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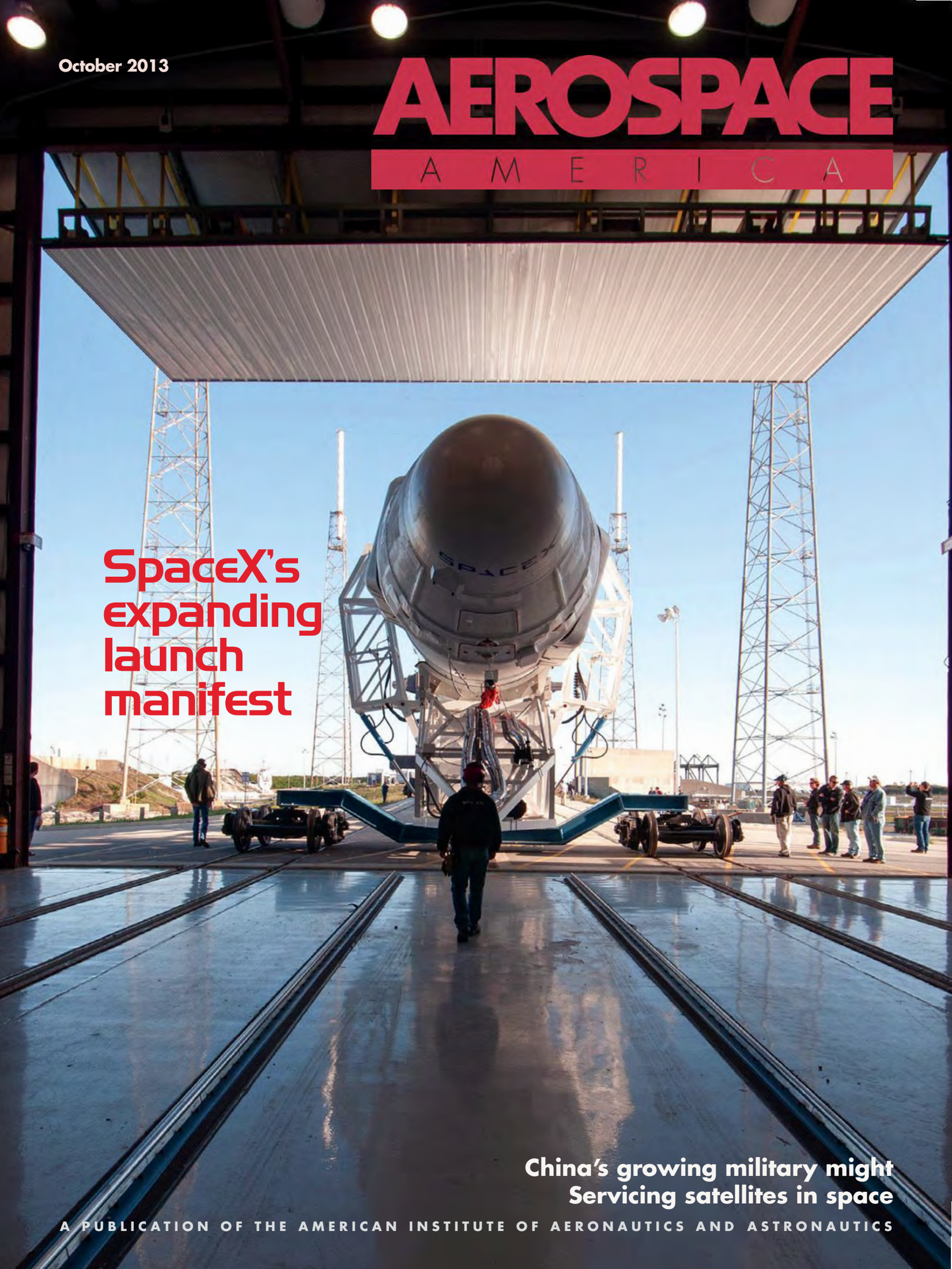

SpaceX's expanding launch manifest

China's growing military might
Servicing satellites in space

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SpaceX's expanding launch manifest

IT IS HARD TO FIND ANOTHER SPACE launch services company with as diverse a customer base as Space Exploration Technologies (SpaceX), because there simply is none. No other company even comes close. Founded only a dozen years ago by Elon Musk, SpaceX has managed to win launch contracts from agencies, companies, consortiums, laboratories, and universities in the U.S., Argentina, Brazil, Canada, China, Germany, Malaysia, Mexico, Peru, Taiwan, Thailand, Turkmenistan, and the Netherlands in a relatively short period. Moreover, it has done so within four completely different markets—civil, commercial, military, and university/nonprofit.

SpaceX has used two different rocket models thus far—Falcon 1 and Falcon 9 v.1.0—and at press time was preparing for the maiden launch of its Falcon 9 v.1.1 in September. That mission is for the Canadian Space Agency and several universities in the U.S., including Cornell, Drexel, Stanford, the University of Colorado at Boulder, and Utah State.

The company is also completing development of Falcon Heavy, which may become the nation's most powerful rocket since Apollo's Saturn V when it is ready for its first launch, sometime in 2015.

So far the company has launched satellites only to LEO. However, it was planning to send its first commercial communications spacecraft, the SES-8 for SES World Skies, to geostationary orbit in September, and its second to GEO, the Thaicom 6 for Shin Satellite, aboard a Falcon 9 v.1.1 this month.

At least seven more GEO comsats are scheduled to go up on v.1.1s during the next two years, including ABS 2A and 3A for Asia Broadcast Satellite of China, Asiasat 6 and 8 for Asia Satellite Telecommunications of China, Satmex 7 and 9 for Satelites Mexicanos of Mexico, the Star One C5 for Star One of Brazil, and the Turkmensat 1 for the Ministry of Communications of Turkmenistan.

A new market

The move to begin launching to GEO is significant, because it opens up an entirely new and potentially lucrative market for SpaceX. It also puts the company into direct competition with commercial launch heavy hitters Arianespace of Europe with its Ariane 5ECA, U.S.-Russian joint venture International Launch Services with its Proton M, and Sea Launch of Russia with its Zenit 3SL and 3SLB.

Still, SpaceX does not seem to be giving up its LEO market. If anything, it is expanding it. Its manifest is packed with more than two dozen micro, nano, pico, and femto (under 1 kg) satellites, but it is also filled with over 100 small spacecraft, including 16 Orbcomm-NG mobile comsats for Orbcomm of Rochelle Park, New Jersey, and 70 Iridium-NEXT mobile comsats for Iridium Communications.

Most launch companies would be ecstatic with just the Iridium and Orbcomm business, or either. These programs not only contain an awful lot of satellites but are also the kind that just keep on giving, because of the need for replacement spacecraft every few years. But keep in mind that this is in *addition* to an already healthy number of GEO comsat launch orders.

Ending the myth

Perhaps the most intriguing thing about SpaceX's satellite launch activities is that they are not even its 'core' business. The company has made a name for itself not primarily for launching satellites, but rather for being the first private company to launch resupply capsules to the ISS. Before SpaceX's unmanned Dragon capsule maneuvered in LEO and successfully linked up with the ISS on May 25, 2012, the space docking feat had been performed only by governments—the U.S., Russia, and China.

The SpaceX docking debunked the myth that has prevailed since the launch of Sputnik in 1957, that space travel can be undertaken only by national governments because of the prohibitive costs and technological challenges involved.

Teal Group believes it is that mythology that has helped discourage more private investment in commercial spaceflight and the more robust growth and development of the space market. We sense this is now changing.

SpaceX has hauled supplies—food, water, equipment, and experiments—to ISS twice since the initial docking, and its next resupply mission is scheduled for January 15, 2014. It has created a new commercial space resupply service that could eventually evolve to become an industry. For now, the company is merely providing a little competition for the Russians and their Soyuz and Progress capsules, fulfilling its obligations under its commercial resupply services (CRS) contract to NASA.

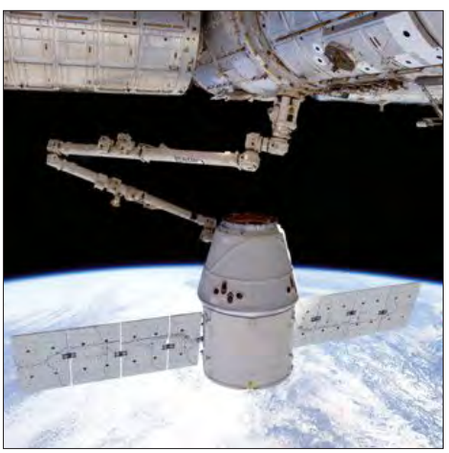
Soon SpaceX will be joined by Orbital Sciences and its Cygnus capsule, which it has been developing under a commercial orbital transportation services contract to NASA. Orbital is preparing to start launching Cygnus aboard Antares rockets in December under an eight-mission CRS contract.

SpaceX has 10 more Dragon ISS resupply missions remaining on its CRS contract with NASA. It is proceeding with development of a human-rated capsule known as DragonRider, capable of transporting a crew of up to seven astronauts. Plans call for launching the first crewed DragonRider by 2015, although we suspect it will be closer to 2017. This work is being done under NASA's Commercial Crew Development 2 program.

SpaceX envisions eventually mating an unmanned Dragon with its Falcon Heavy and sending missions to orbit the Moon. It then hopes ultimately to launch a manned DragonRider to land on the lunar surface by 2020. The company would like to send a series of relatively low-cost Red Dragon landers (based on the Dragon capsule) to Mars, launching them on Falcon Heavies. Yes, the ultimate goal is to send humans to Mars—not astronauts to plant the flag, but settlers to establish a colony.

Against all odds

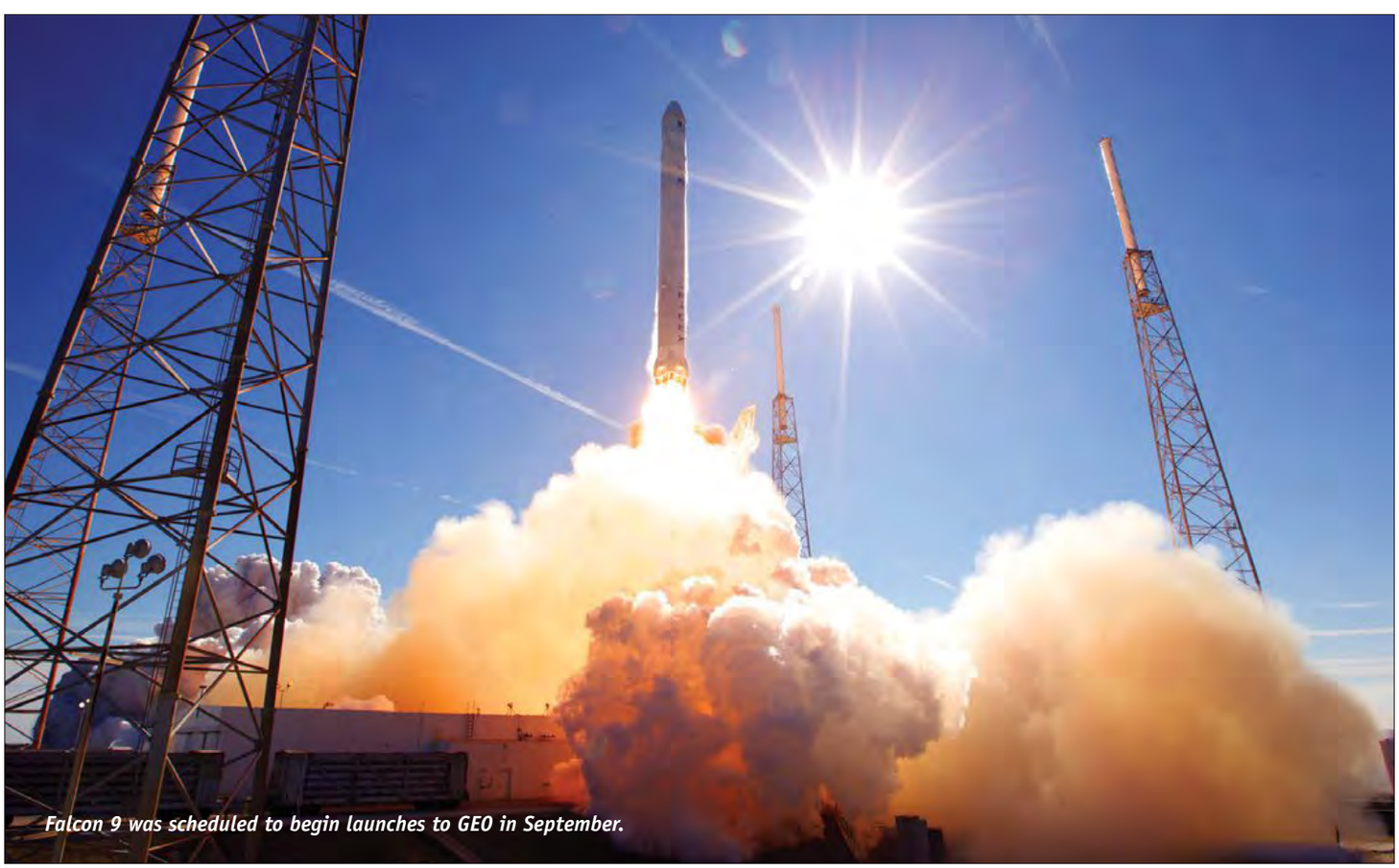
It sounds like pie in the sky. But this has been heard so often when it comes to SpaceX, and consistently the company has overcome tremendous obstacles and proven the mainstream space establishment wrong. SpaceX failed on its first three launch attempts with its Falcon 1, and it simply persisted until it got it right. After the third failure on August 2, 2008, there was strong speculation that the company would have to call it quits. Musk had deep pockets, but he could not endlessly keep financing what appeared to be a losing venture. It was thought that in six months to a year he would either try another launch or announce that he was closing shop.



SpaceX became the first private company to launch resupply capsules to the ISS, with its unmanned Dragon capsule.

What was not expected was that SpaceX would attempt another launch within less than two months. On September 28, 2008, the company completed its first successful Falcon 1 mission, carrying the 165-kg Ratsat demonstration satellite.

In many ways, SpaceX is reminiscent of the U.S. government during the late 1950s and the early 1960s, when so many of its rockets kept blowing up, and it just kept trying until it managed to launch its astronauts to the Moon. The Russians still operate that way. Whenever one of their Proton rockets fails, they launch again within a few months. It is an aggressiveness that some in the space industry may feel is irresponsible. However, it is an attitude that is probably required if you plan to be doing things like sending humans to the Moon and Mars in timeframes of 10 years or less.



Falcon 9 was scheduled to begin launches to GEO in September.

SPACEX MANIFEST *(to LEO unless noted)*

Date Launched	Launcher	Customer	Country	Payload	Mass (kg)
03/24/06	Falcon 1*	Air Force Academy	U.S.	FalconSat 2	19.5
03/20/07	Falcon 1*	NASA/DARPA	U.S.	LCT2/AFSS	150
08/02/08	Falcon 1*	MDA	U.S.	Trailblazer	83.5
		NASA ARC	U.S.	Nanosail-D	4
		NASA ARC	U.S.	PREsat	4
		Space Services	U.S.	Celestis 7	1
09/28/08	Falcon 1	SpaceX	U.S.	Ratsat	165
07/14/09	Falcon 1	Astronautic Technology	Malaysia	RazakSAT	180
06/04/10	Falcon 9 v.1.0	SpaceX	U.S.	Dragon (qual)	< 4,200
08/12/10	Falcon 9 v.1.0	SpaceX	U.S.	Dragon C1	< 4,900
		Northrop Grumman/USC	U.S.	Mayflower-Caerus	5
		NRO	U.S.	QbX 1, 2	5
		Army SMDC	U.S.	SMDC-ONE 1	4
		Los Alamos National Lab	U.S.	Perseus 000 - 003	1.5
05/22/12	Falcon 9 v.1.0	SpaceX	U.S.	Dragon C2	6,650
08/10/12	Falcon 9 v.1.0	NASA	U.S.	Dragon CRS-1	6,650
		Orbcomm	U.S.	Orbcomm-NG 1	142
01/13/13	Falcon 9 v.1.0	NASA	U.S.	Dragon CRS-2	6,650
Planned					
09/13	Falcon 9 v.1.1	SES World Skies	Netherlands	SES-8**	3,200
09/13	Falcon 9 v.1.1	Canadian Space Agency	Canada	Cassiope 1***	375
		University of Colorado	U.S.	DANDE	50
		Cornell University	U.S.	CUSat 1, 2	1
		Drexel (and other univs.)	U.S.	POPACS 1	1
		Drexel (and other univs.)	U.S.	POPACS 2	1.5
		Drexel (and other univs.)	U.S.	POPACS 3	2
		Stanford University	U.S.	SNAPS	0.5
10/13	Falcon 9 v.1.1	Shin Satellite	Thailand	Thaicom 6**	3,325
11/13	Falcon 9 v.1.1	Orbcomm	U.S.	Orbcomm-NG 2 - 9	142
01/15/14	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-3	–
		University of Hawaii	U.S.	Ho'oponopono 2	3.5
		NASA Goddard	U.S.	TechCube 1	3
		Montana Space Grant Consortium	U.S.	FIREBIRD A	2
		California Inst. of Technology	U.S.	LMRSat	2
		Colorado Space Grant Consortium	U.S.	ALL-STAR/THEIA	1
		Colorado Space Grant Consortium	U.S.	Hermes 2	1
		City University of New York	U.S.	CUNYSAT 1	1
04/06/14	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-4	–
		NRL	U.S.	Spinsat	55
2014	Falcon 9 v.1.1	Asia Satellite Telecommunications	China	Asiasat 6**	3,813
2014	Falcon 9 v.1.1	Asia Satellite Telecommunications	China	Asiasat 8**	3,813
2014	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-5	–
2014	Falcon 9 v.1.1	Army SMDC	U.S.	Kestrel Eye 1	14
		NASA JPL	U.S.	IPEX	1

Otherwise, people and investors lose interest, and the costs of such programs grow out of control, thereby decreasing their odds of completion.

In spite of Musk's bold, seemingly outrageous ideas and predictions, it is getting harder and harder to bet against SpaceX. Just look at the company's launch manifest. It is impressive in terms of both length and diversity, not to mention that it was built up within a few short years. The company has not been around very long. Founded in 2002, it has been launching since only 2006. Its first successful launch did not occur until late 2008, yet it has something on the order of 30-40 flights scheduled over the next five years—depending on how payloads are configured. It certainly sounds like a serious business venture.

The only mildly weak area in SpaceX's manifest is the military side. Falcon rockets have launched only six satellites for the Dept. of Defense, including two for the NRO; one for the Air Force Academy; one for the Army Space and Missile Defense Command (SMDC); one for DARPA; and one for the Missile Defense Agency. All of these spacecraft have been small or tiny, and none could be called critical to national security. They were all technology development satellites—the Pentagon was searching for a cheap ride to space, and SpaceX was glad to provide it.

There are only nine military satellites in the manifest. They include the DSCOVR Earth observation STP-2 ISAT technology satellites for the Air Force, the DSX technology satellite for the

Date Launched	Launcher	Customer	Country	Payload	Mass (kg)
2014	Falcon 9 v.1.1	Orbcomm	U.S.	Orbcomm-NG 10 - 18	142
2014	Falcon 9 v.1.1	Satelites Mexicanos	Mexico	Satmex 7**	5,600
		Asia Broadcast Satellite	China	ABS 3A**	1,800
10/20/14	Falcon 9 v.1.1	Ministry of Communications	Turkmenistan	Turkmensat 1**	4,500
11/15/14	Falcon 9 v.1.1	Air Force	U.S.	DSCOVR	440****
		SpaceX	U.S.	SHERPA (demo)	–
		NASA	U.S.	Sunjammer	< 50
12/05/14	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-6	–
		NASA	U.S.	SAGE III	76
12/30/14	Falcon 9 v.1.1	Star One	Brazil	Star One C5**	4,680
03/01/15		NASA	U.S.	Jason 3	553
03/03/15	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-7	–
06/01/15	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-8	–
		Bigelow Aerospace	U.S.	BEAM	1,360
2015	Falcon 9 v.1.1	Satelites Mexicanos	Mexico	Satmex 9**	5,600
		Asia Broadcast Satellite	China	ABS 2A**	1,800
2015	Falcon 9 v.1.1	CONAE	Argentina	SAOCOM 1A	900
		Astronautic Technology	Malaysia	D-Sat	< 25
		Alas Peruanas University	Peru	UAPSat	1
2015	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-9	–
			U.S.	IDA 2	–
2015	Falcon Heavy	AFRL	U.S.	DSX	600
		NRO	Taiwan	Formosat-7A – 7L	217
2015	Falcon 9 v.1.1	Iridium Satellite	U.S.	Iridium-NEXT 3 - 22	800
2015	Falcon 9 v.1.1	Air Force	U.S.	STP-2 ISAT	5,000
2015	Falcon 1e	NRL	U.S.	TacSat-1A	110
12/15	Falcon 9 v.1.1	SpaceX	U.S.	SHERPA 1	–
01/05/16	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-10	–
04/05/16	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-11	–
			U.S.	OCO 3	550
2016	Falcon 1e	GeoOptics	U.S.	Cicero 1 - 6	30
2016	Falcon 9 v.1.1	SpaceX	U.S.	DragonLab 1	–
2016	Falcon 9 v.1.1	Iridium Satellite	U.S.	Iridium-NEXT 23 - 62	800
08/08/16	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-12	–
2016	Falcon 9 v.1.1	SpaceX	U.S.	DragonLab 2	–
2016	Falcon 9 v.1.1	CONAE	Argentina	SAOCOM 1B	900
2016	Falcon 9 v.1.1	SpaceX	U.S.	SHERPA 2	–
2017	Falcon 9 v.1.1	SpaceX	U.S.	DragonRider	–
2017	Falcon 9 v.1.1	Iridium Satellite	U.S.	Iridium-NEXT 63 - 72	800
2017	Falcon 9 v.1.1	SpaceX	U.S.	SHERPA 3	–
2018	Falcon 9 v.1.1	CSA	Canada	RCM 1 - 3	1,300
2018	Falcon 9 v.1.1	Bundeswehr	Germany	SARah Aktiv 1	2,200
2018	Falcon 9 v.1.1	B612 Foundation	U.S.	Sentinel Telescope	1,500
2019	Falcon 9 v.1.1	Bundeswehr	Germany	SARah Passiv 1, 2	1,800

*Launch failure. **GEO. ***Elliptical. ****Lagrange point 1 (L_1).

AFRL, the Kestrel Eye 1 tactical imaging satellite for the Army SMDC, three SARah radar imaging satellites for the German Armed Forces (Bundeswehr), and the Spinsat technology demonstration and TacSat-1A maritime surveillance experimental satellites for the Naval Research Laboratory.

Within a few years, though, SpaceX may be winning its share of launches under the Air Force's Evolved Expendable Launch Vehicle program, which has been the exclusive domain of United Launch Alliance, a Boeing/Lockheed Martin joint venture, for several years. Once SpaceX's Falcon Heavy is certified by the Air Force, it is likely to be selected for at least 14 of the next 50 EELV missions contracted. The prices for Falcon 9 v.1.1 and Falcon Heavy, estimated at nearly half the price of the Atlas Vs and Delta IVs, are going to be attractive to the Air Force, which has long been seeking to reduce its launch costs dramatically—ever since the days of the $350-million-per-mission Titan IV rocket.

Next to cargo resupply work for NASA, Musk views competing head to head with Boeing and Lockheed Martin for EELV contracts as his top priority. Last year the Air Force awarded SpaceX two EELV-class payloads—DSCOVR and STP-2 ISAT. That was the first time a company besides Boeing or Lockheed Martin was allowed into EELV. SpaceX has opened another door for itself, and one that is sure to add noticeably to its manifest.

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