September 2011

AEROSPACE AMERICA

WINGS OF GOLD

One hundred years of U.S. Navy air power

Launch vehicles: A worldwide roundup

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

Soyuz

Launch vehicles

A worldwide roundup

There are just a few achievements that have become generally accepted indicators that a country has achieved 'First World' status. One such indicator is the possession of long-range missiles, from those with regional 'reach' to full-fledged ICBMs.

Having an ICBM also is the first step toward an even more exclusive club—spacefaring nations, whose capabilities fall into four categories: launching satellites into Earth orbit, launching unmanned missions to the Moon and beyond, launching their own astronauts into orbit using their own launch system, and launching their own astronauts to the Moon or beyond.

There currently are 10 members in the first group, four in the second, three in the third (U.S., Russia, China) and one (U.S.) in the fourth. There also is one private company in the third group: Scaled Composites won the 2004 Ansari X Prize by launching three astronauts into suborbit twice, using the same vehicle, in two weeks.

Far more nations have used foreign launch capabilities to place satellites into orbit, just as they have used the U.S. shuttle and Russian Soyuz to send their citizens into orbit, primarily to the ISS. Though this does not give them true 'spacefaring nation' status, it often stimulates national interest in developing some level of self-sufficiency.

Where we will be going in space in the next 50 years is difficult to forecast. But one thing is certain: The withdrawal of the U.S. government from indigenous human spaceflight capability, the increasing capability of China, and the rise of India and others to fill the resulting void will change the future and the nature of human space exploration.

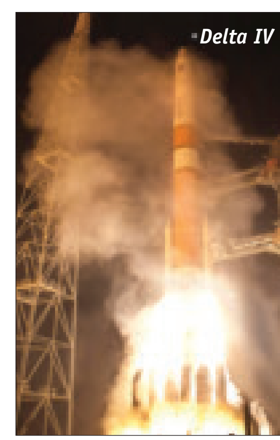
United States

Americans were stunned in October 1957 when the first artificial satellite orbited Earth—the Soviet Sputnik. That achievement spurred the creation of what is now DARPA, tasked to ensure the U.S. would never again experience a technological surprise. It also led to creation of the Army Space & Missiles Command, which was given the first

by **J.R. Wilson**
Contributing writer

A few major 'space powers' continue to dominate the world's launch activities, but the number of nations eyeing membership in that exclusive club is on the rise.


Falcon 9


Delta IV

orders to turn military rockets into space launchers, and NASA, which assumed responsibility for U.S. space programs.

Even as the U.S. struggled with its first attempts to launch satellites, President John F. Kennedy surprised the world by announcing the goal of sending astronauts to the Moon and returning them safely before the end of the 1960s. From Project Mercury's first suborbital crewed flight in 1961 to astronauts setting foot on the Moon in 1969, the U.S. caught up with and then surpassed the Soviet Union in space. Over 40 years later, no other nation has sent humans beyond Earth orbit—nor has the U.S. since December 1972.

Unmanned launches, however, continued to advance. In the 1980s, President Ronald Reagan 'privatized' the launcher business, turning full ownership of the highly successful Delta and Atlas systems over to their builders, McDonnell Douglas (now Boeing) and General Dynamics (now Lockheed Martin). Since 2006, the current versions of both—the Delta II medium, Delta IV heavy, and Atlas V medium/heavy—have been built by United Launch Alliance, a Boeing/Lockheed joint venture.

The space shuttle was to have replaced all ELVs, but the launch frequency envisioned for it never materialized. For now, the future of the Delta II remains murky as its contract with the Air Force ends, leaving NASA to maintain the vehicle's infrastructure. NASA, too, had intended to end its use of the Delta II this year, but recently announced it would keep the vehicle on its list of available launchers, although production has stopped.

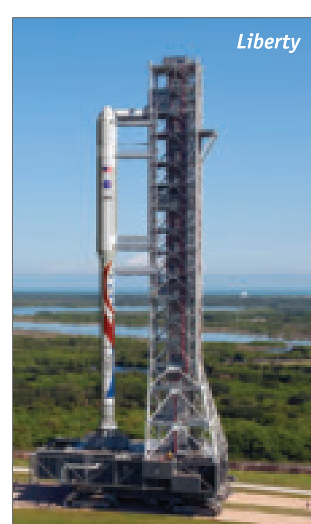
The change resulted from significant increases in Atlas V's cost and the lack of a proven vehicle below the Atlas V/Delta IV class. That also has led NASA to look more closely at new private launch systems, and at non-U.S. launchers.

Until one of the private launchers becomes successful, the only way to reach the ISS, at least through the end of this decade, will be by buying a seat on Russia's Soyuz..

In its July 2010 report to Congress on the future of NASA, the Congressional Research Service (CRS) noted, "While reliance on Soyuz on an interim basis is acceptable, longer term use would not be."

Teal Group analyst Marco Cáceres tells *Aerospace America,* "We're at a pause. We will not have a manned spaceflight capability we can call American—either government or private—for the near term. The hope is that private industry will come through within a few years, certainly with regard to carrying cargo to the space station, but eventually with human-rated vehicles. The hope now lies with companies like SpaceX and Orbital Sciences. But it will take at least three or four more years to develop human-rated vehicles and test them well enough that everyone feels comfortable.

"I would identify Virgin Galactic as…more of a joint venture. Sir Richard Branson owns the vehicle and is British, but the manufacturer is American. That traditionally has not been the way things have gone—human-rated space has always belonged to some government. But when you open up to private industry, they can buy from other countries and claim it as their own, so you have to word it differently—it's not a national capability as in the past.


Liberty

LAUNCH VEHICLE ROUNDUP

Country	Prime Contractor/ Launch Sites	Vehicle Designation	Series	First Launch	Number of Successful/ Failed Launches	Number of Stages	Propellant	Payload Wt., kg
Argentina								
	Space Activities National Commission/ Bahia Blanca	Tronador		1	2007	1 of 2		
				2			Liquid	200 LEO
Brazil								
	CTA Aerospace Technical Center/ Alcântara Launch Center	VLS-1	V1-4	Dec 1997	0 of 2	3	Solid - liquid upper	38 LEO
		Alfa (VLS-2)					Solid	LEO/GEO
		VLM		2016		3 of 4	Solid	150
		Cyclone-4		2013 or 2014				5,300 LEO 1,800 GEO
Canada								
	Planet Space/ Cape Breton, Nova Scotia	Athena III*				3	Solid	794-1, 896 LEO
		Canadian Arrow*				2	Liquid first; solid second	
		Silver Dart*				2	Nova rocket first stage; lifting body second	
China								
		Long March (Chang Zheng)	1D		1 of 2		Liquid	1,500 LEO
			2C		32			2,400 LEO
			2D		14			3,500 LEO
								8,400 LEO
			2G					
			3A		17			8,500 LEO 2,300 GTO
			3B/E					12,000 LEO 5,500 GTO
			3B(A)					
			3C		4			3,700 GTO
			4B		11			4,200 LEO 1,500 GTO
			4C		4			4,200 LEO 1,500 GTO
			5	2014				25,000 LEO 14,000 GTO
			6	2013				500 SSO

We do that already with ILS and SeaLaunch, for example, where both are based in the U.S. but the rockets they use are built by the Russians and Ukrainians."

SpaceX, established in 2002, already has seven successful launches of its Falcon launch vehicle and Dragon reusable spacecraft, and a future 30-launch manifest through 2017 for 10 customers. In December 2008, NASA awarded SpaceX a $1.6-billion contract for at least 12 Falcon/Dragon missions to resupply the ISS through 2015, with a roughly equivalent options package, as part of its commercial orbital transportation services program. The first cargo flight is scheduled for late this year.

The Scaled Composites/Virgin Galactic effort, probably the first private manned transport to go into operation, is intended to provide tourists, at $200,000 a ticket, with a brief trip to the edge of space.

The system comprises a twin-fuselage mothership, WhiteKnight Two, which will carry the reusable suborbital SpaceShipTwo to 50,000 ft, then release it to continue upward using its own hybrid liquid/solid motor. It can carry six passengers and two crew about 6 mi. beyond the Karman Line (at 60 mi. altitude, the break point between Earth's atmosphere and space).

Another industry possibility is the Liberty launcher, a joint venture of Alliant Techsystems (ATK), the Utah-based builder of the shuttle's solid rocket boosters, and Astrium, a subsidiary of EADS and a primary contractor on the Ariane commercial rocket. It would build on ATK's efforts on NASA's Ares rocket, part of the Constellation program planned to replace the shuttle and canceled by President Obama shortly after he took office.

Offered in response to NASA's Commercial Crew Development-2 procurement initiative, the two-stage Liberty would be able to carry 44,500 lb of cargo—or any crew vehicle currently in development—to the ISS. ATK Aerospace Systems Group President Blake Larson says because it is a combination of two proven human-rated launch systems, the Liberty rocket could make its initial test flight by the end of 2013 and reach operational capability in 2015. Liberty will launch it from Kennedy Space Center, using existing facilities.

Proton

For the U.S., the future of space launch is split between military and government use of commercial rockets and commercial launch for civilian customers. It is further divided between manned and unmanned.

Russia

With the end of the shuttle, Russia has regained the lead in space for the fifth time since it began the space race. Although China also now has both manned and unmanned capability, for at least the next few years Russia alone will have the combined capability to launch manned flights to the space station, unmanned payloads to Earth orbit, and interplanetary probes.

Unlike the U.S., which opted for a major technological leap with the shuttle, the Russians have stayed with essentially the same rockets and spacecraft developed by the Soviet Union in the 1960s and 1970s. Although that has given them a record of reliability without significant new investments, it is uncertain whether they will be able to stay ahead of the aggressive Chinese space program, which includes unmanned interplanetary probes and the goal of landing taikonauts on the Moon by 2020.


Soyuz

"Russia is in good shape. They have a good fleet of vehicles—nothing spectacular, basically 1960s technology, but it works," Cáceres says. "The Soyuz is the only vehicle that is human-rated and tried and tested to get people to the space station and back. The vehicle also is very successful in satellite launches. Russia has a very diverse customer base—military, government, and commercial—and has a captive market."

The country is looking to increase domestic launch capabilities with the planned Vostochny Space Center. Billed as a "new stage in the development of Russian cosmonautics," with two launch pads and a training center, it is scheduled to begin satellite and cargo launches in 2015 and manned missions in 2018.

LAUNCH VEHICLE ROUNDUP

Country	Prime Contractor/ Launch Sites	Vehicle Designation	Series	First Launch	Number of Successful/ Failed Launches	Number of Stages	Propellant	Payload Wt., kg
China, continued		Kaituozhe	1					50 LEO
Denmark								
	Copenhagen Suborbitals/ Baltic Sea	HEAT	1X*	2010	1 of 2		Hybrid solid	300 suborb. 50 LEO
			TM65	2012			Bi-liquid	
Europe								
	European Space Agency (Arianespace)/ Guiana Space Center	Ariane 5	ECA	2002	31	2	2 SRB side boosters; cryogenic main stage; liquid	21,000 LEO 10,050 GTO
			ES	2008	2	2		>20 tons
			ME	2016				11.2 tons GTO
		Soyuz-2	ST*	2011				3 tons GEO
		Vega		2011		4	Solid-liquid	2 tonnes HEO 1.5 tonnes HPO
India								
	Indian Space Research Organization (ISRO)	PSLV			9 of 10			1,050 GTO 3,200 LEO
			CA		6			2,100 LEO 1,600 GTO
			XL		1			3,800 LEO 1,140 GTO
			HP					3,800 LEO 1,130 GTO
		GSLV	Mk II		0 of 1			5,100 LEO 2,500 GTO
			III					5,000 GTO
Indonesia								
	Spacetecx/ LAPAN Space Center mobile pad	RPS-01	RX-420	2012 to 2014		4	Solid	25 LEO
		RX-750		2014		5	Liquid	50 LEO
Iran								
	Semnan	Kavoshgar	1	2008	1 of 2	2		
			2	2009		2		
			3*			2		
			4			2		
			5*			2		
		Safir	1	2008		2	Liquid	
			2	2009		2	Solid-liquid	50 LEO

The space program also has involved increasing cooperation with nations such as the U.S. and China, but also with others seeking to develop their own space programs. These would be aimed primarily at launching Earth-orbiting satellites or building launch facilities for use by other nations' rockets.

Russia reportedly has at least seven new launch vehicles at varying stages, from 'concept evaluation' (the MMB nuclear-electric tug, with first launch planned for 2018) to preliminary development (Rus-M for 2015) to development (Angara, 2012). Rus-M and Angara are seen as replacements for the existing Soyuz and Proton rockets. The aging Soyuz manned capsule's replacement—currently called the New Generation Piloted Transport Spacecraft—was displayed in mockup form at the Paris Air Show in July, but when it may be ready for flight is unknown.

Ukraine

When the USSR broke apart, Ukraine—which had produced about 60% of Soviet launch vehicles and more than 400 satellites—became an independent player in space. An estimated 20% of all satellite launches in the world today use Ukrainian rockets, primarily the Zenit, Tsyklon (Cyclone), and Dnepr. Although Ukraine still does not have a domestic launch facility, it officially became the 10th global 'space power'—a nation able to launch its own satellite using its own vehicle—with the August 1995 liftoff of the Sich-1 Earth observation satellite aboard a Cyclone rocket from Russia's Plesetsk launch facility.

In 2009, Ukraine hit a new high mark as the number of its rockets launched that year ranked fourth in the world—tied with China behind Russia, U.S., and Europe/ESA.

Ukraine has provided post-Soviet Russia with military satellites and launch vehicles since 1991 and has been aggressive in making bilateral agreements with other nations and private industry. These entail making satellites, providing launchers, and building and operating new spaceports. Ukraine is working with Brazil to build a new launch facility for the Cyclone-4 rocket and has been invited by Russia to participate in construction of Vostochny.

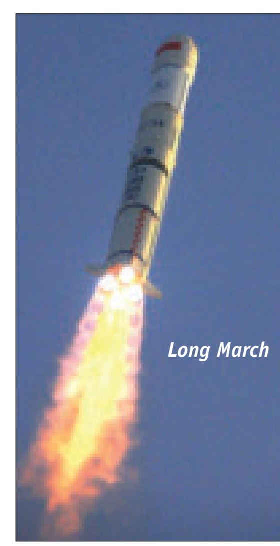

Zenit

In recent years, Ukraine has formed cooperative efforts with China, Japan, Saudi Arabia, Turkey, Nigeria, India, Azerbaijan, Belarus, Canada, Germany, and ESA, in addition to its ongoing work with Russia, the U.S., Kazakhstan, and Brazil, among others.

One major international effort is Sea Launch, a joint venture by Ukraine's Yuzhmash machine plant and Yuzhnoye State Design Office, Boeing Commercial Space (U.S.), Energiya Rocket and Space (Russia), and Akar ASA (Norway). In its first decade (1999-2009), Sea Launch recorded 28 successful missions out of 30 launches, using a Ukrainian two-stage Zenit rocket and Russian third-stage launching from a modified Norwegian ocean oil rig. The company halted operations while working through bankruptcy, but the National Space Agency of Ukraine expects operations to resume late this year with the Intelsat 18 communications satellite, although the launch will be from Kazakhstan's Baikonur Cosmodrome, a land launch option that Sea Launch began offering around 2003.

China

The Chinese space program is evolving far faster than many had anticipated, but currently is about where Russia's was in the 1960s. It has some satellites in orbit—with the annual number of launches beginning to close in on current U.S. and Russian numbers—and some manned orbital flights. It also has set a goal of putting its own space station in orbit by 2020 and landing Chinese taikonauts on the Moon by 2020-2025 and on Mars in the 2030s.


Long March

Some have called it a new space race, while others ask with whom China is racing. The U.S. essentially has abandoned manned spaceflight as a government effort. Russia remains active, but has advanced little beyond what was achieved by the mid-1970s. India, which also has an active satellite launch program and has said it wants to put its citizens on the Moon in the 2020s, has yet to achieve a manned launch and lags behind China on the unmanned side as well. And while other nations are expanding or pursuing unmanned launch capabilities, none is even close to China.

"The Chinese have a huge fleet of vehicles, much more modern than the Russians', but this is a purely government program and they haven't shown they can compete commercially. So as long as they do not, the Russians don't need to worry," Cáceres says. "The Chinese would like to

LAUNCH VEHICLE ROUNDUP

Country	Prime Contractor/ Launch Sites	Vehicle Designation	Series	First Launch	Number of Successful/ Failed Launches	Number of Stages	Propellant	Payload Wt., kg
Iran, continued		Shahab		2007	3 suborbital, 1 orbital of 5			
			5					
			6				Liquid-solid	
		Simorgh		2010				130 lb LEO
Israel								
	IAE	Shavit			6	3		160 LEO
Japan								
	JAXA (IHI Aerospace)	Epsilon	Standard	2013		3	Solid	1,200 LEO
			Optional			3	Solid-compact liquid	700 LEO 450 SSO
	Mitsubishi Heavy Industries	H-II	A		17 of 18			15,000 LEO 6,000 GTO
			B		2			19,000 LEO 8,000 GTO
New Zealand								
	Rocket Lab/ Mercury Island	Atea-1		2009		2		2 suborbital
North Korea								
	KCST/ Tonghae Satellite Launching Ground	Unha	2	2006		3	Liquid-solid	100 LEO
Romania								
	ARCA/ Black Sea	Haas				3		400 LEO
		Helen	2B	2010				
		Stabilo		2006	2	2		
Russia								
	Khrunichev State Research and Production Center/ Plesetsk Cosmodrome (possible future from Baikonur Cosmodrome)	Angara**	1.1	2012			Liquid	1.6 tonnes
			1.2	2013			Liquid	3.5 tonnes LEO 1.8 tonnes GEO
			AS-I					8.8 tonnes GEO
			A4B					
			V			3	Liquid	27 tonnes LEO 11.2 tonnes GEO
			100					100 tonnes LEO
			5-P*					6,350 LEO
			A3*					14,600 LEO 3,600 GTO
			A5					24,500 LEO

get commercial, but they have a lot of government and military launches—14 last year, all with Chinese payloads—so they really don't need to [go commercial].

"Their focus is on building a national space program, and they're perfectly happy with their expendable launch fleet—small, medium, large, all segments of the market. They would like to have a manned capability in orbit, so if they don't join the ISS, which I don't know that they will, they'll probably develop their own space station. I also think they will move quickly to go to the Moon—probably before the end of the decade, and definitely before the Indians."

As with most high-tech programs in China, separating fact from internal hyperbole and external speculation is difficult. A further complication is the Chinese penchant for calling almost every launch vehicle Long March, followed by a series number. Of about 20 versions of Long March built since 1970, nine remain in use and four are still in development, operating from four satellite launch centers in as many provinces around the nation. So it is likely any Chinese mission to the Moon or Mars also will begin atop a Long March.

Adding to the complexity of analyzing China's launch capabilities is the apparent failure of the country's efforts to match its predictions of future success. China should be benefitting from the way the U.S. and Soviet/Russian space programs dealt with unknowns at comparable points in their histories, for example—including the loss of space crews. But most Chinese advances have come in the past decade, following 30 years of comparative lethargy.

China launched its first satellite in 1970, but in its first four decades in space, it launched only 132 rockets, 166 satellites, one unmanned lunar probe, and six taikonauts, who spent a total of nine days in space. By comparison, in its first decade alone, NASA performed about 600 launches involving 800 spacecraft—including multiple probes to Mars, Venus, and the outer planets—and placed 44 astronauts in space, including four who walked on the Moon.

Cáceres notes that China has benefitted from a steady, albeit small, stream of military launches, while the U.S. military launched most of its own satellites rather than using NASA. "China is really committed and is likely to pump more money into its space program than the U.S. ever did."

Andrew Erickson, a Naval War College expert on China's naval and space forces, tells *Aerospace America* that the Chinese approach may prove more successful, for their purposes, than a cursory comparison with the U.S. or Russia might indicate.

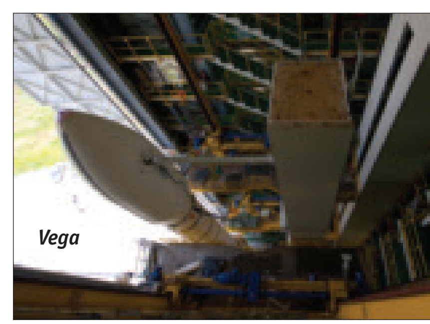
"China appears to have very advanced capabilities in both electrooptical and radar imaging, with very high resolution," says Erickson. "These seem to be exactly the type of capabilities for which to further develop space-based information, surveillance, and reconnaissance to support precision weapons.

"What is especially intriguing is that by employing diverse small satellite designs based on common buses or standardized platforms, China may not need to develop superior heavy spacecraft technologies, but could end up with military space capabilities greater than the sum of their parts."

That may suit their purposes very effectively, although quite differently from the U.S. military space program, which uses larger individual spacecraft. China's current strategy, if it continues, could result in increased future synergies, he believes, propelling China to a more prominent position.

Europe

In 1965, France became the third nation to launch its own satellite; the U.K. followed suit in 1971. But no individual European nation had the money or other resources to mount expansive space programs like those of the U.S. and the Soviet Union/Russia.


Vega

In 1975, France and the U.K. joined eight other western European nations to create the European Space Agency, merging two organizations set up in 1964—the European Launch Development Organization, a six-nation effort to develop a European launcher, and the European Space Research Organization, established by 10 nations to pursue scientific research in space, primarily through European satellites launched by the U.S.

Today ESA has 18 full members and one associate, Canada. Further expansion is likely if efforts to make ESA an official agency of the European Union by 2014 succeed. ESA continues to work with the U.S. and Russia—projects with the latter include developing a new medium-lift launch vehicle, the Soyuz-2—but relies primarily on its own rockets, the Ariane 5 ECA for heavy lift to GTO, Ariane 5 ES for launch to LEO, and the newly developed Vega for small pay-

LAUNCH VEHICLE ROUNDUP

Country	Prime Contractor/ Launch Sites	Vehicle Designation	Series	First Launch	Number of Successful/ Failed Launches	Number of Stages	Propellant	Payload Wt., kg
Russia, continued		RN-45						45 tonnes LEO
		RN-75						75 tonnes LEO
		RN-150						150 tonnes LEO
		Proton			294 of 333			21,000 LEO 6,360 GTO
		Rokot			13 of 14			1,950 LEO
		Strella			1 of 3			1,700 LEO
	Makeyev	Shtil			2			430 LEO
		Volna			0 of 5			100 LEO
	MITT	Start-1			6			532 LEO 167 SSO
	NPO Polyot	Kosmos-3M			422 of 442			1,500 LEO
	TsSKB-Progress/ Plesetsk launch Baikonour launch	Soyuz	FG		31			7,130 LEO
			2.1a/b/v		7			2,800-7,800 LEO 1,700 GTO
			2 ST/ST K					7,800 LEO 3,000 GTO
			U		696 of 715			6,700 LEO 6,950 LEO
		Rus-M		2015				54,000 LEO 11,500 GTO
South Korea								
	KARI Khrunichev/ Naro Space Center	Naro-1			0 of 2	2	Solid-liquid	100 LEO
Ukraine								
	Yuzhmash	Dnepr	1		15 of 16			
		Tsyklon	4					5,500 LEO 1,700 GTO
	Yuzhmash/ RKK Energia	Zenit	3SL		27 of 30			6,100 LEO 5,250 GTO
			3SLB		4			3,750 GTO
	Yuzhnoye	Zenit	2M (SLB)		1			13,920 LEO
		Zenit	3SLBF		1			
United States								
	ATK/Lockheed Martin	Athena	Ic					
			IIc					1,712 LEO
		Space Launch System*						130,000 LEO
	Interorbital Systems/ Spaceport Tonga	Neptune	N30	2011		3	Liquid	30 PLEO
			N45			3	Liquid	45 PLEO
			N1000			4	Liquid	1,000 PLEO
			N4000			4	Liquid	4,000 LEO
		Minotaur	I		10			580 LEO

loads. Arianes have launched more than half the commercial satellites in use worldwide.

India

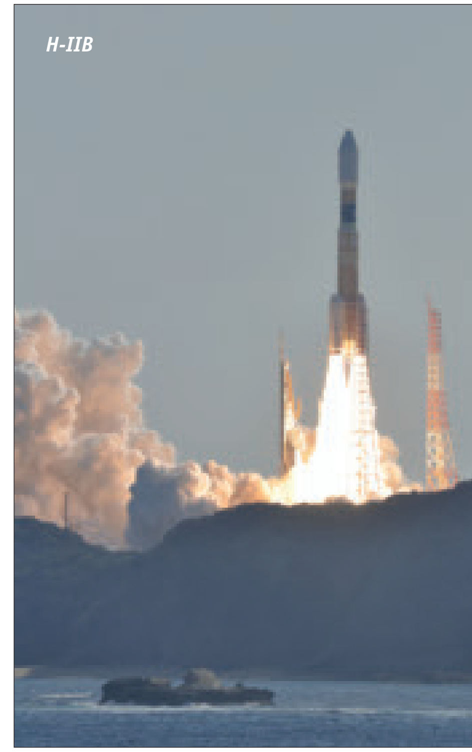
India became a space power in 1980 but has been limited to placing relatively small satellites into LEO—a total of 58 through 2010. Its first rocket, the ASLV (augmented satellite launch vehicle), was discontinued after four launches (including two failures and a partial success). The follow-on PSLV (polar) rocket has achieved most of the successful launches.


PSLV

The GSLV (geosynchronous), larger and roughly comparable to Delta II or Ariane 4, has had a difficult history since its first developmental flight failed in 2001. The second developmental and first operational flights succeeded in 2003 and 2004, respectively; however, three of four subsequent attempts through December 2010 failed, the fourth being listed as a partial success. The next attempt, carrying GSAT-11, India's largest and post powerful communications satellite, is slated for late this year or early 2012.

Given its difficulties getting satellites beyond LEO, India's plan for sending astronauts to the Moon and establishing a permanent base there in the 2020s seems unlikely. The GSLV also will need to demonstrate a solid string of successful launches to GEO before India can begin to compete in the commercial launch arena with the U.S., Russia, Europe, or China.

"The most important things are cost, performance, and reliability. So far, the Indians have not proven they can come up with a reliable competitor to the Russians," Cáceres says, but adds that this does not preclude their joining the manned spaceflight club soon. "The most likely to try is probably India; the most likely to have the capability to succeed would be the Europeans, if they decided to human-rate the Ariane 5."


H-IIB

Japan

Japan is eager to become a full-fledged spacefaring nation, reasserting itself as an Asian power equal to China. The first all-Japanese rocket to launch a Japanese payload into orbit from a domestic site was the H-II in 1994. Because of cost issues, the vehicle was abandoned five years later; its follow-on, the H-IIA, made its first successful launch in 2001. The next year, Japan privatized H-IIA production, and Mitsubishi Heavy Industries became responsible for all development and marketing.

In addition to the H-IIA, Japan Aerospace Exploration Agency, or JAXA, has the H-IIB and H-II transfer vehicle in its operational fleet. It is also developing two others: the Epsilon launch vehicle and the LNG propulsion system, which could be used as the first stage of a reusable vehicle or alone to propel an interorbit transport or planetary probe.

Brazil

Brazil has long been a sleeper on the global scene. It is one of the world's largest nations by area, 'rich' in largely unexploited natural resources, and has the intellectual capital to join the ranks of space powers, but has been slow to capitalize through needed infrastructure construction, in large part because of intermittent economic and political instability.


VSB-30

It also is part of BRIC (Brazil, Russia, India, China) or, sometimes, BRICSA, which includes South Africa. This is a new political bloc

LAUNCH VEHICLE ROUNDUP

Country	Prime Contractor/ Launch Sites	Vehicle Designation	Series	First Launch	Number of Successful/ Failed Launches	Number of Stages	Propellant	Payload Wt., kg
United States, continued	Orbital Sciences/ Cape Canaveral, Vandenberg AFB, Wallops - Kodiak	Minotaur	IV		3			1,735 LEO
			V					
		Pegasus			35 of 40			443 LEO
		Taurus			6 of 9	4		1,350 LEO
			II	2011		2	Solid-liquid	5,750 LEO
	Scorpius Space Launch	SR-M Suborbital			2			
		Sprite						482 LEO
		Liberty						1,910 LEO
		Exodus						8,955 LEO
		Space Freighter						15,320 LEO
	SpaceX/Reagan Test Center Kwajalein Atoll Cape Canaveral or Kwajalein	Falcon	1	2006		2	Liquid	
			1e			2	Liquid	1,010 LEO
			9*	2010	2	2	Liquid	From Cape: 23,050 lb LEO 10,000 lb GTO From Kwaj: 18,870 lb LEO 10,320 lb GTO
			9 Heavy*	2012		2 with dual side boosters	Liquid	53,000 LEO 16,000 GTO
	United Launch Alliance (Boeing/ Lockheed Martin)/ Cape Canaveral and Vandenberg AFB	Delta	II	1989	156 of 158	2 LEO 3 GTO plus 3-9 strapons		6.1 tonnes LEO 2.2 tonnes GTO
			IV	2002	13	2 with 2 strapons	Liquid	48,264 lb LEO 28,620 lb GTO
			IV Heavy		3 of 4			22,950 LEO 12,980 GTO
		Atlas	V*	2002	25 of 26	2	Solid	64,860 LEO 28,660 GTO
			V Heavy*			2	Liquid	25 tons LEO

* *Human rating planned or possible.*

** *A number of designation and configuration changes to the Angara family of launch vehicles in the past decade makes it difficult to determine which specs go with which name.*

This chart shows only those launch systems currently in use or with the greatest likelihood of succeeding in the near term. Chinese, Iranian, and North Korean space launch companies, missions, and specs are among the most difficult to verify. The information in this chart is based on a compilation of multiple sources, looking for common names and details to avoid duplication or programs no longer active and to ensure the inclusion of new launch vehicles.

formed in 2009 with the stated purpose of challenging the U.S. as the only global superpower, giving "emerging and developing economies...a greater voice" and promoting "fundamental research and the development of advanced technologies." BRIC could significantly improve Brazil's future prospects as a spacefaring nation. It already is developing new satellites with China under the China Brazil Earth Resources Satellite program and is negotiating future launches from its two spaceports—Alcantara and MECB (Brazilian Complete Space Mission)—for U.S., Russian, Chinese, and Ukrainian rockets. Late last year Brazil also launched its own mid-sized rocket, VSB-30 V07, on a suborbital flight.

Baikonour Cosmodrome

Iran

Iran is the world's largest question mark, in terms of its ability to launch payloads into space. Russia and China both have been criticized in the past for selling missile technology to Iran. The fact that Iran has had little known success, even with launching small satellites to LEO, indicates that either what it bought was not a complete package or, as every nation attempting spaceflight learns, getting a satellite safely into orbit is not as easy as it may seem.

✈✈✈

In terms of space launch, Russia leads the world, followed by the U.S, with China a fast-growing third—passing Europe/ESA and Ukraine—and both India and Brazil serious contenders. Working together, which would be a first for such a group, they theoretically could leave both the U.S. and Europe far behind in future space launch and exploration capabilities. But thus far, little more than paperwork and rhetoric have emerged from BRIC.

Cáceres says there will be newcomers to the list of launch-capable nations, but he qualifies the prediction with an assessment of just what that will entail: "I'm sure Brazil eventually will do it, because it has the technology and the money. The same with North Korea and Iran—at least for tiny satellites. But if you look at who is launching regularly, it's basically the same five or six."

Many nations are seeking a toehold in space by providing launch facilities. While the number of spaceports—operational, planned, or just claimed—varies with every source, the 'short list' shows 20 nations operating some 30 launch sites, not including a host of new private ones. The longer list, however, includes one planned in Africa, 18 in Asia (mostly China and Russia), four operated by (but not necessarily in) Europe, 14 in or operated by the U.S. and Canada, two in South America, three in Australia, one in the Marshall Islands, and two at sea—a total of 45.

Finding enough launch vehicles doing enough business to justify the cost of building and maintaining a large number of spaceports, however, remains an uncertain prospect. The odds of new launch customers bringing new rockets into the market are far slimmer than existing countries/companies expanding services to meet any growth in demand.

"There probably are 50 or so companies working on launch vehicles, but most won't actually have the capital to do anything more than paper," Cáceres predicts. "China, the U.S., Russia, Europe, Japan, India—maybe South Korea and Israel—but that's about it."

Most experts agree the major U.S. rockets—Atlas V, Delta II and IV, Falcon 9, Minotaur I and IV, Taurus II—will be committed almost exclusively to military and government launch, as will those of China, which will continue to seek a greater degree of commercial diversity.

Of the major players, that leaves Russia, perhaps surprisingly, and ESA's Ariane as the world's primary sources of commercial launches for the foreseeable future, with their greatest challenge likely coming from private industry, primarily in the U.S.

The future is likely to see a widening divide between government and private launchers, satellites and human spaceflight, Earth orbital and interplanetary missions.