

Current Space Launch Vehicles Used by the United States

Nathan Daniels

April 2014

At present, the United States relies on Russian rocket engines to launch satellites into space.

The U.S. also relies on Russia to transport its astronauts to the International Space Station (as the U.S. Space Shuttle program ended in 2011).

Not only does this reliance have direct implications for our launch capabilities, but it also means that we are funding Russian space and missile technology while we could be investing in U.S. based jobs and the defense industrial base.

These facts raises national security concerns, as the United States' relationship with Russia is ever-changing - the situation in Ukraine is a prime example.

This paper serves as a brief, but factual overview of active launch vehicles used by the United States.

First, are the three vehicles with the payload capability to launch satellites into orbit: the Atlas V, Delta IV, and the Falcon 9. The other active launch vehicles will follow in alphabetical order.



NATIONAL SECURITY AND SPACE



Atlas Launch Vehicle History and the Current Atlas V

- Since its debut in 1957 as America's first operational intercontinental ballistic missile (ICBM) designed by the Convair Division of General Dynamics, the Atlas family of launch vehicles has logged nearly 600 flights.
- The missiles saw brief ICBM service, and the last squadron was taken off of operational alert in 1965.
- From 1962 to 1963, Atlas boosters launched the first four American astronauts to orbit the Earth. Various Atlas II models were launched 63 times between 1991 and 2004. There were only six launches of the Atlas III, all between 2000 and 2005. The Atlas V is still in service, with launches planned until 2020.
- Making its debut on August 21, 2002, the Atlas V launch vehicle has successfully flown eight times.
- The Atlas V was formerly operated by Lockheed Martin. It is now operated by the Lockheed Martin-Boeing joint venture, United Launch Alliance (ULA).
- Each Atlas V rocket uses a Russian-built RD-180 main engine to power its first stage and an American-built RL10 engine to power its Centaur upper stage.
- To date, Atlas has launched 82 consecutive successful flights, a record unmatched in the industry, making it one of the premier launch systems in the world and the workhorse of the U.S. space program.



Delta IV

- The Delta IV family of medium-to-heavy launch vehicles became operational when the first launch of Eutelsat's W5 commercial satellite took place on Nov. 20th, 2002.
- There are five versions of the Delta IV launcher, designed by Boeing's Integrated Defense Systems division and built in the United Launch Alliance (ULA) facility in Decatur, Alabama; each incrementally increases the size or weight of the payload to be placed in space.
- Delta IV launches occur from either of two rocket launch sites: On the East Coast of the United States: the Space Launch Complex 37 (SLC-37) at the Cape Canaveral Air Force Station. On the West Coast: Vandenberg Air Force Base's Space Launch Complex 6 (SLC-6) pad for polar-orbit and high-inclination launches.



- Delta IV uses a Rocketdyne RS-68 engine for its 1st stage and a Pratt & Whitney RL-10B2 engine for its 2nd.
- On February 25th, 2014, the United Launch Alliance successfully launched the 25th Delta IV mission carrying a global positioning system satellite for the U.S. Air Force.

Falcon 9

- Falcon 9 is a two-stage rocket designed and manufactured by SpaceX, a private American space company based in Hawthorne, California, for the transport of satellites and the Dragon spacecraft into orbit.
- SpaceX has developed a family of rocket engines, Merlin, which is used on the Falcon 9 vehicle; Merlin engines use RP-1 and liquid oxygen as propellants in a gas-generator power cycle
- Falcon 9's two-stage configuration minimizes the number of separation events -- and with nine first-stage engines, it can safely complete its mission even in the event of an engine shut-down.
- The first Falcon 9 flight was launched from Cape Canaveral Air Force Station on June 4, 2010.
- As of January 2014, SpaceX has made eight launches of the Falcon 9; all eight have successfully delivered their primary payloads into Earth's orbit.



Antares

- Antares, known during early development as Taurus II, is an expendable launch system developed by Orbital Sciences Corporation.
- Orbital selected the name in keeping with the company's tradition of using Greek-derived celestial names for launch vehicles.
- It was designed to launch the Cygnus, an unmanned resupply spacecraft, to the International Space Station as part of NASA's COTS and CRS programs. Antares is the largest rocket operated by Orbital Sciences.
- The first stage uses RP-1 (kerosene) and liquid oxygen (LOX) as propellants, powering two Aerojet AJ-26 engines, which are modified Russian-built NK-33 engines
- The second stage is a solid-fuel rocket, the Castor 30, developed by ATK as a derivative of the Castor 120 solid stage; third stages are optional.
- The first launch of Antares took place from NASA's Wallops Flight Facility on April 21st, 2013. It also demonstrated successful launch missions on September 18th, 2013 and January 9th, 2014.



Athena

- It originally started life in 1993 as the Lockheed Launch Vehicle, or LLV, later changed to Lockheed Martin Launch Vehicle, or LMLV. By its third launch, it was renamed Athena—the goddess of wisdom, and strategic warfare.
- The Athena comes in two versions, Athena I and Athena II. The Athena I has two stages, the Thiokol Castor-120 first stage and a Pratt & Whitney ORBUS 21D upper stage. The Athena II has three stages, the Castor-120 first and second stages, and an ORBUS 21D upper stage.
- Athena was retired from service in 2001; however, in 2010 it was announced from Lockheed Martin and Alliant Techsystems (ATK) that the companies would be teaming up to put it back into production.
- In September 2010, Athena was added to NASA's Launch Services II contract.
- When flights resume, the Athena Ic and Athena IIC configurations will use Castor 30 stages instead of the Orbus 21D stages on the original versions
- Athena will likely be based at Cape Canaveral, Fla. and Kodiak Island, Alaska. The launch sites would provide access to low-inclination and polar orbits, respectively. Vandenberg Air Force Base, Calif., and Wallops Island, Va. would be other options.
- Between Athena I and II, there have been 7 launches: 5 successes and 2 failures; the last being a success on September 30th, 2001.



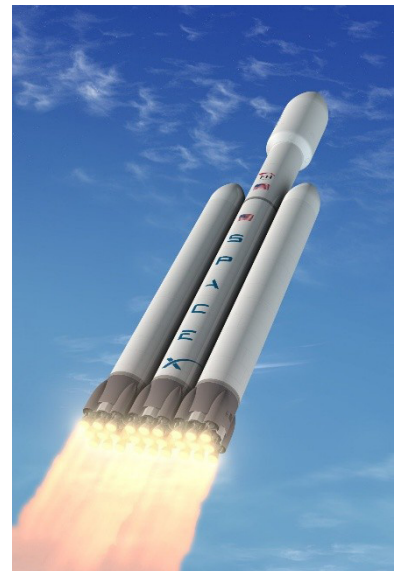
Dragon

- Dragon, manufactured and designed by SpaceX, is a free-flying spacecraft that is launched atop a Falcon 9 booster and designed to deliver both cargo and people to orbit.
- During its un-crewed maiden flight in December 2010, Dragon became the first commercially built and operated spacecraft to be recovered successfully from orbit
- Dragon also made history in 2012 when it became the first commercial spacecraft in to deliver cargo to the International Space Station and safely return cargo to Earth, a feat previously achieved only by governments.
- It is the only spacecraft currently flying that is capable of returning significant amounts of cargo to Earth.
- SpaceX plans to eventually install deployable landing gear and use eight upgraded SuperDraco thrusters to perform a solid earth propulsive landing.
- SpaceX is additionally developing a crewed variant of the Dragon called DragonRider.
- DragonRider will be able to carry up to seven astronauts, or some combination of crew and cargo, to and from low Earth orbit.
- Dragon's first manned test flight is expected to take place in 2-3 years.



Falcon Heavy (In Progress-Expected Launch in 2014)

- Falcon Heavy is expected to be the world's most powerful rocket, a launch vehicle of scale and capability unequaled by any other currently flying.
- With the ability to lift into orbit over 53 metric tons (117,000 lb)--a mass equivalent to a 737 jetliner loaded with passengers, crew, luggage and fuel--Falcon Heavy could lift more than twice the payload of the next closest operational vehicle, the Delta IV Heavy, at one-third the cost.
- Falcon Heavy draws upon the proven heritage and reliability of Falcon 9.
- Its first stage is composed of three Falcon 9 nine engine cores whose 27 Merlin engines together generate nearly 4 million pounds of thrust at liftoff. Only the Saturn V moon rocket, last flown in 1973,



delivered more payload to orbit.

- Falcon Heavy is designed from the outset to carry humans into space and restore the possibility of flying missions with a crew to the Moon or Mars.
- On May 29th, 2012, Intelsat, the world's leading provider of satellite services, and SpaceX, announced the first commercial contract for the Falcon Heavy rocket.

Minotaur I

- The Minotaur I is a four-stage solid fuel space launch vehicle utilizing Minuteman rocket motors for its first and second stages, re-using motors that have been decommissioned as a result of arms reduction treaties.
- The Minotaur I's third and fourth stages, structures, and payload fairing are common with the Pegasus XL rocket and feature flight proven avionics systems.
- Minotaur I is capable of launching payloads up to 580 kg (1,278 lbs) into low Earth Orbit.
- To date, Minotaur I has conducted 11 missions with a 100% success rate, delivering 62 satellites into orbit.



Minotaur IV, V, and VI

- Minotaur IV, which utilizes three government-furnished solid rocket motors from decommissioned Peacekeeper ICBMs and a commercial solid rocket upper stage, is capable of launching payloads up to 1,730 kg (3,814 lb.) to low Earth orbit.
- Minotaur V is an evolutionary version of Minotaur IV, incorporating common structures with relatively minor changes to add a fifth stage.
- Minotaur VI will build on the flight-proven Minotaur IV vehicle by adding a second Peacekeeper lower stage to create a five stage rocket capable of boosting payloads up to 2,600 kg (5,732 lb.) to low Earth orbit.
- The Minotaur IV has had 5 successful launches; V has had 1 successful; VI has had 0 launches to date.



Pegasus and Pegasus XL

- On April 5 1990, Orbital Sciences Corporation launched the first Pegasus rocket from beneath a NASA B-52 aircraft in a mission that originated from the Dryden Flight Research Center in California.

- Pegasus is carried aloft by the Stargazer L-1011 aircraft to approximately 40,000 feet over open-ocean, where it is released and free-falls five seconds before igniting its first stage rocket motor.
- Three main stage boosters featuring solid rocket motors provide the thrust. It flies as a rocket-powered aircraft before leaving the atmosphere.
- With its unique delta-shaped wing, Pegasus typically delivers satellites into orbit in a little over 10 minutes.
- The Pegasus XL, introduced in 1994, has lengthened stages to increase payload performance; resulting in the standard Pegasus being discontinued.
- Pegasus has had 42 launches with both configurations combined since April of 1990, with the last taking place on June 28th, 2013. Three have been failures, and two have been considered “partial failures”, as the orbit was slightly too low.



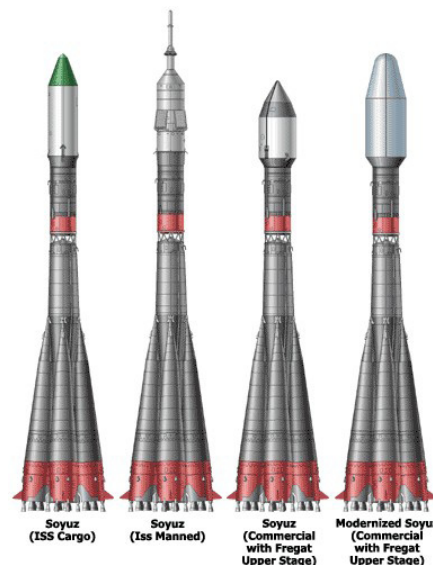
Taurus

- Taurus is a four stage, solid fuel launch vehicle built in the United States by Orbital Sciences Corporation.
- Taurus was designed for easy transportability and rapid set-up and launch; a ground-based variant of Orbital's air-launched Pegasus rocket.
- Taurus has launched 17 satellites in nine missions, with the 1st taking place on March 13th, 1994.
- Launch sites include Wallops Island off of the Eastern shore of Virginia; Vandenberg AFB; Cape Canaveral Air Force Station; and Kodiak Island on the South Coast of Alaska.
- The Taurus first stage, a Castor 120 made by ATK (formerly Thiokol), is based on a Peacekeeper ICBM first stage. Stages 2 and 3 are Orion-50s (like the Pegasus-1 but without wings or stabilizers), and stage 4 is an Orion-38, derived from the Pegasus-3.
- Three of the last four launches have ended in failure, including the February 24, 2009 launch of the Orbiting Carbon Observatory mission and the March 4, 2011 launch of the Glory mission; this resulted in a 700 million dollar loss for NASA, not including the cost of the rockets themselves.



Soyuz

- A family of expendable launch systems developed by OKB-1, and manufactured by TsSKB-Progress in Samara, Russia.
- Vehicles in this family, which have launched both the first satellite and first man into space, trace their roots back to the two-stage R-7A intercontinental ballistic missile; the first in an evolutionary series of launch vehicles, beginning with the launch of Sputnik in 1957.
- According to the European Space Agency, the Soyuz launch vehicle is the most frequently used launch vehicle in the world, with over 1800 manned and unmanned missions to date; far more than any other rocket.
- All Soyuz rockets use RP-1 and liquid oxygen (LOX) propellant, with the exception of the Soyuz-U2, which used Syntin, a variant of RP-1, with LOX.
- Soyuz rockets use various engines, such as the RD-107, RD-117, RD 117A in the 1st stages, the RD-108 and RD-118 in the 2nd stages, and the RD-0110 and RD-0124 in the 3rd stages.
- After the U.S. Space Shuttle program ended in 2011, Soyuz rockets became the only provider of transport for astronauts to the International Space Station.



About the Author:

Nathan Daniels is a Research Assistant & Intern at the American Security Project. He is currently a senior at the University of Tennessee at Martin pursuing a B.A. in Political Science with a concentration in International Security Studies.

See more of Nathan's work here: <http://americansecurityproject.org/about/staff/nathan-daniels/>

Follow him on Twitter: @NathanLDaniels

Further Reading:

[WHITE PAPER – National Security and Space – The Next Space Race: Competition](#)

[National Security and America's Space Challenge](#)

[Senators Call on DOD for Competition in Air Force Space Launch Program](#)

[RD-180 – The Jeopardized Russian Backbone of the US Space Program](#)

[Risk of Russia's Space tie-ins Emerge with Crimea Crisis](#)

Works Cited

Atlas V

<http://www.lockheedmartin.com/us/products/atlas/lv.html>

<http://www.afspc.af.mil/library/factsheets/factsheet.asp?id=3643>

http://web.archive.org/web/20060204073649/http://www.geocities.com/atlas_missile/Chronology.html

Photo Credit – United Launch Alliance

Delta IV

<http://www.boeing.com/boeing/defense-space/space/delta/delta4/delta4.page>

http://www.ulalaunch.com/site/pages/Products_DeltaIV.shtml

http://www.spaceflightnow.com/delta/d365/SpaceflightNow_Delta4_factsheet.pdf

<http://www.ulalaunch.com/site/pages/News.shtml#/167>

<http://www.spacelaunchreport.com/delta4.html>

Photo Credit – United Launch Alliance

Falcon 9

<http://www.spacex.com/falcon9>

<http://web.archive.org/web/20120323073919/http://www.spacex.com/falcon9.php>

<http://www.spacex.com/news/2013/03/26/merlin-engines>

Photo Credit – SpaceX

Antares

http://www.nasa.gov/home/hqnews/2013/apr/HQ_13-114_Antares_launches.html

<http://www.nasaspaceflight.com/2011/12/taurus-ii-changes-name-to-the-antares-ahead-of-debut-launch/>

<http://www.space.com/6257-nasa-taps-spacex-orbital-sciences-haul-cargo-space-station.html>

http://www.orbital.com/LaunchSystems/SpaceLaunchVehicles/Antares/Mission_History/default.aspx

<http://www.orbital.com/LaunchSystems/SpaceLaunchVehicles/Antares/>

http://www.orbital.com/LaunchSystems/Publications/Antares_UsersGuide.pdf

Photo Credit – Orbital Sciences Corporation

Athena

<http://www.lockheedmartin.com/us/products/athena.html>

<http://www.spaceflightnow.com/news/n1003/25athena/>

<http://www.thespacereview.com/article/2234/1>

Photo Credit – NASA

Delta II

<http://www.boeing.com/boeing/defense-space/space/bls/deltaHistory.page>

<http://www.boeing.com/boeing/defense-space/space/delta/delta2/delta2.page>

<http://www.comspacewatch.com/news/viewpr.html?pid=21394>

http://www.ulalaunch.com/site/docs/product_cards/DII_product_card.pdf

<http://www.rocket.com/delta-ii-stage-2-engine>

Photo Credit – United Launch Alliance

Dragon

<http://www.spacex.com/dragon>

<http://www.dailymail.co.uk/sciencetech/article-1336868/SpaceX-Dragon-privately-funded-spaceship-launched-orbit.html>

<http://www.space.com/15805-spacex-private-capsule-launches-space-station.html>

<http://news.nationalgeographic.com/news/2012/05/120525-spacex-dragon-robot-arm-international-space-station-nation/>

Photo Credit – SpaceX

Falcon Heavy

<http://www.spacex.com/falcon-heavy>

<http://www.spaceflightnow.com/news/n1203/11spacex39a/>

<http://www.spacex.com/press/2012/12/19/intelsat-signs-first-commercial-falcon-heavy-launch-agreement-spacex>

Photo Credit – SpaceX

Minotaur Launch Vehicles

<http://www.orbital.com/LaunchSystems/SpaceLaunchVehicles/Minotaur/>

http://www.orbital.com/LaunchSystems/Publications/MinotaurVI_factsheet.pdf

<http://www.astronautix.com/lvs/minotaur.htm>

http://www.orbital.com/LaunchSystems/Publications/MinotaurV_factsheet.pdf

http://www.orbital.com/LaunchSystems/Publications/MinotaurVI_factsheet.pdf

http://www.orbital.com/LaunchSystems/Publications/MinotaurIV_factsheet.pdf

http://www.orbital.com/LaunchSystems/Publications/MinotaurI_factsheet.pdf

Photo Credit – Orbital Sciences Corporation

Pegasus and Pegasus XL

<http://www.orbital.com/LaunchSystems/SpaceLaunchVehicles/Pegasus/>

http://www.orbital.com/LaunchSystems/SpaceLaunchVehicles/Pegasus/Mission_History/default.aspx

http://www.orbital.com/LaunchSystems/Publications/Pegasus_UsersGuide.pdf

Photo Credit – Orbital Sciences Corporation

Taurus

http://www.orbital.com/LaunchSystems/Publications/Taurus_factsheet.pdf#search=taurus

http://www.newscientist.com/article/dn16650-satellite-to-pinpoint-sources-and-sinks-of-co2.html#.UzM4_vldWgU

<http://www.cbsnews.com/news/nasa-launch-mishap-satellite-crashes-into-ocean/>

<http://www.astronautix.com/lvs/taurus.htm>

Photo Credit – Orbital Sciences Corporation

Soyuz

<http://www.arianespace.com/launch-services-soyuz/soyuz-introduction.asp>

http://www.esa.int/Our_Activities/Human_Spaceflight/Delta_Mission/Soyuz_launch_vehicle_The_most_reliable_means_of_space_travel

<http://www.starsem.com/soyuz/soyuz.htm>

<http://www.starsem.com/soyuz/introduction.htm>

http://www.arianespace.com/launch-services-soyuz/Soyuz_Users_Manual_CSG_June06.pdf

Photo Credit – Starsem- The Soyuz Company

BOARD OF DIRECTORS



The Honorable Gary Hart, Chairman

Senator Hart served the State of Colorado in the U.S. Senate and was a member of the Committee on Armed Services during his tenure.



Admiral William Fallon, USN (Ret.)

Admiral Fallon has led U.S. and Allied forces and played a leadership role in military and diplomatic matters at the highest levels of the U.S. government.



Norman R. Augustine

Mr. Augustine was Chairman and Principal Officer of the American Red Cross for nine years and Chairman of the Council of the National Academy of Engineering.



Raj Fernando

Raj Fernando is CEO and founder of Chopper Trading, a technology based trading firm headquartered in Chicago.



The Hon. Donald Beyer

The Hon. Donald Beyer is the former United States Ambassador to to Switzerland and Liechtenstein, as well as a former Lieutenant Governor and President of the Senate of Virginia.



Vice Admiral Lee Gunn, USN (Ret.)

Vice Admiral Gunn is the President of the Institute of Public Research at the CNA Corporation, a non-profit corporation in Virginia.



Lieutenant General John Castellaw, USMC (Ret.)

John Castellaw is President of the Crockett Policy Institute (CPI), a non-partisan policy and research organization headquartered in Tennessee.



Lieutenant General Claudia Kennedy, USA (Ret.)

Lieutenant General Kennedy was the first woman to achieve the rank of three-star general in the United States Army.



Brigadier General Stephen A. Cheney, USMC (Ret.)

Brigadier General Cheney is the Chief Executive Officer of ASP.



General Lester L. Lyles, USAF (Ret.)

General Lyles retired from the United States Air Force after a distinguished 35 year career. He is presently Chairman of USAA, a member of the Defense Science Board, and a member of the President's Intelligence Advisory Board.



Lieutenant General Daniel Christman, USA (Ret.)

Lieutenant General Christman is Senior Vice President for International Affairs at the United States Chamber of Commerce.



Dennis Mehiel

Dennis Mehiel is the Principal Shareholder and Chairman of U.S. Corrugated, Inc.



Robert B. Crowe

Robert B. Crowe is a Partner of Nelson Mullins Riley & Scarborough in its Boston and Washington, DC offices. He is co-chair of the firm's Government Relations practice.



Stuart Piltch

Stuart Piltch is the Co-Founder and Managing Director of Cambridge Advisory Group, an actuarial and benefits consulting firm based in Philadelphia.



Lee Cullum

Lee Cullum, at one time a commentator on the PBS NewsHour and "All Things Considered" on NPR, currently contributes to the Dallas Morning News and hosts "CEO."



Ed Reilly

Edward Reilly is CEO of Americas of FD International Limited, a leading global communications consultancy that is part of FTI Consulting, Inc.



Nelson W. Cunningham

Nelson Cunningham is President of McLarty Associates.



Governor Christine Todd Whitman

Christine Todd Whitman is the President of the Whitman Strategy Group, a consulting firm that specializes in energy and environmental issues.

The American Security Project (ASP) is a nonpartisan organization created to educate the American public and the world about the changing nature of national security in the 21st Century.

Gone are the days when a nation's security could be measured by bombers and battleships. Security in this new era requires harnessing all of America's strengths: the force of our diplomacy; the might of our military; the vigor and competitiveness of our economy; and the power of our ideals.

We believe that America must lead in the pursuit of our common goals and shared security. We must confront international challenges with our partners and with all the tools at our disposal and address emerging problems before they become security crises. And to do this we must forge a bipartisan consensus here at home.

ASP brings together prominent American business leaders, former members of Congress, retired military flag officers, and prominent former government officials. ASP conducts research on a broad range of issues and engages and empowers the American public by taking its findings directly to them via events, traditional & new media, meetings, and publications.

We live in a time when the threats to our security are as complex and diverse as terrorism, nuclear proliferation, climate change, energy challenges, and our economic wellbeing. Partisan bickering and age old solutions simply won't solve our problems. America – and the world - needs an honest dialogue about security that is as robust as it is realistic.

ASP exists to promote that dialogue, to forge that consensus, and to spur constructive action so that America meets the challenges to its security while seizing the opportunities that abound.



American Security Project

www.americansecurityproject.org