Space Launch Report: SpaceX Falcon 9 v1.2 Data Sheet

SpaceX Falcon 9 v1.2
Updated February 22, 2018

Vehicle Configurations

Vehicle Components

Merlin 1C-powered Falcon 9

Falcon 9 v1.1

Falcon 9 v1.2. Flight Log

Falcon 9 Stage Serial Number Log

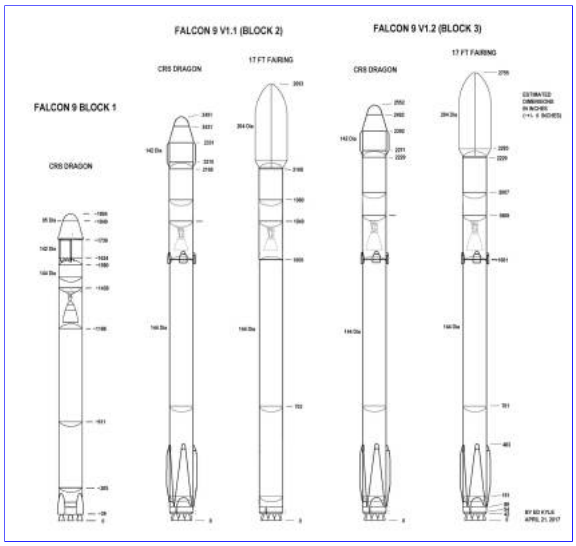
First "Full Thrust" First Stage Hot Fire Test on September 21, 2015

During January, 2015, Martin Halliwell, SES chief technical officer, revealed that SpaceX was introducing a higher- modification of its Merlin 1D engine, with about 20% more thrust, and that SES was deciding whether or not to b fly with the new engine. The company was thinking about skipping its then-planned Spring 2015 launch slot to allo else to fly the "full-thrust" engine first.

That is how the world learned about plans for an upgraded Falcon 9, eventually to be known as Falcon 9 v1.2.

Elon Musk made it official on March 1, 2015, when he stated that Falcon 9 upgrades were planned that would allow for first stage landings during geosynchronous transfer missio upgrades would include a 15% increase in thrust, the use of "deep cryogenic", or "densified", liquid oxygen, and a 10% second stage tank volume increase.

Mr. Musk did not name the upgraded rocket at that time, so industry observers began identifying it as "Falcon 9 v1.2".



Comparison of Falcon 9 Blocks 1, 2, and 3 with Estimated Dimensions

On March 9, Aviation Week & Space Technology reported that SES had decided, after all, to be the first " Falcon 9 customer. SES 9, a communications satellite, would launched to geosynchronous transfer orbit b rocket during the second or third quarter of 2015. SES CEO Karim Michel Sabbagh announced the decisi

On March 17, 2015, SpaceX President Gwynne Shotwell offered more details about the upgraded rocket. the company had gone back to certify extra performance from Merlin 1D. She said "I don't know what we call it. Enhanced Falcon 9, Falcon 9 v1.2, Full-Performance Falcon 9" - indicating that the company still h decided on a name.

She said that the upgraded rocket would provide "about a 30% increase in performance, maybe a little mo also allowing the first stage to be landed on a downrange ship platform during GTO missions. The payloa cutoff point for first stage return was not announced. Without first stage return the new rocket may be ab more than 6 tonnes to GTO.

Shotwell also said that the upgraded Falcon 9 first stage would essentially be used as a side booster for Fal while the Falcon Heavy core would be a different design.

The announced upgrade meant that Falcon 9 would now lift off on 694 tonnes of sea level thrust rather th previous 600 tonnes. Second stage Merlin 1D Vacuum thrust would increase to at least 95 tonnes force. T stage engine would also use a longer nozzle to improve specific impulse, requiring a stretch of the interstag

Illustration of Falcon 9 v1.2 on Rebuilt LC 39A at Kennedy Space Center

During the summer of 2015, SpaceX continued to send mixed signals about t rocket's name. One presentation by SpaceX during the summer of 2015 identi "Falcon 9 Upgrade". During September, 2015 the company began calling it " v1.1 Full Thrust". By early 2016 that name had been dropped, apparently in fa "Falcon 9 v1.2", which was the name filed with the FAA.

A test program involving "full thrust" Merlin engines was completed at McGr during the summer. Meanwhile, the first "Full Thrust" first stage - serial produ number 21 - departed the SpaceX Hawthorne, California factory at the end of arrived at McGregor a few days later.

On September 8, 2015, the stage was erected at the new ground-level test stan stage to installed there. The stand is equipped with a below-grade flame trench stand, which should reduce noise imposed on neighboring communities durin tests, had been completed in 2013. It is also expected to be used for Falcon H hot fire testing.

On September 21, the stage performed a 15 second test firing. A full duration performed on November 19, 2015. The second stage was tested on Novembe

The first stage arrived at Cape Canaveral during the morning of November 20. On December 18, 2015, the first stage, topped by the second stage and integrated Orbcomm G2 p completed a brief static firing at SLC 40 after two days of scrubbed attempts that appeared to be ground-system related, as the test shook down new super-chilling equipment at th

As the stage entered testing, two launch sites were being prepared to handle both it and Falcon Heavy. Space Launch Complex (SLC) 4 East at Vandenberg AFB underwent mod that included changes to its erector transporter and the construction of a propellant densification plant. Launch Complex 39A at the Kennedy Space Center was being totally rebu Falcon Heavy and Falcon 9 v1.2, with a new horizontal processing hangar built on the former crawlerway at the base of the pad and a new pair of railroad tracks leading up to the itself.

Falcon 9 Launches, *Lands*

F9-21 Liftoff

SpaceX returned its Falcon 9 to service on December 22, 2015 when it boosted 11 Orbcomm satellites into or Cape Canaveral, Florida. For the first time, a Falcon 9 first stage boosted back and landed near its launch site. took place at Landing Zone 1 at the former site of Launch Complex 13.

The two-stage kerosene/LOX rocket, sidelined since a June launch failure, returned in upgraded form with hig engines, a stretched second stage and interstage, and supercooled, condensed propellant. The improved rocket initially by SpaceX as a "Falcon 9 v1.1 Full Thrust" but later as "Falcon 9 v1.2", was the 20th Falcon 9 to fly ar produced.

Liftoff from SLC 40 took place at 01:29 UTC. The now 69.799 meter (229 foot) tall rocket, about 1.524 meter taller than v1.1, rose on 694 metric tons (1.53 million pounds) of thrust produced by its nine Merlin 1D first st Previous Falcon 9 v1.1 first stages produced 600 metric tons (1.323 million pounds) of thrust.

F9-21 First Stage Lands at LZ-1 About 10 Minutes After Liftoff

The first stage fired for 2 minutes 20 seconds, separating four seconds later. The second stage ignited improved Merlin Vacuum engine at 2 minutes 35 seconds to begin a nearly eight minute burn to reach 620 x 660 km x 47 deg orbit.

The eleven 172 kg Orbcomm satellites separated in sequence from their center-mounted support pilla 15 minutes and ending 20 minutes after liftoff.

Meanwhile, the first stage performed a roughly 30 second boostback burn beginning about 3 minutes after launch and a 20 second reentry burn about 8 minutes after launch, both using three engines. A fi 32 second single-engine landing burn using only the center engine took place just before the landing, minutes after liftoff.

The stage landed near the center of the circular landing zone. A small fire burned at the base of the st least a half-minute after the center Merlin 1D engine shut down.

First Stage Shortly After Landing

After spacecraft deployment, the upgraded second stage Merlin Vacuum engine restarted both to test its restart capability for future missions and to deorbit the stage in the South south of Australia.

After the mission, Elon Musk announced that the recovered first stage would be used, if possible, for propellant loading and static fire testing at the rebuilt LC 39 Pad A. SpaceX plans to re-fly the stage. The stage was moved to the new Horizontal Integration Facility at LC 39A a couple of days after its landing, where it was photographed and inspected.

During week of January 12, the stage was unexpectedly moved to SLC 40. A crane was used to erected it on the stand rather than the usual erector. On January 14, an unannoun fire attempt was made and aborted after 2-3 seconds when one of the outer engine's thrust fluctuated. After the test, Elon Musk tweeted that the engine would be borescoped and might have ingested something. The stage subsequently returned to LC 39A.

Launch Complex 13 supported 51 Atlas missile and Atlas Agena orbital launches from 1958-1978. The site's mobile service tower was demolished in 2005 and its blockhouse in 2 subsequently built an 86 meter (282 foot) diameter landing pad centered on the spot where the original Atlas missile service tower parked during launches.

Falcon 9 Launches SES 9 (Updated 03/06/16)

SpaceX's second Falcon 9 v1.2 with full thrust Merlin 1D engines boosted the SES 9 communications sate geosynchronous transfer orbit from Cape Canaveral, Florida on March 4, 2016. Liftoff from SLC 40 took 23:35 UTC. The 5,271 kg Boeing BSS-702HP satellite separated about 31 minutes 24 seconds later, after tv the second stage Merlin 1D Vacuum engine.

SpaceX CEO Elon Musk tweeted that SES 9 had been inserted into a transfer orbit with a 40,600 km apog the first Falcon 9 Upgrade geosynchronous transfer orbit mission. The second stage used a minimum resid shutdown to provide as much orbital energy as possible, with a target of 290 km x at least 39,300 km x 28 modified earlier plans to aim for a 26,000 km apogee at the behest of SES.

The insertion change made first stage recovery very unlikely, due to its extra velocity. SpaceX announced launch that it did not expect a successful recovery. A boost-back burn was not used. The first stage only a three-engine reentry burn and a never-before-attempted three-engine final landing burn, but did not surv speed attempt to land on a converted barge positioned more than 600 km downrange. The stage impacted punching a hole through the steel deck. It was the fourth failed barge landing attempt by a Falcon 9 first s

The success followed scrubbed launch attempts on February 24 and 25 due to supercooled LOX temperat T-0 abort on February 28 caused by a low thrust detection in one engine, and a cancelled try on March 1 r from excessive high altitude winds. Prior to the launch attempts, the first stage performed a brief static fire February 22.

Falcon 9 Launches CRS 8, First Stage Lands at Sea

The 23rd Falcon 9 launch vehicle, the third upgraded v1.2 variant, successfully orbited the Dragon 10 spacecraft on NASA's CRS 8 International Space Station cargo hauling miss 8, 2016. After performing the initial mission boost, the rocket's first stage accomplished the first successful landing on a floating platform - the company's converted landing barge positioned about 300 km northeast of the Cape Canaveral Space Launch Complex 40 launch site. It was the fifth such attempt.

Liftoff took place at 20:43 UTC after no delays or scrubs. Dragon was targeted toward a 200 x 360 km x 51.6 deg orbit. The spacecraft carried 3,136 kg of cargo, including the 1,4 Bigelow Expandable Activity Module (BEAM) experiment in the unpressurized trunk section. At more than 8.6 tonne combined Dragon and cargo mass was the heaviest-payload yet launched by a Falcon 9.

F9-23 First Stage After Landing

During its descent, the first stage perform a three-engine boost-back burn, followed by a final single landing burn. Landing took place about 8 minutes 35 seconds after liftoff.

The F9-23 first stage had performed a static firing at SLC 40 on April 5. After its successful static te McGregor, Texas during February, a ground equipment failure damaged multiple engines during a n propulsive test. The engines were repaired or replaced without causing significant delay to the launc

Dragon arrived at ISS on April 10, 2016.

The landing platform with the first stage returned to Port Canaveral during the pre-dawn hours of A 2016. During the day, a crane picked up the stage from the barge and placed it onto a work stand o After several days of processing which included leg removal, the stage was moved to the Launch Co HIF on April 19.

New Falcon 9 Performance Numbers Revealed

On April 30, 2016, SpaceX released new performance data for an improved Falcon 9 v1.2. The two-stage rocket gross mass increased to about 564 tonnes, not including payload, liftoff thrust rose to 775.65 tonnes as Merlin 1D thrust was pushed upward again to 190,000 pounds (86.183 tonnes) at sea level. For the first time, the company gave solid payloa

performance numbers for this version. They were: 22.8 tonnes to LEO x 28.5 deg, 8.3 tonnes to GTO x 27 deg, and 5.5 tonnes GTO x 27 deg when the first stage recovered downrange. The cost for a flight with first stage recovery was listed at $62 million.

By early 2017 it had become apparent that SpaceX referred to this improved version as "Falcon 9 Block 5". Block 5 was designed to perform Dragon 2 Commercial Crew launch NASA, but would also apparently be used for unmanned satellite launches. Elon Musk announced that the first Block 5 launch would occur by the end of 2017.

It had also become known that the company was, as of late 2016/early 2017, still flying "Falcon 9 Block 3". Block 3 thus was the Falcon 9 v1.2 variant. The identity of "Block 4" early March 2017, unknown outside the halls of SpaceX.

Falcon 9 and AMOS 6 Destroyed in Pre Launch Test

Screen Capture from USLaunchReport.com Video of F9-29 Explosion

A Falcon 9 rocket and its $200 million AMOS 6 satellite payload were destroyed during a propellant loading and hot fire test exercise at Cape Canveral on September 1, 2016. The planned to assure all was ready for a September 3 launch that would have placed 5.5 tons in geosynchronous transfer orbit.

Early reports indicated that propellant loading was nearly completed and the test was abo minutes away when a powerful explosion destroyed the rocket and satellite at about 9:07 Eastern Time. A series of smaller explosions occurred during the following minutes as a SLC 40 and a large plume of black smoke drifted across the Florida space center. It was pad explosion in the history of Cape Canaveral/Kennedy Space Center.

A few hours after the explosion, Elon Musk tweeted that the failure appeared to have be second stage liquid oxygen tank. SLC 40 was reported to have been heavily damaged, kn out of service. A day after the failure, SpaceX announced that East Coast launch campai move to Kennedy Space Center Launch Complex 39 Pad A, which at the time was planr ready to support operations beginning in November, 2016.

The AMOS 6 launch would have been the 29th Falcon launch, and the ninth by a Falcon 9 v1.2 variant. The AMOS 6 first stage was test fired at McGregor, Texas on August 5, 2 arrived at Cape Canaveral some time after August 21.

SpaceX subsequently determined that the cause was sudden overpressurization of the second stage liquid oxygen (LOX) tank due to the failure of a composite overwrapped pressu (COPV) containing pressurized helium that was mounted inside the LOX tank. Improper control of subcooled-LOX temperatures may have been involved. Elon Musk suggeste froze within or beneath the composite overwrapping, causing loss of COPV structural integrity. SpaceX performed cryogenic loading tests, with some leading to failure, of small t at its McGregor, Texas test site to confirm the failure mode.

Falcon 9 Returns to Flight

Ending a four-month failure investigation stand-down, SpaceX Corporation's Falcon 9 launch vehicle returned to servic January 14, 2017, orbiting ten IridiumNEXT satellites from Vandenberg AFB in California. The v1.2 variant, informally F9-30 by outside observers (it used first stage number B1029), lifted off from Space Launch Complex 4 East at 17:54 U a hour-long mission that inserted the 860 kg, Thales Alenia Space-built satellites into roughly 610 x 620 km x 86.4 deg o satellites will raise themselves into 780 km operational orbits.

After a 43 minute, 16 second coast, the Falcon 9 second stage restarted for a brief second, circularization burn at first ap 52 minutes 31 seconds after liftoff to complete the powered phase of the flight. Spacecraft separation began at about th 16 seconds mark, with each satellite separating individually separated by about 1.5 minutes.

The first stage performed boost-back, reentry, and landing burns before landing on the converted barge "drone ship" "J the Instructions". It was the first successful first stage landing in two West Coast attempts. Six previous first stage recov been made after Cape canaveral liftoffs.

The launch was the first of seven planned IridiumNext Falcon 9 flights that will replace the company's orbiting "Little I communication satellite constellation.

Falcon 9 had been grounded since F9-29 and its $200 million AMOS 6 satellite payload were destroyed during a pre-lau propellant loading and hot fire test exercise at Cape Canveral on September 1, 2016. SpaceX determined that the cause overpressurization of the second stage liquid oxygen (LOX) tank due to the failure of a composite overwrapped pressur (COPV) containing pressurized helium that was mounted inside the LOX tank. Improper control of subcooled-LOX te may have been involved. Elon Musk of SpaceX suggested that LOX froze within or beneath the composite overwrapping, causing loss of COPV structural integrity.

SpaceX performed cryogenic loading tests, with some leading to failure, of small test vessels at its McGregor, Texas test site to confirm the failure mode. The company also chang propellant loading procedures, more than doubling the LOX loading time.

The F9-30 first and second stages were test fired at the company's McGregor, Texas test site during late October and early November, 2016. The first stage was hot fired at SLC 4 January 5, 2017 after a scrub the previous day. The IridiumNEXT payload was not atop the vehicle during the wet dress rehearsal and hot fire exercise.

F9-30 was the 29th Falcon 9 launch and the ninth v1.2 variant to fly, not including the lost AMOS 6 launch vehicle. It was the first v1.2 to fly from VAFB.

Falcon 9 Debuts from KSC

SpaceX's Falcon 9 orbited the CRS-10 Dragon spacecraft with cargo for the International Space Station from Kennedy Space Center Launch Complex 39 Pad A on February 29, 2 the first Falcon 9 launch from the converted NASA Saturn 5/Space Shuttle launch site. Liftoff took place at 14:39 UTC, following an aborted attempt one day earlier caused by o readings from the second stage thrust vector control system.

Falcon 9's second stage boosted Dragon into a 51.6 deg low earth orbit, with stage cutoff occurring about 9 min 5 sec after liftoff and spacecraft separation taking place about one later. While the second stage was performing its 393 second long burn, the first stage did a 180 deg flip and performed 3-engine boostback burn. It flipped again before performi engine entry burn and a single engine landing burn that began about 7 min 33 sec after liftoff. The stage landed at Cape Canaveral Landing Zone 1, performing the first daylight la third overall, at the site. The second stage was expected to perform a deorbit burn after spacecraft separation.

The CRS-10 Dragon (Dragon spacecraft No. 12) carried about 2,490 kg tonnes of cargo, including 1,530 kg ins pressurized capsule and 960 kg attached to the unpressurized trunk section. Spacecraft berthing at ISS is schec occur on February 21. SpaceX does not announce total spacecraft mass, but based on early publications by the and on more recent expert estimates, CRS-10 Dragon likely weighed about 8,430 kg at liftoff, including cargo.

The flight was performed by the F9-32 vehicle, a v1.2 (or "Block 3") variant, which used first stage number B1 vehicle's stages were test fired at McGregor, Texas, apparently during December, 2016. The first stage perfor static firing at LC 39A on February 12, 2017 after a scrubbed attempt the day before. The first and second stag payload were stacked for the test.

With the flight, Falcon 9 became the first launch vehicle family to perform a second orbital flight in 2017.

For Falcon 9 and Falcon Heavy, SpaceX added a large horizontal processing hangar just south of the SLC 39A and replaced the crawlerway ramp with dual rail tracks for a transporter erector launcher (TEL) to roll upon wl rockets up to the pad. The flame trench was rebuilt and reconfigured, with exhaust now exiting only toward t and large "rainbirds" were added to spray water on the launcher during liftoff. Additional changes to the pad a to support Commercial Crew launches, including installation of a crew access arm on the fixed service tower.

Falcon Heavy is not expected to debut from LC 39A until after Cape Canaveral SLC 40 is restored to service s after mid-2017. Meanwhile, SpaceX hopes to perform a first unmanned flight of its Dragon 2 Commercial Crew spacecraft from LC 39A by year's end. An improved "Block 5" being developed to launch Dragon 2 will perform the launch.

It was the 95th launch from LC 39A, a number that includes 12 Saturn 5 and 82 Space Shuttle liftoffs, the most recent by Shuttle Atlantis on July 8, 2011 for STS-135 mission.

Falcon 9 Reflies First Stage, Orbits SES 10 (March 31, 2017 Update)

SpaceX launched a previously-flown Falcon 9 first stage for the first time on March 30, 2017. The stage, B1021, boosted the F9-33 miss lofted the SES 10 communications satellite to geosynchronous transfer orbit from Kennedy Space Center Launch Complex 39 Pad A. I previously flown during the F9-23 CRS-8 mission on April 8, 2016, when it landed downrange on a converted barge. After a 22:27 UTC B1021 repeated the feat, landing again on the downrange floating platform after performing reentry and landing burns.

After the first stage completed its 2 min 38 sec ascent burn, the Falcon 9 second stage fired its Merlin 1D Vacuum engine for 345 sec to parking orbit. After a 17 min 55 sec coast to the equator above the west African coast, the stage restarted for 53 seconds to accelerate th SES 10 satellite toward a planned 218 x 35,410 km x 26.2 deg transfer orbit. SES 10 separated from the stage 32 min 03 sec after liftoff.

After raising itself to geostationary orbit, Airbus Defense and space-built SES 10 will serve Latin America, using 55 Ku-band transpond equivalents, from 67 deg West.

After the flight, SpaceX CEO Elon Musk announced that the company had, in another first, directed one of the two payload fairing hal landing zone in a test of future payload fairing recovery. The fairing had been equipped with a cold gas thruster system. Eventually, ste parachutes and inflatable shock absorbers will be used to bring the fairings down to recoverable ocean landings.

It was the first reflight of a complete orbital-class liquid fueled rocket stage. Blue Origin's New Shepard rocket had previously reflown, much less taxing suborbital missions. Reusable Space Shuttle orbiters brought back three main engines (SSMEs) and avionics, but expe large external propellant tank that fed the three SSMEs. Space Shuttle solid rocket boosters were also recovered and reused, but they w disassembled after each flight and the motor segments never stayed together to fly again as a unit.

After its 2016 flight, the B1021 stage was partially disassembled (its engines were removed, for example) and was shipped back to the SpaceX factory in Hawthorne, California. A engines were re-installed and other refurbishment work completed, the stage was shipped to the company's McGregor, Texas test site. There, it was test-fired on January 25, 2017 what appeared to be a standard test cycle for a Falcon 9 first stage. The new second stage was also test fired in late January or early February. After shipment to LC 39A's Horizo Integration Facility, the assembled F9-33 rocket performed a five-second static test at LC 39A on March 27, 2017, with no payload installed.

Vehicle Configurations

	LEO Payload (metric tons) 185 km x (1) 28.5 deg (CC) (2) 98 deg (VA) (3) 9.1 deg (KW) (4) 51.6 deg (CC)	Geosynchronous Transfer Orbit Payload (metric tons) 185x35,788 km x 27 deg ~1,800 m/s from GEO	Escape Velocty Payload (5)LEO+3,150 m/s (6)LEO+3,750 m/s	Configuration	Liftoff Height (meters) [1]Dragon [2]PLF	Liftoff Mass (metric tons)	Price (20 $Millions
Falcon 9 Block 1 (Merlin 1C)	9.0 t (1)	3.4 t	2 t (5)	2 Stage Falcon 9 (Merlin 1C)	[1] 48.1 m	318 t	$35-55 m

2010	8.5 t (4)			+ 3.6 m or 5.2 m PLF			
Falcon 9 v1.1 (Block 2) (Merlin 1D) 2013	13.15 t (1)	4.85 t	2.9 t (est)(5)	2 Stage Falcon 9 v1.1 (Merlin 1D) + 3.6 m or 5.2 m PLF	[1] 63.3 m [2] 68.4 m	505.8 t (max)	$54-59.5
Falcon 9 v1.2 (Block 3) Sept 2015	Expendable Theory ~17.4 t (1) Demonstrated 8.626 t (1st stg d/r recovery) 8.43 t (1st stg RTLS)	Expendable Theory ~6.4 t (Blk 3) Demonstrated 5.6 t (Blk 3, stg 1 expended) 6.761 t (Stg 1 expended, Blk 4 Stg 2) 5.282 t (1st stg d/r recovery)	Expendable Theory ~3.8 t (est)(5) Demonstrated 0.57 t to near-escape (1st stg d/r recovery abandoned due high winds)	2 Stage Falcon 9 v1.2 Initial + 3.6 m or 5.2 m PLF	[1] 65.5 m [2] 69.98m	~556 t (no p/l)	$61.2 m (
Falcon 9 Block 5 ~Late 2017	22.8 t (1)	8.3 t 5.5 t (1st stg recovery)	4.02 t (5)	2 Stage Falcon 9 v1.2 + 3.6 m or 5.2 m PLF	[2] 69.98 m	~587 t (max p/l)	$62 m (1s recovery)

Vehicle Components

	Falcon 9 Stage 1 - Block 1 Merlin 1C Version Estimated	**Falcon 9 Stage 2 - Block 1 Merlin 1C Version Estimated**	**Falcon 9 Stage 1 - "v1.1" Merlin 1D Version Estimated**	**Falcon 9 Stage 2 - "v1.1" Merlin 1D Version Estimated**	**Falcon 9 Stage 1 - "v1.2" (Block 3) Merlin 1D Full Thrust Version Estimated**	**Falcon 9 Stage 2 - "v1.2" (Block 3) Merlin 1D Full Thrust Version Estimated**	**Falcon 9 Block 5 Stage 1 - Merlin 1D Fuller Thrust Version Estimated**	**Falcon 5 Stage Merlin Thrust Versio Estima**
Diameter (m)	3.66 m	3.66 m	3.66 m	3.66 m	3.66 m	3.66 m	3.66 m	3.66 m
Length (m)	~30.1 m (est) not incl I/S	~10.0 m incl I/S	~40.9 m (est) not incl I/S	~14.6 m incl I/S	~40.9 m (est) not incl I/S	~16.0 m incl I/S	~40.9 m (est) not incl I/S	~16.0 m incl I/S
Empty Mass (tonnes)	~19.24 t? burnout	~3.1 t? burnout	~19 t? burnout	~4-4.5 t? burnout	~27.2 t? burnout	~4.5 t? burnout	~27.2 t? burnout	~4.5 t? burnou
Propellant Mass (tonnes)	~239.3 t? used	~48.9 t? used	~385 t? used	~93 t? used	~411 t? used	~111.5 t? used	~418.7 t? used	~111.5 used
Total Mass (tonnes)	~258.5 t?	~52 t?	~404 t?	~99 t?	~438.2 t?	~116.0 t?	~445.9 t?	~116.0
Engine	Merlin 1C	Merlin Vac	Merlin 1D	Merlin 1D Vac	Merlin 1D FT	Merlin 1D Vac FT	Merlin 1D FT	Merlin
Engine Mfgr	SpaceX	SpaceX	SpaceX	SpaceX	SpaceX	SpaceX	SpaceX	Space
Fuel	RP1	RP1	RP1	RP1	RP1	RP1	RP1	RP1
Oxidizer	LOX	LOX	LOX	LOX	LOX	LOX	LOX	LOX
Thrust (SL tons)	387.825 t		600.109 t	-	~694 t	-	~775.65 t	-
Thrust (Vac tons)	442.938 t	42.18 t	680.396	81.647 t	~757 t	95.255 t	~846 t	95.255
ISP (SL sec)	266 s	-	282 s	-	283 s?	-	283 s?	-
ISP (Vac sec)	304 s	336 s	311 s	340s	312 s?	348 s?	312 s?	348 s?
Burn Time (sec)	180 s	346 s	185 s?	375 s?	162 s	397 s	161 2	397 s
No. Engines	9	1	9	1	9	1	9	1
Comments	-	-	-	-	-	-	-	-

				Falcon 9 Payload Fairing
Diameter (m)				5.2 m
Length (m)				13.9 m
Empty Mass (tonnes)				~ 2.0 t?

Falcon 9 v1.1 and v1.2 Flight History

```
Date    Vehicle        No.   Payload               Mass  Site  Orbit (kmxkmxdeg)
-------------------------------------------------------------------------------
09/29/13 Falcon 9 v1.1 F9-6  Cassiope/5 Cubesats   0.6   VA 4E  500x1500x80    LEO [8]
12/03/13 Falcon 9 v1.1 F9-7  SES 8                 3.183 CC 40  295x80000x20.8 GTO+[9]
01/06/14 Falcon 9 v1.1 F9-8  Thaicom 6             3.016 CC 40  295x90000x22.5 GTO+[A]
04/18/14 Falcon 9 v1.1 F9-9  CRS-3 Dragon         ~7.76  CC 40  313x332x51.6   LEO/ISS[10]
07/14/14 Falcon 9 v1.1 F9-10 Orbcomm OG2 (6sats)   1.032 CC 40  614x743x47     LEO [11]
08/05/14 Falcon 9 v1.1 F9-11 Asiasat 8             4.535 CC 40  185x35786x24.3 GTO
09/07/14 Falcon 9 v1.1 F9-13 Asiasat 6             4.428 CC 40  184x35762x25.3 GTO
09/21/14 Falcon 9 v1.1 F9-12 CRS-4 Dragon         ~7.716 CC 40  199x359x51.64  LEO/ISS
01/10/15 Falcon 9 v1.1 F9-14 CRS-5 Dragon         ~7.807 CC 40  206x353x51.6   LEO/ISS[12]
02/11/15 Falcon 9 v1.1 F9-15 DSCOVR                0.57  CC 40  187x1371156x37 EEO [13]
```

```
03/02/15 Falcon 9 v1.1 F9-16 Eutelsat 115WB/ABS 3A 4.159 CC 40  400x63300x24.8 GTO+
04/14/15 Falcon 9 v1.1 F9-18 CRS-6 Dragon         ~7.505 CC 40  199x364x51.65  LEO/ISS[14]
04/27/15 Falcon 9 v1.1 F9-17 TurkmenAlem 52E       4.5   CC 40  180x36600x25.5 GTO
06/28/15 Falcon 9 v1.1 F9-20 CRS-7 Dragon         ~7.944 CC 40                [FTO][15]
12/22/15 Falcon 9 v1.2 F9-21 Orbcomm OG2           1.892 CC 40  620x660x47     LEO [16]
01/17/16 Falcon 9 v1.1 F9-19 Jason 3               0.553 VA 4E  1305x1320x66   LEO [17]
03/04/16 Falcon 9 v1.2 F9-22 SES 9                 5.271 CC 40  290x40600x28   GTO [18]
04/08/16 Falcon 9 v1.2 F9-23 CRS 8 Dragon         ~8.626 CC 40  200x360x51.6   LEO/ISS[19]
05/06/16 Falcon 9 v1.2 F9-24 JCSAT 14              4.696 CC 40  189x35957x23.7 GTO [20]
05/27/16 Falcon 9 v1.2 F9-25 Thiacom 8             3.025 CC 40  350x90226x21.2 GTO+[21]
06/15/16 Falcon 9 v1.2 F9-26 Eutelsat 117WB/ABS2A ~4.15  CC 40  395x62591x24.7 GTO+[22]
07/18/16 Falcon 9 v1.2 F9-27 CRS 9 Dragon         ~7.747 CC 40  200x360x51.6   LEO/ISS [23]
08/14/16 Falcon 9 v1.2 F9-28 JCSAT 16              4.6   CC 40  184x35912x20.9 GTO [21]
09/01/16 Falcon 9 v1.2 F9-29 AMOS 6                5.5   CC 40                [PAD][24]
01/14/17 Falcon 9 v1.2 F9-30 Iridium NEXT 1        8.6   VA 4E  667x86.4       LEO [25]
02/19/17 Falcon 9 v1.2 F9-32 CRS-10 Dragon        ~8.43  KC 39A 209x363x51.6   LEO/ISS[26]
03/16/17 Falcon 9 v1.2 F9-31 EchoStar 23           5.6   KC 39A 179x35903x22.4 GTO [27]
03/30/17 Falcon 9 v1.2 F9-33 SES 10                5.282 KC 39A 217x33395x26.3 GTO [28]
05/01/17 Falcon 9 v1.2 F9-34 NROL 76              ~2.8?  KC 39A 400x51?        LEO?[29]
05/15/17 Falcon 9 v1.2 F9-35 Inmarsat 5 F4         6.086 KC 39A 381x69839x24.5 GTO+[30]
06/03/17 Falcon 9 v1.2 F9-36 Dragon 6/CRS-11      ~8.198 KC 39A ~210x360x51.6  LEO/ISS[31]
06/23/17 Falcon 9 v1.2 F9-37 BulgariaSat 1         3.669 KC 39A 210x65640x23.9 GTO+[32]
06/25/17 Falcon 9 v1.2 F9-38 Iridium Next 2        8.60  VA 4E  625x86.4       LEO [33]
07/05/17 Falcon 9 v1.2 F9-39 Intelsat 35e          6.761 KC 39A 296x42742x25.6 GTO [34]
08/14/17 Falcon 9 v1.2 F9-41 CRS-12               ~8.4   KC 39A 210x360x51.6   LEO/ISS[35]
08/24/17 Falcon 9 v1.2 F9-40 Formosat 5            0.475 VA 4E  720x98.28      LEO/S [36]
09/07/17 Falcon 9 v1.2 F9-42 OTV-5 (X-37B)        ~5.00  KC 39A                LEO [37]
10/09/17 Falcon 9 v1.2 F9-44 Iridium NEXT 3        8.6   VA 4E  625x86.6       LEO [38]
10/11/17 Falcon 9 v1.2 F9-43 EchoStar 105/SES 11   5.2   KC 39A 309x40519x27.9 GTO [39]
10/30/17 Falcon 9 v1.2 F9-45 Koreasat 5A           3.7   KC 39A 285x50185x22.0 GTO [40]
12/15/17 Falcon 9 v1.2 F9-47 Dragon 8.2/CRS-13    ~7.7   CC 40                 LEO/ISS[41]
12/23/17 Falcon 9 v1.2 F9-48 Iridium NEXT 4        8.6   VA 4E  625x86.6 deg   LEO [42]
01/08/18 Falcon 9 v1.2 F9-46 Zuma                        CC 40                 LEO?[43]
01/31/18 Falcon 9 v1.2 F9-49 Govsat 1              4.230 CC 40                 GTO [44]
02/22/18 Falcon 9 v1.2 F9-50 Paz/Microsat 2a/b    ~2.000 VA 4E  514x97.4       LEO/S [45]
-------------------------------------------------------------------------------------
```

[8] First Falcon 9 v1.1. First VAFB SLC 4E launch of Falcon 9.
1st stage performed two reentry burns (3 and 1 engine), but 2nd burn cutoff early due high roll rates. 2nd stage restart for disposal burn failed.

[9] First Falcon 9 GTO+ launch. Targeted 295 x 80,000 km x 20.75 degree supersynchronous transfer orbit. Stg 1 briefly restarted post sep. Fire reported in Stg1 octaweb during ascent.

[A] Lower than planned fuel reserves reported at end of final Stg2 burn. Planned orbit achieved.

[10] First Falcon 9 fitted with extending landing legs. First stage performed two retro burns after separation, lowering itself to a simulated landing in the Atlantic off the Georgia/S. Carolina coast.

[11] 2nd Falcon 9 with legs. First stage performed two retro burns and landed in Atlantic but exploded during tip over.

[12] 1st stg attempted landing on converted barge about 320 km downrange, but landed hard on barge and was lost.

[13] 187 x 1,371,156 km x 37 degree insertion orbit. DSCVR bound for Earth-Sun L1. Stg 1 barge landing attempt abandoned due high seas.

[14] First stage landed hard on downrange landing platform and was destroyed.

[15] Broke up at about T+2m 19sec, before staging, due Stg2 LOX tank overpress.

[16] First stage boosted back to CC LZ-1 (former LC 13) and landed. Performed boostback, reentry, and landing burns using 3, 1, and 1 engine. First Falcon 9 v1.2 (Full Thrust) flight.

[17] First stage landed on downrange landing platform, but one leg failed to lock in place. Stage fell over and was destroyed.

[18] First stage landing on downrange platform failed.

[19] 3,136 kg cargo, incl 1,413 kg BEAM in trunk. 1st stg landed on barge (1st barge success).

[20] First stage landed on downrange platform. First GTO landing. First successful 3-engine landing.

[21] First stage landed on downrange platform.

[22] First stage destroyed during landing attempt on downrange platform. One of three engines produced low thrust during final landing burn. Stage "accordianed" on hard landing. Mission otherwise successful.

[23] First stage landed at CC LZ-1.

[24] F9 and AMOS 6 destroyed in explosion during hot fire countdown at SLC 40. Launch was planned for 09/03/16.

[25] First stage (B1029) landed downrange on drone ship "Just Read the Instructions".

[26] First stage (B1031) landed at CC LZ-1.

[27] First stage (B1030) purposely expended. No legs or fins. First expendable v1.2. Allowed heaviest-yet GTO payload.

[28] First Stg 1 reflight using B1021. Stage landed downrange on drone ship

"Of Course I Still Love You". PLF half recovery test.
Planned 218 x 35,410 km x 26.2 deg, but achieved agreed parameters.
[29] First stage (B1032) landed at CC LZ-1. Block 4 second stage.
[30] Expendable first stage (B1034). Heaviest-yet GTO payload. Stg 2 burned to depletion. Block 4 second stage.
[31] First stage (B1035) landed at CC LZ-1. 1st reflight by Dragon C106.
[32] First stage (B1029.2) landed OCISLY. 2nd Stg 1 reflight.
[33] First stage (B1036) landed JRTI.
[34] Expendable first stage (B1037). Heaviest-yet GTO payload. Stg 2 burned to depletion. Block 4 second stage.
[35] First stage B1039 landed at CC LZ-1. First Blk 4 Stg 1.
[36] First stage B1038 landed JRTI.
[37] First stage B1040 landed CC LZ-1. Blk 4 Stg 1&2.
[38] First stage B1041 landed JRTI.
[39] First stage B1031.2 landed on OCISLY downrange.
[40] First stage B1042 landed on OCISLY downrange.
[41] First stage B1035.2 landed LZ-1.
[42] First stage B1036.2 expended.
[43] First stage B1043 landed LZ-1.
[44] First stage B1032.2 expended.
[45] First stage B1038.2 expended. 1st PLF 2.0, recovery attempted.

LIST BY STAGE 1 SERIAL NUMBER

X = Expended
OL = Ocean Landing
DRL = Down Range Platform Landing
LZ1 = Landing Zone 1 Landing
-X = Failed Landing
-S = Successful Landing (Scrapped)
-D = Successful Landing (Saved for Display)
-M = Successful Landing (Mothballed)
STA = Structural Test Article
QTA = Qualification Test Article

Stage 1 No.	Date	Falcon 9 Variant/No.		Description	Mass	Site	Stg1/Result	Orbit
B0001	2007	v1.0		STA				
B0002	2007	v1.0		QTA/Grasshopper				
B0003	06/04/10	v1.0	F9-1	Dragon Qual Unit	~5.5	CC 40	X	LEO
B0004	12/08/10	v1.0	F9-2	Dragon C1	~5.5	CC 40	X	LEO
B0005	05/22/12	v1.0	F9-3	Dragon C2+	~6.02	CC 40	X	LEO/ISS
B0006	10/08/12	v1.0	F9-4	Dragon 3/CRS-1	~6.4	CC 40	X	[LEO/ISS]
B0007	03/01/13	v1.0	F9-5	Dragon 4/CRS-2	~6.54	CC 40	X	LEO/ISS
B1001	2013	v1.1		STA				
B1002	2013	v1.1		QTA/F9R Dev1			X	
B1003	09/29/13	v1.1	F9-6	Cassiope/5 Cubesats	0.6	VA 4E	OL-X	LEO
B10??	2013	v1.1		F9R Dev2 (not flown)				
B10??	12/03/13	v1.1	F9-7	SES 8	3.183	CC 40	X	GTO+
B100?	01/06/14	v1.1	F9-8	Thaicom 6	3.016	CC 40	X	GTO+
B10??	04/18/14	v1.1	F9-9	Dragon 5/CRS-3	~7.76	CC 40	OL-X	LEO/ISS
B10??	07/14/14	v1.1	F9-10	Orbcomm OG2 (6sats)	1.032	CC 40	OL-X	LEO
B10??	08/05/14	v1.1	F9-11	Asiasat 8	4.535	CC 40	X	GTO
B1010	09/21/14	v1.1	F9-12	Dragon 6/CRS-4	~7.716	CC 40	OL-X	LEO/ISS
B1011	09/07/14	v1.1	F9-13	Asiasat 6	4.428	CC 40	X	GTO
B1012	01/10/15	v1.1	F9-14	Dragon 7/CRS-5	~7.807	CC 40	DRL-X	LEO/ISS
B1013	02/11/15	v1.1	F9-15	DSCOVR	0.57	CC 40	OL-X	EEO
B1014	03/02/15	v1.1	F9-16	Eutelsat 115WB/ABS 3A	4.159	CC 40	X	GTO+
B1015	04/14/15	v1.1	F9-18	Dragon 8/CRS-6	~7.505	CC 40	DRL-X	LEO/ISS
B1016	04/27/15	v1.1	F9-17	TurkmenAlem 52E	4.5	CC 40	X	GTO
B1017	01/17/16	v1.1	F9-19	Jason 3	0.553	VA 4E	DRL-X	LEO
B1018	06/28/15	v1.1	F9-20	Dragon 9/CRS-7	~7.944	CC 40	X	[FTO]
B1019	12/22/15	v1.2	F9-21	Orbcomm OG2	1.892	CC 40	LZ1-D	LEO
B1020	03/04/16	v1.2	F9-22	SES 9	5.271	CC 40	DRL-X	GTO
B1021	04/08/16	v1.2	F9-23	Dragon 10/CRS 8	~8.626	CC 40	DRL	LEO/ISS
B1021.2	03/30/17	v1.2	F9-33	SES 10	5.282	KC 39A	DRL-D	GTO
B1022	05/06/16	v1.2	F9-24	JCSAT 14	4.696	CC 40	DRL	GTO
B1022.2	2016	v1.2		TX Hot Fire Tests				
B1023	05/27/16	v1.2	F9-25	Thiacom 8	3.025	CC 40	DRL	GTO+
B1023.2	02/06/18	FH	FH-1	FH Demo Side		KC 39A	LZ1	HCO
B1024	06/15/16	v1.2	F9-26	Eutelsat 117WB/ABS2A	~4.15	CC 40	DRL-X	GTO+
B1025	07/18/16	v1.2	F9-27	Dragon 11/CRS 9	~7.747	CC 40	LZ1	LEO/ISS
B1025.2	02/06/18	FH	FH-1	FH Demo Side		KC 39A	LZ1	HCO
B1026	08/14/16	v1.2	F9-28	JCSAT 16	4.6	CC 40	DRL-S	GTO
B1027	2016	FH	FH-1	FH Core STA				
B1028	09/01/16	v1.2	F9-29	AMOS 6	5.5	CC 40	X	[PAD]
B1029	01/14/17	v1.2	F9-30	Iridium Next 1-10	8.6	VA 4E	DRL	LEO
B1029.2	06/23/17	v1.2	F9-37	BulgariaSat 1	3.669	KC 39A	DRL-M	GTO+
B1030	03/16/17	v1.2	F9-31	EchoStar 23	5.6	KC 39A	X	GTO

B1031	02/19/17	v1.2	F9-32	Dragon 12/CRS-10	~8.43	KC 39A	LZ1	LEO/ISS
B1031.2	10/11/17	v1.2	F9-43	EchoStar 105/SES 11	5.2	KC 39A	DRL	GTO
B1032	05/01/17	v1.2	F9-34	NROL 76	~2.8?	KC 39A	LZ1-M	LEO?
B1032.2	01/31/18	v1.2	F9-49	GovSat 1	4.23	CC 40	X	GTO
B1033	02/06/18	FH	FH-1	FH Demo Core		KC 39A	DRL-X	HCO
B1034	05/15/17	v1.2	F9-35	Inmarsat 5 F4	6.086	KC 39A	X	GTO+
B1035	06/03/17	v1.2	F9-36	Dragon 6.2/CRS-11	~8.198	KC 39A	LZ1	LEO/ISS
B1035.2	12/15/17	v1.2	F9-47	Dragon 8.2/CRS-13	~7.7	CC 40	LZ1	LEO/ISS
B1036	06/25/17	v1.2	F9-38	Iridium Next 11-20	8.60	VA 4E	DRL	LEO
B1036.2	12/23/17	v1.2	F9-48	Iridium Next 4	8.6	VA 4E	X	LEO
B1037	07/05/17	v1.2	F9-39	Intelsat 35e	6.761	KC 39A	X	GTO
B1038	08/24/17	v1.2	F9-40	Formosat 5	0.475	VA 4E	DRL	LEO/S
B1038.2	02/22/18	v1.2	F9-50	Paz/Microsat 2a/b	~2.0	VA 4E	X	LEO
B1039	08/14/17	v1.2	F9-41	Dragon 13/CRS-12	~8.4	KC 39A	LZ1	LEO/ISS
B1040	09/07/17	v1.2	F9-42	OTV-5 (X-37B)	~5.00	KC 39A	LZ1	LEO
B1041	10/09/17	v1.2	F9-44	Iridium Next 3	8.6	VA 4E	DRL	LEO/S
B1041.2	--/--/18	v1.2	F9-51	Iridium Next 5	8.6	VA 4E		LEO/S
B1042	10/30/17	v1.2	F9-45	Koreasat 5A	3.7	KC 39A	DRL	GTO
B1043	01/08/18	v1.2	F9-46	Zuma		CC 40	LZ1	LEO?
B1044	--/--/18	v1.2	F9-52	Hispasat 1F		CC 40		GTO

References

Falcon 9 Data Sheet, SpaceX, 2008
Falcon 9 Users Guide, SpaceX, 2009, updated 2015
Falcon Family Brochure, SpaceX, 2011
Updates at www.spacex.com
Updates on Elon Musk Twitter page
Tom Mueller (SpaceX VP) comments at August 2011 Joint Propulsion Conference
"Iridium NOW & NEXT", IDG Aero Satcom Seminar -- Stockholm, Sweden, Jeffrey White, Iridium Director EMEA & Russia, March 9, 2012
Draft Environmental Impact Statement, SpaceX Texas Launch Site, Vol 1&2, April 2013
SpaceX web site www.spacex.com