SpaceX
COTS Demo C2+
Mission Summary

NASA Advisory Council
Commercial Space Committee
Goddard Space Flight Center
July 23, 2012

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# C2 Primary Mission Objectives

<table>
<thead>
<tr>
<th>Objective</th>
<th>Success Criteria</th>
<th>Verification Method</th>
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</table>
| **1. Licenses and Certifications Complete** | a. Eastern Range certifies launch  
  b. FAA Licenses | a. Cert letter from ER  
  b. Cert letter(s) from FAA for ascent and reentry |
| **2. Launch and orbital insertion** | c. Vehicle ascends through lightning towers without contact  
  d. Successful stage separation and stage 2 ignition  
  e. Dragon inserted into planned orbit – currently 310 km x 340 km (±50 km, altitude not to exceed 368 km)  
  f. Dragon inserted into planned inclination - currently 51.6 degree (±0.25 deg) | c. Visual  
  d. F9 telemetry and/or visual  
  e. Dragon telemetry and/or JSpOC data  
  f. Dragon telemetry and/or JSpOC data |
| **3. On-Orbit Operations** | g. Successful separation of Dragon from stage 2  
  h. Deployment and functionality of solar arrays  
  i. Dragon successfully completes system checkout  
  j. Dragon initiates phasing and height adjustment maneuver  
  k. Dragon performs Abort Demonstration  
  l. Dragon performs AGPS Demonstration  
  m. Dragon establishes communication with ISS using CUCU and shows commanding from ISS  
  n. Dragon performs RGPS Demonstration  
  o. Free Drift demonstration  
  p. Show performance during extended time in orbit (Vacuum, Thermal and Radiation environment) esp. Solar Arrays, Radiators, avionics and non-composite Trunk  
  q. Show performance of new, redundant avionics and spacecraft systems. | g. Dragon telemetry  
  h. Dragon telemetry  
  i. Confirmation by SpaceX Mission Operations using Dragon telemetry  
  j. Dragon telemetry  
  k. Dragon telemetry (Flight Rule G2-11_Abort)  
  l. Dragon telemetry (Flight Rule G2-12_AGPS)  
  m. Dragon and ISS telemetry (Flight Rule G2-21 (3 & 5))  
  n. Dragon telemetry (Flight Rule G2-15_RGPS)  
  o. Dragon telemetry (X-DOR) (Flight Rule G2-14_Free Drift)  
  p. Dragon telemetry confirms Power and Thermal system functioning as predicted; computers/avionics upset rate does not exceed 3X the expected upset rate  
  q. Dragon telemetry confirms redundant systems operating and fails over correctly if required |
| **4. De-orbit burn & separation** | r. Dragon successfully performs de-orbit burn and projects vehicle on target for landing within landing area | r. Dragon telemetry |
| **5. Controlled entry, descent & landing** | s. Dragon successfully deploys main parachutes  
  t. Dragon lands in pre-designated landing ellipse (documented in FAA licensing package) | s. Dragon telemetry and/or visual that minimum required parachutes have deployed  
  t. Dragon telemetry and/or GPS data from recovery boat |
| **6. Recovery** | t. The Dragon capsule is recovered | t. Visual |
# C3 Primary Mission Objectives

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| 1. On-Orbit Operations - Approach | a. Dragon GO to enter Approach Ellipsoid  
b. LIDAR demonstration  
c. Hold demonstration on R-bar  
d. Retreat demonstration on R-bar | a. Verbal confirmation by MCC-H in conjunction with MCC-X (Flight Rule G2-21)  
b. Dragon telemetry (X-DOR) (Flight Rule G2-16_LIDAR)  
c. Dragon telemetry (X-DOR) (Flight Rule G2-18_Hold)  
d. Dragon telemetry (X-DOR) (Flight Rule G2-17_Retreat) |
| 2. ISS-Attached Operations | e. Dragon is commanded to free drift  
f. Dragon is successfully grappled by SSRMS  
g. Dragon PCBM successfully mated with ISS  
h. Dragon hatch is opened  
i. Demonstrate cargo is transferred to and from the ISS | e. Dragon telemetry (Flight Rule G2-21)  
f. ISS telemetry (Flight Rule G2-21)  
g. ISS telemetry (Flight Rule G2-21)  
h. Visual and/or crew report  
i. MCC-Houston |
| 3. On-Orbit Operations - Departure | j. Dragon is successfully de-berthed from ISS  
k. Dragon successfully lowers its orbit for reentry | j. ISS telemetry (Flight Rule G2-21)  
k. Dragon telemetry |
| 4. Recovery | l. Demonstrate cargo is recovered and returned to NASA. | l. Visual |
SpaceX C2+ Launch to the ISS
May 22, 2012
Launch and Ascent

- Successful launch at 3:44 am Cape time on May 22
- Nominal first- and second-stage burn
- Nose cone deployed during second-stage burn
- Orbital insertion of 297 x 346.5 km
  - [POST model 310x345]

Credit: Associated Press
Initialization and Phasing

- Solar array deployment and actuation was nominal
- GNC bay door deployed exposing the GNC sensor suite
- Star tracker attitude initiation worked as expected
- TDRSS S-band telemetry and commanding worked better than expected, including under ISS on approach
C2 Fly-By

- Performed an orbital pass 2.5 km below the ISS
- Successfully performed space-to-space communication via UHF
  - Acquired solid ISS data at a slant range of 70 km
  - Switched to bi-directional communications at a slant range of 14 km
- Demonstrated relative GPS with abort demonstrations
- ISS crew commanded the strobe lights

Credit: Andre Kuipers
R-bar and Berthing

- Demonstrated precision R-bar arrival at 350 m below the ISS
- Initialized proximity sensors (LIDARs and thermal imagers) and converged a solution for range and range rate before proceeding
- Demonstrated hold and retreats commanded by the ISS crew
- Entered free drift at 10 m from the ISS with minimal vehicle body rates
- Successfully berthed to Node 2 Nadir
Berthed Operations

• Performed cargo offload and reload for down mass configuration
• ISS power convertor unit performed nominally during berthed operations
• Berthed duration of 5 days
Departure, Reentry and Recovery

• Nominal deorbit burn initiated for a southerly return
• Nominal parachute deployment and splash down at 8:45 am on 5/31
• Well within landing ellipse, 8 km from the expected landing location
• Dragon recovered on barge within 3.5 hours of splashdown
• Early access cargo delivered within 48 hrs
Dragon Structures, Post Flight Observations

• Post flight visual inspection yielded no new anomalies
  – Revised mortar shock collar appears to have performed much better than C1
  – Float angle of capsule in water suggests that GNC bay remained sealed
  – Cargo returned safely
  – Parachute deployment was nominal
Summary

• All systems performed as expected or better
• All SAA demonstration flight objectives met (C1, C2, and C3)
• Remaining milestone, Demo Readiness Review 3, planned for August 2012
  – Post Flight Review
  – Readiness of next vehicle
• First Commercial Resupply Services mission planned for October 2012