the company has not yet secured enough financing for the space-based segment, these launches are not included in the forecast.

ImageSat International NV

Israel-based ImageSat, founded as West Indian Space in 1997 and officially a Curacao company, provides commercial sub-meter resolution imagery with the Earth Remote Observation Satellite (EROS) family of satellites. Like many remote sensing companies, ImageSat's major customers are governments. Israel Aerospace Industries Ltd. (IAI) manufactures the EROS satellites, and ELBIT- Electro Optics Industries develops the imaging system.

ImageSat currently operates two satellites, EROS A and EROS B. EROS A launched in December 2000 aboard a Russian Start-1 small launch vehicle and should continue to operate until at least 2015, five years beyond its projected service life. EROS B launched aboard a Start-1 in 2006 and should continue to operate until 2022.

IAI is currently building the EROS-C satellite. Though no launch year has been selected, it is expected that EROS-C will be launched in 2016 or2017 aboard a small vehicle. EROS-C is designed to have a service life of about ten years.

MacDonald, Dettwiler and Associates

MDA owns and operates RADARSAT-2. The company is a commercial provider of advanced geospatial information products derived from the high-resolution RADARSAT-1 (no longer in service) and RADARSAT-2 satellites. It also markets and sells data derived from commercial optical satellites and from aerial systems.

RADARSAT-1 was launched on November 4, 1995, aboard a Delta II launch vehicle. The satellite, which was operated by the Canadian Space Agency (CSA), was retired in 2013. RADARSAT-2 launched aboard a Starsem Soyuz intermediate vehicle on December 14, 2007 and remains healthy. RADARSAT-2 features a SAR system capable of producing imagery with 1-meter resolution.

To provide space-based radar data continuity, the Government of Canada, through the CSA, proposed the three-satellite RADARSAT Constellation Mission (RCM). In March 2010, the CSA authorized MDA to perform the Phase C design phase of the RCA program, after MDA successfully completes Phases A and B. In January 2013, CSA signed a CAD $706-million contract with MDA for the construction, launch and initial operations of the three RCM satellites. MDA secured a launch reservation with Space Exploration Technologies (SpaceX) in July 2013 for the launch of all three satellites aboard a Falcon 9 vehicle.

OmniEarth

U.S.-based OmniEarth is partnering with Draper Laboratory, Dynetics, and Harris Corporation to develop a constellation of 18 small remote sesning satellites. These satellites will provide multispectral imagery products covering the entire planet, with a revisit time of one day. The satellites will be able to downlink up to 1.2 gigabytes per second of data and store 1 terabyte of data onboard, a unique capability in commercial satellite remote sensing. OmniEarth is currently seeking financing to fund development of the constellation, which is expected to cost about $250 million. Since financing is not yet finalized and no launch plans have been announced, the 18 satellites have not been included in this year's forecast.

PlanetIQ

PlanetiQ, established in 2012, plans to operate 18 microsatellites to provide weather, climate, and space weather data. The satellites are not equipped with imaging sensors; instead, they will collect atmospheric data including temperature, pressure and water vapor by measuring the bending of signals broadcast from global navigation satellite systems (like the U.S. Navstar Global Positioning System) using RO.

The mass of each satellite is 75 kilograms. The current plan is to launch 12 satellites by 2017 with 18 total by 2019. PlanetiQ is currently raising funds to support initiation of the constellation build in summer 2014.

Planet Labs, Inc.

Planet Labs, Inc., based in California, is a remote sensing and GIS company focused on producing and operating fleet of 100 very small satellites. Because the satellite platforms consist of three stacked cubesats (3U), the sensor focal length is not capable of producing images with resolutions higher than 3 to 5 meters, which is still adequate for environmental monitoring, change detection, and other applications. The large number of very small satellites ensures global coverage for a relatively small investment. Planet Labs raised $52 million in 2013.

Planet Labs (called Cosmogia from 2010 to early 2013) built four prototype Dove satellites, launched as secondary payloads in 2013. In January 2014, 28 Dove satellites, collectively called Flock-1, were launched aboard an Antares vehicle provided by Orbital Sciences Corporation. The satellites were stored within the Cygnus cargo transfer vehicle that berthed with the International Space Station (ISS) on January 12. Once attached to the ISS, the satellites were transferred to the Japanese Kibo module, where a special dispenser was used to eject the satellites one by one into orbit the following month. Shortly after deployment of Flock-1, Planet Labs announced that 72 additional satellites will be deployed between February 2014 and February 2015, bringing the total number to 100. The company indicated plans to use U.S. and Russian vehicles launched from different launch sites in order to deploy satellites into different orbits, thus ensuring global coverage.

The forecast includes 100 satellites deployed during 2014-2015, followed by 25 satellites each year throughout the forecast period to replenish the constellation since each satellite has a service life of 2 to 4 years. However, none of these satellites are expected to drive a launch since it is likely all satellites will be deployed as secondary payloads.

Skybox Imaging

Skybox Imaging, Inc., based in Mountain View, California, is a new entrant to the commercial satellite remote sensing industry. The company obtained a NOAA license for SkySat-1 on April 20, 2010, and has applied to amend the license to include a second satellite, SkySat-2. A third satellite is also planned before the company's 12-satellite polar-orbiting constellation begins deploying in 2015. Skybox manufactures and operates its own satellites and will provide frequently updated imagery and video online.

SkySat-1 launched in 2013 aboard a Dnepr vehicle along with several other satellites. SkySat-2 and SkySat-3 are projected to launch as secondary satellites aboard a Soyuz 2 and a Dnepr, respectively. Six SkySat satellites will follow in 2015, launched together aboard an Orbital Sciences Corporation Minotaur-C. Skybox has also been in discussions with Virgin Galactic for the launch of satellites aboard LauncherOne, a new small-class launch vehicle. Since this vehicle can only carry one SkySat at a time, the forecast projects that six SkySat satellites will be launched individually in 2016 and 2017. Two notional satellites per year in 2019, 2021, and 2023 are anticipated to replenish the constellation, since each satellite has a service life of 6 years.

COMMERCIAL CARGO AND CREW TRANSPORTATION SERVICES

Commercial cargo and crew transportation capabilities include commercial launches of cargo and humans to LEO and external trajectories to the Moon or other solar system destinations. Specifically, commercial cargo and crew transportation captures commercial crew and cargo services in support of NASA's mission and other private industry efforts that may require cargo and crew flights, such as space stations, tourism, privately sponsored scientific expeditions, and the prospecting and mining of non-terrestrial resources.

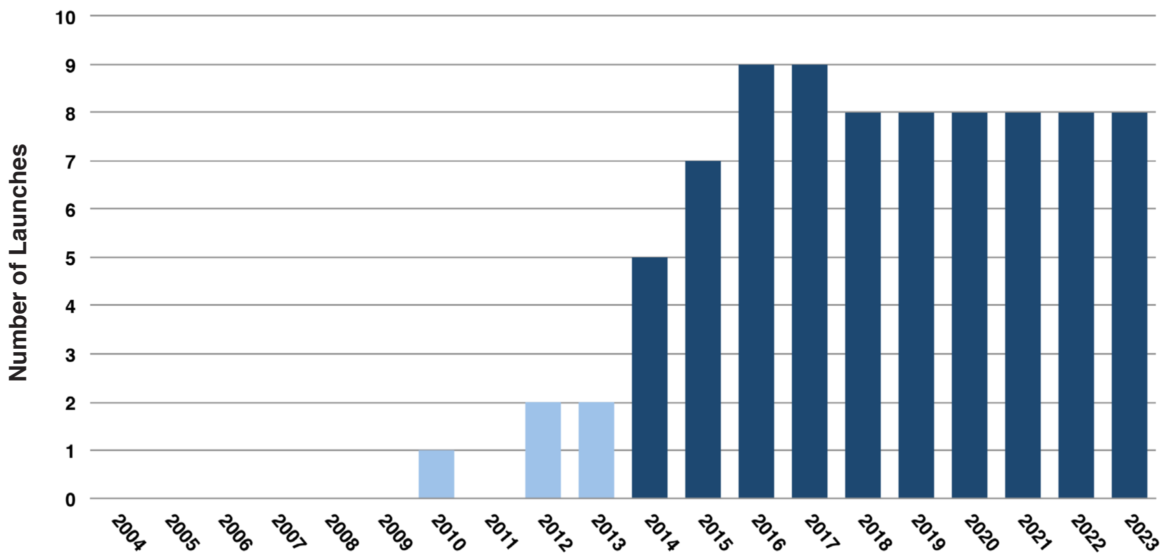
Commercial Cargo and Crew Transportation Services Launch Demand Summary

Seventy-eight commercial cargo and crew launches are projected from 2014 to 2023, as compared to 74 launches in last year's report. All the launches forecasted in the next ten years are in support of commercial crew and cargo resupply to the ISS. The increase in flights projected from last year's forecast is due to several factors. Among them are launch delays of Orbital's first Antares CRS flight and SpaceX's third CRS flight from 2013 into 2014 and a slight increase in the projected number of test and operational flights under NASA's commercial crew program. Figure 18 provides a launch history and projected launch plans for commercial cargo and crew transportation services.

Figure 19 shows the distribution of ISS commercial cargo and crew flights from

2014 to 2023. Note that the first test flights of Falcon 9 and Antares were not funded by NASA and are captured in the forecast section entitled Technology Test and Demonstration Launches.

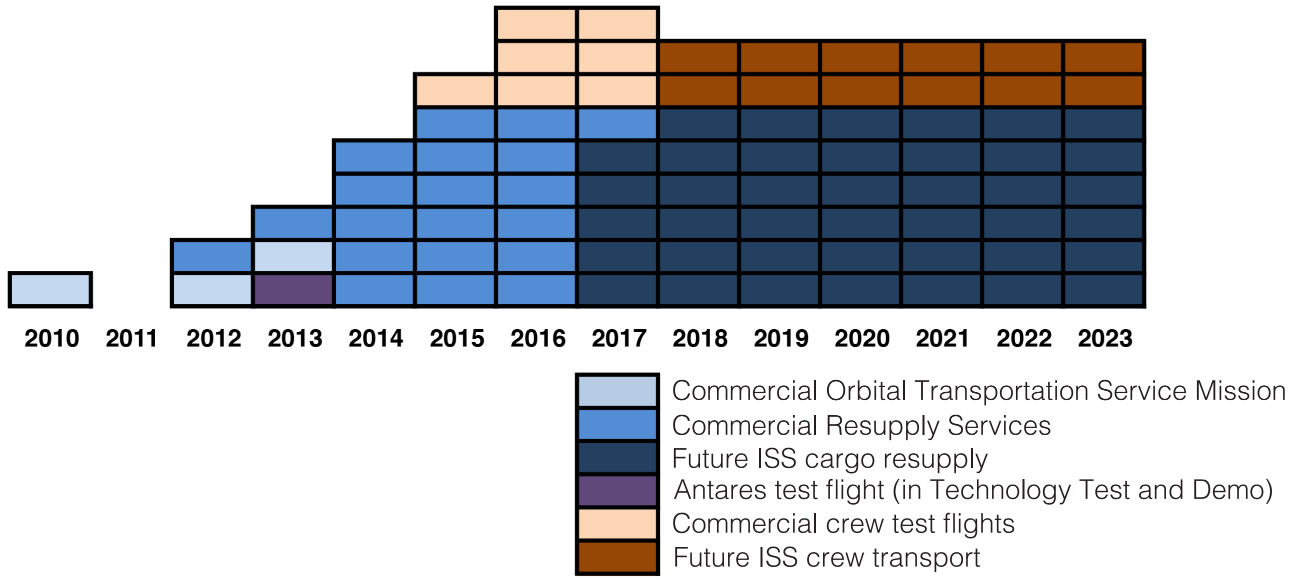
Figure 18. Commercial Cargo and Crew Transportation Services Launch History and Projected Launch Plans



NASA COTS

In 2006, NASA announced the COTS program. COTS focused on the development and demonstration of commercial cargo transportation systems. Total Space Act Agreement (SAA) funding under this program was $889 million. Under COTS, SpaceX developed the intermediate Falcon 9 launch vehicle and the Dragon spacecraft. Orbital Sciences Corporation developed the Cygnus spacecraft and

Figure 19. NASA Commercial Crew and Cargo Projections



[4] *Sources: NASA ISS Flight Plan, March 28, 2013, and NASA FY 2014 Budget Estimates: NASA Mission Launches (FY 2013-2020)*

the medium-class Antares launch vehicle. SpaceX completed its COTS milestones in 2012. Orbital's test flight of Antares launched on April 21, 2013, carrying a Cygnus mass simulator. The company conducted its COTS demonstration mission in September 2013, featuring a fully operational Cygnus that berthed with the ISS. The successful completion of this mission concluded NASA's COTS program.

NASA CRS

In 2008, NASA awarded two CRS contracts to SpaceX and Orbital. SpaceX won a contract valued at $1.6 billion for 12 flights through 2015, and Orbital won a $1.9 billion contract for 8 flights during the same period. Operational flights began in October 2012, with the successful launch of SpaceX's Dragon resupplying the ISS. Orbital's resupply missions began in January 2014. Subsequently, approximately six commercial cargo flights are expected each year through 2023.

NASA Commercial Crew

To stimulate commercial development of a crew transportation capability, NASA initiated the Commercial Crew Development (CCDev) effort in 2010 with $50 million of 2009 American Recovery and Reinvestment Act funding. CCDev focused on development of commercial space transportation concepts and enabling capabilities. The 2010 CCDev awardees were Blue Origin, Boeing, Paragon Space Development Corporation, Sierra Nevada Corporation, and United Launch Alliance (ULA).

In 2011, after completion of the initial CCDev effort, NASA continued investing in commercial crew transportation development with a second competition known as CCDev2. This follow-on effort further advanced commercial crew space transportation system concepts, maturing the design and development of system elements such as launch vehicles and spacecraft. Blue Origin, Boeing, Sierra Nevada Corporation, and SpaceX won awards totaling $315 million. Additionally, NASA awarded unfunded agreements to provide limited technical assistance for advancement of commercial crew space transportation to ULA; Alliant Techsystems (ATK); and Excalibur Almaz, Inc.

In 2012, NASA announced the next phase of commercial crew development, Commercial Crew Integrated Capability (CCiCAP). This new initiative is to facilitate industry's development of an integrated crew transportation system. CCiCap is expected to result in significant maturation of commercial crew transportation systems. Boeing, SpaceX, and Sierra Nevada Corporation won awards totaling over $1.1 billion. In December 2012, NASA awarded $30 million in Certification Products Contracts (CPC) to Boeing, Sierra Nevada, and SpaceX. Under this contract, each of these companies will work toward certifying its spacecraft as safe to carry humans to the ISS. The next award of funding by NASA is planned for mid-2014. Seven orbital test flights are expected between 2015 and 2017 before operational flights take place in late 2017. The initial test missions will not be licensed because they will be considered government flights.

Table 19 describes NASA COTS, CRS, and CCDev Awards.

Table 19. NASA Commercial Crew and Cargo Awards

Program	Year of Space Act Agreement	Value of Space Act Agreement	Companies	Vehicles and Technologies
COTS	2006	$396 million	SpaceX	Dragon
COTS	2006	$207 million	Kistler[5]	K-1
COTS	2008	$288 million	Orbital	Cygnus
CRS	2008	$1.6 billion	SpaceX	Dragon (12 flights)
CRS	2008	$1.9 billion	Orbital	Cygnus (8 flights)
CCDev	2010	$20 million	Sierra Nevada Corp.	Dream Chaser
CCDev	2010	$18 million	Boeing	CST-100
CCDev	2010	$6.7 million	United Launch Alliance (ULA)	Atlas V human rating
CCDev	2010	$3.7 million	Blue Origin	Launch abort systems
CCDev	2010	$1.4 million	Paragon Space	Life support
CCDev2	2011	$112.9 million	Boeing	CST-100 design maturation
CCDev2	2011	$105.6 million	Sierra Nevada Corp.	Dream Chaser design maturation
CCDev2	2011	$75 million	SpaceX	Crewed Dragon development
CCDev2	2011	$22 million	Blue Origin	Launch abort systems
CCDev2	2011	Unfunded	ULA	Atlas V human rating
CCDev2	2011	Unfunded	ATK/Astrium	Liberty development
CCDev2	2011	Unfunded	Excalibur Almaz	Spacecraft development
CCiCAP	2012	$460 million	Boeing	CST-100 crewed maturation
CCiCAP	2012	$440 million	SpaceX	Crewed Dragon maturation
CCiCAP	2012	$212.5 million	Sierra Nevada Corp.	Dream Chaser crewed maturation
CPC	2012	$10 million	Boeing	Crew Certification
CPC	2012	$10 million	Sierra Nevada Corp.	Crew Certification
CPC	2012	$10 million	SpaceX	Crew Certification

[5] *In 2007, NASA terminated the Space Act Agreement with Kistler due to the company's technical and financial shortfalls.*

Bigelow Aerospace

Nevada-based Bigelow Aerospace is developing expandable space habitat technology to support a variety of public and private activities including commercial space stations in LEO and human spaceflight missions beyond LEO. Its manufacturing plant, which occupies 31,731 square meters, is located in North Las Vegas, Nevada. Bigelow Aerospace has launched two prototype spacecraft, Genesis I and Genesis II, on separate Russian Dnepr launch vehicles in 2006 and 2007, respectively. Bigelow Aerospace used these missions to validate its habitat designs and engineering in an actual on-orbit environment.

Bigelow Aerospace is currently developing the Bigelow Expandable Activity Module (BEAM), a technology pathfinder system for the ISS. In December of 2012, NASA awarded Bigelow Aerospace a $17.8 million contract to develop the BEAM, which will launch on the eighth SpaceX CRS flight in 2015. The BEAM is scheduled for a nominal two-year technology demonstration period, wherein ISS crewmembers will gather data on the performance of the module. The BEAM mission period may be extended by NASA, and at the end of its life, the BEAM will be jettisoned from the ISS and will burn up during reentry.

Bigelow Aerospace has also been continuing work on full-scale expandable modules. Specifically, the company is developing the BA 330, which will offer 330 cubic meters of internal volume and can accommodate a crew of up to six, and the BA 2100 or 'Olympus', which will provide roughly 2,100 cubic meters of internal volume. In 2013, Bigelow Aerospace announced that it could modify the BA 330 in a number of ways depending on mission needs. The BA 330-DS would be designed for missions beyond LEO requiring additional radiation shielding. The BA 330-MDS would be designed for surface installations on the Moon. Finally, Bigelow Aerospace is considering a version of the BA 2100 that could carry spacecraft as well as crew, using a large airlock to facilitate transfers. These modules can be linked together to form space stations, and can also be linked together with any of a variety of tugs that the company intends to provide, including a Standard Transit Tug, a Solar Generator Tug, a Docking Node Transporter, and a Spacecraft Capture Tug.

Bigelow Aerospace is also involved in crew transportation. The company is a member of the Boeing CCDev team working on the CST-100 reusable in-space crew transport vehicle.

Bigelow Aerospace has also completed a substantial expansion to its north Las Vegas manufacturing plant. The company's new 180,572 square foot addition now increases the size of Bigelow Aerospace facilities to a total of 341,551 square feet.

Currently, with the exception of the BEAM launch aboard the eighth CRS flight, no launch contracts have been publicly announced. Such contracts will likely not be announced until the company can secure viable crew transportation, such as the Boeing CST-100 or SpaceX Dragon capsules. As a result, launch demand associated with Bigelow Aerospace is not included in this section.

Planetary Resources

In April 2012, Planetary Resources, Inc., a company formed by Space Adventures founder Eric Anderson and X PRIZE Chairman Peter Diamandis, introduced its plans to mine near-Earth asteroids for raw materials. In its initial efforts, Planetary Resources is focusing on telescopes designed to identify resource-rich targets. It has entered into an agreement with Virgin Galactic to launch several constellations of Arkyd-100 Series LEO space telescopes on Virgin Galactic's LauncherOne. LauncherOne is still under development with commercial flights estimated to begin in 2016. The company's A3 cubesat and Arkyd-100 telescope will be launched as secondary payloads during the forecast period.

Other Sources of Future Launch Demand

Several other efforts have been pursued in recent years that will require commercial crew and cargo transportation, or may in the future. Some of these, Inspiration Mars Foundation and Space Adventures, have enough funding to press forward with mission planning and even hardware development. Other efforts like Excalibur Almaz and Golden Spike have raised limited funds. At this time, no launch contracts have been announced, so launch demand associated with these companies is not included in the forecast.

Blue Origin

Blue Origin is a U.S-based company pursuing development of a crewed suborbital transportation system called New Shepard and an orbital crewed system consisting of a Reusable Orbital Space Vehicle (SV) launched aboard a two-stage Orbital Launch Vehicle (OLV). The SV will be designed to carry seven people. The reusable OLV first stage will be powered by a cluster of BE-3 liquid rocket engines. In 2013, the company successfully tested the BE-3, which burns liquid hydrogen and liquid oxygene and produces about 100,000 pounds of thrust. The company has not yet released a schedule for test launches.

Excalibur Almaz

Excalibur Almaz, Limited (EAL), an Isle of Man company, uses elements of a legacy Soviet military space program known as Almaz. EAL's key partners are NPO Mashinostroyenia (the original developer of Almaz), Airbus Group, and Japan Manned Space Systems Corporation. The system includes four three-person reusable return vehicles (RRV) and two Salyut-type Almaz orbital space stations that can stay on-orbit autonomously for one week or dock with the ISS. One of the RRVs will be equipped as an unmanned microgravity laboratory to assist with science flights to LEO. NASA awarded EAL an unfunded SAA for commercial crew transportation as part of CCDev2 activities, and was the first company to complete all of its SAA milestones. If in the future NASA decides to use the system, the baseline vehicle will be the Atlas V. In June 2012, the company announced plans to ferry passengers to and from lunar orbit, with tickets costing around $155 million. EAL intended to begin flight tests of Almaz by late 2014 and to launch its first revenue-generating flight as early as the fourth quarter of 2015. However, details regarding financing have not been provided publicly, and no launch contracts have been announced.

Golden Spike Company

The Golden Spike Company formed to offer private human expeditions to the surface of the Moon by 2019 or 2020. The company's president is former NASA Associate Administrator for Science Alan Stern. Golden Spike estimates the cost for a two-person lunar surface mission will start at $1.4 billion for the first mission, and $1.6 billion for increasingly ambitious subsequent missions. Golden Spike contracted with Northrop Grumman for the design of a new lunar lander capable of carrying two crewmembers.

Inspiration Mars Foundation

The Inspiration Mars Foundation originally hoped to mount a privately funded crewed Mars flyby mission originally planned for 2018. By early 2014, this objective slipped to 2021 and now includes NASA's Space Launch System (SLS) as part of its architecture. The project aims to take advantage of a planetary alignment that will allow a Mars flyby and return in 501 days. The foundation plans to use a single SLS launch to send a Dual Use Upper Stage (DUUS) and a modified Cygnus module into LEO. The SLS and DUUS are currently being developed by NASA. The Cygnus module is provided by Orbital Sciences Corporation as a cargo transport to ISS. A second launch, using a smaller vehicle like an Atlas V or Delta IV, will send a crew of two aboard an NASA's Orion spacecraft. Inspiration Mars Foundation Chairman Dennis Tito will fund mission development for the first two years, during which time additional fundraising and support will be garnered.

Space Adventures

Space Adventures, a broker for space tourism and expeditions, indicated in 2011 that it was in the late planning stages for a three-person expedition to circumnavigate the Moon. Two of the individuals will pay for their seats, while a third will be a Roscosmos cosmonaut. This effort will include two separate launches, one of a Proton-M carrying a Block-DM lunar transfer stage, and one of a Soyuz with two crew members. The ticket price for each of the seats is rumored to be about $150 million. The company has indicated that at least one ticket has been sold and that the other is in final negotiations.

OTHER COMMERCIALLY LAUNCHED SATELLITES

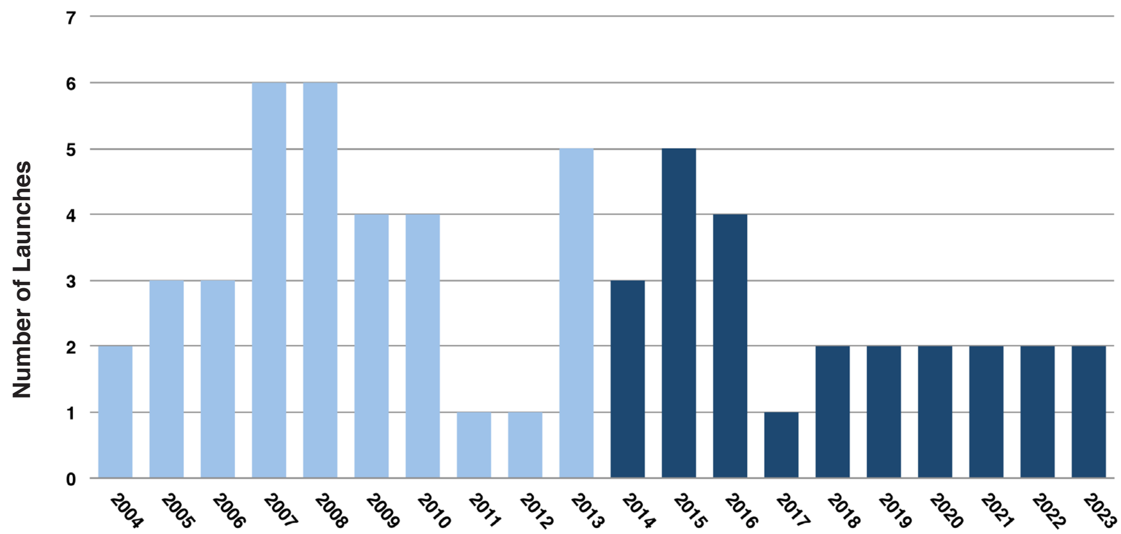
This section contains predominantly government satellites launched commercially. It also includes university payloads that are scientific, education, or outreach. Though many government missions do not commercially procure or obtain commercial licenses for their launches, there are select missions that do, particularly by governments without domestic launch capabilities.

In previous reports, Other Commercially Launched Satellites were discussed in the sections "Science and Engineering – Basic and Applied Research" and "Other Payloads Launched Commercially." For clarity, these sections were combined to provide a more complete picture of the market of commercial launches procured by governments. Government Earth observation and remote sensing programs and other scientific missions are significant customers of commercial launch services to NGSO.

Other Commercially Launched Satellites Demand Summary

The market characterization of the near term (2014-2017) includes 13 manifested launches. For the period 2018-2023, the application of a forecasting method projects 12 launches for an average of 2 in each of the 6 out years. Figure 20 provides a launch history and projected launch plan demands for Other Commercially Launched Satellites.

Figure 20. Other Commercially Launched Satellites Launch History and Projected Launch Plans



2014	2015	2016	2017
ASNARO - Dnepr	SAOCOM 1A - Falcon 9	DragonLab 1 - Falcon 9	DragonLab - Falcon 9
PAZ - Dnepr	Formosat 5 - Falcon 9	DubaiSat-3 - Dnepr	
Google X PRIZE - LM-2C	Gökturk 1 - TBD	EnMAP - PSLV	
	Kompsat 3A - Dnepr	SAOCOM 1B - Falcon 9	
	Deimos - Dnepr		

- **ASNARO 1:** ASNARO is a remote sensing satellite for the Japanese Ministry of Economy, Trade, and Industry manufactured by the NEC. The satellite has a projected mass of 400 kilograms (882 pounds) and will launch on a Dnepr in 2014.
- **DragonLab:** DragonLab is the configuration of the Dragon spacecraft intended for commercial customers that will operate independently of missions to the ISS. DragonLab will function as an orbital laboratory that can host pressurized and unpressurized experiments. The spacecraft is expected to be recoverable and reusable. SpaceX anticipates one DragonLab mission per year starting in 2016.
- **DubaiSat-3:** A follow-on to the DubaiSat-2, launched last year, from the Emirates Institution for Advanced Science and Technology located in the UAE, it is scheduled to launch as a primary payload in a multi-manifested launch aboard Dnepr vehicles in 2016. The satellite has a mass of about 300 kilograms (661 pounds) and will provide improved resolution and faster download speeds.
- **EnMAP:** The German Aerospace Center, DLR, plans to launch the EnMap spacecraft in 2016 on a PSLV vehicle. The spacecraft has a mass of 810 kilograms (1,786 pounds) and will study a range of ecological parameters, including agriculture, forestry, soil, and geology using its hyperspectral instruments. The mission is expected to last five years.
- **FORMOSAT-5:** Formosat-5 is a remote sensing satellite for Taiwan's National Space Organization. It is expected to launch in 2015 on a Falcon 9 vehicle. The satellite is built by Airbus. With a mass of 525 kilograms (1,157 pounds), the satellite will be equipped with an optical payload for remote sensing and a number

of science payloads. The optical payload will provide panchromatic images with a 2-meter (6.5-foot) resolution and multispectral images with a 4-meter (13-foot) resolution.

- **Gökturk-1:** Gökturk-1 is an electro-optical earth observation satellite for the Turkish Ministry of Defense. Italian firm Telespazio is the manufacturer. The satellite is projected to have a mass of up to 5,000 kilograms (11,000 pounds) and is expected to launch in 2015 (originally planned for 2014) on a Vega launch vehicle.
- **KOMPSAT-3A:** Also known as KOMPSAT-3's "brother satellite," KOMPSAT-3A will include the ability to obtain images in the infrared spectrum and panchromatic images, allowing for temperature change monitoring. South Korea's Korean Aerospace Research Institute (KARI) is developing KOMPSAT-3A, which will launch in 2015 (delayed from 2014) on a Dnepr vehicle.
- **PAZ:** PAZ is a radar satellite that will be operated by Hisdesat. It represents part of the Spanish National Earth Observation Program developed and managed jointly by the Ministry of Defense and the Ministry of Industry, Trade and Tourism. Imagery obtained by this satellite, which is based on the TSX-1 bus developed for Infoterra's TerraSAR-X and TanDEM-X, will be used for national security and commercial purposes. PAZ is scheduled to launch aboard a Dnepr vehicle in 2014.
- **SAOCOM-1A, -1B:** SAOCOM-1A is part of Argentina's SAR Observation & Communication (SAOCOM) satellite program and will operate jointly with Italian satellites to provide information for emergency management. The satellite will capture high-resolution images, and when paired with the solid state recorder on board, will be able to store images and share them via its high-bit-rate downlink system. The second Argentine satellite, SAOCOM-1B, will also communicate with Italian satellites to provide information for emergency management. The satellites will launch separately on Falcon 9 vehicles in 2015 and 2016.
- **SARah:** SARah is a German Federal Armed Forces satellite-based radar reconnaissance system. The three synthetic aperture radar (SAR) satellites are a follow-on to Germany's SAR-Lupe system, which is schedule to operate until 2017. Two of the SARah satellites are enhanced reflector technology that was developed for SAR-Lupe and will be built by OHB Systems AG. The third satellite will build by Astrium GmbH using phased array technology similar to TerraSAR-X and TanDEM-X. These satellites are planned for launch on two Falcon 9 missions in 2017 and 2018.

Method for Forecasting Launch Demand

This forecast revised the model for payloads and launches related to basic and applied scientific research that was applied in the 2012 NGSO report. The methodology features a five-year average that includes three prior years and two projected years (for this report, 2010-2014) with equal weight. This simple model is applied to payloads as well as launch vehicles pertaining to basic and applied scientific research beginning in 2017, the mid, and far out-years. This makes the out-years of the projection more sensitive to emerging trends identified in the near-term through research. Because launches of other payloads, from countries without indigenous launch capabilities, are infrequent, the model does not apply a forecasting method to this segment. This does not mean the actual demand is gone, but rather these types of payloads are irregular and efforts to forecast their occurrence in the out-years can lead to an overstatement of launch demand.

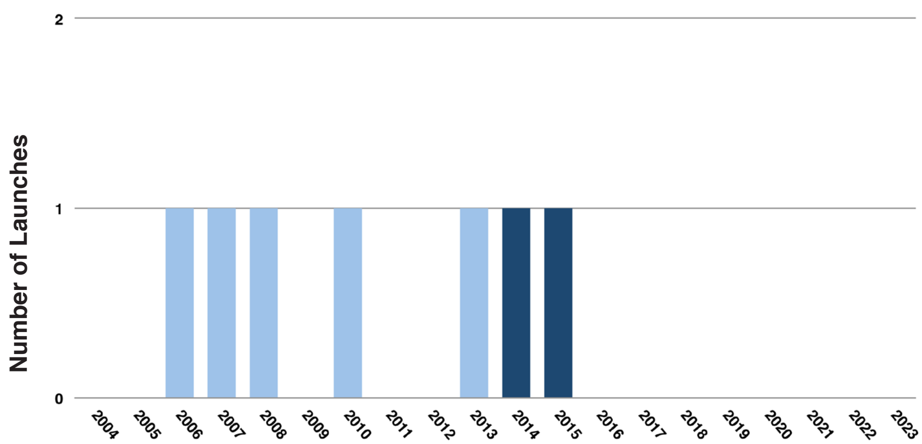
TECHNOLOGY TEST AND DEMONSTRATION LAUNCHES

Technology test and demonstration launches was previously part of Science and Engineering section. Technology test and demonstration launches are conducted to test primarily new launch vehicles such as Antares, Falcon 9, or Falcon Heavy. By their nature, they are uncommon, and one-off events. Placing technology test and demonstration launches in a separate section provides easy identification of these one-off events.

Figure 21 provides a launch history and projected launch plans for technology test and demonstration launches.

The inaugural launch of SpaceX's Falcon Heavy launch vehicle is now planned for launch in 2015. The report also includes the technology test and demonstration launch of the Orion Multi Purpose Crew Vehicle (MPCV), planned to launch aboard a Delta IV Heavy in late 2014.

Figure 21. Technology Test and Demonstration Launch History and Projected Launch Plans



2014	2015	2016	2017
Orion EFT-1 - Delta IV Heavy	Test - Falcon Heavy		

SPECIAL SECTION: MICROSATELLITES

Progress in electronics and other satellite component miniaturization has enabled spacecraft weighing as little as 0.01 to 10 kilograms, known as femto-, pico-, and nanosatellites. Table 20 presents the range of small satellite mass classes.

While pico- and femtosatellites are rare, micro- and nanosatellites, and specifically, a subset of nanosatellites called CubeSats, constitute a substantial share of payloads launched commercially.

Table 20. Small Satellite Mass Classes

Class Name	Kilograms (kg)	Pounds (lb)
Femto	0.01 - 0.1	0.02 - 0.2
Pico	0.09 - 1	0.19 - 2
Nano	0.9 - 10	3 - 22
Micro	11 - 200	23 - 441
Mini	201 - 600	442 - 1,323
Small	601 - 1,200	1,324 - 2,646

CubeSats are a distinctive group of small satellites in the nanosat mass class. CubeSats are miniaturized satellites measuring 10x10x10 centimeters and weighing 1 kilogram, also know as 1 unit (1U). Satellite units can be combined to create double- or triple-unit (2U or 3U) CubeSats with measurements of 10x10x20 centimeters (2U) or 10x10x30 centimeters (3U), respectively. They can offer the standard functions of a normal satellite, including deployment of solar panels, antennas, and booms. By the end of 2013, over 200 CubeSats have launched, and more CubeSats are either ready to launch or in various phases of planning, development and production, or launch preparation.

The original cubesat concept was introduced in 2003 as a low-cost university educational satellite platform and gradually became the standard for most university satellites. Universities are still the main organization building these spacecraft. As CubeSats become more capable, government and private industry have become more interested in launching and operating them. For example, spacecraft manufacturers build these satellites to space-qualify equipment for future use on larger satellites.

Because of their size, individual CubeSats often perform just one function at a time. However, constellations of CubeSats can potentially work together to provide greater functionality. A cubesat constellation would require enough CubeSats that if one or two failed, it would not be mission critical. Beside universities, government agencies have become interested in developing cubesat constellations.

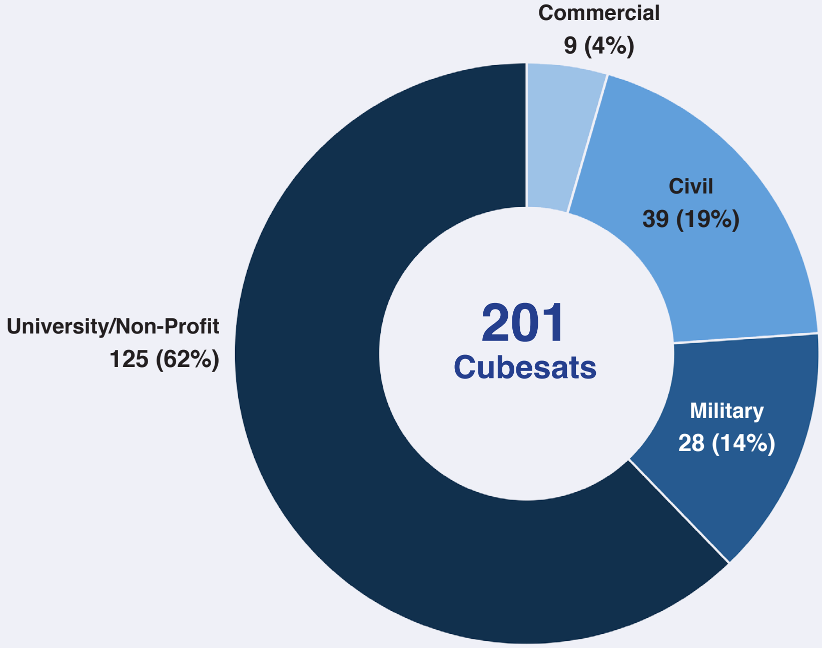
CubeSats are usually launched as piggyback payloads using excess launch capacity on launch vehicles deploying larger primary payloads. Some CubeSats are deployed in orbit, usually from the International Space Station (ISS) after being delivered to it as cargo.

In 2003 - 2013, both non-commercial and commercial launch vehicles launched a total of 201 CubeSats worldwide (see Table 21). The majority of CubeSats were launched for non-profit (mostly university) missions (see Figure 22).

Table 21. CubeSats Launched from 2003 to 2013

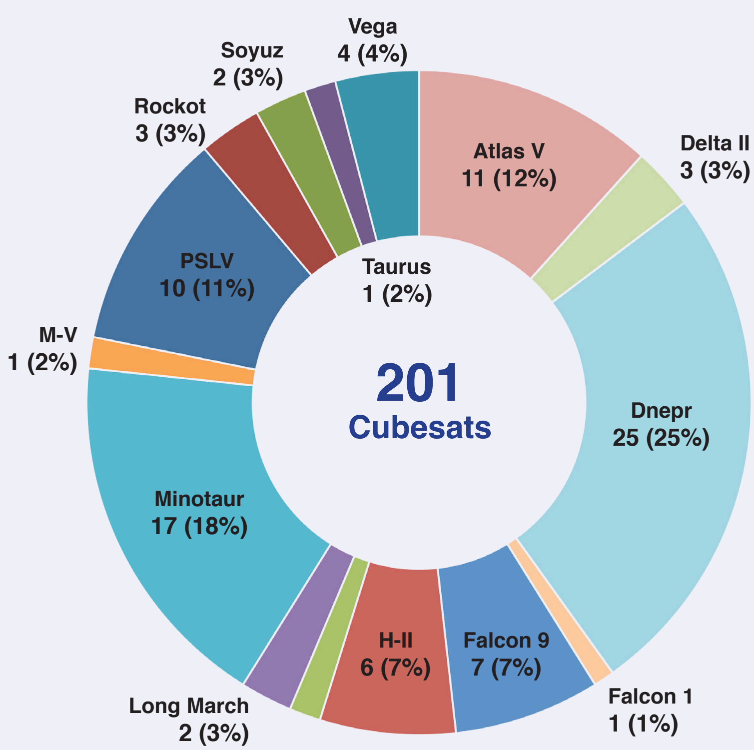
Type of Launch	Cubesats
Commercial	86
Non-Commercial	115
Total CubeSats Launched	**201**

Figure 22. Microsatellites and Nanosatellites Launched in 2003-2013



At present, CubeSats by themselves do not present launch demand. In the commercial space launch industry, launch providers are interested in creating space for smaller secondary payloads to drive the launch price down or increase profits. There have been an increasing number of CubeSats launched over the past decade with a record number launched in 2013. More of them are expected to launch in the future, however, this increase is not expected to affect launch demand in the short term. The market situation may change when commercial suborbital reusable vehicles and small orbital launch vehicles (commercial and non-commercial) introduce new nanosat launch opportunities, including those for CubeSats.

Figure 23. Microsatellites and Nanosatellites Launched by Vehicle, 2003-2013



Historically, a variety of launch vehicles have launched CubeSats (see Figure 23). Over the past decade, the Russian Dnepr launch vehicle has launched the largest number. Other vehicles, such as Atlas V (U.S.), Falcon 9 (U.S.), Minotaur (U.S.), PSLV (India), and Vega (Europe) vehicles have been launching more CubeSats lately.

In 2013, a record number of 92 cubesat class satellites were launched, including 59 CubeSats on 2 launch vehicles launched about only 30 hours apart. Those missions were a U.S. Air Force mission on Minotaur I and a Russian Dnepr mission, both launched in November.

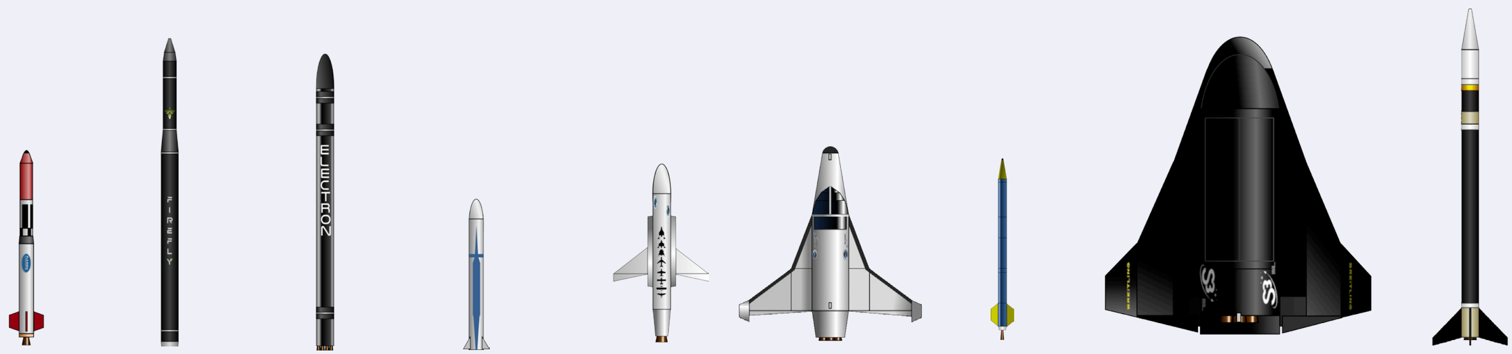
U.S. company NanoRacks also provides capability for orbiting CubeSats from the International Space Station (ISS). Prior to such insertion, the CubeSats are delivered to ISS onboard orbital cargo vehicles, such as the HTV and Cygnus.

In the United States, the NASA Educational Launch of Nanosatellites (ELaNa) program promotes satellite building for space engineering and science education purposes by providing universities and other organizations developing small satellites with free launches aboard vehicles carrying larger primary missions for NASA or other U.S. Government agencies. These include non-commercial launches by vehicles like the Atlas V or commercial launches to the ISS by a Falcon 9 or Antares.

In the commercial launch sector, Virgin Galactic announced LauncherOne in 2012 to launch satellites weighing up to 100 kilograms to LEO, commercial flights projected to begin in 2016. Super Strypi (also known as SPARK) is another launch vehicle scheduled to make its first flight in 2014. It is designed to launch payloads in the range of 300 kg to LEO.

At present, CubeSats are predominantly used for technology demonstration, both in spacecraft technology and satellite applications, such as communications and remote sensing. As the technology matures, more CubeSats are built for scientific, communications, and remote sensing purposes, including emerging commercial applications. Thus, U.S. commercial remote sensing company Planet Labs launched a “Flock” of 75 3U CubeSats from the ISS, delivered by the Cygnus CRS-1 mission in early 2014 and is planning to launch 25 more CubeSats each year during the forecast period. Another Earth remote sensing commercial venture will use 6U CubeSats in an 8-satellite Perseus-O constellation, planned by Dauria Aerospace and Elecnor Deimos. Planetary Resources, Inc. also plans to launch cubesat-sized satellites carrying telescopes designed to identify resource-rich targets among near-Earth asteroids.

Table 22 provides summary information on launch vehicles expected to be introduced during the next five years that are specifically designed to launch microsatellites. The majority of these, DARPA’s Airborne Launch Assist Space Access (ALASA), Generation Orbit’s GOLauncher-2, Virgin Galactic’s LauncherOne, and S3’s Sub Orbital Aircraft Reusable (SOAR), will be air-launched by a carrier aircraft. Lynx III uses rocket power to take off from a conventional runway, reach suborbital space, release a small launch vehicle with a nanosatellite, then return to land like a conventional airplane. Super Strypi is a rail-launched vehicle.



	ALASA	Alpha	Electron	GOLauncher-2	LauncherOne	Lynx III	NEPTUNE 5 NEPTUNE 9 NEPTUNE 36	SOAR	Super Strypi
Operator	DARPA	Firefly Space Systems	Rocket Lab	Generation Orbit	Virgin Galactic	XCOR Aerospace	Interorbital Systems	Swiss Space Systems	DoD
Manufacturer	DARPA, Boeing	Firefly Space Systems	Rocket Lab	Generation Orbit	Virgin Galactic, SSTL	XCOR Aerospace	Interorbital Systems	Dassault, Deimos, Sonaca, Meggitt	Aerojet Rocketdyne, Sandia Labs
LEO Capacity (kg)	45	400	110	45	100	15	30 50 1,000	250	275
Planned First Flight	2015	TBD	2015	2016	2016	TBD	TBD	2017	2014
Method of Launch	Air	Ground	Ground	Air	Air	Suborbital	Ground	Air/Suborbital	Ground (Rail)
Estimated Launch Price	$1M	$9M	$4.9M	$1.75M	$10M	$0.545M	$0.32M $0.533M $10.7M	$10.5M	$15

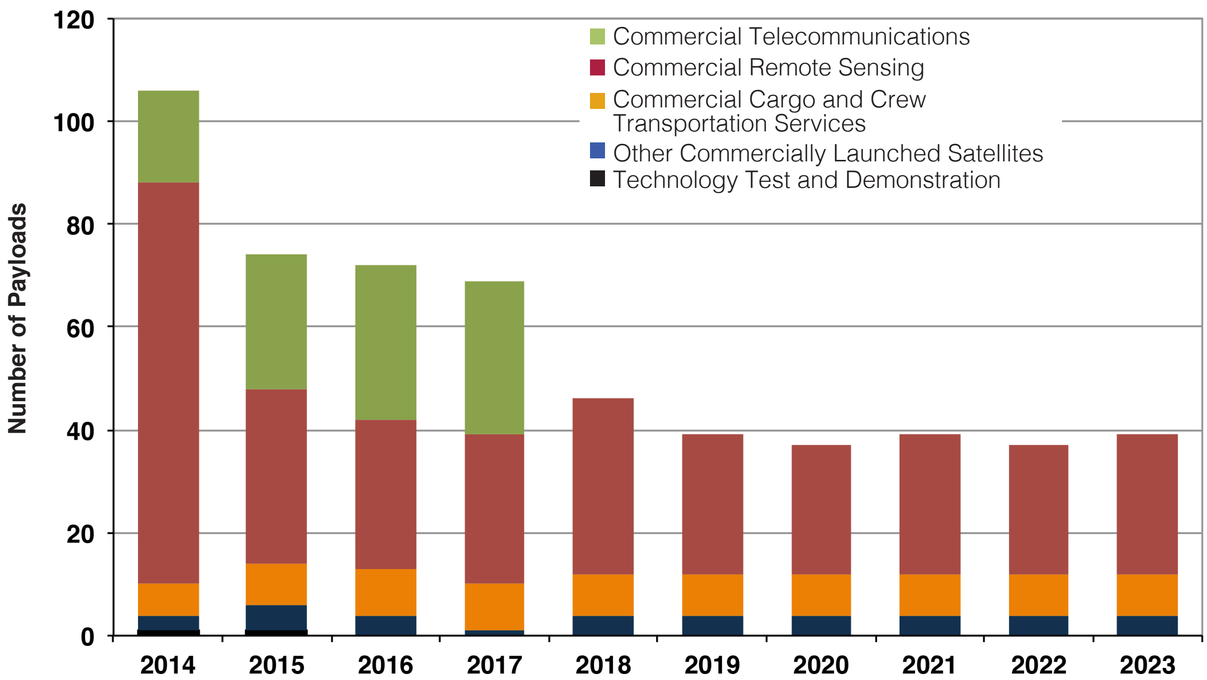
Table 22. Selected Small Launch Vehicles Expected to be Introduced During the Next 5 Years

SATELLITE AND LAUNCH FORECAST TRENDS

The demand for commercial GEO launches for the next 10 years is expected to stay relatively steady at 15 to 17 launches per year. The demand for commercial NGSO launches is expected to increase relatively significantly as major NGSO telecommunication constellations are replenished and NASA ISS commercial crew and cargo resupply missions become more regular. The annual average of NGSO commercial launches is expected to grow from an annual average of 6 launches a year to almost 14 launches annually

From 2014 to 2023, 558 payloads are projected to launch commercially, driving 138 launches with multi-manifesting. Ten more launches over the next decade are projected compared to last year's forecast of 128 launches. This increase is driven primarily by additional flights for commercial crew and cargo and commercial remote sensing. Figures 24 and 25 show the payloads and launches projected from 2013 to 2022. Table 23 provides the specific numbers of payloads and launches for each segment.

Figure 24. Payload Projections



Fifty-eight percent of the predicted launches over the next 10 years are for commercial transportation services. As noted earlier, many of these launches take place on newly developed vehicles. These missions also partly rely on government funding subject to annual appropriations.

Other Commercially Launched Satellites account for 18 percent of launches over the next 10 years. These include a steady stream of basic and applied research and non-commercial remote sensing payloads primarily from countries without indigenous launch capabilities.

Figure 25. Launch Projections

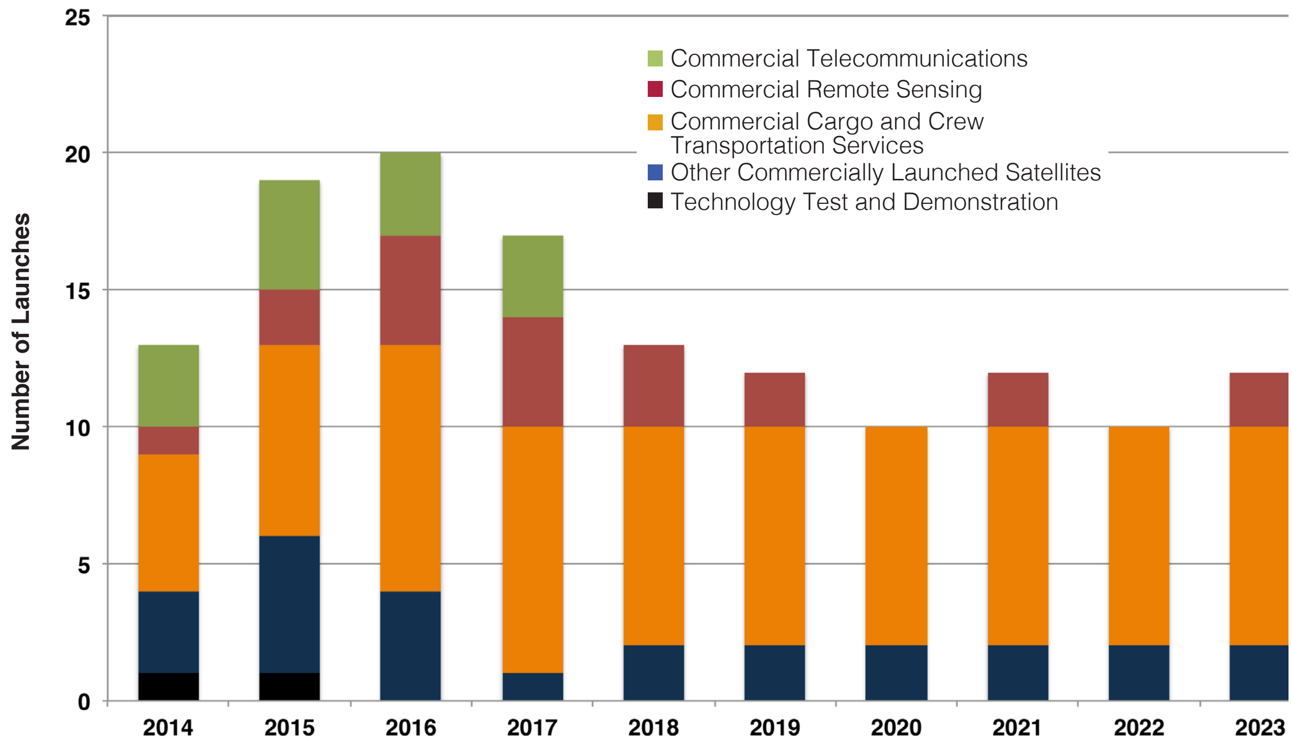


Table 23. Payload and Launch Projections

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total	Avg.
Payloads												
Commercial Telecommunications	18	26	30	30	0	0	0	0	0	0	104	10.4
Commercial Remote Sensing	78	34	29	29	34	27	25	27	25	27	335	33.5
Commercial Cargo and Crew Transportation Services	6	8	9	9	8	8	8	8	8	8	80	8
Other Commercially Launched Satellites	3	5	4	1	4	4	4	4	4	4	37	3.7
Technology Test and Demonstration	1	1	0	0	0	0	0	0	0	0	2	.2
Total Satellites	**106**	**74**	**72**	**69**	**46**	**39**	**37**	**39**	**37**	**39**	**558**	**55.8**
Launches												
Medium-to-Heavy Vehicles	13	18	16	14	13	10	10	10	10	10	124	12.4
Small Vehicles	0	1	4	3	0	2	0	2	0	2	14	1.4
Total Launches	**13**	**19**	**20**	**17**	**13**	**12**	**10**	**12**	**10**	**12**	**138**	**13.8**

The commercial remote sensing accounts for 14 percent of the launches and all the demand for small vehicles. Projected demand is considerably higher in this year's report due the inclusion of new commercial remote sensing companies like Skybox Imaging.

Nine percent of the launches are for commercial telecommunications. Five launches are planned in 2014 and 2015 for ORBCOMM, Globalstar, and O3b satellites. There is another peak of telecommunications launches from 2015 to 2017 as Iridium replaces its satellites. No telecommunications launches are forecasted from 2018 to 2022, after the replacement constellations are completed.

The technology test and demonstration segment accounts for less than 2 percent of launches over the next 10 years, including 2 launches of new technology test and demonstration missions: SpaceX's Falcon Heavy, and NASA's uncrewed test of the Orion MPCV on a Delta IV Heavy.

Payload mass varies significantly in the commercial NGSO market. Increasing numbers of micro- and nanosatellites are launched as secondary or piggyback payloads, and many countries commercially launch mini, small, and medium sized satellites to LEO for scientific research or remote sensing. The number of cubesats launched in 2013 almost double from the previous year. NGSO commercial telecommunications satellites are large constellations of satellites with sizes ranging from nano (AprizeStar) to micro (ORBCOMM) to small (Globalstar, Iridium, O3b), none over 800 kilograms. In contrast, the average mass of a GSO telecommunications satellite is approximately 5,000 kilograms, with many GSO satellites significantly heavier than that. Crew and cargo spacecraft to the ISS and Bigelow space stations will likely include large, heavy, or extra heavy payloads. Table 24 shows the mass distributions of known manifested payloads over the next two years.

There are 138 launches projected, comprising 14 small vehicles and 124 medium-to-heavy vehicles. On average, 1.4 launches take place on small vehicles and 12.4 launches on medium-to-heavy vehicles every year. The 2012 report included 130 total launches composed of 3 small and 127 medium-to-heavy launches.

Table 24. Distribution of Payload Masses in Near-Term Manifest

Mass Class	Mass Class Weight	2014	2015	Total	Percent of Total
Femto, Pico, Nano, Micro	0.01-200 kg (0.02-441 lbs)	41	6	14	17%
Mini	200-600 kg (441-1,323 lbs)	9	13	22	27%
Small	600-1,200 kg (1,323-2,646 lbs)	10	18	28	35%
Medium, Intermediate	1,200-4,200 kg (2,646-9,259 lbs)	3	3	6	7%
Large	4,200-5,400 kg (9,259-11,905 lbs)	0	0	0	0%
Heavy, Extra Heavy	> 5,400 kg (>11,905 lbs)	4	7	11	16%
	Total	**34**	**47**	**81**	**100%**

Launch demand divided among launch vehicle mass classes is depicted in Figure 26. The number of medium-to-heavy launches increased slightly compared to last year's forecast, due to the addition of commercial crew test flights in the mid-term. The relatively high cost of a dedicated launch on a small launch vehicle compared to a secondary or piggyback payload on a larger vehicle has kept the demand for small launch vehicles low. This dynamic is beginning to change as new small vehicle systems like Virgin Galactic's LauncherOne become available. This year's report includes 11 more launches of small vehicles, all that demand coming from commercial remote sensing. Factors smaller payloads continuing to use larger launch vehicles are more multiple-manifest launch services, carrying primary missions on both commercial and non-commercial basis, have become readily available in the recent years; many small payload operators are tied to government funding or national launch capabilities (e.g., small European missions launched by Vega or U.S. university missions getting free rides through programs like NASA's ELaNa). Intermediary companies (such as SpaceFlight Services, Commercial Space Technologies Ltd., and some others) offering brokerage services and pooling together clusters of secondary payloads to be launched together on a single launch vehicle have made the business of booking flights for secondary payloads more organized and predictable.

Table 25 on the next page provides the distribution of launches among the market segments.

Figure 26. Launch Vehicle Projections

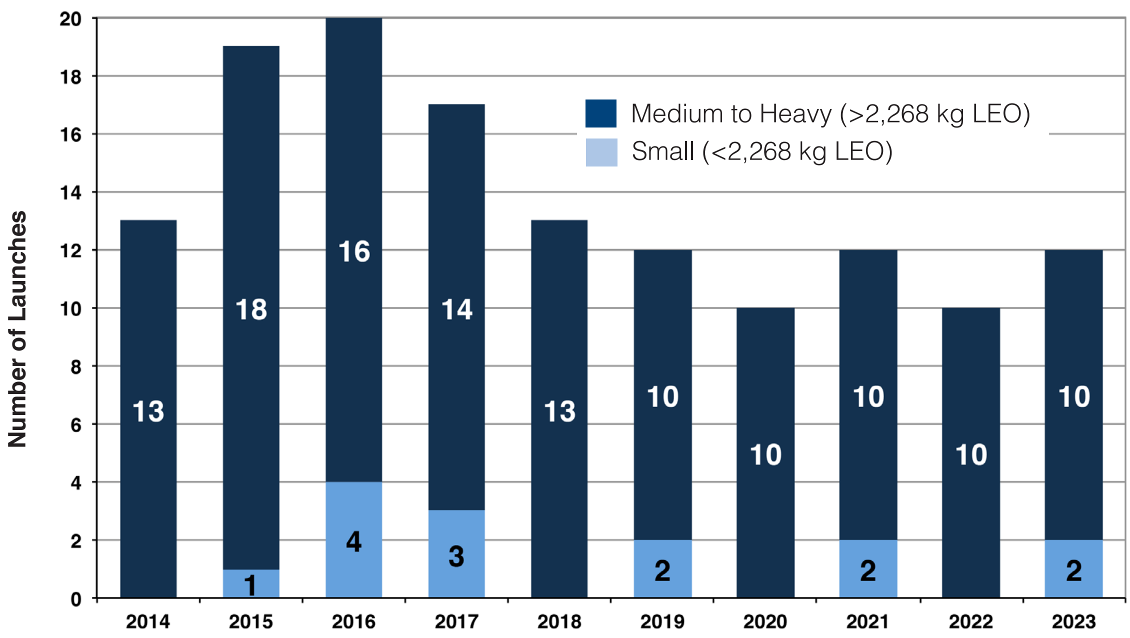


Table 25. Distribution of Launches among Market Segments

Market Segment	Payloads	Launch Demand		
		Small	Medium-to-Heavy	Total
Commercial Telecommunications	104	0	13	13
Commercial Remote Sensing	335	14	6	20
Commercial Cargo and Crew Transportation Services	80	0	78	78
Other Commercially Launched Satellites	37	0	25	25
Technology Test and Demonstration	2	0	2	2
Total	**558**	**14**	**124**	**138**

LAUNCH VEHICLES TYPICALLY USED FOR NGSO MISSIONS

During the forecast period, several changes will occur in the availability of launch vehicles for customers seeking to launch to NGSO on commercially procured vehicles. In the U.S., SpaceX began to launch revenue-generating flights of the Falcon 9 in 2012, and Orbital's Antares vehicle begin revenue-generating flights in 2014. In 2015 Orbital will launch the Minotaur C, essentially a modified Taurus, with Skybox Imaging satellites. The Super Strypi, a rail launched vehicle, may launch for the first time in 2014. Virgin Galactic intends to begin commercial launches of its new LauncherOne vehicle in 2016, and has booked three Skybox Imaging flights that year. Generation Orbit and XCOR are also expected to provide small launch services in the near-term. Stratolaunch Systems, which is developing a vehicle that will be launched from a huge carrier aircraft called Stratolauncher, will introduce its vehicle system in 2018. This vehicle will have a capacity of about 6,000 kg to LEO.

In Europe, Arianespace's small vehicle Vega is now available for commercial launches, and the company will be introducing a replacement to Ariane 5 later in the forecast period. Swiss Space Systems is also expected to introduce its SOAR shuttle in 2017, which will carry small payloads to LEO. China may introduce a small vehicle called the Long March 6, which may be offered commercially, by 2017. The larger Long March-5, -7, and -11 are also expected to be introduced during the forecast period. In 2013, Japan launched its Epsilon small launch vehicle in 2013 and South Korea launched the small Naro-1 vehicle. Russia plans the first launch of its long-awaited Angara series in 2014.

RISK FACTORS THAT AFFECT SATELLITE AND LAUNCH DEMAND

The demand projection is the number of satellites that operators expect to launch in a given year. This demand is typically larger than the number of satellites actually launched. Factors that contribute to the difference between forecasted and realized launches include financial, political, and technical uncertainty.

Financial Uncertainty

- **U.S. national and global economy:** Strong overall economic conditions historically foster growth and expansion in satellite markets. Similarly, relatively weak currency exchange rates in one nation generally create favorable circumstances for exporters and buyers in a given marketplace. Global satellite manufacturers and purchasers have shown strong interest in taking advantage of the highly attractive values offered by the historically low U.S. dollar exchange rates. However, as the dollar rises in value, this trend will reverse.
- **Investor confidence:** After investors suffered large losses from the bankruptcies of high-profile NGSO systems in the early 2000s, confidence in future and follow-on NGSO telecommunications systems have abated.
- **Business case changes:** The satellite owner or operator can experience budget shortfalls, change strategies, or request technology upgrades late in the manufacturing stage, all of which can contribute to schedule delay. An infusion of cash from new investors can revive a stalled system or accelerate schedules.
- **Corporate mergers:** The merging of two or more companies may make it less likely for each to continue previous plans and can reduce the number of competing satellites that launch. Conversely, mergers can have a positive impact by pooling the resources of two weaker firms to enable launches that would not have occurred otherwise.
- **Terrestrial competition:** Satellite services can complement or compete with ground-based technology, such as cellular telephones or communications delivered through fiber optic or cable television lines. Aerial remote sensing also competes with satellite imagery. Developers of new space systems have to plan ahead extensively for design, construction, and testing of space technologies, while developers of terrestrial technologies can react and build to market trends more quickly and might convince investors of a faster return on investment.

Political Uncertainty

- **Increase in government purchases of commercial services:** For a variety of reasons, government entities have been purchasing more space-related services from commercial companies. For example, the DoD continues to purchase significant remote sensing data from commercial providers.
- **Regulatory and political changes:** Export compliance, FCC licensing, NOAA licensing, or international licensing requirements can delay progress on a satellite program. U.S. Government policy regarding satellite and launch vehicle export control has hindered U.S. satellite manufacturers and launch vehicle operators working with international customers. This causes delays as well as cancellations of satellite programs. Changes in FCC or NOAA processes, export control issues associated with space technology, and political relations between countries can all affect demand.
- **Increase in government missions open to launch services competition:**

Some governments keep launch services contracts within their borders to support domestic launch industries. However, ESA has held international launch competitions for some of its small science missions, and some remote sensing satellite launches have been competed. While established space-faring nations are reluctant to open up to international competition, the number of nations with new satellite programs but without space launch access slowly increases.

Technical Uncertainty

- **Satellite lifespan:** Many satellites outlast their planned design life. The designated launch years in this report for replacement satellites are often estimates for when a new satellite will be needed. Lifespan estimates are critical for timing the replacements of existing NGSO satellite systems given the high capital investment required to deploy a replacement system.
- **Need for replacement satellites:** Although a satellite might have a long lifespan, it can be replaced early if it is no longer cost-effective to maintain; or an opportunity might arise that allows a satellite owner or operator to exceed the competition with a technological advancement. Higher resolution commercial remote sensing satellites are an example of this factor.
- **Launch vehicle technical issues:** Launch vehicle manufacturers and operators may have manufacturing, supplier, or component issues or experience launch anomalies or failures. Any of these issues can delay the availability of a launch vehicle or cause a delay at the launch pad. Launch delays can have a cascading effect on subsequent launches. Some missions have specific launch windows (for example, science windows), and missing that window may result in lengthy delays.
- **Satellite technical issues:** Satellite manufacturers may have factory, supplier, or component issues that delay the delivery of a satellite. The likelihood of delays due to technical issues rises as satellite systems become more complex. Anomalies, whether on the ground or on orbit, can affect the delivery of satellites until potential fleet issues (for example, commonality with parts on a satellite awaiting launch) are resolved. Delays in delivery of spacecraft to the launch site can impact the scheduling of launches.
- **Multi-manifesting:** Multi-manifesting, while limited to a few launch vehicles, is dependent on several satellites being delivered on time. Payload compatibility issues may also cause manifesting challenges.
- **Weather:** Inclement weather, including ground winds, flight winds, cloud cover, lightning, and ocean currents can cause launch delays, though these typically are short term (on the order of days).
- **Failure of orbiting satellites:** From the launch services perspective, failure of orbiting satellites can require launching ground spares or ordering new satellites. This only amounts to a small effect on the market, however. A total system failure has not happened to any NGSO constellation.
- **Orbital debris and collision avoidance:** Though relatively rare, launch delays can also occur when conjunction analysis determines that orbital debris has a high probability of introducing risk to the mission.

This page intentionally left blank.

FORECAST APPENDICES

Image credit: Sierra Nevada Corporation

APPENDIX 1: HISTORICAL GSO SATELLITES AND LAUNCHES

Historical data for addressable commercial satellites launched from 1994 through 2013 is shown in Table 26. Historical data for unaddressable satellites launched from 1993 to 2012 is shown in Table 27.

Table 26. Historical Addressable Commercial GSO Satellites Launched (1994-2013)

	1994			1995			1996		
Total Launches	**14**			**17**			**21**		
Total Satellites	**18**			**18**			**25**		
Over 5,400 kg (>11,905 lbm)	0			0			0		
4,200 - 5,400 kg (9,260 - 11,905 lbm)	0			0			0		
2,500 - 4,200 kg (5,510 - 9,260 lbm)	**9**			**14**			**14**		
		Astra 1D	Ariane 4		Astra 1E	Ariane 4	DM3	Arabsat 2A	Ariane 4
		Intelsat 702	Ariane 4		DBS 3	Ariane 4	DM4	Arabsat 2B	Ariane 4
	DM2	PAS 2	Ariane 4		Intelsat 706	Ariane 4		EchoStar 2	Ariane 4
		PAS 3	Ariane 4		NSTAR a	Ariane 4		Intelsat 707	Ariane 4
	DM4	Solidaridad 2	Ariane 4		PAS 4	Ariane 4		Intelsat 709	Ariane 4
		Telstar 402	Ariane 4		Telstar 402R	Ariane 4		MSAT 1	Ariane 4
		DBS 2	Atlas II		AMSC 1	Atlas II		NSTAR b	Ariane 4
		Intelsat 703	Atlas II		Galaxy 3R	Atlas II	DM2	Palapa C2	Ariane 4
		Optus B3	LM-2E		Intelsat 704	Atlas II	DM1	PAS 3R	Ariane 4
					Intelsat 705	Atlas II		AMC 1	Atlas II
					JCSat 3	Atlas II		Hot Bird 2	Atlas II
					APStar 2	LM-2E		Palapa C1	Atlas II
					Asiasat 2	LM-2E		Intelsat 708	LM-3B
					EchoStar 1	LM-2E		Astra 1F	Proton K/DM
Below 2,500 kg (<5,510 lbm)	**9**			**4**			**11**		
	DM3	Brazilsat B1	Ariane 4	DM1	Brazilsat B2	Ariane 44	DM2	Amos 1	Ariane 4
	DM2	BS-3N	Ariane 4	DM1	Hot Bird 1	Ariane 44	DMU	Italsat 2	Ariane 4
	DM1	Eutelsat II F5	Ariane 4	DMU	Insat 2C	Ariane 44	DM1	Measat 1	Ariane 4
	DM4	Thaicom 2	Ariane 4		Koreasat	Delta I	DM4	Measat 2	Ariane 4
	DM1	TurkSat 1A	Ariane 4				DM3	TurkSat 1C	Ariane 4
	DM3	TurkSat 1B	Ariane 4					Inmarsat 3F1	Atlas II
		Orion 1	Atlas II					Inmarsat 3F3	Atlas II
		Galaxy 1R	Delta II					Galaxy 9	Delta II
		APStar 1	LM-3					Koreasat 2	Delta II
								APStar 1A	LM-3
								Inmarsat 3F2	Proton K/DM

= Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 26. Historical Addressable Commercial GSO Satellites Launched (1994-2014) (Continued)

	1997			1998			1999		
Total Launches	**24**			**19**			**19**		
Total Satellites	**28**			**23**			**23**		
Over 5,400 kg (>11,905 lbm)	0			0			0		
4,200 - 5,400 kg (9,260 - 11,905 lbm)	**0**			**0**			**2**		
								Galaxy 11	Ariane 4
								Orion 3	Delta III
2,500 - 4,200 kg (5,510 - 9,260 lbm)	**21**			**14**			**14**		
	DMU	Hot Bird 3	Ariane 4	DM4	Afristar	Ariane 4		AMC 4	Ariane 4
		Intelsat 801	Ariane 4	DM3	Eutelsat W2	Ariane 4	DM1	Arabsat 3A	Ariane 4
		Intelsat 802	Ariane 4		Hot Bird 4	Ariane 4		Insat 2E	Ariane 4
		Intelsat 803	Ariane 4		PAS 6B	Ariane 4		Koreasat 3	Ariane 4
		Intelsat 804	Ariane 4		PAS 7	Ariane 4		Orion 2	Ariane 4
		JCSat 5	Ariane 4		Satmex 5	Ariane 4		Telkom	Ariane 4
		PAS 6	Ariane 4		ST 1	Ariane 4		Telstar 7	Ariane 4
	DM4	Sirius 2	Ariane 4		Hot Bird 5	Atlas II		Echostar 5	Atlas II
	DM2	Thaicom 3	Ariane 4		Intelsat 805	Atlas II		Eutelsat W3	Atlas II
		AMC 3	Atlas II		Intelsat 806	Atlas II		JCSat 6	Atlas II
		DirecTV 6	Atlas II		Galaxy 10	Delta III		Asiasat 3S	Proton K/DM
		EchoStar 3	Atlas II		Astra 2A	Proton K/DM		Astra 1H	Proton K/DM
		Galaxy 8i	Atlas II		EchoStar 4	Proton K/DM		LMI 1	Proton K/DM
		JCSat 4	Atlas II		PAS 8	Proton K/DM		Nimiq	Proton K/DM
		Superbird C	Atlas II					Telstar 6	Proton K/DM
		Agila II	LM-3B					DirecTV 1R	Sea Launch
		APStar 2R	LM-3B						
		Astra 1G	Proton K/DM						
		Asiasat 3	Proton K/DM						
		PAS 5	Proton K/DM						
		Telstar 5	Proton K/DM						
Below 2,500 kg (<5,510 lbm)	**9**			**1**			**1**		
	DM1	AMC 2	Ariane 4	DM4	AMC 5	Ariane 4	DM1	Skynet 4E	Ariane 4
	DM2	BSat 1A	Ariane 4	DM1	Brazilsat B3	Ariane 4			
	DM4	Cakrawarta 1	Ariane 4	DM2	BSat 1B	Ariane 4			
	DM3	Inmarsat 3F4	Ariane 4	DM1	Inmarsat 3F5	Ariane 4			
	DM3	Insat 2D	Ariane 4	DM2	NileSat 101	Ariane 4			
	DM1	Nahuel 1A	Ariane 4	DM3	Sirius 3	Ariane 4			
		Thor II	Delta II		Bonum 1	Delta II			
					Skynet 4D	Delta II			
					Thor III	Delta II			

= Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 26. Historical Addressable Commercial GSO Satellites Launched (1994-2013) (Continued)

	2000			2001			2002		
Total Launches	**20**			**12**			**20**		
Total Satellites	**24**			**14**			**22**		
Over 5,400 kg (>11,905 lbm)	0			0			0		
4,200 - 5,400 kg (9,260 - 11,905 lbm)	**4**			**5**			**9**		
		Anik F1	Ariane 4		DirecTV 4S	Ariane 4		Intelsat 904	Ariane 4
		PAS 1R	Ariane 5		Intelsat 901	Ariane 4		Intelsat 905	Ariane 4
		Garuda 1	Proton K/DM		Intelsat 902	Ariane 4		Intelsat 906	Ariane 4
		Thuraya 1	Sea Launch		XM Rock	Sea Launch		NSS 6	Ariane 4
					XM Roll	Sea Launch		NSS 7	Ariane 4
								Astra 1K	Proton K/DM
								Echostar 8	Proton K/DM
								Intelsat 903	Proton K/DM
								Galaxy 3C	Sea Launch
2,500 - 4,200 kg (5,510 - 9,260 lbm)	**14**			**6**			**11**		
	DM1	Asiastar 1	Ariane 5		Atlantic Bird 2	Ariane 4		Insat 3C	Ariane 4
	DM3	Astra 2B	Ariane 5		Turksat 2A	Ariane 4	DM1	JCSat 8	Ariane 4
		Europe*Star 1	Ariane 4	DM2	Artemis	Ariane 5	DMU	Atlantic Bird 1	Ariane 5
		Eutelsat W1R	Ariane 4	DM1	Eurobird	Ariane 5	DMU	Hotbird 7	Ariane 5
		Galaxy 10R	Ariane 4		Astra 2C	Proton K/DM	DM2	Stellat 5	Ariane 5
		Galaxy IVR	Ariane 4		PAS 10	Proton K/DM		Hispasat 1D	Atlas II
		NSat 110	Ariane 4					Echostar 7	Atlas III
		Superbird 4	Ariane 4					Hotbird 6	Atlas V
		Echostar 6	Atlas II					Eutelsat W5	Delta IV
		Hispasat 1C	Atlas II					DirecTV 5	Proton K/DM
		Eutelsat W4	Atlas III					Nimiq 2	Proton M
		AAP 1	Proton K/DM						
		AMC 6	Proton K/DM						
		PAS 9	Sea Launch						
Below 2,500 kg (<5,510 lbm)	**6**			**3**			**2**		
	DM2	Brazilsat B4	Ariane 4	DMU	Skynet 4F	Ariane 4	DM1	Astra 3A	Ariane 4
	DM2	Nilesat 102	Ariane 4	DM1	BSat 2A	Ariane 5	DM2	NSTAR c	Ariane 5
	DM3	AMC 7	Ariane 5	DM2	BSat 2B	Ariane 5			
	DM4	AMC 8	Ariane 5						
	DM4	Astra 2D	Ariane 5						
	DM1	Insat 3B	Ariane 5						

= Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 26. Historical Addressable Commercial GSO Satellites Launched (1994-2013) (Continued)

	2003			2004			2005		
Total Launches	12			13			15		
Total Satellites	15			13			16		
Over 5,400 kg (>11,905 lbm)	0			3			6		
					Anik F2	Ariane 5	DM1	Spaceway 2	Ariane 5
					Intelsat X	Proton M		Thaicom 4	Ariane 5
					DirecTV 7S	Sea Launch		Inmarsat 4F1	Atlas V
								IA 8	Sea Launch
								Inmarsat 4F2	Sea Launch
								Spaceway 1	Sea Launch
4,200 - 5,400 kg (9,260 - 11,905 lbm)	5			4			4		
		Intelsat 907	Ariane 4		Amazonas	Proton M		AMC 12	Proton M
	DM2	Optus C1	Ariane 5		Eutelsat W3A	Proton M		AMC 23	Proton M
		Rainbow 1	Atlas V		APStar V	Sea Launch		Anik F1R	Proton M
		EchoStar 9	Sea Launch		Estrela do Sul	Sea Launch		XM 3	Sea Launch
		Thuraya 2	Sea Launch						
2,500 - 4,200 kg (5,510 - 9,260 lbm)	6			4			3		
	DM1	Insat 3A	Ariane 5		Superbird 6	Atlas II		Insat 4A	Ariane 5
	DM3	Insat 3E	Ariane 5		MBSat	Atlas III	DMU	XTAR-EUR	Ariane 5
		Asiasat 4	Atlas III		AMC 16	Atlas V		DirecTV 8	Proton M
		HellasSat	Atlas V		AMC 15	Proton M			
		AMC 9	Proton K/M						
		Galaxy 13	Sea Launch						
Below 2,500 kg (<5,510 lbm)	4			2			3		
	DM2	Bsat 2C	Ariane 5		AMC 10	Atlas II	DM1	Telkom 2	Ariane 5
	DM3	e-Bird 1	Ariane 5		AMC 11	Atlas II	DMU	Galaxy 15	Ariane 5
	DM1	Galaxy 12	Ariane 5					Galaxy 14	Soyuz
		Amos 2	Soyuz						

= Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 26. Historical Addressable Commercial GSO Satellites Launched (1994-2013) (Continued)

	2006			2007			2008		
Total Launches	15			12			18		
Total Satellites	19			18			23		
Over 5,400 kg (>11,905 lbm)	2			3			5		
	DM2	Satmex 6	Ariane 5	DM3	Spaceway 3	Ariane 5		ICO G-1	Atlas V
	DM3	DirecTV 9S	Ariane 5		DirecTV 10	Proton M		Ciel 2	Proton M
					NSS 8	Sea Launch		Inmarsat 4F3	Proton M
								DirecTV 11	Sea Launch
								Echostar 11	Sea Launch
4,200 - 5,400 kg (9,260 - 11,905 lbm)	9			6			8		
	DM4	Wildblue 1	Ariane 5	DM2	Astra 1L	Ariane 5	DM3	HotBird 9	Ariane 5
		Astra 1KR	Atlas V	DM1	Skynet 5A	Ariane 5	DM1	Skynet 5C	Ariane 5
		Hotbird 8	Proton M	DM5	Skynet 5B	Ariane 5	DM5	Superbird 7	Ariane 5
		Measat 3	Proton M		Nigcomsat	LM-3B		Astra 1M	Proton M
		Echostar 10	Sea Launch		Anik F3	Proton M		Nimiq 4	Proton M
		Galaxy 16	Sea Launch		SES Sirius 4	Proton M		Galaxy 18	Sea Launch
		JCSat 9	Sea Launch					Galaxy 19	Sea Launch
		Koreasat 5	Sea Launch					Thuraya 3	Sea Launch
		XM 4	Sea Launch						
2,500 - 4,200 kg (5,510 - 9,260 lbm)	6			5			8		
	DM1	Hotbird 7A	Ariane 5	DM2	Galaxy 17	Ariane 5	DM1	Turksat 3A	Ariane 5
	DMU	JCSat 10	Ariane 5	DM1	Insat 4B	Ariane 5	DM2	Badr 6	Ariane 5
	DM1	Spainsat	Ariane 5	DM6	RASCOM 1	Ariane 5	DM2	Protostar 1	Ariane 5
	DM2	Thaicom 5	Ariane 5	DM5	Star One C1	Ariane 5	DM3	Eutelsat W2M	Ariane 5
		Arabsat 4A	Proton M		JCSat 11	Proton M	DM4	Vinasat	Ariane 5
		Arabsat 4B	Proton M				DM4	StarOne C2	Ariane 5
							DM5	AMC 21	Ariane 5
								AMC 14	Proton M
Below 2,500 kg (<5,510 lbm)	2			4			2		
	DM4	AMC 18	Ariane 5	DM3	Bsat 3A	Ariane 5		AMOS 3	Land Launch
	DM3	Optus D1	Ariane 5	DM4	Intelsat 11	Ariane 5		Thor 5	Proton M
				DM4	Optus D2	Ariane 5			
				DM6	Horizons	Ariane 5			

[grey box] = Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 26. Historical Addressable Commercial GSO Satellites Launched (1994-2013) (Continued)

	2009			2010			2011		
Total Launches	**18**			**14**			**12**		
Total Satellites	**22**			**20**			**15**		
Over 5,400 kg (>11,905 lbm)	**8**			**7**			**3**		
	DM1	Amazonas 2	Ariane 5	DM4	Eutelsat W3B	Ariane 5	DM1	Yahsat 1A	Ariane 5
	DM2	NSS 12	Ariane 5		Arabsat 5B	Proton M		Quetzsat	Proton M
		Terrestar 1	Ariane 5		Echostar 14	Proton M		Viasat 1	Proton M
		Intelsat 14	Atlas V		Echostar 15	Proton M			
		DirecTV 12	Proton M		KA-Sat	Proton M			
		Eutelsat W2A	Proton M		SkyTerra 1	Proton M			
		Eutelsat W7	Proton M		XM 5	Proton M			
		Sirius FM5	Proton M						
4,200 - 5,400 kg (9,260 - 11,905 lbm)	**2**			**4**			**6**		
	DM3	Hotbird 10	Ariane 5	DM1	Astra 3B	Ariane 5	DM3	Arabsat 5C	Ariane 5
		Nimiq 5	Proton M	DM2	Arabsat 5A	Ariane 5	DM2	Astra 1N	Ariane 5
				DM6	Hispasat 1E	Ariane 5	DMU	ST 2	Ariane 5
				DM5	Intelsat 17	Ariane 5		Eutelsat W3C	Long March
								Telstar 14R	Proton M
								Atlantic Bird 7	Sea Launch
2,500 - 4,200 kg (5,510 - 9,260 lbm)	**9**			**6**			**6**		
	DM4	JCSat 12	Ariane 5	DM5	Hylas	Ariane 5	DM2	BSAT 3C	Ariane 5
	DM1	Satcom BW1	Ariane 5	DM6	Koreasat 6	Ariane 5	DM1	New Dawn	Ariane 5
	DM2	Thor 6	Ariane 5	DM3	Nilesat 201	Ariane 5	DM3	SES 2	Ariane 5
		Telstar 1N	Land Launch	DM3	RASCOM 1R	Ariane 5		Intelsat 18	Land Launch
		Intelsat 15	Long March	DM1	Satcom BW2	Ariane 5		Asiasat 7	Proton M
		Palapa D	Long March		SES 1	Proton M		DMU SES 3	Proton M/ DM
		Asiasat 5	Proton M						
		Protostar II	Proton M						
		Sicral 1B	Sea Launch						
Below 2,500 kg (<5,510 lbm)	**3**			**3**			**0**		
	DM3	NSS 9	Ariane 5	DM1	Telkom 2	Ariane 5			
	DM4	Optus D3	Ariane 5	DMU	Galaxy 15	Ariane 5			
		Measat 3A	Land Launch		Galaxy 14	Soyuz			

= Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 26. Historical Addressable Commercial GSO Satellites Launched (1994-2013) (Continued)

	2012			2013		
Total Launches	**12**			**13**		
Total Satellites	**21**			**16**		
Over 5,400 kg (>11,905 lbm)	**10**			**10**		
	DM3	Astra 2F	Ariane 5	DM1	Amazonas 3	Ariane 5
	DMU	Echostar 17	Ariane 5	DM2	Alphasat	Ariane 5
	DM2	Intelsat 20	Ariane 5	DM3	Eutelsat 25B	Ariane 5
		Echostar 16	Proton M		Satmex 8	Proton M
		Intelsat 22	Proton M		Eutelsat 7B	Proton M
		SES 4	Proton M		SES 6	Proton M
		SES 5	Proton M		Astra 2E	Proton M
		Yahsat 1B	Proton M		Sirius FM6	Proton M
		Intelsat 19	Sea Launch		Inmarsat 5F1	Proton M
		Intelsat 21	Sea Launch		Intelsat 27	Sea Launch
4,200 - 5,400 kg (9,260 - 11,905 lbm)	**5**			**1**		
	DM4	Eutelsat 21B	Ariane 5		Anik G1	Proton M
	DM1	JCSAT 13	Ariane 5			
	DM5	Skynet 5D	Ariane 5			
		Nimiq 6	Proton M			
		Eutelsat 70B	Sea Launch			
2,500 - 4,200 kg (5,510 - 9,260 lbm)	**6**			**5**		
	DM3	GSAT 10	Ariane 5	DM1	Africasat 1A	Ariane 5
	DM2	Hylas 2	Ariane 5	DM2	GSAT 7	Ariane 5
	DM5	Mexsat 3	Ariane 5	DM 3	Insat 3D	Ariane 5
	DM4	Star One C3	Ariane 5		SES 8	Falcon 9
	DM1	Vinasat 2	Ariane 5		Amos 4	Land Launch
		Intelsat 23	Proton M			
Below 2,500 kg (<5,510 lbm)	**0**			**0**		

= Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 27. Historical Unaddressable Commercial GSO Satellites Launched (1994-2013)

	1994			1995			1996			1997		
Launches	4			1			4			1		
Spacecraft	4			2			5			1		
		DFH 3-1	LM-3A	DMC	Telecom 2C	Ariane 4	DMC	Telecom 2D	Ariane 4		Chinasat 6	LM-3A
		Express	Proton K/DM		Gals 2	Proton K/DM		Chinasat 7	LM-3A			
		Gals-1	Proton K/DM					Express 2	Proton K/DM			
		Gorizont 42	Proton K/DM					Gorizont 43	Proton K/DM			
								Gorizont 44	Proton K/DM			

	1998			1999			2000			2001		
Launches	2			2			5			1		
Spacecraft	2			3			5			1		
		ChinaStar 1	LM-3B		Express A1	Proton K/DM		Express A2	Proton K/DM		Ekran M	Proton M
		Sinosat 1	LM-3C	DM1	Yamal 101	Proton K/DM		Express A3	Proton K/DM			
				DM1	Yamal 102	Proton K/DM		Gorizont 45	Proton K/M			
								SESAT 1	Proton K/DM			
								Chinasat 22	LM-3A			

	2002			2003			2004			2005		
Launches	1			3			2			3		
Spacecraft	1			4			2			3		
		Express A4	Proton K/DM		Express AM22	Proton K/DM		Express AM11	Proton K/DM		Express AM 2	Proton K/DM
				DM1	Yamal 201	Proton K/DM		Express AM1	Proton K/DM		Express AM 3	Proton K/DM
				DM1	Yamal 202	Proton K/DM					Apstar 6	LM-3B
					Chinasat 20	LM-3A						

	2006			2007			2008			2009		
Launches	4			4			3			1		
Spacecraft	4			4			3			2		
		Kazsat	Proton K/DM		Sinosat 3	LM-3B		Venesat 1	LM-3B	DM1	Express MD1	Proton M
		Sinosat 2	LM-4B		Chinasat 6B	LM-3B		Chinasat 9	LM-3B	DM1	Express AM44	Proton M
		Chinasat 22A	LM-3A		Nigcomsat 1	LM-3B		Express AM33	Proton			
		Insat 4C	GSLV		Insat 4CR	GSLV						

	2010			2011			2012			2013		
Launches	3			8			6			8		
Spacecraft	3			10			8			8		
		ChinaSat 6A	LM-3B		GSAT 8	Ariane 5		Apstar 7	LM-3B		Chinasat 15	LM-3B
		ChinaSat 20A	LM-3A		Chinasat 10	LM-3B		Chinasat 2A	LM-3B		Chinasat M	LM-3B
		Insat 4D	GSLV		Chinasat 1A	LM-3B		Chinasat 12	LM-3B		Express AT1	Proton M
					Nigcomsat 1R	LM-3B	DM1	Express MD2	Proton M		Express AT2	Proton M
					Paksat 1R	LM-3B	DM2	Luch 5B	Proton M		Express AM4R	Proton M
				DM1	Amos 5	Proton M	DM1	Telkom 3	Proton M		Express AM6	Proton M
				DM1	Luch 5A	Proton M	DM2	Yamal 300K	Proton M		Kazsat 3	Proton M
					Express AM4	Proton M		Yamal 402	Proton M		Yamal 401	Proton M
				DMA	Kazsat 2	Proton M						
					GSAT 12	PSLV						

APPENDIX 2: HISTORICAL NGSO MARKET ASSESSMENTS

In the last decade of launch activity, there have been significant changes in the amount of payloads and launches forecasted each year, with payloads and launches remaining steady from 2003 to 2006, then beginning to increase in 2007. Overall, the 2013 NGSO report projects demand consistently higher than the average of 5.5 launches per year over the last 10 years.

In the last two decades of commercial NGSO satellite launch activity, the telecommunications market put large constellations of satellites into orbit within a few years, creating a short spurt of intense launch activity. This was the case in 1997 to 1999, when the three major systems, Globalstar, Iridium, and ORBCOMM, launched. The 2013 NGSO report shows the launches scheduled to deploy the replacement satellites for each of the systems. Globalstar plans to complete their constellation in 2015, and a new O3b constellation will launch at the same time as ORBCOMM plans its major launch campaign. The Iridium NEXT deployment schedule does not fully overlap with the other constellations as it did in the late 1990s.

The Other Commercially Launched Satellites and Commercial Remote Sensing Satellite markets create consistent launch demand according to historical figures. Since 1996, there had always been at least one launch of a government satellite launched commercially. The Commercial Remote Sensing Market has low launch demand and it is more sporadic than Other Commercially Launched Satellites.

The number of payloads launched by market sector and the total commercial launches that were internationally competed or commercially sponsored from 2003 through 2012 are provided in Table 28. Small vehicles performed 22 launches during this period, while medium-to-heavy vehicles conducted 33 launches. From 1994 to the end of 2006, the historical number of launches between vehicle classes was roughly equal. This roughly even split is not expected to continue, with a trend emerging since 2007 of payloads increasingly launching on medium-to-heavy vehicles. The 2013 NGSO report estimates the larger vehicle class will continue to conduct the most launches.

Historical satellite and launch data from 2003 through 2013 are shown in Table 29.

Table 28. Historical Payloads and Launches[6]

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Payloads											
Commercial Telecommunication	2	0	0	8	6	2	6	14	1	12	**51**
Commercial Remote Sensing	0	1	1	3	8	1	1	2	0	8	**25**
Commercial Cargo and Crew Transportation Services	0	0	0	0	0	0	1	0	2	2	**5**
Other Commercially Launched Satellites	7	7	3	13	6	7	6	4	1	5	**59**
Technology Test & Demonstration	0	0	1	1	1	0	1	0	0	1	**5**
Total Satellites	**9**	**8**	**5**	**25**	**19**	**10**	**15**	**20**	**4**	**28**	**145**
Launches											
Medium-to-Heavy Vehicles	1	0	2	10	4	2	7	3	3	8	**41**
Small Vehicles	1	3	3	2	6	3	1	0	0	2	**21**
Total Launches	**2**	**3**	**5**	**12**	**10**	**5**	**8**	**3**	**3**	**10**	**62**

[6] Includes payloads open to international launch services procurement and other commercially sponsored payloads. Does not include dummy payloads, piggyback payloads, or satellites that are captive to national flag launch service providers (i.e., U.S. Air Force or NASA satellites, or similar European, Russian, Japanese, or Chinese government satellites that are captive to their own launch providers). Only primary payloads that generate a launch are included, unless combined secondary payloads generate the demand.

Table 29. Historical NGSO Payload and Launch Activities (2004-2013)

Summary	Market Segment	Date	Satellite	Launch Vehicle	
			2013		
28 Satellites 12 Telecommunication 8 Remote Sensing 2 Transportation 6 Other 10 Launches 8 Medium-to-Heavy 2 Small	Telecommunication	2/6/13 6/25/13	Globalstar II 19-24 O3b 01-04 AprizeSat 7-8	Soyuz 2.1a Soyuz 2.1b	Medium-to-Heavy Medium-to-Heavy
	Remote Sensing	8/22/13 11/21/13	Kompsat-5 DubaiSat-2 SkySat-1 WINISAT-1 Dove 1-4	Dnepr Dnept	Medium-to-Heavy Medium-to-Heavy
	Transportation	3/1/13 9/18/13	Dragon CRS D2 Orb-D1	Falcon 9 Antares	Medium-to-Heavy Medium-to-Heavy
	Other	4/21/13 11/19/13	A-ONE STPSAT-3 CASSIOPE SWARM 1-3	Antares Minotaur I Falcon 9 Rockot	Medium-to-Heavy Small Medium-to-Heavy Small
			2012		
4 Satellites 1 Telecommunication 2 Transportation 1 Other 3 Launches 3 Medium-to-Heavy	Telecommunication		ORBCOMM OG2-01[1]		
	Transportation	5/22/12 10/7/12	Dragon COTS Demo 2/3 Dragon CRS D1	Falcon 9 Falcon 9	Medium-to-Heavy Medium-to-Heavy
	Other	12/19/12	Gökturk 2	LM 2D	Medium-to-Heavy
			2011		
20 Satellites 14 Telecommunication 2 Remote Sensing 4 Other 3 Launches 3 Medium-to-Heavy	Telecommunication	7/13/11 12/28/11	Globalstar 2nd Gen. 7-12 AprizeStar 5-6[2] Globalstar 2nd Gen.13-18	Soyuz 2 Soyuz 2	Medium-to-Heavy Medium-to-Heavy
	Remote Sensing		Nigeriasat-2[3A] NX[3B]		
	Other	8/17/11	Sich 2 RASAT Edusat BPA-2	Dnepr	Medium-to-Heavy
			2010		
15 Satellites 6 Telecommunication 1 Remote Sensing 6 Other 1 Test and Demo 1 Transportation 8 Launches 7 Medium-to-Heavy 1 Small	Telecommunication	10/19/10	Globalstar 2nd Gen. 1-6	Soyuz 2	Medium-to-Heavy
	Remote Sensing	6/20/10	TanDEM X	Dnepr M	Medium-to-Heavy
	Other	4/7/10 6/1/10 6/14/10 11/5/10	Cryosat 2 SERVIS 2 Prisma (2 sats) Picard[4] Cosmos-SkyMed 4	Dnepr M Rockot Dnepr M Delta II	Medium-to-Heavy Small Medium-to-Heavy Medium-to-Heavy
	Test and Demo	6/9/10	Falcon 9 Demo Flight	Falcon 9	Medium-to-Heavy
	Transportation	12/8/10	Dragon COTS Demo 1	Falcon 9	Medium-to-Heavy

= Launch Failure

DM# = Dual-manifested Launch with another Unaddressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMA = Dual-manfiested Launch with Addressable Satellite. DMA missions are not counted as a launch in the launch count.

1 ORBCOMM OG2-01 deployed on launch with Dragon CRS 1D

2 AprizeStar 5 & 6 deployed on launch with Sich 2 et al.

3 Nigeriasat-2 and NX deployed on launch with Sich 2 et al.

4 Picard deployed on launch with Prisma Main & Target

Table 29. Historical NGSO Satellite and Payload Activities (2004-2013) (Continued)

Summary	Market Segment	Date	Satellite	Launch Vehicle	
2009					
12 Satellites 2 Telecommunication 3 Remote Sensing 7 Other 5 Launches 2 Medium-to-Heavy 3 Small	Telecommunication		AprizeStar 3-4[5]		
	Remote Sensing	10/8/09	Worldview 2 DEIMOS[6A] UK DMC 2[6B]	Delta II	Medium-to-Heavy
	Other	7/13/09 7/29/09 3/17/09 11/2/09	RazakSat DubaiSat 1 Nanosat 1B GOCE SMOS Proba 2 UGATUSAT[7]	Falcon I Dnepr Rockot Rockot	Small Medium-to-Heavy Small Small
2008					
19 Satellites 6 Telecommunication 6 Remote Sensing 6 Other 1 Test and Demo 10 Launches 4 Medium-to-Heavy 6 Small	Telecommunication	6/19/08	Orbcomm Replacement 1-5 Orbcomm CDS-3	Cosmos 3M	Small
	Remote Sensing	8/29/08 9/6/08	RapidEye 1-5 GeoEye-1	Dnepr 1 Delta II	Medium-to-Heavy Medium-to-Heavy
	Other	3/27/08 4/16/08 7/22/08 8/3/08 10/1/08 10/24/08	SAR Lupe 4 C/NOFS SAR Lupe 5 Trailblazer[F] THEOS Cosmo-SkyMed 3	Cosmos 3M Pegasus XL Cosmos 3M Falcon 1 Dnepr 1 Delta II	Small Small Small Small Medium-to-Heavy Medium-to-Heavy
	Test and Demo	9/28/08	Falcon 1 Mass Simulator	Falcon 1	Small
2007					
25 Satellites 8 Telecommunication 3 Remote Sensing 13 Other 1 Test and Demo 12 Launches 10 Medium-to-Heavy 2 Small	Telecommunication	5/30/07 10/21/0	Globalstar Replacement 1-4 Globalstar Replacement 5-8	Soyuz Soyuz	Medium-to Heavy Medium-to-Heavy
	Remote Sensing	6/15/07 9/18/07 12/14/07	TerraSAR-X WorldView 1 RADARSAT 2	Dnepr Delta II SoyuzD	Medium-to-Heavy Medium-to-Heavy Medium-to-Heavy
	Other	4/17/07 4/23/07 6/7/07 7/2/07 11/1/07 12/8/07	Egyptsat SaudiComsat 3-7 Saudisat 3 AGILE AAM Cosmos-SkyMed 1 SAR Lupe 2 SAR Lupe 3 Cosmo-SkyMed 2	Dnepr PSLV Delta II Cosmos 3M Cosmos 3M Delta II	Medium-to-Heavy Medium-to-Heavy Medium-to-Heavy Small Small Medium-to-Heavy
	Test and Demo	6/28/07	Genesis II	Dneor	Medium-to-Heavy
2006					
5 Satellites 1 Remote Sensing 3 Other 1 Test and Demo 5 Launches 2 Medium-to-Heavy 3 Small	Remote Sensing	4/25/06	EROS B	START 1	Small
	Other	7/28/06 12/27/06 12/19/06	Kompsat 2 Corot SAR Lupe 1	Rockot Soyuz 2 1B Cosmos	Small Medium-to-Heavy Small
	Test and Demo	7/12/06	Genesis 1	Soyuz 2 1B	Medium-to-Heavy

5 AprizeStar 3 & 4 deployed on launch with DubaiSat 1
6 DEIMOS and UK DMC 2 deployed on launch with DubaiSat 1
7 UGATUSAT deployed on launch with Meteor 3M-N3
F Launch Failure

Table 29. Historical NGSO Satellite and Payload Activities (2004-2013) (Continued)

Summary	Market Segment	Date	Satellite	Launch Vehicle	
			2005		
8 Satellites 1 Remote Sensing 7 Other 3 Launches 3 Small	Remote Sensing	10/27/05	Beijing 1	Cosmos	Small
	Other	10/8/08 6/21/05	Cryosat Cosmos 1 Rubin 5[8A] Sinah 1[8B] SSETI Express[8C] Mozhayets 5[9D] Topsat[9E]	Rockot[F] Volna[F]	Small Small
			2004		
9 Satellites 2 Telecommunication 7 Other 2 Launches 1 Medium-to-Heavy 1 Small	Telecommunication		LatinSat (2 sats)[9]		
	Other	5/20/04 6/29/04	Rocsat 2 Demeter AMSat-Echo[10A] SaudiComSat 1-2[10B] SaudiSat 2[10C] Unisat 3[10D]	Taurus Dnepr	Small Medium-to-Heavy

8 Rubin 5, Sinah 1, SSETI Express, Mozhayets 5, and Topsat deployed on launch with Beijing 1
9 LatinSat deployed on launch with Demeter
10 AMSat-Echo, SaudiComSAT 1-2, SaudiSat 2, and Unisat 3 deployed on launch with Demeter
11 Rubin 4-DSI deployed on launch with BilSat 1
F Launch Failure

APPENDIX 3: VEHICLE SIZES AND ORBITS

Small launch vehicles are defined as those with a payload capacity of less than 2,268 kilograms (5,000 pounds) at 185 kilometers (100 nautical miles) altitude and a 28.5-degree inclination. Medium-to-heavy launch vehicles are capable of carrying more than 2,269 kilograms at 185 kilometers altitude and a 28.5-degree inclination.

Commercial NGSO systems use a variety of orbits:

- Low Earth orbits (LEO) range from 160-2,400 kilometers (100-1,500 miles) in altitude, varying between a 0 degree inclination for equatorial coverage and a 101 degree inclination for global coverage.
- Medium Earth orbits (MEO) begin at 2,400 kilometers (1,500 miles) in altitude and are typically at a 45-degree inclination to allow global coverage with fewer high-powered satellites. However, MEO is often a term applied to any orbit between LEO and GSO.
- Elliptical orbits (ELI, also known as highly elliptical orbits, or HEO) have apogees ranging from 7,600 kilometers (4,725 miles) to 35,497 kilometers (22,000 miles) in altitude and up to a 116.5-degree inclination, allowing satellites to "hang" over certain regions on Earth, such as North America.
- External or non-geocentric orbits (EXT) are centered on a celestial body other than Earth. They differ from ELI orbits in that they are not closed loops around Earth, and a spacecraft in EXT will not return to an Earth orbit. In some cases, this term is used for payloads intended to reach another celestial body, such as the Moon.

APPENDIX 4: MASS CLASSES FOR GSO AND NGSO PAYLOADS

Table 30. Mass Classes for GSO and NGSO Payloads

Class Name	Kilograms (kg)	Pounds (lb)
Femto	0.01 - 0.1	0.02 - 0.2
Pico	0.09 - 1	0.19 - 2
Nano	1.1 - 10	3 - 22
Micro	11 - 200	23 - 441
Mini	201 - 600	442 - 1,323
Small	601 - 1,200	1,324 - 2,646
Medium	1,201 - 2,500	2,647 - 5,512
Intermediate	2,501 - 4,200	5,513 - 9,259
Large	4,201 - 5,400	9,260 - 11,905
Heavy	5,401 - 7,000	11,906 - 15,432
Extra Heavy	>7,001	>15,433

APPENDIX 5: ACRONYMS

21AT	Twenty First Century Aerospace Technology Company Ltd.
ABS	Asia Broadcast Satellite
AIS	Automatic Identification System
ADF	Australian Defense Force
ATK	Alliant Technologies
ATV	Automated Transfer Vehicle
BEAM	Bigelow Expandable Activity Module
BMBF	Federal Ministry of Education and Research
BPA	Blok Perspektivnoy Avioniki
CASSIOPE	Cascade, Smallsat, and Ionospheric Polar Explorer
CAST	Chinese Academy of Space Technology
CCAFS	Cape Canaveral Air Force Station
CCDev	Commercial Crew Development
CCiCAP	Commercial Crew Integrated Capacity
CEO	Chief Executive Officer
CHIRP	Commercially Hosted Infrared Payload Flight Demonstration Program
COMSTAC	Commercial Space Transportation Advisory Committee
COTS	Commercial Orbital Transportation Services
CPC	Certification Product Contract
CRS	Commercial Resupply Services
CSA	Canadian Space Agency
CSSWE	Colorado Student Space Weather Experiment
CST-100	Crew Space Transportation-100
CXBN	Cosmic X-Ray Background
DARS	Digital Audio Radio Service
DBS	Direct Broadcasting Services
DEM	Digital Elevation Model
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German space agency)
DMC	Disaster Monitoring Constellation
DMCii	DMC International Imaging, Ltd.
DTH	Direct-to-Home
EADS	European Aeronautic Defence and Space Company
EAL	Excalibur Almaz, Ltd.
ECA	Export Credit Agency
EDRS	European Data Relay System
EGNOS	European Geostationary Navigation Overlay Service
ELaNa	Educational Launch of Nanosatellites

ELI	Highly Elliptical Orbit
EROS	Earth Remote Observation Satellite
ESA	European Space Agency
EXIM	Export-Import Band
EXT	External or Non-Geocentric Orbit
FAA AST	Federal Aviation Administration, Office of Commercial SpaceTransportation
FCC	Federal Communications Commission
FY	Fiscal Year
FSS	Fixed Satellite Services
GIS	Geographic Information Systems
GMW	GeoMetWatch
GPS	Global Positioning System
GSLV	Geosynchronous Satellite Launch Vehicle
GSO	Geosynchronous Orbit
GTO	Geosynchronous Transfer Orbit
HDTV	High Definition Television Services
HEO	Highly Elliptical Orbit
HPA	Hosted Payload Alliance
ICL	Imperial College London
ILS	International Launch Services
IPO	Initial Public Offering
ISRO	Indian Space Research Organization
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
ITT	International Telephone & Telegraph
ITU	International Telecommunications Union
KARI	Korea Aerospace Research Institute
KSLV	Korean Space Launch Vehicle
LEO	Low Earth Orbit
LCRD	Laser Communications Relay Demonstration
LLC	Limited Liability Company
MEO	Medium Earth Orbit
MHI	Mitsubishi Heavy Industries, Ltd.
MPCV	Multi Purpose Crew Vehicle
MSS	Mobile Satellite Services
NASA	National Aeronautics and Space Administration
NEC	Nippon Electric Company
NGA	National Geospatial-Intelligence Agency

NGSO	Non-Geosynchronous Orbits
NOAA	National Oceanic and Atmospheric Administration
O3b	Other Three Billion Networks, Ltd.
OHB	Orbitale Hochtechnologie Bremen
Orbital	Orbital Sciences Corporation
PSLV	Polar Satellite Launch Vehicle
RCM	RADARSAT Constellation Mission
RRV	Reusable Return Vehicle
SAA	Space Act Agreement
SAR	Synthetic Aperture Radar
SBAS	Satellite-Based Augmentation Systems
SNC	Sierra Nevada Corporation
SpaceX	Space Exploration Technologies Corporation
SPOT	Satellite Pour l'Observation de la Terre
SSL	Space Systems Loral
SSO	Sun-Synchronous Orbit
SSTL	Surrey Satellite Technology Limited
TBD	To Be Determined
TSX	TerraSAR X-band
UAE	United Arab Emirates
UCISAT	University of California, Irvine Satellite
UHF	Ultra-High Frequency
ULA	United Launch Alliance
USLM	United States Munitions List
USAF	United States Air Force
WAAS	Wide Area Augmentation System

2014 Worldwide Orbital Launch Events

Date			Vehicle	Site		Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
5-Jan-14			GSLV	Satish Dhawan		GSAT 14	GEO	ISRO	ISRO	Communications		S	S
6-Jan-14	√	+	Falcon 9	CCAFS	*	Thaicom 6	GEO	Thaicom	Orbital Sciences Corp.	Communications	$61.2M	S	S
9-Jan-14	√	+	Antares 120	MARS		Orb 1 (plus 33 satellites internally for ISS deployment)	LEO	Orbital Sciences Corp.	Orbital Sciences Corp.	Cargo	$80M	S	S
23-Jan-14			Atlas V 401	CCAFS		TDRS L	GEO	NASA	Boeing	Communications		S	S
5-Feb-14			Soyuz U	Baikonur		Progress 54P	LEO	Roscosmos	RSC Energia	Cargo		S	S
6-Feb-14	√		Ariane 5 ECA	Guiana Space Center	*	Athena Fidus	GEO	Itsalian Space Agency	Thales Alenia Space	Communications	$190M	S	S
						ABS 2	GEO	Asia Broadcast Satellite	Space Systems Loral	Communications			S
14-Feb-14	√		Proton M	Baikonur	*	Turksat 4A	GEO	Türksat A.Ş.	MELCO	Communications	$85M	S	S
20-Feb-14			Delta IV Medium+(4,2)	CCAFS		Navstar GPS 2F-05	MEO	USAF	Boeing	Navigation		S	S
27-Feb-14			H-IIA 202	Tanegashima		GPM-Core	LEO	JAXA/NASA	NASA, JAXA, Ball Aerospace, NICT	Remote Sensing		S	S
						Ginrei	LEO	Shinshu University	Shinshu University	Development			S
						STARS II	LEO	Kagawa University	Kagawa University	Development			S
						TeikyoSat 3	LEO	Teikyo University	Teikyo University	Scientific			S
						KSAT 2	LEO	Kagoshima University	Kagoshima University	Scientific			S
						OPUSAT	LEO	Osaka Prefecture University	Osaka Prefecture University	Development			S
						INVADER	LEO	University of Tokyo	University of Tokyo	Development			S
						ITF 1	LEO	Tsukuba University	Tsukuba University	Development			F
15-Mar-14			Proton M	Baikonur		Express AT1	GEO	RSCC	ISS Reshetnev	Communications		S	S
						Express AT2	GEO	RSCC	ISS Reshetnev	Communications			S
22-Mar-14	√		Ariane 5 ECA	Guiana Space Center	*	Astra 5B	GEO	SES	Airbus	Communications	$190M	S	S
					*	Amazonas 4A	GEO	Hispasat	Orbital Sciences Corp.	Communications			S
23-Mar-14			Soyuz 2.1b	Plestesk		Cosmos 2494 (Glonass M)	MEO	Russian Aerospace Defence Forces	ISS Reshetnev	Navigation		S	S
25-Mar-14			Soyuz FG	Baikonur		Soyuz TMA 12M	LEO	Roscosmos	RSC Energia	Crew		S	S
31-Mar-14			Long March 2C	Jiuquan		Shijian 11-06	SSO	PLA	CALT	Development		S	S
3-Apr-14			Atlas V 401	VAFB		USA 249 (DMSP-5D3-F19)	LEO	USAF	Lockheed Martin	Meteorological		S	S
3-Apr-14			Soyuz 2.1a	Guiana Space Center		Sentinel 1A	SSO	ESA	Thales Alenia Space	Scientific		S	S
4-Apr-14			PSLV XL	Satish Dhawan		IRNSS 1B	GEO	ISRO	ISRO	Navigation		S	S
9-Apr-14			Soyuz U	Baikonur		Progress 23M	LEO	Roscosmos	RKK Energia	Cargo		S	S
9-Apr-14			Shavit	Palmachim		Ofeq 10	LEO	IDF	IAI	IMINT		S	S
10-Apr-14			Atlas V 541	CCAFS		USA 250 (NRO L-67)	TBD	NRO	Classified	Classified		S	S
16-Apr-14			Soyuz U	Baikonur		EgyptSat 2	LEO	NARSS	RSC Energia	Remote Sensing		S	S
18-April-14	√	+	Falcon 9	CCAFS	*	Spx 3	LEO	SpaceX	SpaceX	Cargo	$61.2M	S	S
						KickSat	LEO	Cornell University	Cornell University	Communications			F
						ALL-STAR THEIA	LEO	CoSGC	CoSGC	Development			S
						SporeSat 1	LEO	Purdue University	Purdue University	Scientific			S
						TestSat-Lite	LEO	Taylor University	Taylor University	Development			S
						PhoneSat 2.5	LEO	NASA	NASA	Development			S

Date			Vehicle	Site		Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
28-Apr-14			Proton M	Baikonur		Luch 5V	GEO	Roscosmos	ISS Reshetnev	Communications		S	S
						KazSat 3	GEO	JSC KazSat	ISS Reshetnev, Thales Alenia Space	Communications			S
30-Apr-14			Vega	Guiana Space Center		KazEOSat 1	SSO	Kazakhstan Gharysh Sapary	Airbus	Remote Sensing		S	S
6-May-14			Soyuz 2.1a	Plesetsk		Cosmos 2495 (Kobalt M)	LEO	Russian Aerospace Defence Forces	TsSKB Progress	IMINT		S	S
15-May-14			Proton M	Baikonur		Express AM4R	GEO	RSCC	ISS Reshetnev	Communications		F	F
17-May-14			Delta IV Medium+(4,2)	CCAFS		USA 251 (Navstar GPS 2F-6)	MEO	USAF	Boeing	Navigation		S	S
22-May-14			Atlas V 401	CCAFS		USA 252	TBD	NRO	Classified	Classified		S	S
23-May-14			Rockot	Plesetsk		Cosmos 2496 (Strela 3M 10)	LEO	Russian Aerospace Defence Forces	NPO PM	Communications		S	S
						Cosmos 2497 (Strela 3M 11)	LEO	Russian Aerospace Defence Forces	NPO PM	Communications			S
						Cosmos 2498 (Strela 3M 12)	LEO	Russian Aerospace Defence Forces	NPO PM	Communications			S
24-May-14			H-IIA 202	Tanegashima		ALOS 2 (Daichi 2)	SSO	JAXA	JAXA	Remote Sensing		S	S
						RISING 2 (Raijin)	SSO	Tohoku University	Tohoku University	Remote Sensing			S
						UNIFORM 1	SSO	Wakayama University	Wakayama University	Remote Sensing			S
						SOCRATES	SSO	NICT	AES	Remote Sensing			S
						SPROUT	SSO	Nihon University	Nihon University	Development			S
26-May-14	√	+	Zenit 3SL	Odyssey Platform	*	Eutelsat 3B	GEO	Eutelsat	Airbus	Communications	$95M	S	S
28-May-14			Soyuz FG	Baikonur		Soyuz TMA 13M	LEO	Roscosmos	RSC Energia	Crew		S	S
14-Jun-14			Soyuz 2.1b	Plesetsk		Cosmos 2500 (Glonass M)	MEO	Russian Aerospace Defence Forces	ISS Reshetnev	Navigation		S	S
19-Jun-14	√		Dnepr	Dombarovsky	*	Deimos 2	SSO	Deimos Space	Satrec Initiative	Remote Sensing	$24M	S	S
						ANTELSAT	SSO	Uruguayan Facultad de Ingeniería de la Universidad de la República	Uruguayan Facultad de Ingeniería de la Universidad de la República	Development			S
						Aerocube 6	SSO	The Aerospace Corp.	The Aerospace Corp.	Development			S
					*	AprizSat 9 and 10	SSO	ExactEarth	Space Quest	Communications			S
						BRITE CA 1 and 2	SSO	UTIAS	UTIAS	Scientific			S
						BugSat 1	SSO	Satellogic S.A.	Satellogic S.A.	Remote Sensing			S
						DTUSat 2	SSO	Danmarks Tekniske Universitet	Danmarks Tekniske Universitet	Development			S
						Duchifat 1	SSO	Space Laboratory of the Herzliya Science Center	Space Laboratory of the Herzliya Science Center	Scientific			S
					*	Flock 1c 1-11	SSO	Planet Labs	Planet Labs	Remote Sensing			S
						Hodoyoshi 3 and 4	SSO	University of Tokyo	University of Tokyo	Remote Sensing			S
						KazEOSat 2	SSO	Kazakhstan Gharysh Sapary	Kazakhstan Gharysh Sapary	Remote Sensing			S
					*	Lemur 1	SSO	Spire	Spire	Development			S
						Nanosat C BR-1	SSO	INPE	INPE	Scientific			S
						PACE	SSO	National Cheng Kung University	National Cheng Kung University	Development			S
					*	Perseus M1 and 2	SSO	Dauria Aerospace	Dauria Aerospace	Remote Sensing			S
						PolyITAN 1	SSO	National Technical University of Ukraine	National Technical University of Ukraine	Development			S
					*	POPSAT HIP 1	SSO	Microspace	Microspace	Development			S
						QB50 P1 and P2	SSO	von Karman Institute	ISIS	Scientific			S
						SaudiSat 4	SSO	KACST	KACST	Development			S
					*	TableSat Aurora	SSO	SPUTNIX	SPUTNIX	Development			S
						Tigrisat	SSO	University of Rome	University of Rome	Remote Sensing			S
						UniSat 6	SSO	University of Rome	University of Rome	Development			S

Date			Vehicle	Site		Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
30-Jun-14	√		PSLV CA	Satish Dhawan	*	SPOT 7 (Azersky)	SSO	Azercosmos	Airbus	Remote Sensing	$15M	S	S
						Alsat	SSO	DLR	DLR	Development			S
						CanX-4 and 5	SSO	UTIAS	UTIAS	Development			S
						VELOX I	SSO	Nanyang Technological University	Nanyang Technological University	Development			S
2-Jul-14			Delta II 7320-10	VAFB		OCO 2	SSO	NASA	Orbital Sciences Corp.	Remote Sensing		S	S
3-Jul-14			Rockot	Plesetsk		Gonets M8	LEO	Roscosmos	NPO PM	Communications		S	S
						Gonets M9	LEO	Roscosmos	NPO PM	Communications			S
						Gonets M10	LEO	Roscosmos	NPO PM	Communications			S
8-Jul-14			Soyuz 2.1b	Baikonur		Meteor M2	SSO	Hydrometeorological Center of Russia	NPP VNIIEM	Meteorological		S	S
						AISat 2	SSO	UTIAS	UTIAS	IMINT			S
					*	DX 1	SSO	Dauria Aerospace	Dauria Aerospace	Development			S
						MKA PN2 (Relek)	SSO	Roscosmos	Lavotchkin	Scientific			S
					*	SkySat 2	SSO	Skybox Imaging	Skybox Imaging	Remote Sensing			S
					*	TechDemoSat 1	SSO	SSTL	SSTL	Development			S
						UKube 1	SSO	UK Space Agency	Clyde Space	Development			S
10-Jul-14	√		Soyuz 2.1b	Guiana Space Center	*	O3b FM3, FM6, FM7, FM8	MEO	O3b	Thales Alenia Space	Communications	$80M	S	S
13-Jul-14	√	+	Antares 120	MARS	*	Orb 2 (plus 33 satellites internally for ISS deployment)	LEO	Orbital Sciences Corp.	Orbital Sciences Corp.	Cargo	$80M	S	S
14-Jul-14	√	+	Falcon 9	CCAFS	*	ORBCOMM 2 F3, F4, F6, F7, F9, F11	LEO	ORBCOMM	Sierra Nevada Corp.	Communications	$61.2M	S	S
18-Jul-14			Soyuz 2.1a	Baikonur		Foton M4	LEO	Roscosmos	TsSKB Progress	Scientific		S	S
23-Jul-14			Soyuz U	Baikonur		Progress M24	LEO	Roscosmos	RSC Energia	Cargo		S	S
28-Jul-14			Delta IV Medium+(4,2)	CCAFS		USA 253 (GSSAP 1)	GEO	USAF	Orbital Sciences Corp.	IMINT		S	S
						USA 254 (GSSAP 2)	GEO	USAF	Orbital Sciences Corp.	IMINT			S
						USA 255 (ANGELS)	GEO	AFRL	Lockheed Martin	Development			S
29-Jul-14			Ariane 5 ES	Guiana Space Center		ATV 5 (Georges Lemaître)	LEO	ESA	Airbus	Cargo		S	S
2-Aug-14			Atlas V 401	CCAFS		USA 256 (Navstar GPS 2F-7)	MEO	USAF	Boeing	Navigation		S	S
5-Aug-14	√	+	Falcon 9	CCAFS	*	AsiaSat 8	GEO	AsiaSat	Space Systems Loral	Communications	$61.2M	S	S
9-Aug-14			Long March 4C	Jiuquan		Yaogan 20A, 20B, 20C	LEO	PLA	CAST	IMINT		S	S
13-Aug-14	√	+	Atlas V 401	VAFB	*	WorldView 3	SSO	DigitalGlobe	Ball Aerospace	Remote Sensing	$150M	S	S
19-Aug-14			Long March 4B	Taiyuan		Gaofen 2	SSO	CNSA	CAST	Remote Sensing		S	S
						Heweliusz	SSO	Polish Academy of Sciences	Space Research Center	Scientific			S
22-Aug-14			Soyuz 2.1b	Guiana Space Center		Galileo FOC 1 (Doresa)	MEO	European Global Navigation Satellite Systems Agency	OHB System GmbH	Navigation		P	F
						Galileo FOC 2 (Milena)	MEO	European Global Navigation Satellite Systems Agency	OHB System GmbH	Navigation			F
4-Sep-14			Long March 2D	Jiuquan		Chuangxin 1-04	SSO	Chinese Academy of Sciences	Chinese Academy of Sciences	Communications		S	S
						Lingqiao	SSO	Tsinghua University	Tsinghua University	Development			S
7-Sep-14	√	+	Falcon 9	CCAFS	*	AsiaSat 6	GEO	AsiaSat	Space Systems Loral	Communications	$61.2M	S	S
8-Sep-14			Long March 4B	Taiyuan		Yaogan 21	SSO	Chinese National Space Agency	CAST	IMINT		S	S
						Tiantuo 2	SSO	National University of Defense Technology	National University of Defense Technology	Development			S
11-Sep-14	√		Ariane 5 ECA	Guiana Space Center	*	MEASAT 3B	GEO	MEASAT Satellite Systems	Airbus	Communications	$190M	S	S
					*	Optus 10	GEO	SingTel Optus	Space Systems Loral	Communications			S
17-Sep-14			Atlas V 401	CCAFS		USA 257 (CLIO)	TBD	NRO	Classified	Classified		S	S

Date			Vehicle	Site		Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
21-Sep-14	√	+	Falcon 9	CCAFS	*	Spx 4 (plus 1 satellite internally for ISS deployment)	LEO	SpaceX	SpaceX	Cargo	$61.2M	S	S
25-Sep-14			Soyuz FG	Baikonur		Soyuz TMA-14M	LEO	Roscosmos	RSC Energia	Crew		S	S
27-Sep-14			Proton M	Baikonur		Olymp K	GEO	Russian Aerospace Defence Forces	ISS Reshetnev	Communications		S	S
28-Sep-14			Long March 2C	Jiuquan		Shijian 11-07	SSO	PLA	Dongfanghong Satellite Co.	Development		S	S
7-Oct-14			H-IIA 202	Tanegashima		Himawari 8	GEO	Japan Meteorological Agency	MELCO	Meteorological		S	S
15-Oct-14			PSLV XL	Satish Dhawan		IRNSS 1C	GEO	ISRO	ISRO	Navigation		S	S
16-Oct-14	√		Ariane 5 ECA	Guiana Space Center	*	Intelsat 30	GEO	Intelsat	Space Systems Loral	Communications	$190M	S	S
					*	ARSAT 1	GEO	AR-SAT	INVAP	Communications			S
20-Oct-14			Long March 4C	Taiyuan		Yaogan 22	SSO	PLA	CAST	IMINT		S	S
21-Oct-14			Proton M	Baikonur		Express AM6	GEO	RSCC	ISS Reshetnev	Communications		S	S
23-Oct-14			Long March 3C	Xichang		Chang'e 5	EXT	Chinese National Space Agency	CAST	Development		S	S
27-Oct-14			Long March 2C	Jiuquan		Shijian 11-08	SSO	PLA	Dongfanghong Satellite Co.	Development		S	S
28-Oct-14	√	+	Antares 120	MARS	*	Orb 3 (plus 29 satellites internally for ISS deployment)	LEO	Orbital Sciences Corp.	Orbital Sciences Corp.	Cargo	$80M	F	F
29-Oct-14			Soyuz 2.1a	Baikonur		Progress M25	LEO	Roscosmos	RSC Energia	Cargo		S	S
29-Oct-14			Atlas V 401	CCAFS		USA 258 (Navstar GPS 2F-8)	MEO	USAF	Boeing	Navigation		S	S
30-Oct-14			Soyuz 2.1a	Plesetsk		Meridian 7	ELI	Russian Aerospace Defence Forces	ISS Reshetnev	Communications		S	S
6-Nov-14	√		Dnepr	Dombarovsky		Asnaro 1	SSO	J-spacesystems	NEC	Development	$24M	S	S
						Chubusat 1	SSO	Nagoya University	Nagoya University	Development			S
						Hodoyoshi 1	SSO	University of Tokyo	University of Tokyo	Remote Sensing			S
						QSAT-EOS	SSO	Kyushu University	Kyushu University	Development			S
						TSUBAME	SSO	Tokyo Institute of Technology	Tokyo Institute of Technology	Scientific			S
14-Nov-14			Long March 2C	Taiyuan		Yaogan 23	SSO	PLA	CAST	IMINT		S	S
20-Nov-14			Long March 2D	Jiuquan		Yaogan 24	SSO	PLA	CAST	IMINT		S	S
21-Nov-14			Kuaizhou	Jiuquan		Kuaizhou 2	LEO	Chinese Academy of Sciences	Chinese Academy of Sciences	Development		S	S
23-Nov-14			Soyuz FG	Baikonur		Soyuz TMA-15M	LEO	Roscosmos	RSC Energia	Crew		S	S
30-Nov-14			Soyuz 2.1b	Plesetsk		Cosmos 2502 (Glonass K1)	MEO	Russian Aerospace Defence Forces	ISS Reshetnev	Navigation		S	S
3-Dec-14			H-IIA 202	Tanegashima		Hayabusa 2	EXT	JAXA	NEC	Scientific		S	S
						DESPATCH	EXT	Tama Art University	Tama Art University	Development			S
						PROCYON	EXT	JAXA	NEC	Scientific			S
						Shin'en 2	EXT	Kagoshima University	Kagoshima University	Development			S
5-Dec-14	√	+	Delta IV Heavy	CCAFS		EFT 1	LEO	NASA	Lockheed Martin	Development	$350M	S	S
6-Dec-14	√		Ariane 5 ECA	Guiana Space Center	*	DirecTV 14	GEO	DirecTV	Space Systems Loral	Communications	$190M	S	S
					*	GSAT 16	GEO	ISRO	ISRO	Communications			S
7-Dec-14			Long March 4B	Taiyuan		CBERS 4	SSO	INPE/CASC	CASC	Remote Sensing		S	S
10-Dec-14			Long March 4C	Jiuquan		Yaogan 25A, 25B, 25C	SSO	PLA	CAST	IMINT		S	S
13-Dec-14			Atlas V 541	VAFB		USA 259 (NRO L-35)	TBD	NRO	Classified	Classified		S	S
15-Dec-14			Proton M	Baikonur		Yamal 401	GEO	Gazprom	Thales Alenia Space	Communications		S	S
18-Dec-14	√		Soyuz 2.1b	Guiana Space Center		O3b FM9, FM10, FM11, FM12	MEO	O3b	Thales Alenia Space	Communications	$80M	S	S
19-Dec-14			Strela	Baikonur		Kondor E	LEO	Roscosmos	NPO PM	Remote Sensing		S	S
23-Dec-14			Angara A5	Plesetsk		Dummy Payload	LEO	Khurnichev	Khrunichev	Test		S	S
25-Dec-14			Soyuz 2.1b	Plesetsk		Cosmos 2503 (Lotos S)	LEO	Russian Aerospace Defence Forces	TsSKB Progress, KB Arsenal	ELINT		S	S

Date		Vehicle	Site		Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
26-Dec-14		Soyuz 2.1b	Baikonur		Resurs P2	SSO	Roscosmos	TsSKB Progress	Remote Sensing		S	S
27-Dec-14		Long March 4B	Taiyuan		Yaogan 26	SSO	PLA	CAST	IMINT		S	S
27-Dec-14	√	Proton M	Baikonur	*	Astra 2G	GEO	SES	Airbus	Communications	$85M	S	S
31-Dec-14		Long March 3A	Xichang		Fengyun 2G	GEO	China Meteorological Administration	SAST	Meteorological		S	S

√ Denotes commercial launch, defined as a launch that is internationally competed or FAA-licensed, or privately financed launch activity. For multiple manifested launches, certain secondary payloads whose launches were commercially procured may also constitute a commercial launch.
\+ Denotes FAA-licensed launch.
* Denotes a commercial payload, defined as a spacecraft that serves a commercial function or is operated by a commercial entity.
L and M refer to the outcome of the Launch and Mission: S=Success, P=Partial Success, F=Failure.
Notes: All prices are estimates.
All launch dates are based on local time at the launch site.

DEFINITIONS

Commercial Suborbital or Orbital Launch

A commercial suborbital or orbital launch has one or more of these characteristics:

- The launch is licensed by FAA AST.
- The primary payload's launch contract was internationally competed (see definition of internationally competed below). A primary payload is generally defined as the payload with the greatest mass on a launch vehicle for a given launch.
- The launch is privately financed without government support.

Launch Failure

A launch failure happens when the payload does not reach a usable orbit (an orbit where some portion of the mission can be salvaged) or is destroyed as the result of a launch vehicle malfunction.

Internationally Competed

An internationally competed launch contract is one in which the launch opportunity was available in principle to any capable launch service provider. Such a launch is considered commercial.

Commercial Payload

A commercial payload has one or both of these characteristics:

- The payload is operated by a private company.
- The payload is funded by the government, but provides satellite service partially or totally through a private or semi-private company. This distinction is usually applied to certain telecommunications satellites whose transponders are partially or totally leased to a variety of organizations, some or all of which generate revenues. Examples include Russia's Express and Ekran series of spacecraft.

All other payloads are classified as non-commercial (government civil, government military, or non-profit).

Orbits

A spacecraft in geostationary Earth orbit (GSO) is synchronized with the Earth's rotation, orbiting once every 24 hours, and appears to an observer on the ground to be stationary in the sky. Geosynchronous (GEO) is a broader category used for any circular orbit at an altitude of 35,852 kilometers (22,277 miles) with a low inclination (i.e., near or on the equator).

Non-geosynchronous orbit (NGSO) satellites are those in orbits other than GEO.

They are located in low Earth orbit (LEO, lowest achievable orbit to about 2,400 kilometers, or 1,491 miles), medium Earth orbit (MEO, 2,400 kilometers to GEO), SSO (Sun Synchronous Orbit), and all other orbits or trajectories. ELI ("elliptical") describes a highly elliptical orbit (such as those used for Russian Molniya satellites), and EXT ("external") describes trajectories beyond GEO (such as interplanetary trajectories).

Vehicle Mass Class

Small launch vehicles are defined as those with a payload capacity of less than 2,268 kilograms (5,000 pounds) at 185 kilometers (100 nautical miles) altitude and a 28.5-degree inclination. Medium to heavy launch vehicles are capable of carrying more than 2,269 kilograms at 185 kilometers altitude and a 28.5-degree inclination.

Federal Aviation Administration
Office of Commercial Space Transportation

800 Independence Avenue SW
Washington, DC 20591

http://www.faa.gov/go/ast