Federal Aviation Administration

2013 Commercial Space Transportation Forecasts

May 2013

FAA Commercial Space Transportation (AST) and the Commercial Space Transportation Advisory Committee (COMSTAC)

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

Image Credit: NASA/Bill Ingalls

Table of Contents

List of Tables

List of Figures

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

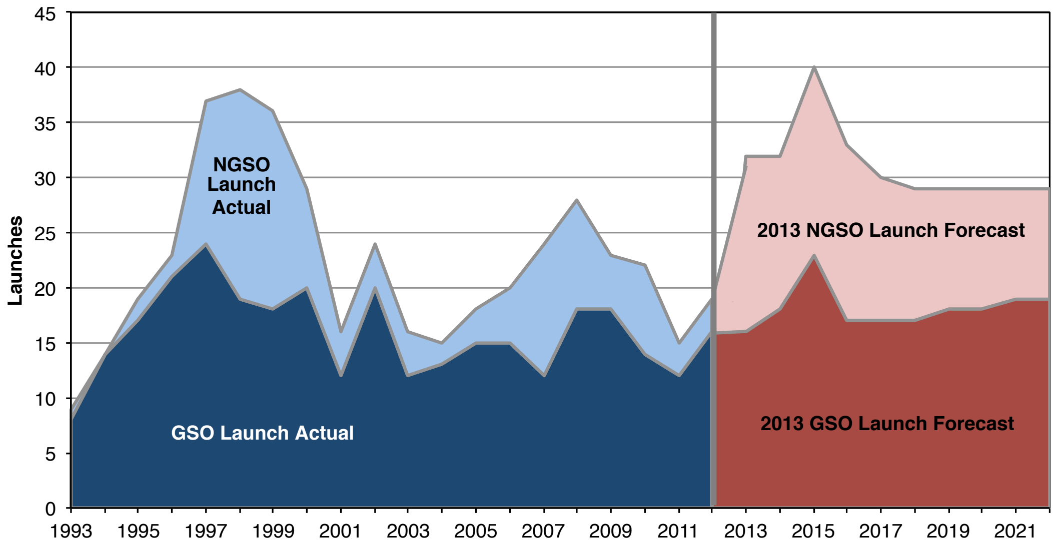
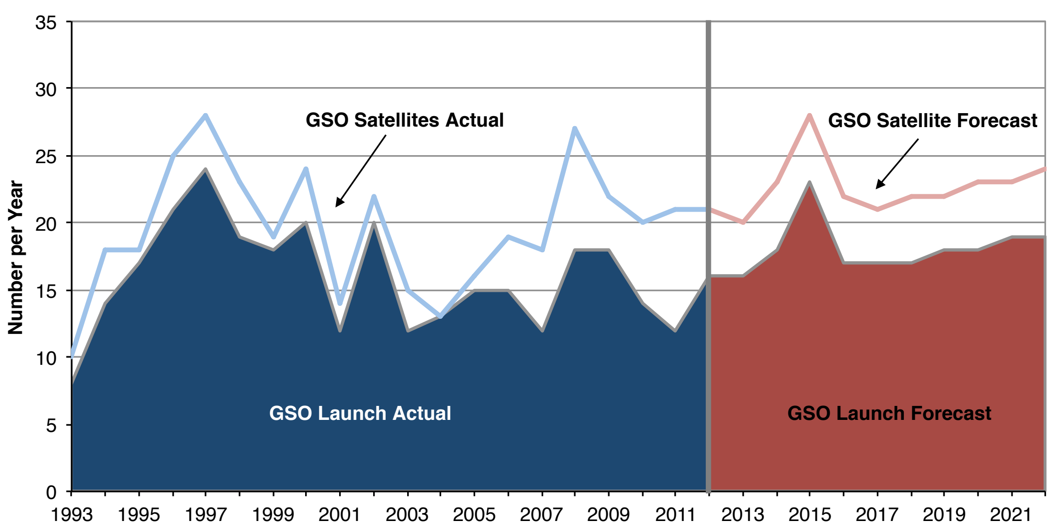


Table 1. Commercial Space Transportation Payload and Launch Forecasts

	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**

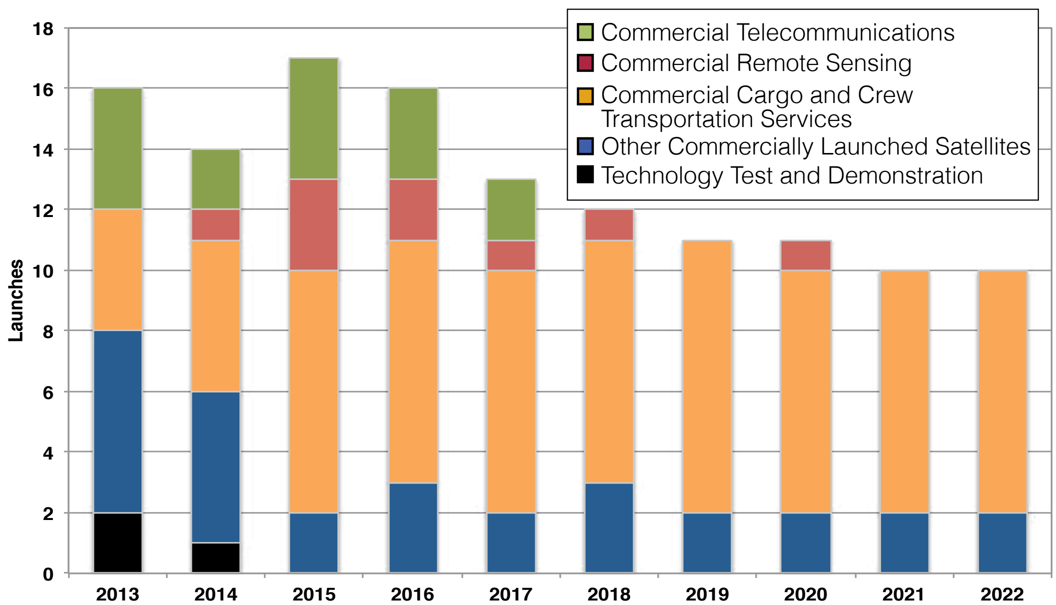
The GSO market remains stable with a projected demand of 22.8 satellites per year, up slightly from last year's projection of 21.2 satellites per year. Figure 2 shows the 2013 GSO Historical Launches and Launch Forecast. Forty percent of GSO satellites projected to launch from 2013 to 2022, are in the 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.

Figure 2. 2013 GSO Historical Launches and Launch Forecast



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.

Figure 3. Projected NGSO Launches from 2013-2022



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

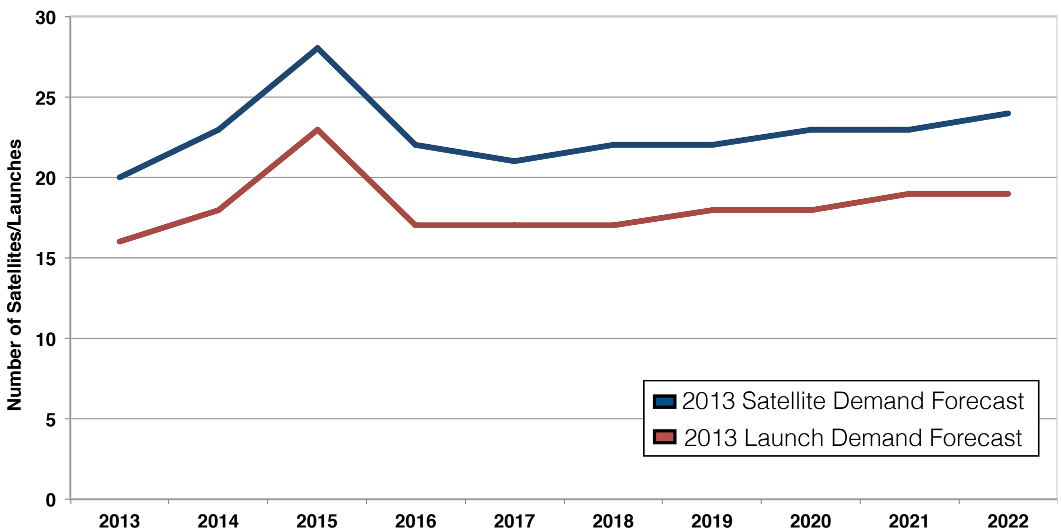


Table 2. Forecast Commercial GSO Satellite and Launch Demand

	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

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.

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

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

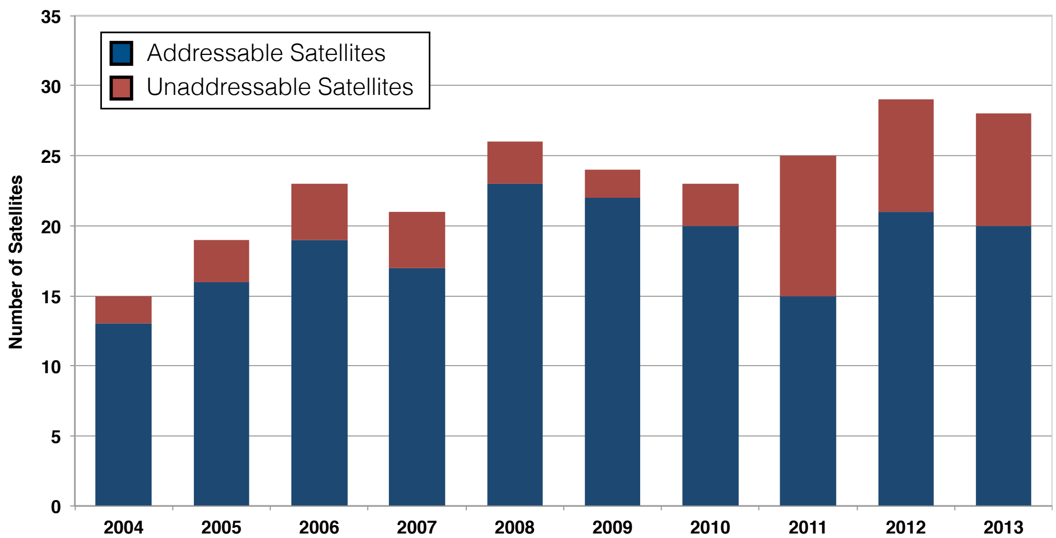


Table 4. Addressable and Unaddressable Satellites Since 2004

	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.

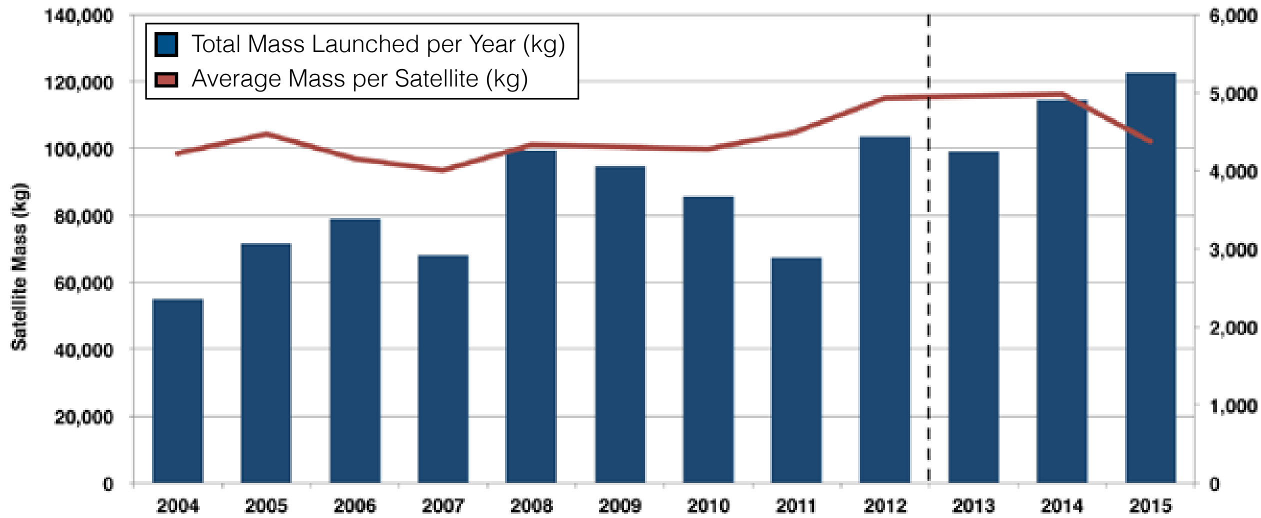
Likewise, the heaviest mass class continues to dominate, with 48 percent of satellites launched in 2012 falling into this mass class. Nearly half of the satellites projected for launch from 2013 through 2015 are in the extra-heavy class.

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.

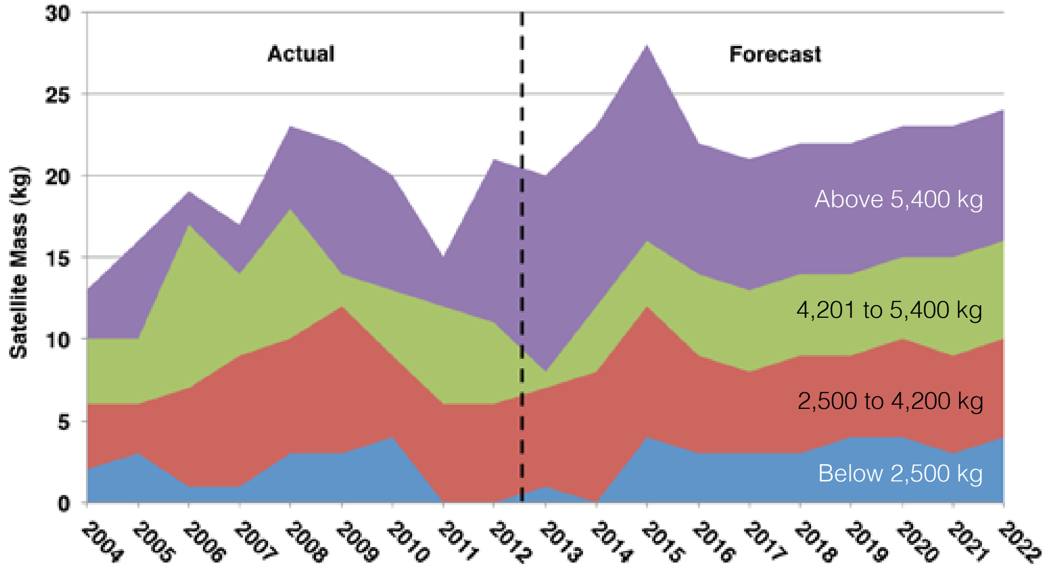
In 2012, Boeing signed a contract jointly procured by Asia Broadcast Satellite (ABS) and Satmex for four all-electric design 702SP satellites. Since then, Astrium, CAST (China), Lockheed Martin, OHB, Orbital, SSL, and Thales have all indicated they already have – or will offer – that technology to their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

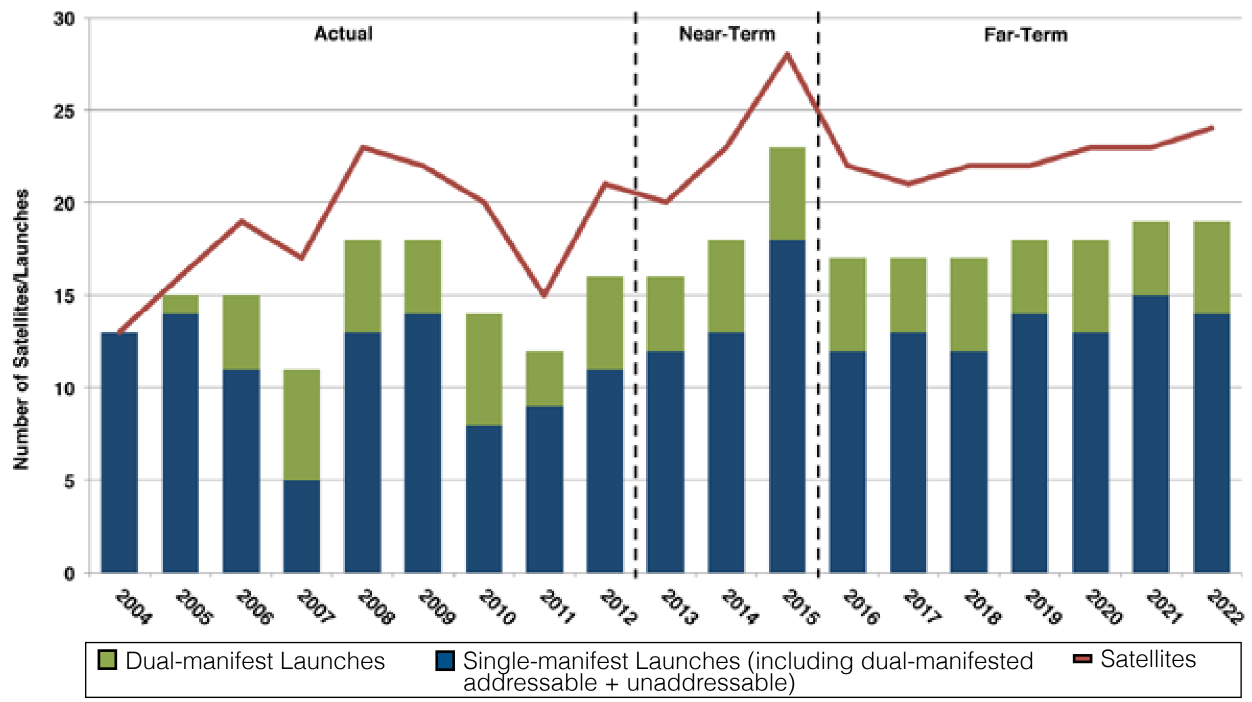
Several launch services providers are capable of lofting two satellites simultaneously into geosynchronous transfer orbit (GTO). The demand analysis for launch vehicles must take into consideration this capability. Care must be taken in that inclusion into the forecast must be based upon the addressability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

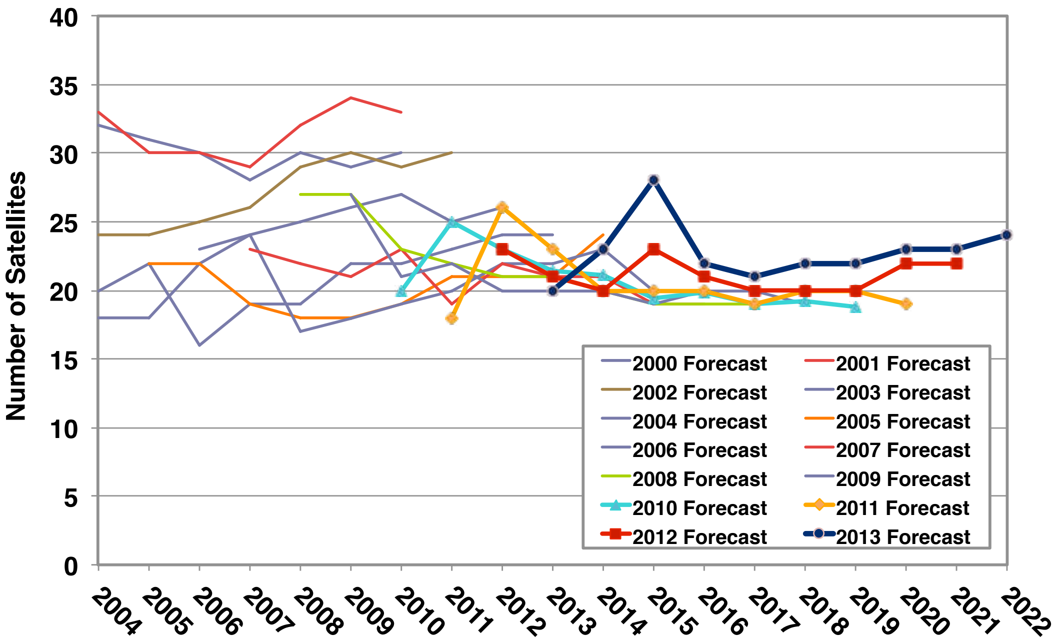
Comparison with Previous COMSTAC Forecasts

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.

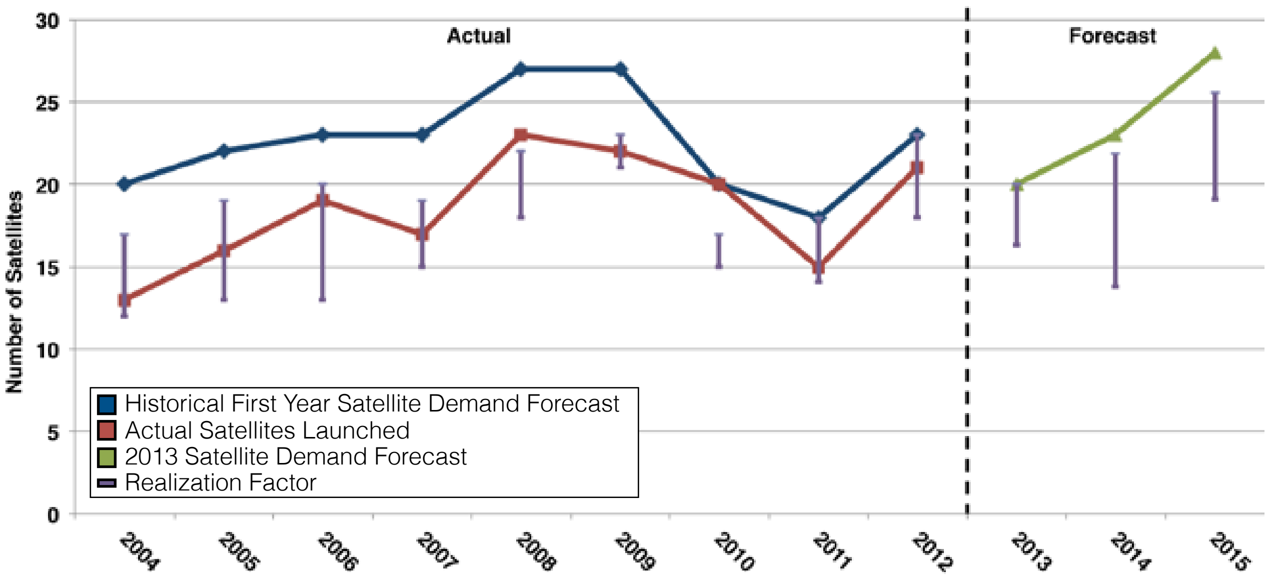
The consistent overestimation illustrates the "bow-wave" effect of the forecast: survey respondents list satellites that were planned to be launched the previous year but slipped into the subsequent year, without compensating for the subsequent year's satellite launches concurrently slipping forward.

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%	↑
Availability of affordable insurance	0%	11%	22%	67%	0%	↓
Availability of financing	0%	33%	56%	11%	0%	=
Demand for satellite services	0%	44%	11%	22%	22%	↓
Regional or global economic conditions	11%	44%	33%	11%	0%	↓
Consolidation of satellite service providers	0%	11%	78%	11%	0%	↑
Availability of required operating licenses	0%	22%	33%	33%	11%	↑
International or domestic regulatory issues	0%	56%	33%	0%	11%	**New**
Availability of export licenses	0%	11%	56%	33%	0%	↓
Availability of launch vehicles that meet your requirements	11%	11%	44%	22%	11%	↑
Availability of satellite systems that meet your requirements	0%	0%	22%	67%	11%	=
Reliability of launch systems	11%	22%	22%	44%	0%	↓
Reliability of satellite systems	11%	0%	44%	44%	0%	↑
Introduction of new satellite technologies	0%	11%	33%	56%	0%	**New**
Introduction of new or upgraded launch vehicles	0%	0%	44%	33%	22%	**New**

↑ More positive compared to 2012 ↓ More negative compared to 2012 = No changed compared to 2012

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.

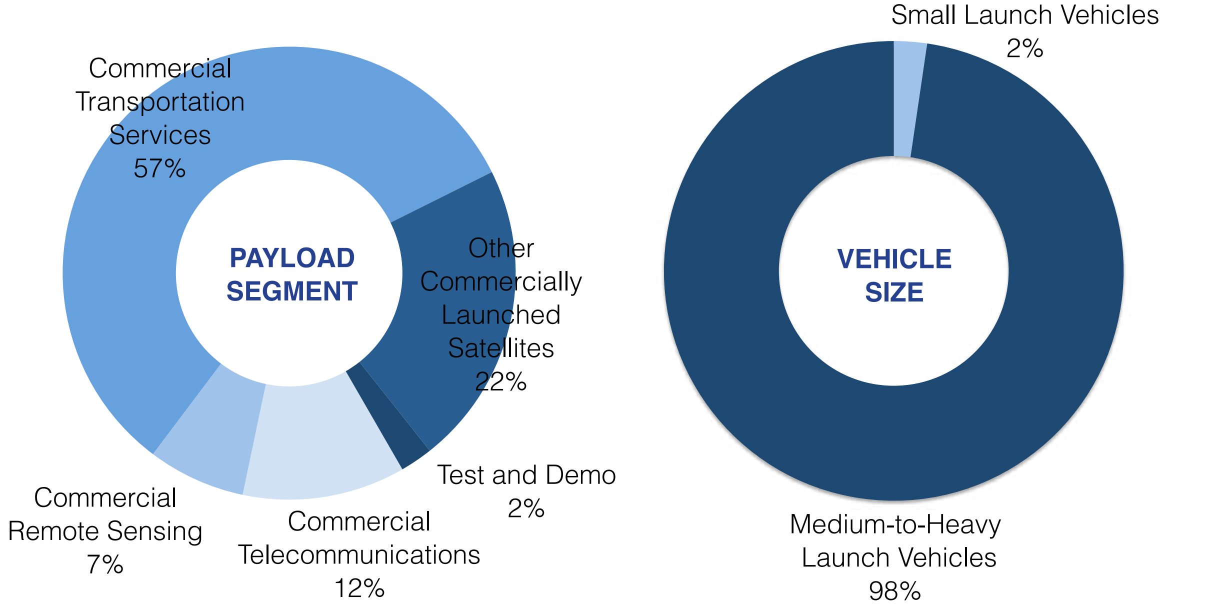
The above industry sectors do not include government regulators, finance sources, insurers, or other additional industry sectors. It is important to note these sectors exist and influence demand within the commercial NGSO launch market.

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

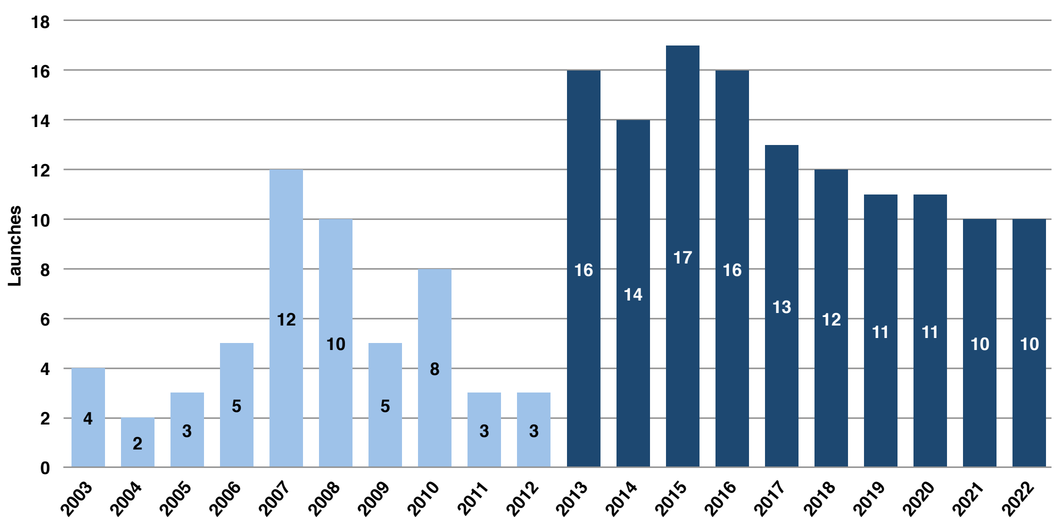


Fifty-seven percent of the NGSO launches projected for the next 10 years are for commercial crew and cargo to the ISS. This marks an increase from a 50 percent share projected for this segment in the 2012 report, due to commercial cargo launches rescheduled from 2012 to later dates and the addition of 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

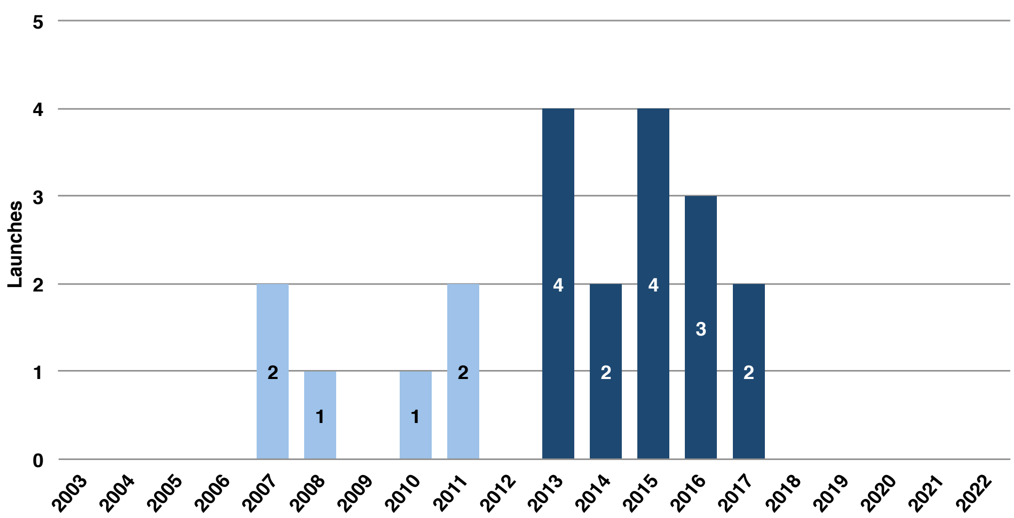
Commercial Telecommunication Satellites

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		Orbit Type	First Launch	Status
		Number (on orbit/ operational)	Mass kg (lb)			
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		Orbit Type	First Launch	Status
		Number (on orbit/ operational)	Mass kg (lb)			
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.

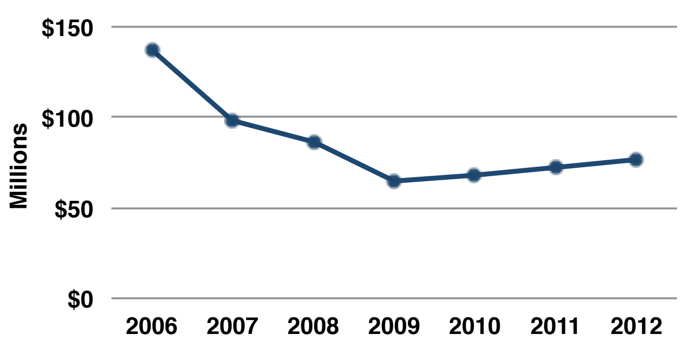
As a result of the S-band problems, Globalstar's revenues started to slip in 2006. In response to these declining revenues, Globalstar lowered prices for its customers and developed a simplex service product called the Satellite Pour l'Observation de la Terra (SPOT) Satellite Global Positioning System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

Figure 14. Publicly Reported Globalstar Annual Revenue



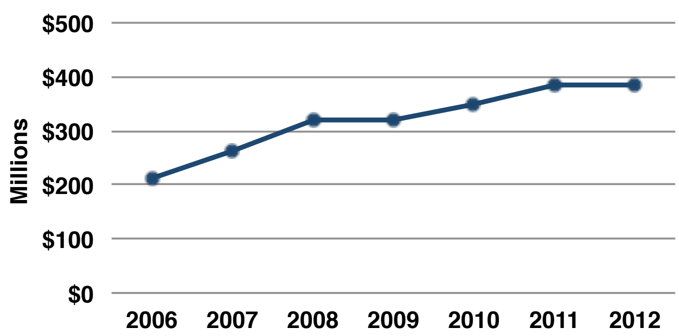
Iridium

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.

Iridium revenues are presented in Figure 15.

Figure 15. Publicly Reported Iridium Annual Revenue



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.

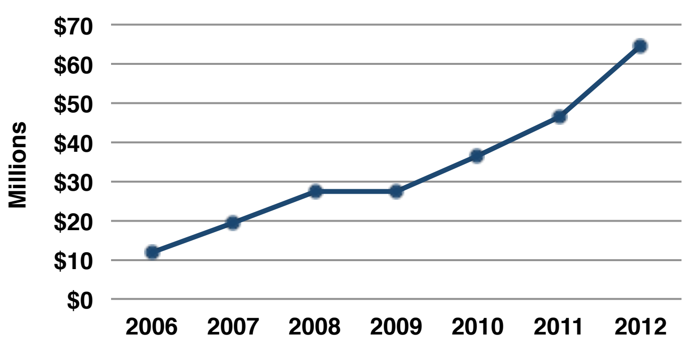
ORBCOMM's plans for replacing its current constellation are underway. Seventeen satellites of the 18-satellite second generation constellation are either under construction or awaiting launch. All satellites in the constellation include AIS payloads. ORBCOMM ordered the satellites in 2008 from Sierra 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.

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.

Figure 16. Publicly Reported ORBCOMM Annual Revenue



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

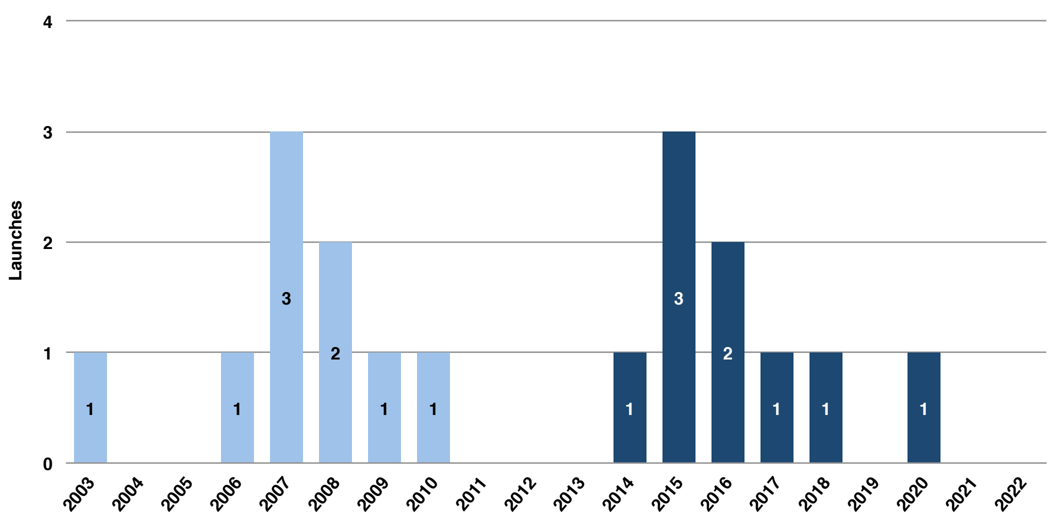
Remote sensing refers to any orbital platform with optical or radar sensors trained on Earth to gather data for geographic analysis, military use, meteorology, or climatology. The remote sensing industry comprises three markets: aerial imagery, satellite imagery, and geographic information systems (GIS). 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	EROS C - TBD	Rapideye - TBD	RCM-1 - TBD	GeoEye-2 - Atlas V
	DMC3-2 - Dnepr	TerraSar-NG - TBD			
	DMC3-3 - Dnepr				

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

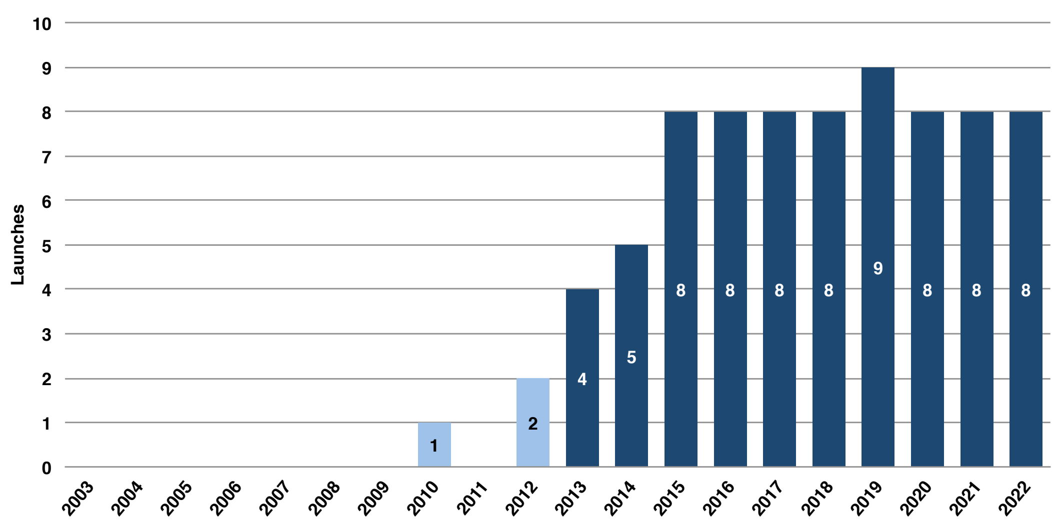
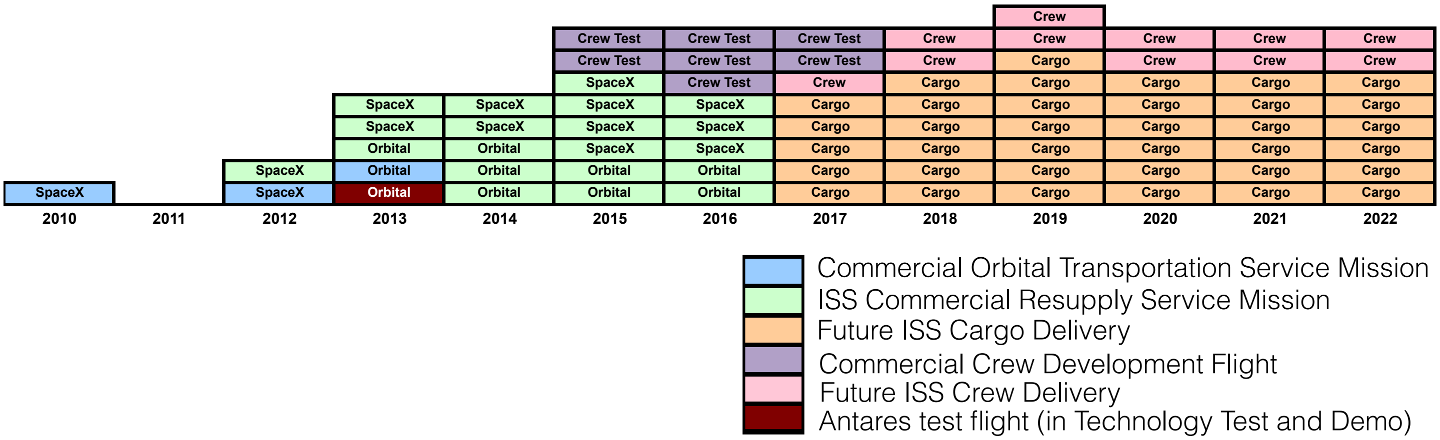


Figure 19 shows the distribution of ISS commercial cargo and crew flights from 2013 to 2022. One test flight of Orbital's Antares, and one Orbital COTS flight are also included.

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

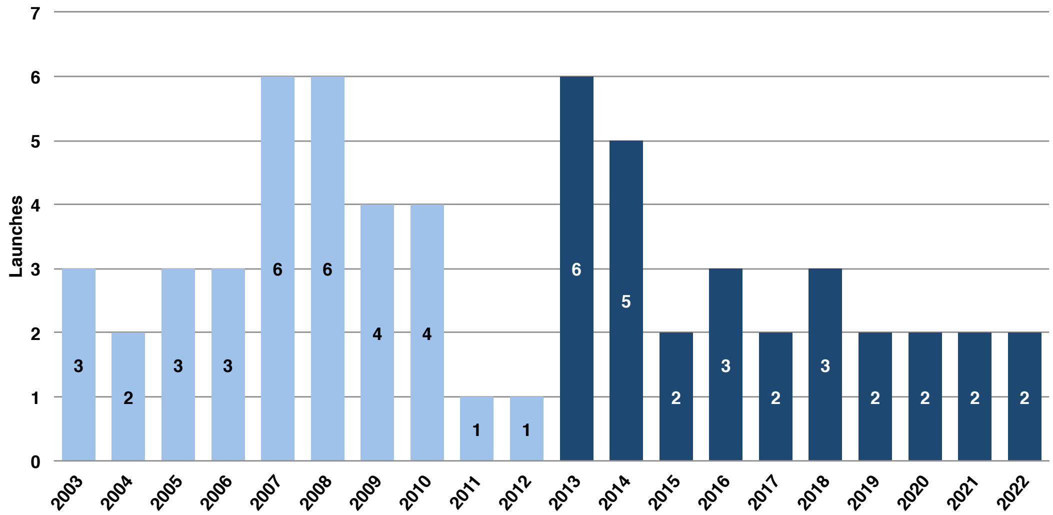
The market characterization of the near term (2013-2016) includes 12 manifested basic and applied scientific research launches and 4 remote sensing launches for countries without indigenous launch capability. For the period 2017-2022, the application of a forecasting method projects 12 basic and applied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

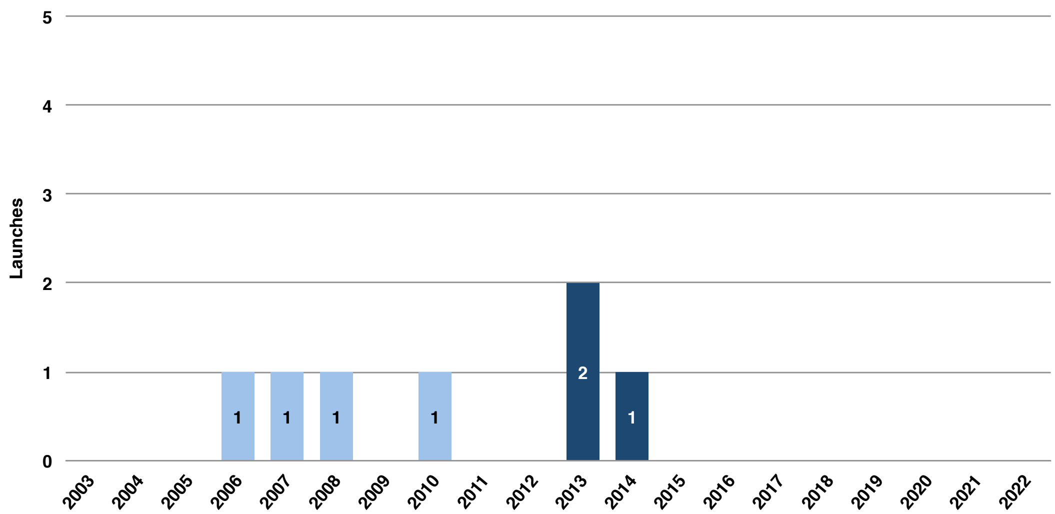
This forecast revised the model for payloads and launches related to basic and applied scientific research that was applied in the 2012 NGSO report. The methodology features a five-year average that includes three prior years and two projected years (for this report, 2010-2014) with equal weight. This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

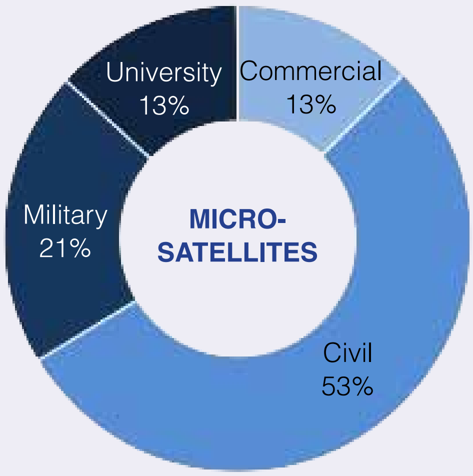
In the last 10 years, both non-commercial and commercial launch vehicles launched a total of almost 300 microsats and smaller class satellites worldwide (see Table 21).

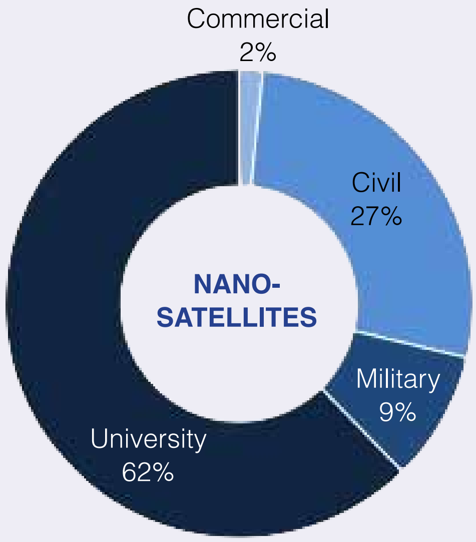
In 2003 to 2012, the majority of microsats were launched for government civil missions, whereas the nanosat market was dominated by universities (see Figure 22). The only two pico-satellites during this period were free-flying imagers DCAM 1 and DCAM 2, launched as part of the Japanese IKAROS interplanetary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

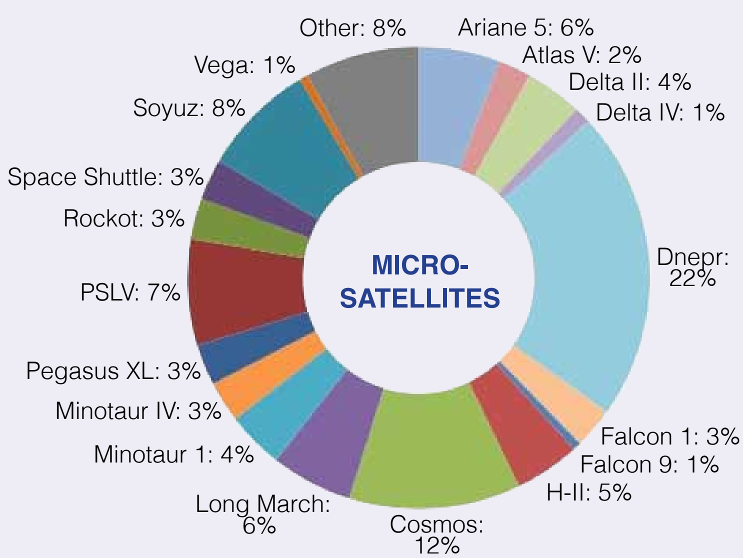


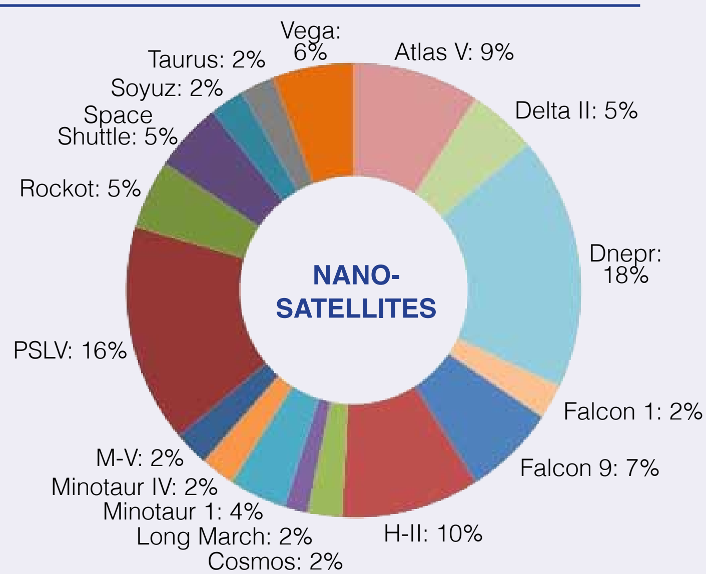


Microsats rarely drive launch demand and nanosats almost never do. In the commercial space launch industry, launch providers are interested in creating space for smaller secondary payloads to drive the launch price down or increase profits. Although there have been a significant number of nanosats launched 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

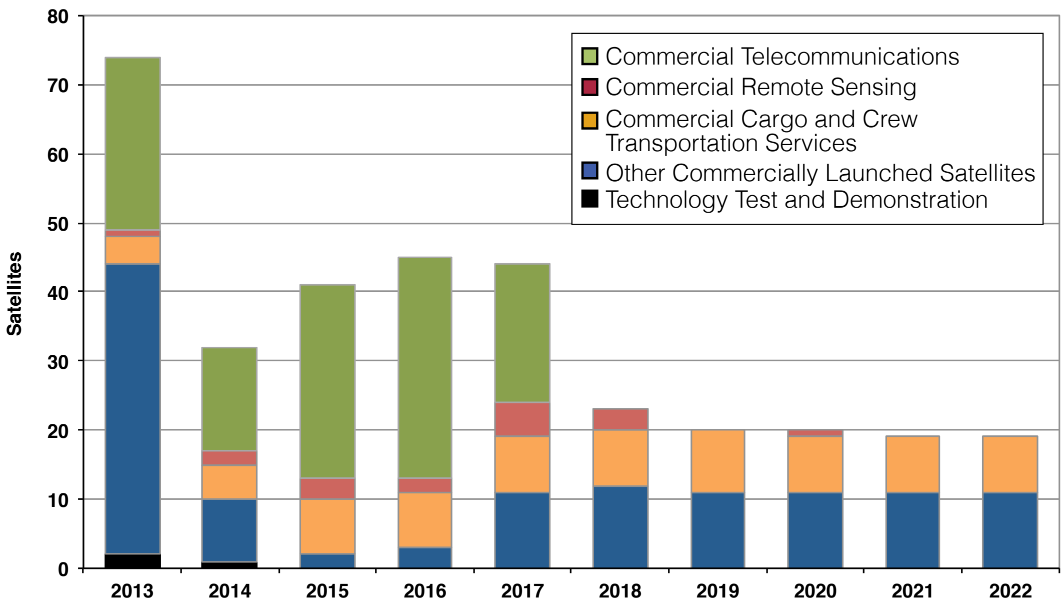


Figure 25. Launch Projections

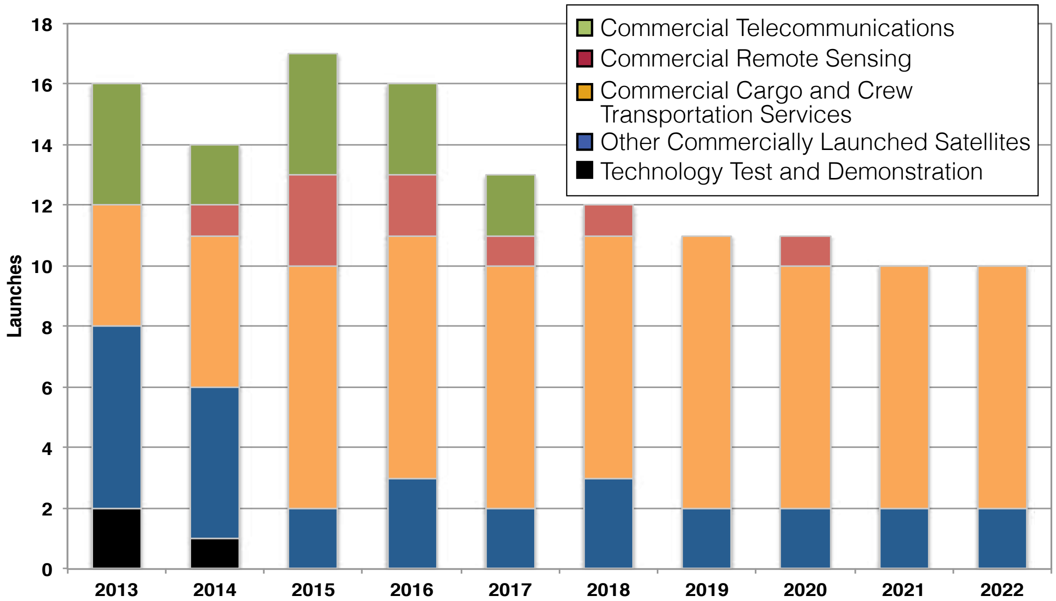


Table 22. Payload and Launch Projections

	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.

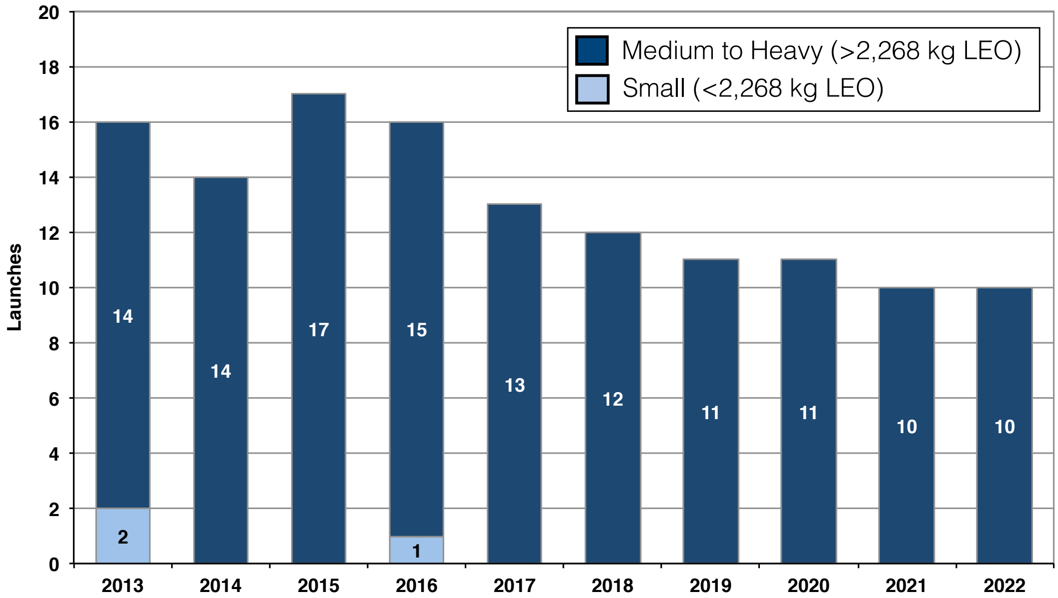
Table 23. Distribution of Payload Masses in Near-Term Manifest

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

Market Segment	Payloads	Launch Demand		
		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.

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			

(grey box) = Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 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		Anik F1	Ariane 4		DirecTV 4S	Ariane 4
		Orion 3	Delta III		PAS 1R	Ariane 5		Intelsat 901	Ariane 4
					Garuda 1	Proton K/DM		Intelsat 902	Ariane 4
					Thuraya 1	Sea Launch		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	Asiastar 1	Ariane 5		Atlantic Bird 2	Ariane 4
	DM1	Arabsat 3A	Ariane 4	DM3	Astra 2B	Ariane 5		Turksat 2A	Ariane 4
		Insat 2E	Ariane 4		Europe*Star 1	Ariane 4	DM2	Artemis	Ariane 5
		Koreasat 3	Ariane 4		Eutelsat W1R	Ariane 4	DM1	Eurobird	Ariane 5
		Orion 2	Ariane 4		Galaxy 10R	Ariane 4		Astra 2C	Proton K/DM
		Telkom	Ariane 4		Galaxy IVR	Ariane 4		PAS 10	Proton K/DM
		Telstar 7	Ariane 4		NSat 110	Ariane 4			
		Echostar 5	Atlas II		Superbird 4	Ariane 4			
		Eutelsat W3	Atlas II		Echostar 6	Atlas II			
		JCSat 6	Atlas II		Hispasat 1C	Atlas II			
		Asiasat 3S	Proton K/DM		Eutelsat W4	Atlas III			
		Astra 1H	Proton K/DM		AAP 1	Proton K/DM			
		LMI 1	Proton K/DM		AMC 6	Proton K/DM			
		Nimiq	Proton K/DM		PAS 9	Sea Launch			
		Telstar 6	Proton K/DM						
		DirecTV 1R	Sea Launch						
Below 2,500 kg (<5,510 lbm)	1			6			3		
	DM1	Skynet 4E	Ariane 4	DM2	Brazilsat B4	Ariane 4	DMU	Skynet 4F	Ariane 4
				DM2	Nilesat 102	Ariane 4	DM1	BSat 2A	Ariane 5
				DM3	AMC 7	Ariane 5	DM2	BSat 2B	Ariane 5
				DM4	AMC 8	Ariane 5			
				DM4	Astra 2D	Ariane 5			
				DM1	Insat 3B	Ariane 5			

= Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 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 905 Ariane 4 Intelsat 906 Ariane 4 NSS 6 Ariane 4 NSS 7 Ariane 4 Astra 1K Proton K/DM Echostar 8 Proton K/DM Intelsat 903 Proton K/DM Galaxy 3C Sea Launch	Intelsat 907 Ariane 4 DM2 Optus C1 Ariane 5 Rainbow 1 Atlas V EchoStar 9 Sea Launch Thuraya 2 Sea Launch	Amazonas Proton M Eutelsat W3A Proton M APStar V Sea Launch Estrela do Sul Sea Launch
2,500 - 4,200 kg (5,510 - 9,260 lbm)	11	6	4
	Insat 3C Ariane 4 DM1 JCSat 8 Ariane 4 DMU Atlantic Bird 1 Ariane 5 DMU Hotbird 7 Ariane 5 DM2 Stellat 5 Ariane 5 Hispasat 1D Atlas II Echostar 7 Atlas III Hotbird 6 Atlas V Eutelsat W5 Delta IV DirecTV 5 Proton K/DM Nimiq 2 Proton M	DM1 Insat 3A Ariane 5 DM3 Insat 3E Ariane 5 Asiasat 4 Atlas III HellasSat Atlas V AMC 9 Proton K/M Galaxy 13 Sea Launch	Superbird 6 Atlas II MBSat Atlas III AMC 16 Atlas V AMC 15 Proton M
Below 2,500 kg (<5,510 lbm)	2	4	2
	DM1 Astra 3A Ariane 4 DM2 NSTAR c Ariane 5	DM2 Bsat 2C Ariane 5 DM3 e-Bird 1 Ariane 5 DM1 Galaxy 12 Ariane 5 Amos 2 Soyuz	AMC 10 Atlas II AMC 11 Atlas II

= Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 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		

[grey box] = Launch Failure

DM# = Dual-manifested Launch with another Addressable Satellite. Example: DM1 was paired with DM1, DM2 with DM2, etc.

DMU = Dual-manfiested Launch with Non-Addressable Satellite. DMU missions are counted as a single launch in the launch count.

Table 26. Historical 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			

[shaded] = 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 1 Telecommunication 2 Transportation 1 Other **3 Launches** 3 Medium-to-Heavy	Telecommunication		ORBCOMM OG2-01[1]		
	Transportation	5/22/12 10/7/12	Dragon COTS Demo 2/3 Dragon CRS D1	Falcon 9 Falcon 9	Medium-to-Heavy Medium-to-Heavy
	Other	12/19/12	Göktürk 2	LM 2D	Medium-to-Heavy
2011					
20 Satellites 14 Telecommunication 2 Remote Sensing 4 Other **3 Launches** 3 Medium-to-Heavy	Telecommunication	7/13/11 12/28/11	Globalstar 2nd Gen. 7-12 AprizeStar 5-6[2] Globalstar 2nd Gen.13-18	Soyuz 2 Soyuz 2	Medium-to-Heavy Medium-to-Heavy
	Remote Sensing		Nigeriasat-2[3A] NX[3B]		
	Other	8/17/11	Sich 2 RASAT Edusat BPA-2	Dnepr	Medium-to-Heavy
2010					
15 Satellites 6 Telecommunication 1 Remote Sensing 6 Other 1 Test and Demo 1 Transportation **8 Launches** 7 Medium-to-Heavy 1 Small	Telecommunication	10/19/10	Globalstar 2nd Gen. 1-6	Soyuz 2	Medium-to-Heavy
	Remote Sensing	6/20/10	TanDEM X	Dnepr M	Medium-to-Heavy
	Other	4/7/10 6/1/10 6/14/10 11/5/10	Cryosat 2 SERVIS 2 Prisma (2 sats) Picard[4] Cosmos-SkyMed 4	Dnepr M Rockot Dnepr M Delta II	Medium-to-Heavy Small Medium-to-Heavy Medium-to-Heavy
	Test and Demo	6/9/10	Falcon 9 Demo Flight	Falcon 9	Medium-to-Heavy
	Transportation	12/8/10	Dragon COTS Demo 1	Falcon 9	Medium-to-Heavy

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	
2009					
12 Satellites 2 Telecommunication 3 Remote Sensing 7 Other **5 Launches** 2 Medium-to-Heavy 3 Small	Telecommunication		AprizeStar 3-4[5]		
	Remote Sensing	10/8/09	Worldview 2 DEIMOS[6A] UK DMC 2[6B]	Delta II	Medium-to-Heavy
	Other	7/13/09 7/29/09 3/17/09 11/2/09	RazakSat DubaiSat 1 Nanosat 1B GOCE SMOS Proba 2 UGATUSAT[7]	Falcon I Dnepr Rockot Rockot	Small Medium-to-Heavy Small Small
2008					
19 Satellites 6 Telecommunication 6 Remote Sensing 6 Other 1 Test and Demo **10 Launches** 4 Medium-to-Heavy 6 Small	Telecommunication	6/19/08	Orbcomm Replacement 1-5 Orbcomm CDS-3	Cosmos 3M	Small
	Remote Sensing	8/29/08 9/6/08	RapidEye 1-5 GeoEye-1	Dnepr 1 Delta II	Medium-to-Heavy Medium-to-Heavy
	Other	3/27/08 4/16/08 7/22/08 8/3/08 10/1/08 10/24/08	SAR Lupe 4 C/NOFS SAR Lupe 5 Trailblazer[F] THEOS Cosmo-SkyMed 3	Cosmos 3M Pegasus XL Cosmos 3M Falcon 1 Dnepr 1 Delta II	Small Small Small Small Medium-to-Heavy Medium-to-Heavy
	Test and Demo	9/28/08	Falcon 1 Mass Simulator	Falcon 1	Small
2007					
25 Satellites 8 Telecommunication 3 Remote Sensing 13 Other 1 Test and Demo **12 Launches** 10 Medium-to-Heavy 2 Small	Telecommunication	5/30/07 10/21/0	Globalstar Replacement 1-4 Globalstar Replacement 5-8	Soyuz Soyuz	Medium-to Heavy Medium-to-Heavy
	Remote Sensing	6/15/07 9/18/07 12/14/07	TerraSAR-X WorldView 1 RADARSAT 2	Dnepr Delta II SoyuzD	Medium-to-Heavy Medium-to-Heavy Medium-to-Heavy
	Other	4/17/07 4/23/07 6/7/07 7/2/07 11/1/07 12/8/07	Egyptsat SaudiComsat 3-7 Saudisat 3 AGILE AAM Cosmos-SkyMed 1 SAR Lupe 2 SAR Lupe 3 Cosmo-SkyMed 2	Dnepr PSLV Delta II Cosmos 3M Cosmos 3M Delta II	Medium-to-Heavy Medium-to-Heavy Medium-to-Heavy Small Small Medium-to-Heavy
	Test and Demo	6/28/07	Genesis II	Dneor	Medium-to-Heavy
2006					
5 Satellites 1 Remote Sensing 3 Other 1 Test and Demo **5 Launches** 2 Medium-to-Heavy 3 Small	Remote Sensing	4/25/06	EROS B	START 1	Small
	Other	7/28/06 12/27/06 12/19/06	Kompsat 2 Corot SAR Lupe 1	Rockot Soyuz 2 1B Cosmos	Small Medium-to-Heavy Small
	Test and Demo	7/12/06	Genesis 1	Soyuz 2 1B	Medium-to-Heavy

5 AprizeStar 3 & 4 deployed on launch with DubaiSat 1
6 DEIMOS and UK DMC 2 deployed on launch with DubaiSat 1
7 UGATUSAT deployed on launch with Meteor 3M-N3
F Launch Failure

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

Summary	Market Segment	Date	Satellite	Launch Vehicle	
2005					
8 Satellites 1 Remote Sensing 7 Other **3 Launches** 3 Small	Remote Sensing	10/27/05	Beijing 1	Cosmos	Small
	Other	10/8/08 6/21/05	Cryosat Cosmos 1 Rubin 5[8A] Sinah 1[8B] SSETI Express[8C] Mozhayets 5[9D] Topsat[9E]	Rockot[F] Volna[F]	Small Small
2004					
9 Satellites 2 Telecommunication 7 Other **2 Launches** 1 Medium-to-Heavy 1 Small	Telecommunication		LatinSat (2 sats)[9]		
	Other	5/20/04 6/29/04	Rocsat 2 Demeter AMSat-Echo[10A] SaudiComSat 1-2[10B] SaudiSat 2[10C] Unisat 3[10D]	Taurus Dnepr	Small Medium-to-Heavy
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.

APPENDIX 6: ACRONYMS

21AT	Twenty First Century Aerospace Technology Company Ltd.
ABS	Asia Broadcast Satellite
AIS	Automatic Identification System
ADF	Australian Defense Force
ATK	Alliant Technologies
ATV	Automated Transfer Vehicle
BEAM	Bigelow Expandable Activity Module
BMBF	Federal Ministry of Education and Research
BPA	Blok Perspektivnoy Avioniki
CASSIOPE	Cascade, Smallsat, and Ionospheric Polar Explorer
CAST	Chinese Academy of Space Technology
CCAFS	Cape Canaveral Air Force Station
CCDev	Commercial Crew Development
CCiCAP	Commercial Crew Integrated Capacity
CEO	Chief Executive Officer
CHIRP	Commercially Hosted Infrared Payload Flight Demonstration Program
COMSTAC	Commercial Space Transportation Advisory Committee
COTS	Commercial Orbital Transportation Services
CPC	Certification Product Contract
CRS	Commercial Resupply Services
CSA	Canadian Space Agency
CSSWE	Colorado Student Space Weather Experiment
CST-100	Crew Space Transportation-100
CXBN	Cosmic X-Ray Background
DARS	Digital Audio Radio Service
DBS	Direct Broadcasting Services
DEM	Digital Elevation Model
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German space agency)
DMC	Disaster Monitoring Constellation
DMCii	DMC International Imaging, Ltd.
DTH	Direct-to-Home
EADS	European Aeronautic Defence and Space Company
EAL	Excalibur Almaz, Ltd.
ECA	Export Credit Agency
EDRS	European Data Relay System
EGNOS	European Geostationary Navigation Overlay Service
ELaNa	Educational Launch of Nanosatellites

ELI	Highly Elliptical Orbit
EROS	Earth Remote Observation Satellite
ESA	European Space Agency
EXIM	Export-Import Band
EXT	External or Non-Geocentric Orbit
FAA AST	Federal Aviation Administration, Office of Commercial Space Transportation
FCC	Federal Communications Commission
FY	Fiscal Year
FSS	Fixed Satellite Services
GIS	Geographic Information Systems
GMW	GeoMetWatch
GPS	Global Positioning System
GSLV	Geosynchronous Satellite Launch Vehicle
GSO	Geosynchronous Orbit
GTO	Geosynchronous Transfer Orbit
HDTV	High Definition Television Services
HEO	Highly Elliptical Orbit
HPA	Hosted Payload Alliance
ICL	Imperial College London
ILS	International Launch Services
IPO	Initial Public Offering
ISRO	Indian Space Research Organization
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
ITT	International Telephone & Telegraph
ITU	International Telecommunications Union
KARI	Korea Aerospace Research Institute
KSLV	Korean Space Launch Vehicle
LEO	Low Earth Orbit
LCRD	Laser Communications Relay Demonstration
LLC	Limited Liability Company
MEO	Medium Earth Orbit
MHI	Mitsubishi Heavy Industries, Ltd.
MPCV	Multi Purpose Crew Vehicle
MSS	Mobile Satellite Services
NASA	National Aeronautics and Space Administration
NEC	Nippon Electric Company
NGA	National Geospatial-Intelligence Agency
NGSO	Non-Geosynchronous Orbits

NOAA	National Oceanic and Atmospheric Administration
O3b	Other Three Billion Networks, Ltd.
OHB	Orbitale Hochtechnologie Bremen
Orbital	Orbital Sciences Corporation
PSLV	Polar Satellite Launch Vehicle
RCM	RADARSAT Constellation Mission
RRV	Reusable Return Vehicle
SAA	Space Act Agreement
SAR	Synthetic Aperture Radar
SBAS	Satellite-Based Augmentation Systems
SNC	Sierra Nevada Corporation
SpaceX	Space Exploration Technologies Corporation
SPOT	Satellite Pour l’Observation de la Terre
SSL	Space Systems Loral
SSO	Sun-Synchronous Orbit
SSTL	Surrey Satellite Technology Limited
TBD	To Be Determined
TSX	TerraSAR X-band
UAE	United Arab Emirates
UCISAT	University of California, Irvine Satellite
UHF	Ultra-High Frequency
ULA	United Launch Alliance
USLM	United States Munitions List
USAF	United States Air Force
WAAS	Wide Area Augmentation System

Federal Aviation Administration

Office of Commercial Space Transportation
800 Independence Avenue SW
Washington, DC 20591

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