## Manned Systems

## Briefing

Dragon is a fully autonomous, reusable capsule designed to initially deliver cargo to the International Space Station (ISS) at low earth orbit (LEO) and ultimately crews of astronauts to the facility. The capsule can be used for a variety of mission applications, including highly responsive payload hosting; sensors/apertures up to 3.5 meters in diameter, instruments and sensor testing; spacecraft deployment; space physics and relativity experiments; radiation effects research; microgravity research; life science and biotech studies; earth sciences and observations; materials and space environments research; rendezvous and inspection; and robotic servicing.

A prototype of the space-craft-the Dragon C1completed a demonstration flight aboard a Falcon 9 rocket on December 8, 2010. Previously, a structural model of the capsule had been used as the dummy payload for the maiden launch of the Falcon 9 on June 4, 2010. Since 2010, three Dragon missions have been launched, including Dragon C2 (May 22, 2012), which docked with ISS for the first time, and two commercial ISS resupply services flights-Dragon CRS-1, and


CRS-2, CRS-3, CRS-4, CRS-5 and CRS-6 on October 8, 2012; March 1, 2013; April 18, 2014; September 21, 2014; January 10, 2015; and April 14, 2015 respectively. The CRS-7 mission attempted on June 28, 2015 failed when its Falcon 9 v 1.1 launch vehicle experienced an overpressure anomaly in its upper stage and exploded about 139 seconds into flight.

## Recent Developments

The $27^{\text {th }}$ Dragon resupply capsule (CRS-25) was successfully launched to the ISS July 15, 2022 aboard a Falcon 9 v1.2 rocket from Cape Canaveral, FL. It carried a payload mass of $2,630 \mathrm{~kg}$. The next Dragon resupply mission (CRS-26) to the ISS is scheduled for November 18, 2022. It will carry the iROSA 1A and iROSA 3B solar arrays, produced by Boeing.

## Executive

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(owner \& operator)

## Manufacturers

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(prime contractor)

## Specifications

| Mass (dry): | $4,200 \mathrm{~kg}$ |
| :--- | :--- |
| Height (with Trunk): | 7.2 m |
| Diameter: | 3.7 m |
| Mission duration: | $1 \mathrm{wk} \mathrm{-2} \mathrm{yr}$ |
| Command uplink: | $300 \mathrm{Kbp} / \mathrm{s}$ |
| Telemetry/data downlink: | $300 \mathrm{Mbit} / \mathrm{s}$ |
| Volume |  |
| Total launch payload: | $25 \mathrm{~m}^{3}$ |
| Return launch payload: | $11 \mathrm{~m}^{3}$ |
| Spacecraft payload: | $11 \mathrm{~m}^{3}$ |
| Trunk payload: | $14 \mathrm{~m}^{3}$ |
| Payload launch capacity: | $6,000 \mathrm{~kg}$ |
| Payload return capacity: | $3,000 \mathrm{~kg}$ |
|  |  |
| *34 mith extended trunk |  |
|  |  |
| Subsystems |  |

## Frame

The capsule is made up of ized cargo and eventually the three primary segments: the Nosecone, which provides protection during ascent; the Spacecraft, which houses the pressur-
crew, along with the service section which contains the avionics, the reaction control system (RCS), parachutes, and other
support infrastructure; and the Trunk, which provides stowage for unpressurized cargo and support for the solar arrays and thermal radiators.

## Launch Systems

The Dragon capsules have been launched by Falcon 9 v1.0
and Falcon 9 v 1.1 rockets, built by $\underline{\text { SpaceX }}$. The Falcon 9 v 1.2
will be used for future Dragon missions.

## Guidance \& Control

Attitude control and maneuvering is provided by 18 Draco thrusters, built by SpaceX. The thrusters, which run on monome-
thyl hydrazine fuel and nitrogen tetroxide oxidizer. generate 400 newtons of force. They have a multiple start capability. The
flight computer system consists of three pairs of computers.

## Power

Twin solar panels generate an average of 1,500 watts of electrical power; 4,000 watts at peak.

## Launch History

| Date | Payload | Mass | Launch Vehicle | Orbit | Launch Site |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Mission 1 |  |  |  |  |  |
| 12/08/10 | Dragon C1 | 4,900 kg | Falcon 9 v 1.0 | low earth | Cape Canaveral AFS |
| Mission 2 |  |  |  |  |  |
| 05/22/12 | Dragon C2 | 6,650 kg | Falcon 9 v 1.0 | low earth | Cape Canaveral AFS |
| Mission 3 |  |  |  |  |  |
| 10/08/12 | Dragon CRS-1 Orbcomm-NG 1 | $\begin{aligned} & \hline 6,650 \mathrm{~kg} \\ & 142 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.0}$ | low earth | Cape Canaveral AFS |
| Mission 4 |  |  |  |  |  |
| 03/01/13 | Dragon CRS-2 | 6,650 kg | Falcon 9 v 1.0 | low earth | Cape Canaveral AFS |
| Mission 5 |  |  |  |  |  |
| 04/18/14 | Dragon CRS-3 | 6,650 kg | Falcon 9 v 1.1 | low earth | Cape Canaveral AFS |
|  | KickSat 1 <br> ALL-STAR/THEIA <br> SporeSat 1 <br> TechCube 1 <br> LMRSat <br> TestSat-Lite (TSAT) <br> Hermes 2 <br> Phonesat 2.5 <br> Sprite 1 - Sprite 104 | $\begin{aligned} & 5.5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 4 \mathrm{~kg} \\ & 2 \mathrm{~kg} \\ & 2 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & .01 \mathrm{~kg} \text { (er } \end{aligned}$ |  |  |  |
| Mission 6 |  |  |  |  |  |
| 09/21/14 | Dragon CRS-4 ISS-RapidScat Spinsat | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 589 \mathrm{~kg} \\ & 57 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.1}$ | low earth | Cape Canaveral AFS |
| Mission 7 |  |  |  |  |  |
| 01/10/15 | Dragon CRS-5 CATS Dove 98 (Flock-1d' 1) Dove 99 (Flock-1d' 2) AESP-14 | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 494 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1} 1.1$ | low earth | Cape Canaveral AFS |
| Mission 8 |  |  |  |  |  |
| 04/14/15 | Dragon CRS-6 <br> Dove 100 (Flock-1e 1) <br> Dove 101 (Flock-1e 2) <br> Dove 102 (Flock-1e 3) <br> Dove 103 (Flock-1e 4) <br> Dove 104 (Flock-1e 5) <br> Dove 105 (Flock-1e 6) <br> Dove 106 (Flock-1e 7) <br> Dove 107 (Flock-1e 8) <br> Dove 108 (Flock-1e 9) <br> Dove 109 (Flock-1e 10) <br> Dove 110 (Flock-1e 11) <br> Dove 111 (Flock-1e 12) <br> Dove 112 (Flock-1e 13) <br> Dove 113 (Flock-1e 14) <br> Arkyd-3R <br> Centennial 1 | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 5 \mathrm{~kg} \\ & 4 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.1}$ | low earth | Cape Canaveral AFS |
| Mission 9 |  |  |  |  |  |
| 06/28/15* | Dragon CRS-7 <br> IDA 1 <br> Dove 114 (Flock-1f 1) | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 521 \mathrm{~kg} \\ & 5 \mathrm{~kg} \end{aligned}$ | $\text { Falcon } 9 \mathrm{v} 1.1$ | low earth | Cape Canaveral AFS |


|  | Dove 115 (Flock-1f 2) <br> Dove 116 (Flock-1f 3) <br> Dove 117 (Flock-1f 4) <br> Dove 118 (Flock-1f 5) <br> Dove 119 (Flock-1f 6) <br> Dove 120 (Flock-1f 7) <br> Dove 121 (Flock-1f 8) | 5 kg <br> 5 kg <br> 5 kg <br> 5 kg <br> 5 kg <br> 5 kg <br> 5 kg |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Mission 10 |  |  |  |  |  |
| 04/08/16 | Dragon CRS-8 BEAM | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 1,360 \mathrm{~kg} \end{aligned}$ | Falcon 9 v 1.2 | low earth | Cape Canaveral AFS |
| Mission 11 |  |  |  |  |  |
| 07/18/16 | Dragon CRS-9 IDA 2 | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 525 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.2}$ | low earth | Cape Canaveral AFS |
| Mission 12 |  |  |  |  |  |
| 02/19/17 | Dragon CRS-10 STPSat-5 (Houston 5) SAGE III | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 200 \mathrm{~kg} \\ & 76 \mathrm{~kg} \end{aligned}$ | Falcon 9 v 1.2 | low earth | Cape Canaveral AFS |
| Mission 13 |  |  |  |  |  |
| 06/03/17 | Dragon CRS-11 <br> NICER <br> ROSA <br> MUSES <br> Bird B (BRAC Onnesha) <br> Bird G (GhanaSat 1) <br> Bird J (Toki) <br> Bird M ((Mazaalai) <br> Bird N ((Nigeria EduSat 1) | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 372 \mathrm{~kg} \\ & 325 \mathrm{~kg} \\ & 305 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon 9 v 1.2 | low earth | Cape Canaveral AFS |
| Mission 14 |  |  |  |  |  |
| 08/14/17 | Dragon CRS-12 <br> CREAM <br> Kestrel Eye 2M <br> ASTERIA <br> Dellingr <br> OSIRIS-3U | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 1,258 \mathrm{~kg} \\ & 50 \mathrm{~kg} \\ & 12 \mathrm{~kg} \\ & 10 \mathrm{~kg} \\ & 5 \mathrm{~kg} \end{aligned}$ | Falcon 9 v 1.2 | low earth | Cape Canaveral AFS |
| Mission 15 |  |  |  |  |  |
| 12/15/17 | Dragon CRS-13 <br> TSIS 1 <br> Space Debris Sensor (SDS) | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 363 \mathrm{~kg} \\ & 25 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.2}$ | low earth | Cape Canaveral AFS |
| Mission 16 |  |  |  |  |  |
| 04/02/18 | Dragon CRS-14 <br> MISSE-FF 1 <br> ASIM <br> PFCS <br> RemoveDEBRIS (RemDeb) <br> DebrisSat 1 <br> DebrisSat 2 <br> RemDeb Net <br> UBAKUSAT <br> 1KUNS-PF <br> Irazú (Batsú-CS 1) | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 435 \mathrm{~kg} \\ & 330 \mathrm{~kg} \\ & 107 \mathrm{~kg} \\ & 100 \mathrm{~kg} \\ & 50 \mathrm{~kg} \\ & 50 \mathrm{~kg} \\ & 20 \mathrm{~kg} \\ & 4 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon 9 v 1.2 | low earth | Cape Canaveral AFS |
| Mission 17 |  |  |  |  |  |
| 06/29/18 | Dragon CRS-15 ECOSTRESS <br> Biarri-Squad 1 <br> Biarri-Squad 2 <br> Biarri-Squad 3 <br> Bird BTN (Bhutan 1) | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 490 \mathrm{~kg} \\ & 4 \mathrm{~kg} \\ & 4 \mathrm{~kg} \\ & 4 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon 9 v 1.2 | low earth | Cape Canaveral AFS |


|  | Bird MYS (UiTMSAT 1) Bird PHL (MAYA 1) | $\begin{aligned} & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Mission 18 |  |  |  |  |  |
| 12/05/18 | Dragon CRS-16 <br> GEDI <br> RRM3 <br> UNITE <br> TechEdSat 8 (TES) <br> CAT (CATsat) 1 <br> CAT (CATsat) 2 <br> Delphini (AUSAT) 1 <br> Quantum Radar 1 <br> Quantum Radar 2 | $\begin{aligned} & \hline 6,650 \mathrm{~kg} \\ & 4 \mathrm{~kg} \\ & 2.5 \mathrm{~kg} \\ & \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.2}$ | low earth | Cape Canaveral AFS |
| Mission 19 |  |  |  |  |  |
| 05/04/19 | Dragon CRS-17 <br> Red-Eye 1 (Pinot) <br> OCO 3 <br> STP-H6 | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 100 \mathrm{~kg} \end{aligned}$ | Falcon 9 v1.2 | low earth | Cape Canaveral AFS |
| Mission 20 |  |  |  |  |  |
| 07/25/19 | Dragon CRS-18 <br> IDA 3 <br> ORCA <br> RFTSat 1 <br> Quantum Radar 3 <br> NARSScube 2 | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 526 \mathrm{~kg} \end{aligned}$ $1 \mathrm{~kg}$ | Falcon $9 \mathrm{v1.2}$ | low earth | Cape Canaveral AFS |
| Mission 21 |  |  |  |  |  |
| 12/05/19 | Dragon CRS-19 <br> HISUI <br> CIRiS <br> MiniCarb (CNGB) <br> SORTIE <br> VPM <br> CryoCube 1 <br> QARMAN (QB50 BE05) <br> AztechSat 1 <br> EdgeCube <br> MakerSat 1 | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 500 \mathrm{~kg} \\ & 6 \mathrm{~kg} \\ & \\ & 8 \mathrm{~kg} \\ & \\ & 4 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon 9 v 1.2 | low earth | Cape Canaveral AFS |
| Mission 22 |  |  |  |  |  |
| 03/07/20 | Dragon CRS-20 <br> Bartolomeo (CEPHFISS) <br> Lynk 4 (Lynk the World) <br> Gundam Satellite <br> Quetzal (Guatesat) 1 | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 500 \mathrm{~kg} \\ & 10 \mathrm{~kg} \\ & 3 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon 9 v1.2 | low earth | Cape Canaveral AFS |
| Mission 23 |  |  |  |  |  |
| 12/06/20 | Dragon CRS-21 <br> Nanoracks Bishop Airlock | $\begin{aligned} & \hline 6,650 \mathrm{~kg} \\ & 1,050 \mathrm{~kg} \end{aligned}$ | Falcon 9 v 1.2 | low earth | Cape Canaveral AFS |
| Mission 24 |  |  |  |  |  |
| 06/03/21 | Dragon CRS-22 <br> iROSA 2B <br> iROSA 4B <br> Gundam Satellite <br> RamSat <br> SOAR <br> MIR-Sat 1 | $\begin{aligned} & \hline 6,650 \mathrm{~kg} \\ & 600 \mathrm{~kg} \\ & 600 \mathrm{~kg} \\ & 3 \mathrm{~kg} \\ & 2 \mathrm{~kg} \\ & 2 \mathrm{~kg} \\ & 1 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.2}$ | low earth | Cape Canaveral AFS |
| Mission 25 |  |  |  |  |  |
| 08/29/21 | Dragon CRS-23 IOD-AMBER | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & 6 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.2}$ | low earth | Cape Canaveral AFS |


|  | CAPSat SPACE-HAUC CUAVA PR_CuNaR 2 Maya 3 Maya 4 Binar 1 | 4 kg <br> 4 kg <br> 3 kg <br> 3 kg <br> 1 kg <br> 1 kg <br> 1 kg |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Mission 26 |  |  |  |  |  |
| 12/31/21 | Dragon CRS-24 <br> STP-H7 <br> STP-H8 <br> DAILI <br> Light 1 <br> PATCOOL <br> TARGIT <br> GASPACS <br> GT 1 <br> FEES 2 | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & \mathrm{n} / \mathrm{a} \\ & \mathrm{n} / \mathrm{a} \\ & 6 \mathrm{~kg} \\ & 3 \mathrm{~kg} \\ & 3 \mathrm{~kg} \\ & 3 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 0.3 \mathrm{~kg} \end{aligned}$ | Falcon $9 \mathrm{v1.2}$ | low earth | Cape Canaveral AFS |
| Mission 27 |  |  |  |  |  |
| 07/15/22 | Dragon CRS-25 EMIT <br> BeaverCube <br> CLICK A <br> D3 <br> JAGSAT 1 <br> CapSat 1 <br> FUTABA <br> HSU-SAT 1 <br> TUMnanoSAT | $\begin{aligned} & 6,650 \mathrm{~kg} \\ & \mathrm{n} / \mathrm{a} \\ & 3 \mathrm{~kg} \\ & 3 \mathrm{~kg} \\ & 2 \mathrm{~kg} \\ & 2 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & 1 \mathrm{~kg} \\ & \hline \end{aligned}$ | Falcon $9 \mathrm{v1.2}$ | low earth | Cape Canaveral AFS |

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## Contract Briefs

Date Source Value Details

Space Exploration Technologies

| 08/18/06 | NASA | \$278,000,000 | Phase I contract for the Commercial Orbital Transportation Services (COTS) developmental program to provide commercial resupply services to the International Space Station. Contract conditioned on meeting all specified milestones. |
| :---: | :---: | :---: | :---: |
| 12/23/08 | NASA | \$1,600,000,000 | Commercial Resupply Services 1 (CRS-1) contract to provide 12 resupply flights to the International Space Station carrying a minimum of $20,000 \mathrm{~kg}$. |
| 04/18/11 | NASA | \$75,000,000 | Phase II contract for the Commercial Crew Development 2 (CCDev 2) program to develop an ISS crew transportation vehicle. |
| 01/14/16 | NASA | \$1,500,000,000* | Commercial Resupply Services 2 (CRS-2) contract extension to provide seven resupply flights to the International Space Station through 2024. |
| 10/16/20 | NASA | - | Commercial Resupply Services 2 (CRS-2) contract extension to provide two resupply flights to the International Space Station through 2024. |
| 03/25/22 | NASA | - | Commercial Resupply Services 2 (CRS-2) contract extension to provide six resupply flights to the International Space Station through 2026. |

* Teal Group estimate


## Costs

Estimated cost of a Dragon flight is $\$ 150$ million.

## Teal Group Evaluation

The first launch of the Dragon on December 7, 2012 was a demonstration flight meant to test its systems in space and be recovered in the ocean. By all accounts, it was a successful mission. The big test for the capsule, however, took place on May 22, 2012 when it rendezvoused and docked with ISS to deliver supplies. That was the first operational flight, and it was successful, opening the way for Dragon commercial resupply services (CRS) missions- 27 of which have been completed. One of the commercial missions ended in failure. Among the key tests during the maiden docking flight was to determine if the capsule's robotic systems were able to abort docking activities in the event of a malfunction or
problem. As it approaches ISS, Dragon must be able to automatically orient itself and place itself in a position to be grappled and hauled in by the station's Canadarm2 robotic arm. It is hard to overemphasize the importance of the first Dragon docking with ISS-both to NASA and the United States, as it represented the first time a commercial US robotic capsule had ever flown to the station. Up to until then, these types of missions had been reserved for the Space Shuttle and Russia's Soyuz and Progress capsules.

The success of the first docking flight did nothing less than mark the beginning of an entirely new era for spaceflight. It began the transition from a time when NASA-owned and -operated ve-
hicles dominated the space industry to one in which private companies with their own rockets and capsules lead the way in providing access to space and creating new markets... driven by both the technological challenges and the profit motive. Over the past decade, SpaceX has been focused on delivering cargo to ISS, essentially eliminating US dependency on Russia's Progress supply capsule. As of last year, the company has begun also transporting astronauts to and from the station, eliminating NASA's dependency on Russian Soyuz rockets and capsules for that function as well. That's where SpaceX's human-rated variant of Dragon called "Dragon V2" has filled the need.

## Past Customers

Dragons have been used to agencies, companies, organizacarry payloads for the following
tions, or universities: NASA

## Launch Forecast

| (payload units) | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | :--- |
| Dragon | 3 | 3 | 3 | 3 | 3 | 3 | 3 | - | - |  |


[^0]:    * launch failure

