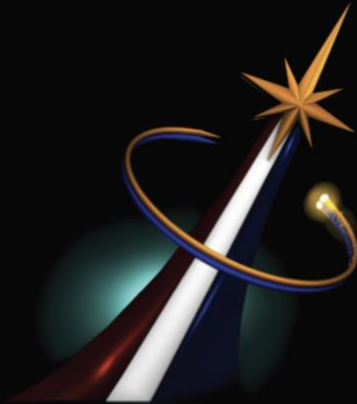


National Aeronautics and Space Administration



COMMERCIAL CREW PROGRAM

**American Rockets
American Spacecraft
American Soil**

www.nasa.gov



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Working side-by-side with our two partners:



What is Commercial Crew?

NASA's Commercial Crew Program is working with the American aerospace industry as companies develop and operate a new generation of spacecraft and launch systems capable of carrying crews to low-Earth orbit and the International Space Station. Commercial transportation to and from the station will provide expanded utility, additional research time and broader opportunities for discovery on the orbiting laboratory.

The station is a critical testbed for NASA to understand and overcome the challenges of long-duration spaceflight. As commercial companies focus on providing human transportation services to and from low-Earth orbit, NASA is freed up to focus on building spacecraft and rockets for deep space missions.

How is the Commercial Crew Program Different?

The Commercial Crew Program represents a revolutionary approach to government and commercial collaborations for the advancement of space exploration.

NASA's Prior Approach for Obtaining Crew Transportation Systems

Since the Mercury program in the early 1960s, NASA has used an almost identical operating model to achieve its goals of human spaceflight. This includes the Space Shuttle Program and the American portions of the International Space Station. NASA would identify a need for a crew transportation system and then the agency's engineers and specialists would oversee every development aspect of the spacecraft, support systems and operations plans. A commercial aerospace contractor would be chosen to build the system, ensuring that it meets the specifications spelled out by NASA. Personnel from NASA would be heavily involved and oversee the processing, testing, launching and operation of the crew system to ensure safety and reliability. All of the hardware and infrastructure would be owned by NASA.

Commercial Crew's Approach for Obtaining Crew Transportation Systems

NASA identified a need for a crew transportation system and a broad set of requirements that would be necessary to ensure crew safety. In the case of commercial crew, the need centered around a safe, reliable and cost-effective means of getting humans to low-Earth orbit, including the International Space Station, and return safely to Earth. Interested companies are free to design in a way they think is best and are encouraged to apply their most efficient and effective manufacturing and business operating techniques. The companies own and operate their hardware and infrastructure. NASA's engineers and aerospace specialists work closely with the commercial companies, allowing for substantial insight into the development process and offering up expertise and available resources.

The Commercial Crew Program is the first time this model has been implemented.

For more, click here: <https://www.nasa.gov/content/commercial-crew-program-the-essentials/>.

Biographies

Crew



Bob Behnken

Flight Assignment: SpaceX Demo-2

Selected to NASA Astronaut Corps: 2000

Previous Spaceflights: Two

Robert L. Behnken was selected as an astronaut by NASA in 2000 and is a veteran of two space shuttle flights. He currently is training for the Demo-2 flight of SpaceX's Crew Dragon spacecraft, the first crew flight for the company's next-generation spacecraft. Behnken will be the joint operations commander for the mission, responsible for activities such as rendezvous, docking and undocking, as well as Demo-2 activities while the spacecraft is docked to the space station. Behnken and his crewmate, Doug Hurley, are working closely with SpaceX to develop the company's new spacecraft

systems. Crew Dragon will provide round-trip crew transportation services to the International Space Station and, along with Boeing's CST-100 Starliner spacecraft, return the nation's ability to launch humans to space from the United States. A native of Missouri, Behnken flew on space shuttle missions STS-123 in March 2008 and STS-130 in February 2010. He logged more than 708 hours in space and more than 37 hours during six spacewalks. Behnken is a colonel in the U.S. Air Force.

Find more about Behnken here: <https://www.nasa.gov/astronauts/biographies/robert-l-behnen>



Victor Glover

Flight Assignment: SpaceX's First Operational Mission/Crew-1

Selected to NASA Astronaut Corps: 2013

Previous Spaceflights: None

Victor J. Glover Jr. was selected as an astronaut by NASA in 2013. He currently is training for the first operational flight—the second crew flight—for SpaceX's Crew Dragon spacecraft and a long-duration mission aboard the International Space Station. Glover and his crewmates, Mike Hopkins, Soichi Noguchi and Shannon Walker, are working closely with SpaceX on their new spacecraft systems. Crew Dragon will provide round-trip crew transportation services to the International Space Station and, along with Boeing's CST-100 Starliner spacecraft, return the nation's ability to launch

humans to low-Earth orbit from the United States. The California native holds a Bachelor of Science in general engineering, a Master of Science in flight test engineering, a Master of Science in systems engineering and a Master of Military Operational Art and Science. Glover, a U.S. Navy commander, is a naval aviator and was a test pilot in the F/A-18 Hornet, Super Hornet and EA-18G Growler.

Find more about Glover here: <https://www.nasa.gov/astronauts/biographies/victor-j-glover>



Mike Hopkins

Flight Assignment: SpaceX's First Operational Mission/Crew-1

Selected to NASA Astronaut Corps: 2009

Previous Spaceflights: One

Michael S. Hopkins was selected as an astronaut by NASA in 2009 and is a veteran of one space mission. He currently is training for the first operational flight—the second crew flight—for SpaceX's Crew Dragon spacecraft and a long-duration mission aboard the International Space Station. Hopkins and his crewmate, Victor Glover, Soichi Noguchi and Shannon Walker, are working closely with SpaceX on their new spacecraft systems. Crew Dragon will provide round-trip crew transportation services to the International Space Station and, along with Boeing's CST-100 Starliner

spacecraft, return the nation's ability to launch humans to low-Earth orbit from the United States. The Missouri native was a member of the Expedition 37/38 crew and has logged 166 days in space and conducted two spacewalks totaling 12 hours and 58 minutes. Hopkins is a colonel in the U.S. Air Force.

Find more about Hopkins here: <https://www.nasa.gov/astronauts/biographies/michael-s-hopkins>



Doug Hurley

Flight Assignment: SpaceX Demo-2

Selected to NASA Astronaut Corps: 2000

Previous Spaceflights: Two

Douglas G. Hurley was selected as an astronaut by NASA in 2000 and is a veteran of two spaceflights. Hurley currently is training for the Demo-2 flight of SpaceX's Crew Dragon spacecraft, the first crewed flight for the company's next-generation spacecraft. Hurley will be the spacecraft commander for Demo-2, responsible for activities such as launch, landing and recovery. He and his crewmate, Bob Behnken, are working closely with SpaceX to develop its new spacecraft systems, which will provide round-trip crew transportation services to the International Space Station and,

along with Boeing's Starliner, return the ability to launch humans into low-Earth orbit from the United States. A native of New York, Hurley piloted space shuttle missions STS-127 in July 2009 and STS-135 in July 2011. He has logged more than 680 hours in space. Hurley is a retired U.S. Marine Corps colonel.

Find more about Hurley here: <https://www.nasa.gov/astronauts/biographies/douglas-g-hurley>



Soichi Noguchi

Flight Assignment: SpaceX's First Operational Mission/Crew-1

Selected to Japan Aerospace Exploration Agency: 1996

Previous Spaceflights: Two

Soichi Noguchi was selected as an astronaut candidate by the National Space Development Agency of Japan (currently, Japan Aerospace Exploration Agency, JAXA) in 1996 and is a veteran of two space missions. He currently is training for the first operational flight—the second crew flight—for SpaceX's Crew Dragon spacecraft and a long-duration mission aboard the International Space Station. Noguichi and his crewmates, Victor Glover, Mike Hopkins and Shannon Walker, are working closely with SpaceX on their new spacecraft systems. Crew Dragon will provide round-trip

crew transportation services to the International Space Station and, along with Boeing's CST-100 Starliner spacecraft, return the nation's ability to launch humans to low-Earth orbit from the United States. The Japanese native was a member of the STS-114 and Expedition 22/23 crews, was the first Japanese astronaut to perform EVAs on the space station and has logged over 20 hours during three spacewalks.

Find more about Noguchi here: <https://iss.jaxa.jp/en/astro/biographies/noguchi/index.html>



Shannon Walker

Flight Assignment: SpaceX First Operational Mission/Crew-1

Selected to NASA Astronaut Corps: 2004

Previous Spaceflights: One

Shannon Walker was selected as an astronaut by NASA in 2004 and is a veteran of two spaceflights. She currently is training for the first operational flight—the second crew flight—for SpaceX's Crew Dragon spacecraft and a long-duration mission aboard the International Space Station. Walker and her crewmates, Victor Glover, Mike Hopkins and Soichi Noguchi, are working closely with SpaceX on their new spacecraft systems. Crew Dragon will provide round-trip crew transportation services to the International Space Station and, along with Boeing's Starliner, return the ability to

launch humans into low-Earth orbit from the United States. A native of Houston, TX, Walker served as a crew member for Expeditions 24 and 25 and is one of only 35 people to be both astronauts and aquanauts, having commanded the NASA Extreme Environments Mission Operations (NEEMO) 15 mission. She has logged more than 160 days in space. Walker holds several degrees including a Doctorate of Philosophy in Space Physics.

Find more about Walker here: <https://www.nasa.gov/astronauts/biographies/walker-shannon>

NASA



Jim Bridenstine

James Frederick “Jim” Bridenstine was nominated by President Donald Trump, confirmed by the U.S. Senate, and sworn in as NASA’s 13th administrator on April 23, 2018.

Bridenstine was elected in 2012 to represent Oklahoma’s First Congressional District in the U.S. House of Representatives, where he served on the Armed Services Committee and the Science, Space and Technology Committee.

Bridenstine’s career in federal service began in the U.S. Navy, flying the E-2C Hawkeye off the USS Abraham Lincoln aircraft carrier. It was there that he flew combat missions in Iraq and Afghanistan and accrued most of his 1,900 flight hours and 333 carrier-arrested landings. He later moved to the F-18 Hornet and flew at the Naval Strike and Air Warfare Center, the parent command to TOPGUN.

After transitioning from active duty to the U.S. Navy Reserve, Bridenstine returned to Tulsa, Oklahoma, to be the Executive Director of the Tulsa Air and Space Museum & Planetarium.

Bridenstine was promoted to the rank of Lieutenant Commander in 2012 while flying missions in Central and South America in support of America’s war on drugs. Most recently, he transitioned to the 137th Special Operations Wing of the Oklahoma Air National Guard.

Bridenstine completed a triple major at Rice University, and earned his MBA at Cornell University. He has three children with his wife, Michelle.

Robert Cabana – Center Director, Kennedy Space Center

<https://www.nasa.gov/centers/kennedy/about/biographies/cabana.html>

Mark Geyer – Center Director, Johnson Space Center

<https://www.nasa.gov/centers/johnson/about/people/orgs/bios/geyer.html>

Kathy Lueders – Program Manager, Commercial Crew Program

<https://www.nasa.gov/centers/kennedy/about/biographies/lueders.html>

Steve Stich – Deputy Manager, Flight Development and Operations, Commercial Crew Program

https://www.nasa.gov/content/steve_stich

Pat Forrester – NESC Chief Astronaut

https://www.nasa.gov/offices/nesc/team/Pat_Forrester_bio.html

Kirk Shireman – Manager, International Space Station Program

<https://www.nasa.gov/feature/kirk-a-shireman-iss-program-manager>

Joel Montalbano – Deputy Manager, International Space Station Program

<https://www.nasa.gov/feature/joel-montalbano-deputy-iss-program-manager>

SpaceX

Elon Musk



Elon Musk leads Space Exploration Technologies (SpaceX), where he oversees the development and manufacturing of advanced rockets and spacecraft for missions to and beyond Earth orbit.

Founded in 2002, SpaceX's mission is to enable humans to become a spacefaring civilization and a multi-planet species by building a self-sustaining city on Mars. In 2008, SpaceX's Falcon 1 became the first privately developed liquid-fuel launch vehicle to orbit the Earth. Following that milestone, NASA awarded SpaceX with contracts to carry cargo and crew to the International Space Station (ISS). A global leader in commercial launch services, SpaceX is the first commercial provider to launch and recover a spacecraft from orbit, attach a commercial spacecraft to the International Space Station and successfully land an orbital-class rocket booster. By pioneering the development of fully and rapidly reusable rockets and spacecraft, SpaceX is dramatically reducing the cost of access to space, the first step in making life on Mars a reality in our lifetime.

Elon also leads Tesla, which makes electric cars, giant batteries and solar products. Previously, Elon co-founded and sold PayPal, the world's leading Internet payment system, and Zip2, one of the first internet maps and directions services, which helped bring major publishers, including the New York Times and Hearst, online.

Gwynne Shotwell



As President and COO of SpaceX, Gwynne Shotwell is responsible for day-to-day operations and 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 more than 100 launches, representing more than \$10 billion in business. Shotwell is a member of the SpaceX Board of Directors.

Prior to joining SpaceX, Shotwell spent more than 10 years at the Aerospace Corporation, holding positions in space systems engineering, technology and 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.

In addition to being named the 2018 Satellite Executive of the Year, Shotwell was awarded the AIAA Goddard Astronautics Awards as well as the American Society of Mechanical Engineers Ralph Coats Roe Medal. Fortune Magazine placed Shotwell at No. 42 on its list of the World's 50 Greatest Leaders in 2018 and Forbes named her No. 70 on its list of Power Women in 2017.

In 2014, Shotwell was appointed to the United States Export Import Bank's Advisory Committee and the Federal Aviation Administration's Management Advisory Council. Shotwell was elected to the honorable grade of Fellow with the American Institute of Aeronautics and Astronautics.

Through leadership in both corporate and external science, technology, engineering and math (STEM) programs, Shotwell has helped raise over \$1.4 million for STEM programs reaching thousands of students nationwide.

Shotwell received, with honors, her bachelor's and master's degrees from Northwestern University in mechanical engineering and applied mathematics, and serves on their board. She has authored dozens of papers on a variety of space-related subjects.

Benji Reed



Benjamin "Benji" Reed is the director of Crew Mission Management at SpaceX. In this role he is helping spearhead the company's development and certification efforts for the Crew Transportation System, including the Dragon spacecraft, Falcon 9 rocket, ground systems and operations. Prior to this position, Benji was a mission manager for Dragon cargo missions to the International Space Station, including the CRS-3 mission, which carried the first science payloads in the Dragon trunk. Over the past 20 years, he has been a leader in various commercial aerospace and NASA programs, including hardware development serving the Hubble Space Telescope, space station and planetary science missions. He spent many years as the co-owner of a software and Internet development firm and also has been a teacher.

A native of Boulder, Colorado, Benji graduated from the University of Colorado with a degree in mathematics, working at the Center for Astrophysics and Space Astronomy on programs, including the Far Ultraviolet Spectrographic Explorer and the Cosmic Origins Spectrograph. He lives in Los Angeles, California, with his wife and three children.

Astronaut Training

Nine U.S. astronauts are working with Boeing or SpaceX for specific mission training. The crews are working side-by-side with Boeing and SpaceX to understand the new spacecraft and launch systems, the spacesuits and refining how they're going to operate in space.

The astronauts also are preparing to live and work aboard the space station, where they could stay for up to six months. The astronauts go through significant preparation for space station missions, including learning how to conduct spacewalks, maintain the space station and perform a myriad of research investigations covering all scientific disciplines.

The astronauts have participated in many nominal and off-nominal mission simulations, studying every aspect of their spacecraft, as well as launch, in-orbit and landing procedures. This intense work ensures they are prepared for any situation that may arise during their mission.

Commercial Crew Program Timeline

2010

NASA invests about \$50 million for Commercial Crew Development Round 1 (CCDev1) to stimulate efforts within the private sector to aid in the development and demonstration of safe, reliable and cost-effective crew transportation capabilities. Companies include:

- Blue Origin
- Boeing
- Paragon Space Development Corporation
- Sierra Nevada Corporation
- United Launch Alliance

2011

NASA continues to develop partnerships with industry through Commercial Crew Development Round 2 (CCDev2) by awarding nearly \$270 million to four companies and providing expertise to an additional three companies to further development and demonstration of safe, reliable and cost-effective transportation capabilities. The agency's funded agreements are with:

- Blue Origin
- Boeing
- Sierra Nevada Corporation
- SpaceX

The agency's unfunded agreements are with:

- Alliant Techsystems Inc.
- Excalibur Almaz Inc.
- United Launch Alliance

2012

Commercial Crew Integrated Capability (CCiCap) continues the development of three fully integrated systems in August 2012. The Space Act Agreements call for industry partners to develop crew transportation capabilities and to perform tests to verify, validate and mature integrated designs. Companies include:

- Boeing
- Sierra Nevada Corporation
- SpaceX

2013

Kickoff of the Certification Products Contracts (CPC), is the first of a two-phase certification plan. The three U.S. companies work with NASA to develop data products to implement the agency's flight safety and performance requirements. This includes implementation across all aspects of the space system, including the spacecraft, launch vehicle, and ground and mission operations. NASA awards a total of about \$30 million under the CPC contracts. Companies include:

- Boeing
- Sierra Nevada Corporation
- SpaceX

2014

Commercial Crew Transportation Capability (CCtCap), the second of a two-phase certification plan for commercially built and operated integrated crew transportation systems, begins. Through its certification efforts, NASA will ensure the selected commercial transportation systems meet the agency's safety and performance requirements for transporting NASA crew to the International Space Station. NASA awards a total of \$6.8 billion under CCtCap contracts. Companies include:

- Boeing
- SpaceX

2015

NASA names four astronauts as Commercial Crew Cadre to work with Boeing and SpaceX as the companies refine their spacecraft systems. The crew provides invaluable user experience feedback to help shape their hardware and systems to ensure they are ready for flight.

Astronauts include:

- Bob Behnken
- Eric Boe
- Doug Hurley
- Suni Williams

2016

Boeing and SpaceX design and manufacture hardware for testing to ensure their spacecraft can handle the harsh environment of space.

The International Docking Adapter, or IDA, is installed on the International Space Station. Two IDAs will ultimately serve as the docking points for Boeing's CST-100 Starliner and SpaceX's Crew Dragon.

2017

Boeing and SpaceX continue development and testing to prepare for emergency situations and ensure human safety.

Boeing and SpaceX unveil brand-new spacesuits to be worn by crews while on board each company's spacecraft.

2018

Testing ramps up and nears completion for Boeing and SpaceX as they prepare their hardware, systems, flight crews and ground support teams for launch.

NASA assigns nine astronauts to crew Boeing and SpaceX's test flights and first operational missions on Starliner and Crew Dragon.

2019

Flight Test Schedule:

SpaceX Demo-1 (March 2-8, 2019)

Boeing Boeing Pad Abort Test (November 4, 2019)

Boeing Orbital Test Flight (December 20-22, 2019)

2020

Flight Test Schedule:

SpaceX In-Flight Abort Test (January 19, 2020)

SpaceX Demo-2: May 27, 2020

All other future launch dates are currently under review.

At the successful conclusion of crewed test flights for both Boeing and SpaceX, NASA will certify each company's systems, and operational missions will begin with the flight of Starliner-1 and Crew-1.

National Investment

NASA, Boeing and SpaceX, with the help of contractors throughout America, are on the cusp of something amazing. Men and women at locations across the country have dedicated countless hours to the Commercial Crew Program to achieve a common goal: restore our nation's ability to launch humans to the International Space Station from U.S. soil.

This government-private industry partnership has significant economic benefits, with more than 1,000 suppliers employing workers in all 50 states to support commercial crew spacecraft systems. Great minds are applying their most efficient and innovative approaches to launch astronauts back into low-Earth orbit on American-made spacecraft and rockets.



LAUNCH AMERICA



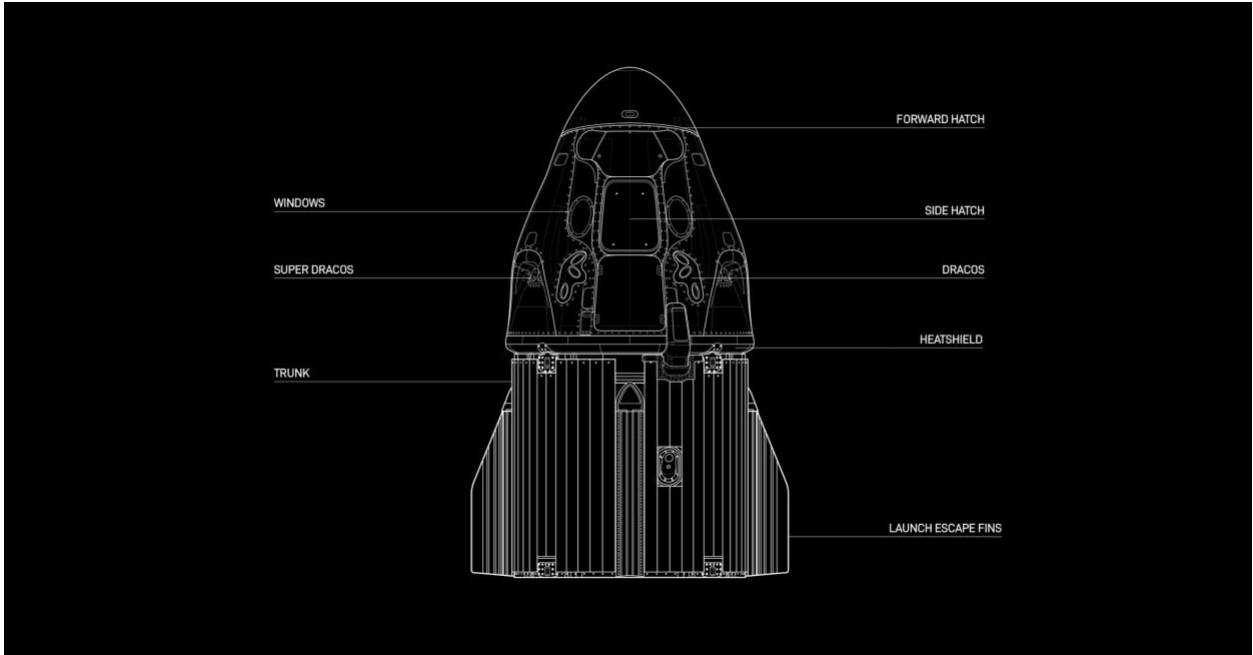
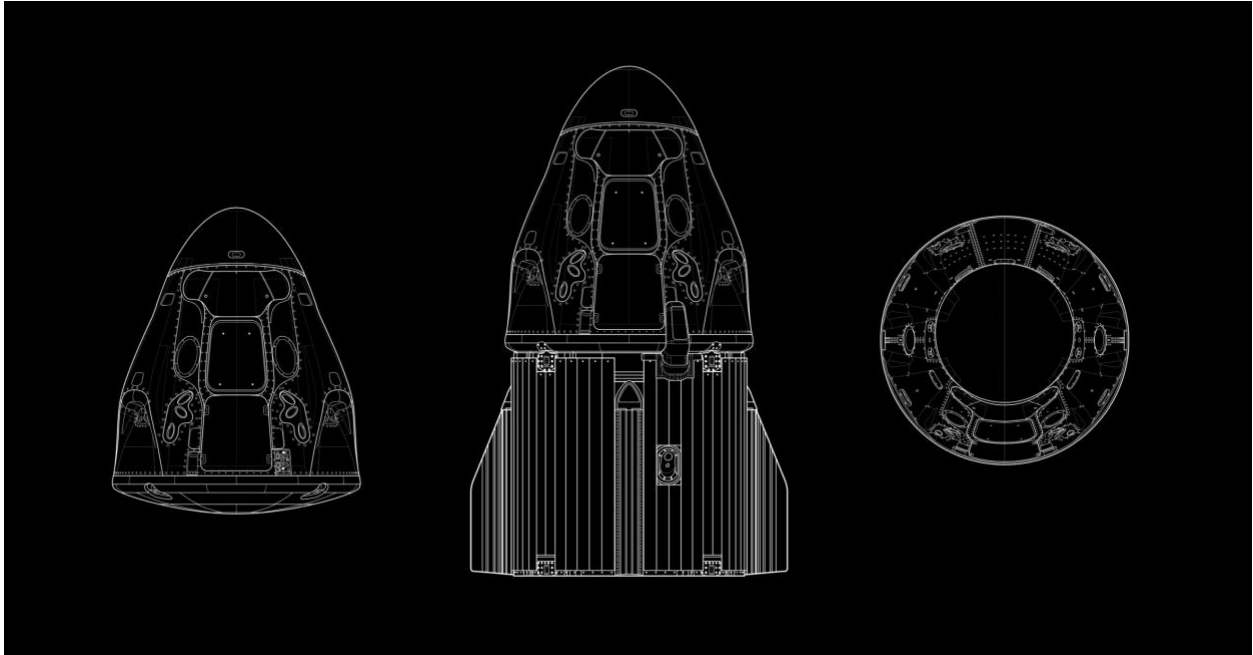
Demo-2

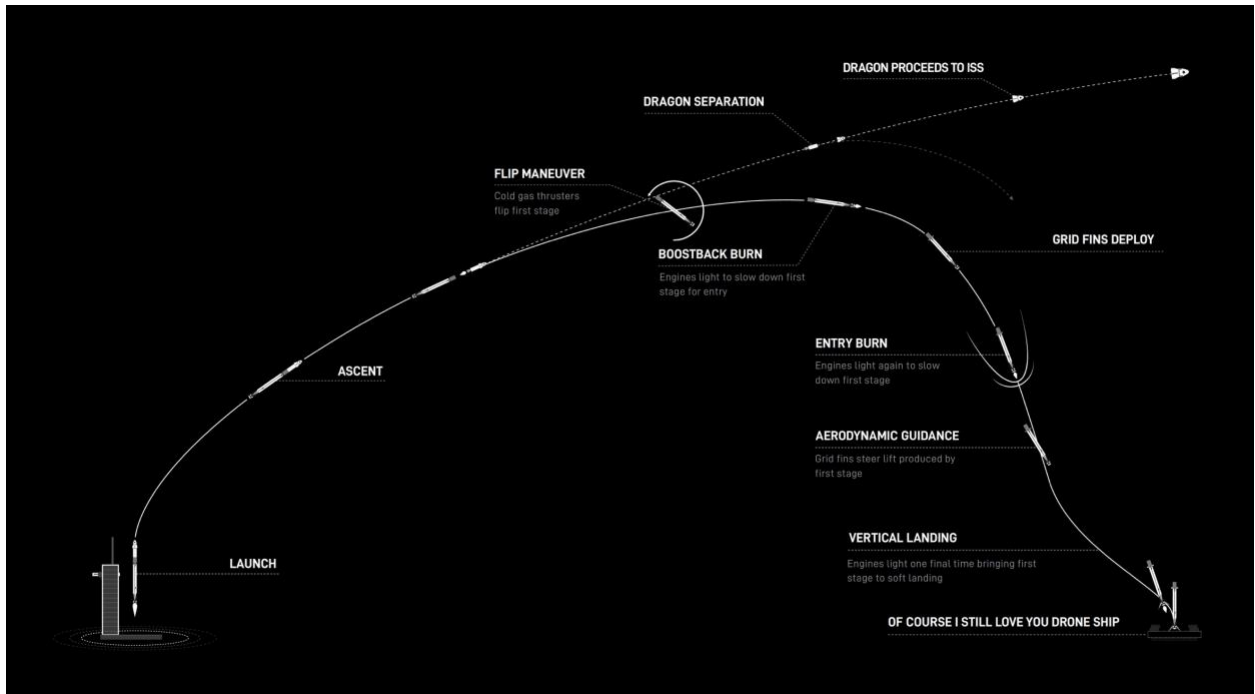
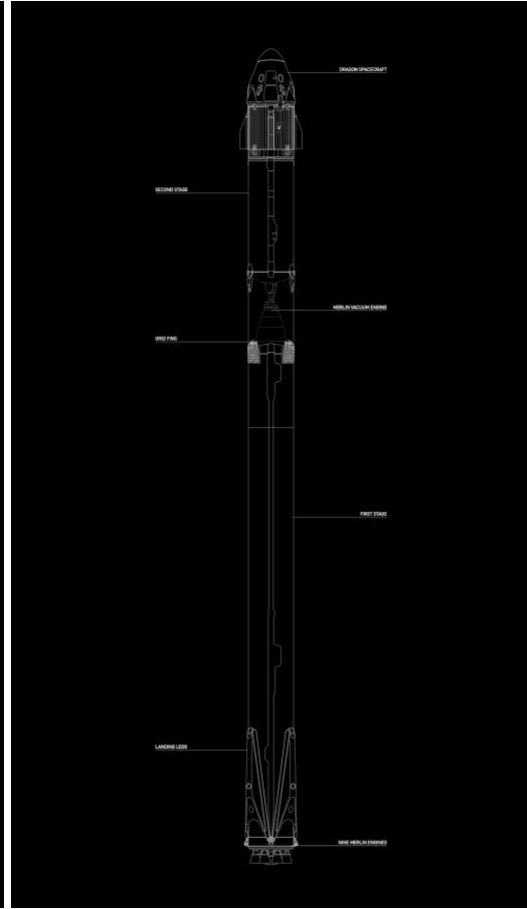
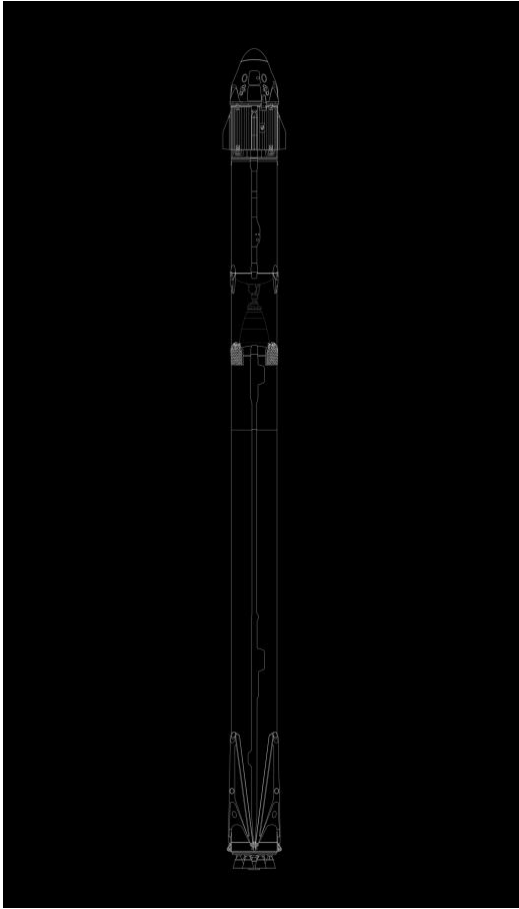
This is SpaceX's final flight test, which will validate all aspects of its crew transportation system, including its spacecraft (Crew Dragon), launch vehicle (Falcon 9), launch pad (LC-39A), and operations capabilities.

On this mission, NASA astronauts Bob Behnken and Doug Hurley will don SpaceX's spacesuits, be transported to the launch pad, and board SpaceX's next-generation spacecraft. Once Crew Dragon's hatch is closed, its launch escape system will be armed, which will prepare the spacecraft to separate from the launch vehicle in the unlikely event of anomaly on the pad or during ascent.

Launch and ascent will be consistent with SpaceX's Cargo Resupply Services Dragon missions' trajectories and staging events, with the notable exception that astronauts will be onboard. Once in orbit, the crew and SpaceX mission control will verify the vehicle is performing as intended by testing the environmental control system, the displays and control system, and the maneuvering thrusters, among other things. In about 24 hours, Crew Dragon will be in position to rendezvous and dock with the space station. Crew Dragon is designed to dock autonomously, but crew onboard the spacecraft and the Space Station will diligently monitor the performance of the spacecraft as it approaches and docks.

[Falcon 9 Crew Dragon Launch Weather Criteria](#)





Mission Timeline

COUNTDOWN

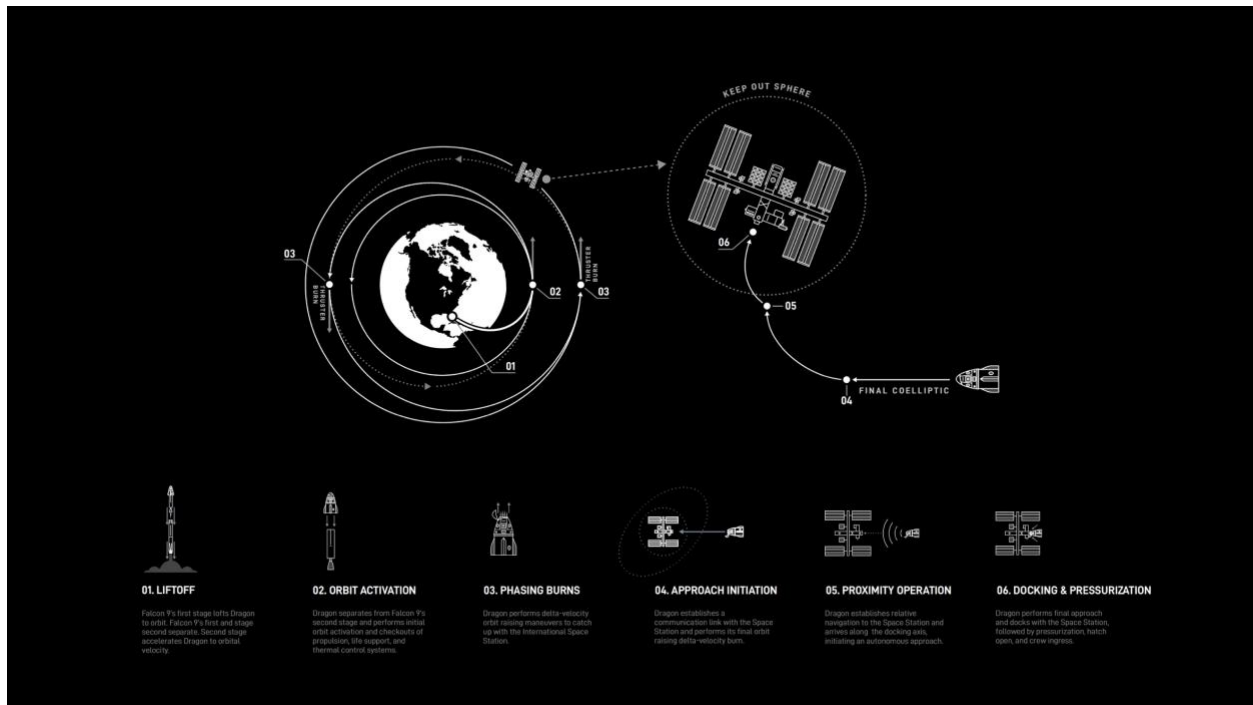
(all times are approximate and adjustments may occur prior to launch)

Hour/Min/Sec	Events
-04:15:00	Crew weather brief
-04:05:00	Crew handoff
-04:00:00	Suit donning and checkouts
-03:22:00	Crew Walk Out from Neil Armstrong Operations and Checkout Building
-03:15:00	Crew Transportation to Launch Complex 39A
-02:55:00	Crew arrives at pad
-02:35:00	Crew ingress
-02:20:00	Communication check
-02:15:00	Verify ready for seat rotation
-02:14:00	Suit leak checks
-01:55:00	Hatch close
-00:45:00	SpaceX Launch Director verifies go for propellant load
-00:42:00	Crew access arm retracts
-00:37:00	Dragon launch escape system is armed
-00:35:00	RP-1 (rocket grade kerosene) loading begins
-00:35:00	1st stage LOX (liquid oxygen) loading begins
-00:16:00	2nd stage LOX loading begins
-00:07:00	Falcon 9 begins engine chill prior to launch
-00:05:00	Dragon transitions to internal power
-00:01:00	Command flight computer to begin final prelaunch checks
-00:01:00	Propellant tank pressurization to flight pressure begins
-00:00:45	SpaceX Launch Director verifies go for launch
-00:00:03	Engine controller commands engine ignition sequence to start
-00:00:00	Falcon 9 liftoff

LAUNCH, LANDING AND DRAGON DEPLOYMENT

(all times are approximate and adjustments may occur prior to launch)

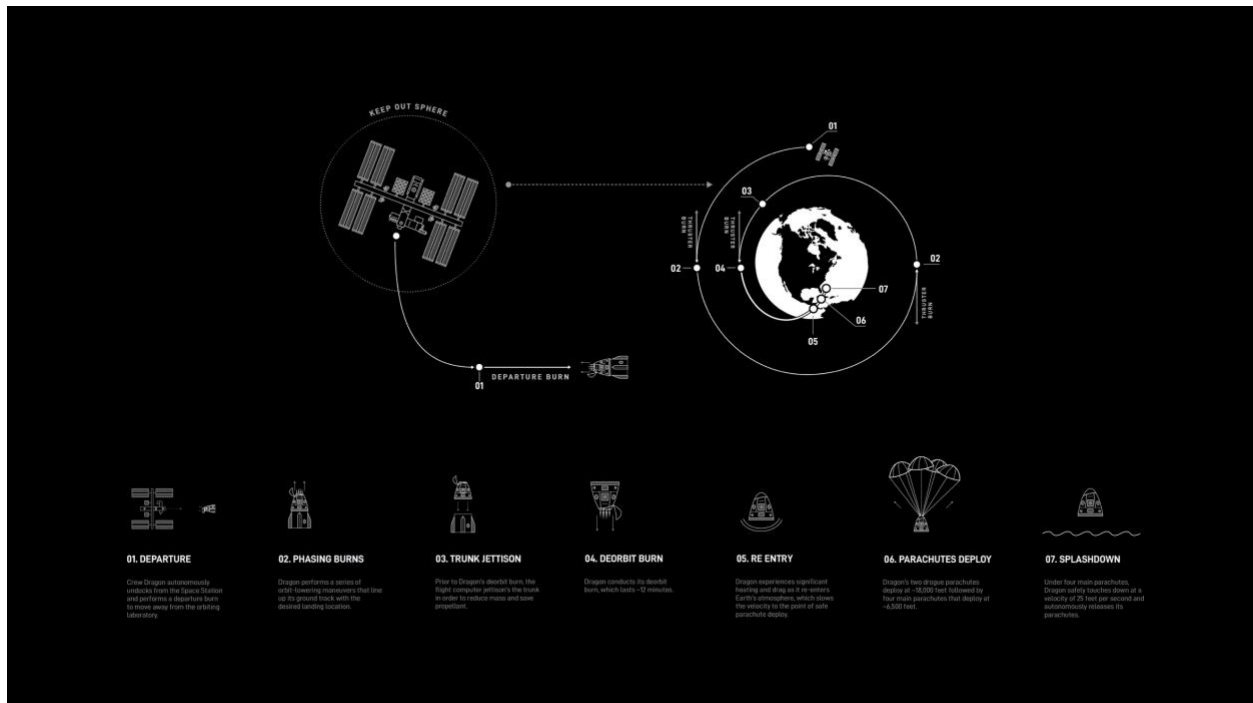
Hour/Min/Sec	Events
+00:00:58	Max Q (moment of peak mechanical stress on the rocket)
+00:02:33	1st stage main engine cutoff (MECO)
+00:02:36	1st and 2nd stages separate
+00:02:44	2nd stage engine starts
+00:07:15	1st stage entry burn
+00:08:47	2nd stage engine cutoff (SECO-1)
+00:08:52	1st stage entry burn
+00:09:22	1st stage landing
+00:12:00	Crew Dragon separates from 2nd stage
+00:12:46	Dragon nosecone open sequence begins



ISS Docking

Crew Dragon will perform a series of phasing maneuvers to gradually approach and autonomously dock with the International Space Station on Thursday, May 28, at approximately 11:30 a.m. EDT.

After successfully docking, the crew will be welcomed aboard the International Space Station, where they will become members of the Expedition 63 crew. They will perform tests on Crew Dragon in addition to conducting research and other tasks with the space station crew.



Return Flight

Although the Crew Dragon being used for this flight test can stay in orbit about 110 days, the specific mission duration will be determined once on station based on the readiness of the next commercial crew launch. The operational Crew Dragon spacecraft will be capable of staying in orbit for at least 210 days as a NASA requirement.

At the conclusion of the mission, Behnken and Hurley will board Crew Dragon, which will then autonomously undock, depart the space station, and re-enter Earth's atmosphere. Upon splashdown off Florida's Atlantic Coast, the crew will be picked up by the SpaceX recovery ship and returned to the dock at Cape Canaveral.

Crew-1

Crew-1 will be the first in a series of regular, rotational flights to the International Space Station following NASA's certification of the new SpaceX crewed system. Certification will follow completion and validation of SpaceX's test flight with astronauts, known as Demo-2.

Pending the successful Demo-2 test, NASA astronauts Victor Glover, Mike Hopkins, Shannon Walker and JAXA astronaut Soichi Noguchi will launch aboard Crew Dragon on SpaceX's Falcon 9 rocket from Launch Complex 39A at NASA's Kennedy Space Center in Florida. The crew will remain on station for approximately six months. The Crew-1 mission is targeted for later in 2020.

SpaceX Operations

Crew Dragon



Designed with crew and reuse in mind, Crew Dragon is an innovative achievement worthy of the challenge to advance human spaceflight.

Name: Crew Dragon, SpaceX's next-generation spacecraft

Mission: SpaceX's Crew Dragon spacecraft will re-establish an American human launch capability, beginning with flights to the International Space Station, which will increase the use of the orbiting laboratory's unique research environment.

Crew Dragon is an autonomous spacecraft designed to deliver **crew and critical cargo** to orbiting destinations.

Crew Dragon launches atop a **Falcon 9** rocket from Launch Complex 39A at NASA's Kennedy Space Center in Florida.

As part of NASA's Commercial Resupply Services contract with SpaceX, the company developed its Dragon spacecraft to carry cargo to space, but it was designed with people in mind from the beginning.

Crew Dragon Design and Development

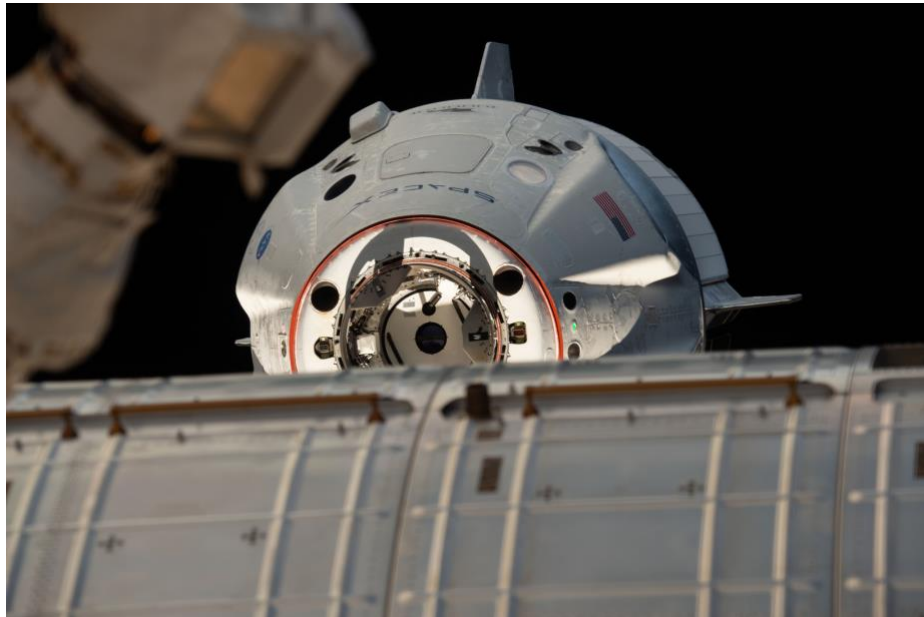
Crew Dragon was developed in collaboration with **NASA's Commercial Crew Program**.

In 2014, NASA awarded Commercial Crew Transportation Capability (CCtCap) contracts to Boeing and SpaceX to each safely and cost-effectively transport astronauts to the International Space Station from the United States.

Crew Dragon is capable of carrying up to seven passengers but will carry **up to four astronauts for NASA missions**, and is designed for water landings.

Crew Dragon's displays will provide **real-time information** on the state of the spacecraft's capabilities—anything from the spacecraft's position in space, to possible destinations, to the environment on board.

Crew Dragon is a **fully autonomous** spacecraft that can be monitored and controlled by onboard astronauts and SpaceX mission control in Hawthorne, California.



Dragon is composed of two main elements: the capsule, which is designed to carry crew and critical, pressurized cargo, and the trunk, which is an unpressurized service module. The capsule is subdivided into the pressurized section, the service section and the nose cone, which is opened once on orbit and stowed prior to re-entry.

Near the base of the capsule, but outside the pressurized structure, are the **Draco thrusters**, which allow for orbital maneuvering. Additional Draco thrusters are housed under the nose cone, along with Dragon's Guidance Navigation and Control (GNC) sensors.

Dragon's **trunk** provides the mating interface for the capsule to Falcon 9 on its ascent to space. On orbit, half of the trunk contains a solar array, which powers Dragon, and the other half contains a radiator, which rejects heat. Both the radiator and solar array are mounted to the exterior of the trunk, which remains attached to Dragon until shortly before re-entry when the trunk is jettisoned.

Crew Dragon was designed with **three windows** so passengers can take in views of Earth, the Moon and the wider solar system right from their seats.

Crew Dragon has an **Environmental Control and Life Support System (ECLSS)** that provides a comfortable and safe environment for crew members. During their trip, astronauts on board can set the spacecraft's interior temperature to between 65 and 80 degrees Fahrenheit.

Crew Dragon features an advanced abort system with **eight SuperDraco engines** and a series of parachutes that can be activated instantaneously from the moment they are armed on the launch pad all the way through orbital insertion.

SpaceX has designated **two U.S. offshore splashdown sites** for the Crew Dragon. The primary splashdown location is in the Atlantic Ocean offshore from Cape Canaveral, Florida. The secondary splashdown location is in the Gulf of Mexico, ranging from south of Brownsville, Texas, to an area north of the Florida Keys up to 170 nautical miles offshore.

In August 2018, NASA announced the first astronauts who will fly aboard Demo-2 and SpaceX's first operational mission, or Crew-1. In Demo-2, NASA astronauts Bob Behnken and Doug Hurley will be the first to fly aboard Crew Dragon. The Demo-2 flight test is part of the path to certification for Crew Dragon.

Following the successful Demo-2 flight test and completion of the NASA certification process, SpaceX will begin regular crew rotation missions to the space station, beginning with Crew-1. Those assigned to Crew-1 are NASA astronauts Victor Glover, Mike Hopkins, Shannon Walker and JAXA astronaut Soichi Noguchi.

NASA has ordered six crew rotation missions to the International Space Station from SpaceX. Crew-1 will be the first of these rotation missions.



Falcon 9



Falcon 9 is a two-stage rocket designed and manufactured by SpaceX for the reliable and safe transport of satellites and the Dragon spacecraft into orbit. Falcon 9 is the first orbital class rocket capable of reflight.

Falcon 9 made history in 2012 when it delivered Dragon into the correct orbit for rendezvous with the International Space Station, making SpaceX the first commercial company to visit the station. Since then, Falcon 9 has made numerous trips to space, delivering satellites to orbit as well as delivering and returning cargo from the space station for NASA. Falcon 9, along with the Dragon spacecraft, was designed from the outset to deliver humans into space, and under an agreement with NASA, SpaceX is actively working toward this goal.

Falcon 9's first stage incorporates nine Merlin engines and aluminum-lithium alloy tanks containing liquid oxygen and rocket-grade kerosene (RP-1) propellant. After ignition, a hold-before-release system ensures that all engines are verified for full-thrust performance before the rocket is released for flight. Then, with thrust greater than five 747s at full power, the Merlin engines launch the rocket to space. Unlike airplanes, a rocket's thrust actually increases with altitude; Falcon 9 generates more than 1.7 million pounds of thrust at sea level but produces over 1.8 million pounds of thrust in the vacuum of space. The first-stage engines are gradually throttled near the end of first-stage flight to limit launch vehicle acceleration as the rocket's mass decreases with the burning of fuel.

The interstage is a composite structure that connects the first and second stages and holds the release and separation system. Falcon 9 uses an all-pneumatic stage separation system for low-shock, highly reliable separation that can be tested on the ground, unlike pyrotechnic systems used on most launch vehicles.

Falcon 9 is equipped with an Autonomous Flight Termination System to be used in the unlikely event that the rocket drifts off course or becomes unresponsive.

Carbon fiber landing legs and hypersonic grid fins, all stowed during ascent, are two of the critical elements essential to ensure safe and successful landing of the Falcon 9 first stage.

Technical Overview

- Height: 70 meters or 229.6 feet
- Mass: 549,054 kilograms or 1,207,920 pounds
- Payload to Low Earth Orbit: 22,800 kilograms or 50,265 pounds
- Diameter: 3.7 meters or 12 feet



SpaceX Spacesuit



SpaceX designed its spacesuit for astronauts to wear inside the Crew Dragon spacecraft as they fly to and from the International Space Station and to ensure their safety as they operate in low-Earth orbit.

The suit is custom-made for each passenger aboard Crew Dragon and is designed to be functional, lightweight, and to offer protection from potential depressurization.

A single connection point on the suit's thigh attaches life support systems, including air and power connections.



The helmet is custom manufactured using 3D printing technology and includes integrated valves, mechanisms for visor retraction and locking, and microphones within the helmet's structure.

NASA astronauts have been performing spacesuit fit checks and other testing to prepare for missions, including the first pressurized spacesuit tests.



Launch Complex 39A



Launch Complex 39A (LC-39A) was **originally built** for the Apollo/Saturn V rockets that launched American astronauts on their historic journeys to the Moon and back.

Since the late 1960s, Pads A and B at Kennedy Space Center's Launch Complex 39 have served as backdrops for America's most significant human spaceflight endeavors—**Apollo, Skylab, Apollo-Soyuz and space shuttle.**

In 2014, Space Exploration Services, or SpaceX, **signed a property agreement** with NASA for use and operation of LC-39A for 20 years, part of Kennedy Space Center's transition to a multi-user spaceport.

SpaceX modified LC-39A to adapt it to the needs of the company's **Falcon 9 and Falcon Heavy rockets.**

SpaceX constructed a **Horizontal Integration Facility** near the perimeter of the pad where rockets are processed for launch prior to rollout to the pad for liftoff.

The **Transporter Erector (TE)** is used to move the Crew Dragon spacecraft to the top of the Falcon 9 rocket on the launch pad.

Standing 212 feet high—more than 20 stories—the TE moves launch-ready rockets and spacecraft from the processing hangar at the base of the pad up to the pad surface and into a vertical position over the flame trench.

The TE is a much larger and stronger version of the erector the company uses at Space Launch Complex 40, and is used for processing and launching Falcon Heavy rockets.

The first SpaceX launch from LC-39A was SpaceX's 10th Commercial Resupply Services mission to the International Space Station, known as CRS-10. The launch on Falcon 9 took place on Feb. 19, 2017, and carried supplies and research to the space station. Since then, CRS-11 and CRS-12 have also launched from LC-39A.

SpaceX will use LC-39A for its Crew Dragon missions to the International Space Station.

Ascent



COUNTDOWN

(all times are approximate and adjustments may occur prior to launch)

Hour/Min/Sec	Events
-00:45:00	SpaceX Launch Director verifies go for propellant load
-00:42:00	Crew access arm retracts
-00:37:00	Dragon launch escape system is armed
-00:35:00	RP-1 (rocket grade kerosene) loading begins
-00:35:00	1st stage LOX (liquid oxygen) loading begins
-00:16:00	2nd stage LOX loading begins
-00:07:00	Falcon 9 begins engine chill prior to launch
-00:05:00	Dragon transitions to internal power
-00:01:00	Command flight computer to begin final prelaunch checks
-00:01:00	Propellant tank pressurization to flight pressure begins
-00:00:45	SpaceX Launch Director verifies go for launch
-00:00:03	Engine controller commands engine ignition sequence to start
-00:00:00	Falcon 9 liftoff

LAUNCH, LANDING AND DRAGON DEPLOYMENT

(all times are approximate and adjustments may occur prior to launch)

Hour/Min/Sec	Events
+00:00:58	Max Q (moment of peak mechanical stress on the rocket)
+00:02:33	1st stage main engine cutoff (MECO)
+00:02:36	1st and 2nd stages separate
+00:02:44	2nd stage engine starts
+00:07:15	1st stage entry burn
+00:08:47	2nd stage engine cutoff (SECO-1)

+00:08:52	1st stage entry burn
+00:09:22	1st stage landing
+00:12:00	Crew Dragon separates from 2nd stage
+00:12:46	Dragon nosecone open sequence begins

ISS Docking

Crew Dragon will perform a series of phasing maneuvers to gradually approach and autonomously dock with the International Space Station approximately one day after launch.

Retrieving Crew Dragon



After missions to the International Space Station, Crew Dragon will re-enter Earth's atmosphere and deploy drogue parachutes, prior to unfurling the spacecraft's four main parachutes.

In a normal scenario, Crew Dragon will splash down off of Florida's eastern coast. SpaceX's recovery ship is equipped with a crane to lift the capsule out of the water and onto the main deck of the ship. The ship is also outfitted with a medical treatment facility and a helipad in the center of the vessel, allowing for immediate treatment and swift transport to a hospital in the unlikely event of an astronaut medical emergency after splashdown.

SpaceX's backup splashdown location for NASA missions is in the Gulf of Mexico.

Safety and Innovation

Crew safety remains NASA's primary responsibility and priority for all human spaceflight programs. Since the beginning of NASA's Commercial Crew Program, safety has been built into the agency's requirements as a direct result of NASA's extensive experience in human spaceflight systems development and operations.

NASA and its commercial partners, Boeing and SpaceX, have developed systems that prioritize crew safety and survival, including launch pad emergency escape and egress systems. When commercial crew launches astronauts on test flights, both companies will have completed an uncrewed flight test to the International Space Station and demonstrated their ability to safely fly astronauts away from an emergency situation.

These commercial systems are required to meet NASA's safety and performance requirements to be certified to transport NASA and international partner astronauts to the space station.

Foundation of Innovation

NASA's Commercial Crew Program tailored requirements for a new generation of human-rated spacecraft, allowing the industry to create innovative design solutions, manufacturing processes, operational methods and engineering techniques. The result has been a series of components, systems and now spacecraft and rockets that will soon take astronauts to and from the International Space Station in a manner that is both cost-effective and reliable.

At the heart of the innovation is an approach that is new to NASA's human spaceflight programs, which calls on the private industry to design, build and operate spacecraft and rockets along with all their related ground systems, control centers and support infrastructure.

To learn more on innovation and the Commercial Crew Program, click <https://www.nasa.gov/feature/business-innovation-key-to-commercial-crew-program-s-success>

Certification

The certification process is based upon NASA's decades of experience, as well as the combined talents and experience of the Boeing and SpaceX engineers, technicians and managers. NASA teams will use flight data from the uncrewed flight tests, spacecraft abort tests and, ultimately, the crew flight tests to verify that the systems meet NASA's safety and performance requirements. The crew aboard the flight test to the station will validate that the spacecraft systems operate as planned in both autonomous and manual settings.

NASA will verify that throughout these flight tests the companies demonstrated compliance with Commercial Crew Program hardware and software requirements, NASA standards for design and construction, engineering and management processes, and validation of the entire crew transportation system in a flight environment. The companies will then work with NASA to resolve issues as necessary to certify the systems meet NASA's safety and performance requirements outlined in the Commercial Crew Transportation Capability (CCtCap) contracts.

Following NASA certification, the companies will begin flying their six operational missions with NASA and international partner astronauts

A Space-Borne Lifeboat

New, American-made spacecraft flying to the International Space Station will play a big role in bringing resident crews back home to Earth, but their missions also include the ability to provide the orbiting laboratory with a temporary shelter in case of an emergency in space or even a safe ride back to Earth with short notice.

The scenarios that would call for the spacecraft to operate as space-borne lifeboats have not occurred on the space station before, but mission planners have long made sure they are prepared. An electrical issue or ammonia leak on the space station could call for astronauts to shelter inside a Commercial Crew Program spacecraft long enough to correct the problem.

To learn more about the life saving potential of commercial spacecraft docked to the space station, click

<https://www.nasa.gov/feature/commercial-crew-spacecraft-will-offer-a-quick-escape-from-station>

International Docking Adapter

Getting to orbit is a milestone and not a destination. It is no small feat to dock with our orbiting outpost. But before that feat can be achieved, the International Space Station needed an upgrade.

The International Docking Adapters were built to the International Docking System Standard, which features built-in systems for automated docking and uniform measurements. That means any destination or any spacecraft can use the adapters in the future—from the new commercial spacecraft to other international spacecraft yet to be designed. The adapters also include fittings so power and data can be transferred from the station to the visiting spacecraft.

Boeing's CST-100 and SpaceX's Crew Dragon spacecraft will dock at the adapters in the near future when bringing astronauts to the station as part of NASA's Commercial Crew Program.

For more information on the International Docking Adapters, click

<https://www.nasa.gov/feature/meet-the-international-docking-adapter>

Space Station Research

The addition of the Boeing Starliners and SpaceX Crew Dragons to the manifest of spacecraft heading to the International Space Station in the near future raises more than the opportunity for astronauts to fly to and from space aboard American spacecraft. It also increases the amount of science and broadens the research that can be performed aboard the orbiting laboratory.

That's because the new generation of human-rated spacecraft are being designed to carry time-critical science to and from the space station along with astronauts. Researchers will be able to work with astronauts aboard the station to undertake a wide array of different science investigations and will benefit from the increased opportunity to see their research returned back to Earth for continued examination.

To learn more about the benefits of commercial crew to space station research, click

<https://www.nasa.gov/feature/commercial-crew-missions-offer-research-bonanza-for-space-station>

Helicopter Rescue Training

When astronauts splash down into the ocean after their journey to the International Space Station on SpaceX's Crew Dragon spacecraft, recovery teams must be able to transport them to land quickly. In the unlikely event of an astronaut medical emergency, SpaceX has outfitted each of its recovery ships with a medical treatment facility and a helipad in the center of the vessel.

To read more about SpaceX's helicopter rescue training, click

<https://blogs.nasa.gov/commercialcrew/2018/11/05/spacex-rehearses-helicopter-landing-at-sea/>

Water Rescue Training

Rescue and recovery involves meticulous planning and close coordination among NASA, the Department of Defense (DOD) and company recovery teams for Crew Dragon. In the event of a variety of contingency landings, an elite team is prepared to rescue the crew anywhere in the world.

In preparation for both launch and landing, U.S. Air Force "Guardian Angel" pararescue forces will be pre-positioned in key locations, alert and ready to deploy at a moment's notice. Should a spacecraft splash down within 200 nautical miles of the launch site, an HC-130 aircraft, along with two HH-60 Pave Hawk helicopters, will deploy from Patrick Air Force Base in Florida. These aircraft will carry a team of up to nine Guardian Angels—also known as pararescue specialists—along with rescue equipment and medical supplies.

To read more about water rescue training, click

<https://www.nasa.gov/feature/rescue-operations-take-shape-for-commercial-crew-program-astronauts>

Triage and Medical Evacuation Training

It is vital that teams prepare for launch day operations, including possible but unlikely emergency scenarios, and simulations are key to getting teams as ready as possible.

Teams from NASA, HSFS and SpaceX have conducted joint medical triage and medical evacuation (medevac) training exercises at NASA's Kennedy Space Center in Florida.

To read more about joint medevac training, click

<https://blogs.nasa.gov/commercialcrew/2018/10/25/commercial-crew-teams-practice-triage-and-medical-evacuation/>

Crew Dragon Abort System

"A loud whoosh, faint smoke trail and billowing parachutes marked a successful demonstration Wednesday by SpaceX of its Crew Dragon spacecraft abort system – an important step in NASA's endeavor to rebuild America's ability to launch crews to the International Space Station from U.S. soil. The successful test of the spacecraft's launch escape capabilities proved the spacecraft's ability to carry astronauts to safety in the unlikely event of a life-threatening situation on the launch pad."

To read more about successful pad abort test of Crew Dragon, click

<https://www.nasa.gov/press-release/spacex-demonstrates-astronaut-escape-system-for-crew-dragon-spacecraft>

To see the pad abort test footage, click

<https://www.youtube.com/watch?v=FRqLNdwsPBM>

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Multimedia

Commercial Crew Program Facebook

<https://www.facebook.com/NASACommercialCrew>

Commercial Crew Program Twitter

https://twitter.com/commercial_crew?lang=en

Commercial Crew Program YouTube Playlist

<https://www.youtube.com/playlist?list=PLBE9B5BD2A8B10113>

Commercial Crew Program Blog

<https://blogs.nasa.gov/commercialcrew>

NASA Image Archive - Commercial Crew Program

<https://images.nasa.gov/search-results?q=commercial%20crew&page=1&media=image,video,audio&yearStart=1920&yearEnd=2018>

SpaceX B-roll

Demo-2 Resource Reel

<https://archive.org/search.php?query=subject%3A%22DM-2+Resource+Reel%22>

CCP Resource Reel

<https://archive.org/search.php?query=subject%3A%22CCP+Resource+Reel%22>

Demo-2 Trailer Video

https://images.nasa.gov/details-NHQ_050420_DEMO_2_TRAILER

Demo-2 Full Mission Animation

https://images.nasa.gov/details-KSC-20200513-MH-SPX01-0001-SpaceX_Demo-2_Mission_Animation-3250103

Doug Hurley answering common questions

<https://archive.org/search.php?query=subject%3A%22DM-2+Crew+Interview+-+Doug+Hurley%22>

Doug Hurley media interviews on NASA TV

https://archive.org/details/iss063m261221939-NASA_SpaceX_Demo2_Douglas_Hurley_Interviews_2020_0501

Bob Behnken answering common questions

<https://archive.org/search.php?query=subject%3A%22DM-2+Crew+Interview+-+Bob+Behnken%22>

Bob Behnken media interview on NASA TV

https://archive.org/details/NASA_SpaceX_Demo2_Robert_Behnken_Interviews_2020_0501

SpaceX Dry Dress Rehearsal (January 2020)

https://images.nasa.gov/details-KSC-20200117-MH-MMS01-0001-SpaceX_In-Flight_Abort_Dry_Dress_Rehearsal_re-edit-3246949

Demo-2 End-to-End Pad Rescue Demonstration

https://images.nasa.gov/details-KSC-20200403-MH-SPX01-0001-SpaceX_Demo-2_End_to_End_Pad_Rescue_Demonstration_DRONE-3247730

Astronauts Bob Behnken and Doug Hurley training in Crew Dragon

https://images.nasa.gov/details-KSC-20190225-MH-SPX01-0001-SpaceX_Demo-2_Astronauts_Train_in_Crew_Dragon.html

Animation of the sequence for the Crew Dragon In Flight Abort Test

<https://www.youtube.com/watch?v=qObBRM4euxk&feature=youtu.be>

Drone footage from Demo-1 static fire test

https://images.nasa.gov/details-KSC-20190225-MH-SPX03-0001-SpaceX_Crew_Access_Arm.html

Interior of Crew Dragon

https://images.nasa.gov/details-KSC-20190225-MH-SPX02-0001-Inside_the_SpaceX_Crew_Dragon_Spacecraft.html

Time-lapse video of Falcon 9 and Crew Dragon being raised from horizontal to vertical

https://images.nasa.gov/details-KSC-20190225-MH-SPX04-0001-SpaceX_Crew_Dragon_Falcon_9_Goes_Vertical.html

Demo-1 mission highlights

https://images.nasa.gov/details-SpaceX_DM1_Highlights_Reel_MP4.html

Demo-1 isolated launch views

https://images.nasa.gov/details-KSC_20190302-MH-NAS01-0001-SpaceX_Demo-1_NASA_Launch_Views-3213397.html

NASA Commercial Crew Program - astronaut training resource reel

https://images.nasa.gov/details-jsc2018m000320_CCP_Crew_Training_Resource_Reel.html

Pad abort test footage from 2015

<https://www.youtube.com/watch?v=FRqLNdwsPBM>

Explainer Videos

NASA Commercial Crew Program: Our Destiny Lies Above Us

https://www.youtube.com/watch?v=z-0M3h_saiA

Meet the Flight Test Crews

<https://www.youtube.com/watch?v=RU6QkU8w60c>

Astronaut Flight Prep

<https://www.youtube.com/watch?v=gpouNI1sgqA>

The Spacecraft

<https://www.youtube.com/watch?v=zrBTu389aqY>

The Flight Tests

<https://www.youtube.com/watch?v=aoU5P2SSCho>

Supporting Critical Research

<https://www.youtube.com/watch?v=FCVJWNbhb14>

Dawn of a New Era

<https://www.youtube.com/watch?v=5qrUVh-Xev8&t=4s>

STEM Engagement



The NextGen STEM Commercial Crew Program brings the accomplishments of NASA and our commercial partners, Boeing and SpaceX, to audiences through a variety of educational resources and opportunities. These hands-on, authentic STEM activities and classroom resources, including apps like “Rocket Science: Ride to Station,” engage students and educators in the mission while helping build a strong and growing U.S. space industry in low Earth orbit by providing meaningful STEM experiences to the future generation of explorers.

To learn more, click here:

https://www.nasa.gov/stem/nextgenstem/commercial_crew/index.html

To access the app, click here:

<https://www.nasa.gov/stem-ed-resources/rocket-science-ride-to-station.html>