SPACEX

COTS 2 MISSION

PRESS KIT

COTS 2 Mission Press Kit

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HIGH-RESOLUTION PHOTOS AND VIDEO

SpaceX will post photos and video throughout the mission.

High-Resolution photographs can be downloaded from: http://spacexlaunch.zenfolio.com
Broadcast quality video can be downloaded from: https://vimeo.com/spacexlaunch/videos

MORE RESOURCES ON THE WEB

Mission updates will be posted to:

www.SpaceX.com
www.twitter.com/elonmusk
www.twitter.com/spacex
www.facebook.com/spacex
http://www.youtube.com/spacexchannel

For NASA coverage, visit:

http://www.nasa.gov/spacex
http://www.nasa.gov/nasatv
http://www.nasa.gov/station.

WEBCAST INFORMATION

The launch will be webcast live, with commentary from SpaceX corporate headquarters in Hawthorne, CA, at www.spacex.com.

The webcast will begin approximately 40 minutes before launch.

SpaceX hosts will provide information specific to the flight, an overview of the Falcon 9 rocket and Dragon spacecraft, and commentary on the launch and flight sequences. It will end when the Dragon spacecraft separates from the 2nd stage of the Falcon 9 rocket.

SPACEX MEDA CONTACT

Kirstin Brost Grantham
Director of Communications, SpaceX
202-649-2716
media@spacex.com

NASA PUBLIC AFFAIRS CONTACTS

Josh Byerly
Public Affairs Officer
COTS Program Lead, NASA Johnson Space Center
281-483-5111

Kelly Humphries
Public Affairs Officer
International Space Station Program Lead
NASA Johnson Space Center
281-483-5111

George Diller
Public Affairs Officer
Launch Operations, NASA Kennedy Space Center
321-867-2468

Michael Braukus
Public Affairs Officer
Human Exploration and Operations
NASA Headquarters
202-358-1979

SPACEX

COTS 2 Demonstration

First Attempt by a Commercial Company to Send a Spacecraft to the Space Station

A New Era in Spaceflight

We stand at the dawn of an exciting new era in space travel: one in which NASA and commercial companies work in partnership to provide rapid advances in space transportation.

This SpaceX mission is a milestone in that transition, marking the first time in history that a commercial company will attempt to send a spacecraft to the International Space Station, something only a few governments have ever accomplished. This is a demonstration mission, a test flight primarily designed to provide NASA and SpaceX with valuable insight to ensure successful future missions.

Mission Highlights

During the mission, Dragon must perform a series of complex tasks, each presenting significant technical challenges (timeline could change):

- Day 1/Launch Day: SpaceX's Falcon 9 rocket launches a Dragon spacecraft into orbit from the Cape Canaveral Air Force Station.
- Day 2: Dragon orbits Earth as it travels toward the International Space Station.
- Day 3: Dragon's sensors and flight systems are subject to a series of complicated tests to determine if the vehicle is ready to berth with the space station; these tests include maneuvers and systems checks that see the vehicle come within 1.5 miles of the station.
- Day 4: NASA decides if Dragon is allowed to attempt to berth with the station. If so, Dragon approaches; it is captured by station's robotic arm and attached to the station. This requires extreme precision even as both Dragon and station orbit the earth every 90 minutes.
- Day 5 - TBD: Astronauts open Dragon's hatch, unload supplies and fill Dragon with return cargo.
- TBD: After approximately two weeks, Dragon is detached from the station and returns to Earth, landing in the Pacific, hundreds of miles west of Southern California.

Pushing the Envelope, Success is Not Guaranteed

Demonstration launches are conducted to determine potential issues so that they might be addressed and – by their very nature – carry a significant risk. All spaceflight is incredibly complicated, and this flight introduces a series of new challenges -- it is only the third flight of the Falcon 9 rocket, the second of the Dragon capsule, and the first for a number of all-new components necessary to berth with the International Space Station. If any aspect of the mission is not successful, SpaceX will learn from the experience and try again.

2nd Flight of the NASA COTS Program

This is SpaceX's second demonstration flight under a 2006 Commercial Orbital Transportation Services (COTS) agreement with NASA to develop the capability to carry cargo to and from the International Space Station. To date, SpaceX has received $381 million for completing 37 out of 40 milestones worth a possible $396 million set in that agreement. Completed milestones include the first test flight in December 2010, during which SpaceX became the first commercial company to send a spacecraft to low-Earth orbit and recover it successfully, something that only three governments – the United States, Russia and China – have ever done.

Next Up

Once SpaceX has successfully demonstrated Dragon's ability to berth with the space station, it will begin to fulfill a 2008 contract signed with NASA for a minimum of 12 flights carrying supplies to and from the space station. Without the space shuttle, Dragon is the only spacecraft in the world capable of returning significant cargo from the space station. Falcon 9 and Dragon were designed to carry astronauts in the future; these cargo missions will yield valuable flight experience toward this goal.

SpaceX Demonstration Mission

MISSION OVERVIEW

For the first time in history, a private corporation is set to prove it can deliver cargo to the International Space Station. At the Cape Canaveral Air Force Station, Fla., a Falcon 9 rocket belonging to Space Exploration Technologies (SpaceX), is being prepared to place its Dragon spacecraft into orbit on a test mission to the orbital outpost.

Working for the past six years under NASA's Commercial Orbital Transportation Services program (COTS), both SpaceX and Orbital Sciences Corp. have been pursuing independent efforts to design, test and fly two brand new cargo vehicles. These will provide the United States with safe, reliable and efficient cargo delivery services to the orbiting complex NASA built with its international partners.

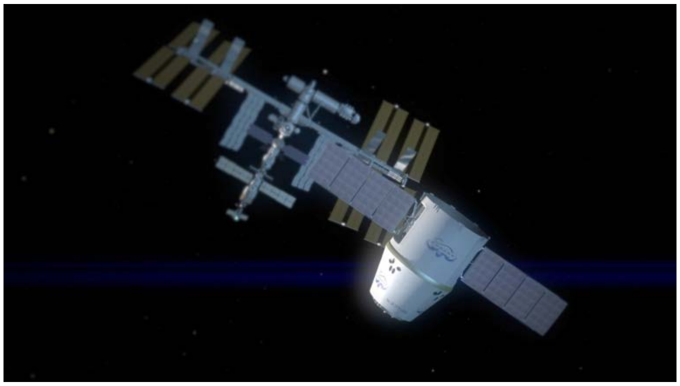
The first COTS demonstration flight that SpaceX completed was in December 2010, where it proved that it could launch, orbit and recover its Dragon spacecraft. Prior to that, the maiden flight of the Falcon 9 demonstrated it could launch a Dragon capsule simulator atop a Falcon 9 rocket. This upcoming mission will prove that Dragon can rendezvous and berth with the International Space Station.

After launching from the Cape Canaveral Air Force Station, Dragon will begin its journey to the space station. Just under 10 minutes after launch, Dragon will reach its preliminary orbit, deploy its solar arrays and begin a carefully choreographed series of engine firings to reach the station. During this part of the flight, Dragon will demonstrate the first set of tests as part of its COTS milestone requirements. The spacecraft will perform a test of its Absolute GPS (AGPS) system, using global positioning system satellites to determine its location. It also will conduct a free drift demonstration, allowing the spacecraft to float freely with all of its thrusters inhibited. Then Dragon will perform a demonstration of its abort capability, to ensure it could move away from the station if necessary.

On the third day of the flight, Dragon will perform a burn that will bring it to a path 2.5 kilometers (1.5 miles) below the station. During this "fly-under," Dragon will establish UHF communication with the station using its COTS Ultra-high frequency Communication Unit (CUCU). Dragon will perform a test of its Relative GPS (RGPS) system, which uses the relative positions of the spacecraft to the space station to determine its location. Also, using the crew command panel (CCP) on board the station, the Expedition crew will briefly interact with Dragon, monitoring the fly-under and sending a command to Dragon to turn on its strobe light. This ability for the crew to send commands to Dragon will be important for the next day's activity. Once the fly-under is complete, Dragon will fire its engines to begin a loop out in front, above and then behind the station in a racetrack pattern at a distance between 7-10 kilometers (4-6.2 miles). This will set the spacecraft up for a re-rendezvous with the station the next day.

For its final day of approach to the station, Dragon will perform another engine burn that will bring it 2.5 kilometers (1.5 miles) below the station once again. A go/no-go is performed by the Mission Control Houston team to allow Dragon to perform another set of burns that will bring it to within 1.4 kilometers (0.87 miles) of the station. Another go/no-go will take place from Mission Control Houston, and then Dragon will move from up to 250 meters (820 feet) from the station. The next set of COTS milestone demonstrations will begin, the first of which is Dragon's test of its LIDAR system. This test will confirm that Dragon's position and velocity is accurate by comparing the

LIDAR image that Dragon receives against Dragon's thermal imagers. A series of checkout maneuvers will commence. The Dragon flight control team in Hawthorne, Calif., will command the spacecraft to approach the station from its hold position. It will move from 250 meters to 220 meters below the station (720 feet). The crew, using the CCP, will then command Dragon to retreat, and the spacecraft will move back down to the hold point. This test will ensure that Dragon's range to the ISS is accurate, and that the flight control team sees the spacecraft's acceleration and braking perform as expected. It will hold at 250 meters, and once again the Dragon flight team will command it to approach the station. At the 220 meter position, the crew will command the vehicle to hold.



Another go/no-go is performed in Houston, and then Dragon is permitted to enter inside the Keep-Out Sphere (KOS), an imaginary circle drawn 200 meters (656 feet) around the station that prevents the risk of collision with the orbiting complex. Dragon will proceed to a position 30 meters (98 feet) from the station and will automatically hold. Another go/no-go is completed, and then Dragon will proceed to the 10 meter (32 feet) position, which is the capture point. A final go/no-go is performed, and the Mission Control Houston team will notify the crew they are go to capture Dragon.

At that point, Expedition 31 crew member Don Pettit will use the station's robotic arm, which measures 17.6 meters (57.7 feet) long, to reach out and grapple the Dragon spacecraft. Pettit, with the help of fellow crewmember Andre Kuipers, will guide Dragon to the bottom, Earth-facing side of the Harmony node, where it will be attached to the station. If the rendezvous and Dragon testing runs long, Mission Control could elect to leave Dragon grappled to the station's arm overnight before berthing it the next day.

The crew will open the hatch between the Dragon and the station the following day, after performing an inspection of the air inside Dragon, a standard procedure for any visiting vehicle. The crew will spend about 25 hours over the next couple of weeks unloading the Dragon of the cargo that was flown up to the station. On this test flight, Dragon will transport 460 kilograms (1,014 pounds) of cargo and will return 620 kilograms (1,367 pounds). Because this is a test flight, the cargo being brought to the station is considered non-critical and includes additional food, water and clothing for the station residents. It will supplement what was flown on the European Space Agency's Automated Transfer Vehicle, which docked with the station on March 28.

Dragon will spend about two weeks attached to the space station, at which point the crew will detach it from Harmony, maneuver it out to the 10 meter release point and then will ungrapple the vehicle. Dragon will perform a series of engine burns that will place it on a trajectory to take it away from the vicinity of the station. Mission Control Houston will then confirm that Dragon is on a safe path away from the complex.

Approximately four hours after Dragon leaves the station, it will conduct its deorbit burn, which lasts about seven minutes. It takes about 30 minutes for Dragon to re-enter the Earth's atmosphere and splashdown in the Pacific Ocean, about 450 kilometers (250 miles) off the West Coast of the United States.

Dragon Recovery

The Dragon spacecraft is targeted to land in the Pacific Ocean, a few hundred miles west of Southern California.

The landing location is controlled by firing the Draco thrusters during reentry. In a carefully timed sequence of events, dual drogue parachutes deploy at 45,000 feet to stabilize and slow the spacecraft.

Full deployment of the drogues triggers the release of the main parachutes, each 116 feet in diameter, at about 10,000 feet, with the drogues detaching from the spacecraft. Main parachutes further slow the spacecraft's descent to approximately 16 to 18 feet per second. Oversized parachutes are critical in ensuring a safe landing for crew members. Even if Dragon were to lose one of its main parachutes, the two remaining chutes would still ensure a safe landing.

SpaceX will use a 185 -foot working barge equipped with a crane and pulled by a tug boat, an 80 -foot crew boat, and two 25 -foot rigid hull inflatable boats (RIB) to conduct recovery operations. On board will be approximately a dozen SpaceX engineers and technicians as well as a 4 -person dive team.

When Dragon returns, the boats will be waiting outside the targeted landing area, which is a few days' journey from land.

Once Dragon lands in the water, the 25 -foot boats will carry the experienced dive team to the floating spacecraft. They will secure the vehicle and tow it to the barge, where the crane will pick it up and place it on deck.

On this mission, Dragon will be recovered by ship. Long term, once SpaceX has proven the ability to control reentry accurately, we intend to add deployable landing gear to touch down on land.

Mission Objectives

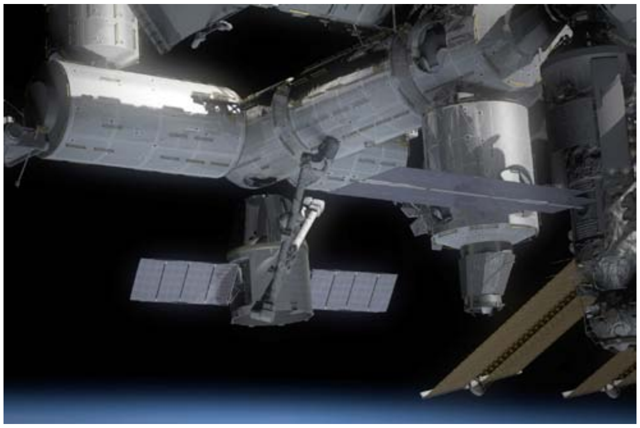
While the Dragon spacecraft's attempt to visit the International Space Station represents an historic first, the act of berthing itself represents only one of many significant challenges involved in this demonstration mission. Successfully attaching to the space station is an important goal, but it is only one measure of success.

During this flight, SpaceX must complete milestones for two separate missions – COTS 2 and COTS 3. SpaceX and NASA agreed on the following objectives for those two missions.

COTS 2 OFFICIAL MISSION OBJECTIVES

Complete Licenses and Certifications:

- United States Air Force 45th Space Wing certifies launch.
- Federal Aviation Administration issues licenses to launch and to return the spacecraft from orbit.



Rocket Launch and Spacecraft Inserted into Orbit:

- Falcon 9 rocket ascends through lightning towers on the launch site without contact.
- Rocket's first stage separates from its second stage, and the second stage engine ignites.
- Rocket's second stage places the Dragon spacecraft into planned orbit -- currently 310 km x 340 km above the Earth (+50 km, altitude not to exceed 368 km).
- Dragon is also placed in planned inclination -- currently 51.6 degrees (+0.25 degree).

On-Orbit Operations:

- Dragon spacecraft separates from rocket's second stage.
- Solar arrays deploy from Dragon's trunk and function properly.
- Dragon completes system checkout.
- Dragon initiates phasing and height adjustment maneuver.
- Dragon performs Abort Demonstration.
- Dragon performs Absolute GPS Demonstration.
- Dragon establishes communication with International Space Station using SpaceX's COTS UHF Communication Unit (CUCU). Astronauts on the space station are able to issue commands to Dragon using the Crew Command Panel (CCP).
- Dragon performs Relative GPS Demonstration.
- Dragon demonstrates free drift, then stops and floats freely in orbit as it will when grappled by the space station's robotic arm.
- Dragon's performance during extended time in orbit is demonstrated, testing that the vehicle's components are able to operate in the environments (vacuum, thermal, and radiation) found in space, especially Dragon's solar arrays, radiators, avionics, and trunk.
- Performance of new, redundant (triple string) avionics and of spacecraft systems is demonstrated.

De-orbit Burn & Separation:

- Dragon's Draco thrusters successfully perform de-orbit burn sending the vehicle back to Earth on target for landing within landing area.

Controlled Entry, Descent, and Landing:

- Dragon successfully deploys main parachutes.
- Dragon lands in set landing area in the Pacific Ocean, west of Southern California.

Recovery:

- The Dragon spacecraft is successfully recovered.

COTS 3 MISSION OBJECTIVES

On-Orbit Operations -- Approach:

- NASA approves Dragon to enter Approach Ellipsoid.
- Laser Imaging Detection and Ranging (LIDAR) camera used for navigation during approach to the space station are tested.
- Dragon holds on R-bar.
- Dragon demonstrates a retreat on R-bar.

International Space Station -- Attached Operations:

- Dragon is commanded to free drift.
- Dragon is successfully grappled by the station's robotic arm - Space Station Remote Manipulator System (SSRMS).
- Dragon's Passive Common Berthing Mechanism (PCBM) successfully mates with the International Space Station.
- Astronauts open Dragon's hatch.
- Astronauts remove cargo from Dragon then load cargo onto Dragon.

On-Orbit Operations -- Departure:

- Dragon is successfully de-berthed from the Space Station.
- Dragon successfully lowers its orbit for reentry.

Recovery:

- Outbound cargo is recovered on earth and returned to NASA.

Mission Timeline

Times and Dates Are Subject to Change

PRE-LAUNCH

Hour Min Sec	Events
- 7:30:30	Vehicles are powered on
- 3:50:00	Commence loading liquid oxygen (LOx)
- 3:40:00	Commence loading RP-1 (rocket grade kerosene)
- 3:15:00	LOx and RP-1 loading complete
- 0:10:30	F9 terminal count autosequence started
- 0:05:30	Dragon terminal count auto starts
- 0:02:30	SpaceX Launch Director verifies go for launch
- 0:02:00	Range Control Officer (USAF) verifies range is go for launch
- 0:01:00	Command flight computer state to startup, turn on pad deck and Niagara Water
- 0:00:40	Pressurize propellant tanks
- 0:00:03	Engine controller commands engine ignition sequence to start
0:00:00	Falcon 9 Launch

LAUNCH

Hour Min Sec	Events
0:01:24	Max Q
0:03:00	1st stage engine shutdown/Main Engine Cut Off (MECO)
0:03:05	1st and 2nd stages separate
0:03:12	Stage 2 engine starts
0:03:52	Dragon nose cone jettisoned
0:09:14	2nd stage engine cut off (SECO)
0:09:49	Dragon separates from 2nd stage

On Orbit Operations/Initial Demonstrations in the Far Field

0:11:53	Start sequence to deploy solar arrays
0:54:49	Demonstrate absolute GPS
2:26:48	Start GNC Bay door deployment, this door holds sensors necessary for rendezvous
2:40:49	Relative navigation sensors checkout, checks LIDAR and Thermal Imager
8:46:52	Demonstrate full abort, demonstrates Dragon’s ability to abort with a continuous burn
9:57:58	Pulsed abort demonstration, checks Dragon’s ability to perform abort using pulsating burns
10:37:58	Demonstrate Dragon’s ability to free drift

DRAGON PHASING –Dragon Moves Closer to the Space Station Day 2

- Co-elliptic burns, place Dragon in a circular orbit
- Height adjust burns, start adjusting altitude higher towards station

FLYBY OPERATIONS Day 3

- Height adjust burn carries Dragon 2.5 km below the station (GO/NO-GO)
- Dragon demonstrates relative GPS
- Dragon starts receiving and transmitting information from/to the CUCU unit on the station
- Height adjust burn carries Dragon away from ISS

RE-RENDEZVOUS – Dragon flies around the station, returning to its original approach location Day 3-4

- Dragon begins burns that carry the spacecraft above the space station (GO/NO-GO)
- Rear height adjust burn, Dragon starts a series of maneuvers that place it behind and below the space station (GO/NO-GO)

HEIGHT ADJUST MANEUVERS TO CAPTURE Day 4

- Height adjust burn, Dragon begins burns that bring it within 2.5 km of station (GO/NO-GO)
- Dragon again receives and sends information from/to the CUCU unit on station
- Height adjust burn, brings Dragon 1.2 km from station (GO/NO-GO)
- Height adjust burn, carries Dragon into the station's approach ellipsoid (GO/NO-GO)

R-BAR TO CAPTURE (Radial Bar is an imaginary line connecting station to center of the Earth) Day 4

- Dragon LIDAR Demo, shows LIDAR is providing Dragon with necessary information for proximity operations
- Dragon holds at 250 meters (GO/NO-GO) for Demo Maneuvers
- Dragon begins R-Bar Demonstration (GO/NO-GO)
- Dragon holds at 30 meters
- Dragon holds at capture point, 10 meters below the station
- Station's robotic arm (SSRMS) captures Dragon (GO/NO-GO)
- Dragon berths

RETURN TBD

- Dragon vestibule de-mate and depressurization
- Station's robotic arm uninstalls Dragon
- Robotic arm releases Dragon
- Dragon starts departure burns
- Dragon closes the guidance, navigation and control bay door
- Deorbit burn
- Trunk jettisoned
- Drogue chutes deployed
- Main chutes deployed
- Dragon lands in water and is recovered

Dragon Cargo Manifest
USOS (U.S. On-Orbit Segment) Cargo

LAUNCH

Food and Crew Provisions	674 pounds (306 kilograms)
• 13 bags standard rations	• Food, about 117 standard meals, and 45 low-sodium meals
• 5 bags low-sodium rations	
• Crew clothing	
• Pantry items (batteries, etc)	
• SODF and Official Flight Kit	

Utilization Payloads	46.3 pounds (21 kilograms)
• NanoRacks Module 9 for U.S. National Laboratory	• NanoRacks-CubeLabs Module-9 uses a 2 cube unit box for student competition investigations using 15 liquid mixing tube assemblies that function similar to commercial glow sticks. Science goals for NanoRacks-CubeLabs Module-9 range from microbial growth to water purification in microgravity
• Ice bricks	• For cooling and transfer of experiment samples

Cargo Bags	271.1 pounds (123 kilograms)
• Cargo bags	• Preposition of cargo bags for future flights

Computers and Supplies	22 pounds (10 kilograms)
• Laptop, batteries, power supply cables	

Total Cargo Mass	1,014 pounds (460 kilograms)
Total Mass Including Packaging	1,146 pounds (520 kilograms)

National Aeronautics and Space Administration

Dragon Cargo Manifest

USOS (U.S. On-Orbit Segment) Cargo

RETURN

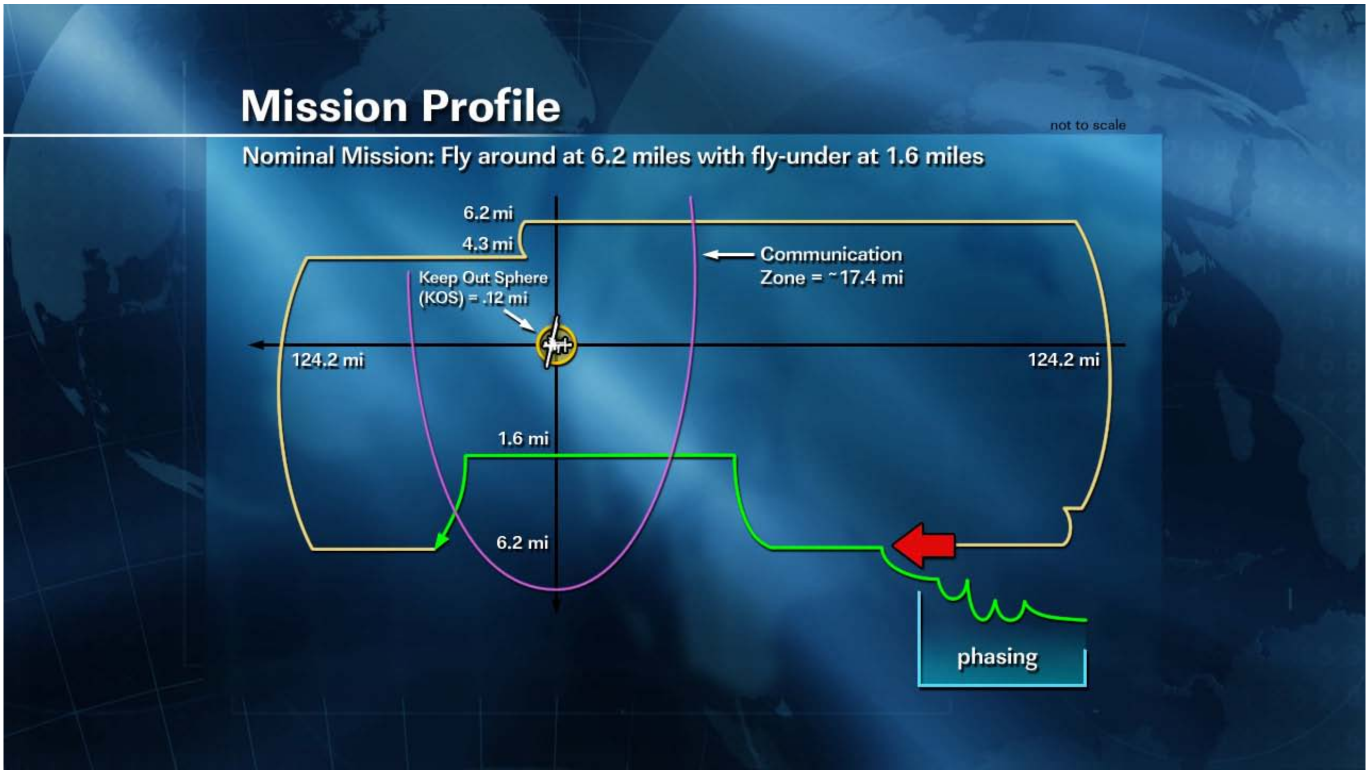
Crew Preference Items	315 pounds (143 kilograms)
• Crew preference items, official flight kit items	

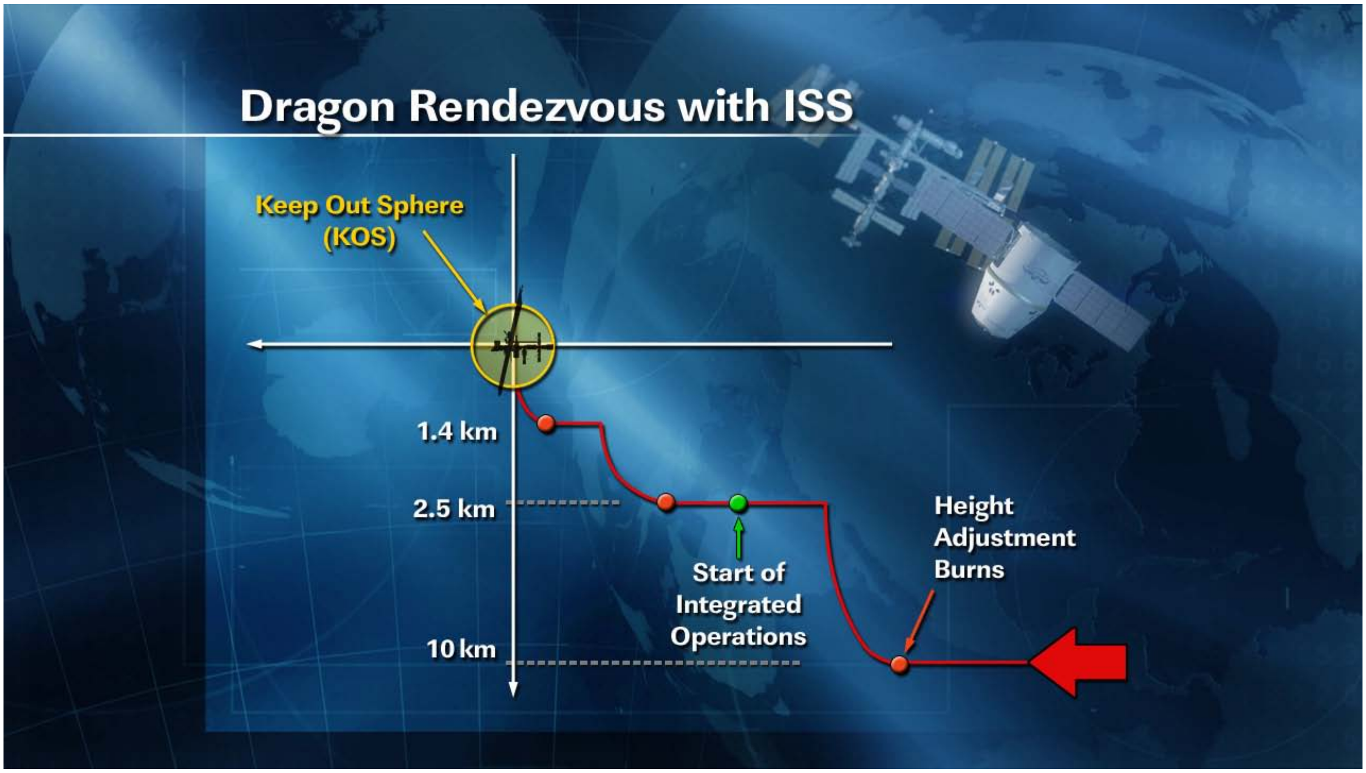
Utilization Payloads	205 pounds (93 kilograms)
• "Plant Signaling" hardware (16 Experiment Unique Equipment Assemblies)	• Plant Signaling seeks to understand the molecular mechanisms plants use to sense and respond to changes in their environment. Ambient Hardware return only; no plant sample return (24 kg)
• Shear History Extensional Rheology Experiment (SHERE) Hardware	• SHERE seeks to understand how liquid polymers behave in microgravity by measuring response to straining and stressing. Ambient hardware return; no samples (36 kg)
• Materials Science Research Rack (MSRR) Sample Cartridge Assemblies (Qty 3)	• MSRR experiments examined various aspects of alloy materials processing in microgravity • SETA (Solidification along a Eutectic path in Ternary Alloys-2) • MICAST/CETSOL (Microstructure Formation in Casting of Technical Alloys under Diffusive and Magnetically Controlled Convective Conditions/Columnar-to-Equiaxed Transition in Solidification Processing) • Ambient hardware return with samples (9kg)
• Other	• Supporting research hardware such as Combustion Integrated Rack (CIR) and Active Rack Isolation (ARIS) components, double cold bags, MSG Tapes

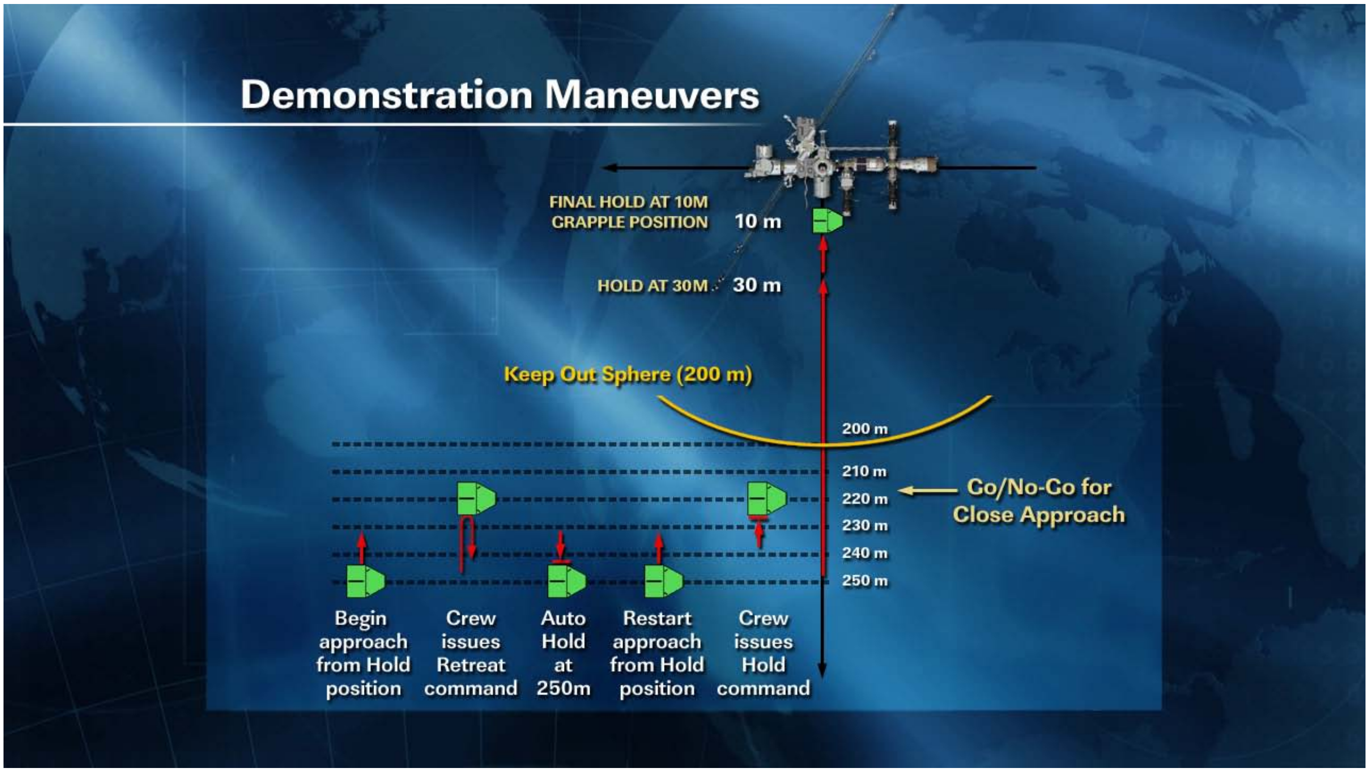
Systems Hardware	760 pounds (345 kilograms)
• Multifiltration Bed • Fluids Control and Pump Assembly • Iodine Compatible Water Containers • JAXA Multiplexer	

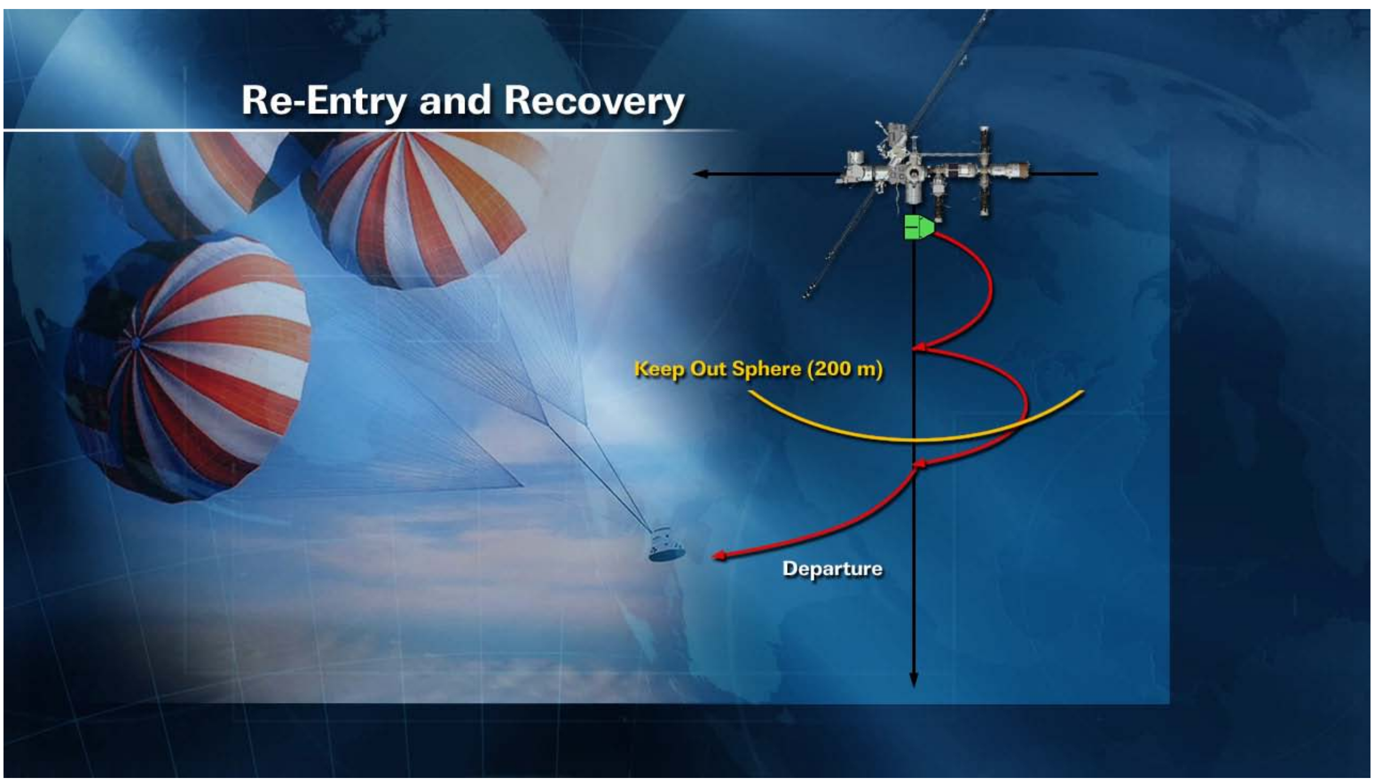
Spacewalk Hardware	86 pounds (39 kilograms)
• EMU hardware and gloves for previous crew members	

Total Cargo Mass	1,367 pounds (620 kilograms)
Total Mass Including Packaging	1,455 pounds (660 kilograms)


Mission Profile
not to scale
Nominal Mission: Fly around at 6.2 miles with fly-under at 1.6 miles
6.2 mi
4.3 mi
Keep Out Sphere
(KOS) = .12 mi
Communication
Zone = ~17.4 mi
124.2 mi
124.2 mi
1.6 mi
6.2 mi
phasing


Dragon Rendezvous with ISS
Keep Out Sphere
(KOS)
1.4 km
2.5 km
10 km
Start of
Integrated
Operations
Height
Adjustment
Burns


Demonstration Maneuvers
FINAL HOLD AT 10M
GRAPPLE POSITION
10 m
HOLD AT 30M
30 m
Keep Out Sphere (200 m)
200 m
210 m
220 m
230 m
240 m
250 m
Go/No-Go for
Close Approach
Begin approach from Hold position
Crew issues Retreat command
Auto Hold at 250m
Restart approach from Hold position
Crew issues Hold command


Re-Entry and Recovery
Keep Out Sphere (200 m)
Departure

International Space Station Overview

The International Space Station is an unprecedented achievement in global human endeavors to conceive, plan, build, operate and use a research platform in space.

Almost as soon as the space station was habitable, researchers began using it to study the impact of microgravity and other space effects on several aspects of our daily lives. With more than 1,200 experiments completed on the station to date, the unique scientific platform continues to enable researchers from all over the world to put their talents to work on innovative experiments that could not be performed anywhere else.

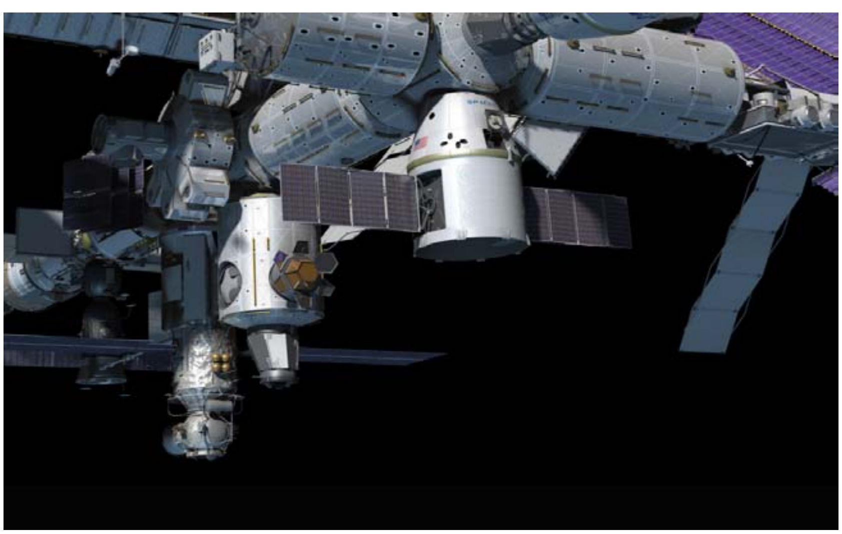
The space station represents the culmination of more than two decades of dedicated effort by a multinational team of agencies spanning Canada, Europe, Japan, Russia and the United States. While the various space agency partners may emphasize different aspects of research to achieve their goals in the use of space station, they are unified in using the space station to its full potential as a research platform for the betterment of humanity.

The space station provides the first laboratory complex where gravity, a fundamental force on Earth, is virtually eliminated for extended periods. This ability to control the variable of gravity in experiments opens up unimaginable research possibilities. As a research outpost, the station is a test bed for future technologies and a laboratory for new, advanced industrial materials, communications technology, medical research, and more.

In the areas of human health, telemedicine, education and observations from space, the station already has provided numerous benefits to human life on Earth. Vaccine development research, station-generated images that assist with disaster relief and farming, and education programs that inspire future scientists, engineers and space explorers are just some examples of research benefits, which are strengthening economies and enhancing the quality of life on Earth.

Clearly visible with the naked eye in the night sky, the expansive International Space Station is a working laboratory orbiting 240 statute miles (386.24 kilometers) above the Earth traveling at 17,500 miles per hour (32,410 kilometers per hour) and is home to an international crew.

The most complex scientific and technological endeavor ever undertaken, the five supporting agencies represent 15 nations: the U.S., Canada, Japan, Russia, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.



On-orbit assembly began in November 1998 with the launch of its first module, Zarya, and was completed with the departure of the Space Shuttle Atlantis on the program's final flight in June 2011. The station is as large as a five-bedroom home with two bathrooms, a gymnasium and a 360-degree bay window, and provides crew members with more than 33,000 cubic feet (935 cubic meters) of habitable volume. The station weighs nearly 1 million pounds (419,600 kilograms) and measures 361 feet (110.03 meters) end to end, which is equivalent to a U.S. football field including the end zones. The station's solar panels exceed the wingspan of a Boeing 777 jetliner and harness enough energy from the sun to provide electrical power to all station components and scientific experiments.

The station now includes the Russian-built Zarya, Zvezda, Pirs, Poisk and Rassvet modules; the U.S.-built Unity, Harmony connection modules, the Quest airlock module, the Tranquility module and 360-degree-view Tranquility module and the Permanent Multipurpose Module. Research facilities populate the U.S. Destiny Laboratory, the European Columbus Laboratory, and the Japanese Kibo laboratory and external experiment platform. The Canadian-provided Canadarm2 robotic arm and its Mobile Servicing System give the station a movable space crane, and the Special Purpose Dexterous Manipulator, or Dextre, provides a smaller two-armed robot capable of handling delicate assembly tasks. This space cherry-picker can move along the Integrated Truss Structure, forms the backbone of the station, and connects the station's solar arrays, cooling radiators and spare part platforms.

The station's first resident crew, Expedition 1, marked the beginning of a permanent international human presence in space, arriving at the station in a Russian Soyuz capsule in November 2000. For almost a dozen years, station crews have provided a continuous human presence in space, with crews averaging six months at a time through the current 30th expedition.

With the assembly of the space station at its completion and the support of a full-time crew of six, a new era of utilization for research is beginning. During the space station assembly phase, the potential benefits of space-based research and development were demonstrated, including the advancement of scientific knowledge based on experiments conducted in space, development and testing of new technologies, and derivation of Earth applications from new understanding.

The space station also is a vital precursor for future human exploration, where humans are learning how to combat the psychological and physiological effects of being in space for long periods, conducting both fundamental and applied research, testing technologies and decision-making processes.

The 2005 NASA Authorization Act designated the U.S. segment of the space station as a national laboratory. As the Nation's only national laboratory on-orbit, the space station National Lab fosters relationships among NASA, other federal entities, and the private sector, and advances science, technology, engineering and mathematics education through utilization of the space station's unique capabilities as a permanent microgravity platform with exposure to the space environment. NASA's research goals for the space station are driven by the NASA Authorization Act of 2010 and are focused on the following four areas: human health and exploration, technology testing for enabling future exploration, research in basic life and physical sciences, and earth and space science.

The International Space Station Program's greatest accomplishment is as much a human achievement as it is a technological one—how best to plan, coordinate, and monitor the varied activities of the Program's many organizations. The program brings together international flight crews; multiple launch vehicles; globally distributed launch, operations, training, engineering, and development facilities; communications networks; and the international scientific research community.

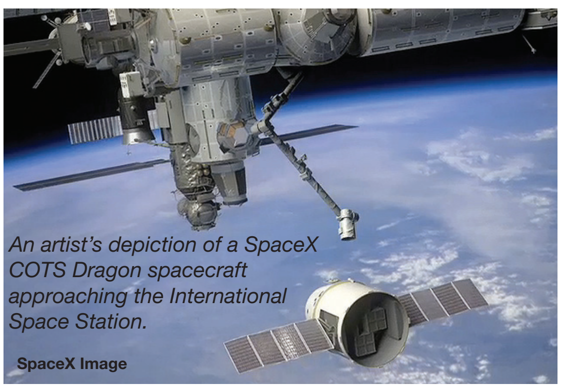
Elements launched from different countries and continents are not mated together until they reach orbit, and some elements that have been launched later in the assembly sequence were not yet built when the first elements were placed in orbit.

Construction, assembly and operation of the International Space Station requires the support of facilities on the Earth managed by all of the international partner agencies and countries involved in the program. These include construction facilities, launch support and processing facilities, mission operations support facilities, research and technology development facilities and communications facilities.

Operating the space station is even more complicated than other space flight endeavors because it is an international program. Each partner has the primary responsibility to manage and run the hardware it provides. The addition of commercial partners as providers of resupply and, in the future, crew transportation services, adds a new dimension to this complexity.

Commercial Orbital Transportation Services
Overview

Through a revolutionary program begun in 2006, NASA is investing financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable and cost-effective space transportation capabilities. This initiative is helping spur the innovation and development of new spacecraft and launch vehicles from commercial industry, creating a new way of delivering cargo to low-Earth orbit and the International Space Station (ISS).



An artist's depiction of a SpaceX COTS Dragon spacecraft approaching the International Space Station.

SpaceX Image

As NASA sets its sights on exploring once again beyond low-Earth orbit, the ability of the private sector to provide routine access to space and the ISS is of vital importance. NASA's Commercial Orbital Transportation Services (COTS) program is the catalyst for this expanding new industry.

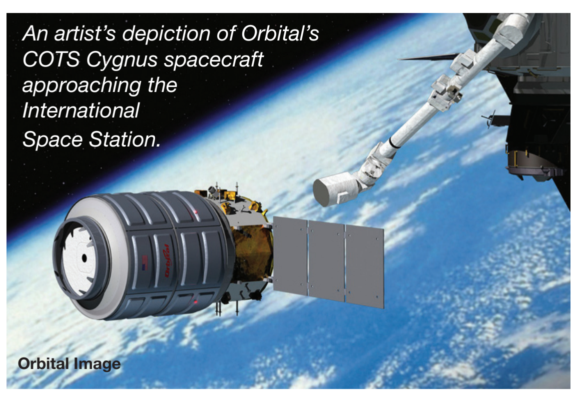
Under COTS, NASA is helping commercial partners develop and demonstrate their own cargo space transportation capabilities to serve the U.S. Government and other potential customers. The companies lead and direct their own efforts, with NASA providing technical and financial assistance.

NASA is investing approximately $800M toward cargo space transportation demonstrations. A unique aspect of the COTS program is that the companies are paid incrementally as they reach certain milestones. This encourages steady progress toward their goals and reduces costs to NASA since the commercial partners are also investing company resources.

COTS was created with four different capabilities that companies could pursue:

- Capability A: External/unpressurized cargo delivery and disposal
- Capability B: Internal/pressurized cargo delivery and disposal
- Capability C: Internal/pressurized cargo delivery and return
- Capability D: Crew transportation (currently not funded under COTS)

Two companies have funded COTS agreements with NASA: Space Exploration Technologies (SpaceX) and Orbital Sciences Corporation (Orbital). Since their competitive selection, both have been working vigorously to develop technologies and capabilities to complete orbital space flight demonstrations. The ISS Program has already purchased future cargo delivery services from both companies to resupply the space station through 2015.



An artist's depiction of Orbital's COTS Cygnus spacecraft approaching the International Space Station.

Orbital Image

Orbital Sciences Corporation

Just 100 miles up the coast from where the Wright brothers first flew their airplane at Kitty Hawk, North Carolina, Orbital plans to launch its new COTS system at the Mid-Atlantic Regional Spaceport (MARS), located at NASA's Wallops Flight Facility in Virginia. Founded in 1982, Orbital's COTS system design is based on the new Antares rocket with a liquid oxygen (LOX)/kerosene (RP-1) first stage powered by two Aerojet AJ-26 engines. The Antares second stage uses ATK's Castor 30 solid-propellant motor derived from its flight-proven Castor 120. The spacecraft, known as Cygnus, is derived from Orbital's heritage DAWN and STAR projects and ISS cargo carriers. After delivering cargo to ISS, Cygnus destructively reenters Earth's atmosphere.

An artist's depiction of the Orbital Antares rocket on the MARS launch pad at NASA's Wallops Flight Facility in Va.

Space Exploration Technologies

At Florida's Cape Canaveral, within sight of the launch locations of every NASA human spaceflight mission to date, SpaceX will launch its Falcon 9 and Dragon spacecraft. Founded in 2002, SpaceX has designed these systems from the ground up using the best of modern technology. The Falcon 9, which will launch the Dragon to low-Earth orbit, uses SpaceX-designed Merlin LOX/RP-1 engines, with nine in the first stage and one in the second stage. The Dragon spacecraft is designed to carry cargo to ISS and return cargo to Earth. In December 2010, during the first COTS flight, SpaceX became the first private company to successfully return a spacecraft from Earth orbit.

An image of the SpaceX Falcon 9 rocket on Pad 40 at Cape Canaveral, Fla.

By the Numbers

Launch Vehicle	Orbital Antares	SpaceX Falcon 9
Height	40.1 m	48.1 m
Diameter	3.90 m	3.66 m
Mass at Launch	275,000 kg	313,000 kg
Payload to International Space Station Orbit	5,200 kg	9,800 kg
First Stage		
Thrust	3.27 MN (735,000 lbs)	3.80 MN (854,000 lbs)
Propellant	LOX and RP-1	LOX and RP-1
Second Stage		
Thrust	322 kN (72,000 lbs)	414 kN (93,000 lbs)
Propellant	Solid propellant	LOX and RP-1

Cargo Spacecraft	Orbital Cygnus	SpaceX Dragon
Height	5.1 m	5.9 m
Diameter	3.05 m	3.66 m
Maximum Pressurized Cargo		
Up Mass / Volume	1,700 kg / 18.75 m^3	3,310 kg / 6.8 m^3
Down Mass / Volume	2,000 kg / 18.75 m^3 disposed	2,500 kg / 6.8 m^3
Maximum Unpressurized Cargo		
Up Mass / Volume	0	3,310 kg / 14 m^3
Down Mass / Volume	0	2,600 kg / 14 m^3 disposed

Reflects proposed configurations of the early resupply missions to the International Space Station.

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

www.nasa.gov

FS-2012-04-014B-JSC

SpaceX Company Overview

Space Exploration Technologies (SpaceX) is an American company that designs, manufactures and launches American rockets and spacecraft.

The company was founded in 2002 by Elon Musk to revolutionize space transportation in order to eventually make it possible for people to live on other planets.

Today, SpaceX is advancing the boundaries of space technology through its Falcon launch vehicles and Dragon spacecraft.

The company's prototype rocket, Falcon 1, was the first privately developed liquid-fueled rocket to reach orbit. The more powerful Falcon 9 rocket debuted with back-to-back successful flights in June and December of 2010. The December flight included the first flight of the Dragon spacecraft, and SpaceX again made history by becoming the first commercial company to send a spacecraft to orbit and return it safely to Earth – a feat previously accomplished by three nations, the United States, Russia and China.

Later this year, SpaceX's Falcon 9 rocket and Dragon spacecraft will take over the job of delivering cargo to and from the International Space Station under a $1.6 billion Commercial Resupply Services contract with NASA for a minimum of 12 missions. Although initially carrying cargo, Falcon 9 and Dragon were designed to one day carry astronauts, and cargo flights will provide valuable experience towards this goal. In April 2011, NASA awarded SpaceX a $75 million contract to prepare Dragon for transporting astronauts into space, and the company has already completed significant milestones as a part of that contract.

SpaceX is producing the most advanced launch vehicles in the world, and the international launch market has responded -- commercial launches now represent over 60 percent of the company's upcoming missions. In total, the company has approximately $4 billion in contracts and has more than 40 launches on its manifest. These successes have helped the company to be cash flow positive for the last five years.

Looking to the future, SpaceX has announced its plans for Falcon Heavy, the most powerful rocket in the world, second only to the Apollo-era Saturn V. Falcon Heavy will be able to carry payloads weighing over 53 metric tons to orbit, offering more than twice the performance of other commercial launch vehicles, and will make possible missions that were previously unachievable.

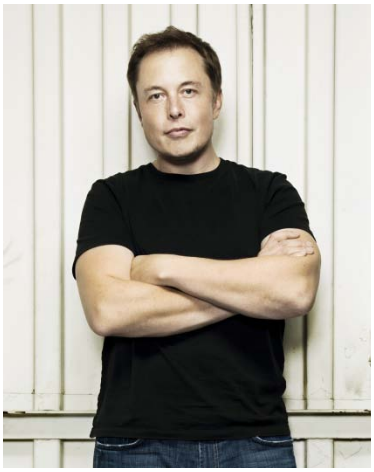
Long term, SpaceX is working towards the goal of building vehicles that are fully and rapidly reusable, a key element to radically reducing the cost of spaceflight in order to truly revolutionize space exploration. Dragon is a reusable spacecraft, and SpaceX is working to develop the world's first fully reusable launch vehicle.

SpaceX is a private company owned by management and employees, with minority investments from Founders Fund, Draper Fisher Jurvetson, and Valor Equity Partners. The company has over 1,700 employees at its headquarters in Hawthorne, CA; launch facilities at the Cape Canaveral Air Force Station and Vandenberg Air Force Base; rocket development facility in McGregor, TX; and offices in Chantilly, VA, and Washington, DC.

For more information, visit the SpaceX website at www.SpaceX.com.

SpaceX Leadership

ELON MUSK
Founder, Chief Executive Officer and Chief Technology Officer



Elon Musk is the chief executive officer and chief technology officer of Space Exploration Technologies (SpaceX), which develops rockets and spacecraft for missions to Earth orbit and beyond. Musk served as chief engineer for Falcon 1, the first privately developed liquid-fueled rocket to reach orbit, as well as Falcon 9 and the Dragon spacecraft. In 2008, SpaceX won a NASA contract to replace the cargo transport function of the space shuttle with Falcon 9 and Dragon. NASA decided in 2010 to also entrust the commercial sector with astronaut transport. F9/Dragon is considered by many to be the leading system for that role.

Musk's other primary activity is serving as CEO and product architect of Tesla Motors, where he has overseen product development and design from the beginning, including design of the all-electric Tesla Roadster and Model S sedan. Musk is also the non-executive chairman of SolarCity, the leading provider of solar power systems in California. Prior to SpaceX, Musk co-founded PayPal, the world's leading Internet payment system, and served as the company's chairman and CEO. Before PayPal, Musk co-founded Zip2, a provider of Internet software to the media industry.

In 2007, Musk was recognized for his work by Research and Development magazine, receiving its Innovator of the Year Award. He received the 2007/2008 American Institute of Aeronautics and Astronautics award for his contribution to the field of space transportation. In 2008, Musk was named one of the 75 most influential people of the 21st century by Esquire magazine and received the Aviation Week 2008 Laureate for the most significant achievement in the space industry. In 2009, the National Space Society awarded Musk its Von Braun Trophy, given for leadership of the most significant achievement in space. In 2010, Musk was recognized as a Living Legend in Aviation by the Kitty Hawk Foundation for creating the Falcon 9 rocket and Dragon spacecraft. Most recently, Musk was awarded the $250,000 Heinlein Prize for his significant and practical contributions to the commercialization of space.

Musk has a physics degree from the University of Pennsylvania along with a business degree from Wharton, and he currently serves as a member of the Stanford University Engineering Advisory Board.

GWYNNE SHOTWELL
President

Gwynne Shotwell is president of SpaceX, responsible for day-to-day operations and for managing all customer and strategic relations to support company growth. She joined SpaceX in 2002 as Vice President of Business Development and built the Falcon vehicle family manifest to over 40 launches, representing over $3 billion in revenue. Shotwell is a member of the SpaceX Board of Directors.

Prior to joining SpaceX, Shotwell spent more than ten years at the Aerospace Corporation. There she held positions in space systems engineering & technology, as well as project management. She was promoted to the role of chief engineer of an MLV-class satellite program, managed a landmark study for the Federal Aviation Administration on commercial space transportation, and completed an extensive analysis of space policy for NASA's future investment in space transportation. Shotwell was subsequently recruited to be director of Microcosm's Space Systems Division, where she served on the executive committee and directed corporate business development.

In 2004, she was elected statewide to the California Space Authority Board of Directors and served on its executive committee. She has also served as an officer of the AIAA Space Systems Technical Committee. Shotwell participates in a variety of STEM (Science, Technology, Engineering, and Mathematics)-related programs, including the Frank J. Redd Student Scholarship Competition; under her leadership the committee raised over $350,000 in scholarships in six years.

Shotwell received, with honors, her bachelor's and master's degrees from Northwestern University in mechanical engineering and applied mathematics. She has authored dozens of papers on a variety of subjects, including standardizing spacecraft/payload interfaces, conceptual small spacecraft design, infrared signature target modeling, shuttle integration, and reentry vehicle operational risks.

SpaceX Launch Manifest

SpaceX is producing the most advanced launch vehicles in the world, and the international launch market has responded. Today SpaceX has approximately $4 billion in contracts and commercial launches now represent over 60 percent of our upcoming missions.

Customer	Vehicle Arrival at Launch Site	Vehicle	Launch Site
NASA COTS 2/3	2011	F9/Dragon	Cape Canaveral
ORBCOMM - Multiple Flights	2012-2014	Multiple	Cape Canaveral
MDA Corp. (Canada)	2012	Falcon 9	Vandenberg
NASA Resupply to ISS – Flight 1	2012	F9/Dragon	Cape Canaveral
NASA Resupply to ISS – Flight 2	2012	F9/Dragon	Cape Canaveral
Falcon Heavy Demo Flight	2012	Falcon Heavy	Vandenberg
SES (Europe)	2013	Falcon 9	Cape Canaveral
Thaicom (Thailand)	2013	Falcon 9	Cape Canaveral
NASA Resupply to ISS – Flight 3	2013	F9/Dragon	Cape Canaveral
NASA Resupply to ISS – Flight 4	2013	F9/Dragon	Cape Canaveral
NSPO (Taiwan)	2013	Falcon 9	Vandenberg
AsiaSat	2014	Falcon 9	Cape Canaveral
AsiaSat	2014	Falcon 9	Cape Canaveral
NASA Resupply to ISS – Flight 5	2014	F9/Dragon	Cape Canaveral
NASA Resupply to ISS – Flight 6	2014	F9/Dragon	Cape Canaveral
NASA Resupply to ISS – Flight 7	2014	F9/Dragon	Cape Canaveral
Space Systems/Loral	2014	Falcon 9	Cape Canaveral
CONAE (Argentina)	2014	Falcon 9	Vandenberg
DragonLab Mission 1	2014	F9/Dragon	Cape Canaveral

SpaceX Launch Manifest (cont.)

Customer	Vehicle Arrival at Launch Site	Vehicle	Launch Site
Asia Broadcast Satellite/Satmex	2014	Falcon 9	Cape Canaveral
Spacecom (Israel)	2015	Falcon 9	Cape Canaveral
NASA Resupply to ISS – Flight 8	2015	F9/Dragon	Cape Canaveral
NASA Resupply to ISS – Flight 9	2015	F9/Dragon	Cape Canaveral
NASA Resupply to ISS – Flight 10	2015	F9/Dragon	Cape Canaveral
Bigelow Aerospace	2015	Falcon 9	Cape Canaveral
DragonLab Mission 2	2015	F9/Dragon	Cape Canaveral
SES (Europe)	2015	Falcon 9	Cape Canaveral
CONAE (Argentina)	2015	Falcon 9	Vandenberg
Iridium – Flight 1	2015	Falcon 9	Vandenberg
Iridium – Flight 2	2015	Falcon 9	Vandenberg
Iridium – Flight 3	2015	Falcon 9	Vandenberg
NASA Resupply to ISS – Flight 11	2015	F9/Dragon	Cape Canaveral
NASA Resupply to ISS – Flight 12	2015	F9/Dragon	Cape Canaveral
Asia Broadcast Satellite/Satmex	2015	Falcon 9	Cape Canaveral
Iridium – Flight 4	2016	Falcon 9	Vandenberg
Iridium – Flight 5	2016	Falcon 9	Vandenberg
Iridium – Flight 6	2016	Falcon 9	Vandenberg
Iridium – Flight 7	2017	Falcon 9	Vandenberg
Iridium – Flight 8	2017	Falcon 9	Vandenberg

SpaceX Facilities

SPACE LAUNCH COMPLEX 40, CAPE CANAVERAL AIR FORCE STATION

Cape Canaveral, FL

Set on the Atlantic coast of Florida, the SpaceX launch pad is located only three and a half miles southeast of NASA's space shuttle launch site.

Before SpaceX moved in, Space Launch Complex 40 (SLC-40) was used by the U.S. Air Force for many years to launch Titan rockets, which are among the most powerful rockets in the U.S. fleet. Fifty-five Titan III and Titan IV rockets launched from the site from 1965 to 2005.

SpaceX took over the facility in November 2007 and became the first purely commercial launch program at Cape Canaveral.

On June 4, 2010, SpaceX successfully launched the Falcon 9 rocket for the first time from SLC-40. Six months later, on December 8, 2010, the company made history again with the first launch of the Dragon spacecraft, the first private spacecraft to successfully return to Earth from orbit. With plans to launch 10 to 12 missions per year in support of NASA space station resupply and commercial satellite customers, SpaceX is building on the strong heritage of Cape Canaveral.

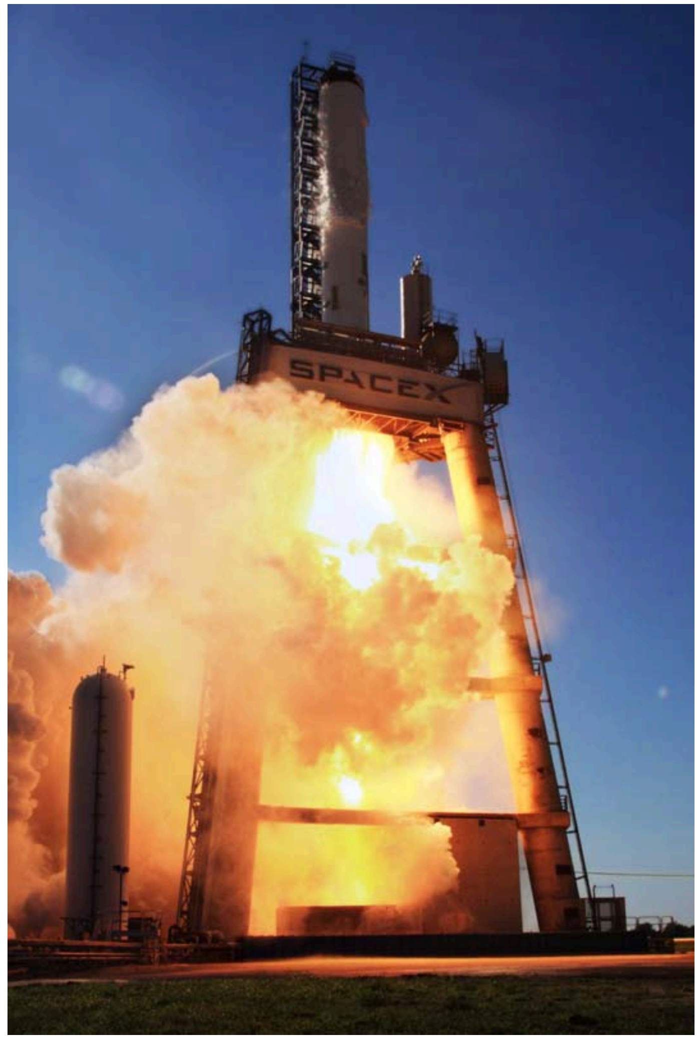
SPACEX HEADQUARTERS

Hawthorne, CA

Vehicles are designed and manufactured at SpaceX headquarters in Hawthorne, CA, which is also home to mission control.

ROCKET DEVELOPMENT FACILITY
McGregor, TX

Engines and structures are tested at a 600-acre state-of-the-art Rocket Development Facility in McGregor, TX.



VANDENBERG AIR FORCE BASE LAUNCH SITE
Near Lompoc, CA

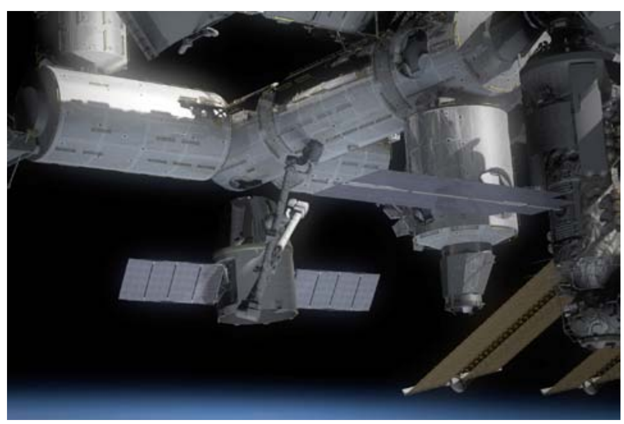
In addition to Cape Canaveral, SpaceX is developing a new launch pad at Vandenberg Air Force Base.

Dragon Overview

QUICK FACTS

Dragon is a free-flying, reusable spacecraft developed using the best of 21st century technology by SpaceX under NASA's Commercial Orbital Transportation Services (COTS) program. Dragon is made up of a pressurized capsule that will carry pressurized cargo on this mission and an unpressurized trunk that houses its solar panels and can be used to carry unpressurized cargo.

- Dragon represents the best of cutting-edge technology. SpaceX developed Dragon from a blank sheet to its first mission in just over 4 years.
- In December 2010, Dragon became the first privately developed spacecraft to return safely from orbit – a feat previously achieved by just three nations (the United States, Russia, and China).
- Dragon is 4.4 meters (14.4 feet) tall and 3.66 meters (12 feet) in diameter. The trunk is 2.8 meters (9.2 feet) tall and 3.66 meters (12 feet) wide. With the solar panels fully extended, the vehicle measures 16.5 meters (54 feet) wide.
- Although this demonstration mission carries only cargo, Dragon was designed from the outset with crew- carrying capability in mind; SpaceX is in the process of developing necessary systems for transporting crew, such as seating, a launch escape system, and environmental control and life support systems.
- Dragon has the most powerful heat shield in the world; designed in cooperation with NASA, it is made of a material called PICA-X, a high-performance variant on NASA's original Phenolic Impregnated Carbon Ablator (PICA).
- Dragon is capable of carrying over 3,310 kilograms, split between pressurized cargo inside the capsule and unpressurized cargo carried in the trunk.
- While this mission is carrying cargo only, future Dragon missions will be capable of carrying 7 passengers in the crew configuration.
- Lifting reentry for landing precision and low-g's.



DRAGON HIGHLIGHTS

Exceptional Technology, Exceptional Spacecraft

Draco Thrusters:

Eighteen Draco thrusters used for orbital maneuvering and attitude control (providing system redundancy). Powered by nitrogen tetroxide / monomethylhydrazine (NTO/MMH) storable propellants; 90 lbf (400 N) thrust used for on-orbit maneuvering, de-orbit burns, and re-entry attitude.

Power:

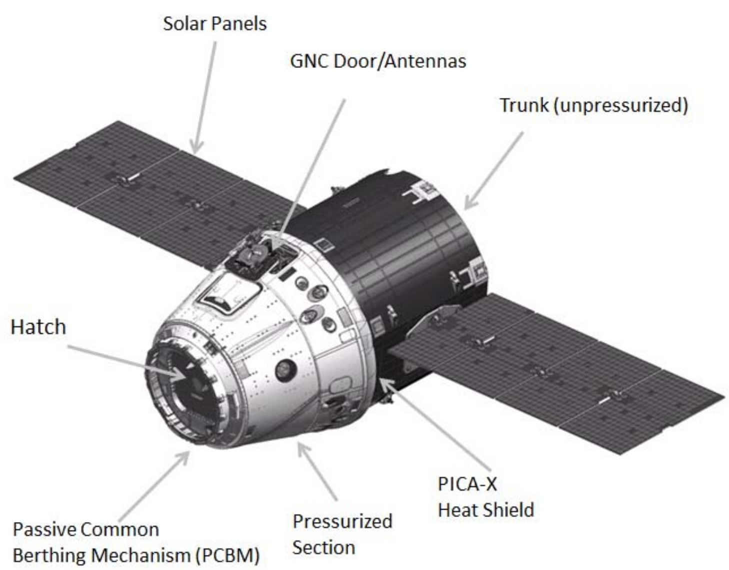
Two solar array wings on trunk (8 panels total).

Avionics:

Two-fault tolerant avionics system with extensive heritage.

Communications:

- Communications between Dragon and the ISS are provided by COTS UHF Communications Unit (CUCU). CUCU was delivered to the Space Station on STS-129.
- ISS crew command Dragon using the Crew Command Panel (CCP).
- Dragon can also communicate on S-band via either tracking and data relay system (TDRSS) or ground stations.



Environmental Control System:

Astronauts will enter Dragon to remove cargo.

- Provides a habitable cabin: Air circulation, fire detection and suppression, lights.
- Pressure control, pressure and humidity monitoring.

Thermal Protection System:

- Primary heat shield: Tiled Phenolic Impregnated Carbon Ablator (PICA), fabricated in-house.
- Backshell: SpaceX Proprietary Ablative Material (SPAM).

Transporting Crew:

To ensure a rapid transition from cargo to crew, SpaceX has designed the cargo and crew configurations to be nearly identical, with notable exceptions including the need for a crew escape system, the life support system, and onboard controls that allow the crew to take control from the flight computer when needed. This focus on commonality minimizes the design effort and simplifies the human-rating process, allowing systems critical to Dragon crew safety and ISS safety to be fully tested on unmanned demonstration flights and cargo resupply missions.

Falcon 9 Overview

QUICK FACTS

- Made in America: All structures, engines, avionics, and ground systems designed, manufactured and tested in the United States by SpaceX.
- Falcon 9 with a Dragon spacecraft is 48.1 meters (157 feet) tall. The vehicle from the COTS 2 flight is capable of producing one million pounds of thrust in a vacuum.
- Cutting-edge technology makes Falcon 9 the vehicle of choice for commercial and government customers. SpaceX has approximately 40 Falcon 9 missions on the manifest.
- Named for the Star Wars Millennium Falcon; 9 refers to the nine Merlin engines that power the first stage; one Merlin vacuum engine powers the second stage.
- Designed from day one to safely carry crew.
- Achieved 100% mission success on its first two flights (June 2010 and December 2010).
- The first rocket completely designed in the 21st century; developed from a blank sheet to first launch in four-and-a-half years (November 2005 to June 2010) for less than $300 million.
- Advanced design for maximum reliability. Falcon 9 features a simple two-stage design to limit separation events, and with nine engines on the first stage, it can still safely complete its mission in the event of an engine failure. The main causes of launch failures are stage separation events and engine failures.

FALCON 9 ROCKET

Exceptional Technology, Exceptional Vehicle

Falcon 9 is a two-stage rocket powered by liquid oxygen and rocket grade kerosene (RP-1). It was designed from the ground up by SpaceX for the reliable and cost-efficient transport of satellites to low Earth orbit and geosynchronous transfer orbit, and for sending SpaceX's Dragon spacecraft, including manned missions, to orbiting destinations such as the International Space Station.

Falcon 9 saw its first successful launch on June 4, 2010, and its second on December 8, 2010.

First Stage

The Falcon 9 tank walls are made from an aluminum lithium alloy. SpaceX manufactures the tanks using friction-stir welding, the strongest and most reliable welding technique available. Nine SpaceX Merlin regeneratively cooled engines power the Falcon 9 first stage. After ignition of the first-stage engines, the Falcon 9 is held down and not released for flight until all propulsion and vehicle systems are confirmed to be operating nominally. The interstage, which connects the upper and lower stages for Falcon 9, is a composite structure with an aluminum honeycomb core and carbon fiber face sheets. Falcon 9 uses an all-pneumatic stage separation system proven on its predecessor, Falcon 1.

Second Stage

The second stage tank of Falcon 9 is simply a shorter version of the first-stage tank and uses most of the same tooling, material and manufacturing techniques. This results in significant cost savings in vehicle production. A single Merlin engine powers the Falcon 9 upper stage. For added reliability of restart, the engine has dual redundant pyrophoric igniters using triethylaluminum-triethylborane (TEA-TEB).

MERLIN ENGINE

Falcon 9 is powered by nine Merlin engines in the first stage and one in the second stage. The nine Merlin engines generate one million pounds of thrust in vacuum. The Merlin engine was developed internally at SpaceX, but draws upon a long heritage of space proven engines. The pintle-style injector at the heart of Merlin was first used in the Apollo program for the lunar module landing engine, one of the most critical phases of the mission.

Propellant is fed via a single-shaft, dual-impeller turbopump operating on a gas generator cycle. The turbopump also provides the high pressure kerosene for the hydraulic actuators, which then recycles into the low-pressure inlet. This design approach eliminates the need for a separate hydraulic power system and means that thrust vector control failure by running out of hydraulic fluid is not possible. A third use of the turbopump is to provide roll control by actuating the turbine exhaust nozzle (on the second-stage engine).

Combining three functions into one device that can be verified as functioning before the vehicle is allowed to lift off provides a significant improvement in system-level reliability.

Reliability

Before the spacecraft even reaches orbit, Falcon 9 must once again perform successfully. Of the world's current launch vehicle families, 75% have had at least one failure in the first three flights.

An analysis of launch failure history between 1980 and 1999 by Aerospace Corporation showed that 91% of known failures can be attributed to three causes: engine failures, stage separation failures and, to a much lesser degree, avionics failures. With nine Merlin engines clustered together to make up the first stage, the vehicle is capable of sustaining an engine failure and still successfully completing its mission. This is an improved version of the architecture employed by the Saturn V and Saturn I rockets of the Apollo Program, which had flawless flight records despite losing engines on a number of missions. With only two stages, Falcon 9 limits problems associated with separation events. And SpaceX has an incredibly advanced avionics system.

SpaceX uses a hold-before-release system — a capability required by commercial airplanes, but not implemented on many launch vehicles. After the first-stage engine ignites, the Falcon 9 is held down and not released for flight until all propulsion and vehicle systems are confirmed to be operating normally. An automatic safe shut-down occurs and propellant is unloaded if any issues are detected.

FACT SHEET

Vision: The World's Premier Gateway to Space

Mission: One Team ... Delivering Assured Space Launch, Range and Combat Capabilities for the Nation

Leadership/Organization

Wing Leadership: The 45th Space Wing is commanded by Brig. Gen. Anthony J. Cotton.

Groups: The wing is organized into four groups to accomplish its mission:

- Launch Group: Supports launch vehicle and spacecraft processing from flight hardware arrival through launch.
- Operations Group: Operates and maintains the Eastern Range assets and responsible for airfield operations, weather and communication support.
- Mission Support Group: Provides support through various functions to the people and mission.
- Medical Group: Provides medical, dental, environmental and public health services.

At a Glance

Commander: Brig. Gen. Anthony J. Cotton
Number of Personnel: 9,477
Annual Payroll: $306.3 million
Number of Indirect Jobs Created: 4,797
$ Value of Jobs Created: $204 million
Annual Expenditures: $649.2 million
Total Economic Impact (FY10): $1.142 billion
 # Airmen Deployed: Approximately 100+

Fleet: Atlas VI, Delta IV, Falcon 9, Trident II
Satellites Processed: GPS, WGS, MILSTAR
Eastern Range Size: 15 million square miles
Next Scheduled Launch: www.patrick.af.mil

Tenants/Mission Partners
The 45th Space Wing has more than 35 major mission partners and tenants at Patrick AFB and Cape Canaveral AFS, including:

- Defense Equality Opportunity Management Institute
- Air Force Technical Applications Center
- National Aeronautics and Space Administration
- Naval Ordnance Test Unit
- 920th Rescue Wing
- Joint Stars Task Force
- Department of State
- Air Force Office of Special Investigations
- 333rd Recruiting Squadron
- American Red Cross

Control of the Battlefield Begins Here!

(Current as of October 2011)
Point of contact: 45th Space Wing Public Affairs, 321-494-5933, 45swpa@patrick.af.mil