



**Space Exploration
Technologies (SpaceX)
Orbital Debris Assessment
Report (ODAR)
Cargo Dragon**

February 9, 2017

SECTION 1: CARGO DRAGON MISSION OVERVIEW

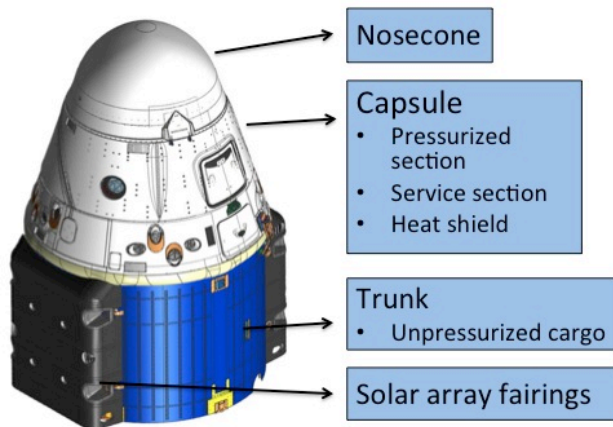
Mission Overview:

Space Exploration Technologies Corp. (SpaceX) provides cargo delivery services to the International Space Station (ISS) under its Commercial Resupply Services (CRS) contract with the National Aeronautics and Space Administration (NASA). To date, SpaceX has completed 9 cargo delivery missions to the ISS.

SpaceX launches the Dragon spacecraft on a SpaceX Falcon 9 launch vehicle into an elliptical orbit. The launch is licensed by the Federal Aviation Administration (FAA). Once inserted into orbit, Dragon performs orbital maneuvers to rendezvous with the ISS. Once in proximity of the ISS robotic arm, Dragon is captured and berthed to the ISS for up to 37 days. After completion of ISS operations, Dragon is released from the ISS again by the robotic arm and performs a series of departure burns to safely maneuver away from the ISS and begin the reentry phase of flight.

Dragon has been designed to perform controlled & guided atmospheric reentry back to earth. The FAA licenses Dragon's reentry.

Below is a Dragon vehicle overview.



Launch Vehicle & Launch Site: Falcon 9, Cape Canaveral and Kennedy Space Center, Florida.

Mission Duration: Up to 40 days.

Launch and Deployment Profile: Dragon will be separated from the second stage of the Falcon 9 launch vehicle and inserted into an elliptical orbit to continue a rendezvous profile to the ISS.

Orbital Selection: The orbital profile is chosen for rendezvous with the ISS.

SECTION 2: SPACECRAFT DESCRIPTION

Dragon is a fully autonomous spacecraft with both pressurized and unpressurized sections. Dragon is composed of two main elements: the pressurized cargo module, or “capsule,” and the unpressurized cargo module, or “trunk”.

The capsule performs all the functions of a service module and is fully recoverable. It includes a pressurized section, a service section, and a nosecone, and contains all the structure and subsystems required for transport of pressurized cargo to the ISS. Dragon’s trunk remains attached through launch and ISS operations but is jettisoned shortly before reentry.

Dragon’s thrusters perform all on-orbit maneuvers, including operations such as rendezvous and approach to the ISS; deorbit burns; and attitude control throughout the mission, including during re-entry.

SECTION 3: ASSESSMENT OF SPACECRAFT DEBRIS RELEASED DURING NORMAL OPERATIONS

In coordination with NASA, SpaceX has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability that the Dragon spacecraft will become a source of debris. During ISS cargo missions, the Dragon spacecraft releases three objects during the launch – the nosecone and two solar array fairings. During reentry, the Dragon spacecraft releases the trunk. These objects are analyzed for debris and collision avoidance as part of the FAA launch and reentry licensing process. No other objects are released.

SECTION 4: ASSESSMENT OF SPACECRAFT EXPLOSION OR COLLISION RISK

In coordination with NASA, SpaceX has assessed and limited the probability of accidental explosions during and after completion of mission operations. A failure modes and effects analysis of the Dragon spacecraft on orbit has been undertaken with insight from NASA. All risks were deemed to be not credible or have been mitigated or controlled to be within acceptable levels for NASA.

SpaceX has also assessed and limited the probability becoming a source of debris by collisions with large debris or other operational space stations. An effective review and analysis of the failure modes associated with the Dragon spacecraft on orbit has been undertaken with insight from NASA. All risks were deemed to be not credible or have been mitigated or controlled to be within acceptable levels for NASA.

SpaceX has assessed and limited the probability of unintended contact with the ISS. Dragon's approach to the ISS is closely coordinated between ISS operations staff and SpaceX operations staff. The approach involves successive maneuvers of Dragon to a series of waypoints below ISS, with well-developed contingency plans for aborting the approach if necessary. Once Dragon is in the immediate vicinity of the ISS, the ISS crew grapples the Dragon spacecraft and it is passively berthed to ISS. SpaceX flight software has been developed and is maintained and updated using a rigorous NASA acceptance procedure.

The Dragon spacecraft is screened for conjunctions by NASA (with support from JSPOC) between the launch and reentry phases of operations. Phasing burns are adjusted to address any conjunction risks.

Dragon is designed to safely execute a controlled reentry under license with the FAA into Earth's atmosphere after departure from ISS as a part of nominal mission operations.

SECTION 5: ASSESSMENT OF POST-MISSION DISPOSAL

Dragon is designed to safely execute a controlled reentry under license with the FAA into Earth's atmosphere after departure from ISS as a part of nominal mission operations.