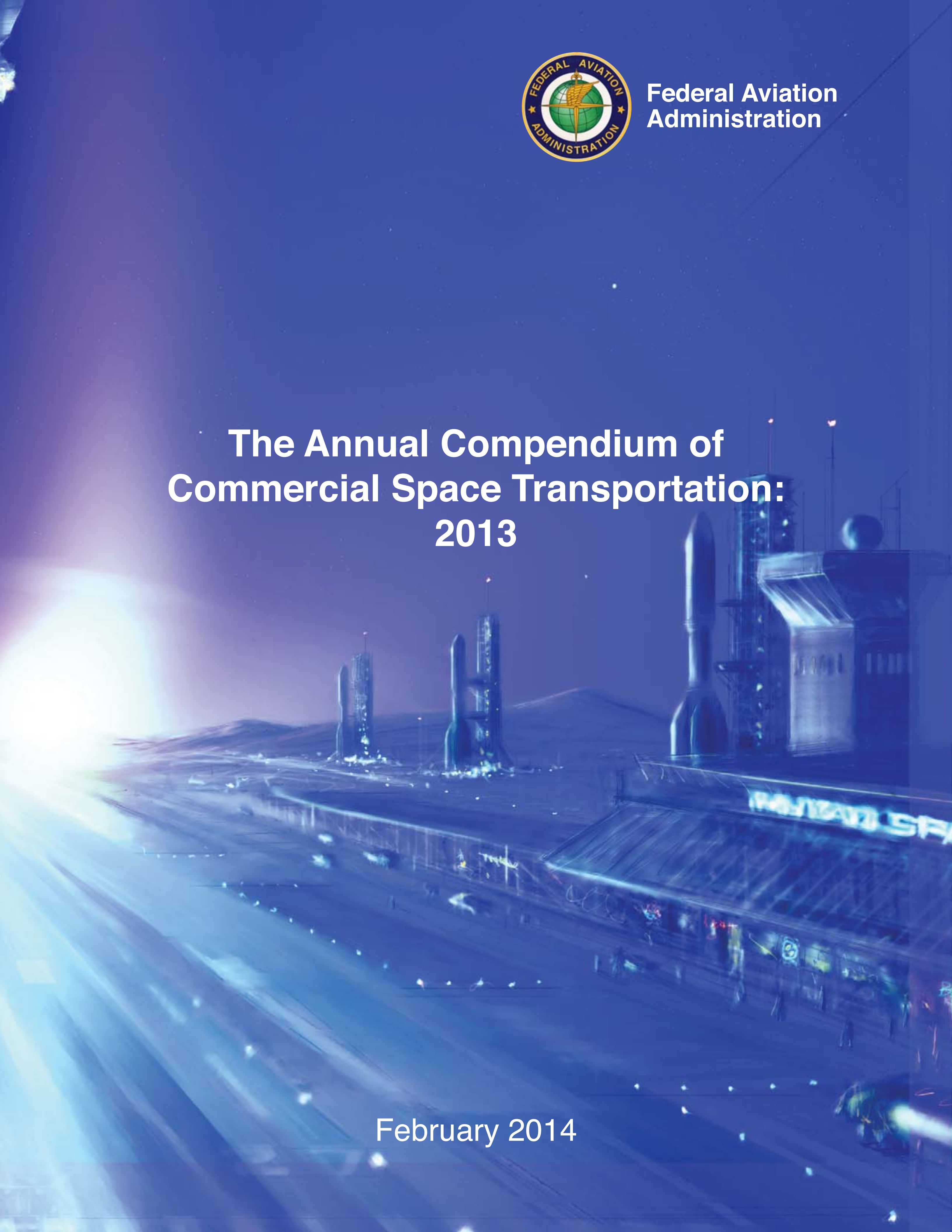
Federal Aviation Administration



The Annual Compendium of Commercial Space Transportation: 2013

February 2014

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 (2014)

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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 2013;
- orbital launch vehicles, suborbital reusable vehicles, and on-orbit vehicles and platforms that launched in 2013 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 2013.

See the appendices for other resources, including:

- the 2013 manifest of worldwide orbital launches;
- definitions of terminology; and
- a list of acronyms and abbreviations.

2013 BUSY YEAR IN U.S. COMMERCIAL SPACEFLIGHT

- Highest estimated U.S. launch revenues in 5 years: $340M
- Busiest year for development of safety regulations and environmental reviews
- Highest number of active and proposed commercial launch sites
- Highest number of licensed and permitted launches since 2008

TOTAL LICENSED ORBITAL LAUNCHES 7 (40% ↑ from 2012)

TOTAL PERMITTED LAUNCHES 7 (250% ↑ from 2012)

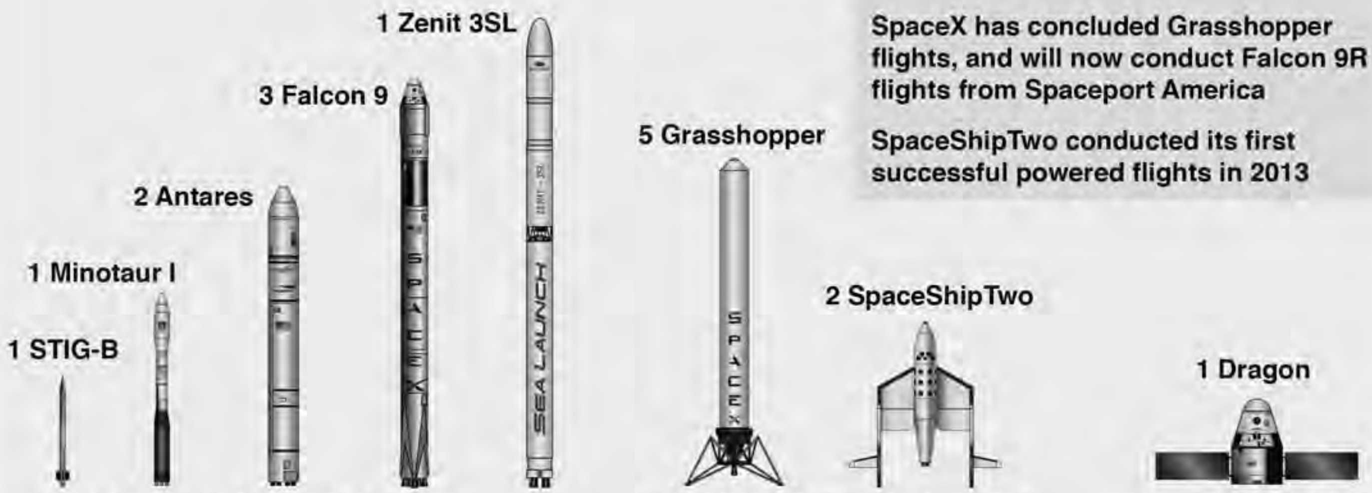
$440M 2013 estimated FAA-licensed launch revenues

The Antares vehicle flew for the first time in 2013

The Falcon 9v.1.1 vehicle flew for the first time in 2013

SpaceX has concluded Grasshopper flights, and will now conduct Falcon 9R flights from Spaceport America

SpaceShipTwo conducted its first successful powered flights in 2013



Licensed Launch Activity | Permitted Launch Activity | Reentry Activity

FAA AST 2013 ACTIVITIES

LICENSES AND PERMITS

45% increase in launch licenses, reentry licenses, and experimental permits from previous year (16 in 2013, 11 in 2012)
Processing license application for Virgin Galactic
Working with Florida, New Mexico, and Texas on new launch support facilities and launch sites
Issued safety approval for space training to Black Sky Training

ENVIRONMENTAL IMPACT ASSESSMENTS

Began an environmental impact study activity for proposed Shiloh site in Florida
Completed environmental assessment of Brownsville site in Texas

INFORMING REGULATIONS

Developed a lessons learned database to improve spaceflight safety
Developed with industry a comprehensive list of safety practices for commercial human spaceflight safety regulations
Drafted human spaceflight guidelines

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

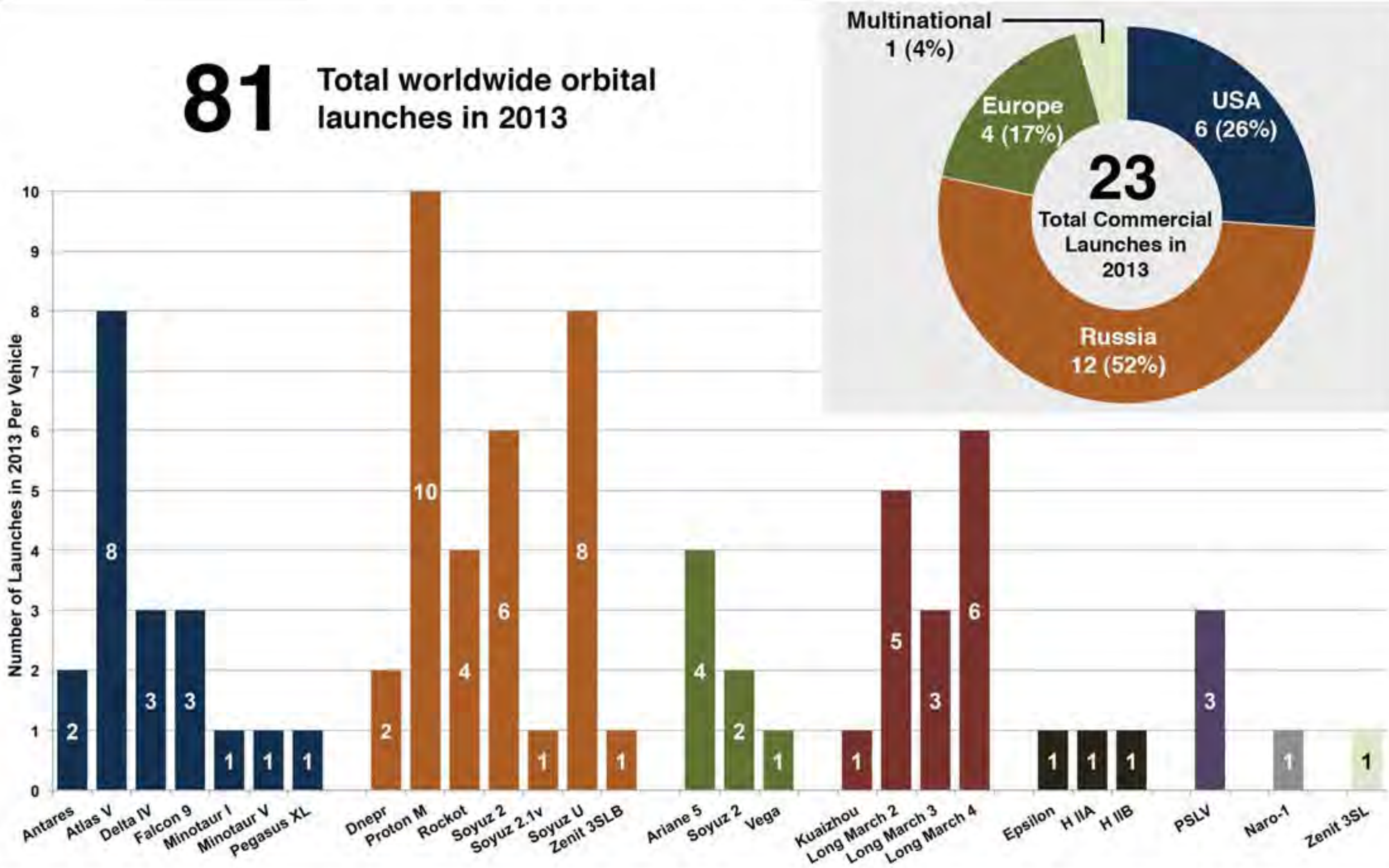
ACTIVE LICENSES, PERMITS, AND APPROVALS

(December 31, 2013)

18 Licenses **2** Experimental Permits **5** Safety Approvals

2013 Orbital Launches by Vehicle

81 Total worldwide orbital launches in 2013



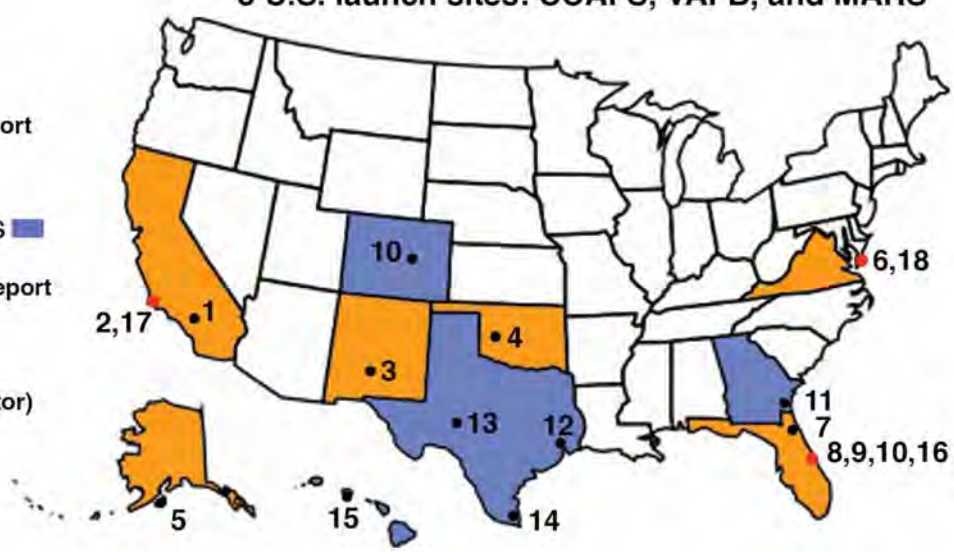
2013: Highest Number of Active and Proposed Commercial Orbital and Suborbital Launch Sites

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

STATES WITH PROPOSED SITES
9 - Shiloh
10 - Space Coast Regional Spaceport
11 - Camden County
12 - Ellington
13 - Midland
14 - Brownsville (sole site operator)
15 - Spaceport Kalaeloa

FEDERAL SITES
16 - CCAFS
17 - VAFB 18 - WFF

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



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COMMERCIAL SPACE TRANSPORTATION 2013 YEAR IN REVIEW

This section summarizes U.S. and international orbital launch activities for calendar year 2013. The summary is from a separately released FAA AST report: Commercial Space Transportation: 2013 Year in Review.

Cover Art: John Sloan (2014)

EXECUTIVE SUMMARY

The Commercial Space Transportation: 2013 Year in Review summarizes U.S. and international orbital launch activities for calendar year 2013, including launches licensed by the Federal Aviation Administration's Office of Commercial Space Transportation (FAA AST).

In 2013, the United States, Russia, Europe, China, Japan, India, South Korea, and multinational provider Sea Launch conducted a total of 81 orbital launches, 23 of which were commercial (See Figure 1). In 2012 there were 78 launches, including 20 commercial launches. Three of the 81 launches failed; two government launches, China's Long March 4B launch of CBERS and Russia's Proton M launch of Glonass M46, 48, and 49 satellites, and, one commercial launch, Sea Launch's Zenit 3SL launch of Intesat 27.

Highlights of 2013 in the orbital space launch industry:

- The United States performed six commercial orbital launches. 2008 was the last time the U.S. had six commercial launches;
- SpaceX performed the first U.S. commercial communication satellite launch to geosynchronous transfer orbit (GTO) in five years;
- The new U.S. Antares launch vehicle, built by Orbital Sciences Corporation, performed a successful inaugural flight and enabled a successful Cygnus resupply mission to the International Space Station (ISS) on its second launch;
- The successful Antares/Cygnus mission to the ISS marked the conclusion of the NASA Commercial Orbital Transportation Services (COTS) program, the subsequent commercial ISS resupply missions will be under NASA Commercial Resupply Services (CRS) program;
- In addition to Antares, four more new orbital launch vehicles were successfully introduced worldwide, including the Minotaur V by Orbital (United States), the Kuaizhou (China), the Epsilon by Mitsubishi Heavy Industries (Japan), and the Soyuz 2.1v (Russia);
- The U.S. launch provider United Launch Alliance (ULA) had its busiest year to date with 11 missions, launching 8 Atlas V and 3 Delta IV rockets;
- Two robotic missions to Mars were successfully launched and sent on their interplanetary journeys: NASA's Mars Atmosphere and Volatile Evolution (MAVEN) launched by Atlas V and an Indian Mars Orbiter Mangalyaan launched by PSLV, both in November 2013;
- Two lunar missions were successfully launched, the NASA Lunar Atmosphere and Dust Environment Explorer (LADEE) mission launched by a Minotaur V and the Chinese Chang'e 3 lander and rover mission launched by a Long March 3B;

- Record number of 92 cubesat class satellites were launched, including 59 cubesats on 2 launch vehicles launched 30 hours apart. Those missions were a U.S. Air Force mission on Minotaur I and a Russian Dnepr mission, both launched in November.

Revenues from the 23 commercial orbital launches in 2013 were estimated to be about $1.9 billion. These revenues are consistent with commercial launch revenue in 2011 but show nearly half-billion dollar lower results than in 2009, 2010, and 2012. The United States estimated commercial orbital launch revenues of $339.5 million were the highest in the last five-year (See Figure 2).

FAA AST licensed seven commercial orbital launches in 2013, compared to five licensed launches in 2012. SpaceX’s Falcon 9 vehicle had three licensed launches: one in March, under NASA’s CRS program, one for the Canadian Space Agency (CSA) in September, and one for satellite operator SES in December. Orbital’s Antares was used for two FAA-licensed launches, its inaugural launch in April, and an ISS resupply mission in September. Orbital’s Minotaur I performed a successful FAA-licensed launch under the U.S. Air Force Operationally Responsive Space (ORS) program. Sea Launch’s Zenit 3SL failed launch of Intelsat 27 was an FAA-licensed launch.

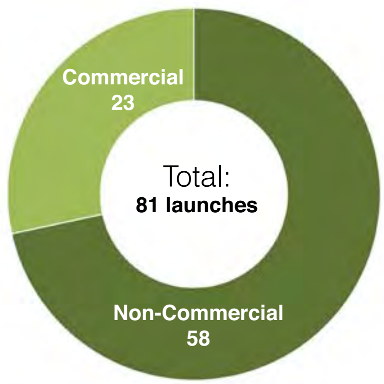


Figure 1. 2013 Total Worldwide Launch Activity

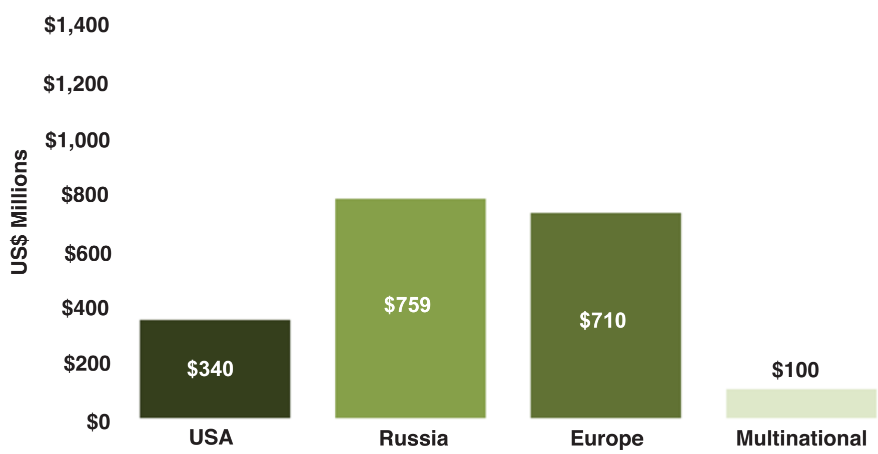


Figure 2. Estimated 2013 Commercial Launch Revenues

2013 LAUNCH ACTIVITY

WORLDWIDE ORBITAL LAUNCH ACTIVITY

Launch providers from the United States, Russia, Europe, China, Japan, India, South Korea, and one multinational provider conducted a total of 81 launches in 2013, 23 of which were commercial (see Figure 3 and Tables 1 and 2). This is higher than the previous 5-year average of 77 total launches and 21 commercial launches per year. The following is a summary of worldwide orbital commercial launches in 2013, by country.

- The United States conducted 19 launches in 2013, 6 more launches than in 2012. Six of the 19 launches were commercial, 4 more than in 2012.
- Russia had the most total launches (32) as well as the most commercial launches (12). This is 8 more launches than Russia had in 2012, with 24 total launches, 7 of which were commercial. Russia experienced one failure of a Proton M launch vehicle while attempting to launch three Glonass satellites for the Russian national satellite navigation system.
- Europe conducted 7 launches in 2013, 4 of which were commercial, a drop from 10 total launches, 6 of which were commercial in 2012.
- China had 15 orbital launches, all non-commercial, a drop from 19, including two commercial launches in 2012.
- The multinational Sea Launch Zenit 3SL launch vehicle performed one failed launch attempt in 2013. In 2012, there were three successful commercial launches by Sea Launch.
- India and Japan each had three non-commercial launches, a slight increase from two launches each in 2012.
- South Korea successfully launched Naro-1 (KSLV-1) launch vehicle. It was the rocket's first successful launch after two failed launch attempts in 2009 and 2010.
- There were 11 commercial launches of GEO satellites in 2013, four launches less than in 2012 and the lowest number since 2007.

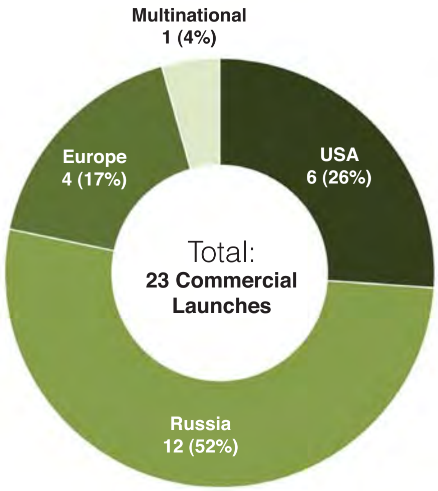


Figure 3. 2013 Worldwide Commercial Launch Activity

Country/Region	Commercial Launches	Non-Commercial Launches	Launches
United States	6	13	19
Russia	12	20	32
Europe	4	3	7
China	0	15	15
Japan	0	3	3
India	0	3	3
South Korea	0	1	1
Multinational	1	0	1
TOTAL	***23***	***58***	***81***

Table 1. 2013 Worldwide Orbital Launch Events

Date	Launch Vehicle	Launching Country/ Region	Primary Payload Name	Orbit	Launch Outcome
2/1/2013	Zenit 3SL	Multinational	Intelsat 27	GEO	Failure
2/6/2013	Soyuz 2.1a	Russia	Globalstar 2nd Gen 19	LEO	Success
2/7/2013	Ariane 5 ECA	Europe	Amazonas 3	GEO	Success
3/1/2013	Falcon 9 v1.0 Dragon	USA	Dragon ISS 2D	LEO	Success
3/26/2013	Proton M/ Breeze-M	Russia	SatMex 8	GEO	Success
4/15/2013	Proton M/ Breeze-M	Russia	Anik G1	GEO	Success
4/21/2013	Antares 120	USA	Cygnus Mass Simulator	LEO	Success
5/14/2013	Proton M/ Breeze-M	Russia	Eutelsat 3D	GEO	Success
6/3/2013	Proton M/ Breeze-M	Russia	SES 6	GEO	Success
6/25/2013	Soyuz 2.1b	Europe	O3b 01	MEO	Success
7/25/2013	Ariane 5 ECA	Europe	Alphasat I-XL	GEO	Success
8/22/2013	Dnepr	Russia	Kompsat 5	SSO	Success
8/29/2013	Ariane 5 ECA	Europe	Eutelsat 25B	GEO	Success
9/1/2013	Zenit 3SLB	Russia	Amos 4	GEO	Success
9/18/2013	Antares 120	USA	Cygnus COTS Demo	LEO	Success
9/29/2013	Falcon 9 v1.1	USA	Cassiope	LEO	Success
9/30/2013	Proton M/ Breeze-M	Russia	Astra 2E	GEO	Success
10/25/2013	Proton M/ Breeze-M	Russia	Sirius FM-6	GEO	Success
11/19/2013	Minotaur I	USA	STPSAT-3	LEO	Success
11/21/2013	Dnepr	Russia	DubaiSat 2	SSO	Success
11/22/2013	Rockot	Russia	Swarm 1	LEO	Success
12/3/2013	Falcon 9 v1.1	USA	SES-8	GEO	Success
12/8/2013	Proton M/ Breeze-M	Russia	Inmarsat 5-F1	GEO	Success

Table 2. 2013 Worldwide Commercial Launch Events

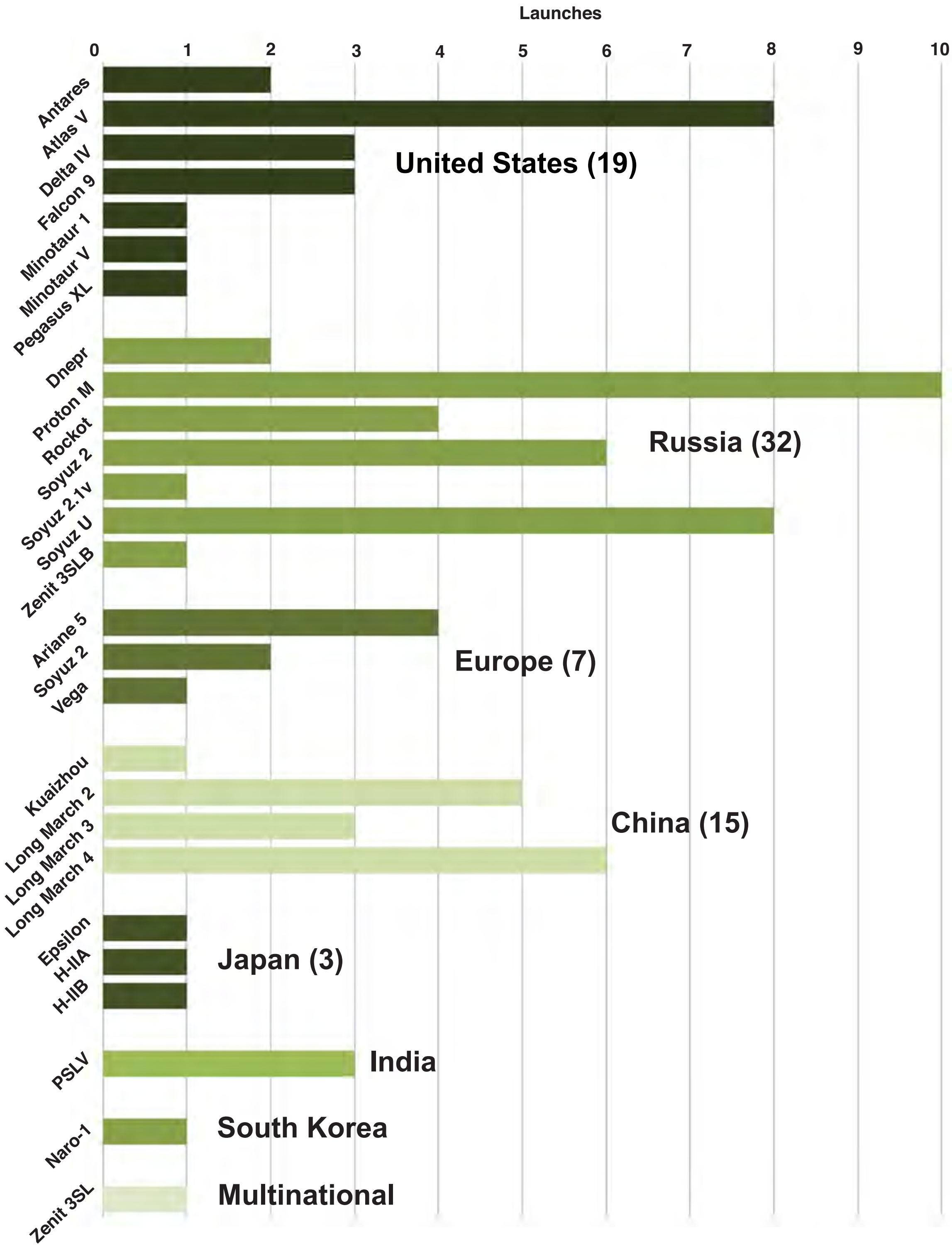


Figure 4. 2013 Launch Vehicle Use

Worldwide Launch Revenues

Estimated revenues from the 23 commercial launch events in 2013 amounted to approximately $1.9 billion. These revenues are consistent with commercial launch revenue in 2011 but show nearly half-billion dollar lower results than in 2009, 2010, and 2012. The following are 2013 revenues by country:

- Commercial launch revenues in the United States amounted to $339.5 million, the highest in the last five years. Estimated commercial launch revenue for 2012 was $108 million.
- Russian commercial launch revenues were approximately $759 million, up 22 percent from last year. The Proton returned to flight quickly after the July failure. This minimized slips of commercial launches to 2014.
- European commercial launch revenues were approximately $710 million, a 54 percent drop from 2012.
- China did not perform any commercial launches in 2013, while it had earned an estimated total of $90 million for its two commercial launches in 2012.
- Multinational (Sea Launch) revenues from its single 2013 launch were estimated as $100 million, down from $300 million in 2012.

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.

[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 seven FAA-licensed orbital launches in 2013 (see Table 3) from four different launch sites.

SpaceX's Falcon 9 vehicle made three licensed launches: a CRS mission to the ISS, launch of a Canadian Space Agency (CSA) satellite from Vandenberg Air Force Base (VAFB), and an SES commercial telecommunications satellite.

Orbital's Antares had two FAA-licensed launches, the inaugural launch in April, and the second launch under NASA's COTS program in September from Mid-Atlantic Regional Spaceport (MARS).

Date	Vehicle	Primary Payload	Orbit	Launch Outcome
1-Feb-13	Zenit 3SL	Intelsat 27	GEO	Failure
1-Mar-13	Falcon 9	Dragon CRS	LEO	Success
21-Apr-13	Antares	Cygnus Mass Simulator	LEO	Success
18-Sep-13	Antares	Cygnus COTS Demo	LEO	Success
29-Sep-13	Falcon 9	Cassiope	LEO	Success
19-Nov-13	Minotaur I	STPSAT-3	LEO	Success
3-Dec-13	Falcon 9	SES-8	GEO	Success

Table 3. 2013 FAA-Licensed Orbital Launch Events

A Minotaur I, also provided by Orbital, performed a successful FAA-licensed launch under the U.S. Air Force ORS program.

Sea Launch's Zenit 3SL vehicle performed one FAA-licensed launch attempt that resulted in a failure and the loss of a commercial telecommunications satellite Intelsat 27.

Over the past five years (in 2009–2013), FAA has on average licensed about four launches per year. However, in 2008, FAA licensed 11 launches, including 5 Sea Launch Zenit 3SL launches of commercial GEO communications satellites. With the Zenit 3SL grounded after the launch failure and more U.S. vehicles performing commercial launches, the increase in licensed launches is predominantly by U.S. launch organizations. SpaceX and Orbital plan 10 to 15 licensed launches in 2014, Sea Launch plans one launch in 2014. Figures 5 and 6 summarize the number of FAA-licensed orbital launches and revenue in 2009-2013.

United States

U.S. launch vehicles provided 13 U.S. government launches and 6 commercial launches in 2013. Of the 13 government launches, 5 were for NASA and 8 were for DoD. The three commercial SpaceX and Orbital launches to the ISS and the U.S. Air Force ORS-3 mission on the Minotaur I 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 2013.

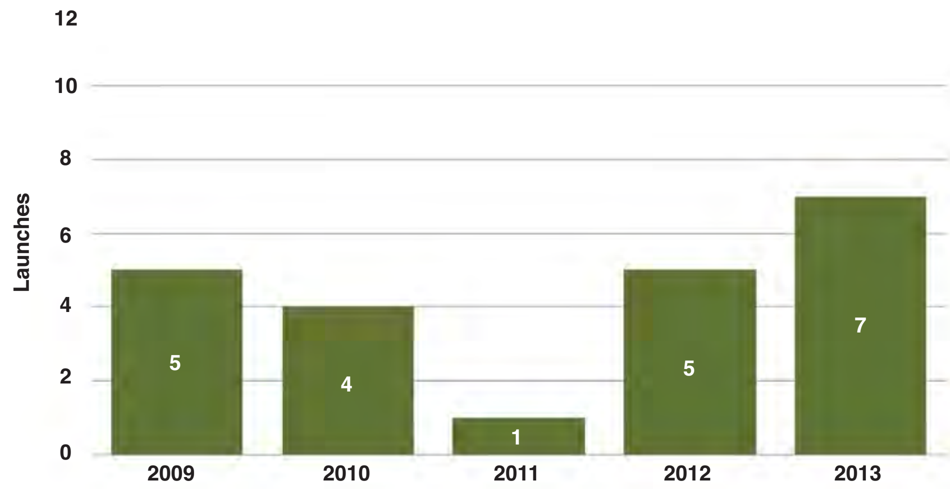


Figure 5 FAA-licensed Orbital Launch Events, 2009-2013

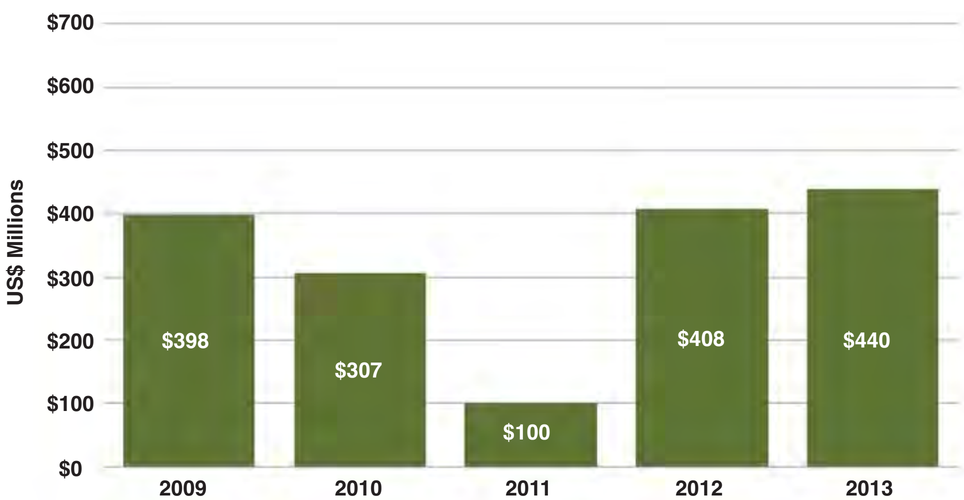


Figure 6. Estimated Revenue for FAA-licensed Orbital Launch Events, 2009-2013

The following is a list of U.S.-based launch service providers, highlighting their launch activity in 2013. 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, Pegasus, and Taurus vehicles for orbital launch.

Orbital performed five launches in 2013. Its new Antares launch vehicle performed a successful inaugural flight in April and enabled a successful Cygnus resupply mission to the ISS in its second launch in September. In June, a Pegasus XL launched NASA's IRIS payload from Kwajalein Island. In September, Orbital's new vehicle from the Minotaur family, Minotaur V, launched the NASA lunar probe LADEE. Another Minotaur vehicle, Minotaur I, launched a U.S. Air Force primary payload STPSAT-3 and 28 cubesat class satellites for several government civil, military, and non-profit missions.

Space Exploration Technologies Corporation

SpaceX performed three commercial Falcon 9 launches in 2013. In March, Falcon 9 v1.0 launched the Dragon capsule carrying supplies to the ISS. This mission was performed under NASA's CRS program. In September, the company launched the Cassiope remote sensing mission for CSA, and in December deployed a commercial telecommunications satellite SES-8 to geosynchronous transfer orbit (GTO). The latter two launches were performed by a new version of the Falcon 9 rocket, Falcon 9 v1.1

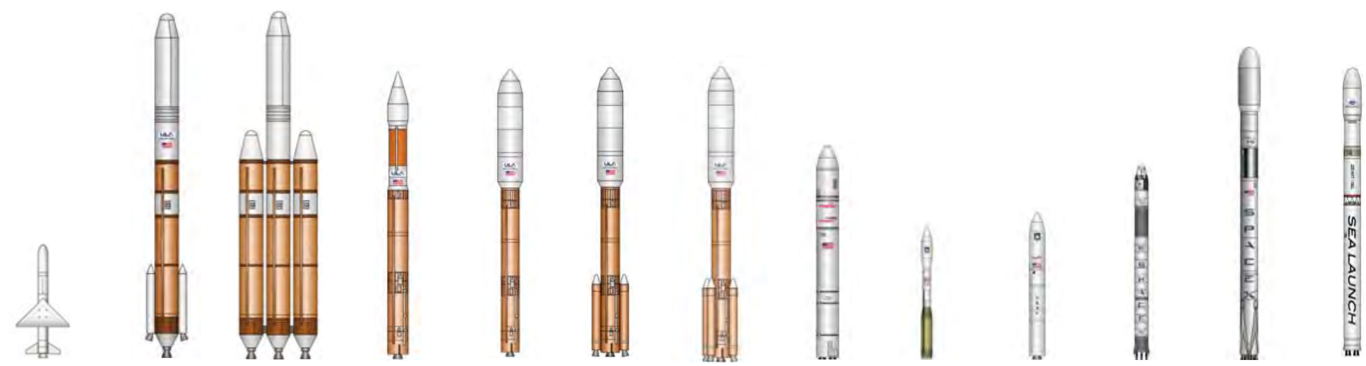
United Launch Alliance

ULA manufactures and operates Boeing-heritage Delta vehicles and Lockheed Martin-heritage Atlas vehicles. ULA is a partnership between Boeing and Lockheed Martin. In 2013, ULA conducted a record number of 11 non-commercial U.S. government launches.

Delta IV vehicles placed three DoD payloads into orbit: WGS 5, WGS 6, and NRO L-65. Atlas V vehicles placed eight primary payloads, five for DoD, three for NASA (including one jointly with the U.S. Geological Survey) into orbit: SBIRS GEO 2, Navstar GPS 2F-04, MUOS 2, AEHF 3, NRO L-39, TDRS K, MAVEN, and Landsat DCM.

FAA-Licensed Multinational Launches: Sea Launch AG

Zenit 3SL, a launch vehicle operated by multinational commercial launch provider Sea Launch AG, attempted to deploy one commercial GEO communications satellite for commercial operator Intelsat. The launch attempt resulted in a failure.



Vehicle	Pegasus XL	Delta IV Medium+ (5,4)	Delta IV Heavy	Atlas V 401	Atlas V 501	Atlas V 531	Atlas V 551	Antares 120	Minotaur I	Minotaur V	Falcon 9 v1.0	Falcon 9 v.1.1	Zenit 3SL
2013 Total Launches	1	2	1	5	1	1	1	2	1	1	1	2	1
2013 Licensed Launches	0	0	0	0	0	0	0	2	1	0	1	2	1
Launch Reliability (2013)	1/1 100%	2/2 100%	1/1 100%	5/5 100%	1/1 100%	1/1 100%	1/1 100%	2/2 100%	1/1 100%	1/1 100%	1/1 100%	2/2 100%	0/1 0%
Launch Reliability (Last 10 Years)	8/8 100%	4/4 100%	6/7 86%	18/18 100%	5/5 100%	3/3 100%	4/4 100%	2/2 100%	11/11 (100%)	1/1 100%	5/5 100%	2/2 100%	23/25 92%
Year of First Launch	1994	2009	2004	2002	2010	2011	2006	2013	2000	2013	2010	2013	1999
Active Launch Sites	CCAFS, Kwajalein, VAFB	CCAFS, VAFB	CCAFS, VAFB	CCAFS, VAFB	CCAFS, VAFB	CCAFS, VAFB	CCAFS, VAFB	MARS	CCAFS, VAFB, MARS, KLC	MARS	CCAFS	CCAFS, VAFB	Odyssey Pacific Ocean Platform
LEO kg (lbs)	450 (992)	13,774 (30,365)	22,560 (49,740)	9,797 (21,598)	8,123 (17,908)	15,575 (34,337)	18,814 (41,478)	4,900 (10,780)	580 (1,279)	--	9,000 (19,842)	13,150 (28,991)	--
GTO kg (lbs)	--	7,434 (16,389)	14,420 (31,791)	4,750 (10,470)	3,775 (8,320)	7,475 (16,470)	8,900 (19,620)	--	--	640 (1,411)	--	4,850 (10,692)	6,160 (13,580)

Table 4. U.S. and FAA-Licensed Launch Vehicles Active in 2013

FAA Reentry License Summary

There was one reentry conducted under an FAA reentry license in 2013. SpaceX's Dragon spacecraft performed the licensed reentry, in March 2013, completing its second CRS mission to the ISS. (See Table 5 for details.)

Vehicle	SpaceX Dragon
2013 Total Reentries	1
2013 Licensed Reentries	1
Launch Reliability (2013)	1/1 100%
Reentry Reliability (Last 10 Years)	4/4 100%
Year of First Reentry	2010
Reentry Sites	Pacific Ocean
Payload to LEO,kg(lbs)	6,000 (13,228)
Payload from LEO, kg (lbs)	3,000 (6,614)

Table 5. FAA-Licensed Reentry Vehicles Active in 2013

FAA Suborbital Launch Summary

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

- Armadillo Aerospace's STIG-B vehicle made an FAA-licensed suborbital flight from Spaceport America. Later in the year the company announced it was going on hiatus;
- Virgin Galactic's SpaceShipTwo performed two successful powered flight tests authorized under an FAA experimental permit; and
- SpaceX performed five successful suborbital launches of its Grashopper vertical takeoff vertical landing (VTVL) rocket authorized under an FAA Experimental Permit. These flights were part of a test program leading to the development of a reusable first stage for the Falcon 9 orbital launch vehicle.

Other highlights of the suborbital vehicle development activities include:

- Masten Space Systems' XA-0.1B "Xombie" completed an 80-second flight to test for NASA featuring a closed-loop planetary Guidance, Navigation and Control system as prototype landing instruments for future missions to the Moon or Mars; and
- Blue Origin tested it BE-3 liquid-hydrogen rocket engine at its facility in Van Horn, Texas. This engine will be used for the company's suborbital vehicle, New Shepard, and ultimately for its orbital vehicle.

Operator	Type of FAA Authorization	Launch Date	Vehicle
Armadillo Aerospace	Launch Operator License (LRLO 12-080)	5-Jan	STIG-B
Scaled Composites	Experimental Permit (EP 12-007)	29-Apr 5-Sep	SpaceShipTwo
SpaceX	Experimental Permit (EP 12-008)	7-Mar 19-Apr 14-Jun 13-Aug 7-Oct	Grasshopper

Table 6. FAA 2013 Suborbital License and Permit Flight Summary

Vehicle	Rockot	Dnepr	Soyuz 2	Soyuz 2.1v	Proton M	Ariane 5 ECA	Soyuz 2	Vega
Country/Region	Russia	Russia	Russia	Russia	Russia	Europe	Europe	Europe
2013 Total Launches	4	2	5	1	10	4	2	1
Launch Reliability (2013)	4/4 100%	2/2 100%	5/5 100%	1/1 100%	9/10 90%	4/4 100%	2/2 100%	1/1 100%
Launch Reliability (Last 10 Years)	17/18 94%	6/6 100%	17/19 89%	1/1 100%	69/77 90%	38/39 97%	6/6 100%	2/2 100%
Year of First Launch	1994	2010	2004	2013	2001	2002	2011	2012
Active Launch Sites	Baikonur, Plesetsk	Baikonur, Dombarovsky	Baikonur, Plesetsk	Baikonur, Plestesk	Baikonur	Kourou	Kourou	Kourou
LEO kg (lbs)	2,150 (4,740)	3,700 (8,157)	4,850 (10,692)	3,000 (6,614)	23,000 (50,706)	21,000 (46,297)	4,850 (10,692)	2,300 (5,071)
GTO kg (lbs)	--	--	1,700 (3,800)	1,400 (3,086)	6,920 (15,256)	9,500 (20,944)	3,250 (7,165)	--

Table 7. Non-U.S. Commercially Available Launch Vehicles Active in 2013

Vehicle	Long March 2C	Long March 2D	Long March 3B	H-IIA	H-IIB	Epsilon Standard	PSLV CA	PSLV XL
Country/Region	China	China	China	Japan	Japan	Japan	India	India
2013 Total Launches	2	2	3	1	1	1	1	1
Launch Reliability (2013)	2/2 100%	2/2 100%	3/3 100%	1/1 100%	1/1 100%	1/1 100%	1/1 100%	1/1 100%
Launch Reliability (Last 10 Years)	18/19 95%	17/17 100%	21/21 100%	20/21 95%	3/3 100%	1/1 100%	3/3 100%	2/2 100%
Year of First Launch	1975	1992	1996	2001	2009	2013	2009	2012
Active Launch Sites	Jiuquan, Taiyuan, Xichang	Jiuquan	Xichang	Tanegashima	Tanegashima	Uchinoura	Satish Dhawan	Satish Dhawan
LEO kg (lbs)	3,850 (8,488)	1,300 (2,866)	--	10,000 (23,046)	16,500 (36,376)	1,200 (2,646)	2,100 (4,630)	1,800 (3,968)
GTO kg (lbs)	1,250 (2,756)	--	5,100 (11,244)	6,000 (13,228)	8,000 (17,600)	--	--	1,140 (2,513)

Table 7. Non-U.S. Commercially Available Launch Vehicles Active in 2013 (continued)

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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.

An Antares vehicle, manufactured and operated by Orbital Science Corporation, being prepared for launch at Virginia's Mid-Atlantic Regional Spaceport.

Image credit: Orbital

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 2013 there were 81 orbital launches, 23 of which were commercial. The year included many "firsts" for the space launch industry as a whole and for the U.S. commercial launch industry in particular, including the successful completion of NASA's Commercial Orbital Transportation Services (COTS) program. The following are 2013 highlights of the commercial launch industry:

Six of the 19 U.S. launches this year were commercial orbital launches, second largest number after Russia with 12 commercial launches.

- Orbital Sciences' new launch vehicle Antares performed its first two launches:
  - The second launched birthed to the International Space Station (ISS), marking the successful conclusion of the NASA's COTS program.
  - Orbital's future commercial cargo flights to the ISS will be under the NASA's Commercial Resupply Services (CRS) program.
- SpaceX had its second CRS flight resupplying the ISS. The company also performed two successful commercial launches of its upgraded Falcon 9 v1.1 and tested its reusability technology in test flights of the Grasshopper experimental vehicle and engine relights of its first stage.
  - The demonstration launch of the upgraded Falcon 9 rocket was from Vandenberg Air Force Base (VAFB) and delivered the Canada's CASSIOPE satellite into a polar orbit.
  - The second mission launched SES's commercial telecommunications satellite to GTO. 2009 was the last time the U.S launched a commercial satellite to GTO: Intelsat 14 on ULA's Delta IV rocket.
- Record numbers of cubesats were launched on two launches thirty hours apart in November.
  - Orbital's Minotaur I was an FAA licensed launch for the U.S. military ORS-3 mission that included 28 cubesats.
  - Russian Dnepr launch vehicle launching 31 cubsats alongside remote sensing satellite, DubaiSat-2.This launched carried the most ever satellites into orbit.
- Though not commercial launches, there were a number of significant launches by foreign governments.
  - India launched of its first Mars orbiter.
  - China successfully landed its first rover on the Moon.
  - China launched a new four stage all solid launch vehicle, Kuaizhou, weighing 30 metric tons and capable of putting 500 kg (1,102 lb) into LEO, approximately the same capacity as a Minotaur 1 rocket.
  - Successful inaugural launch of the Epsilon launch vehicle by the Japanese Space Agency (JAXA). Epsilon can place 1,200 kg (2,646 lb) into LEO and can potentially reduce launch costs compared to Japan's heavier vehicles H-IIA and H-IIB.
  - Russia's successful first launch of a new smaller version of its Soyuz launch vehicle: Soyuz 2.1v is reportedly introduced as replacement of the discontinued Kosmos and Tsyklon vehicles and a backup for the Rockot vehicle.

- 2013 saw three failed orbital launch attempts:
  - A Zenit 3SL launch vehicle operated by commercial launch provider Sea Launch performed a failed launch attempt of a commercial communications satellite Intelsat 27.
  - A Proton M launch vehicle failed to launch three Russian Government navigation satellites in July; The Proton M rockets later successfully returned to flight in October with two commercial and two non-commercial launches.
  - A Chinese Long March 4B launch vehicle failed to launch a China/Brazil Earth Resource Satellite (CBERS) in December.

These and other 2013 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, Pegasus XL, Taurus, Falcon 9, Atlas V, and Delta IV. The Antares from Orbital Sciences Corporation (Orbital) perfomed two successful launches in 2013. 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 2014. The Antares will be commercially available, but the availability of Super Strypi for commercial use is uncertain. Another Orbital Sciences launch vehicle, Minotaur I, launched by the U.S. Air Force under the FAA license in September 2013, is generally not available for launches of payloads on commercial basis.

Operator	Vehicle	Year of First Launch	Total/2013 Launches	Active Launch Sites	Mass to GTO kg (lb)	Mass to LEO kg (lb)	Mass to SSO kg (lb)
Orbital Sciences Corp.	Antares	2013	2/2	MARS	--	6,120 (13,492)	4,500 (9,920)
Orbital Sciences Corp.	Pegasus XL	1994	32/1	CCAFS, Kwajalein, VAFB, WFF	--	475 (1,045)	325 (715)
Orbital Sciences Corp.	Taurus	1994	9/0	VAFB	--	1,160 (2,552)	1,600 (3,520)
SpaceX	Falcon 9	2010	7/3	CCAFS	4,850 (10,692)	13,150 (28,991)	--
United Launch Alliance	Atlas V	2002	42/8	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)
United Launch Alliance	Delta IV	2002	24/3	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)
UH, Sandia, Aerojet Rocketdyne	Super Strypi	2014	0/0	Barking Sands	--	200 (441)	--

Table 1. U.S. Commercial Launch Vehicles

NON-U.S COMMERCIAL ORBITAL LAUNCH VEHICLES

There are 11 expendable launch vehicle types available for commercial use outside the United States: Ariane 5, Soyuz 2, Vega, Long March 2D, Long March 3A, Rockot, Proton M, Dnepr, Epsilon, H-IIA/B, and Zenit 3SL/SLB.

Operator	Vehicle	Year of First Launch	Total/2013 Launches	Active Launch Sites	Mass to GTO kg (lb)	Mass to LEO kg (lb)	Mass to SSO kg (lb)
Arianespace	Ariane 5	1996	71/6	Guiana Space Center	9,500 (20,944)	21,000 (46,297)	10,000 (22,046)
Arianespace	Soyuz 2	2004	22/2	Baikonur, Guiana Space Center, Plesetsk	3,250 (7,165)	4,850 (10,692)	4,400 (9,700)
Arianespace	Vega	2012	2/1	Guiana Space Center	--	1,500 (3,307)	--
CGWIC	Long March 2	2C: 1975 2D: 1992	2C: 34/2 2D:13/2	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: 13/3 BE:13/0 C: 10/0	Xichang	A: 2,600 (5,732) B: 5,100 (11,244) BE: 5,500 (12,125) C: 3,800 (8,378)	--	--
Eurockot	Rockot	1990	23/3	Baikonur, Plesetsk	--	2,140 (4,718)	--
ILS	Proton M	2001	78/10	Baikonur	6,920 (15,256)	23,000 (50,706)	--
ISC Kosmotras	Dnepr	1999	19/2	Baikonur, Dombarovsky	--	3,700 (8,157)	2,300 (5,071)
JAXA	Epsilon	2013	1/1	Uchinoura	--	1,200 (2,646)	700 (1,543)
Mitsubishi	H-IIA/B	A: 2001 B: 2009	A: 22/1 B: 4/1	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: 35/1 3SLB: 6/1	Baikonur, Sea Launch	3SL: 6,000 (13,228) 3SLB: 3,500 (7,716)	--	--

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

Antares

Orbital Sciences Corp.

Antares 120

Antares 130

Antares 121

Antares 131

Antares 122

Antares 132

Orbital Sciences Corporation began offering its Antares, a two-stage vehicle designed to launch government and commercial satellites to low Earth orbit, Cygnus cargo modules to the International Space Station, 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, which until now has focused on solid-fueled systems like Pegasus, Taurus, and Minotaur. The Antares consists of a first stage produced by Ukrainian Yuzhnoye Design Office (Yuzhnoye), which is 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. Six variants of the Antares will be available to customers. 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 vehicle is launched from the Mid-Atlantic Regional Spaceport (MARS), located on Virginia's Wallops Island.

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
2

Reliability
100%

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.

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)

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
42

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)

	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 is scheduled t launch the first flight of NASA's orbital vehicle, Orion. The mission, Exploration Flight Test (EFT-1), may qualify as a commercial launch and require an FAA license. The launch is currently planned for the second half of 2014.

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
24

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 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.

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 2
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)

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.

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).

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 2014 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 2014
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

TAURUS

Orbital Sciences Corp.

Orbital Sciences Corporation offers the four-stage small-class vehicle, Taurus, as an option for ssatellite customers. The Taurus, essentially a ground-launched version of the Pegasus, was developed under sponsorship of the Defense Advance Research Projects Agency (DARPA). Several variants of the Taurus are available, allowing Orbital to mix and match different stages and fairings to address customer needs.

The Taurus launches primarily 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).

Taurus 3210

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 1994
Number of launches 9
Reliability 67%
Launch sites CCAFS (SLC-46) MARS (Pad 0-B) VAFB (SLC-376E)

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)

Taurus 2110, 3110, 3113

ARIANE 5

Arianespace

Ariane 5 ECA

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 Astrium 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 Astrium 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. The Ariane 5 has launched 71 times since its introduction in 1996, with 57 consecutive successes since 2003. The Ariane 5 ECA variant has flown 42 times.

Launch service provider	Arianespace
Company headquarters	France
Manufacturer	Arianespace

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	42 (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)

Ariane 5 ES

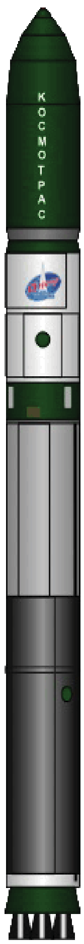
Fairing	Length, m (ft)	Diameter, m (ft)
Standard Fairing	17 (55.8)	5.4 (17.7)

	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	EADS Astrium	Europropulsion	EADS Astrium
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 19 times, with 1 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.

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 19
Reliability 95%
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 will be 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)

H-IIA/B

H-IIA Launch Services

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.

Launch service provider H-IIA 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) 26
Reliability (A/B) 96%
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)

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

	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: 34, LM-2D: 13
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 (X)	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

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.

Long March 3C

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: 10

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

Launch site
XSLC

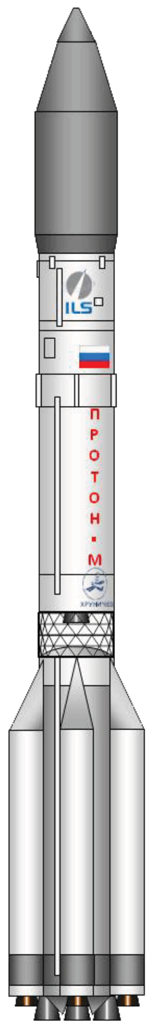
GTO capacity, kg (lb)
2,600-5,500 (5,732-12,125)

	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.*

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).

The Proton M consists of a first stage powered by six RD-276 engines, a second stage powered by three RD-0210 engines, and a third stage powered by an RD-0123 engine. The fourth stage is a Breeze-M powered by one 14D30 engine. The Breeze-M also features 4 settling thrusters and 12 attitude control thrusters. The payload fairing covers both the payload and the Breeze-M upper stage during launch. Until December 2012, the Russian government used an earlier version of the Proton, often called the Proton K. It will now use 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.

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 79
Reliability 90%
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.

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

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
21

Reliability
90%

Launch site
Plesetsk (LC-133)

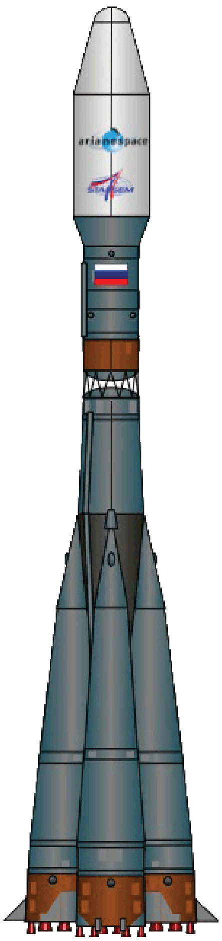
LEO capacity, kg (lb)
1,820-2,150 (4,012-4,740)

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

	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.

Launch service provider	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	28
Reliability	100%
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

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. 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 1500 km.

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, Vosotchny, 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

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.

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 2
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

Zenit-3SLB

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, 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.

Launch service provider	Sea Launch AG
Company headquarters	Switzerland
Manufacturer	Yuzhnoye

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: 35 3SLB: 6
Reliability	3SL: 91% 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)

	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
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 and possibly from other sites like Cape Canaveral Spaceport's SLC-46.
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 kilograms (33 pounds). The Lynx Mark III will roll out after successful test flights of the prototype Lynx Mark I and operational experience with Lynx Mark II.
LauncherOne	The Spaceship Company	2016	Virgin Galactic will offer LauncherOne, a small-class orbital launch vehicle. It will use the WhiteKnightTwo carrier aircraft and an air-launched expendable rocket stage (called LauncherOne) to carry the payload. The payload capacity will be 225 kilograms (500 pounds). SkyBox Imaging and GeoOptics have already signed contracts with Virgin Galactic for the launch of their satellites.
Stratolaunch Carrier Aircraft	Stratolaunch Systems	2017	Stratolaunch is an orbital launch services venture involving Scaled Composites (design and manufacture of carrier aircraft), Orbital (design and manufacture of the rocket stage), and Dynetics (design and manufacture of the mating and integration system). The carrier aircraft is composed of a twin-fuselage design incorporating two 747-400 airframes. 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.
GOLauncher	Generation Orbit and Space Propulsion Group	2016	Generation Orbit is introducing 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 20-30 kilograms (44-66 pounds) into LEO.
NEPTUNE	Interorbital Systems (IOS)	TBD	Mojave-based IOS is developing a line of NEPTUNE vehicles to send micro- and small-class satellites into orbit. NEPTUNE variants are composed of clusters of Common Propulsion Modules (CPMs); for example, the NEPTUNE 5 consists of five CPMs and can send a 30-kilogram (66-pound) payload into LEO. IOS has performed engine tests during the past few years and is planning operational launches from Tonga.

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
Long March 5, 6, and 7	China Academy of Launch Vehicle Technology (CALT) and Shanghai Academy of Spaceflight Technology (SAST)	2014	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.
Tsyklon 4	Yuzhnoye Design Office	2014	The Brazilian Space Agency signed an agreement with the Ukrainian Space Agency to support development of the Tsyklon 4. Based on the Tsyklon 3, the Tsyklon 4 is a three-stage, medium-class launch vehicle. 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.
Angara	Khrunichev State Research and Production Space Center	2017	Since 1995, the Angara has been an effort to produce modular launch vehicles with a CCB using LOX and kerosene as propellants and powered by an RD-191 engine. Two small-class Angara 1 versions will use one CCB, a medium-class Angara 3 will use three, the heavy-class Angara A5 will use five, and the heavy-class Angara A7 will use seven CCBs. The vehicles will also use Breeze-KM and Breeze-M upper stages. An inaugural launch is planned for 2014, but there have been reports on possible further delays in the program.

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

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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 conducts its first powered flight on April 29, 2013.

Image credit: MarsScientific.com and Clay Center Observatory

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 2014. 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. 2013 Highlights include:

- Armadillo Aerospace's STIG-B vehicle made an FAA-licensed suborbital flight from Spaceport America, but later in the year the company announced it is going on hiatus;
- Virgin Galactic's SpaceShipTwo performed two successful powered flight tests authorized under an FAA experimental permit;
- XCOR Aerospace successfully performed tests of its piston pump-powered rocket engine destined for use as the propulsion system for the company's Lynx vehicle;
- Masten Space Systems' XA-0.1B "Xombie" completed an 80-second flight for NASA to test a closed-loop planetary Guidance, Navigation and Control system as prototype landing instruments for future missions to the Moon or Mars;
- Blue Origin tested it BE-3 liquid-hydrogen rocket engine at its facility in Van Horn, Texas. This engine will be used for the company's suborbital vehicle, New Shepard, and ultimately for its orbital vehicle.

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
Armadillo Aerospace	STIG B	--	50** (110)	Not announced	2013, now on hiatus
Blue Origin	New Shepard	3+	120** (265)	Not announced	Not announced
Masten Space Systems	Xaero Xogdor	-- --	12 (26) 25 (55)	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	2014
XCOR Aerospace	Lynx Mark I Lynx Mark II Lynx Mark III	1 1 1	120 (265) 120 (265) 770 (1,698)	$95,000 per seat $95,000 per seat $95,000 per seat, $500,000 for small sat. launch	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.

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

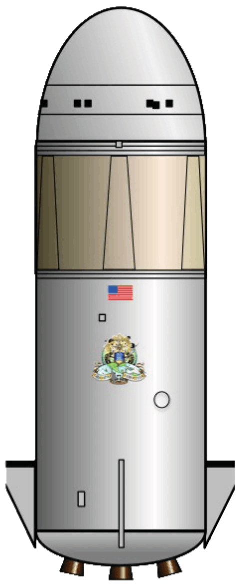
Mass, kg (lb) ~5,000 (11,023)
Length, m (ft) 10 (33)
Wingspan, m (ft) 7.3 (24)

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.

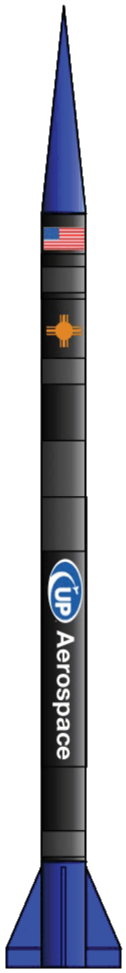
Operator Blue Origin
Company Headquarters USA
Manufacturer Blue Origin
Launch Site Van Horn, Texas

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 six times. UP Aerospace is headquartered in Denver, Colorado, with launch facilities at Spaceport America in New Mexico.

Operator	UP Aerospace
Company Headquarters	USA
Manufacturer	UP Aerospace
Launch Site	Spaceport America

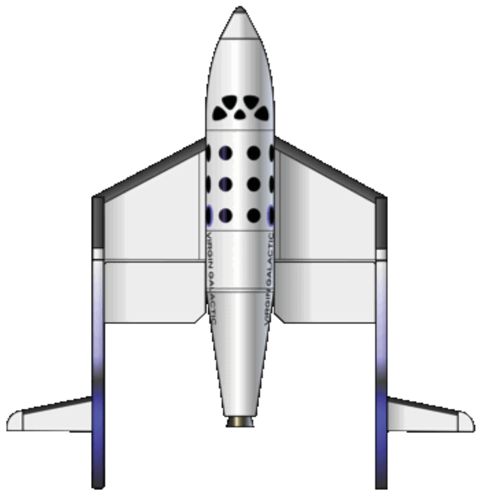
Mass, kg (lb)	354 (780)
Length, m (ft)	6.1 (20)
Diameter, m (ft)	0.26 (0.85)
Engine	1 x UPA-264-C
Engine Manufacturer	Cesaroni Technologies
Thrust, kN (lbf)	36.6 (8,228)
Propellant	Solid

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.

	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)

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
2014

Seats
Pilots: 2
Participants: 6

Price
$250,000 per seat

Cargo Capacity, kg (lb)
600 (1,323)

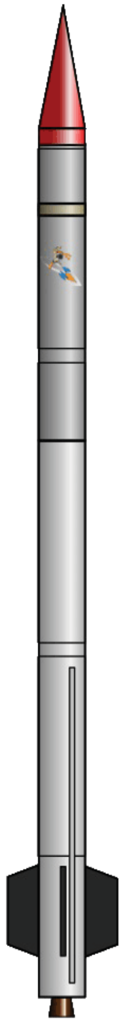
Apogee, km (mi)
110 (68.4)

Time in Microgravity
5 minutes

Flight Duration
~120 minutes

STIG-B

Armadillo Aerospace



STIG-B

Armadillo Aerospace was developing two suborbital reusable vehicles, the Suborbital Transport Inertially Guided (STIG) (not crewed) and Hyperion (crewed).

The STIG family of vehicles were reusable, vertical takeoff, parachute recoverable suborbital vehicles. STIG-B was a larger version of the company's STIG-A vehicle and was capable of launching 50-kilogram (110-pound) payloads to an altitude of 100 kilometers (62 miles).

In October 2012, STIG-B performed the first licensed launch from Spaceport America. Shortly after the third launch in January 2013, Armadillo Aerospace went on hiatus.

Operator Armadillo Aerospace
Company Headquarters USA
Manufacturer Armadillo Aerospace
Launch Site Spaceport America

Length, m (ft) 10.6 (35)
Diameter, m (ft) 0.5 (1.6)
Engine Manufacturer Armadillo Aerospace
Propellant LOX/ethanol

Vehicle Type Vertical takeoff, parachute recovery
Year Launch Operations Began 2012
Cargo Capacity, kg (lb) 50 (110)
Apogee, km (mi) 100 (62)
Time in Microgravity ~4 minutes
Flight Duration ~20 minutes

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

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

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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.

A SpaceX Dragon used for the 2013 CRS-2 mission as seen from the ISS.

Image credit: SpaceX

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.

2013 highlights in on-orbit vehicle and platform development by commercial companies included:

- In February, SpaceX's Dragon vehicle completed its second CRS resupply mission to the ISS. NASA has contracted for 10 more cargo resupply missions from SpaceX;
- In September, Orbital Sciences' Cygnus module successfully berthed with the ISS, marking the completion of NASA's COTS program. The second Cygnus flight to resupply ISS was postponed to early 2014 because of a coolant leak repair on ISS;
- In October, Sierra Nevada Corporation (SNC) performed a drop test of its Dream Chaser crewed lifting-body spacecraft. The unpiloted mission was successful, but the vehicle experienced a landing gear malfunction during landing;
- In January, NASA awarded Bigelow Aerospace a $17.8 million dollar contract to provide its Bigelow Expandable Activity Module (BEAM) to the ISS in 2015;
- SNC signed an agreement with Bigelow Aerospace to develop a common berthing mechanism for BEAM, allowing it to be attached to the station; and,
- In December, Blue Origin performed a successful test of its 100,000 pound-force BE-3 LOX/LH2 engine at at its facility in Van Horn, Texas.

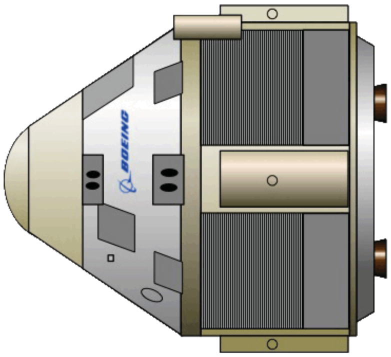
Details on on-orbit vehicle and platforms are provided in the following fact sheets.

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 (crew)	Falcon 9	TBD	7	2015
Orbital	Cygnus (Standard)	Antares	2,000 (4,409)	0	2013
Orbital	Cygnus (Enhanced)	Antares	2,700 (5,952)	0	2014
Boeing	CST-100	Atlas V Delta IV Falcon 9	TBD	7	2016
SNC	Dream Chaser	Atlas V	TBD	7	2016
Blue Origin	Space Vehicle	Atlas V Blue Origin RBS	TBD	7	TBD
Excalibur Almaz	Almaz Reusable Return Vehicle	TBD	10,000 (22,046)	3	TBD
Operator	**Platform**	**On-Orbit Vehicle**	**Maximum Volume m³ (ft³)**	**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

CST-100

Boeing

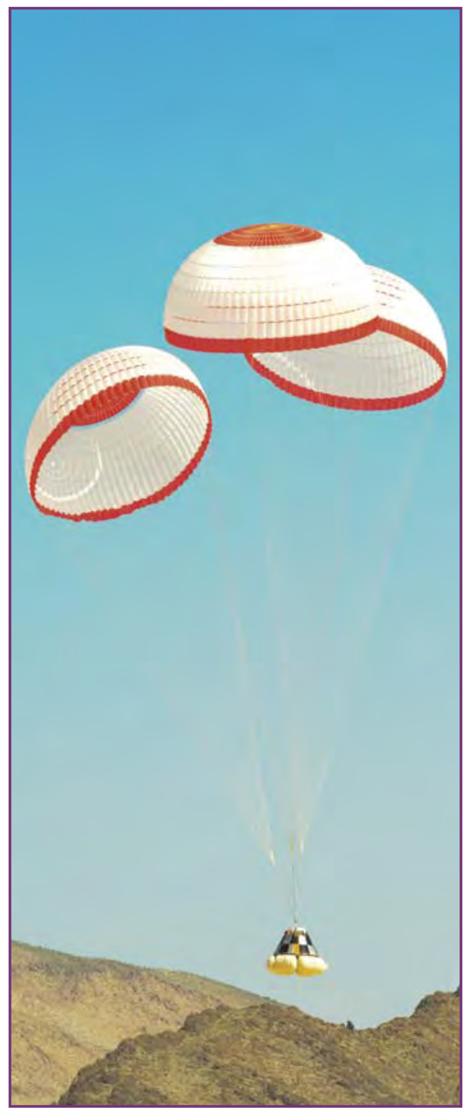


CST-100

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.

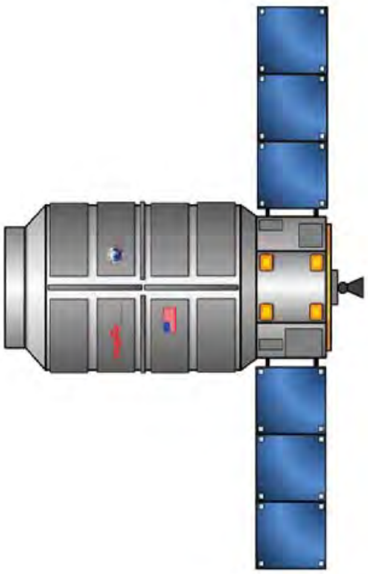
Operator Boeing
Company Headquarters USA
Manufacturer Boeing
Launch Site CCAFS (SLC-41)
Launch Vehicle Atlas V
Landing Type Parachute splashdown
Year Operations Begin ~2017



	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

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.

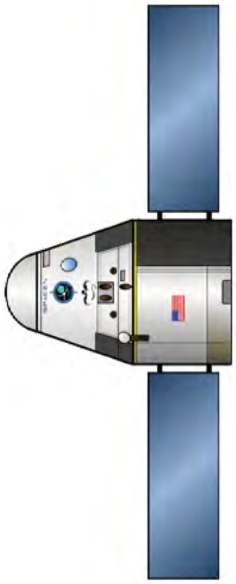
Once the Cygnus undocks from the ISS, it can stay in orbit for two years before it is programmed to reenter. According to orbital, Cygnus has hosted payload and nanosatellite (cubesat) deployment capabilities.

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

	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.

The crewed version is almost identical to the cargo version, but includes a life support system, crew escape system, and onboard controls for the crew to take over from the flight computer when needed.

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. SpaceX has also secured funding from NASA for its efforts to develop Dragon's crew capabilities, through the CCDev-2 program in 2011 and the CCiCap program in 2012. Combined, these two awards amount to $515 million.

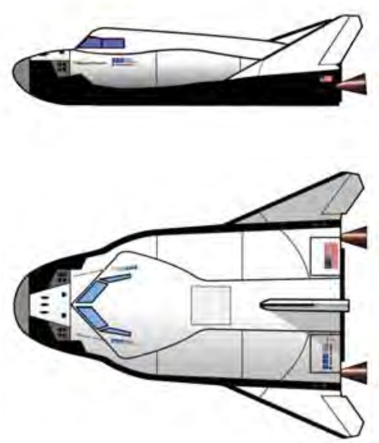
Operator SpaceX
Company Headquarters USA
Manufacturer SpaceX
Launch Site CCAFS (SLC-40)
Launch Vehicle Falcon 9
Landing Type Parachute splashdown
Year Operations Began Dragon Cargo: 2012 Crew Dragon: 2017

	Dragon Cargo	Crew Dragon
Vehicle type	Cargo, reusable	Crewed, reusable
Crew	0	7
Length, m (ft)	4.4 (14.4)	4.4 (14.4)
Diameter, m (ft)	3.6 (11.8)	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	18 x Draco thrusters
Propellant	NTO/MMH	NTO/MMH
Power, kW (peak)	4	--

Dream Chaser

Sierra Nevada Corp.

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 ~2017



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.

	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

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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.

New Mexico's Spaceport America.

Image credit: Spaceport America

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 2013, FAA AST issued eight launch site operator licenses. Table 9 below lists orbital and suborbital FAA-licensed commercial launch sites, often called spaceports, in the United States. 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 17 active launch and reentry sites, the U.S. Government manages 8, state agencies manage 8 FAA-licensed commercial sites in partnership with private industry, and a university manages 1. Four sites are dedicated to orbital launch activity, eight do suborbital launches only, and five can do 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 Grasshopper 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 11. 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	2013 Launches
California Spaceport, California	Spaceport Systems International	1996	18-Sep-2016	None
Mid-Atlantic Regional Spaceport, Virginia	Virginia Commercial Space Flight Authority	1997	18-Dec-2017	Antares (2) Minotaur V (1) Minotaur I (1)
Kodiak Launch Complex, Alaska	Alaska Aerospace Corporation	1998	23-Sep-2018	None
Cape Canaveral Spaceport, Florida	Space Florida	1999	30-Jun-2015	None
Mojave Air and Space Port, California	East Kern Airport District	2004	16-Jun-2014	SpaceShipTwo (2), Xaero
Oklahoma Spaceport, Oklahoma	Oklahoma Space Industry Development Authority	2006	11-Jun-2016	None
Spaceport America, New Mexico	New Mexico Spaceport Authority	2008	14-Dec-2018	STIG-B (1) SpaceLoft XL (2)
Cecil Field Spaceport, Florida	Jacksonville Aviation Authority	2010	10-Jan-2015	None

Table 8. FAA-licensed Commercial Launch Sites

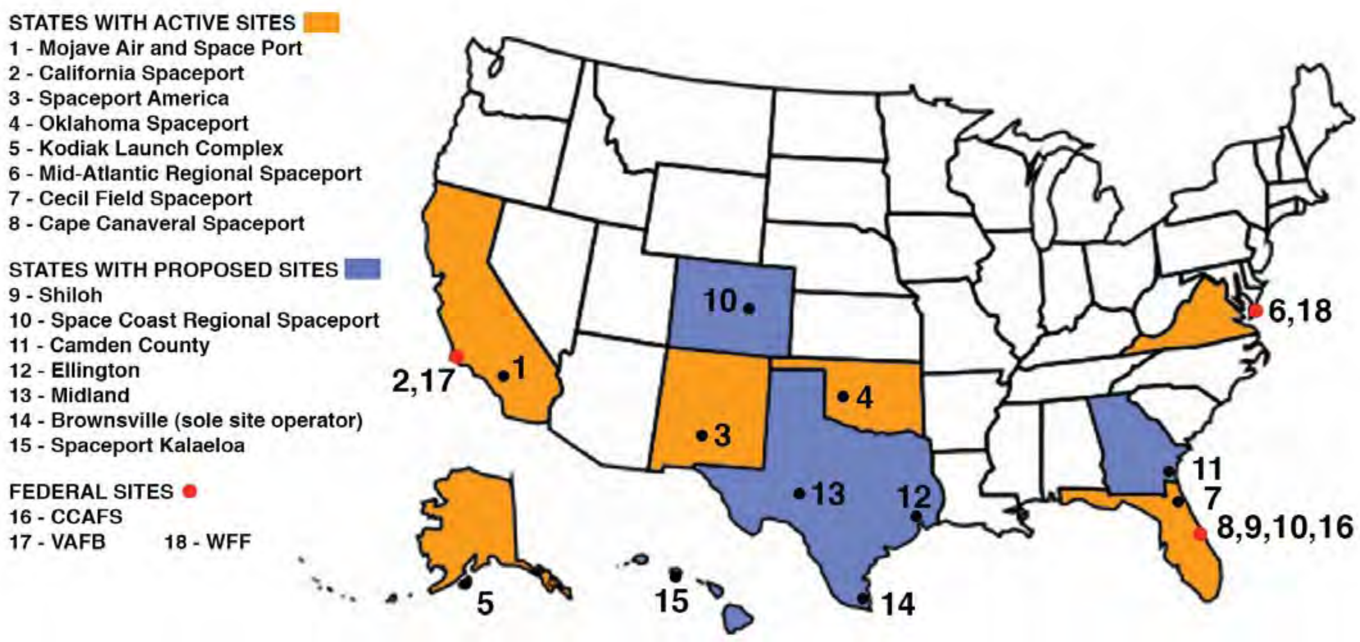


Figure 1. U.S. Federal and Non-Federal Launch Sites.

2013 Highlights

Seven FAA-licensed orbital and suborbital launches took place from launch sites in the U.S. Spaceport America kicked off the year with a launch of Armadillo Aerospace's STIG-B vehicle. A SpaceX Falcon 9 was launched from CCAFS in support of a cargo mission to the ISS. In April, Orbital Sciences performed the inaugural launch of its Antares orbital launch vehicle with a mass simulator, followed in September by another Antares launch of a Cygnus, this time to the ISS under NASA's COTS program. Later that month, SpaceX launched its upgraded Falcon 9 for the first time from VAFB carrying a Canadian satellite. In November, an FAA-licensed Minotaur I launched a payload in support of the US Air Force Operationally Responsive Space (ORS) program from the Wallops Flight Facility. SpaceX rounded out the year with a Falcon 9 launch of an SES payload from CCAFS.

Other 2013 spaceport highlights include:

SpaceX was selected by NASA to take over Launch Complex 39A at NASA's Kennedy Space Center. After the Space Shuttle retirement, NASA decided to transfer it to a commercial operator. SpaceX proposed using 39A for launching its Falcon 9 vehicle, including, in the future, its Falcon Heavy version.

In May SpaceX announced that the future planned higher-altitude, higher-velocity test flights of its Grasshopper experimental rocket would take place at Spaceport America. SpaceX signed a three year lease to use the spaceport. The previous Grasshopper test launches have been performed at its McGregor, Texas site.

Houston City Council approved funding of approximately $700,000 to obtain an FAA commercial launch site license for the Ellington Field airport run by the city. According to the Houston Airport System, the license could be obtained in 2014. The preparation activities include an environmental ssessment and launch site location and operation plans.

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
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.
Ellington Field	City of Houston	Texas	The City of Houston has begun a feasibility study of using the airport at Ellington Field to support a wide range of commercial space activities.
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.
Midland Spaceport	City of Midland	Texas	The City of Midland is in the process of applying for a launch site license. XCOR signed an agreement in July 2012 to be a tenant at the spaceport.
Roosevelt Roads Naval Station	Puerto Rico	Puerto Rico	This proposed spaceport is located at the former Roosevelt Roads Naval Station in Puerto Rico.
Spaceport Kalaeloa	Hawaiian Office of Aerospace Development	Hawaii	A funding bill to support an application for a launch site license became law on July 16, 2009. FAA AST awarded the State of Hawaii a STIM grant for an environmental assessment in preparation for the launch site application process.
Titusville-Cocoa Beach Airport	Titusville-Cocoa Beach Airport	Florida	This proposed spaceport would support commercial SRV activities.
West Texas Spaceport	Pecos County/ West Texas Spaceport Development Corporation	Texas	To develop this proposed spaceport, Blue Origin would build upon test site infrastructure established for NASA/USAF rocket testing. A Pecos County/West Texas Spaceport Development Corporation seat remains active on the county board.

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

California Spaceport
Vandenberg Air Force Base

SSI

U.S. Air Force

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: 650
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)

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.

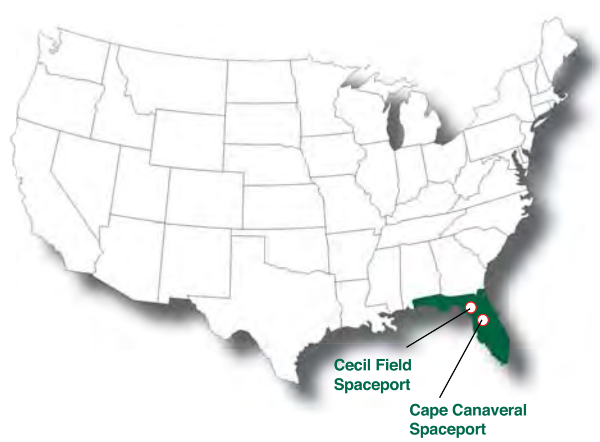
CAPE CANAVERAL SPACEPORT
CECIL FIELD SPACEPORT

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 for NASA's forthcoming Space Launch System and Orion crewed capsule. It is also working with Space Florida to lease facilities for commercial use.

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: 681
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.

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 Wallops Flight Facility

VCSFA
NASA

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: 8 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 Pad 0-A Pad 0-B ***WFF*** Three launch pads Two launchers Runway for unmanned aerial systems 11 assembly and processing facilities Solid motor storage Liquid fueling facilities

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 $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.

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.

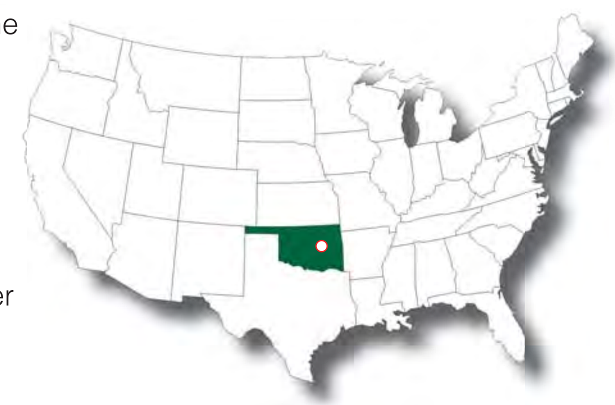
East Kern Airport District has been awarded three FAA Space Transportation Infrastructure Matching (STIM) grants since 2010, totalling $273,750 for aquisition of an emergency rescue vehicle, development of a supplemental environmental assessment, and the purchase of specialized firefighting equipment.

Oklahoma Spaceport

Oklahoma Space Industry Development Authority

Location
Oklahoma
Owner/Operator
OSIDA
Launch Site Type
FAA licensed
Year Established
2006
Description
Provides launch and 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.

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 $209 million.

The spaceport's first FAA-licensed launch occurred in October 2012.

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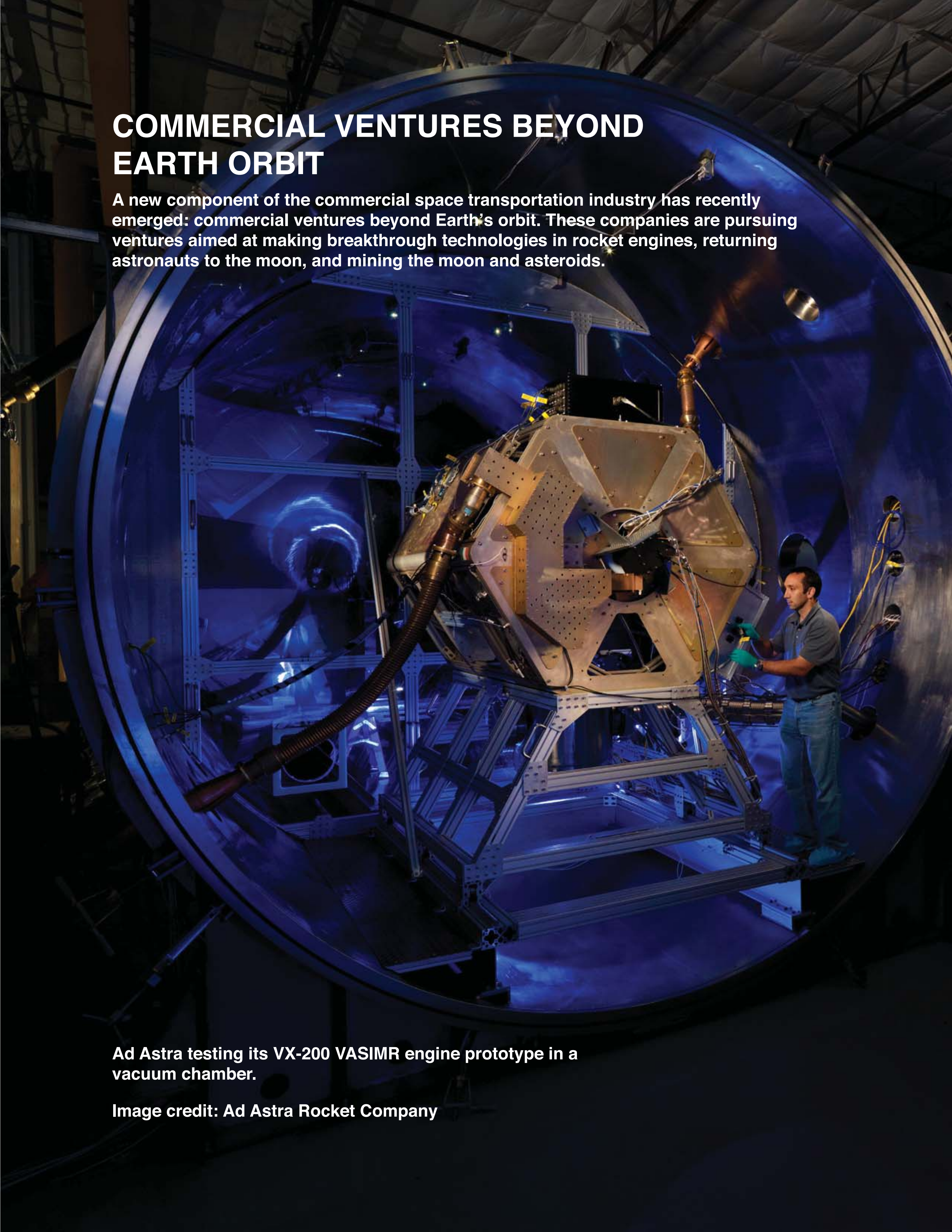
COMMERCIAL VENTURES BEYOND EARTH ORBIT

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.



Ad Astra testing its VX-200 VASIMR engine prototype in a vacuum chamber.

Image credit: Ad Astra Rocket Company

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 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: 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 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.

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 2015.

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.

Artist's conception of Arkyd-100 Series LEO space telescope.

Image credit: Planetary Resources

Cis-Lunar Efforts

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.

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 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.

Mars One: Mars One plans to establish a permanent human settlement on Mars in 2025. Instead of trying to bring crews back to Earth, Mars One will send additional crews every two years, thus building a permanent human presence on Mars. Funds for the mission come from investors, sales of broadcasting rights and partnership agreements. In 2013, Mars One received over 200,000 applications from prospective crew members and contracted aerospace partners for the mission hardware.

Artist's conception of 200 kW VASIMR Solar Electric Propulsion (SEP) Vehicle.

Image credit: Ad Astra Rocket Company

New Engine Technologies

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% 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.

Artist's conception of SKYLON.

Image credit: Reaction Engines Ltd

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 has recently attained $100 million UK government funding towards a full engine demonstration program.

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.

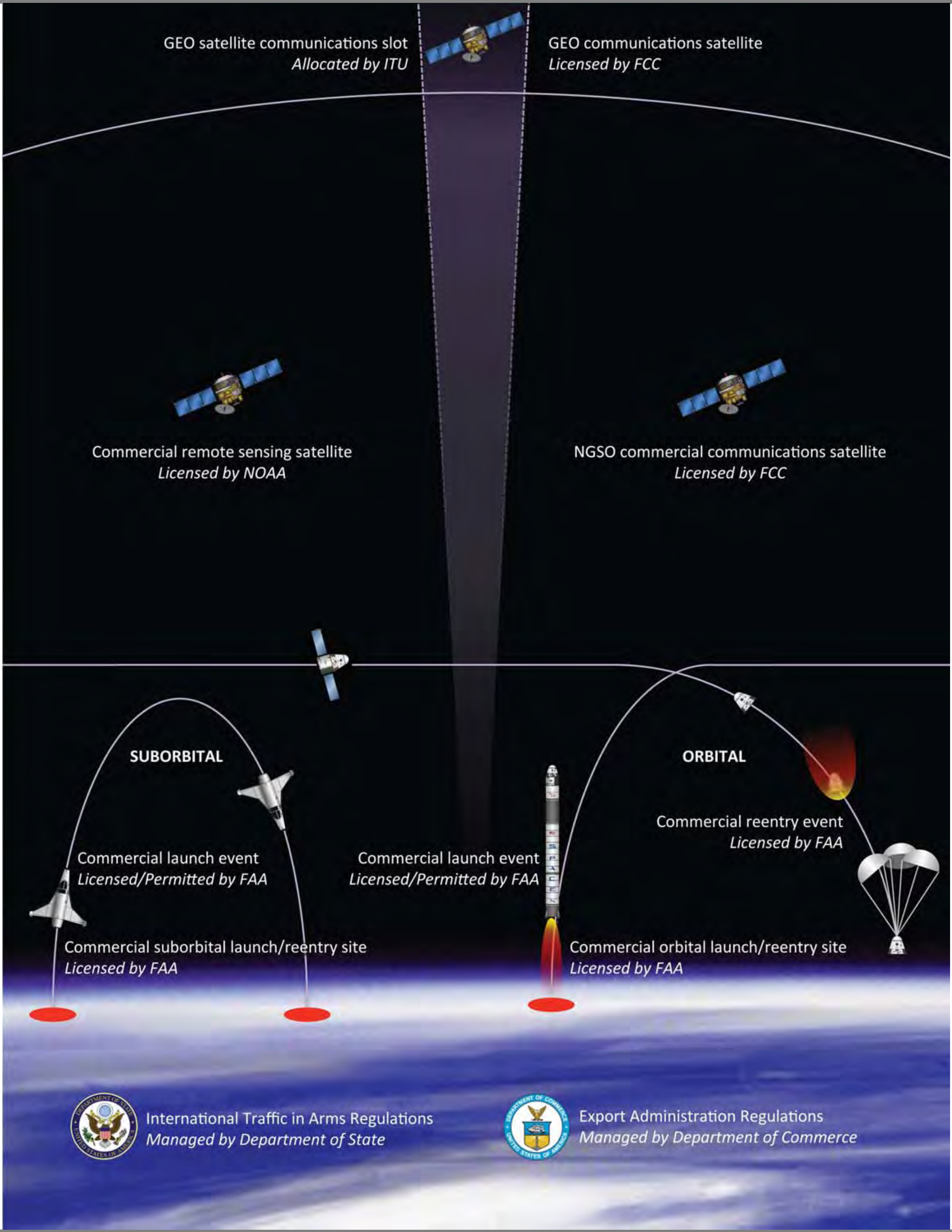
In recent years, the commercial space transportation industry has broadened its scope from delivering commercial communication satellites to orbit to launching satellites for a variety of Earth remote sensing purposes. Now the industry is set to deliver supplies, and ultimately crew, to the ISS, and 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.

Blue Origin's BE-3 engine is tested at NASA's Stennis Space Center in 2013.

Image credit: Blue Origin


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. (See Figure 2 on facing page.) Laws at the state level also impact commercial space transportation.

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 License

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

Operator	Type of FAA Authorization	Issue Date	Vehicle	Launch Site
United Launch Alliance	Launch Vehicle License	03-Jun-2013	Delta IV Heavy	CCAFS
Orbital Sciences Corp.	Launch Vehicle License	05-Jun-2013	Antares	MARS
Orbital Sciences Corp.	Launch Vehicle License	07-Jun-2013	Minotaur I	Wallops Flight Facility
SpaceX	Launch License	02-Aug-2013	Falcon 9	VAFB
SpaceX	Launch License	25-Oct-2013	Falcon 9	CCAFS

Table 11. FAA AST License Activity in 2013

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

Experimental Permit

This permit allows SRVs 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 and reentries for a particular vehicle design, and is valid for a one-year renewable term.

Airworthiness Certificate

This certificate authorizes an aircraft to operate in flight. There are two classifications of airworthiness certificates: standard and special. The FAA can grant special airworthiness certificates to experimental aircraft, such as SRVs in development.

Certain classes of small rockets are exempt from licensing requirements—Class 2 and Class 3 rockets obtain a waiver. "Class 2" rockets are defined as, "a high power rocket, other than a model rocket, that is propelled by a motor or motors having a combined total impulse of 40,960 Newton-seconds (9,208 pound-seconds) or less." Class 3 rockets are defined as "an advanced high power rocket, other than a model rocket or high-power rocket." The purpose of this waiver is to ensure these rockets, some of which use liquid propulsion and reach suborbital altitudes, do not affect air traffic or jeopardize public safety.

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 can 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.

Operator	Type of FAA Authorization	Date	Vehicle/ Purpose
SpaceX	Experimental Permit Renewal	18-Oct-2013	Grasshopper
Scaled Composites	Experimental Permit Renewal	23-May-2013	SpaceShipTwo
Black Sky Training	Safety Approval	28-Mar-2013	Scenario Based Physiology Training

Table 12. Other FAA Commercial Space Transportation Regulatory Activity

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 would extend 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.

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.

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COMMERCIAL SPACE TRANSPORTATION FORECASTS

This section presents 2013 Commercial Space Transportation Forecasts, previously released by FAA AST and the Commercial Space Transportation Advisory Committee (COMSTAC).

Orbital Sciences Corporation successfully launches its Antares vehicle from Virginia's Mid-Atlantic Regional Spaceport to the ISS.

Image credit: NASA/Bill Ingalls

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 2013 through 2022.

The 2013 Commercial Space Transportation Forecasts report is in two sections:

- *The COMSTAC 2013 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 2013 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) orbits beyond the Earth.

Together, the COMSTAC and FAA forecasts project an average annual demand of 31.2 commercial space launches worldwide from 2013 through 2022, up from 29.1 launches in the 2012 forecasts. The reports project an average of 18.2 commercial GSO launches and 13.0 NGSO launches for 2013 through 2022. 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 2013 through 2022.

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 2013 GSO and NGSO Historical Launches and Launch Forecasts

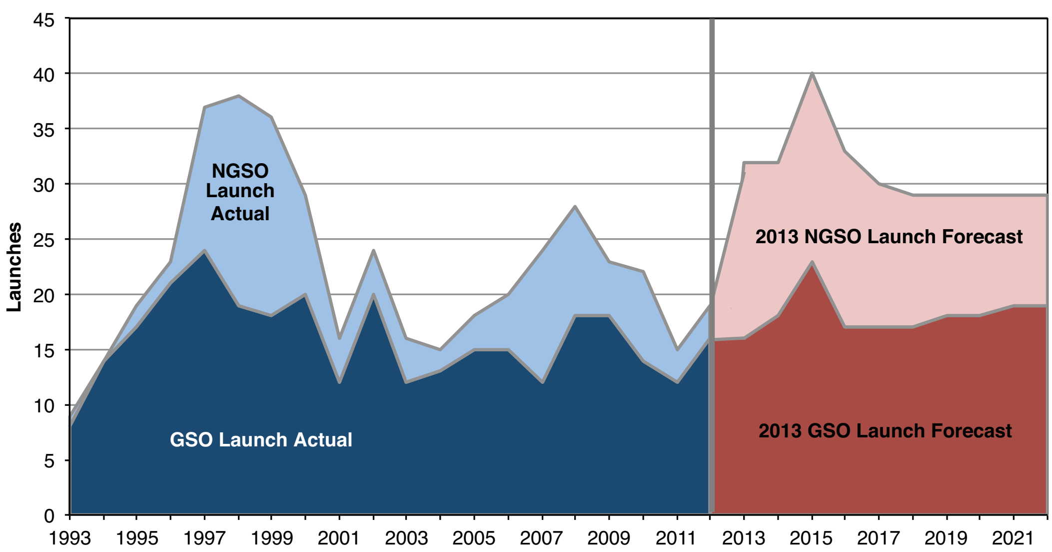

Table 1. Commercial Space Transportation Payload and Launch Forecasts

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Avg.
Payloads												
GSO Forecast (COMSTAC)	20	23	28	22	21	22	22	23	23	24	228	22.8
NGSO Forecast (FAA)	74	32	41	45	44	23	20	20	19	19	337	33.7
Total Satellites	**94**	**55**	**69**	**67**	**65**	**45**	**42**	**43**	**42**	**43**	**565**	**56.5**
Launches												
GSO Medium-to-Heavy	16	18	23	17	17	17	18	18	19	19	182	18.2
NGSO Medium-to-Heavy	14	14	17	15	13	12	11	11	10	10	127	12.7
NGSO Small	2	0	0	1	0	0	0	0	0	0	3	0.3
Total Launches	**32**	**32**	**40**	**33**	**30**	**29**	**29**	**29**	**29**	**29**	**312**	**31.2**

EXECUTIVE SUMMARY

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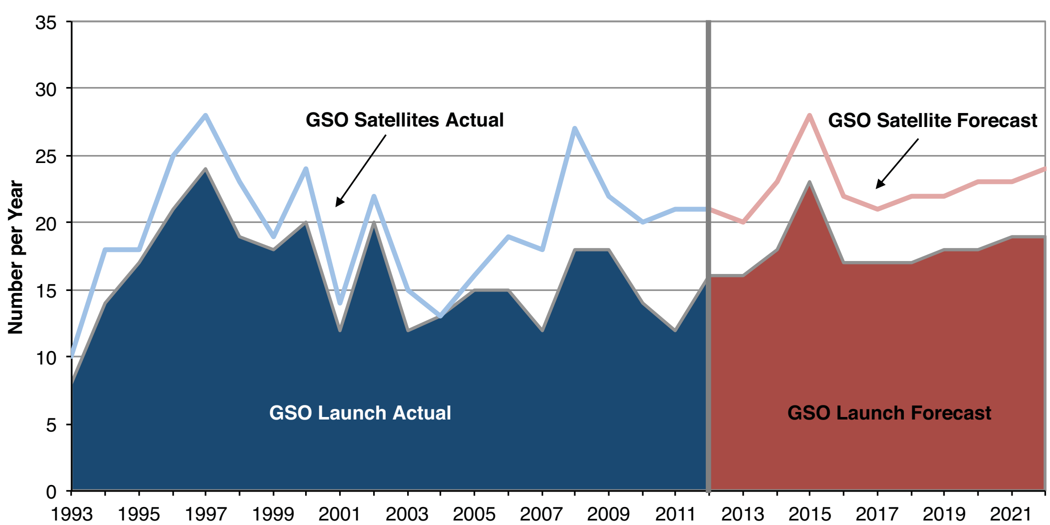
- *The FAA's 2013 Commercial Space Transportation Forecast for Non-Geosynchronous Orbits (NGSO)*, which projects commercial launch demand

Figure 2. 2013 GSO Historical Launches and Launch Forecast



for satellites to NGSO, such as low Earth orbit (LEO), medium Earth orbit (MEO), elliptical (ELI) orbits, and external (EXT) orbits beyond the Earth.

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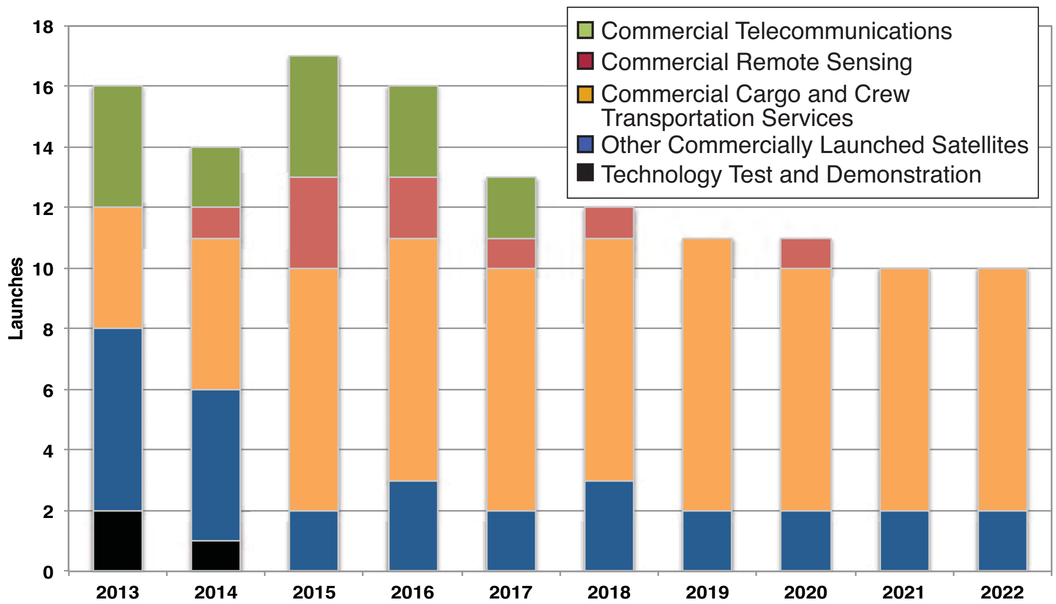
It is important to distinguish between forecast demand and the number of satellites actually launched. Launch vehicle and satellite programs are complex, and susceptible to delays, which generally makes the forecast demand for launches the upper limit of actual launches in the near-term forecast.

Figure 3. Projected NGSO Launches from 2013-2022



The GSO market remains stable with a projected demand of 22.8 satellites per year, up slightly from last year's projection of 21.2 satellites per year. Figure 2 shows the 2013 GSO Historical Launches and Launch Forecast. Forty percent of GSO satellites projected to launch from 2013 to 2022, are in the heaviest mass class (above 5,400 kilograms). At the same time, 13 percent of the satellites in the same period are in the lowest mass class (below 2,500 kilograms). In 2013, 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.

For NGSO, from 2013 to 2022, 337 payloads are projected to launch commercially on 130 launches. The NGSO market projects an average of 13.0 launches per year from 2013 to 2022, which is only slightly up from last year’s average of 12.8 launches. Figure 3 shows the projected NGSO launches for the next 10 years. The launch demand peaks in 2015, with 17 launches, due to the deployment of Iridium, Globalstar, and DMCii payloads, frequent commercial crew and cargo launches to the ISS, and the start of test flights for the commercial crew program. For the telecommunications sector, a drop in launch demand is expected after 2017, when telecommunication constellations, including Iridium, finish deployment, while commercial remote sensing and test and demonstration launches remain stable. Almost 60 percent (74) of the launches within the forecast are for commercial cargo and crew services to the ISS. Some of these launches will take place on vehicles that are not yet proven and partly rely on government funding that is subject to annual appropriations, therefore, technical or financial issues could delay ISS resupply launches.

For the last 10 years, there has been an average of 44 NGSO launches per year. Only 12 percent (approximately 5 launches per year) of these launches were commercial. The forecast predicts a more than doubling of the annual commercial NGSO launch numbers from historical annual averages. This increase is due to cyclical redeployment of commercial telecommunication constellations and commercial resupply of the ISS.

New commercial launch services providers such as SpaceX, with its Falcon 9 and Falcon Heavy, and Orbital Sciences Corp., with its Antares, are developing and demonstrating their vehicle capabilities for application to commercial and government markets. The Antares vehicle made its maiden flight in April. Lockheed Martin has stated its intentions to position the Atlas V more competitively in the commercial market.

New vehicles expected to become available within the next two to three years include Athena (U.S.), Epsilon (Japan), and Long March 6 (China). These vehicles are designed to launch several micro- and small-class payloads at a time and primarily aimed at the NGSO market. The per-kilogram cost to NGSO for a small-class launch vehicle tends to be higher than that for a larger capacity vehicle, which may make these new small-class launch vehicles too expensive for many micro-satellite customers. Therefore, many small NGSO satellites may go as piggyback payloads on larger vehicles leaving small-class launch vehicles with the smaller market of time-critical delivery of payloads to orbit.

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

COMSTAC 2013 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 *2013 Commercial Geosynchronous Orbit (GSO) Launch Demand Forecast* (the Report). This year's Report is the 21st 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 10 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 and 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

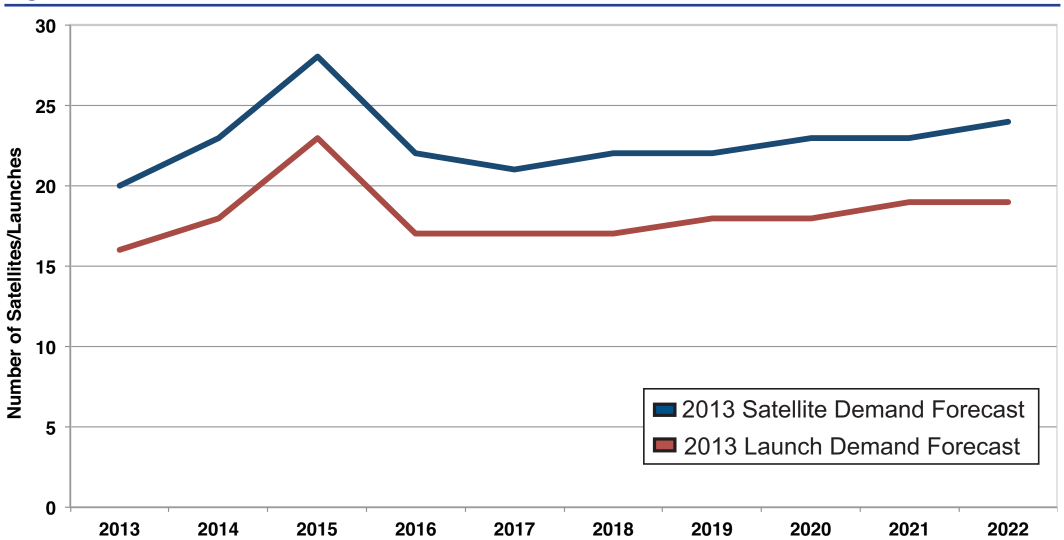


Table 2. Forecast Commercial GSO Satellite and Launch Demand

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Average
Satellite Demand	20	23	28	22	21	22	22	23	23	24	228	22.8
Launch Demand	16	18	23	17	17	17	18	18	19	19	182	18.2
Dual Launch Demand	4	5	5	5	4	5	4	5	4	5	46	4.6

The number of addressable satellites launched in 2012 rebounded from 2011, after having dropped for each of the previous three years. This increase came in spite of satellite delays and launch failures. The key findings of this report are:

- The 2013 COMSTAC GSO forecast projects 20 addressable commercial GSO satellites on 16 launches in 2013 and an annual average of 22.8 satellites on 18.2 launches for the period from 2013 through 2022. This is up from last year's forecast of 21.2 satellites and 16.3 launches per year.
- The number of unaddressable launches is increasing, as is average satellite mass.
- 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.

It is important to distinguish between forecast demand and the number of satellites that are actually launched. Satellite programs, like most complex projects, 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 and 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 20 satellites are projected to be launched in 2013, applying the realization factor adjusts this to a range of 16 to 20 satellites.

HISTORY OF THE REPORT

Table 3. 2013 GSO Forecast Team

Forecast Team Member	Affiliated Company
Alan Keisner	Space Exploration Technologies
Chitta Ratana	Space Systems Loral
Chris Kunstadter	XL Insurance
Jozsef Lore	The Boeing Company
Kate Maliga	The Tauri Group
Pete Stier	Sea Launch
Rob Unverzagt	The Aerospace Corporation
Veronica Johnson	United Launch Alliance

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. The Forecast Team sought input from global satellite operators, satellite manufacturers and launch service providers for a projection of their organization's launch plans and a broad, industry-wide estimate of total GSO launches. In addition, input was sought on a variety of factors that might affect satellite launch demand in the future.

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

Satellite Operators:

- EchoStar*
- Hisdesat
- Inmarsat
- NewSat
- SingTel Optus
- Sirius XM* (also responded in 2012)
- SpaceCom
- Star One

Satellite Manufacturers:

- Boeing* (also responded in 2012)
- SSL* (also responded in 2012)

Launch Service Providers:

- Arianespace* (also responded in 2012)
- MHI
- Sea Launch* (also responded in 2012)
- SpaceX* (also responded in 2012)

* = U.S. company or company with significant U.S. operations

The Forecast Team, using input from global satellite operators, satellite manufacturers and launch service providers, 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 (2013–2015) of the 10-year forecast period. The combined comprehensive inputs as well as the above sources are then used to generate the long-term demand forecast from 2016 to 2022.

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, and
- New launch vehicle capabilities.

The production cycle for today’s satellite models 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 continued at the same high rate as seen in the 2012 forecast, as the Chinese and Russian government-owned aerospace companies continued packaging satellites, launches, and financing for commercial satellite programs. This trend is expected to continue as Chinese, Russian, Indian, and Japanese satellite manufacturers pursue such contracts on a strategic, non-competitive basis. Figure 5 and Table 4 compare the numbers of addressable and unaddressable satellites since 2004.

Figure 5. Addressable and Unaddressable Satellites since 2004

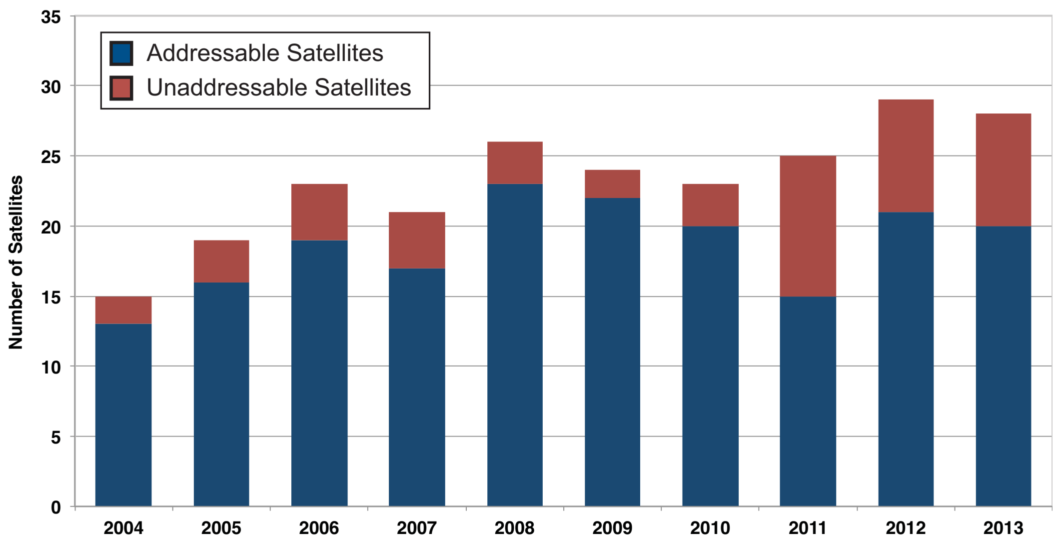


Table 4. Addressable and Unaddressable Satellites Since 2004

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Addressable	13	16	19	17	23	22	20	15	21	20
Unaddressable	2	3	4	4	3	2	3	10	8	8
Total	**15**	**19**	**23**	**21**	**26**	**24**	**23**	**25**	**29**	**28**

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 kilograms to 2,500 kilograms. This adjustment captures the growth in mass of the smallest commercial GSO satellites currently 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 kilograms, which fall in the intermediate mass class range. Even with the increase in the upper limit of the smallest mass class in 2008, there were no launches of satellites in this class in 2011 and 2012. Furthermore, only one satellite in this class is projected to be launched in 2013, and none are projected in 2014. Unaddressable launches in this class abound, with many medium class satellites from Russia and India being launched from 2011 through 2013.

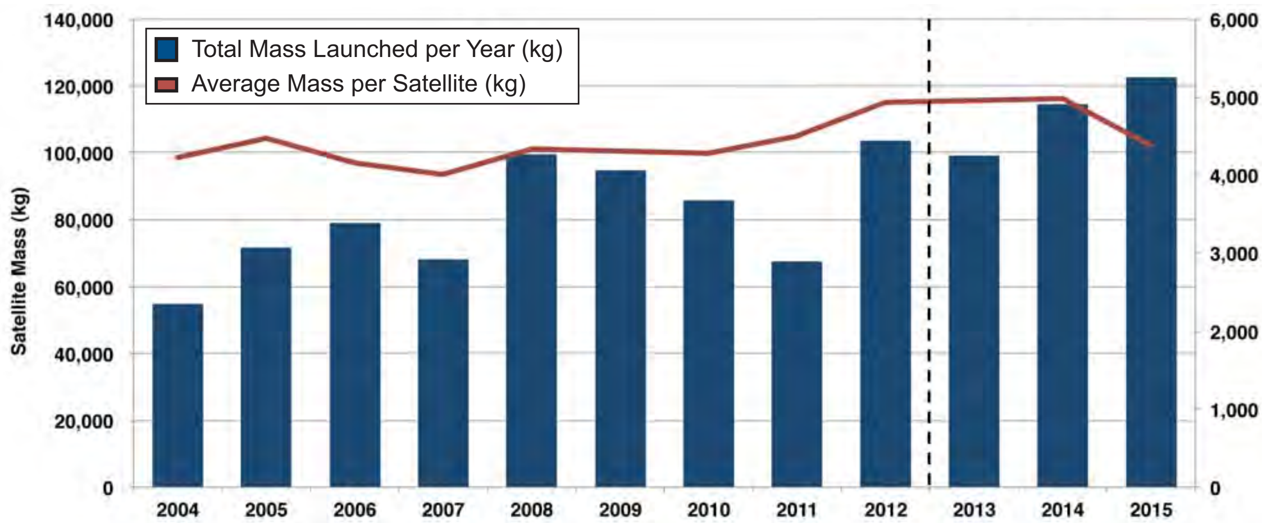
Likewise, the heaviest mass class continues to dominate, with 48 percent of satellites launched in 2012 falling into this mass class. Nearly half of the satellites projected for launch from 2013 through 2015 are in the extra-heavy class.

Table 6 and Figure 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, as does the total number of transponders. The average mass of satellites launched in the past nine years was over 4,000 kilograms, reaching a new high in 2012. The average mass in 2013 is expected to increase even further, with a shift to heavier, higher power satellites. The 20 satellites scheduled for launch in 2013 have a mass of 99,133 kilograms, for an expected average satellite mass of 4,957 kilograms.

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

	Actual									Forecast		
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total Mass Launched per Year (kg)	54,867	71,441	78,988	68,114	99,601	94,670	85,681	67,554	103,595	99,133	114,535	122,633
Average Mass per Satellite (kg)	4,221	4,465	4,157	4,007	4,330	4,303	4,284	4,504	4,933	4,957	4,980	4,380

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



One technical development that may affect the trend towards increasing satellite mass is the development of satellites using exclusively 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.

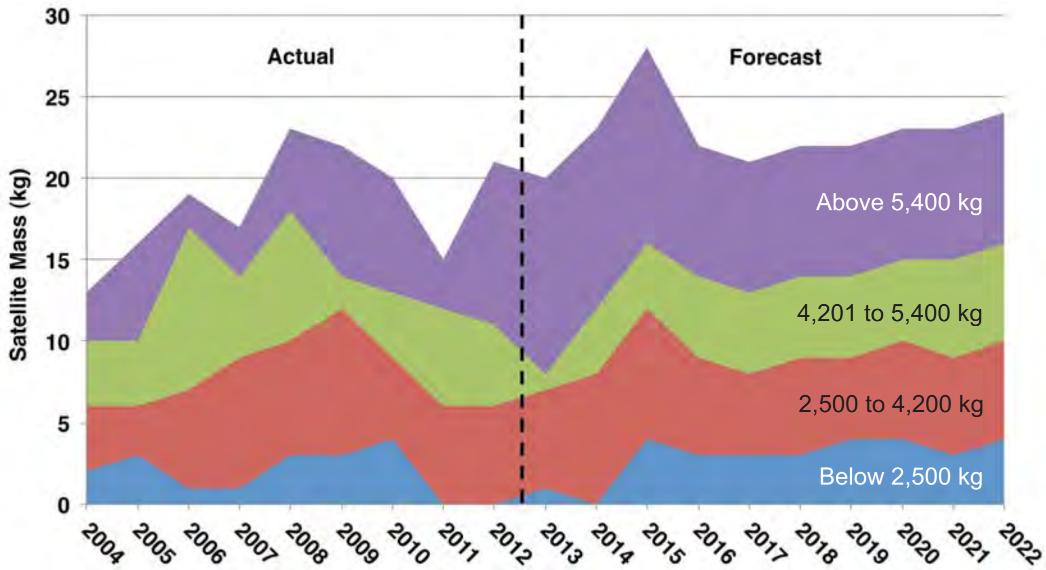
In 2012, Boeing signed a contract jointly procured by Asia Broadcast Satellite (ABS) and Satmex for four all-electric design 702SP satellites. Since then, Astrium, CAST (China), Lockheed Martin, OHB, Orbital, SSL, and Thales have all indicated they already have – or will offer – that technology to their customers in the near future.

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

Table 7. Trends in Satellite Mass Class Distribution

	Actual									Forecast										Total 2013 to 2022	Avg. 2013 to 2022	% of Total 2013 to 2022
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022			
Above 5,400 kg	3	6	2	3	5	8	7	3	10	12	11	12	8	8	8	8	8	8	8	91	9.1	40%
4,201 to 5,400 kg	4	4	10	5	8	2	4	6	5	1	4	4	5	5	5	5	5	6	6	46	4.6	20%
2,500 to 4,200 kg	4	3	6	8	7	9	5	6	6	6	8	8	6	5	6	5	6	6	6	62	6.2	27%
Below 2,500 kg	2	3	1	1	3	3	4	0	0	1	0	4	3	3	3	4	4	3	4	29	2.9	13%
Total	**13**	**16**	**19**	**17**	**23**	**22**	**20**	**15**	**21**	**20**	**23**	**28**	**22**	**21**	**22**	**22**	**23**	**23**	**24**	**228**	**22.8**	**100%**

Figure 7. Trends in Satellite Mass Class Distribution



Dual-Manifesting

Several launch services providers are capable of lofting two satellites simultaneously into geosynchronous transfer orbit (GTO). 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 the satellites flown. A 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.

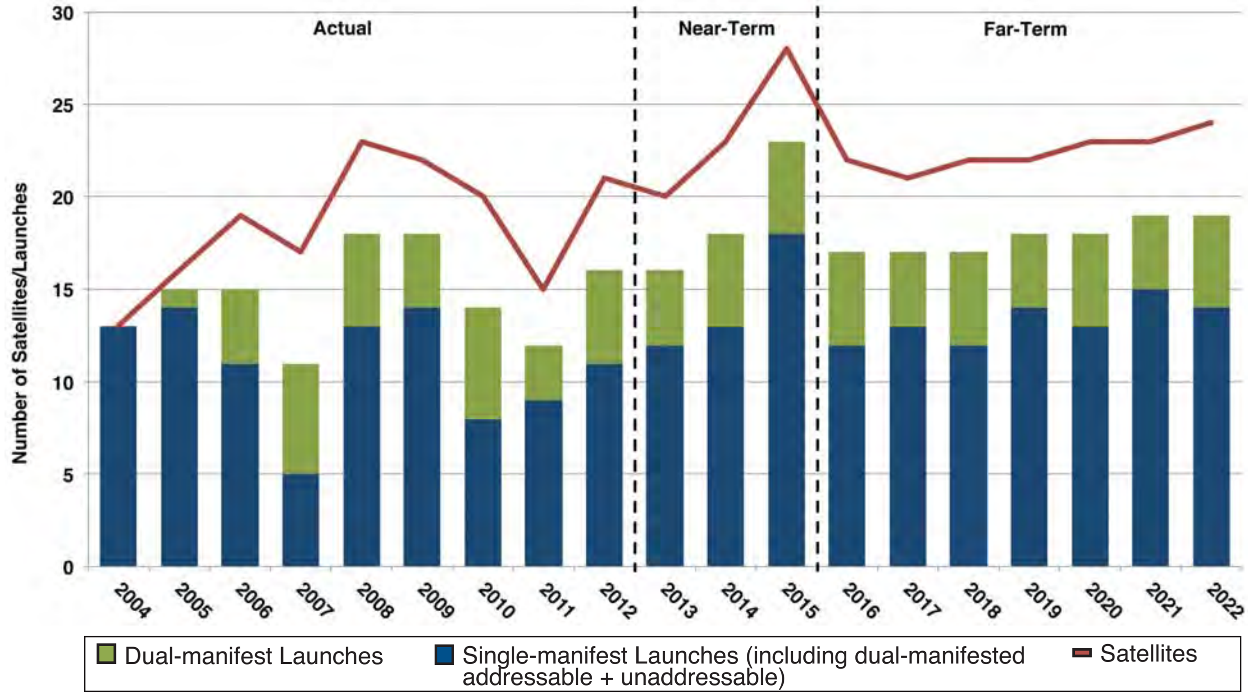
Arianespace's Ariane 5 vehicle has been lofting dual-manifested, competitively-procured, commercial launch services missions for over 10 years. The Forecast Team determined the near-term number of dual manifest launches on Ariane 5 by assessing the existing backlog of satellites through 2015. Arianespace has stated it plans to launch five dual-manifested missions in 2013, up to six in 2014, and, due to commitments for European government missions for ESA and the European Commission (Galileo, ATV, and the Bepi Columbo mission to Mercury), three in 2015. International Launch Services with its 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 ABS and Satmex.

Dual-manifesting for two large satellites together is not yet possible. Arianespace typically attempts to match satellites that together have a total mass approaching 10,000 kilograms. Arianespace is investing in the Ariane 5

Mid-life Evolution program which plans to raise the operational capability by 10 percent or more by 2018, thus enabling it to carry two large satellites. The debut of SpaceX's Falcon Heavy launch vehicle will also permit dual manifesting of larger satellites. The introduction of solar 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 2013 satellite and launch demand forecast through 2022 as well as actual launch statistics for 2004 through 2012.

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 2013 to 2015 show an increase in the number of satellites to be launched over the previous three years (2010-2012). As noted earlier, the trend is to build heavier, more capable satellites; nearly 50 percent of the satellites to be launched in the next three years are in the heaviest mass class.

Table 8. Commercial GSO Satellite Near-Term Manifest

	2013			2014			2015		
Total	20			23			28		
Below 2,500 kg	1			0			4		
	DM	Insat 3D	Ariane 5				DM	ABS 2A	Falcon 9
							DM	ABS 3A	Falcon 9
							DM	F4	Falcon 9
							DM	Satmex 7	Falcon 9
2,500 - 4,200 kg	6			8			8		
	DM	Azersat 1	Ariane 5	DM	Amazonas 4A	Ariane 5	DM	Turksat 5A	Ariane 5
	DM	GSAT 7	Ariane 5	DM	ARSAT 1	Ariane 5	DM	Arsat 2	Ariane 5
	DM	Optus 10	Ariane 5	DM	GSAT 11	Ariane 5	DM	GSAT 18	Ariane 5
		SES 8	Falcon 9	DM	GSAT 16	Ariane 5		Amazonas 4B	Proton
		Thaicom 6	Falcon 9	DM	Hispasat AG1	Ariane 5		Bulsatcom	Launch TBD
		AMOS 4	Land Launch	DM	Thor 7	Ariane 5		Satellite TBD*	Launch TBD
					Turksat 4A	Proton		Satellite TBD*	Launch TBD
					Turksat 4B	Proton		Satellite TBD*	Launch TBD
4,201 - 5,400 kg	2			4			4		
		Anik G1	Proton	DM	Eutelsat 9B	Ariane 5		Amos 6	Falcon 9
		Eutelsat 3B	Proton	DM	Sicral 2	Ariane 5		Eutelsat 8WB	Launch TBD
					Asiasat 6	Falcon 9		JCSAT 14	Launch TBD
					Asiasat 8	Falcon 9		Satellite TBD*	Launch TBD
Above 5,400 kg	11			11			12		
	DM	ABS 2	Ariane 5	DM	DTV 14	Ariane 5	DM	Arabsat 6E	Ariane 5
	DM	Alphasat	Ariane 5	DM	DTV 15	Ariane 5	DM	BADR 7	Ariane 5
	DM	Amazonas 3	Ariane 5	DM	Intelsat 30	Ariane 5	DM	Echostar 18	Ariane 5
	DM	Astra 5B	Ariane 5	DM	Measat 3B	Ariane 5	DM	Jabiru 1	Ariane 5
	DM	Eutelsat 25B	Ariane 5	DM	Star One C4	Ariane 5	DM	NBN 1A	Ariane 5
		Astra 2E	Proton		Astra 2G	Proton	DM	NBN 1B	Ariane 5
		Inmarsat 5 F1	Proton		Inmarsat 5 F2	Proton	DM	Satellite TBD*	Ariane 5
		Satmex 8	Proton		Inmarsat 5 F3	Proton		SES 9	Falcon 9
		SES 6	Proton		Intelsat 31	Proton		Mexsat 2	Proton
		Sirius FM6	Proton		Mexsat 1	Proton		Satellite TBD*	Launch TBD
		Intelsat 27	Sea Launch		Eutelsat 3B	Sea Launch		Satellite TBD*	Launch TBD
								Satellite TBD*	Launch TBD

DM = Potential Dual-Manifested Satellites

* = Satellite proposed, not yet identified publicly

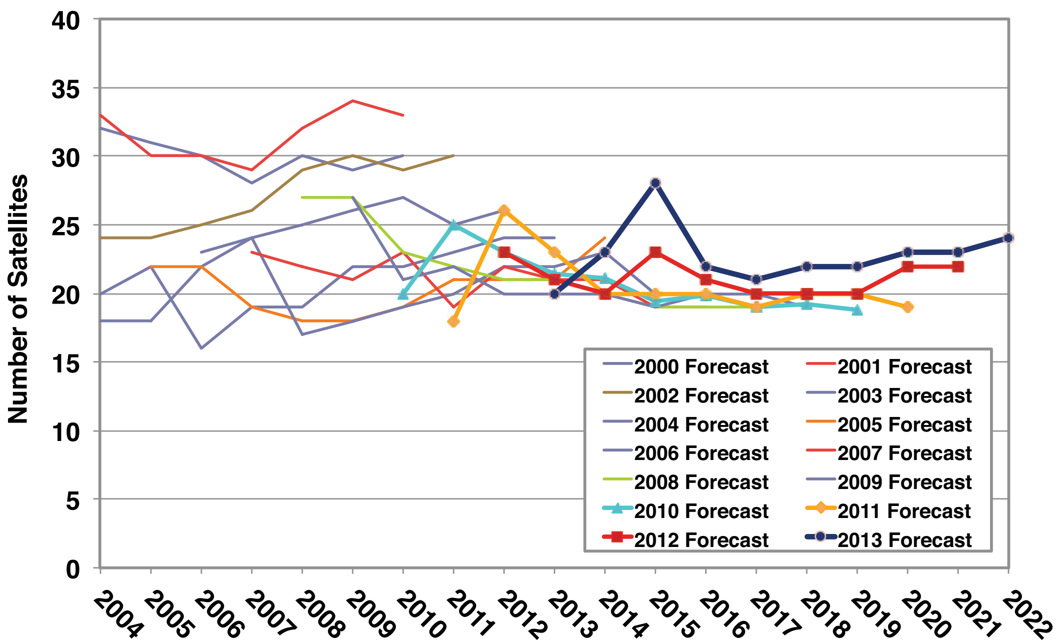
Comparison with Previous COMSTAC Forecasts

The current forecast shows a slight increase over previous reports in average annual launches for the next 10 years. The average number of satellites for the forecast period was in a narrow range in the reports from 2004 to 2012—between 20.5 and 21.8 satellites. The 2013 Report shows an increase in satellite activity from the 2012 Report, up by 1.6 satellites per year for the next 10 years with an average of 22.8.

The 2012 Report projected 23 satellites to be launched in 2012. The reduction to 21 satellites actually launched in 2012 reflects:

- Satellite technical issues, which resulted in the need to rework several satellites awaiting launch;
- Changing business climate for several operators who encountered financial issues; and
- Reclassification of several launches as unaddressable.

Figure 9. Comparison of Annual Forecasts: 2004-2013



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 missions have specific launch windows (such as science 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 make launch slots available 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 100 percent of the forecast number, with an average of 78 percent. For the past five years, the range was 81 percent to 100 percent, with an average of 88 percent. Based on this methodology, while 20 satellites are forecast for launch in 2013, the expected realization for 2013 is 16 to 20 satellites.

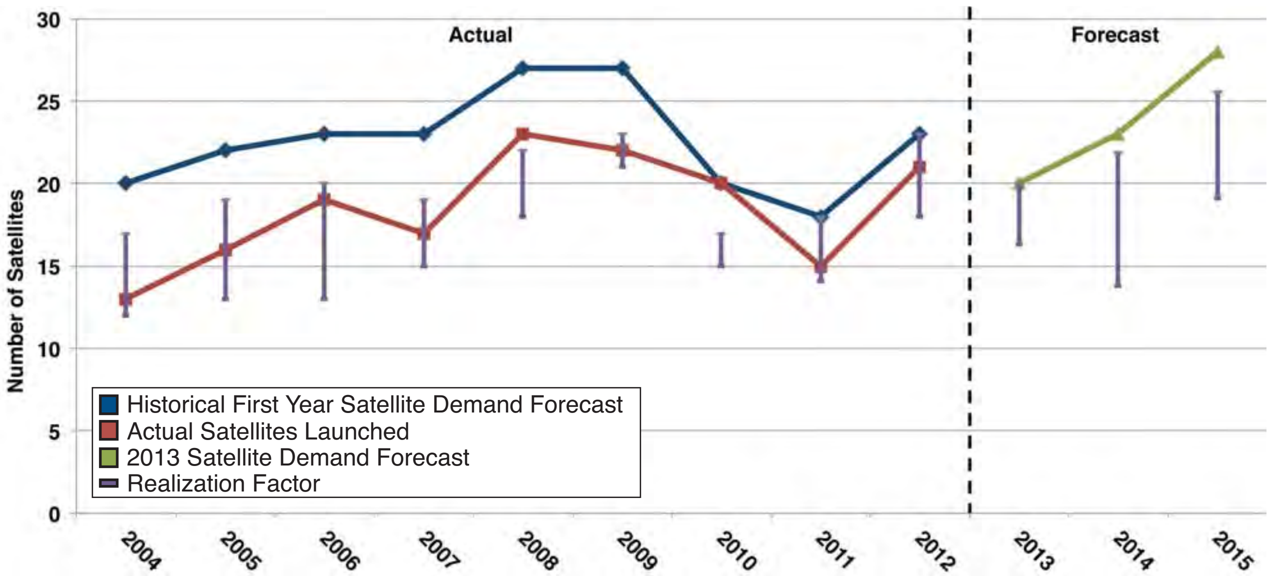
The consistent overestimation illustrates the "bow-wave" effect of the forecast: survey respondents list satellites that were planned to be launched the previous year but slipped into the subsequent year, without compensating for the subsequent year's satellite launches concurrently slipping forward.

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 45 percent to 105 percent, with an average of 75 percent. For the past five years, the range was 60 percent to 95 percent, with an average of 79 percent. Using the same methodology, while 23 satellites are forecast to be launched in 2014, the expected realization for 2014 is 14 to 22 satellites.

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 2012 report forecast 23 satellites for launch in 2012, with a realization range of 18 to 23 satellites. Twenty-one satellites were actually launched in 2012.

Figure 10. Realization Factor



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;
- Increased travel and cultural integration;
- Adoption of commercial solutions by governments to supplement defense and military capabilities; and
- Revolution in software applications, creating new information portals for consumers.

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 distribution 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 explosion 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.

Deregulation

Many countries are experiencing economic advantages and growth in consumer classes by opening their telecommunications markets to domestic and foreign competition. In Asia, Africa, and South America, new competitive sectors in telephone, TV broadcasting, and Internet are emerging, replacing state-controlled service monopolies. Many countries are now securing rights to bandwidth by establishing national regulators, as well as through international regulators such as the International Telecommunication Union (ITU), to exercise rights to frequency spectrum and orbital slots for delivery of satellite services. New operators are entering the marketplace, such as Hong Kong direct-to-home (DTH) operator Asia Broadcast Satellite, Abu Dhabi DTH operator Yahsat, Azerbaijan FSS operator Azerspace, Bulgarian DTH operator Bulsatcom, and U.S.-Swedish mobile broadband operator OverHorizon. India is contemplating relaxation of its highly regulated satellite market to allow increased satellite services and content from foreign satellite operators. It is anticipated that over the next 10 years, relaxed regulation in the Middle East, Africa, Southern and Eastern Asia, and South America will account for more than 60 percent of new transponder and bandwidth demand globally.

Mobility

The global demand from enterprises and consumers for mobile communications has exploded 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 their DirecTV service to 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 SkyPerfecTV 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 in the past year, 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 operations such as communications. The U.S. Department of Defense has continually increased its demand for commercially procured bandwidth in recent years and may order more satellites under commercial contracts to meets its growing needs. 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 SkyPerfecTV, 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 Great Britain's Avanti and Australia's NewSat and National Broadband Network systems. INMARSAT is developing 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.

Other companies in the MSS market are performing well. INMARSAT continues to perform strongly with steady demand in its vertical enterprise markets as it prepares to deploy 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 very successful and is considering system expansion with a potential fourth spacecraft 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. 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.

Impact of Hosted Payloads on the Commercial Satellite Industry

The U.S. Government has made remarkable progress over the past year laying the foundation for a new business approach that would expand the scope of capabilities and services that the commercial space sector could provide to both the civil and national security sectors. This new business approach relies on hosting government payloads on commercial satellites, and involves close coordination between the relevant U.S. government agency, the satellite operator, and the satellite manufacturer. There are many aspects of this new approach that must be worked out, but the government's efforts to embrace this business model are expected to have a positive effect on the commercial space industry.

Hurdles to the Routine Use of Commercial Hosting

- *Lack of synchronicity between commercial and military procurement standards.* Whereas commercial schedules vary from 20 to 36 months, the timeframe for a government hosted payload is typically much longer.
- *Hampered by U.S. governmental rules and policies.* Export control regulations, policies mandating U.S. launch vehicles for government payloads, and the lack of an efficient contract vehicle have made it difficult for the U.S. Government to leverage the commercial space sector.
- *Information security with government hosted payloads.* The government is concerned about the vulnerability of their sensor data and communication links as it is transmitted from the satellite back down to a U.S. government facility.
- *Budget cuts.* The recent downturn in the U.S. economy and subsequent budget cuts made it challenging to fund investments in hosted payloads while trying to maintain and upgrade existing U.S. satellite constellations.

Recent Strides to Help Advance Commercial Hosting

- *Buying payloads in advance of commercial host services.* In 2012, NASA selected SSL to find a host satellite for a 2017 launch of their Laser Communications Relay Demonstration (LCRD) terminal. NASA's Tropospheric Emissions Monitoring of Pollution (TEMPO) hosted payload will also be procured before the host spacecraft is identified. These initiatives on the part of NASA to begin payload development early will ensure that mature payloads can be delivered on time for integration to their commercial hosts.
- *Pre-qualify prime contractors to supply hosting services.* The Air Force Space and Missile Systems Center (SMC) is preparing an indefinite delivery, indefinite-quantity contract for hosted payload services on commercial satellites. The effort will identify a pool of qualified satellite manufacturers and owner-operators who can offer host services, set the technical standard for payload accommodations, and facilitate the contractual work for all parties.
- *Disaggregation.* The Air Force has been studying the concept of moving from multiple payloads on one large spacecraft to having them on several smaller satellites (or even hosted payloads), with the intent of reducing overall mission costs and enhancing constellation resilience.

- *Increase budget allocation for non-traditional commercial approaches.* Hosted opportunities are increasingly being outlined for funding, as indicated by the Air Force's recent 2014 budget request for the space modernization initiative.

Impact to the Commercial Space Sector

- *Cost savings and/or revenue generation.* There is a mutual benefit to both the government agency and the satellite operator in sharing the cost of the satellite and launch vehicle. The operator also benefits from the additional revenue generated by the hosted payload.
- *Closing the business case.* Cost savings and revenue potential are particularly important for satellite operators who want to launch a satellite but are CAPEX-limited. The prospect of routine commercial hosting opportunities will increase demand for commercial satellites because owner-operators will be able to close more business cases with the addition of a hosted payload.
- *Access to new technology.* In some cases, hosted payloads provide access to new technologies. For instance, the host of the LCRD terminal will be allowed to operate the instrument after NASA's two-year mission.

In summary, commercial hosting of government payloads will continue to gain traction as a viable complement or alternative to the traditional and costly heritage constellations. As these non-traditional approaches for providing space services to the government sector catch on, hosted payloads are expected to have a positive impact on the commercial satellite business by increasing satellite demand and access to new technologies.

Launch Service Providers

Competition has increased in the geosynchronous 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. Comsat launch services awards will more than ever before be based on overall best value as perceived by satellite operator customers with key factors being proven reliability, schedule assurance, manifest availability, available scheduling, and a compelling value proposition.

SpaceX completed its fifth flight of it Falcon 9 launch vehicle in March with its second cargo resupply mission to the International Space Station. The company is now turning its efforts to flying a commercial payload to LEO to demonstrate payload fairing separation technology. Once completed, SpaceX will begin launching several satellites into GTO for various satellite operators. Falcon 9 can deliver ~4,850 kilograms into GTO from CCAFS. The company is developing the Falcon Heavy launch vehicle which will be capable of lofting ~12,000 kilograms 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 5 Mid-life Extension program which will increase capacity from ~9,400 kilograms today to ~11,300 kilograms 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 in the marketplace. 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 kilograms into GTO from Baikonur. Introduction of a 5 meter payload fairing in 2016 will allow deployments of satellites with mass up to 5,850 kilograms. 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 completed three missions in 2012, but experienced a failure on its first mission of 2013. A Failure Review Oversight Board has determined the root cause of the incident while developing corrective actions. 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 increase the addressable market for the Zenit-3SL going forward. The company is in the process of finalizing plans to increase the Zenit-3SL's lift capacity to 6,700 kilograms and introducing fairing modifications. The Land Launch Zenit-3SLB/F remains in the market for lofting small/medium satellites to GTO from Baikonur and is scheduled to launch two satellites in 2013.

Japan and India are considering launching commercial to GTO, but have been stymied by high costs, unproven vehicles, and ITAR restrictions. 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 5,800 kilograms to GTO. MHI is working a cost reduction strategy to make the vehicle more competitive in the commercial marketplace. **India's Space Research Organization** (ISRO) plans to return to flight with its GSLV vehicle after experiencing two failures in 2010. ISRO also plans to debut its new GSLV Mark III vehicle which is capable of lofting ~4,000 kilograms 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.

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, to name a few.

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.

Regulatory Environment

ITAR remains an issue for U.S. satellite manufacturers as international competitors develop commercial satellite offerings that are not subject to U.S. export control regulations. The U.S. Department of State’s approval to export satellites to international launch sites applies to U.S.-built satellites and satellites using U.S. parts. Thales Alenia Space has been selling a version of its Spacebus platform produced without 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. ITAR-free satellites will enable launch contracts to be awarded to launch service providers currently restricted from importing ITAR-controlled components. ITAR-free satellites may encourage non-U.S. satellite manufacturers to abandon flight-proven U.S. components. Eight ITAR-free commercial GSO satellites launched between 2005 and 2012, most on Long March launch vehicles. The U.S. Government, through the Departments of State, Commerce, and Defense and the U.S. Congress, is currently implementing changes to the export control regime to make export regulations less onerous and improve the competitiveness of U.S. satellite manufacturers in the global marketplace. In December 2012, Congress passed provisions to reform the export control framework for satellites and related items. Satellites and related items may now return to the Commerce Control List, rather than the Department of State’s United States Munitions List (USML). The U.S. President has the authority to remove these items from the USML.

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 get satellite operators, launch agencies, and all other users of space to recognize and respond to the growing threat from space debris. While the GSO population has not suffered catastrophic losses due to debris in geosynchronous orbit, the issue is being studied closely. All of the 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 geosynchronous orbit, launch activity may be affected as operators consider their response.

Financial Markets

Uncertainty still impacts global financial markets creating mixed results for funding satellite services sector businesses. Stock markets have exhibited recent volatility with investors nervous about the slowing growth of the Chinese economy, the continuing gridlock in economic policy in Washington D.C. along with the impacts to the U.S. economy as a result of the imposed budget sequestration, and the overall lower growth rates in satellite company earnings and revenue streams. Traditional equity investors in this sector 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 nevertheless experiencing issues securing new debt and equity financing. Intelsat's new IPO was forced to reduce its average price 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. Publicly traded competitors SES and Eutelsat offer shareholders hefty dividends which Intelsat will not be doing for now as it focuses on deleveraging.

Export credit agency financing continued to play a strong role in contributing to satellite business sector growth. The U.S.-based Ex-Im Bank has financed 60 percent 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 system 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 players are emerging in the export-import financing sector as export credit agencies from China and Russia seek to win business for domestic contractors to provide jobs and build technological capabilities.

Alternative financing sources for new starts such as venture capital funding from non-traditional space investors and the debut of crowdsourcing has also contributed to satellite business sector growth. Planetary Resources which is seeking to develop a spacecraft to conduct asteroid mining has recently landed a major equity backer in engineering services giant Bechtel Corp. which joins backers including executives from Google, the Perot Group, and formerly Microsoft. Start-up earth imaging company SkyBox Imaging has been able to raise more than $90 million in equity from an otherwise sheepish equity market by creating a business model permitting capital investment to be made in increments as the project completes milestones. This runs counter to the currently accepted project business model wherein large capital spending commitments are needed upfront before cash flow begins. A non-profit consortium of universities and public and private organizations, Kentucky Space LLC, announced the creation of Space Tango to assist new space businesses in developing innovations and novel applications. Selected companies will have access to technical and business advisories and U.S. government facilities. Crowdfunding website Kickstarter has been tapped to fund small space projects via public financial participation for ventures including Kicksat, which plans to fly hundreds of Sprites (satellites on microchips) inside a triple cubesat, and SkyCube which plans to capture Earth images and tweet messages from space. Crowdfunding campaigns help project developers identify enthusiastic backers for support which many new small start-ups are unlikely to attain with traditional established private investors who want detailed business plans and equity participation in return for financing. The B612 Foundation which seeks to deploy a space telescope in orbit to identify near-Earth asteroids is inviting people from around the world to contribute $10 or more to realize the mission.

Given the long lead-times associated with deploying GSO spacecraft on orbit, 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 35 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 recent good experience in space insurance, 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. When the business cycle eventually turns, and adverse experience reduces available capacity, pricing will increase, and insurance for commercial space programs may be constrained. 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 2012 Report.

The following eight satellite operators responded to the questionnaire. The Forecast Team offers special thanks to these companies for providing this additional input:

- Echostar (2 responses) (United States)
- Hisdesat (Spain)
- Inmarsat (England)
- NewSat (Australia)
- SingTel Optus (Australia)
- Sirius XM (United States)*
- Spacecom (Israel)
- Star One (Brazil)

* = 2012 respondent

Although there was little carryover in respondents from 2012 to 2013, the basic composition of the respondents remained constant. Two respondents were U.S. companies in both 2012 and 2013, with the remaining respondents from the international community. For this reason, it seems reasonable to make comparisons between last year's survey and this year's.

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 2013 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. Respondents indicated increasing dissatisfaction with the reliability of launch systems but were upbeat about the introduction of new or upgraded launch vehicles. Perception of regulatory issues remained negative.

Reflecting continuing global economic woes, the responses to financial concerns remained somewhat negative. The availability of financing was a continuing concern for the 2013 respondents, with 33 percent reporting some negative impact compared with 33 percent reporting some or significant negative impact in 2012. Respondents also saw an impact from decrease in demand for satellite services with 44 percent of the respondents reporting some negative impact compared with 33 percent in 2012. Operators were more confident in their ability to compete with terrestrial services in 2013, with only 22 percent reporting a negative impact in 2013 compared with 33 percent in 2012.

Operators continue to be satisfied with the variety of satellite systems available to them. Operators had mixed opinions about launch vehicles, however. Operators were generally optimistic about the impact of new satellite technologies, with 56 percent forecasting some positive impact on their business plans. Opinions on launch vehicles were mixed. On the plus side, only 22 percent of the 2013 respondents said the availability of launch vehicles had some or significant negative impact on their plans, compared to 33 percent of the 2012 respondents. Perception of launch vehicle reliability has decreased again, with 33 percent of the 2013 responses indicating a negative impact compared to 17 percent of the 2012 respondents. This dissatisfaction with launch vehicle reliability has increased dramatically since the 2011 survey when none of the operators expressed any concerns about launch vehicle reliability. This can likely be attributed to the recent string of Proton failures and the 2013 Sea Launch failure. All of the respondents responded either neutrally or favorably to the introduction of new/upgraded launch vehicles.

The regulatory category reflected some significant changes from 2012. Eleven percent of the 2013 respondents experienced some negative impact as a result of their inability to obtain required export licenses, compared to zero percent of the 2012 respondents. However, only 22 percent of the 2013 respondents saw a negative impact on their ability to obtain required operating licenses, as opposed to 50 percent of the 2012 responses. In response to one of the new questions, 56 percent of the respondents saw some negative impact due to international or domestic regulatory issues.

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	2013 vs. 2012
Ability to compete with terrestrial services	0%	22%	56%	22%	0%	Increase
Availability of affordable insurance	0%	11%	22%	67%	0%	Decrease
Availability of financing	0%	33%	56%	11%	0%	Same
Demand for satellite services	0%	44%	11%	22%	22%	Decrease
Regional or global economic conditions	11%	44%	33%	11%	0%	Decrease
Consolidation of satellite service providers	0%	11%	78%	11%	0%	Increase
Availability of required operating licenses	0%	22%	33%	33%	11%	Increase
International or domestic regulatory issues	0%	56%	33%	0%	11%	New
Availability of export licenses	0%	11%	56%	33%	0%	Decrease
Availability of launch vehicles that meet your requirements	11%	11%	44%	22%	11%	Increase
Availability of satellite systems that meet your requirements	0%	0%	22%	67%	11%	Same
Reliability of launch systems	11%	22%	22%	44%	0%	Decrease
Reliability of satellite systems	11%	0%	44%	44%	0%	Increase
Introduction of new satellite technologies	0%	11%	33%	56%	0%	New
Introduction of new or upgraded launch vehicles	0%	0%	44%	33%	22%	New

2013 COMMERCIAL SPACE TRANSPORTATION FORECAST FOR NON-GEOSYNCHRONOUS ORBITS

INTRODUCTION

The *2013 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).

Report Purpose and Methodology

The 2013 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.

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;[1] and
- Technology test and demonstration.

[1] This category combines two categories from previous iterations of this report: science and engineering and other payloads launched commercially.

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) 2014 ISS traffic model.

Commercial NGSO Launch Industry Sectors

Demand for commercial space launch typically flows from top to bottom through the following industry sectors: satellite and commercial transportation service operators, satellite manufacturers, launch providers, and launch vehicle manufacturers.

Satellite and Commercial Transportation Service Operators

Operators purchase and operate payloads (spacecraft) that provide services such as commercial telecommunications, commercial remote sensing, science missions, and commercial cargo and crew transportation services. Their customers include private companies, militaries, national space programs, universities, and the general public.

Operators include private companies, government agencies, public-private partnerships, universities, and non-profit entities. Private sector payload operators typically focus on a particular service segment, for example, DigitalGlobe in the remote sensing segment and Iridium and ORBCOMM in the telecommunications segment. Government agencies operate a range of satellite systems and other types of payloads across multiple service segments.

Spacecraft Manufacturers

These organizations include private companies, universities, and occasionally government organizations that construct satellites for satellite operators. Most manufacturers can produce spacecraft for multiple service sectors, although some specialize in a particular segment. Spacecraft often include components or instruments obtained from multiple suppliers. Typically, one manufacturer serves as the prime contractor for a spacecraft and is responsible for integrating components.

Launch Providers

These companies provide launch services for spacecraft under contracts with payload operators, although sometimes these contracts are signed with spacecraft manufacturers (in arrangements known as delivery-on-orbit).

Launch Vehicle Manufacturers

These organizations include private companies, government organizations, and mixed publicly-privately owned entities that design and build rocket launch vehicles for launching payloads, including satellites, crew vehicles, and other spacecraft. Launch vehicle manufacturers can be the same entities as launch providers, be partial owners of launch provider companies, or market their launch vehicles through launch providers under agreements or contracts.

Although the industry sectors are distinct, many companies are active in more than one of them. For example, companies such as Orbital Sciences Corporation (Orbital) or Space Exploration Technologies (SpaceX) build and launch their own rockets, and manufacture and operate spacecraft.

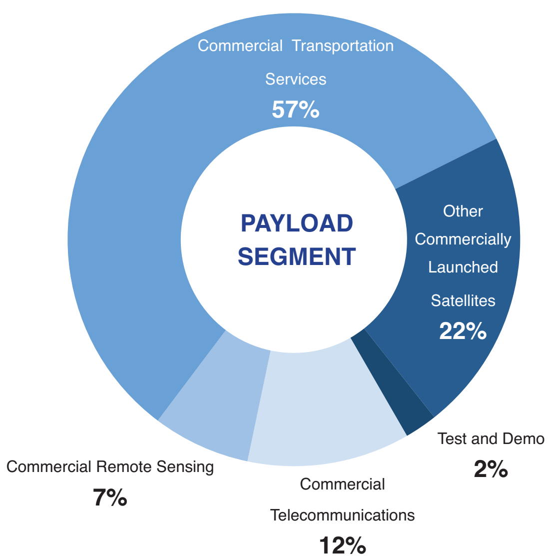
The above industry sectors do not include government regulators, finance sources, insurers, or other additional industry sectors. It is important to note these sectors exist and influence demand within the commercial NGSO launch market.

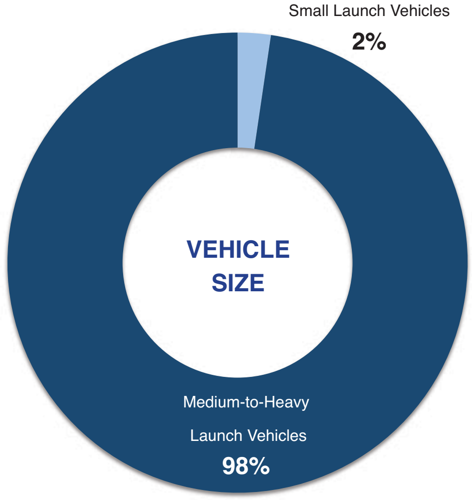
REPORT SUMMARY

The report projects an average demand of 13 launches per year worldwide during the period 2013 through 2022. The launch demand peaks in 2015, with 17 launches, due to the deployment of Iridium, Globalstar, and DMCii payloads; frequent commercial crew and cargo launches to the ISS; and the start of test flights for the commercial crew program. For the telecommunications sector, a drop in launch demand is expected after 2017, when telecommunication constellations, including Iridium, finish deployment. This average is comparable to last year's average of 12.8 launches per year. 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 44 NGSO launchers per year. Only 12 percent of these launches (approximately 5 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 12.7 medium-to-heavy vehicle launches per year and 0.3 small vehicle launches per year for 2013 to 2022. The launches in the next 10 years are predominantly commercial launches to the ISS and replacement telecommunication satellites, all of which require medium-to-heavy vehicles. Ninety-eight 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 continued to decrease, and the number of medium-to-heavy launches increased slightly. This trend is expected to continue due to such factors as 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. 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



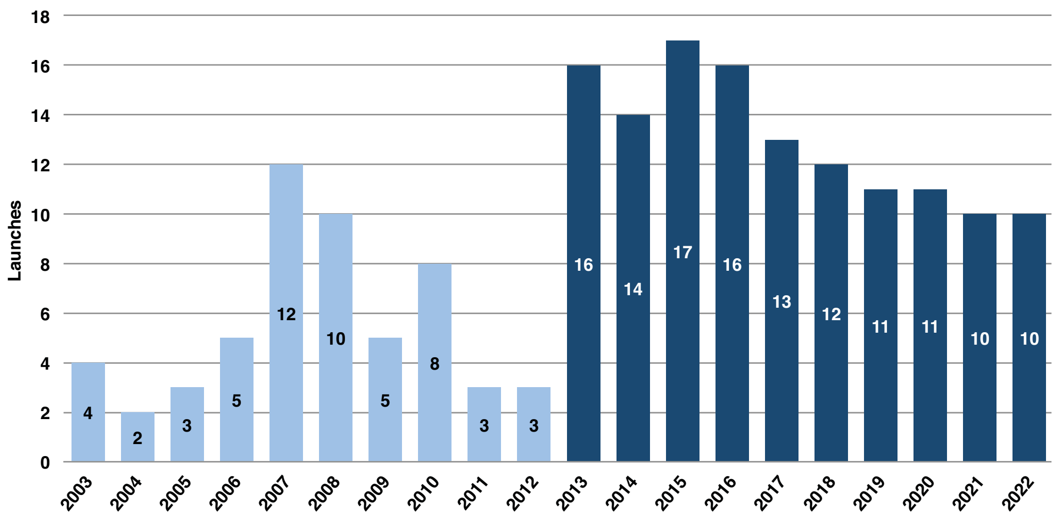


Fifty-seven percent of the NGSO launches projected for the next 10 years are for commercial crew and cargo to the ISS. This marks an increase from a 50 percent share projected for this segment in the 2012 report, due to commercial cargo launches rescheduled from 2012 to later dates and the addition of new commercial crew test flights beginning in 2015. Some of the launches to the ISS are scheduled for vehicles 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 resupply 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 22 percent of the launch market. Telecommunications satellites comprise 12 percent of the launch market, launching 35 percent of the forecasted payloads, all of them multi-manifested or launched as secondary payloads. It is the third largest segment of commercial market for NGSO, but it is expected to significantly drop off after 2018 when the major NGSO telecommunications constellations, Iridium, Globalstar, ORBCOMM, and O3b, are deployed. Commercial remote sensing launches account for 7 percent of the launch market, and have had a steady demand for one to two launches a year.

The annual launch rate during the next 10 years is considerably higher than in the previous decade (see Figure 12). Commercial space transportation and telecommunications constellation replenishments continue to drive this increase.

Figure 12. Commercial NGSO Launch History and Projected Launch Plans



Last year's report predicted 11 launches for 2012, but only 3 occurred, which demonstrates the challenge of projecting launch rates across all segments. The Antares Demo Flight (now successfully launched) and the Cygnus Commercial Orbital Transportation Services (COTS) Demo were both delayed into 2013 due to pad construction delays and ground test issues. Five Other Commercially Launched Satellites did not launch due to various reasons. The second Dragon resupply mission was delayed into 2013, but has since completed a successful launch and reentry. A large portion of commercial launch services is tied to the development and launch of new systems both on the payload and launch vehicle sides of the industry.

In addition to this forecasting challenge, it is still too early to predict with accuracy new and emerging markets. If NASA's needs for commercial cargo and crew to the ISS grow, Bigelow Aerospace launches its space stations, the space tourism market matures, and commercial companies launch payloads to the Moon and Mars, there can be significant growth in NGSO launches in 2018 and beyond. For example, if O3b's new MEO broadband telecommunications satellite constellation is successful, it may lead to deployment of additional satellites in subsequent years. According to O3b, a fully extended constellation would require 16 more satellites (launched 4 at a time), which would result in 4 additional NGSO launches during the forecast period.

In this report, the near-term launch projection (2013-2016) is based on publicly announced launch demand. Table 11 identifies all NGSO satellites manifested for 2013 through 2016 that drive a launch. The report projects 16 NGSO launches for 2013 and 14 for 2014. However, applying a realization factor, the actual NGSO launches are more likely to be between seven and ten in 2013, and five and eight in 2014. 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 2013 and 2014. The mid- and long-term launch projections (2017-2022) are based on publicly available information from satellite service providers, correspondence with service providers, and estimates of when existing constellations will reach end of life and require replacement.

The 2013 projection includes the maiden flights of Orbital's Antares rocket and SpaceX's new launch vehicle, Falcon Heavy; the Cygnus COTS Demo to the ISS; and the deployment of the first O3b telecommunications satellites to MEO. The 2014 projection for total launches includes the first flight of NASA's Orion Multi Purpose Crew Vehicle (MPCV) demo on a Delta IV Heavy. Maiden flights, new vehicles, new satellite systems, and new spacecraft missions have a greater than normal chance of slipping into the next year. The *Risk Factors* section of this report discusses projection uncertainty in detail.

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

Service Type	2013	2014	2015	2016
Commercial Telecommunications Satellites	Globalstar (6) - Soyuz 2	O3b (4) - Soyuz 2	Globalstar (6) - Soyuz 2	Iridium (10) - Falcon 9
	O3b (4) - Soyuz 2	ORBCOMM (9) - Falcon 9	Iridium (2) - Dnepr	Iridium (10) - Falcon 9
	O3b (4) - Soyuz 2		Iridium (10) - Falcon 9	Iridium (10) - Falcon 9
	ORBCOMM (9) - Falcon 9		Iridium (10) - Falcon 9	
Commercial Remote Sensing Satellites		Worldview-3 - Atlas V	DMC3-1 - Dnepr	EROS C - TBD
			DMC3-2 - Dnepr	TerraSAR-NG - TBD
			DMC3-3 - Dnepr	
Commercial Cargo and Crew Transportation Services[3]	Cygnus COTS Demo - Antares	Cygnus CRS Flight - Antares	Crew Test Flight - TBD	Crew Test Flight - TBD
	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares	Crew Test Flight TBD	Crew Test Flight - TBD
	Dragon CRS Flight - Falcon 9	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares	Crew Test Flight - TBD
	Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	Cygnus CRS Flight - Antares	Cygnus CRS Flight - Antares
		Dragon CRS Flight - Falcon 9	Dragon CRS Flight - Falcon 9	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
Other Commercially Launched Satellites	ASNARO - Dnepr	Gökturk 1 - TBD	INGENIO - TBD	DragonLab 1 - Falcon 9
	CASSIOPE - Falcon 9	Formosat 5 - Falcon 9	SAOCOM 1B - Falcon 9	DubaiSat-3 - Dnepr
	DubaiSat 2 - Dnepr	Kompsat 3A - Dnepr		EnMAP - PSLV
	Kompsat 5 - Dnepr	PAZ - Dnepr		
	ORS-3 Enabler - Minotaur I	SAOCOM 1A - Falcon 9		
	SWARM (3) - Rockot			
Technology Test and Demonstration Launches	Test Package - Antares	Orion MPCV Demo - Delta IV Heavy		
	Test Package - Falcon Heavy			
Total Payloads (includes secondary)	**74**	**32**	**41**	**45**
Total Launches	**16**	**14**	**17**	**16**
Launch Realization Factor Applied	**7-10**	**5-8**		

[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

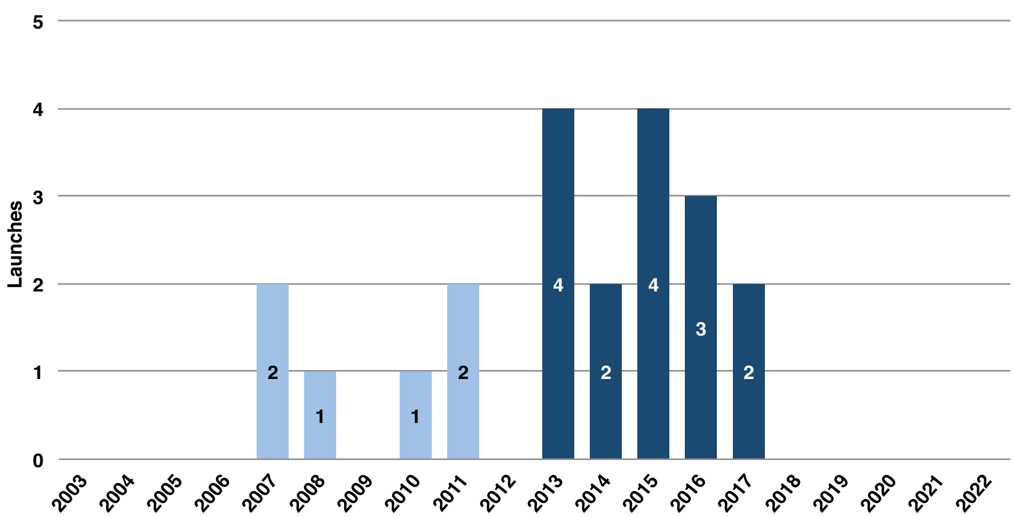
Commercial Telecommunication Satellites

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 2013 through 2017, between two and four launches of NGSO telecommunications satellites will occur each year. There will be four launches in 2013, as Globalstar, ORBCOMM, and the emerging MEO Ka-band broadband operator O3b launch their satellites, and there will be an average of three launches per year between 2015 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 2018 through 2021. Figure 13 provides a representation of telecommunications launch history and projected launch plans.

Figure 13. Commercial Telecommunications Launch History and Projected Launch Plans



2013	2014	2015	2016	2017
Globalstar - Soyuz 2	O3b - Soyuz 2	Globalstar - Soyuz 2	Iridium - Falcon 9	Iridium - Falcon 9
O3b - Soyuz 2	ORBCOMM - Falcon 9	Iridium - Dnepr	Iridium - Falcon 9	Iridium - Falcon 9
O3b - Soyuz 2		Iridium - Falcon 9	Iridium - Falcon 9	
ORBCOMM - Falcon 9		Iridium - Falcon 9		

Narrowband NGSO Telecommunications Systems

Narrowband LEO systems (see Table 12) operate at frequencies below 1 GHz. 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 (LatinSat), is partially operational with eight satellites on orbit and will reach its full 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

System/ Operator	Prime Contractor	Satellites		Orbit Type	First Launch	Status
		Number (on orbit/ operational)	Mass kg (lb)			
Operational						
ORBCOMM/ ORBCOMM Inc.	Orbital Sciences Corp. (1st Gen.); SNC (2nd Gen.)	41/27	43 (95) (1st Gen.); 142 (313) (2nd Gen.)	LEO	1997	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.
Under Development						
AprizeStar (LatinSat)/ Aprize Satellite	SpaceQuest	8/6	10 (22)	LEO	2002	Planned 12- to 30-satellite system, with intermittent launches based on availability of funding. Two satellites are planned for launch in 2013 and two more in 2014. The company expects to continue launching two AprizeSat satellites every year or two for as long as Dnepr cluster launches are available.

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, with technical anomalies. 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 early 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. plans an initial deployment of its first eight 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	0/0	700 (1,540)	MEO	2013	The first eight satellites of the constellation plan to launch in 2013. Four more will be deployed 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	Date License Granted or Updated	Remarks
ORBCOMM	3/31/1998	Authorized Orbital Communications Corporation to modify its non-voice, non-geostationary mobile-satellite service system, initially licensed and authorized in 1994.
Iridium Satellite LLC	7/17/2001	Authorized Iridium to operate feeder uplinks in the 29.1-29.25 Mobile-Satellite Service (MSS).
Globalstar	7/17/2001	Authorized Globalstar, L.P. to use spectrum in the 2 GHz band to provide Mobile-Satellite Service (MSS) from NGSO and geosynchronous satellite orbit (GSO) satellites.
Iridium Satellite LLC	2/8/2002	Granted assignment of licenses and authorizations pertaining to the operation of the Iridium Mobile Satellite Service System.
Globalstar	1/30/2003	Denied Globalstar's "Application for Modification of License" and its "Request for Waiver and Modification of Implementation Milestones for 2 GHz MSS System."
Iridium Satellite LLC	6/24/2003	Modified the authorization currently held by Iridium 2 GHz LLC to use spectrum in the 2 GHz band to provide mobile-satellite service.
Iridium Satellite LLC	10/7/2003	Modified the licenses of Iridium Constellation, LLC and Iridium, US LP (collectively "Iridium") and authorized Iridium to operate satellites in the "Big LEO" mobile-satellite service (MSS) system in the 1620.10-1621.35 MHz frequency band.
Globalstar	3/8/2004	International authorizations granted.
Globalstar	6/24/2004	Denied the Application for Review filed by Globalstar, LP.
Iridium Satellite LLC	9/3/2004	Modified the authorizations of Iridium to operate space and earth stations in the "Big LEO" MSS.
AprizeStar	2010	FCC license issued in 2010 covers AprizeSat 1 through 6. It is modified and extended to cover AprizeSat 7 and 8 launched in 2012.

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. These satellites have not suffered from the technical anomalies of the other operational satellites, but their addition 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.

Arianespace, through its Starsem affiliate, launched Globalstar's 24 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 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 Thales Alenia Space 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 Thales Alenia Space in September 2012, tentatively to launch in 2015. Because no launch contracts have been made for these additional Globalstar satellites and any launch would be contingent on the health of the satellites on orbit, this report does not project additional launches beyond 2015.

Figure 14. Publicly Reported Globalstar Annual Revenue

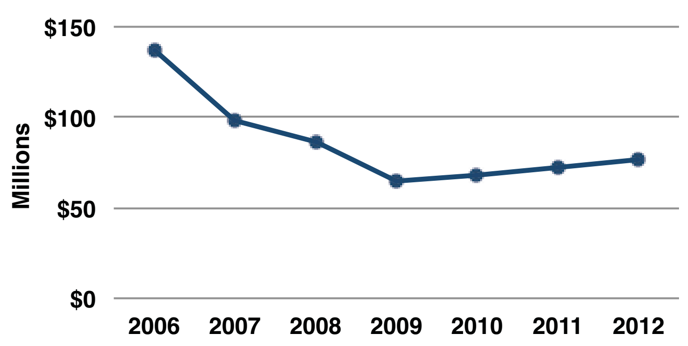


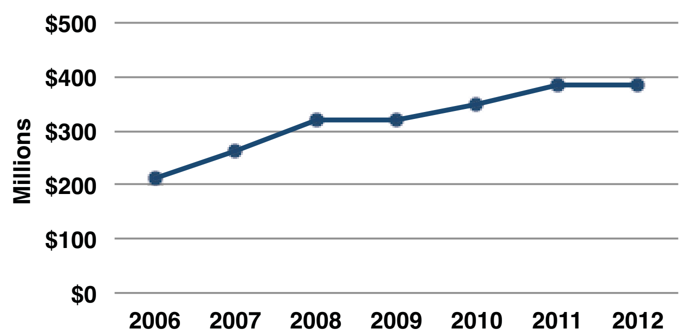
Figure 14 shows the decline in Globalstar's revenues from 2006 to 2009 and a rise beginning in 2010, due to higher revenues from the SPOT Satellite GPS Messenger service and simplex data services and improvements in duplex and simplex services after second generation satellite deployment. Because of 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 Thales Alenia Space 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.

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.

Figure 15. Publicly Reported Iridium Annual Revenue



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.

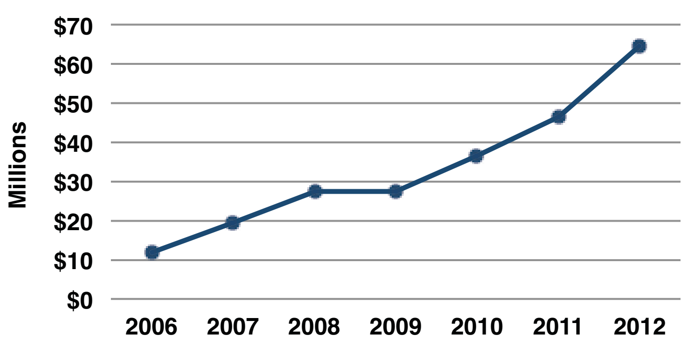
In 2008, six ORBCOMM satellites launched on a Russian Cosmos 3M vehicle to begin replacing the legacy constellation deployed in 1999. One of the planned upgrades to the constellation was the addition of the Automatic Identification System (AIS), a sea vessel identification and tracking system. Shortly 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 constellation.

A prototype ORBCOMM OG2 satellite was launched by SpaceX 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.

Figure 16. Publicly Reported ORBCOMM Annual Revenue



ORBCOMM currently plans to launch its remaining satellites on two separate Falcon 9 vehicles in 2013 and 2014. The missions may or may not include a replacement satellite to ORBCOMM OG2-01. Between 8 and 12 satellites will be launched in 2013, and the remainder of the 18-satellite constellation will launch in 2014.

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 (also known by its International Telecommunications Union (ITU) registration as LatinSat) satellites weighing 10 kilograms (22 pounds) each, launched as secondary payloads on Russian Dnepr vehicles: two satellites a year in 2002, 2004, 2009, and 2011. Two more satellites were scheduled to launch as secondary payloads on a Dnepr vehicle in 2012. The launch was delayed and is currently expected to take place in 2013. Two more satellites are expected to be deployed by another Dnepr multi-manifest launch in early 2014. The satellites have an estimated orbit life of 10 years; therefore, the company needs to launch at least 6 more satellites before 2019 to maintain a 12-satellite constellation. This includes two satellites to complete the constellation and four to replace the satellites launched in 2002 and 2004. 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, is a new company that 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. Additional 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. In the run-up to the launch of its first satellites in 2013, O3b has 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.

Thales Alenia Space is under contract to build 16 communications satellites for O3b; 12 are currently under construction. O3b is under a launch services agreement with Arianespace for two Soyuz launches from French Guiana in 2013. Each Soyuz will deploy four O3b satellites in MEO in the equatorial plane. In late 2011, O3b raised $137 million to cover the construction and launch of an additional four satellites to launch on a Soyuz in 2014.

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 2013-2022 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	Under construction	10 years

COMMERCIAL REMOTE SENSING SATELLITES

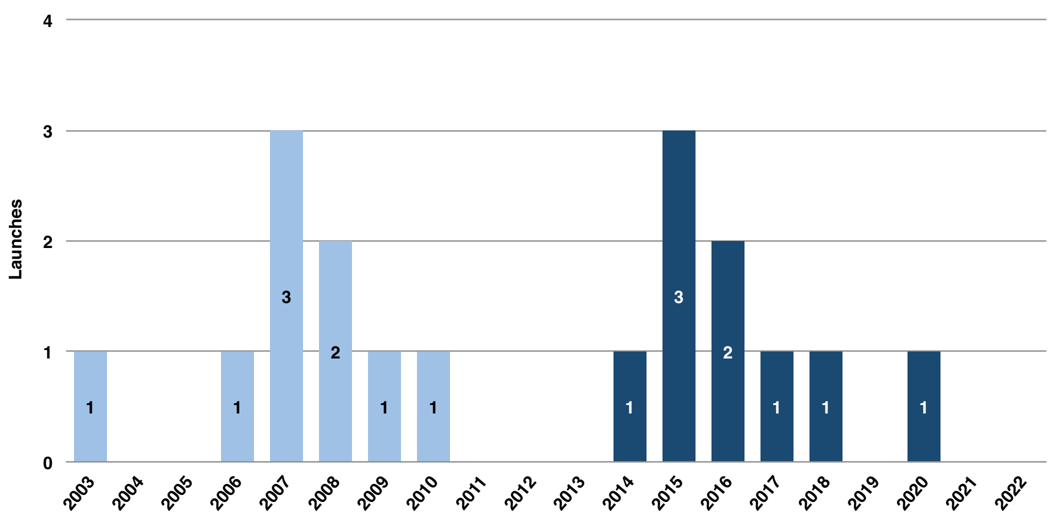
Remote sensing refers to any orbital platform with optical or radar sensors trained on Earth to gather data for geographic analysis, military use, meteorology, or climatology. The remote sensing industry comprises three markets: aerial imagery, satellite imagery, and geographic information systems (GIS). GIS consists of images obtained from aircraft or satellites integrated with layers of information, usually customized according to user needs. GIS constitutes the largest part of the industry both in terms of demand and revenue generation.

The commercial satellite remote sensing market consists of companies that operate satellites with optical or radar sensors trained on Earth to capture imagery used to generate revenue. This contrasts with remote sensing satellites funded by governments for military use or science missions. However, governments often serve as the largest customers of commercial satellite remote sensing companies and are often key partners in developing and operating expensive satellites. To generate profits and produce a return on investment, all companies that operate remote sensing satellites also provide GIS services.

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 0.8 per year through the forecast period. A peak in the number of launches can be seen in 2015, reflecting projected deployment of satellites operated by DMCii. Figure 17 provides a launch history and projected launch plans for commercial remote sensing satellites.

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



2014	2015	2016	2017	2018	2020
Worldview-3 - Atlas V	DMC3-1 - Dnepr DMC3-2 - Dnepr DMC3-3 - Dnepr	EROS C - TBD TerraSar-NG - TBD	Rapideye - TBD	RCM-1 - TBD	GeoEye-2 - Atlas V

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 27 remote sensing licenses issued or amended since 1993. Ten of these licenses have been granted to DigitalGlobe, GeoEye, or their predecessor companies, and several have been issued for university cubesat missions (see Table 17).

Table 17. NOAA Remote Sensing Licenses

Licensee	Date License Granted or Updated	Remarks
DigitalGlobe	1/4/1993	License originally issued to WorldView for EarlyBird satellite.
ORBIMAGE (d/b/a GeoEye)	5/5/1994	License originally issued to Orbital Sciences Corporation for OrbView-3.
DigitalGlobe	9/6/1994	License issued for QuickBird-1 and QuickBird-2.
AstroVision	1/23/1995	First license issued for a commercial GSO system.
Ball Aerospace & Technologies	11/21/2000	First license issued for a commercial SAR system.
DigitalGlobe	12/14/2000	License issued for a QuickBird follow-on.
ORBIMAGE (d/b/a/ GeoEye)	6/17/2003	Update to license for SeaStar satellite, changing name to OrbView-2. Originally issued to Orbital Sciences Corporation.
DigitalGlobe	9/29/2003	License issued for four-satellite high-resolution system (WorldView).
Northrop Grumman	2/20/2004	License issued for MEO system called “Continuum” with 0.5-meter resolution.
ORBIMAGE (d/b/a/ GeoEye)	8/12/2004	License originally issued to ORBIMAGE, Inc. for OrbView-5, now GeoEye-1.
Technica	12/8/2005	License issued for four-satellite EagleEye system.
ORBIMAGE (d/b/a/ GeoEye)	1/10/2006	IKONOS system license transfer from Space Imaging to ORBIMAGE.
Northrop Grumman	8/24/2009	License issued for commercial SAR system called “Trinidad.”
GeoEye, Inc.	1/14/2010	Amendment of IKONOS Block II license to change system name to GeoEye-2 and GeoEye-3.
DISH Operating LLC	2/2/2010	License transfer from EchoStar to DISH for GSO satellite (Echostar-XVI) with television camera for low-resolution imagery.
Skybox Imaging, Inc.	4/20/2010	License issued for LEO satellite SkySat-1. Application for amendment to include SkySat-2 submitted in 2011.
GeoMetWatch	9/15/2010	License issued for GSO satellite GMW-1.
Kentucky Space	10/19/2010	License issued for LEO cubesat KySat-1. Satellite launched with NASA’s Glory in 2011.
University of California	11/17/2010	License issued for use of cell phone camera aboard cubesat UCISAT-1.
University of Michigan	8/11/2011	License issued for use of imaging sensor aboard cubesat M-Cubed. Satellite launched with NPP in 2011.
Kentucky Space	1/27/2012	License issued for operation of KySat-2, a replacement for KySat-1, which was lost in a launch failure.
Cosmogia, Inc.	2/10/2012	License issued for operation of cubesat Dove-1. The satellite launched aboard the inaugural flight of Antares in 2013.
Drexel University	3/30/2012	License issued for operation of cubesat DragonSat-1. Satellite schedule to launch with SpaceX ISS resupply mission 2 aboard Falcon 9.
Cosmogia, Inc.	5/4/2012	License issued for operation of Dove-2.
Cosmogia, Inc.	9/2/2012	License issued for operation of Dove-3 and Dove-4.
California Polytechnic State University	12/4/2012	License issued for operation of the cubesat IPEX.
Southern Stars	2/18/2013	License issued for operation of cubesat SkyCube.

Since the last NGSO report was published, NOAA issued two licenses to Cosmogia for operation of three test and demonstration cubesats (Dove-2 through Dove-4), one license to CalPoly for operation of a test and demonstration cubesat called IPEX, and one license to Southern Stars for operation of an education and outreach cubesat called SkyCube. Launch of these satellites is captured in the Other Commercially Launched Satellites section of the report, as they are not commercial remote sensing systems.

Commercial remote sensing satellites in the near-term portion of this report (2012-2015) were announced by their respective companies, are under construction, and are scheduled for a launch. Satellites projected for the latter portion of the report (2016-2021) are based on published statements regarding the service lives of satellites currently operating on orbit.

The major companies operating or actively developing NGSO remote sensing satellites across the globe are profiled below in Table 18. These satellites have been or are likely to be launched commercially.

Table 18. Commercial Remote Sensing Systems

System	Operator	Manufacturer	Satellites	Mass kg (lb)	Highest Resolution (m)	Revisit Time (hrs.)	Launch Year
Operational & Under Development							
DMC3	DMC International Imaging Ltd.	SSTL	DMC3 1-3	350 (771)	1	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
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

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. In August 2010, the company announced Ball Aerospace would build a new satellite, WorldView-3, to launch aboard an Atlas V intermediate- to heavy-class vehicle in 2014. WorldView-3 will collect imagery in eight short-wave-infrared bands plus eight multispectral bands, which will extend the already industry-leading capabilities of DigitalGlobe's commercial imaging constellation. Another satellite, GeoEye-2, is currently under construction, and the company expects to place it in storage upon completion to serve 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. The merger resulted in one less launch planned over the next 10 years. The GeoEye-2 satellite was placed in storage as a ground spare.

DMC International Imaging

DMC International Imaging, Ltd. (DMCii), based in the United Kingdom, operates the Disaster Monitoring Constellation (DMC). DMCii is a wholly owned subsidiary of Surrey Satellite Technology Ltd. (SSTL).

DMC is composed of SSTL-built satellites for Algeria (Alsat-1), China (Beijing-1), Nigeria (Nigeriasat-1, Nigeriasat-2, and NX), Spain (Deimos-1), Turkey (Bilsat-1), and the United Kingdom (UK-DMC and UK-DMC2). The satellites orbit at an altitude of 700 kilometers (435 miles). The constellation's primary purpose is to distribute imagery for commercial and humanitarian purposes.

DMC became fully operational in 2006, with satellites evenly distributed in a single sun-synchronous orbit (SSO). The constellation currently consists of nine satellites launched between 2002 and 2011, each owned and controlled by the contributing nation. Nigeria's satellites Nigeriasat-2 and NX were launched in 2011 and are 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 forecast for a 2015 launch. Each DMC3 satellite will provide one-meter panchromatic and four-meter multispectral imaging.

BMBF/DLR/Astrium

TerraSAR-X and TanDEM-X were manufactured and are operated through a public-private partnership arrangement between German Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung; BMBF), the German Aerospace Center (DLR) and Astrium. Imagery is marketed and sold by Astrium GEO-Information Services, along with products obtained through SPOT, Pléiades, Formosat-2, and Deimos-1 satellites. Imagery obtained from the satellites is of value for users worldwide in programs like the European Global Monitoring for Environment and Security program and the international Global Earth Observation System of Systems.

TerraSAR-X launched aboard a Russian Dnepr vehicle in 2007 and provides up to one-meter resolution X-band radar imagery for government and commercial use. It is the first of Germany's TerraSAR-X generation (TSX-1) of synthetic aperture radar (SAR) satellites. The satellite reaches the end of its design life in 2012 but should continue operating until at least 2015.

The second member of the TSX-1 generation is the TerraSAR-X Add-On for Digital Elevation Measurement (TanDEM-X) satellite. It launched in 2010, also aboard a Dnepr vehicle. TanDEM-X provides government and commercial clients with digital elevation model (DEM) data. DEM data captures the raw surface structure of the Earth, without vegetation and artificial objects. TanDEM-X expects to remain operational until about 2018.

Work is currently underway at Astrium on a second generation of SAR satellites called TSX-2. This generation will consist of at least one satellite, called TerraSAR-NG, planned for launch in 2015. The launch vehicle has not yet been selected, but leading contenders include the medium Dnepr or Indian PSLV.

As part of its strategic planning, DLR and Astrium are also discussing a next generation of satellites beyond the 2018 timeframe to replace the TSX-1 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.

ImageSat International NV

Israel-based ImageSat, founded as West Indian Space in 1997, and officially a Netherlands Antilles 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. 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 2014, four years beyond its projected service life. EROS B launched aboard a Start-1 in 2006 and should continue to operate until 2020.

Israel Aircraft Industries is currently building the EROS-C satellite. Though no launch year has been selected, it is assumed EROS-C will launch in approximately three years (2016) aboard a small vehicle.

MacDonald, Dettwiler and Associates

MacDonald, Dettwiler and Associates, Ltd. (MDA) is a global communications and information company providing operational solutions to commercial and government organizations worldwide. The company is a commercial provider of advanced geospatial information products derived from the high-resolution RADARSAT-1 and RADARSAT-2 radar satellites. It also markets and sells data derived from commercial optical satellites and from aerial systems.

The Canadian Space Agency (CSA) operates RADARSAT-1, while RADARSAT-2 is operated by MDA in partnership with the Government of Canada. On November 4, 1995, the RADARSAT-1 satellite launched aboard a Delta II launch vehicle. RADARSAT-2 launched aboard a Starsem Soyuz intermediate vehicle on December 14, 2007.

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.

Each RCM satellite will have a mass of about 1,200 kilograms (2,600 pounds). All three satellites will be launched together on a single launch vehicle, which has not yet been selected.

PlanetIQ

PlanetIQ, established in 2012, plans to operate 12 microsatellites in support of weather, climate, and space weather data requirements. The satellites are not equipped with imaging sensors; instead, they will collect environmental earth observation data by measuring the signal strength of GPS satellites in a proven process called radio occultation. Total cost for the space segment is expected to be about $160 million, which is currently being raised. Because funding is not yet secure and details regarding the satellite constellation are not yet available, launches of PlanetIQ satellites are not included in this year's forecast.

RapidEye

RapidEye is headquartered near Berlin, Germany and has additional offices in Luxembourg, Canada, and the United States. The company operates a five-satellite multispectral remote sensing constellation that provides wide-area, repetitive coverage and 5-meter-pixel-size multi-spectral imagery. MDA was the prime contractor for the mission, responsible for design and implementation. MDA subcontracted SSTL in the UK to construct the satellites.

The RapidEye constellation launched aboard a Dnepr launch vehicle from Baikonur, Kazakhstan on August 29, 2008. The five satellites are expected to remain operational long after their original planned lifetime of seven years.

Though planning for the next generation of satellites is underway, RapidEye has not released details publicly.

Skybox Imaging

Skybox Imaging, Inc., based in Mountain View, California, is a new entrant to the commercial satellite remote sensing industry. The company was awarded a NOAA license for SkySat-1 on April 20, 2010, and has applied to amend the license to include a second satellite, SkySat-2. Both satellites will operate in a polar orbit and constitute the first elements of a projected 20-plus satellite constellation. Skybox manufactures and operates its own satellites and will provide frequently updated imagery online.

SkySat-1 is scheduled to launch in 2013 aboard a Dnepr vehicle along with several other satellites. SkySat-2, also multi-manifested with other payloads, should follow in 2014 aboard a Soyuz vehicle.

COMMERCIAL CARGO AND CREW TRANSPORTATION SERVICES

Commercial cargo and crew transportation capabilities include commercial launches of cargo and humans to LEO. Specifically, commercial cargo and crew transportation includes NASA's COTS development, CRS to the ISS, and commercial crew development efforts. This section also describes non-ISS commercial human spaceflight; emerging activities related to Bigelow orbital facilities, Excalibur Almaz, and Inspiration Mars flights; and other potential sources of future launch demand.

Commercial Cargo and Crew Transportation Services Launch Demand Summary

Seventy-four launches are projected from 2013 to 2022, as compared to 64 launches in last year's report. The increase in flights for the near term is due to the delays of Orbital's Antares test flight and subsequently the Cygnus COTS demo. For the mid-term (2015 to 2017) the increase in flights is caused by the inclusion of seven new commercial crew development test flights, which were recently announced.

Commercial cargo and crew transportation services make up 57 percent of launches in this report. If commercial vehicles begin launching Bigelow space stations, Excalibur Almaz modules, and Inspiration Mars missions, the number of launches in this section could grow in the out-years. The 74 launches in this section carry financial and technical risk, because the launches are on new launch vehicles or new spacecraft developed with NASA-appropriated funds. This launch projection represents NASA's current plans for commercial cargo and crew services to the ISS. Figure 18 provides a launch history and projected launch plans for commercial transportation services.

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

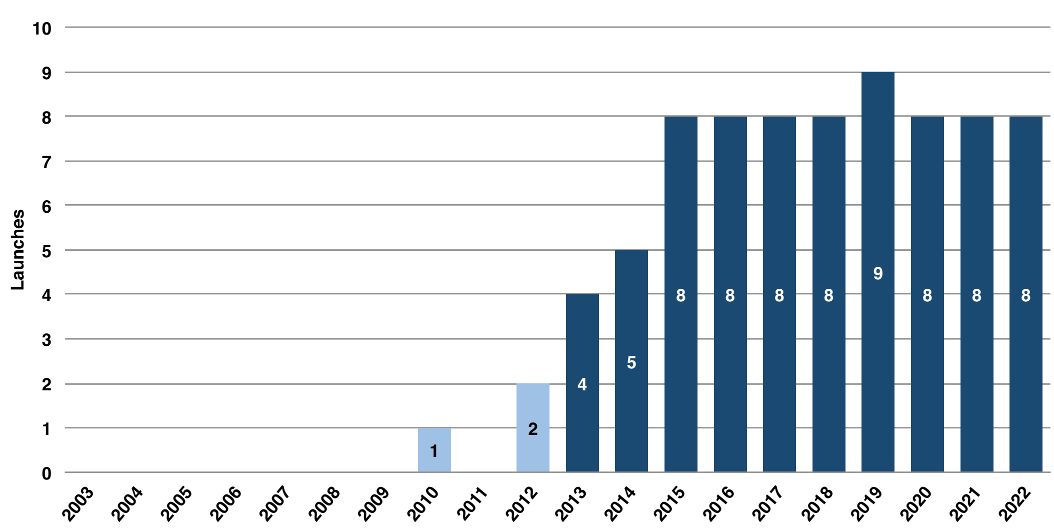
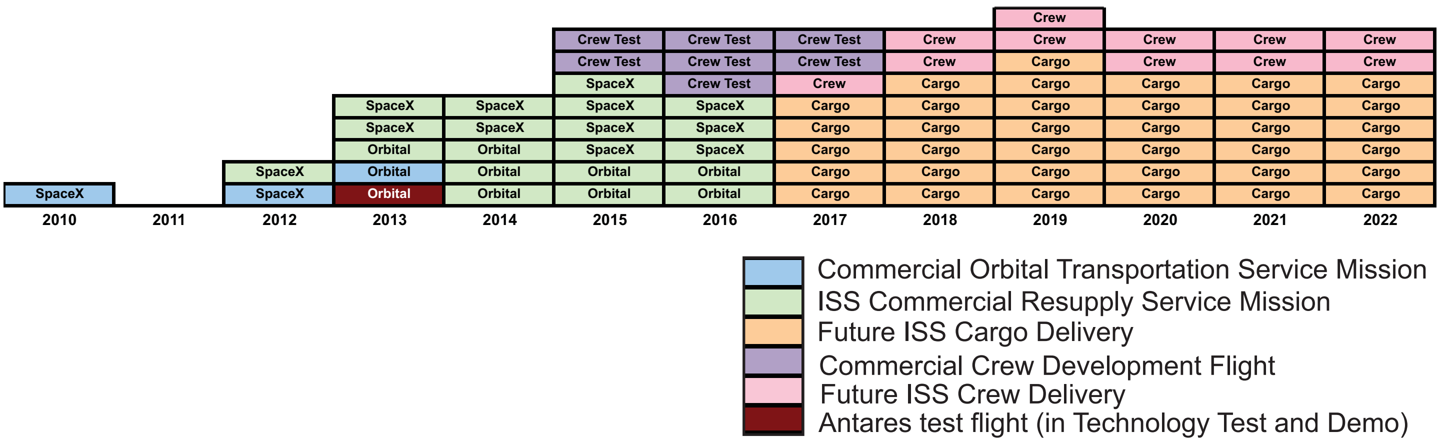


Figure 19 shows the distribution of ISS commercial cargo and crew flights from 2013 to 2022. One test flight of Orbital’s Antares, and one Orbital COTS flight are also included.

Figure 19. Forecast of COTS, CRS. and Commercial Crew Missions[4]



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

NASA COTS

In 2006, NASA announced the COTS program. COTS focuses on the development and demonstration of commercial cargo transportation systems. Total Space Act Agreement (SAA) funding under this program was $891 million. Under COTS, SpaceX developed the intermediate Falcon 9 launch vehicle and the Dragon spacecraft. Orbital developed the Cygnus spacecraft and the medium Antares launch vehicle.

In May of 2012, SpaceX completed its final milestones under the COTS program with the Dragon spacecraft’s successful berthing and cargo delivery to the ISS, along with the subsequent demonstration of safe cargo recovery back to earth. The test flight of Antares launched on April 21, 2013. Antares successfully deployed a mass simulator. Orbital’s COTS demonstration mission is planned for mid-2013.

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 will commence after successful completion of their COTS demonstration mission. Subsequently, approximately six commercial cargo flights are expected annually through 2022.

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), who is partnering with EADS Astrium; 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. For the next step, 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.

NASA expects commercial crew transportation services to the ISS to begin by late 2017, with two flights per year. These flights are included in this year's report. Some providers within the program anticipate flying as early as 2015. However, reductions in program funding below NASA's requested levels could delay the development of crew spacecraft.

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 dedicated to developing and deploying expandable space habitat technology to support a variety of public and private activities including commercial space stations in LEO and NASA human spaceflight missions beyond LEO. 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 is now in the process of constructing 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. The company is also working on two newer systems: the BA 2100 or 'Olympus', which, as the name indicates, will provide roughly 2,100 cubic meters of internal volume, and the Bigelow Expandable Activity Module (BEAM), a technology pathfinder 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 performance 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 is also involved in crew transportation. The company became a member of the Boeing CCDev team working on the CST-100 reusable in-space crew transport vehicle. Additionally, Bigelow Aerospace and SpaceX agreed to conduct a joint marketing effort to offer rides on SpaceX's Dragon and Falcon 9 launch vehicle to carry passengers to Bigelow habitats orbiting the Earth. Bigelow Aerospace has signed memorandums of understanding with national space agencies, companies, and governmental entities in the UAE, Netherlands, Sweden, Singapore, Japan, the United Kingdom, and Australia. 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.

Excalibur Almaz, Limited

Excalibur Almaz, Limited (EAL), an Isle of Man company, uses elements of a legacy Soviet military space program known as Almaz. 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.

EAL engaged in an unfunded SAA with NASA for commercial crew transportation, as part of CCDev2 activities, and became the first company to complete all of its SAA milestones. During the partnership, EAL and NASA reviewed the design of the new RRV, its system requirements, and its compatibility with launch vehicle alternatives. 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 intends to begin flight tests of the Almaz hardware by late 2014 and to launch its first revenue-generating flight as early as the fourth quarter of 2015. Current plans are for the reentry vehicles to launch atop Soyuz launch vehicles. EAL's key partners are NPO Mashinostroyenia (the original developer of Almaz), EADS Astrium, and Japan Manned Space Systems Corporation.

If EAL's plans come to fruition on its current schedule, it could create additional demand for commercial launches. However, details regarding financing have not been provided publicly, and no launch contracts have been announced. As a result, launch demand associated with EAL is not included in this report.

Inspiration Mars

The Inspiration Mars Foundation is mounting a privately funded crewed Mars flyby mission scheduled for 2018. The project aims to take advantage of a planetary alignment that will allow a Mars flyby and return in 501 days.

The company plans to choose a space capsule and rocket from those already on the market and to modify them to carry two people. The company is looking at several scenarios, from one launch to multiple launches, and reviewing several launch vehicles and capsules.

Inspiration Mars Foundation Chairman Dennis Tito will personally fund mission development for the first two years, during which time additional fundraising and support will be garnered. As no launch contracts have been announced, launch demand associated with the Inspiration Mars Foundation is not included in this report.

Other Sources of Future Launch Demand

Planetary Resources, the B612 Foundation, and Golden Spike are three examples of commercial ventures that have the potential to drive launches in future forecasts. At this time, launch contracts have not been signed for any of the missions, so launch demand associated with these companies is not included in the forecast.

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. Planetary Resources 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 B612 Foundation

The B612 Foundation is a non-profit organization 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 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 2017 or 2018.

Golden Spike

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, and its board is led by former Johnson Space Center director Gerry Griffin. 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 has contracted with Northrop Grumman for the design of a new lunar lander.

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

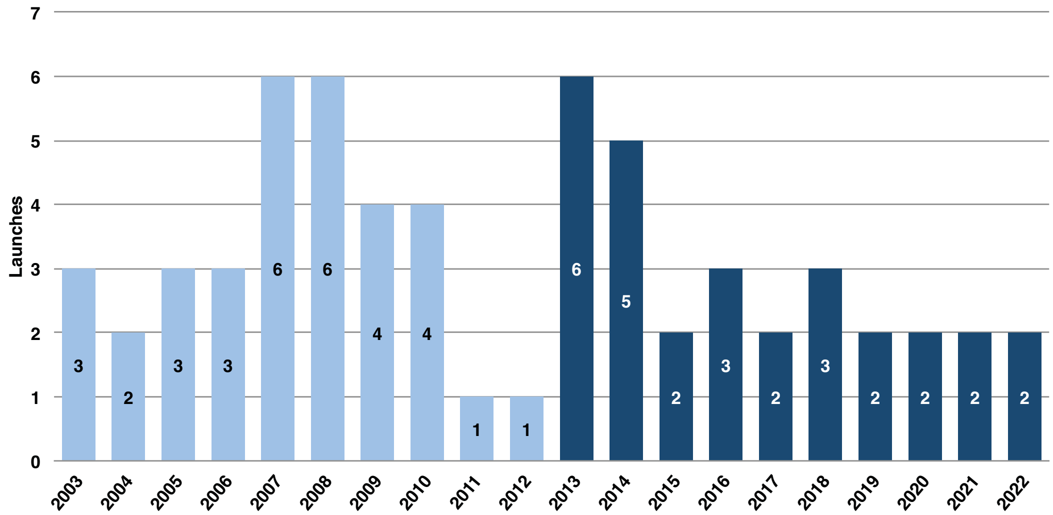
The market characterization of the near term (2013-2016) includes 12 manifested basic and applied scientific research launches and 4 remote sensing launches for countries without indigenous launch capability. For the period 2017-2022, the application of a forecasting method projects 12 basic and applied scientific research 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.

At the beginning of 2012, four launches were forecasted, but only one launched, Gökturk-2. Three launches by foreign providers, for KOMPSAT-5, DubaiSat-2, and the SWARM constellation, were delayed for various reasons. It is important to note that although these payloads and their associated launch vehicles have been delayed, the programs still expect to launch. Manifests and public sources point to these payloads launching in 2013.

On December 18, 2012, a Chinese Long March 2D successfully launched Turkey's Gökturk-2 remote sensing satellite. Development of Gökturk-1 continues, with the launch delayed to 2014. Future Gökturk satellite launches are planned on a new Turkish small launch vehicle, slated to begin development in 2013. In effect, this will remove future Gökturk launches from the list of commercial launches to NGSO since there will be no longer international competition for launching these spacecraft.

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



2013	2014	2015	2016
ASNARO 1 - Dnepr	Formosat 5 - Falcon 9	INGENIO - TBD	DragonLab 1 - Falcon 9
CASSIOPE - Falcon 9	Göktürk 1 - TBD	SAOCOM 1B - Falcon 9	DubaiSat-3 - TBD
DubaiSat-2 - Dnepr	Kompsat 3A - Dnepr		EnMAP - PSLV
Kompsat 5 - Dnepr	PAZ - Dnepr		
ORS-3 Enabler - Minotaur I	SAOCOM 1A - Falcon 9		
SWARM (3) - Rockot			

Examples of missions in this category and within the near term manifest of this forecast include:

- **ASNARO 1:** ASNARO is a remote sensing satellite for the Japanese Ministry of Economy, Trade, and Industry manufactured by the Nippon Electric Company (NEC). The satellite has a projected mass of 400 kilograms (882 pounds) and will launch on a Dnepr in 2013.

- **CASSIOPE:** The Cascade, Smallsat, and Ionospheric Polar Explorer (CASSIOPE) spacecraft, manufactured by MDA, is scheduled to launch in 2013 on a Falcon 9 launch vehicle. The payload has a mass of about 500 kilograms (1,100 pounds). The satellite will space-qualify high-performance payload components that will be used in the Cascade mission, also developed by MDA.

- **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-2, -3:** Two remote sensing satellites, from the Emirates Institution for Advanced Science and Technology located in the UAE, are scheduled to launch as primary payloads in multi-manifested launches aboard Dnepr vehicles in 2013 and 2016. Each satellite has a mass of about 300 kilograms (661 pounds) and will provide improved resolution and faster download speeds.

- **EnMAP:** The German space agency, 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 manifested to launch in 2014 on a Falcon 9 vehicle. 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 2014 on a medium to heavy launch vehicle.

- **INGENIO:** INGENIO is the first Spanish optical Earth observation satellite. The mission will provide high-definition panchromatic and multi-spectral ground imaging for various applications that can be used in mapping, urban planning, agriculture, water management, environmental monitoring, and risk and safety management. Launch of the satellite is planned in 2015 on a medium to heavy 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 2014 on a Dnepr vehicle.

- **KOMPSAT-5:** KOMPSAT-5 is a 1,280-kilogram (2,816-pound) satellite with a SAR platform. Originally scheduled for launch in 2011, the payload is now scheduled for a single-manifest Dnepr launch in 2013. The satellite will provide images up to 1-meter resolution for use in geographic information applications, environmental monitoring, and disaster response. KARI and European manufacturer Thales Alenia Space manufactured the satellite, with Alcatel Alenia Space responsible for producing the X-band SAR sensor.

- **ORS-3 Enabler:** ORS-3 is the third mission of the Operationally Responsive Space (ORS) program. The payload is an experimental avionics package mounted to the last stage of the launch vehicle. The objective is to test space-based rocket tracking technology and an autonomous termination system. ORS-3 will be integrated into a Minotaur I for an FAA-licensed flight in 2013. This mission is using an FAA-licensed launch to demonstrate an alternative execution method for launch services that reduces overall costs.
- **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 2014 and 2015, respectively.
- **SWARM 1, 2, 3:** The SWARM constellation consists of three satellites and is designed to improve knowledge of the Earth's interior composition and climate. ESA selected EADS Astrium to develop and build the constellation of three satellites. The satellites will measure the strength and direction of the Earth's magnetic field from a polar orbit. The SWARM constellation will launch in 2013 on a Rockot, one of the two small vehicle launches manifested during this forecast.

Method for Forecasting Launch Demand

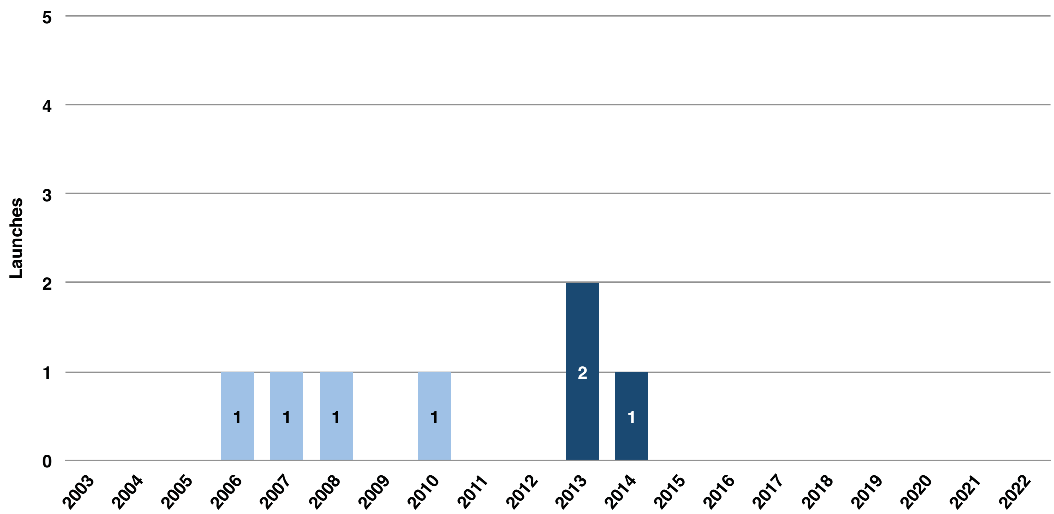
This forecast revised the model for payloads and launches related to basic and applied scientific research that was applied in the 2012 NGSO report. The methodology features a five-year average that includes three prior years and two projected years (for this report, 2010-2014) with equal weight. This 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 last year’s 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.

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



2013	2014
Test Package - Antares	Orion MPCV - Delta IV Heavy
Test Package - Falcon Heavy	

The successful inaugural launch of Orbital’s Antares vehicle, which occurred in April 2013, is included in this section, as is the demonstration flight of SpaceX’s Falcon Heavy launch vehicle, planned for launch in 2013. 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 2014.

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.

Table 20. Small Satellite Mass Classes

Class Name	Kilograms (kg)	Pounds (lb)
Femto	0.01 - 0.1	0.02 - 0.2
Pico	0.1 - 1	0.2 - 2
Nano	1 - 10	2 - 22
Micro	10 - 200	22 - 441
Mini	200 - 600	441 - 1,323
Small	600 - 1,200	1,323 - 2,646

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. Microsatellites, or microsats, are often multi-manifested with satellites of a similar class on small launch vehicles. Smaller microsats and nanosatellites, or nanosats, are usually launched as piggyback payloads.

A **piggyback payload** is a spacecraft or satellite that is carried into space using excess launch capacity on a rocket. Spacecraft lighter than 100 kg are often launched as piggyback payloads. Piggyback launching allows operators to place their spacecraft in orbit at a significantly lower cost than launching as a primary payload.

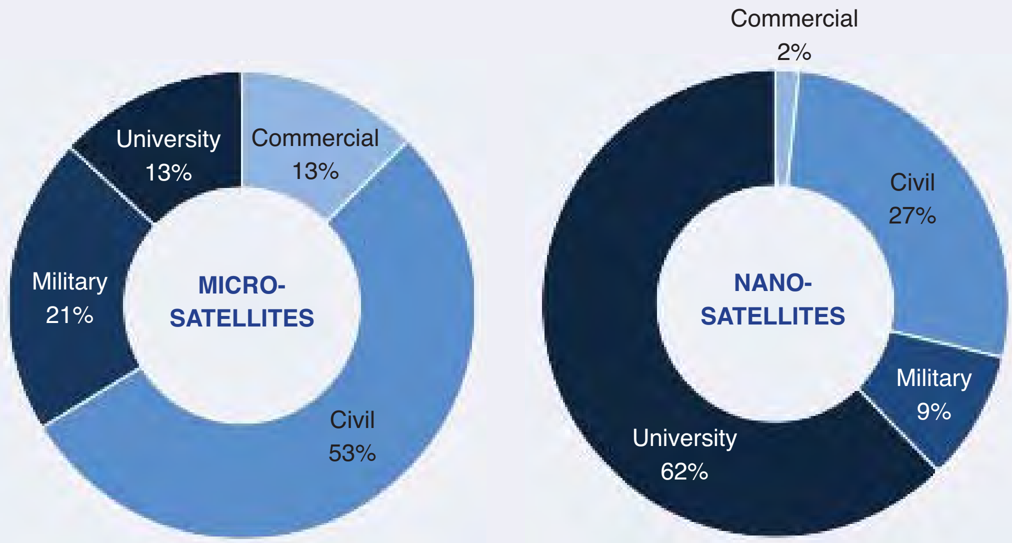
In the last 10 years, both non-commercial and commercial launch vehicles launched a total of almost 300 microsats and smaller class satellites worldwide (see Table 21).

In 2003 to 2012, the majority of microsats were launched for government civil missions, whereas the nanosat market was dominated by universities (see Figure 22). The only two pico-satellites during this period were free-flying imagers DCAM 1 and DCAM 2, launched as part of the Japanese IKAROS interplanetary solar sail mission in 2010.

Table 21. Micro and Smaller Satellites Launch in 2003-2012

Type of Launch	Microsatellites	Nanosatellites	Pico- and Femtosatellites
Commercial	65	21	0
Non-Commercial	110	101	2
Total Payloads Launched	**175**	**122**	**2**

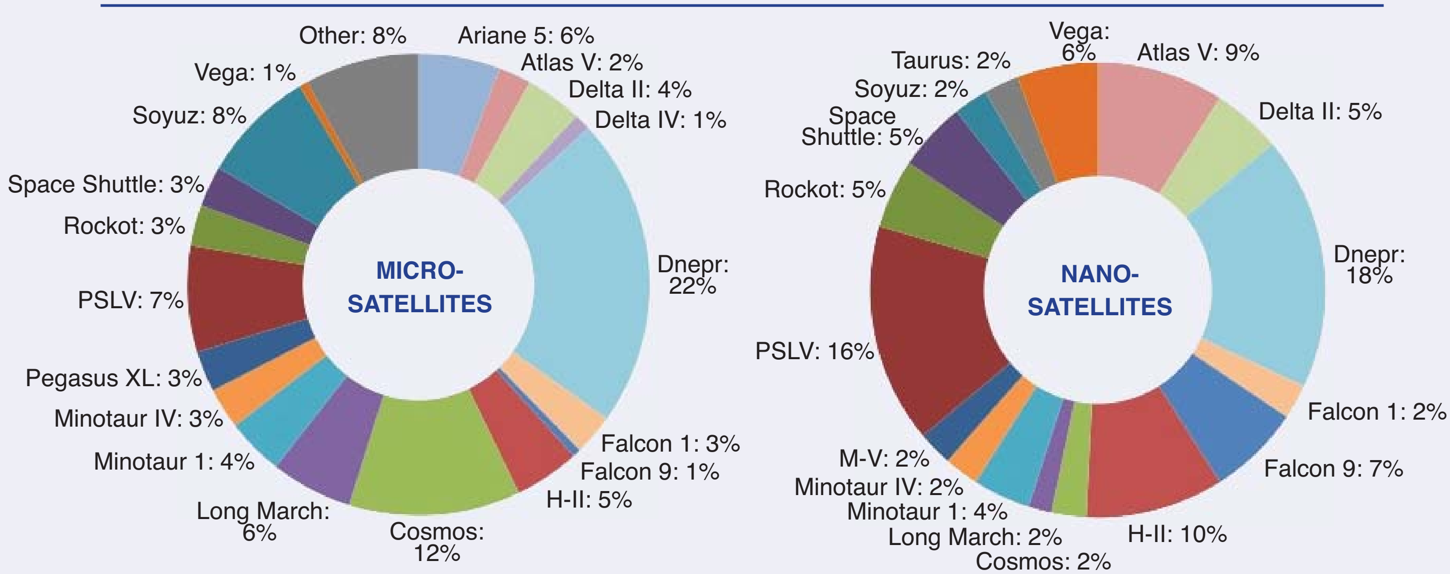
Figure 22. Microsatellites and Nanosatellites Launched in 2003-2012



Microsats rarely drive launch demand and nanosats almost never do. 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. Although there have been a significant number of nanosats launched over the last 10 years, and more of them are expected to launch in the future, 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, dedicated to launching payloads of the nanosat and smaller classes.

Historically, a variety of launch vehicles have launched microsats and nanosats (see Figure 23). Over the past decade, the Russian Dnepr launch vehicle has launched the most micro- and nanosatellites. However, due to delays and uncertain launch schedules, there have been fewer Dnepr launches in the past two years, and the Atlas V (U.S.), Falcon 9 (U.S.), PSLV (India), and Vega (Europe) vehicles have launched more microsats and nanosatellites.

Figure 23. Microsatellites and Nanosatellites Launched by Vehicle, 2003-2012



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. Over 75 cubesats have launched, and approximately, 100 and 150 cubesats are either ready to launch or in various phases of 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.

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. It uses an expendable two-stage liquid-fueled rocket air-launched from a WhiteKnightTwo aircraft, the carrier aircraft for the suborbital reusable vehicle SpaceShipOne. Virgin Galactic projects to begin LauncherOne flights in 2016.

While microsats are widely used for various satellite applications, including commercial communications (e.g., ORBCOMM and AprizeStar) and remote sensing (e.g., RapidEye), nanosats are predominantly used for technology demonstration, both in spacecraft technology and satellite applications, such as communications and remote sensing. As the technology matures, more nanosatellites are built for scientific, communications, and remote sensing purposes.

Appendix 4 presents a summary of secondary NGSO payloads to launch commercially during the forecast period. It includes publicly announced microsats and nanosats, along with a few larger satellites, that are manifested in the near term to launch commercially.

SATELLITE AND LAUNCH FORECAST TRENDS

On average, for the past five years, there have been 77 total launches and 21 commercial launches per year. 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.

From 2013 to 2022, 337 payloads are projected to launch commercially, driving 130 launches with multi-manifesting. This projection is comparable to last year's report, which projected 128 launches from the 2012 to 2021 timeframe. Figures 24 and 25 show the payloads and launches projected from 2013 to 2022. Table 22 provides the specific numbers of payloads and launches for each segment.

Figure 24. Payload Projections

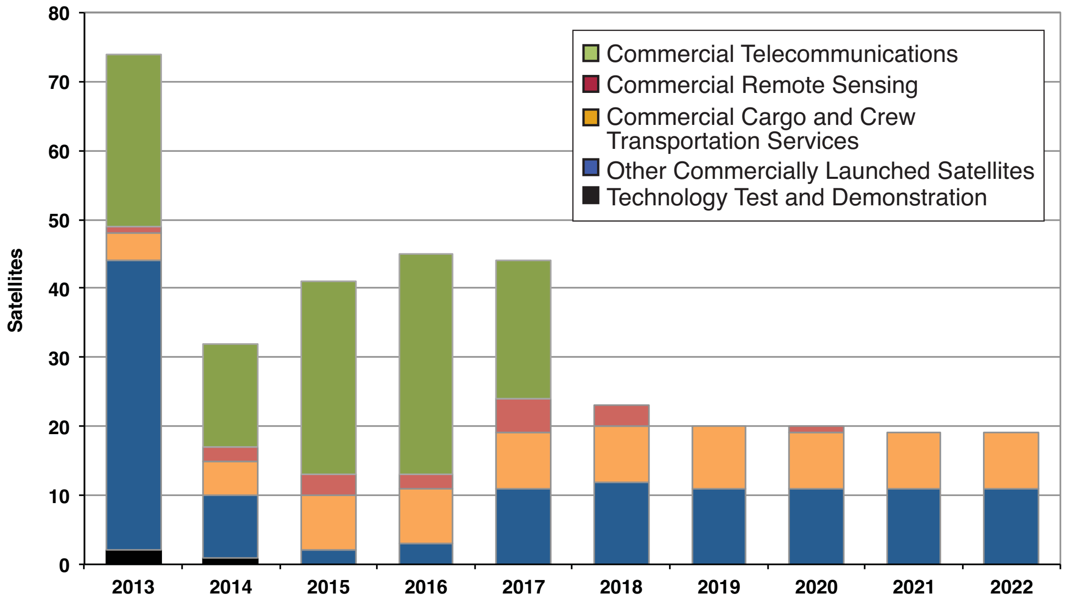


Figure 25. Launch Projections

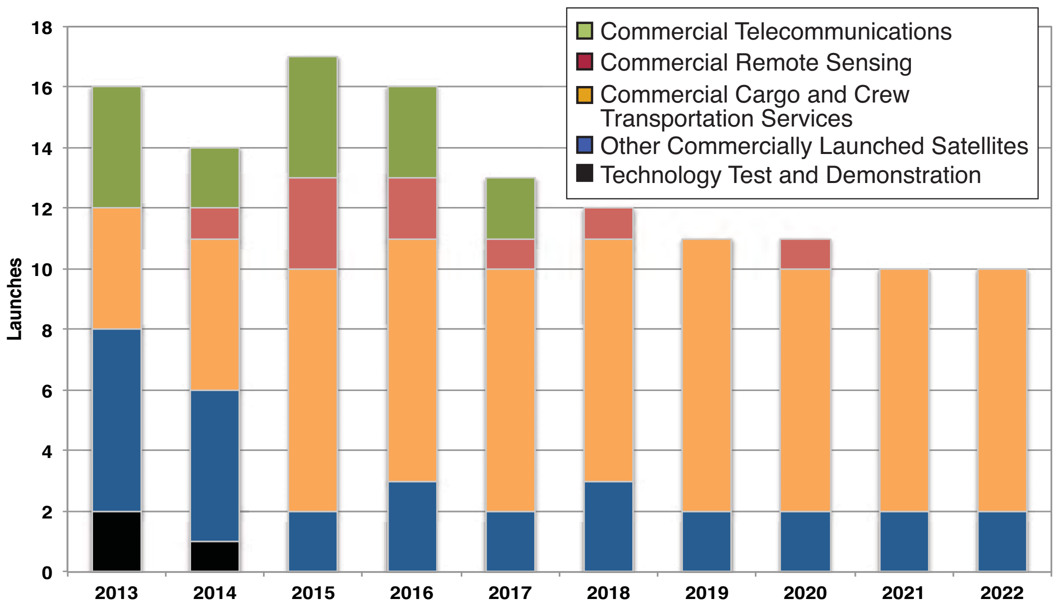


Table 22. Payload and Launch Projections

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	Avg.
Payloads												
Commercial Telecommunications	25	15	28	32	20	0	0	0	0	0	**120**	**12.0**
Commercial Remote Sensing	1	2	3	2	5	3	0	1	0	0	**17**	**1.7**
Commercial Cargo and Crew Transportation Services	4	5	8	8	8	8	9	8	8	8	**74**	**7.4**
Other Commercially Launched Satellites	42	9	2	3	11	12	11	11	11	11	**123**	**12.3**
Technology Test and Demonstration	2	1	0	0	0	0	0	0	0	0	**3**	**0.3**
Total Satellites	**74**	**32**	**41**	**45**	**44**	**23**	**20**	**20**	**19**	**19**	**337**	**33.7**
Launches												
Medium-to-Heavy Vehicles	14	14	17	15	13	12	11	11	10	10	**127**	**12.7**
Small Vehicles	2	0	0	1	0	0	0	0	0	0	**3**	**0.3**
Total Launches	**16**	**14**	**17**	**16**	**13**	**12**	**11**	**11**	**10**	**10**	**130**	**13.0**

Fifty-seven 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 22 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.

Twelve percent of the launches are for commercial telecommunications. Four launches are planned in 2013 to replace 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 commercial remote sensing industry is characterized by relatively stable satellite replacement schedules, and it represents seven percent of the launch demand market. A peak in the number of launches is expected in 2015, reflecting projected deployment of satellites operated by DMCii.

The technology test and demonstration segment accounts for 2 percent of launches over the next 10 years, including 3 launches of new technology test and demonstration missions: Orbital's Antares vehicle, 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. 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 23 shows the mass distributions of known manifested payloads over the next two years.

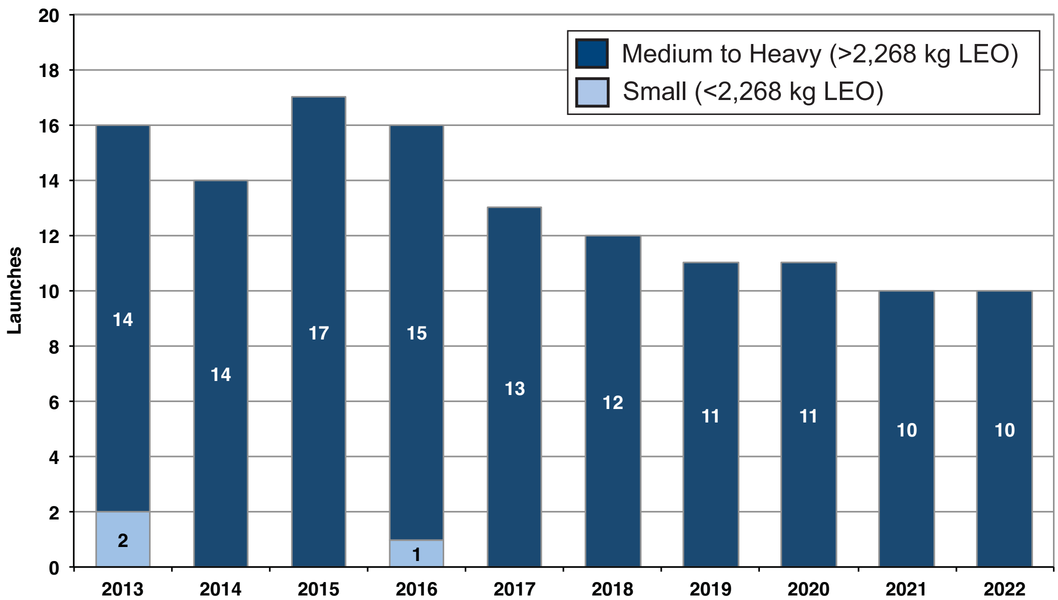
Table 23. Distribution of Payload Masses in Near-Term Manifest

Mass Class	Mass Class Weight	2013	2014	Total	Percent of Total
Femto, Pico, Nano, Micro	0.01-200 kg (0.02-441 lbs)	38	7	**45**	**42%**
Mini	200-600 kg (441-1,323 lbs)	15	11	**26**	**25%**
Small	600-1,200 kg (1,323-2,646 lbs)	14	6	**20**	**19%**
Medium, Intermediate	1,200-4,200 kg (2,646-9,259 lbs)	3	5	**8**	**8%**
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	3	**7**	**7%**
	Total	**74**	**32**	**106**	**100%**

There are 130 launches projected, comprising 3 small vehicles and 127 medium-to-heavy vehicles. On average, 0.3 launches take place on small vehicles and 12.7 launches on medium-to-heavy vehicles every year. The 2012 report included 128 total launches composed of 8 small and 120 medium-to-heavy launches.

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. Other factors supporting this trend 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.

Figure 26. Launch Vehicle Projections



Two of the three projected small launches are for Other Commercially Launched Satellites: a Rockot for the SWARM constellation and a Minotaur I for ORS-3. An additional small vehicle, yet to be announced, will launch the EROS-C remote sensing satellite. All other launches are expected to be on medium-to-heavy vehicles.

One hundred-twenty telecommunications payloads will require 15 multiple-manifested launches in the next 10 years. The projected number of launches for the Commercial Transportation Services and Other Commercially Launched Satellites segments is 74 and 29, respectively. Commercial transportation spacecraft all require medium-to-heavy launch vehicles. Payloads in the Other Commercially Launched Satellites segment will use a mix of medium-to-heavy and small launch vehicles, and multiple payloads will frequently co-manifest on the same launch. Commercial remote sensing satellites are projected to launch on eight medium-to-heavy launch vehicles and one small launch vehicle.

Table 24 provides the distribution of launches among the market segments.

Table 24. Distribution of Launches among Market Segments

		Launch Demand		
Market Segment	Payloads	Small	Medium-to-Heavy	Total
Commercial Telecommunications	120	0	15	**15**
Commercial Remote Sensing	17	1	8	**9**
Commercial Cargo and Crew Transportation Services	74	0	74	**74**
Other Commercially Launched Satellites	123	2	27	**29**
Technology Test and Demonstration	3	0	3	**3**
Total	**337**	**3**	**127**	**130**

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. Some new vehicles will be introduced, while others will retire.

In the U.S., SpaceX began to launch revenue-generating flights of the Falcon 9 in 2012, and Orbital's new Antares vehicle may begin revenue-generating flights in 2014. In both cases, these flights launch under NASA's CRS contracts. In addition, Lockheed Martin Commercial Launch Services will provide upgraded variants of the Athena launch vehicle, with launches expected during the forecast period. Virgin Galactic intends to begin commercial launches of its new LauncherOne vehicle in 2016.

In Europe, Arianespace's small vehicle Vega is available to perform flights. China is working on a small vehicle called the Long March 6, which may be offered commercially. The first launch of this vehicle is expected early in the forecast period. Japan plans to inaugurate its Epsilon small launch vehicle in 2013, while South Korea continues to develop its Korean Space Launch Vehicle system, which includes the small Naro-1 vehicle. The Naro-1, previously known as the Korean Space Launch Vehicle (KSLV-1) had its first successful launch in January 2013. In Russia, the Angara 1, a light version of the anticipated Angara series, will replace the Cosmos-3M, Tsyklon, and Rockot launch vehicles.

The new vehicles expected to become available within the next two to three years— Athena, Epsilon, and Long March 6—will launch one or more micro- and small-class payloads at a time. For NGSO, the per-kilogram cost to orbit for a small launch vehicle tends to be higher than the per-kilogram cost of a larger capacity vehicle, which may make these new small launch vehicles too expensive for many microsatellite customers. Because of cost, as well as reasons listed above, many small NGSO satellites may go as piggyback payloads on larger vehicles, leaving small launch vehicles with the smaller market of time-critical delivery of payloads on orbit.

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.

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APPENDICES

Image credit: Sierra Nevada Corporation

APPENDIX 1: HISTORICAL GSO SATELLITES AND LAUNCHES

Historical data for addressable commercial satellites launched from 1993 through 2012 is shown in Table 25. Historical data for unaddressable satellites launched from 1993 to 2012 is shown in Table 26.

Table 25. Historical Addressable Commercial GSO Satellites Launched (1993-2012)

	1993			1994			1995		
Total Launches	8			14			17		
Total Satellites	10			18			18		
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)	6			9			14		
		Astra 1C	Ariane 4		Astra 1D	Ariane 4		Astra 1E	Ariane 4
	DM2	DBS 1	Ariane 4		Intelsat 702	Ariane 4		DBS 3	Ariane 4
		Galaxy 4	Ariane 4	DM2	PAS 2	Ariane 4		Intelsat 706	Ariane 4
		Intelsat 701	Ariane 4		PAS 3	Ariane 4		NSTAR a	Ariane 4
	DMU	Solidaridad 1	Ariane 4	DM4	Solidaridad 2	Ariane 4		PAS 4	Ariane 4
		Telstar 401	Atlas II		Telstar 402	Ariane 4		Telstar 402R	Ariane 4
					DBS 2	Atlas II		AMSC 1	Atlas II
					Intelsat 703	Atlas II		Galaxy 3R	Atlas II
					Optus B3	Long March 2E		Intelsat 704	Atlas II
								Intelsat 705	Atlas II
								JCSat 3	Atlas II
								APStar 2	Long March 2E
								Asiasat 2	Long March 2E
								EchoStar 1	Long March 2E
Below 2,500 kg (<5,510 lbm)	4			9			4		
	DM1	Insat 2B	Ariane 4	DM3	Brazilsat B1	Ariane 4	DM1	Brazilsat B2	Ariane 44
	DM1	Hispasat 1B	Ariane 4	DM2	BS-3N	Ariane 4	DM1	Hot Bird 1	Ariane 44
	DM2	Thaicom 1	Ariane 4	DM1	Eutelsat II F5	Ariane 4	DMU	Insat 2C	Ariane 44
		NATO 4B	Delta II	DM4	Thaicom 2	Ariane 4		Koreasat 1	Delta II
				DM1	TurkSat 1A	Ariane 4			
				DM3	TurkSat 1B	Ariane 4			
					Orion 1	Atlas II			
					Galaxy 1R	Delta II			
					APStar 1	Long March 3			

= 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 25. Historical Addressable Commercial GSO Satellites Launched (1993-2012) (Continued)

	1996			1997			1998		
Total Launches	21			24			19		
Total Satellites	25			28			23		
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)	14			21			14		
	DM3	Arabsat 2A	Ariane 4	DMU	Hot Bird 3	Ariane 4	DM4	Afristar	Ariane 4
	DM4	Arabsat 2B	Ariane 4		Intelsat 801	Ariane 4	DM3	Eutelsat W2	Ariane 4
		EchoStar 2	Ariane 4		Intelsat 802	Ariane 4		Hot Bird 4	Ariane 4
		Intelsat 707	Ariane 4		Intelsat 803	Ariane 4		PAS 6B	Ariane 4
		Intelsat 709	Ariane 4		Intelsat 804	Ariane 4		PAS 7	Ariane 4
		MSAT 1	Ariane 4		JCSat 5	Ariane 4		Satmex 5	Ariane 4
		NSTAR b	Ariane 4		PAS 6	Ariane 4		ST 1	Ariane 4
	DM2	Palapa C2	Ariane 4	DM4	Sirius 2	Ariane 4		Hot Bird 5	Atlas II
	DM1	PAS 3R	Ariane 4	DM2	Thaicom 3	Ariane 4		Intelsat 805	Atlas II
		AMC 1	Atlas II		AMC 3	Atlas II		Intelsat 806	Atlas II
		Hot Bird 2	Atlas II		DirecTV 6	Atlas II		Galaxy 10	Delta III
		Palapa C1	Atlas II		EchoStar 3	Atlas II		Astra 2A	Proton K/DM
		Intelsat 708	Long March 3B		Galaxy 8i	Atlas II		EchoStar 4	Proton K/DM
		Astra 1F	Proton K/DM		JCSat 4	Atlas II		PAS 8	Proton K/DM
					Superbird C	Atlas II			
					Agila II	Long March 3B			
					APStar 2R	Long March 3B			
					Aatra 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)	11			7			9		
	DM2	Amos 1	Ariane 4	DM1	AMC 2	Ariane 4	DM4	AMC 5	Ariane 4
	DMU	Italsat 2	Ariane 4	DM2	BSat 1A	Ariane 4	DM1	Brazilsat B3	Ariane 4
	DM1	Measat 1	Ariane 4	DM4	Cakrawarta 1	Ariane 4	DM2	BSat 1B	Ariane 4
	DM4	Measat 2	Ariane 4	DM3	Inmarsat 3F4	Ariane 4	DM1	Inmarsat 3F5	Ariane 4
	DM3	TurkSat 1C	Ariane 4	DM3	Insat 2D	Ariane 4	DM2	NileSat 101	Ariane 4
		Inmarsat 3F1	Atlas II	DM1	Nahuel 1A	Ariane 4	DM3	Sirius 3	Ariane 4
		Inmarsat 3F3	Atlas II		Thor II	Delta II		Bonum 1	Delta II
		Galaxy 9	Delta II					Skynet 4D	Delta II
		Koreasat 2	Delta II					Thor III	Delta II
		APStar 1A	Long March 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 25. Historical Addressable Commercial GSO Satellites Launched (1993-2012) (Continued)

	1999	2000	2001
Total Launches	18	20	12
Total Satellites	19	24	14
Over 5,400 kg (>11,905 lbm)	0	0	0
4,200 - 5,400 kg (9,260 - 11,905 lbm)	2	4	5
	Galaxy 11 Ariane 4 Orion 3 Delta III	Anik F1 Ariane 4 PAS 1R Ariane 5 Garuda 1 Proton K/DM Thuraya 1 Sea Launch	DirecTV 4S Ariane 4 Intelsat 901 Ariane 4 Intelsat 902 Ariane 4 XM Rock Sea Launch XM Roll Sea Launch
2,500 - 4,200 kg (5,510 - 9,260 lbm)	16	14	6
	AMC 4 Ariane 4 DM1 Arabsat 3A Ariane 4 Insat 2E Ariane 4 Koreasat 3 Ariane 4 Orion 2 Ariane 4 Telkom Ariane 4 Telstar 7 Ariane 4 Echostar 5 Atlas II Eutelsat W3 Atlas II JCSat 6 Atlas II Asiasat 3S Proton K/DM Astra 1H Proton K/DM LMI 1 Proton K/DM Nimiq Proton K/DM Telstar 6 Proton K/DM DirecTV 1R Sea Launch	DM1 Asiastar 1 Ariane 5 DM3 Astra 2B Ariane 5 Europe*Star 1 Ariane 4 Eutelsat W1R Ariane 4 Galaxy 10R Ariane 4 Galaxy IVR Ariane 4 NSat 110 Ariane 4 Superbird 4 Ariane 4 Echostar 6 Atlas II Hispasat 1C Atlas II Eutelsat W4 Atlas III AAP 1 Proton K/DM AMC 6 Proton K/DM PAS 9 Sea Launch	Atlantic Bird 2 Ariane 4 Turksat 2A Ariane 4 DM2 Artemis Ariane 5 DM1 Eurobird Ariane 5 Astra 2C Proton K/DM PAS 10 Proton K/DM
Below 2,500 kg (<5,510 lbm)	1	6	3
	DM1 Skynet 4E Ariane 4	DM2 Brazilsat B4 Ariane 4 DM2 Nilesat 102 Ariane 4 DM3 AMC 7 Ariane 5 DM4 AMC 8 Ariane 5 DM4 Astra 2D Ariane 5 DM1 Insat 3B Ariane 5	DMU Skynet 4F Ariane 4 DM1 BSat 2A Ariane 5 DM2 BSat 2B 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 25. Historical Addressable Commercial GSO Satellites Launched (1993-2012) (Continued)

	2002			2003			2004	
Total Launches		20			12		13	
Total Satellites		22			15		13	
Over 5,400 kg (>11,905 lbm)		0			0		3	
							Anik F2	Ariane 5
							Intelsat X	Proton M
							DirecTV 7S	Sea Launch
4,200 - 5,400 kg (9,260 - 11,905 lbm)		9			5		4	
		Intelsat 904	Ariane 4		Intelsat 907	Ariane 4	Amazonas	Proton M
		Intelsat 905	Ariane 4	DM2	Optus C1	Ariane 5	Eutelsat W3A	Proton M
		Intelsat 906	Ariane 4		Rainbow 1	Atlas V	APStar V	Sea Launch
		NSS 6	Ariane 4		EchoStar 9	Sea Launch	Estrela do Sul	Sea Launch
		NSS 7	Ariane 4		Thuraya 2	Sea Launch		
		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)		11			6		4	
		Insat 3C	Ariane 4	DM1	Insat 3A	Ariane 5	Superbird 6	Atlas II
	DM1	JCSat 8	Ariane 4	DM3	Insat 3E	Ariane 5	MBSat	Atlas III
	DMU	Atlantic Bird 1	Ariane 5		Asiasat 4	Atlas III	AMC 16	Atlas V
	DMU	Hotbird 7	Ariane 5		HellasSat	Atlas V	AMC 15	Proton M
	DM2	Stellat 5	Ariane 5		AMC 9	Proton K/M		
		Hispasat 1D	Atlas II		Galaxy 13	Sea Launch		
		Echostar 7	Atlas III					
		Hotbird 6	Atlas V					
		Eutelsat W5	Delta IV					
		DirecTV 5	Proton K/DM					
		Nimiq 2	Proton M					
Below 2,500 kg (<5,510 lbm)		2			4		2	
	DM1	Astra 3A	Ariane 4	DM2	Bsat 2C	Ariane 5	AMC 10	Atlas II
	DM2	NSTAR c	Ariane 5	DM3	e-Bird 1	Ariane 5	AMC 11	Atlas II
				DM1	Galaxy 12	Ariane 5		
					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 25. Historical Addressable Commercial GSO Satellites Launched (1993-2012) (Continued)

	2005			2006			2007		
Total Launches	15			15			12		
Total Satellites	16			19			18		
Over 5,400 kg (>11,905 lbm)	6			2			3		
	DM1	Spaceway 2	Ariane 5	DM2	Satmex 6	Ariane 5	DM3	Spaceway 3	Ariane 5
		Thaicom 4	Ariane 5	DM3	DirecTV 9S	Ariane 5		DirecTV 10	Proton M
		Inmarsat 4F1	Atlas V					NSS 8	Sea Launch
		IA 8	Sea Launch						
		Inmarsat 4F2	Sea Launch						
		Spaceway 1	Sea Launch						
4,200 - 5,400 kg (9,260 - 11,905 lbm)	4			9			6		
		AMC 12	Proton M	DM4	Wildblue 1	Ariane 5	DM2	Astra 1L	Ariane 5
		AMC 23	Proton M		Astra 1KR	Atlas V	DM1	Skynet 5A	Ariane 5
		Anik F1R	Proton M		Hotbird 8	Proton M	DM5	Skynet 5B	Ariane 5
		XM 3	Sea Launch		Measat 3	Proton M		Nigcomsat	Long March 3B
					Echostar 10	Sea Launch		Anik F3	Proton M
					Galaxy 16	Sea Launch		SES Sirius 4	Proton M
					JCSat 9	Sea Launch			
					Koreasat 5	Sea Launch			
					XM 4	Sea Launch			
2,500 - 4,200 kg (5,510 - 9,260 lbm)	3			6			5		
		Insat 4A	Ariane 5	DM1	Hotbird 7A	Ariane 5	DM2	Galaxy 17	Ariane 5
	DMU	XTAR-EUR	Ariane 5	DMU	JCSat 10	Ariane 5	DM1	Insat 4B	Ariane 5
		DirecTV 8	Proton M	DM1	Spainsat	Ariane 5	DM6	RASCOM 1	Ariane 5
				DM2	Thaicom 5	Ariane 5	DM5	Star One C1	Ariane 5
					Arabsat 4A	Proton M		JCSat 11	Proton M
					Arabsat 4B	Proton M			
Below 2,500 kg (<5,510 lbm)	3			2			4		
	DM1	Telkom 2	Ariane 5	DM4	AMC 18	Ariane 5	DM3	Bsat 3A	Ariane 5
	DMU	Galaxy 15	Ariane 5	DM3	Optus D1	Ariane 5	DM4	Intelsat 11	Ariane 5
		Galaxy 14	Soyuz				DM4	Optus D2	Ariane 5
							DM6	Horizons	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 25. Historical Addressable Commercial GSO Satellites Launched (1993-2012) (Continued)

	2008			2009			2010		
Total Launches	18			18			14		
Total Satellites	23			22			20		
Over 5,400 kg (>11,905 lbm)	5			8			7		
		ICO G-1	Atlas V	DM1	Amazonas 2	Ariane 5	DM4	Eutelsat W3B	Ariane 5
		Ciel 2	Proton M	DM2	NSS 12	Ariane 5		Arabsat 5B	Proton M
		Inmarsat 4F3	Proton M		Terrestar 1	Ariane 5		Echostar 14	Proton M
		DirecTV 11	Sea Launch		Intelsat 14	Atlas V		Echostar 15	Proton M
		Echostar 11	Sea Launch		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)	8			2			4		
	DM3	HotBird 9	Ariane 5	DM3	Hotbird 10	Ariane 5	DM1	Astra 3B	Ariane 5
	DM1	Skynet 5C	Ariane 5		Nimiq 5	Proton M	DM2	Arabsat 5A	Ariane 5
	DM5	Superbird 7	Ariane 5				DM6	Hispasat 1E	Ariane 5
		Astra 1M	Proton M				DM5	Intelsat 17	Ariane 5
		Nimiq 4	Proton M						
		Galaxy 18	Sea Launch						
		Galaxy 19	Sea Launch						
		Thuraya 3	Sea Launch						
2,500 - 4,200 kg (5,510 - 9,260 lbm)	8			9			6		
	DM1	Turksat 3A	Ariane 5	DM4	JCSat 12	Ariane 5	DM5	Hylas	Ariane 5
	DM2	Badr 6	Ariane 5	DM1	Satcom BW1	Ariane 5	DM6	Koreasat 6	Ariane 5
	DM2	Protostar 1	Ariane 5	DM2	Thor 6	Ariane 5	DM3	Nilesat 201	Ariane 5
	DM3	Eutelsat W2M	Ariane 5		Telstar 1N	Land Launch	DM3	RASCOM 1R	Ariane 5
	DM4	Vinasat	Ariane 5		Intelsat 15	Long March	DM1	Satcom BW2	Ariane 5
	DM4	StarOne C2	Ariane 5		Palapa D	Long March		SES 1	Proton M
	DM5	AMC 21	Ariane 5		Asiasat 5	Proton M			
		AMC 14	Proton M		Protostar II	Proton M			
					Sicral 1B	Sea Launch			
Below 2,500 kg (<5,510 lbm)	2			3			3		
		AMOS 3	Land Launch	DM3	NSS 9	Ariane 5	DM2	COMS 1	Ariane 5
		Thor 5	Proton M	DM4	Optus D3	Ariane 5	DM4	BSAT 3B	Ariane 5
					Measat 3A	Land Launch		Intelsat 16	Proton M

= 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 25. Historical Addressable Commercial GSO Satellites Launched (1993-2012) (Continued)

	2011			2012		
Total Launches	12			12		
Total Satellites	15			21		
Over 5,400 kg (>11,905 lbm)	3			10		
	DM1	Yahsat 1A	Ariane 5	DM3	Astra 2F	Ariane 5
		Quetzsat	Proton M	DMU	Echostar 17	Ariane 5
		Viasat 1	Proton M	DM2	Intelsat 20	Ariane 5
					Echostar 16	Proton M
					Intelsat 22	Proton M
					SES 4	Proton M
					SES 5	Proton M
					Yahsat 1B	Proton M
					Intelsat 19	Sea Launch
					Intelsat 21	Sea Launch
4,200 - 5,400 kg (9,260 - 11,905 lbm)	6			5		
	DM3	Arabsat 5C	Ariane 5	DM4	Eutelsat 21B	Ariane 5
	DM2	Astra 1N	Ariane 5	DM1	JCSAT 13	Ariane 5
	DMU	ST 2	Ariane 5	DM5	Skynet 5D	Ariane 5
		Eutelsat W3C	Long March		Nimiq 6	Proton M
		Telstar 14R	Proton M		Eutelsat 70B	Sea Launch
		Atlantic Bird 7	Sea Launch			
2,500 - 4,200 kg (5,510 - 9,260 lbm)	6			6		
	DM2	BSAT 3C	Ariane 5	DM3	GSAT 10	Ariane 5
	DM1	New Dawn	Ariane 5	DM2	Hylas 2	Ariane 5
	DM3	SES 2	Ariane 5	DM5	Mexsat 3	Ariane 5
		Intelsat 18	Land Launch	DM4	Star One C3	Ariane 5
		Asiasat 7	Proton M	DM1	Vinasat 2	Ariane 5
	DMU	SES 3	Proton M/DM		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 26. Historical Unaddressable Commercial GSO Satellites Launched (1993-2012)

	1993			1994			1995			1996		
Launches	3			4			1			4		
Spacecraft	3			4			2			5		
		Gorizont	Proton K/DM		DFH 3-1	Long March 3A	DMC	Telecom 2C	Ariane 4	DMC	Telecom 2D	Ariane 4
		Gorizont 40	Proton K/DM		Express	Proton K/DM		Gals 2	Proton K/DM		Chinasat 7	Long March 3A
		Gorizont 41	Proton K/DM		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

	1997			1998			1999			2000		
Launches	1			2			2			5		
Spacecraft	1			2			3			5		
		Chinasat 6	Long March 3A		ChinaStar 1	Long March 3B		Express A1	Proton K/DM		Express A2	Proton K/DM
					Sinosat 1	Long March 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	Long March 3A

	2001			2002			2003			2004		
Launches	1			1			3			2		
Spacecraft	1			1			4			2		
		Ekran M	Proton M		Express A4	Proton K/DM		Express AM22	Proton K/DM		Express AM11	Proton K/DM
							DM1	Yamal 201	Proton K/DM		Express AM1	Proton K/DM
							DM1	Yamal 202	Proton K/DM			
								Chinasat 20	Long March 3A			

	2005			2006			2007			2008		
Launches	3			4			4			3		
Spacecraft	3			4			4			3		
		Express AM 2	Proton K/DM		Kazsat	Proton K/DM		Sinosat 3	Long March 3B		Venesat 1	Long March 3B
		Express AM 3	Proton K/DM		Sinosat 2	Long March 4B		Chinasat 6B	Long March 3B		Chinasat 9	Long March 3B
		Apstar 6	Long March 3B		Chinasat 22A	Long March 3A		Nigcomsat 1	Long March 3B		Express AM33	Proton
					Insat 4C	GSLV		Insat 4CR	GSLV			

	2009			2010			2011			2012		
Launches	1			3			8			6		
Spacecraft	2			3			10			8		
	DM1	Express MD1	Proton M		ChinaSat 6A	Long March 3B		GSAT 8	Ariane 5		Apstar 7	Long March 3B
	DM1	Express AM44	Proton M		ChinaSat 20A	Long March 3A		Chinasat 10	Long March 3B		Chinasat 2A	Long March 3B
					Insat 4D	GSLV		Chinasat 1A	Long March 3B		Chinasat 12	Long March 3B
								Nigcomsat 1R	Long March 3B	DM1	Express MD2	Proton M
								Paksat 1R	Long March 3B	DM2	Luch 5B	Proton M
							DM1	Amos 5	Proton M	DM1	Telkom 3	Proton M
							DM1	Luch 5A	Proton M	DM2	Yamal 300K	Proton M
								Express AM4	Proton M		Yamal 402	Proton M
							DMA	Kazsat 2	Proton M			
								GSAT 12	PSLV			

= 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.

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 27. 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 2012 are shown in Table 28.

Table 27. Historical Payloads and Launches[6]

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
Payloads											
Commercial Telecommunication	0	2	0	0	8	6	2	6	14	1	**39**
Commercial Remote Sensing	1	0	1	1	3	6	3	1	2	0	**18**
Commercial Cargo and Crew Transportation Services	0	0	0	0	0	0	0	1	0	2	**3**
Other Commercially Launched Satellites	8	7	7	3	13	6	7	6	4	1	**62**
Technology Test and Demonstration	0	0	0	1	1	1	0	1	0	0	**4**
Total Satellites	**9**	**9**	**8**	**5**	**25**	**19**	**12**	**15**	**20**	**4**	**126**
Launches											
Medium-to-Heavy Vehicles	1	1	0	2	10	4	2	7	3	3	**33**
Small Vehicles	3	1	3	3	2	6	3	1	0	0	**22**
Total Launches	**4**	**2**	**3**	**5**	**12**	**10**	**5**	**8**	**3**	**3**	**55**

[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 28. Historical NGSO Payload and Launch Activities (2003-2012)

Summary	Market Segment	Date	Satellite	Launch Vehicle	
2012					
4 Satellites	Telecommunication		ORBCOMM OG2-01[1]		
1 Telecommunication	Transportation	5/22/12	Dragon COTS Demo 2/3	Falcon 9	Medium-to-Heavy
2 Transportation		10/7/12	Dragon CRS D1	Falcon 9	Medium-to-Heavy
1 Other	Other	12/19/12	Göktürk 2	LM 2D	Medium-to-Heavy
3 Launches					
3 Medium-to-Heavy					
2011					
20 Satellites	Telecommunication	7/13/11	Globalstar 2nd Gen. 7-12	Soyuz 2	Medium-to-Heavy
14 Telecommunication			AprizeStar 5-6[2]		
2 Remote Sensing		12/28/11	Globalstar 2nd Gen.13-18	Soyuz 2	Medium-to-Heavy
4 Other	Remote Sensing		Nigeriasat-2[3A]		
			NX[3B]		
3 Launches	Other	8/17/11	Sich 2	Dnepr	Medium-to-Heavy
3 Medium-to-Heavy			RASAT		
			Edusat		
			BPA-2		

1 ORCBCOMM 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 28. Historical NGSO Satellite and Payload Activities (2003-2012) (Continued)

Summary	Market Segment	Date	Satellite	Launch Vehicle	
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
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

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 28. Historical NGSO Satellite and Payload Activities (2003-2012) (Continued)

Summary	Market Segment	Date	Satellite	Launch Vehicle	
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
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
2003					
9 Satellites 1 Remote Sensing 8 Other **4 Launches** 1 Medium-to-Heavy 3 Small	Remote Sensing	6/26/03	OrbView 3	Pegasus XL	Small
	Other	6/2/03 9/27/03 10/30/03	Mars Express Beagle 2 BilSat 1 BNSCSat KaistSat 4 NigeriaSat 1 SERVIS 1 Rubin 4-DSI[11]	Soyuz Cosmos Rockot	Medium-to-Heavy Small Small

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 29. Mass Classes for GSO and NGSO Payloads

Class Name	Kilograms (kg)	Pounds (lb)
Femto	0.01 - 0.1	0.02 - 0.2
Pico	0.1 - 1	0.2 - 2
Nano	1 - 10	2 - 22
Micro	10 - 200	22 - 441
Mini	200 - 600	441 - 1,323
Small	600 - 1,200	1,323 - 2,646
Medium	1,200 - 2,500	2,646 - 5,512
Intermediate	2,500 - 4,200	5,512 - 9,259
Large	4,200 - 5,400	9,259 - 11,905
Heavy	5,400 - 7,000	11,905 - 15,432
Extra Heavy	> 7,000	> 15,432

APPENDIX 5: SUMMARY OF SECONDARY NGSO PAYLOADS LAUNCHED COMMERCIALLY

Table 30 provides details on launched and forecasted secondary payloads listed in this report. Payloads are listed in alphabetical order.

Table 30. Secondary NGSO Payloads Launched Commercially

Satellite	Launch Year	Launch Vehicle	Mass kg (lb)	Description of Capability
Black Night I	2013	Minotaur I	1 (2)	Black Night 1 is an experimental nanosatellite designed by West Point cadets. The satellite will be launched as part of NASA's ELaNa initiative.
BPA-3	2013	Dnepr	1,910 (4,211)	The Ukrainian BPA-3 is designed to remain attached to a Dnepr's third stage to test navigation equipment for launch vehicles, spacecraft, and civilian aircraft. It is an experiment for technology development related to aircraft and spacecraft navigation developed by Kharton-Arkos, the manufacturers of the Dnepr control system.
CANX 3-C	2013	Dnepr	7 (15)	CANX 3-C is a Polish satellite mission to make photometric observations of stars to examine their variability. The satellite was built in conjunction with the University of Vienna, Vienna University of Technology, and the University of Toronto.
CINEMA-1	2014	Atlas V	3 (7)	Cinema-1 was developed by the University of California Berkeley to conduct research and space weather measurements.
CINEMA-2, -3	2013	Dnepr	3 (7)	CINEMA-2 and -3 were developed by the University of California Berkeley, Kyung Hee University of South Korea, Imperial College London (ICL), and NASA Ames Research Center. The satellites will conduct research and space weather measurements.
Copper Cube	2013	Minotaur I	1 (2)	Copper Cube is a 1U cubesat developed by St. Louis University. Its mission is to perform a first flight of a commercially available, compact microbolometer array to evaluate its use for Earth observation and space situational awareness.
CP-5	2014	Atlas V	1 (2)	CP-5 is a 1U cubesat developed by Cal Poly's PolySat Program. The payload is designed to test a deployable spacecraft de-orbiting film mechanism consisting of a miniature solar sail.
CSSWE	2014	Atlas V	4 (9)	CSSWE was built by the University of Colorado as a space weather experiment to monitor solar particles reaching Earth.
CUSat 1, 2	2013	Falcon 9	45 (99)	CUSat 1 and 2 will demonstrate a process through which one satellite can diagnose the structural health and configuration of another. The satellites are part of Cornell University's Nanosat-4 Program.
CXBN	2014	Atlas V	3 (7)	CXBN, built by Morehead State University, is a nanosatellite designed to make observations of the cosmic X-ray background.
Delfi-n3Xt	2013	Dnepr	5 (11)	The Delfi University of Technology, the University of Twente, and TNO (a Dutch partner) are working together to build Delfi-n3Xt. The satellite is to provide systems engineering experience, scientific writing experience, and various other skills to the students participating in the design and development. The satellite will test various micro-technologies for space applications, which were developed by sources in the Dutch space sector.

Table 30. Secondary NGSO Payloads Launched Commercially (Continued)

Satellite	Launch Year	Launch Vehicle	Mass kg (lb)	Description of Capability
Dove-1	2013	Antares	6 (13)	Earth Observing start-up Cosmogia launched the triple-unit (3U) cubesat built with non-space components and housing a small camera. The satellite launched on Antares inaugural flight in April 2013.
DragonSat 1	2013	Minotaur I	1 (2)	DragonSat 1 is an experimental nanosatellite developed by Drexel University and Drexel Space Systems Lab. The nanosatellite will be launched as part of NASA’s ELaNa initiative.
FUNcube-1	2013	Dnepr	1 (2)	A UK amateur education satellite built by AMSAT-UK. The friendly user interface allows students to access and monitor information on the satellite such as battery voltages and temperatures, spin rate, and attitude.
Genesat 2	2013	Minotaur I	4 (9)	Genesat 2 is a technology demonstration nanosatellite mission between NASA and various universities to study the effects of microgravity on biological cultures.
GOMX-1	2013	Dnepr	2 (4)	Students from Aalborg University in Denmark developed an amateur radio payload to send into SSO. The satellite will include a camera designed to take color images of Earth. Additionally, it will include a receiver that will be tested and have its performance characterized.
IPEX	2013	Minotaur I	1 (2)	IPEX is a cubesat mission for NASA’s Jet Propulsion Laboratory. Its mission is to demonstrate operation of autonomous instrument processing, downlink operations, and ground station operations.
Phonesat 1.0 (3)	2013	Antares	1 (2)	Phonesat 1.0 is a technology demonstration mission by NASA Ames Research Center to prove that commercial smartphones can operate as avionics systems on a cubesat.
POPACS (3)	2013	Falcon 9	2 (4)	POPACS was developed by Morehead State University, Gil Moore, the University of Arkansas, Planetary Systems Corporation, and Montana State University to assess changes in the density of the upper atmosphere in response to heightened solar activity.
SPA-1 Trailblazer	2013	Minotaur I	1 (2)	SPA-1 Trailblazer is an experimental nanosatellite that will provide a proof of concept to SPA, provide flight heritage and receive radiation exposure measurements, and provide a space qualification platform for additive manufacturing technology.
STPSat-3	2013	Minotaur I	180 (397)	STPSAT-3, developed by the USAF Space Test Program, will carry five experiments designed to host various space situational awareness sensors and a pair of space environment sensors.
STSat-3	2013	Dnepr	150 (330)	The South Korean-designed STSat-3 is designed to test technologies related to bus structure, battery performance, and onboard computer performance. It will test these components by providing infrared images of the galaxy and aiding in land classification research and monitoring of water quality.
SwampSat	2013	Minotaur I	1 (2)	SwampSat is a nanosatellite developed by the University of Florida to test a new system for attitude control.
Tethersat	2013	Minotaur I	3 (7)	Tethersat is a 3U cubesat developed the Naval Postgraduate School to test electrodynamic tether propulsion. The satellite is launched by the USAF Space Test Program and NASA’s ELaNa initiative.
TJSat	2013	Minotaur I	1 (2)	Thomas Jefferson Sat, (TJSat) is an experimental education cubesat built by Fairfax, Virginia high school.

Table 30. Secondary NGSO Payloads Launched Commercially (Continued)

Satellite	Launch Year	Launch Vehicle	Mass kg (lb)	Description of Capability
Triton 1, 2	2013	Dnepr	3 (7)	Triton 1 and 2 are 3U nanosatellites developed by Innovative Solutions in Space BV to test an experimental advanced Automatic Identification System receiver.
UniSat-5	2013	Dnepr	12 (26)	This is the sixth satellite designed and manufactured by students and professors from the School of Aerospace Engineering at the University of Rome. Students from Morehead State University also contributed to the design and manufacturing of the satellite. UniSat-5 will test equipment in space conditions and allow for microgravity experimentation of various projects.
UWE-3	2013	Dnepr	1 (2)	The third satellite out of the University of Würzburg will test adaptations of Internet protocols to the space environment while maintaining the ability to control its attitude, a new feature among the UWE satellites.
Vermont Lunar Cubesat	2013	Minotaur I	1 (2)	The Vermont Lunar Cubesat was developed by the Vermont Technical College and is a test for circum-lunar flight using a triple cubesat.
WNISat-1	2013	Dnepr	10 (22)	WNISat-1 is set to monitor the atmosphere and ice conditions in the routes of the Arctic Sea. The satellite will also monitor carbon dioxide in the atmosphere using visible and near-infrared cameras to capture details.

ACRONYMS AND ABBREVIATIONS

21AT	Twenty First Century Aerospace Technology Company Ltd.
ABS	Asia Broadcast Satellite
ACS	Alcântara Cyclone Space
ADF	Australian Defense Force
AEHF	Advanced Extreme High Frequency (EHF)
AIS	Automatic Identification System
APT	APT Satellite Holdings Limited
ATK	Alliant TechSystems
ATV	Automated Transfer Vehicle
AVUM	Attitude and Vernier Upper Module
AWOS	Automated Weather Observing System
BEAM	Bigelow Expandable Activity Module
BLS	Boeing Launch Services
BMBF	Federal Ministry of Education and Research
BPA	Blok Perspektivnoy Avioniki
BTS	Bi-Propellant Third Stage
CALT	China Academy of Launch Vehicle Technology
CASC	China Aerospace Science and Technology Corporation
CASSIOPE	Cascade, Smallsat, and Ionospheric Polar Explorer
CAST	Chinese Academy of Space Technology
CBC	Common Booster Core
CCAFS	Cape Canaveral Air Force Station
CCB	Common Core Booster
CCDev	Commercial Crew Development
CCiCap	Commercial Crew Integrated Capability
CEO	Chief Executive Officer
CGWIC	China Great Wall Industry Corporation
CHIRP	Commercially Hosted Infrared Payload Flight Demonstration Program
CLF	Commercial Launch Facility
COE-CST	Center of Excellence for Commercial Space Transportation
COMSTAC	Commercial Space Transportation Advisory Committee
COO	Chief Operations Officer
COTS	Commercial Orbital Transportation Services
CPC	Certification Product Contract
CPM	Common Propulsion Modules
CRS	Commercial Resupply Services

CSA	Canadian Space Agency
CSLAA	Commercial Space Launch Amendments Act
CSSWE	Colorado Student Space Weather Experiment
CST-100	Crew Space Transportation (CST)-100
CTS	Crew Transportation System
CXBN	Cosmic X-Ray Background
DARPA	Defense Advanced Research Projects Agency
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.
DoD	Department of Defense
DTH	Direct-to-Home
EADS	European Aeronautic Defence and Space Company N.V.
EAL	Excalibur Almaz, Ltd.
EAR	Export Administration Regulations
ECA	Export Credit Agency
EDRS	European Data Relay System
EELV	Evolved Expendable Launch Vehicle Program
EFT	Exploration Flight Test
EGNOS	European Geostationary Navigation Overlay Service
EIS	Environmental Impact Study
ELaNa	Educational Launch of Nanosatellites
ELI	Highly Elliptical Orbit
EROS	Earth Remote Observation Satellite
ESA	European Space Agency
EXIM	Export-Import Bank
EXT	External or Non-Geocentric Orbit
FAA	Federal Aviation Administration
FAA AST	Federal Aviation Administration's Office of Commercial Spac Transportation
FAR	Friends of Amateur Rocketry
FCC	Federal Communications Commission
FSS	Fixed Satellite Services
FY	Fiscal Year
GEO	Geostationary Earth Orbit

GIS	Geographic Information Systems
GMW	GeoMetWatch
GPS	Global Positioning System
GSLV	Geosynchronous Satellite Launch Vehicle
GSO	Geosynchronous Orbit
GTO	Geosynchronous Transfer Orbit
HALS	High Altitude Launch Service
HAPS	Hydrazine Auxiliary Propulsion System
HDTV	High Definition Television Services
HEO	Highly Elliptical Orbit
HPA	Hosted Payload Alliance
HTHL	Horizontal takeoff Horizontal Landing
HTV	H-II Transfer Vehicle
HYLAS	Highly Adaptable Satellite
ICBM	Intercontinental Ballistic Missile
ICL	Imperial College London
ILS	International Launch Services
IOS	Interorbital Systems
IPO	Initial Public Offering
ISC Kosmotras	International Space Company Kosmotras
ISPCS	International Symposium for Personal and Commercial Spaceflight
ISRO	Indian Space Research Organization
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
ITT	International Telephone & Telegraph
ITU	International Telecommunications Union
JAA	Jacksonville Aviation Authority
JAXA	Japan Aerospace Exploration Agency
JCSAT	Japan Communications Satellite
KARI	Korea Aerospace Research Institute
KOMPSAT	Korea Multi-Purpose Satellite
KSC	Kennedy Space Center
KSLV	Korean Space Launch Vehicle
LARES	Laser Relativity Satellite
LCRD	Laser Communications Relay Demonstration
LEO	Low Earth Orbit
LH2	Liquid Hydrogen
LLC	Limited Liability Company

LLS	Launch License
LMCLS	Lockheed Martin Commercial Launch Services
LOX	Liquid Oxygen
LRLO	Launch Operator License
LSO	Launch License Order
LSP	NASA Launch Services Program
MARS	Mid-Atlantic Regional Spaceport
Masten	Masten Space Systems
MEO	Medium Earth Orbit
MHI	Mitsubishi Heavy Industries, Ltd.
MPCV	Multi Purpose Crew Vehicle
MSG	Meteosat Second Generation
MSS	Mobile Satellite Services
MUOS	Mobile User Objective System
NASA	National Aeronautics and Space Administration
NASTAR	National Aerospace Training and Research (NASTAR) Center
NDAA	National Defense Authorization Act
NEC	Nippon Electric Company
NESDIS	National Environmental Satellite, Data, and Information Service
NGA	National Geospatial-Intelligence Agency
NGSO	Non-Geosynchronous Orbit
NLS	NASA Launch Services
NLV	Nanosat Launch Vehicle
NMSA	New Mexico Spaceport Authority
NOAA	National Oceanic and Atmospheric Administration
NPO Lavotchkin	Lavotchkin Research and Production Association, Russia
NPRM	Notice of Proposed Rulemaking
NRO	National Reconnaissance Office
O3b	Other Three Billion Networks, Ltd.
OHB	Orbitale Hochtechnologie Bremen
Orbital	Orbital Sciences Corporation
ORS	Operationally Responsive Space
OSD	Office of the Secretary of Defense
OSIDA	Oklahoma Space Industry Development Authority
PCM	Pressurized Cargo Module
PMRF	Pacific Missile Range Facility
PSLV	Polar Satellite Launch Vehicle
PWR	Pratt & Whitney Rocketdyne
RBS	Reusable Booster System

RBSP	Radiation Belt Storm Probes
RCM	RADARSAT Constellation Mission
RCS	Reaction Control System
RKK Energia	S.P. Korolev Rocket and Space Corporation Energia
RLS	Reentry License
RRV	Reusable Return Vehicle
SAA	Space Act Agreement
Sandia	Sandia National Laboratories
SAR	Synthetic Aperture Radar
SAST	Shanghai Academy of Spaceflight Technology
SBAS	Satellite-Based Augmentation Systems
SBIR	Small Business Innovation Research
SES	Société Européenne des Satellites
SLF	Space Shuttle Launch Facility
SLS	Space launch System
SNC	Sierra Nevada Corporation
SNL	Sandia National Laboratories
SpaceX	Space Exploration Technologies Corporation
SPARK	Spaceborne Payload Assist Rocket - Kauai
SPOT	Satellite Pour l'Observation de la Terre
SRB	Solid Rocket Booster
SRV	Suborbital Reusable Vehicle
SSI	Spaceport Systems International
SSL	Space Systems Loral
SSO	Sun-Synchronous Orbit
SSTL	Surrey Satellite Technology Limited
STIM Grants	Space Transportation Infrastructure Matching Grants
STTR	Small Business Technology Transfer
SXC	Space Expedition Corporation
TBA	To Be Announced
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
USAF	United States Air Force
USLM	United States Munitions List
VAFB	Vandenberg Air Force Base

VASIMR	Variable Specific Impulse Magnetoplasma Rocket
VCSFA	Virginia Commercial Space Flight Authority
VTVL	Vertical Takeoff Vertical Landing
WAAS	Wide Area Augmentation System
WFF	Wallops Flight Facility
XA-1.0	Extreme Altitude 1.0
XCOR	XCOR Aerospace, Inc.

2013 Worldwide Orbital Launch Events

Date			Vehicle	Site		Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
15-Jan-13			Rockot	Plesetsk		Cosmos 2482	LEO	Russian Space Forces (VKS)	Reshetnev Company	Communications		S	S
						Cosmos 2483	LEO	Russian Space Forces (VKS)	Reshetnev Company	Communications			S
						Cosmos 2484	LEO	Russian Space Forces (VKS)	Reshetnev Company	Communications			S
27-Jan-13			H-IIA 202	Tanegashima		IGS-4D (RADAR)	SSO	Japan Defense Agency	Mitsubishi Electric Corp.	Intelligence		S	S
						IGS-5 Optical Demonstration	SSO	Japan Defense Agency	Mitsubishi Electric Corp.	Intelligence			S
30-Jan-13			Naro-1	Naro Space Center		STSAT-2C	LEO	KARI	Korean Advanced Institute of Science and Technology	Scientific		S	S
30-Jan-13			Atlas V 401	CCAFS		TDRS K	GEO	NASA	The Boeing Company	Communications		S	S
1-Feb-13	√		Zenit 3SL	Pacific Ocean	*	Intelsat 27	GEO	Intelsat	Boeing Satellite Systems	Communications	$100M	F	F
6-Feb-13	√		Soyuz 2.1a	Baikonur	*	Globalstar 2nd Gen 19	LEO	Globalstar, Inc.	Thales Alenia Space	Communications	$50M	S	S
					*	Globalstar 2nd Gen 20	LEO	Globalstar, Inc.	Thales Alenia Space	Communications			S
					*	Globalstar 2nd Gen 21	LEO	Globalstar, Inc.	Thales Alenia Space	Communications			S
					*	Globalstar 2nd Gen 22	LEO	Globalstar, Inc.	Thales Alenia Space	Communications			S
					*	Globalstar 2nd Gen 23	LEO	Globalstar, Inc.	Thales Alenia Space	Communications			S
					*	Globalstar 2nd Gen 24	LEO	Globalstar, Inc.	Thales Alenia Space	Communications			S
7-Feb-13	√		Ariane 5 ECA	Kourou	*	Amazonas 3	GEO	Hispasat	Space Systems/Loral	Communications	$220M	S	S
						Azersat 1	GEO	Government of Azerbijan	Orbital Sciences Corp.	Communications			S
11-Feb-13			Soyuz U2/ Progress	Baikonur		Progress M-18M	LEO	Russian Federal Space Agency (Roscosmos)	RKK Energia	ISS		S	S
11-Feb-13			Atlas V 401	VAFB		Landsat DCM	SSO	NASA/U.S. Geological Survey	Orbital Sciences Corp.	Remote Sensing		S	S
25-Feb-13			PSLV Standard	Satish Dhawan		Saral	SSO	ISRO	ISRO	Remote Sensing		S	S
						6 secondary payloads (including cubesats)							S
1-Mar-13	√	+	Falcon 9 v1.0 Dragon	CCAFS	*	Dragon ISS 2D	LEO	Space Exploration Technologies	Space Exploration Technologies	ISS	$56.5M	S	S
19-Mar-13			Atlas V 401	CCAFS		SBIRS GEO 2	GEO	U.S. Air Force	Lockheed Martin Corp.	Early Warning		S	S
26-Mar-13	√		Proton M/ Breeze-M	Baikonur	*	SatMex 8	GEO	Satelites Mexicanos S.A. de C.V.	Space Systems/Loral	Communications	$85M	S	S
28-Mar-13			Soyuz U2/Soyuz	Baikonur		Soyuz TMA-08M	LEO	Russian Federal Space Agency (Roscosmos)	RKK Energia	Crewed		S	S
15-Apr-13	√		Proton M/ Breeze-M	Baikonur	*	Anik G1	GEO	Telesat	Space Systems/Loral	Communications	$85M	S	S
19-Apr-13			Soyuz 2.1a	Baikonur		Bion M1	LEO	Russian Federal Space Agency (Roscosmos)	TsSKB Progress	Scientific		S	S
						6 secondary payloads (including cubesats)							S
21-Apr-13	√	+	Antares 120	MARS	*	Cygnus Mass Simulator	LEO	Orbital Sciences Corp.	Orbital Sciences Corp.	Test	$77.5M	S	S
						4 secondary payloads (including cubesats)							S
24-Apr-13			Soyuz U2/ Progress	Baikonur		Progress M-19M	LEO	Russian Federal Space Agency (Roscosmos)	RKK Energia	ISS		S	S

Date	Vehicle	Site	Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
26-Apr-13	Long March 2D	Jiuquan	GAOFEN 1	SSO	China Aerospace Science and Technology Corporation (CASC)	China Aerospace Science and Technology Corporation (CASC)	Remote Sensing		S	S
			3 secondary payloads (including cubesats)							S
26-Apr-13	Soyuz 2.1b	Plesetsk	Glonass M47	MEO	Russian Space Forces (VKS)	Reshetnev Company	Navigation		S	S
1-May-13	Long March 3B	Xichang	* Chinasat 11 (Sinosat 7)	GEO	China Direct Broadcast Satellite Co., Ltd (CHINA DBSAT)	Aerospace Dongfanghong Satellite Company	Communications		S	S
6-May-13	Vega	Kourou	Proba-V	SSO	European Space Agency	QINETIQ	Remote Sensing		S	S
			VNREDSat 1A	SSO	Vietnam Acadamy of Science & Technology	EADS Astrium	Remote Sensing			S
			ESTCube 1	SSO	Tartu University	Tartu University	Development			S
14-May-13 √	Proton M/ Breeze-M	Baikonur	* Eutelsat 3D	GEO	Eutelsat	Thales Alenia Space	Communications	$85M	S	S
15-May-13	Atlas V 401	CCAFS	Navstar GPS 2F-04	MEO	U.S. Air Force	The Boeing Company	Navigation		S	S
24-May-13	Delta IV Medium+ (5,4)	CCAFS	WGS 5	GEO	U.S. Air Force	Boeing Satellite Systems	Communications		S	S
28-May-13	Soyuz U2/Soyuz	Baikonur	Soyuz TMA-09M	LEO	Russian Federal Space Agency (Roscosmos)	RKK Energia	Crewed		S	S
3-Jun-13 √	Proton M/ Breeze-M	Baikonur	* SES 6	GEO	SES World Skies	EADS Astrium	Communications	$85M	S	S
5-Jun-13	Ariane 5 ES	Kourou	ATV 4	LEO	European Space Agency	EADS Astrium	ISS		S	S
7-Jun-13	Soyuz 2.1b	Plesetsk	Cosmos Persona	SSO	Russian Space Forces (VKS)	RKK Energia	Intelligence		S	S
11-Jun-13	Long March 2F	Jiuquan	Shenzhou 10 Orbital Module	LEO	China Aerospace Science and Technology Corporation (CASC)	China Academy of Space Technology (CAST)	Development		S	S
			Shenzhou 10 Descent Module	LEO	China Aerospace Science and Technology Corporation (CASC)	China Academy of Space Technology (CAST)	Crewed			S
25-Jun-13 √	Soyuz 2.1b	Kourou	* O3b 01	MEO	O3b Networks	Thales Alenia Space	Communications	$50M	S	S
			* O3b 02	MEO	O3b Networks	Thales Alenia Space	Communications			S
			* O3b 03	MEO	O3b Networks	Thales Alenia Space	Communications			S
			* O3b 04	MEO	O3b Networks	Thales Alenia Space	Communications			S
25-Jun-13	Soyuz 2.1b	Baikonur	Resurs P1	SSO	Russian Federal Space Agency (Roscosmos)	Khrunichev State Research and Production Space Center	Remote Sensing		S	S
27-Jun-13	Strela	Baikonur	Kondor E	LEO	NPO Machinostroyeniya	NPO Machinostroyeniya	Remote Sensing		S	S
27-Jun-13	Pegasus XL	VAFB	IRIS (USA)	SSO	NASA	Lockheed Martin Corp.	Scientific		S	S
1-Jul-13	PSLV XL	Satish Dhawan	IRNSS 1A	GEO	ISRO	ISRO	Navigation		S	S
2-Jul-13	Proton M/Block DM	Baikonur	Glonass M46	MEO	Russian Space Forces (VKS)	Reshetnev Company	Navigation		F	F
			Glonass M48	MEO	Russian Space Forces (VKS)	Reshetnev Company	Navigation			F
			Glonass M49	MEO	Russian Space Forces (VKS)	Reshetnev Company	Navigation			F
15-Jul-13	Long March 2C	Jiuquan	Shi Jian 11-05	SSO	China Academy of Space Technology (CAST)	Aerospace Dongfanghong Satellite Company	Scientific		S	S
19-Jul-13	Long March 4C	Taiyuan	Chuang Xin-3	SSO	China - TBA	China - TBA	Communications		S	S
			Shiyan Weixing-7	SSO	China - TBA	China - TBA	Scientific			S
			Shi Jian-15	SSO	China - TBA	China - TBA	Scientific			S

Date			Vehicle	Site		Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
19-Jul-13			Atlas V 551	CCAFS		MUOS 2	GEO	US Navy	Lockheed Martin Commercial Space Systems	Communications		S	S
25-Jul-13	√		Ariane 5 ECA	Kourou	*	Alphasat I-XL	GEO	Inmarsat	EADS Astrium	Communications	$220M	S	S
					*	Insat 3D	GEO	ISRO	ISRO	Meteorological			S
27-Jul-13			Soyuz U2/ Progress	Baikonur		Progress M-20M	LEO	Russian Federal Space Agency (Roscosmos)	RKK Energia	ISS		S	S
3-Aug-13			H-IIB	Tanegashima		HTV-4	LEO	JAXA	Mitsubishi Electric Corp.	ISS		S	S
7-Aug-13			Delta IV Medium+ (5,4)	CCAFS		WGS 6	GEO	U.S. Air Force	Boeing Satellite Systems	Communications		S	S
22-Aug-13	√		Dnepr	Dombarovskiy		Kompsat 5	SSO	KARI	KARI	Remote Sensing	$12M	S	S
28-Aug-13			Delta IV Heavy	VAFB		NRO L-65	TBD	NRO	Classified	Classified		S	S
29-Aug-13	√		Ariane 5 ECA	Kourou	*	Eutelsat 25B	GEO	Eutelsat	Space Systems/Loral	Communications	$220M	S	S
						GSAT-7 (Insat 4F)	GEO	Indian Ministry of Defense	ISRO	Communications			S
1-Sep-13	√		Zenit 3SLB	Baikonur	*	Amos 4	GEO	SpaceCom Limited	Israel Aerospace Industries	Communications	$60M	S	S
2-Sep-13			Long March 4C	Jiuquan		Yaogan 17 Main	LEO	People's Liberation Army (PLA)	China Academy of Space Technology (CAST)	Remote Sensing		S	S
						Yaogan 17 Subsat 1	LEO	People's Liberation Army (PLA)	China Academy of Space Technology (CAST)	Remote Sensing			S
						Yaogan 17 Subsat 2	LEO	People's Liberation Army (PLA)	China Academy of Space Technology (CAST)	Remote Sensing			S
6-Sep-13			Minotaur V	WFF		LADEE	EXT	NASA	NASA	Scientific		S	S
12-Sep-13			Rockot	Plesetsk		Gonets M-05	LEO	Smolsat	Reshetnev Company	Communications		S	S
						Gonets M-06	LEO	Smolsat	Reshetnev Company	Communications			S
						Gonets M-07	LEO	Smolsat	Reshetnev Company	Communications			S
14-Sep-13			Epsilon Standard	Uchinoura		SPRINT-A	LEO	JAXA	JAXA	Scientific		S	S
18-Sep-13			Atlas V 531	CCAFS		Advanced EHF 3	GEO	DoD	Lockheed Martin Space Systems	Communications		S	S
18-Sep-13	√	+	Antares 120	MARS	*	Cygnus COTS Demo	LEO	Orbital Sciences Corp.	Orbital Sciences Corp.	Test	$77.5M	S	S
23-Sep-13			Long March 4C	Taiyuan		Feng Yun 3C	SSO	China State Meteorological Administration	Shanghai Institute of Satellite Engineering	Meteorological		S	S
25-Sep-13			Kuaizhou	Jiuquan		Kuaizhou 1	SSO	China Aerospace Science and Industry Corporation (CASIC)	China Aerospace Science and Industry Corporation (CASIC)	Remote Sensing		S	S
25-Sep-13			Soyuz U2/Soyuz	Baikonur		Soyuz TMA-10M	LEO	Russian Federal Space Agency (Roscosmos)	RKK Energia	Crewed		S	S
29-Sep-13	√	+	Falcon 9 v1.1	VAFB		Cassiope	LEO	Canadian Space Agency (CSA)	MacDonald, Dettwiler, and Associates Ltd. (MDA)	Development	$56.5M	S	S
						6 secondary payloads (including cubesats)	LEO						S
30-Sep-13	√		Proton M/ Breeze-M	Baikonur	*	Astra 2E	GEO	SES Astra	EADS Astrium	Communications	$85M	S	S
25-Oct-13			Long March 4B	Jiuquan		Shi Jian-16	LEO	China - TBA	China - TBA	Development		S	S
25-Oct-13	√		Proton M/ Breeze-M	Baikonur	*	Sirius FM-6	GEO	Sirius Satellite Radio Inc.	Space Systems/Loral	Communications	$85M	S	S
29-Oct-13			Long March 2C	Taiyuan		Yaogan 18	SSO	China - TBA	China - TBA	Remote Sensing		S	S
5-Nov-13			PSLV Standard	Satish Dhawan		Mangalyaan (Mars Orbiter India)	EXT	ISRO	ISRO	Scientific		S	S
7-Nov-13			Soyuz U2/Soyuz	Baikonur		Soyuz TMA-11M	LEO	Russian Federal Space Agency (Roscosmos)	RKK Energia	Crewed		S	S

Date			Vehicle	Site		Payload(s)	Orbit	Operator	Manufacturer	Use	Comm'l Price	L	M
11-Nov-13			Proton M/ Breeze-M	Baikonur		Raduga-1M3	GEO	Russian Space Forces (VKS)	Reshetnev Company	Communications		S	S
18-Nov-13			Atlas V 401	CCAFS		MAVEN	EXT	NASA	Lockheed Martin Corp.	Scientific		S	S
						8 secondary payloads (including cubesats)	LEO						S
19-Nov-13	√	+	Minotaur I	WFF		STPSAT-3	LEO	U.S. Air Force	Ball Aerospace and Technologies Corp.	Development		S	S
						28 secondary payloads (including cubesats)	LEO						S
20-Nov-13			Long March 4C	Taiyuan		Yaogan 19	SSO	China - TBA	China - TBA	Remote Sensing		S	S
21-Nov-13	√		Dnepr	Dombarovskiy		DubaiSat 2	SSO	EIAST	Korean Advanced Institute of Science and Technology	Remote Sensing	$12M	S	S
						31 secondary payloads (including cubesats)	LEO						S
22-Nov-13	√		Rockot	Plesetsk		Swarm 1	LEO	European Space Agency	EADS Astrium	Scientific	$30M	S	S
						Swarm 2	LEO	European Space Agency	EADS Astrium	Scientific			S
						Swarm 3	LEO	European Space Agency	EADS Astrium	Scientific			S
25-Nov-13			Long March 2D	Jiuquan		Shiyan Weixing-5	SSO	China - TBA	China - TBA	Remote Sensing		S	S
25-Nov-13			Soyuz U2/ Progress	Baikonur		Progress M-21M	LEO	Russian Federal Space Agency (Roscosmos)	RKK Energia	ISS		S	S
1-Dec-13			Long March 3B	Xichang		Chang'e 3 (Lander and Rover)	EXT	China Academy of Space Technology (CAST)	China Academy of Space Technology (CAST)	Scientific		S	S
3-Dec-13	√	+	Falcon 9 v1.1	CCAFS	*	SES-8	GEO	SES	Orbital Sciences Corp.	Communications	$56.5M	S	S
5-Dec-13			Atlas V 501	VAFB		NRO L-39	TBD	NRO	TBA	Classified		S	S
						12 secondary payloads (including cubesats)	LEO						S
8-Dec-13	√		Proton M/ Breeze-M	Baikonur	*	Inmarsat 5-F1	GEO	Inmarsat	Boeing Satellite Systems	Communications	$85M	S	S
9-Dec-13			Long March 4B	Taiyuan		CBERS 3/Ziyuan-1C	SSO	INPE	China Academy of Space Technology (CAST)	Remote Sensing		F	F
19-Dec-13			Soyuz 2.1b	Kourou		GAIA	EXT	European Space Agency	EADS Astrium	Scientific		S	S
20-Dec-13			Long March 3B	Xichang	*	Tupac Katari	GEO	Bolivian Space Agency	China Great Wall Industry Corp. (CGWIC)	Communications		S	S
25-Dec-13			Rockot	Plesetsk		Cosmos 2488	LEO	Russian Space Forces (VKS)	Reshetnev Company	Communications		S	S
						Cosmos 2489	LEO	Russian Space Forces (VKS)	Reshetnev Company	Communications			S
						Cosmos 2489	LEO	Russian Space Forces (VKS)	Reshetnev Company	Communications			S
26-Dec-13			Proton M/ Breeze-M	Baikonur		Express AM-5	GEO	Russian Satellite Communciation Co.	Reshetnev Company	Communications		S	S
28-Dec-13			Soyuz 2.1v	Plesetsk		AIST II	LEO	RKK Energia	RKK Energia	Development		S	S
						SKRL-756 1	LEO	Russia - TBA	Russia - TBA	Test			S
						SKRL-756 2	LEO	Russia - TBA	Russia - TBA	Test			S

V 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.