Crew Dragon, SpaceX's Next-Generation Spacecraft

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 the first-stage flight to limit launch vehicle acceleration as the rocket's mass decreases with the burning of fuel.

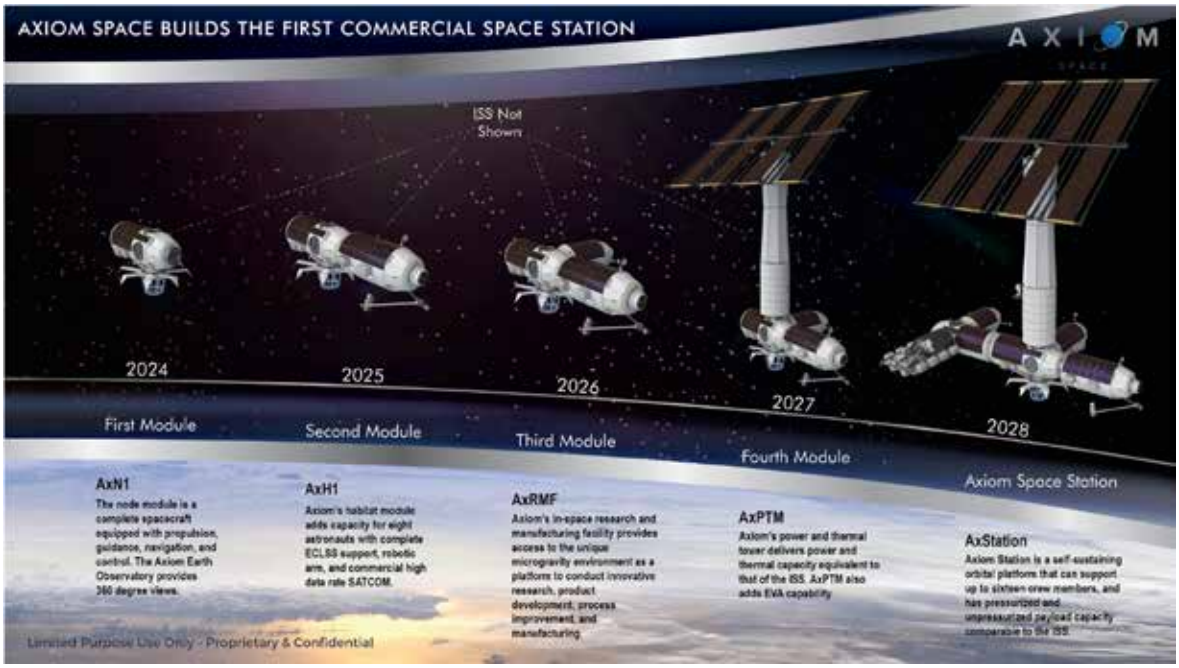
The interstage is a composite structure that connects the first and second stages and holds the release and separation system. Falcon 9 uses an all-pneumatic stage separation system (a highly reliable separation that can be tested on the ground) for low shock, unlike pyrotechnic systems used on most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

The Era of Accessible Private Spaceflight

Given Commercial Crew's apparent success, NASA is also hoping to use this model for private spaceflights as well. In February 2020, Space Adventures, Inc., a Virginia-based space tourism company founded in 1998 by the American entrepreneur and aerospace engineer Eric C. Anderson, signed a deal with SpaceX, announcing its plans to fly private citizens into orbit on the Crew Dragon. Under the agreement, Space Adventures will use the SpaceX Falcon 9 rocket to fly up to four passengers to Earth orbit on a standalone mission aboard a Crew Dragon spacecraft in late 2021 or 2022. The mission would not dock with the space station but would instead fly into an orbit that could reach an altitude two-to-three times higher than the International Space Station. Space Adventures offers various programs such as Orbital spaceflight missions to the International Space Station, Circumlunar missions around the Moon, zero gravity flights, cosmonaut training programs, spaceflight qualification programs, and reservations on future suborbital spacecraft. To date, Space Adventures has arranged eight orbital trips to the International Space Station for seven wealthy customers, businessman Dennis Tito in 2001, South



African entrepreneur Mark Shuttleworth in 2002, American entrepreneurs Greg Olsen in 2005, Anousheh Ansari in 2006, Microsoft co-founder Charles Simonyi (twice) in 2007 and 2009, computer game developer Richard Garriott in 2008, and lastly Cirque du Soleil founder Guy Laliberte in 2009.

SpaceX's Crew Dragon is also expected to be used to shuttle tourists to and from Axiom Space's planned space station. SpaceX has signed a contract with Houston-based space startup, Axiom Space, to ferry four astronauts, including a commander professionally trained by Axiom alongside three private astronauts to and from the International Space Station. The mission, set to launch as soon as the second half of 2021, will allow the crew to live aboard the ISS and experience at least eight days of microgravity and views of Earth that can only be fully appreciated in the large, venerable station. The crew will be selected and trained by Axiom, with SpaceX providing the taxi service. Axiom Space, Inc. is an American privately funded aerospace manufacturer and orbital spaceflight services company headquartered in Houston, Texas. Founded in 2016 by the previous program manager for the International Space Station from 2005-2015, Michael T. Suffredini, the company plans commercial missions in late 2021 to the International Space Station (ISS) and aims to own and operate the world's first commercial space station. The company's leadership team is composed mainly of former NASA employees. As NASA shifts human spaceflight aspirations beyond low Earth orbit, Axiom's goal is to create the commercial infrastructure necessary to push humanity forward in space. The company outlines broad commercial activities, including human spaceflight for national and private astronauts, in-space research and manufacturing, and space exploration support. In 2020, NASA awarded Axiom a $140 million contract on 28 February 2020, to provide at least one habitable commercial module to be attached to the ISS as the agency continues to open the station for commercial use. The module will connect to the space station's Node 2 forward port to demonstrate its ability to provide products and services and begin the transition to a sustainable low-Earth orbit economy in which NASA is one of many customers. Next, NASA and Axiom will begin negotiations on the terms and price of a firm-fixed-price contract with a five-year base performance period and a two-year option.

Developing commercial destinations in low-Earth orbit is one of five elements of NASA's plan to open the International Space Station to new commercial and marketing opportunities. NASA's five-point plan addresses both the supply-side and demand-side for a new economy, enabling the use of government resources for commercial activities, creating the opportunity for private astronaut missions to the space station, enabling commercial destinations in

low-Earth orbit, identifying and pursuing activities that foster new and emerging markets, and quantifying NASA's long-term demand for activities in low-Earth orbit. Through these combined efforts, NASA aims to meet its long-term needs in low-Earth orbit well beyond the International Space Station's life. The agency's ultimate goal in low-Earth orbit is to partner with industry to achieve a strong ecosystem in which NASA is one of many customers purchasing services and capabilities at a lower cost. More than 50 companies are already conducting commercial research and development on the space station via the International Space Station U.S. National Laboratory. NASA has also worked with ten different companies to install more than 14 commercial facilities on the station that support research and development projects for NASA and the ISS National Lab. This effort is intended to broaden the scope of commercial activity on the space station beyond the ISS National Lab mandate, which is limited to research and development. NASA aims to enable commercial manufacturing and production and allow both NASA and private astronauts to conduct new commercial activities aboard the orbiting laboratory. Additionally, NASA plans to allow private astronaut missions of up to 30 days on the International Space Station. Considering the market demand, the agency intends to accommodate up to two short-duration private astronaut missions per year to the International Space Station. These missions will be privately funded, dedicated commercial spaceflights that will use a U.S. spacecraft developed under NASA's Commercial Crew Program.

From a broader perspective, the industry implications of commercial space travel remain various and promising. Demand for space travel among those that can afford it may rise significantly as barriers to entry decline. Moreover, the development of new spacecraft will encourage growth within the manufacturing sector because of the vast supply chains in spacecraft manufacturing. For the space economy to take off, countries will also need to put regulations in place that ensure safety and reliability in many areas, including vehicle safety and debris mitigation. In the future of space tourism, the commercial space travel industry has unbounded potential. However, whether SpaceX or anybody else can offer orbital flight for humans at a price that can actually yield a profit, SpaceX's crew launch brings humanity closer towards the viability of accessible commercial space travel.

Launch Complex 39A

Launch Complex 39A (LC-39A) was initially 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 the 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 multiuser 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 pad's perimeter 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 launchpad. 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 to process and launch 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 February 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.