Coordinates: 33.9207°N 118.3278°W

SpaceX

Space Exploration Technologies Corp. (**SpaceX**) is an American aerospace manufacturer and space transportation services company headquartered in Hawthorne, California. It was founded in 2002 by Elon Musk with the goal of reducing space transportation costs to enable the colonization of Mars. SpaceX manufactures the Falcon 9 and Falcon Heavy launch vehicles, several rocket engines, Dragon cargo and crew spacecraft and Starlink satellites.

SpaceX's achievements include the first privately funded liquid-propellant rocket to reach orbit (Falcon 1 in 2008), the first private company to successfully launch, orbit, and recover a spacecraft (Dragon in 2010), the first private company to send a spacecraft to the International Space Station (Dragon in 2012), the first vertical take-off and vertical propulsive landing for an orbital rocket (Falcon 9 in 2015), the first reuse of an orbital rocket (Falcon 9 in 2017), and the first private company to send astronauts to orbit and to the International Space Station (SpaceX Crew Dragon Demo-2 and SpaceX Crew-1 missions in 2020). SpaceX has flown and reflown the Falcon 9 series of rockets over one hundred times.

SpaceX is developing a large internet satellite constellation named Starlink. In January 2020 the Starlink constellation became the largest satellite constellation in the world. SpaceX is also developing Starship, a privately funded super heavy-lift launch system for interplanetary spaceflight. Starship is intended to become the primary SpaceX orbital vehicle once operational, supplanting the existing Falcon 9, Falcon Heavy and Dragon fleet. Starship will be fully reusable and will have the highest payload capacity of any orbital rocket ever on its debut, scheduled for the early 2020s.

Contents

Space Exploration Technologies Corp.

Headquarters in December 2017; plumes from a flight of a Falcon 9 rocket are visible overhead

Trade name	SpaceX
Type	Private
Industry	Aerospace
Founded	6 May 2002[1]
Founder	Elon Musk
Headquarters	Hawthorne, California, United States 33.9207°N 118.3278°W
Key people	Elon Musk (CEO and CTO, 2002–present)[2] Gwynne Shotwell (President and COO)[3]
Products	Several launch vehicles Several rocket engines Dragon capsules Starship (in development) Starlink ASDS landing platforms
Services	Orbital rocket launch
Revenue	▲US$2 billion (2019)
Owner	Elon Musk Trust (54% equity; 78% voting

	control)[4]
Number of employees	9,500 (Feb 2021)
Website	www.spacex.com (https://www.spacex.com)

History

2001–2004: Founding

In 2001 Elon Musk conceptualized *Mars Oasis*, a project to land a miniature experimental greenhouse and grow plants on Mars. He announced that the project would be "the furthest that life's ever traveled" in an attempt to regain public interest in space exploration and increase the budget of NASA.[5][6][7] Musk tried to purchase cheap rockets from Russia but returned empty-handed after failing to find rockets for an affordable price.[8][9]

On the flight home Musk realized that he could start a company that could build the affordable rockets he needed.[9] According to early Tesla and SpaceX investor Steve Jurvetson,[10] Musk calculated that the raw materials for building a rocket were only 3% of the sales price of a rocket at the time. By applying vertical integration,[8] producing around 85% of launch hardware in-house,[11] and the modular approach of modern software engineering, Musk believed SpaceX could cut launch price by a factor of ten and still enjoy a 70% gross margin.[12]

In early 2002 Musk started to look for staff for his new space company, soon to be named SpaceX. Musk approached rocket engineer Tom Mueller (later SpaceX's CTO of propulsion), and invited him to become his business partner. Mueller agreed to work for Musk, and thus SpaceX was born.[13] SpaceX was first headquartered in a warehouse in El Segundo, California. By November 2005, the company had 160 employees.[14]

Musk has stated that one of his goals with SpaceX is to decrease the cost and improve the reliability of access to space, ultimately by a factor of ten.[15]

2005–2009: Falcon 1 and first orbital launches

SpaceX developed its first orbital launch vehicle, the Falcon 1, with private funding.[16][17] The Falcon 1 was an expendable two-stage-to-orbit small-lift launch vehicle. The total development cost of Falcon 1 was approximately US$90 million.[18]

The first successful Falcon 1 launch in September 2008

In 2005 SpaceX announced plans to pursue a human-rated commercial space program through the end of the decade, a program which would later become the Dragon spacecraft.[19] In 2006 NASA announced that the company was one of two selected to provide crew and cargo resupply demonstration contracts to the ISS under the COTS program.[20]

The first two Falcon 1 launches were purchased by the United States Department of Defense under a program that evaluates new US launch vehicles suitable for use by DARPA.[17][21][22] The first three launches of the rocket, between 2006 and 2008, all resulted in failures. The first successful launch was achieved on 28 September 2008. The Falcon 1 was retired after its second successful launch in July 2009, to allow SpaceX to focus on the development of a larger orbital rocket, the Falcon 9.[23]

2010–2012: Falcon 9, Dragon, and NASA contracts

SpaceX originally intended to follow its light Falcon 1 launch vehicle with an intermediate capacity vehicle, the Falcon 5.[24] SpaceX instead decided in 2005 to proceed with the development of the Falcon 9, a reusable heavier lift vehicle. Development of the Falcon 9 was accelerated by NASA, which committed to purchase

several commercial flights if specific capabilities were demonstrated. This started with seed money from the Commercial Orbital Transportation Services (COTS) program in 2006.[25] The overall contract award was US$278 million to provide development funding for the Dragon spacecraft, Falcon 9, and demonstration launches of Falcon 9 with Dragon.[25] As part of this contract, the Falcon 9 launched for the first time in June 2010 with the Dragon Spacecraft Qualification Unit, using a mockup of the Dragon spacecraft. The first operational Dragon spacecraft was launched in December 2010 aboard COTS Demo Flight 1, the Falcon 9's second flight, and safely returned to Earth after two orbits, completing all its mission objectives.[26] By December 2010, the SpaceX production line was manufacturing one Falcon 9 (and Dragon spacecraft) every three months.[27]

Play media

Video of the first launch of Falcon 9

In April 2011, as part of its second-round Commercial Crew Development (CCDev) program, NASA issued a US$75 million contract for SpaceX to develop an integrated launch escape system for Dragon in preparation for human-rating it as a crew transport vehicle to the ISS.[28] In August 2012 NASA awarded SpaceX a firm, fixed-price Space Act Agreement (SAA) with the objective of producing a detailed design of the entire crew transportation system. This contract includes numerous key technical and certification milestones, an uncrewed flight test, a crewed flight test, and six operational missions following system certification.[29]

Dragon capsule after recovery from ocean landing in December 2010, following the first operational Dragon mission COTS-1

In early 2012 approximately two-thirds of the company stock was owned by the founder Musk[30] and his 70 million shares were then estimated to be worth US$875 million on private markets,[31] valuing SpaceX at US$1.3 billion.[32] In May 2012, with the Dragon C2+ launch Dragon became the first commercial spacecraft to deliver cargo to the International Space Station.[33] After the flight, the company private equity valuation nearly doubled to US$2.4 billion or US$20/share.[34][35] By that time, SpaceX had operated on total funding of approximately US$1 billion over its first decade of operation. Of this, private equity provided approximately US$200 million, with Musk investing approximately US$100 million and other investors having put in about US$100 million.[36]

SpaceX's active reusability test program began in late 2012 with testing low-altitude, low-speed aspects of the landing technology.[37] The Falcon 9 prototypes performed vertical takeoffs and landings (VTOL). High-velocity, high-altitude tests of the booster atmospheric return technology began in late 2013.[37]

2013–2015: Commercial launches and rapid growth

SpaceX launched the first commercial mission for a private customer in 2013. In 2014 SpaceX won nine contracts out of the 20 that were openly competed worldwide.[38] That year Arianespace requested that European governments provide additional subsidies to face the competition from SpaceX.[39][40] From 2014 SpaceX capabilities and pricing also began to affect the market for launch of U.S. military payloads, which for nearly a decade was dominated by the large U.S. launch provider United Launch Alliance (ULA).[41] The monopoly had allowed launch costs by the U.S. provider to rise to over US$400 million over the years.[42]

In January 2015 SpaceX raised US$1 billion in funding from Google and Fidelity, in exchange for 8.33% of the company, establishing the company valuation at approximately US$12 billion.[43] The same month SpaceX announced the development of a new satellite constellation, called Starlink, to provide global broadband internet service. The following June, the company asked the federal government for permission to begin testing for the project, aiming to build a constellation of 4,425 satellites.[44]

The Falcon 9 had its first major accident in late June 2015, when the seventh ISS resupply mission CRS-7 exploded after launch.[45] The problem was discovered to be a failed 2-foot-long steel strut that held a helium pressure vessel, which broke free due to the force of acceleration. This caused a breach and allowed high-pressure helium to escape into the low-pressure propellant tank, causing the failure.[46]

Launch of Falcon 9 carrying ORBCOMM OG2-M1, July 2014

2015–2017: Reusability milestones

SpaceX first achieved a successful landing and recovery of a first stage in December 2015 with Falcon 9 Flight 20.[47] In April 2016 the company achieved the first successful landing on the autonomous spaceport drone ship (ASDS) *Of Course I Still Love You* in the Atlantic Ocean.[48] By October 2016, following the successful landings, SpaceX indicated they were offering their customers a 10% price discount if they choose to fly their payload on a reused Falcon 9 first stage.[49]

In early September 2016 a Falcon 9 exploded during a propellant fill operation for a standard pre-launch static fire test.[50] The payload, the Amos-6 communications satellite valued at US$200 million, was destroyed.[51] The explosion was caused by the liquid oxygen that is used as propellant turning so cold that it solidified and ignited with carbon composite helium vessels.[52] Though not considered an unsuccessful flight, the rocket explosion sent the company into a four-month launch hiatus while it worked out what went wrong. SpaceX returned to flight in January 2017.[53]

On 30 March 2017 SpaceX launched a returned Falcon 9 for the SES-10 satellite. This was the first time a re-launch of a payload-carrying orbital rocket went back to space.[54] The first stage was recovered again, also making it the first landing of a reused orbital class rocket.[55]


Employees with the Dragon capsule at SpaceX HQ in Hawthorne, California, February 2015


Long-exposure of launch (left) and landing (right) during the Falcon 9 flight 20, the first successful return and vertical landing of an orbital rocket.

2017–2018: Leading global commercial launch provider

In July 2017 the Company raised US$350 million for a valuation of US$21 billion.[56] In 2017 SpaceX achieved a 45% global market share for awarded commercial launch contracts.[57] By March 2018, SpaceX had over 100 launches on its manifest representing about US$12 billion in contract revenue.[58] The contracts included both commercial and government (NASA/DOD) customers.[59] This made SpaceX the leading global commercial launch provider measured by manifested launches.[60]

In 2017 SpaceX formed a subsidiary, The Boring Company,[61] and began work to construct a short test tunnel on and adjacent to the SpaceX headquarters and manufacturing facility, utilizing a small number of SpaceX employees,[62] which was completed in May 2018,[63][64] and opened to the public in December 2018.[65] During 2018, The Boring Company was spun out into a separate corporate entity with 6% of the equity going to SpaceX, less than 10% to early employees, and the remainder of the equity to Elon Musk.[65]

Falcon 9 first stage on an autonomous spaceport drone ship (ASDS) barge after the first successful landing at sea, SpaceX CRS-8 mission.

2019–present: Starship, Starlink, and first crewed launches

On 11 January 2019 SpaceX announced it would lay off 10% of its workforce in order to help finance the Starship and Starlink projects.[67] Musk had announced his plans to build large spaceships to reach Mars already at the International Astronautical Congress (IAC) of 2016.[68] Construction of initial prototypes and tests for Starship started in early 2019 in Florida and Texas. All Starship construction and testing moved to the new SpaceX South Texas launch site later that year. In May 2019 SpaceX also launched the first large batch of 60 Starlink satellites, beginning the deployment of what would become the world's largest commercial satellite constellation the following year.[69]

SpaceX orbital launches by year[66]

SpaceX raised a total of US$1.33 billion of capital across three funding rounds in 2019.[70] By May 2019 the valuation of SpaceX had risen to US$33.3 billion[71] and reached US$36 billion by March 2020.[72]

On 30 May 2020 SpaceX successfully launched two NASA astronauts (Doug Hurley and Bob Behnken) into orbit on a Crew Dragon spacecraft during Crew Dragon Demo-2, making SpaceX the first private company to send astronauts to the International Space Station and marking the first crewed launch from American soil in 9 years.[73][74] The mission launched from Kennedy Space Center Launch Complex 39A (LC-39A) of the Kennedy Space Center in Florida.[75]

On 19 August 2020, after a US$1.9 billion funding round, one of the largest single fundraising pushes by any privately held company, SpaceX's valuation increased to US$46 billion.[76][77][78] In February 2021 SpaceX raised an additional US$850 million in an equity round at approximately $420 per share, raising the company valuation to about US$74 billion.[78]

Summary of achievements

Major achievements of SpaceX are in the reuse of orbital-class launch vehicles and cost reduction in the space launch industry. Most notable of these being the continued landings and relaunches of the first stage of Falcon 9. As of December 2020, SpaceX has used two separate first-stage boosters, B1049 and B1051, seven times each.[79] SpaceX is defined as a private space company and thus its achievements can also be counted as firsts by a private company.

List of achievements by SpaceX

Date	Achievement	Flight
28 September 2008	First privately funded fully liquid-fueled rocket to reach orbit.[80]	Falcon 1 flight 4
14 July 2009	First privately developed liquid-fueled rocket to put a commercial satellite in orbit.	RazakSAT on Falcon 1 flight 5
9 December 2010	First private company to successfully launch, orbit, and recover a spacecraft.	SpaceX Dragon on SpaceX COTS Demo Flight 1
25 May 2012	First private company to send a spacecraft to the International Space Station (ISS).[81]	Dragon C2+
22 December 2015	First landing of an orbital rocket's first stage on land.	Falcon 9 flight 20
8 April 2016	First landing of an orbital rocket's first stage on an ocean platform.	Falcon 9 flight 23
30 March 2017	First relaunch and landing of a used orbital first stage.[54]	B1021 on Falcon 9 flight 32
30 March 2017	First controlled flyback and recovery of a payload fairing.[82]	Falcon 9 flight 32
3 June 2017	First re-flight of a commercial cargo spacecraft.[83]	Dragon C106 on SpaceX CRS-11 mission.
6 February 2018	First private spacecraft launched into heliocentric orbit.	Elon Musk's Tesla Roadster on Falcon Heavy test flight
2 March 2019	First private company to send a human-rated spacecraft to orbit.	Crew Dragon Demo-1, on Falcon 9 flight 69
3 March 2019	First private company to autonomously dock a spacecraft to the International Space Station (ISS).	Crew Dragon Demo-1, on Falcon 9 flight 69
25 July 2019	First use of a full-flow staged combustion cycle engine (Raptor) in a free flying vehicle.[84] The benefit is a much longer life than conventional engines; it is expected to able to be re-used 1000 times.[85]	*Starhopper*
11 November 2019	First reuse of payload fairing. The fairing was from the ArabSat-6A mission in April 2019.	Starlink 1 Falcon 9 launch
January 2020	SpaceX became the largest commercial satellite constellation operator in the world.[69]	Starlink 3 Falcon 9 launch
30 May 2020	First private company to send humans into orbit.[86]	Crew Dragon Demo-2
31 May 2020	First private company to send humans to the International Space Station (ISS).[87]	Crew Dragon Demo-2
24 Jan 2021	Most spacecraft launched into space on a single mission, with 143 satellites.[a][88]	Transporter-1 on Falcon 9

a. Excluding the passive objects launched as part of Project West Ford

Hardware

Launch vehicles

SpaceX has developed three launch vehicles. The small-lift Falcon 1 was the first launch vehicle developed and was retired in 2009. The medium-lift Falcon 9 and the heavy-lift Falcon Heavy are both operational. The Falcon 1 was a small rocket capable of placing several hundred kilograms into low Earth orbit. It launched five times between 2006 and 2009, of which 2 successfully.[89] It functioned as an early test-bed for developing concepts and components for the larger Falcon 9.[89] The Falcon 1 was the first privately funded, liquid-fueled rocket to reach orbit.[80]

The landing of a Falcon 9 Block 5 first stage at Cape Canaveral in July 2019 – VTVL technologies are utilized in many of SpaceX's launch vehicles.

Falcon 9 is an medium-lift launch vehicle capable of delivering up to 22,800 kilograms (50,265 lb) to orbit, competing with the Delta IV and the Atlas V rockets, as well as other launch providers around the world. It has nine Merlin engines in its first stage. The Falcon 9 v1.0 rocket successfully reached orbit on its first attempt on 4 June 2010. Its third flight, COTS Demo Flight 2, launched on 22 May 2012, and was the first commercial spacecraft to reach and dock with the International Space Station (ISS).[33] The vehicle was upgraded to Falcon 9 v1.1 in 2013, Falcon 9 Full Thrust in 2015, and finally to Falcon 9 Block 5 in 2018.

Falcon Heavy Rocket on Launch Pad 39A in Cape Canaveral, Florida.

The Falcon Heavy is a heavy-lift launch vehicle capable of delivering up to 63,800 kg (140,700 lb) to Low Earth orbit (LEO) or 26,700 kg (58,900 lb) to Geosynchronous transfer orbit (GTO). It uses three slightly modified Falcon 9 first stage cores with a total of 27 Merlin 1D engines.[90][91] The Falcon Heavy successfully flew its inaugural mission on 6 February 2018, launching Musk's personal Tesla Roadster into heliocentric orbit[92]

Both the Falcon 9 and Falcon Heavy are certified to conduct launches for the National Security Space Launch (NSSL). As of March 2021, the Falcon 9 and Heavy family have been launched 115 times, resulting in 113 full mission successes (98%), one partial success, and one failure. Additionally, one rocket and its payload were destroyed before launch in preparation for an on-pad static fire test (see List of Falcon 9 and Falcon Heavy launches).

Rocket engines

Since the founding of SpaceX in 2002 the company has developed four families of rocket engines — Merlin, Raptor, and the retired Kestrel for launch vehicle propulsion, and the Draco control thrusters. Merlin is a family of rocket engines that uses liquid oxygen (LOX) and RP-1 as propellants in a gas-generator power cycle. The Merlin engine was originally designed for sea recovery and reuse. The injector at the heart of Merlin is of the pintle type that was first used in the Apollo Program for the lunar module landing engine. Propellants are fed via a single shaft, dual impeller turbo-pump. Kestrel is a LOX/RP-1 pressure-fed rocket engine and was used as the Falcon 1 rocket's second stage main engine. It is built around the same pintle

architecture as SpaceX's Merlin engine but does not have a turbo-pump, and is fed only by tank pressure. Its nozzle is ablatively cooled in the chamber and throat, is also radiatively cooled, and is fabricated from a high strength niobium alloy. Both names for the Merlin and Kestrel engines are derived from species of North American falcons: the American kestrel and the merlin.[93]

The Merlin 1D engine, SpaceX's most numerous engine, undergoing testing at SpaceX's Rocket Development and Test Facility in McGregor, Texas.

Draco engines are hypergolic liquid-propellant rocket engines that utilize monomethyl hydrazine fuel and nitrogen tetroxide oxidizer. Each Draco thruster generates 400 N (90 lb_f) of thrust.[94] They are used as reaction control system (RCS) thrusters on the Dragon spacecraft.[95] SuperDraco engines are a much more powerful version of the Draco thrusters, which were initially meant to be used as landing and launch escape system engines on Dragon 2. The concept of using retro-rockets for landing was scrapped in 2017 when it was decided to perform a traditional parachute descent and splashdown at sea.[96]

Raptor is a new family of methane-fueled full-flow staged combustion cycle engines to be used in its future Starship launch system.[97] Development versions were test-fired in late 2016.[98] On 3 April 2019, SpaceX conducted a successful static fire test in Texas on its *Starhopper* vehicle, which ignited the engine while the vehicle remained tethered to the ground.[99] On 25 July 2019, SpaceX conducted a successful test hop of 20 meters of its *Starhopper*.[100] This was followed by higher altitude flights that further tested Raptor performance.[101]

First test firing of a scale Raptor development engine in September 2016 in McGregor, Texas.

Dragon spacecraft

The Dragon is a spacecraft design to carry cargo or up to seven astronauts into orbit, dock to the ISS, and safely return to Earth. The first version of Dragon, used only for cargo, was first launched in 2010. The currently operational second generation Dragon spacecraft, also known as Dragon 2, had its first flight to the ISS in early 2019.

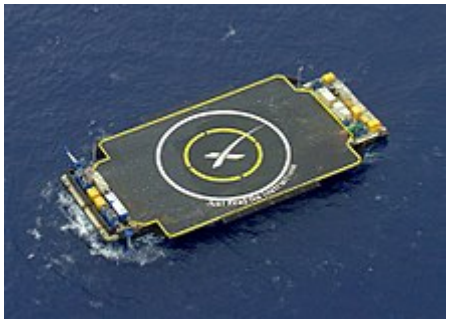
The SpaceX's Crew Dragon spacecraft, designed to deliver crew to and from the International Space Station as part of the Commercial Crew Development program.

On 27 March 2020 SpaceX revealed the Dragon XL resupply spacecraft to carry pressurized and unpressurized cargo, experiments and other supplies to NASA's planned Gateway under a Gateway Logistics Services (GLS) contract.[102] The equipment delivered by Dragon XL missions could include sample collection materials, spacesuits and other items astronauts may need on the Gateway and on the surface of the Moon, according to NASA. It will launch on SpaceX Falcon Heavy rockets from pad 39A at the Kennedy Space Center in Florida. The Dragon XL will stay at the Gateway for six to 12 months at a time, when research payloads inside and outside the cargo vessel could be operated remotely, even when crews are not present.[103] Its payload capacity is expected to be more than 5 t (5,000 kg; 11,000 lb) to lunar orbit.[104]

On 7 December 2020 SpaceX launched new cargo Dragon to Space Station for 100th successful Falcon 9 flight. This is the first launch for this redesigned cargo Dragon, and also the first mission for SpaceX's new series of CRS missions under a renewed contract with NASA. It is carrying 6,400 lb (2,900 kg) of both

supplies for the Space Station and its crew, as well as experimental supplies and equipments for the research being done on the Station. This version of Dragon can carry 20% more than the last cargo spacecraft from SpaceX, and it also has twice the number of powered lockers for climate controlled transportation of experimental material.[105]

Autonomous spaceport drone ships



An autonomous spaceport drone ship in position prior to Falcon 9 Flight 17 carrying CRS-6.

SpaceX routinely returns the first stage of Falcon 9 and Falcon Heavy rockets after orbital launches. The rocket flights and land to a predetermined landing site using only its own propulsion systems.[106] When propellent margins do not permit a return to launch site (RTLS), rockets return to floating landing platform in the ocean, called autonomous spaceport drone ships (ASDS). The autonomous spaceport drone ships are named after giant starships from the Culture series stories by science fiction author Iain M. Banks.[107]

SpaceX also plans to introduce floating launch platforms. These are modified oil rigs to use in the 2020s to provide a sea launch option for their second-generation launch vehicle: the heavy-lift Starship system, consisting of the Super Heavy booster and Starship second stage. SpaceX has purchased two deepwater oil rigs, for Starship launches, and both platforms are undergoing refit for their new role.[108]

Starship

SpaceX Starship SN8 prototype during a flight test, December 2020.

SpaceX is developing a fully reusable super-heavy lift launch system, Starship. The Starship system comprises a reusable first stage, called Super Heavy, and a reusable second stage and space vehicle. The system is intended to replace all of the company's existing launch vehicle hardware by the early 2020s.[109][110]

SpaceX initially envisioned a 12-meter-diameter ITS concept in 2016 which was solely aimed at Mars transit and other interplanetary uses. In 2017 SpaceX articulated a smaller 9-meter-diameter BFR to replace all of SpaceX launch service provider capabilities — Earth-orbit, lunar-orbit, interplanetary missions, and potentially, even intercontinental passenger transport on Earth — but do so on a fully reusable set of vehicles with a markedly lower cost structure.[111] A large portion of the components on Starship are made of 301 stainless steel, with some being manufactured from 304L stainless steel.[112] Private passenger Yusaku Maezawa has contracted to fly around the Moon in Starship in 2023.[113]

The company's long-term vision is the development of technology and resources suitable for human colonization on Mars.[114] A rocket every two years or so could provide a base for the people arriving in 2025 after a launch in 2024.[115][116] According to Steve Jurvetson, Musk believes that by 2035 at the latest, there will be thousands of rockets flying a million people to Mars, in order to enable a self-sustaining human colony.[117]

Starlink

Play media

Starlink satellites passing overhead and visible with a naked eye. These satellites launched on 22 April 2020.

Starlink is a internet satellite constellation under development by SpaceX. The Internet service will use 4,425 cross-linked communications satellites in 1,100 km orbits. Owned and operated by SpaceX, the goal of the business is to increase profitability and cash flow, to allow SpaceX to build its Mars colony.[118] Development began in 2015, initial prototype test-flight satellites were launched on the SpaceX Paz satellite mission in 2017. In May 2019 SpaceX launched the first batch of 60 satellites aboard a Falcon 9.[119] By November 2020, SpaceX had launched 955 Starlink satellites. Initial test operation of the constellation began in late 2020.

In March 2017 SpaceX filed with the Federal Communications Commission plans to field a constellation of an additional 7,518 V-band satellites in non-geosynchronous orbits to provide communications services.[120] In February 2019 SpaceX formed a sibling company, **SpaceX Services, Inc.**, to license the manufacture and deployment of up to 1,000,000 fixed satellite Earth stations that will communicate with its Starlink system.[121] The Federal Communications Commission (FCC) awarded SpaceX with nearly US$900 million worth of federal subsidies to support rural broadband customers through the company's Starlink satellite internet network. SpaceX won subsidies to bring service to customers in 35 U.S. states.[122]

Other projects

In June 2015 SpaceX announced that they would sponsor a Hyperloop competition, and would build a 1.6 km (0.99 mi) long subscale test track near SpaceX's headquarters for the competitive events.[123][124] The first competitive event was held at the track in January 2017, the second in August 2017 and the third in December 2018.[125][126][127]

In collaboration with doctors and academic researchers SpaceX invited during 2020 all employees to participate in the creation of a COVID-19 antibody-testing program. As such 4300 employees volunteered to provide blood-samples resulting in a peer-reviewed scientific paper crediting eight SpaceX employees as coauthors and suggesting that a certain level of COVID-19 anti-bodies may provide lasting protection against the virus.[128][129]

Facilities

SpaceX is headquartered in Hawthorne, California, which also serves as its primary manufacturing plant. The company operates a research and major operation in Redmond, Washington, owns a test site in Texas and operates three launch sites, with another under development. SpaceX also operates regional offices in Texas, Virginia, and Washington, D.C.[59] SpaceX was incorporated in the state of Delaware.[130]

Headquarters, manufacturing, and refurbishment facilities

SpaceX Headquarters is located in the Los Angeles suburb of Hawthorne, California. The large three-story facility, originally built by Northrop Corporation to build Boeing 747 fuselages,[131] houses SpaceX's office space, mission control, and, as of 2018, all operational launch vehicle manufacturing. Starship construction is in a new site in South Texas.[132]

The area has one of the largest concentrations of aerospace headquarters, facilities, and/or subsidiaries in the U.S., including Boeing/McDonnell Douglas main satellite building campuses, Aerospace Corp., Raytheon, NASA's Jet Propulsion Laboratory, Air Force Space Command's Space and Missile Systems Center at Los Angeles Air Force Base, Lockheed Martin, BAE Systems, Northrop Grumman, and AECOM, etc., with a large pool of aerospace engineers and recent college engineering graduates.[131]

SpaceX utilizes a high degree of vertical integration in the production of its rockets and rocket engines.[8] SpaceX builds its rocket engines, rocket stages, spacecraft, principal avionics and all software in-house in their Hawthorne facility, which is unusual for the aerospace industry. Nevertheless, SpaceX still has over 3,000 suppliers with some 1,100 of those delivering to SpaceX nearly weekly.[133]

The headquarters of the company, located in Hawthorne, California.

Development and test facilities

SpaceX operates its first Rocket Development and Test Facility in McGregor, Texas. All SpaceX rocket engines are tested on rocket test stands, and low-altitude VTVL flight testing of the Falcon 9 Grasshopper v1.0 and F9R Dev1 test vehicles in 2013–2014 were carried out at McGregor. Testing of the much larger Starship prototypes is conducted in the SpaceX South Texas launch site near Brownsville, Texas.[132]

The company purchased the McGregor facilities from Beal Aerospace, where it refitted the largest test stand for Falcon 9 engine testing. SpaceX has made a number of improvements to the facility since purchase and has also extended the acreage by purchasing several pieces of adjacent farmland. In 2011 the company announced plans to upgrade the facility for launch testing a VTVL rocket,[134] and then constructed a half-acre concrete launch facility in 2012 to support the Grasshopper test flight program.[135] As of October 2012, the McGregor facility had seven test stands that are operated "18 hours a day, six days a week"[136] and is building more test stands because production is ramping up and the company has a large manifest in the next several years. In addition to routine testing, Dragon capsules (following recovery after an orbital mission), are shipped to McGregor for de-fueling, cleanup, and refurbishment for reuse in future missions.


Falcon 9 v1.1 rocket cores under construction at the SpaceX Hawthorne facility, November 2014.


SpaceX McGregor engine test bunker, September 2012

Launch facilities

SpaceX currently operates three orbital launch sites, at Cape Canaveral Space Force Station, Vandenberg Air Force Base, and Kennedy Space Center, and is under construction on a fourth in Brownsville, Texas. SpaceX has indicated that they see a niche for each of the four orbital facilities and that they have sufficient launch business to fill each pad.[137] The Vandenberg launch site enables highly inclined

orbits (66–145°), while Cape Canaveral enables orbits of medium inclination (28.5–51.6°).[138] Before it was retired, all Falcon 1 launches took place at the Ronald Reagan Ballistic Missile Defense Test Site on Omelek Island.

SpaceX west coast launch facility at Vandenberg Air Force Base, during the launch of CASSIOPE, September 2013.

Cape Canaveral Space Force Station

Cape Canaveral Space Launch Complex 40 (SLC-40) is used for Falcon 9 launches to low Earth and geostationary orbits. SLC-40 is not capable of supporting Falcon Heavy launches. As part of SpaceX's booster reusability program, the former Launch Complex 13 at Cape Canaveral, now renamed Landing Zone 1, has been designated for use for Falcon 9 first-stage booster landings.

Vandenberg Air Force Base

Vandenberg Space Launch Complex 4 (SLC-4E) is used for payloads to polar orbits. The Vandenberg site can launch both Falcon 9 and Falcon Heavy,[139] but cannot launch to low inclination orbits. The neighboring SLC-4W has been converted to Landing Zone 4, where SpaceX has successfully landed three Falcon 9 first-stage boosters, the first in October 2018.[140]

Falcon 9 Flight 20 landing on Landing Zone 1 in December 2015

Kennedy Space Center

On 14 April 2014, SpaceX signed a 20-year lease for Launch Pad 39A.[141] The pad was subsequently modified to support Falcon 9 and Falcon Heavy launches. SpaceX launched its first crewed mission to the ISS from Launch Pad 39A on 30 May 2020.[142]

Boca Chica, Texas

In August 2014 SpaceX announced they would be building a commercial-only launch facility near Brownsville, Texas.[143][144] The Federal Aviation Administration (FAA) issued the permit in July 2014.[145] SpaceX started construction on the new launch facility in 2014 with production ramping up in the latter half of 2015,[146] with the first suborbital launches from the facility in 2019.[132]

The Starship assembly building under construction at Boca Chica in August 2020

Satellite prototyping facility

In January 2015 SpaceX announced it would be entering the satellite production business and global satellite internet business. The first satellite facility is a 30,000 sq ft (2,800 m^2) office building located in Redmond, Washington. As of January 2017, a second facility in Redmond was acquired with 40,625 sq ft (3,774.2 m^2) and has become a research and development laboratory for the satellites.[147] In July 2016, SpaceX acquired an additional 8,000 sq ft (740 m^2) creative space in Irvine, California (Orange County) to focus on satellite communications.[148][149]

Launch contracts

SpaceX won demonstration and actual supply contracts from NASA for the International Space Station (ISS) with technology the company developed. SpaceX is also certified for U.S. military launches of Evolved Expendable Launch Vehicle-class (EELV) payloads. With approximately 30 missions on the manifest for 2018 alone, SpaceX represents over US$12 billion under contract.[59]

NASA

COTS

In 2006 NASA announced that SpaceX had won a NASA Commercial Orbital Transportation Services (COTS) Phase 1 contract to demonstrate cargo delivery to the International Space Station (ISS), with a possible contract option for crew transport.[150] Through this contract, designed by NASA to provide "seed money" through Space Act Agreements for developing new capabilities, NASA paid SpaceX US$396 million to develop the cargo configuration of the Dragon spacecraft, while SpaceX self-invested more than US$500 million to develop the Falcon 9 launch vehicle.[151] These Space Act Agreements have been shown to have saved NASA millions of dollars in development costs, making rocket development ~4–10 times cheaper than if produced by NASA alone.[152]

The COTS 2 Dragon is berthed to the International Space Station (ISS) by Canadarm2.

In December 2010 the launch of the SpaceX COTS Demo Flight 1 mission, SpaceX became the first private company to successfully launch, orbit and recover a spacecraft.[153] Dragon successfully berthed with the ISS during SpaceX COTS Demo Flight 2 in May 2012, a first for a private spacecraft.[154]

Commercial cargo

Commercial Resupply Services (CRS) are a series of contracts awarded by NASA from 2008 to 2016 for delivery of cargo and supplies to the ISS on commercially operated spacecraft. The first CRS contracts were signed in 2008 and awarded US$1.6 billion to SpaceX for 12 cargo transport missions, covering deliveries to 2016.[155] SpaceX CRS-1, the first of the 12 planned resupply missions, launched in October 2012, achieved orbit, berthed and remained on station for 20 days, before re-entering the atmosphere and splashing down in the Pacific Ocean.[156] CRS missions have flown approximately twice a year to the ISS since then. In 2015, NASA extended the Phase 1 contracts by ordering an additional three resupply flights from SpaceX, for a total of 15 cargo transport.[157][155] After further extensions late in 2015, SpaceX is currently scheduled to fly a total of 20 resupply missions.[158] A second phase of contracts, known as CRS-2, were awarded in January 2016 for cargo transport flights beginning in 2019 and expected to last through 2024.

In March 2020 NASA contracted SpaceX to develop the Dragon XL spacecraft to send supplies to the Lunar Gateway space station. Dragon XL will be launched on a Falcon Heavy.[159]

Commercial crew

SpaceX is responsible for transportation of NASA astronauts to and from the ISS. The NASA contracts started as part of the Commercial Crew Development (CCDev) program, aimed at developing commercially operated spacecraft capable of delivering astronauts to the ISS. The first contract was awarded to SpaceX in 2011,[160][161] followed by another in 2012 to continue development and testing of its Dragon 2 spacecraft.[162]


Crew Dragon undergoing testing prior to flight

In September 2014 NASA chose SpaceX and Boeing as the two companies that would be funded to develop systems to transport U.S. crews to and from the ISS.[163] SpaceX won US$2.6 billion to complete and certify Dragon 2 by 2017. The contracts include at least one crewed flight test with at least one NASA astronaut aboard. Once Crew Dragon achieves NASA certification, the contract requires SpaceX to conduct at least two, and as many as six, crewed missions to the space station.[163] SpaceX completed the first key flight test of its Crew Dragon spacecraft, a Pad Abort Test, in May 2015.[164]

In early 2017 SpaceX was awarded four additional crewed missions to the ISS from NASA.[165] In early 2019 SpaceX successfully conducted a full uncrewed test flight of Crew Dragon, which docked to the ISS and then splashed down in the Atlantic Ocean.[166] In January 2020, SpaceX conducted an in-flight abort test, the last test flight before flying crew, in which the Dragon spacecraft fired its launch escape engines in a simulated abort scenario.[167]

On 30 May 2020 the Crew Dragon Demo-2 mission was launched to the International Space Station with American astronauts Bob Behnken and Doug Hurley. This was the first time a crewed vehicle had launched from the U.S. since 2011, and the first commercial crewed launch to the ISS.[168] The Crew-1 mission was successfully launched to the International Space Station on 16 November 2020, with NASA astronauts Michael Hopkins, Victor Glover and Shannon Walker along with JAXA astronaut Soichi Noguchi,[169] all members of the Expedition 64 crew.[170]

National defense

In 2005 SpaceX announced that it had been awarded an Indefinite Delivery/Indefinite Quantity (IDIQ) contract, allowing the United States Air Force to purchase up to US$100 million worth of launches from the company.[171] In April 2008, NASA announced that it had awarded an IDIQ Launch Services contract to SpaceX for up to US$1 billion, depending on the number of missions awarded. The contract covers launch services ordered by June 2010, for launches through December 2012.[172] Musk stated in the same 2008 announcement that SpaceX has sold 14 contracts for flights on the various Falcon vehicles.[172] In December 2012, SpaceX announced its first two launch contracts with the United States Department of Defense (DoD). The United States Air Force Space and Missile Systems Center awarded SpaceX two EELV-class missions: Deep Space Climate Observatory (DSCOVR) and Space Test Program 2 (STP-2). DSCOVR was launched on a Falcon 9 launch vehicle in 2015, while STP-2 was launched on a Falcon Heavy on 25 June 2019.[173]

In May 2015 the United States Air Force announced that the Falcon 9 v1.1 was certified for National Security Space Launch (NSSL), which allows SpaceX to contract launch services to the Air Force for any payloads classified under national security.[174] This broke the monopoly held since 2006 by United Launch Alliance (ULA) over the U.S. Air Force launches of classified payloads.[175] In April 2016 the U.S. Air Force awarded the first such national security launch to SpaceX to launch the 2nd GPS 3 satellite for US$82.7 million.[176] This was approximately 40% less than the estimated cost for similar previous missions.[177] SpaceX also launched the 3rd GPS 3 launch on 20 June 2020.[178] In March 2018 SpaceX secured an additional US$290 million contract from the U.S. Air Force to launch another three GPS III satellites.[179]

In 2016 the U.S. National Reconnaissance Office (NRO) purchased launches from SpaceX, with the first taking place on 1 May 2017.[180] In February 2019, SpaceX secured a US$297 million contract from the U.S. Air Force to launch another three national security missions, all slated to launch no earlier than FY 2021.[181]

On 7 August 2020 the U.S. Space Force awarded its National Security Space Launch (NSSL) contracts for the following 5–7 years. SpaceX won a contract for US$316 million for one launch. In addition, SpaceX will handle 40% of the U.S. militaries satellite launch requirements over the period.[182]

Launch of the STP-2 mission in June 2019

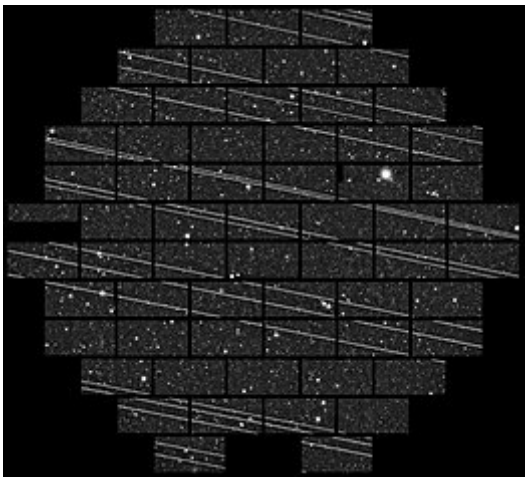
Space tourism

In February 2020 Space Adventures announced plans to fly private citizens into orbit on Crew Dragon.[183] The Crew Dragon vehicle would launch from LC-39A with up to four tourists on board, and spend up to five days in a low Earth orbit with an apogee of over 1,000 km (620 mi).[184]

Criticism and controversies

Starlink

The planned large number of Starlink satellites has met with criticism from the astronomical community because of concerns for light pollution.[185][186][187] Astronomers claim that the number of visible satellites will outnumber visible stars and that their brightness in both optical and radio wavelengths will severely impact scientific observations. Astronomers have raised concerns about the constellations' effect on ground-based astronomy and how the satellites will add to an already jammed orbital environment. It ignited conversations about the ethics of a single company unilaterally changing the night sky's appearance.[188]



Signal pollution in a 333-second exposure image taken from the Blanco four-meter telescope at the Cerro Tololo Inter-American Observatory.

The large number of satellites employed by Starlink also creates a long-term danger of space debris resulting from placing thousands of satellites in orbit and the risk of causing a satellite collision, potentially triggering a phenomenon known as Kessler syndrome, which is a cascading collision effect between satellites and debris in Earth orbit that could cause all of the satellites to become inoperable.[189][190]

Armenian protests against Turkish satellite launch

The Armenian community of Los Angeles County, California staged protests at SpaceX headquarters in Hawthorne in October 2020[191] demanding the cancellation of Türksat 5A satellite launch on a Falcon 9 rocket. This was preceded by a mass email campaign to SpaceX staff and members of the media by concerned

Armenians around the world, asking the company to cancel the launch contract with the Turkish government.[192] The Armenians claimed that the satellite could be used by the Turkish government for military purposes, in view of Turkey's current provision of unmanned aerial vehicles to Azerbaijan in its armed conflict with Armenia involving the Nagorno-Karabakh region.[193]

Launch market competition and pricing pressure

SpaceX's low launch prices, especially for communication satellites flying to geostationary transfer orbit (GTO), have resulted in market pressure on its competitors to lower their own prices.[8] Prior to 2013, the openly competed comsat launch market had been dominated by Arianespace (flying the Ariane 5) and International Launch Services (flying the Proton).[194] With a published price of US$56.5 million per launch to low Earth orbit, Falcon 9 rockets were the cheapest in the industry.[195] European satellite operators are pushing the European Space Agency (ESA) to reduce launch prices of the Ariane 5 and the future Ariane 6 rockets as a result of competition from SpaceX.[196] In 2014 no commercial launches were booked to fly on the Russian Proton rocket.[38]

SpaceX also put an end to the United Launch Alliance (ULA) monopoly of U.S. military payloads when it began to compete for national security launches. In 2015, anticipating a slump in domestic, military, and spy launches, ULA stated that it would go out of business unless it won commercial satellite launch orders.[197] To that end, ULA announced a major restructuring of processes and workforce in order to decrease launch costs by half.[198][199]

Congressional testimony by SpaceX in 2017 suggested that the NASA Space Act Agreement process of "setting only a high-level requirement for cargo transport to the space station [while] leaving the details to industry" had allowed SpaceX to design and develop the Falcon 9 rocket on its own at a substantially lower cost. According to NASA's own independently verified numbers, SpaceX's total development cost for both the Falcon 1 and Falcon 9 rockets was estimated at approximately US$390 million. In 2011 NASA estimated that it would have cost the agency about US$4 billion to develop a rocket like the Falcon 9 booster based upon NASA's traditional contracting processes, about ten times more.[152]

In the first quarter of 2020, SpaceX launched over 61,000 kg (134,000 lb) of payload mass to orbit while all Chinese, European, and Russian launchers placed approximately 21,000 kg (46,000 lb), 16,000 kg (35,000 lb) and 13,000 kg (29,000 lb) in orbit, respectively, with all other launch providers launching approximately 15,000 kg (33,000 lb).[200]

In May 2020 NASA's administrator Jim Bridenstine remarked that thanks to NASA's investments into SpaceX the United States has 70% of the commercial launch market, a major improvement since 2012 when there were no commercial launches from the country.[201]

Board of directors

SpaceX board of directors as of January 2021[202]

Joined Board	Name	Titles
2002[203]	Elon Musk	Founder, Chairman, CEO and CTO of SpaceX; co-founder, CEO and Product Architect of Tesla; former Chairman of Tesla, Inc.; former Chairman of SolarCity[203]
2002[204]	Kimbal Musk	Board member, Tesla[205]
2009[206]	Gwynne Shotwell	President and COO of SpaceX[207]
2009[206]	Luke Nosek	Co-founder, PayPal[208]
2009[206]	Steve Jurvetson	Co-founder, Future Ventures fund[209]
2010[210]	Antonio Gracias	CEO and Chairman of the Investment Committee at Valor Equity Partners[211]
2015[212]	Donald Harrison	President of global partnerships and corporate development, Google[213]

See also

- Blue Origin
- Human mission to Mars
- List of crewed spacecraft
- Private spaceflight
- Space colonization
- SpaceX Mars program

A book on this topic is available: ***Book:SpaceX***

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- Official website (http://www.spacex.com)