# SpaceX
# COTS Demo C2+
# Mission Summary

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

**Alan Lindenmoyer**
Program Manager

# C2 Primary Mission Objectives

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

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# C3 Primary Mission Objectives

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

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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
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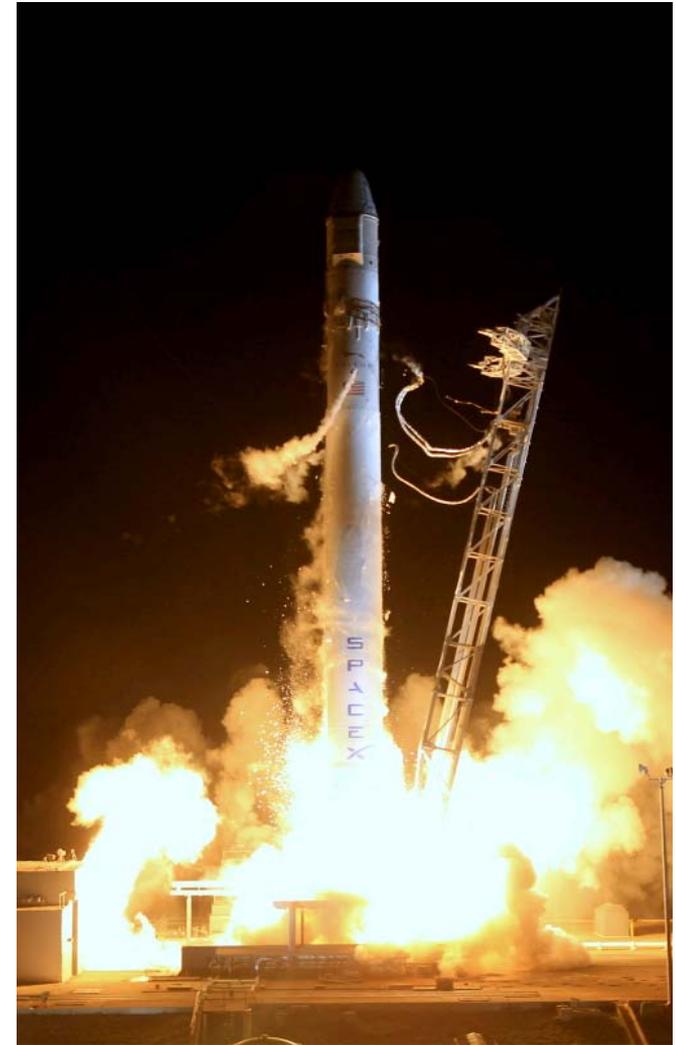
# Initialization and Phasing

- **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 that expected, including under ISS on approach**
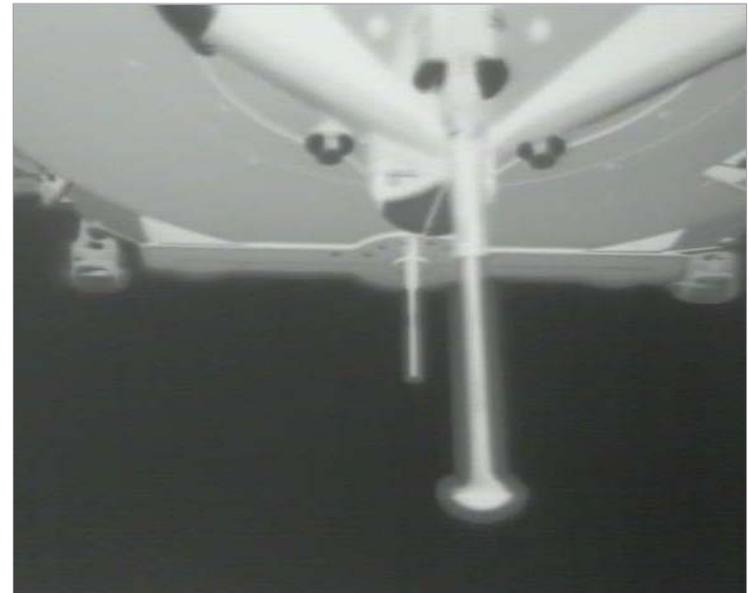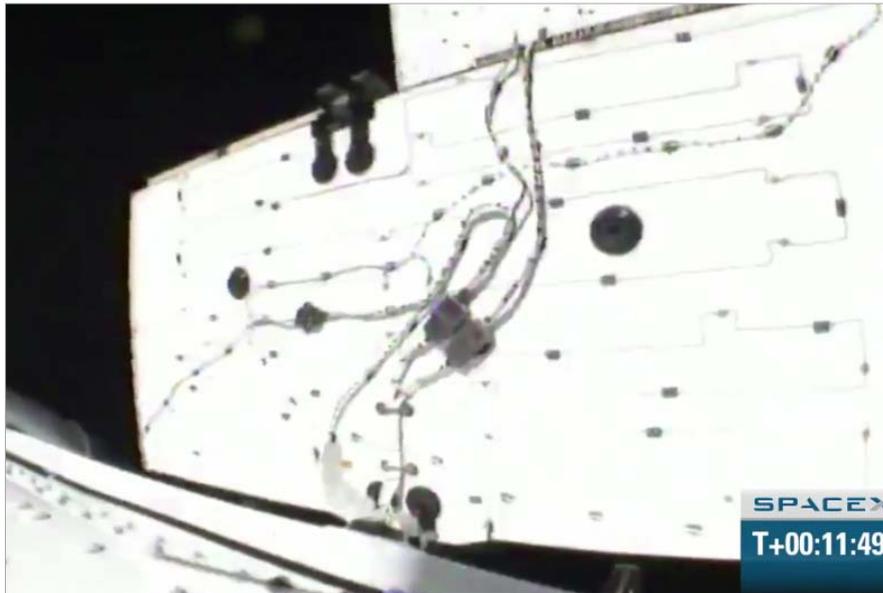
# C2 Fly-By

- **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

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# 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**



Credit: NASA
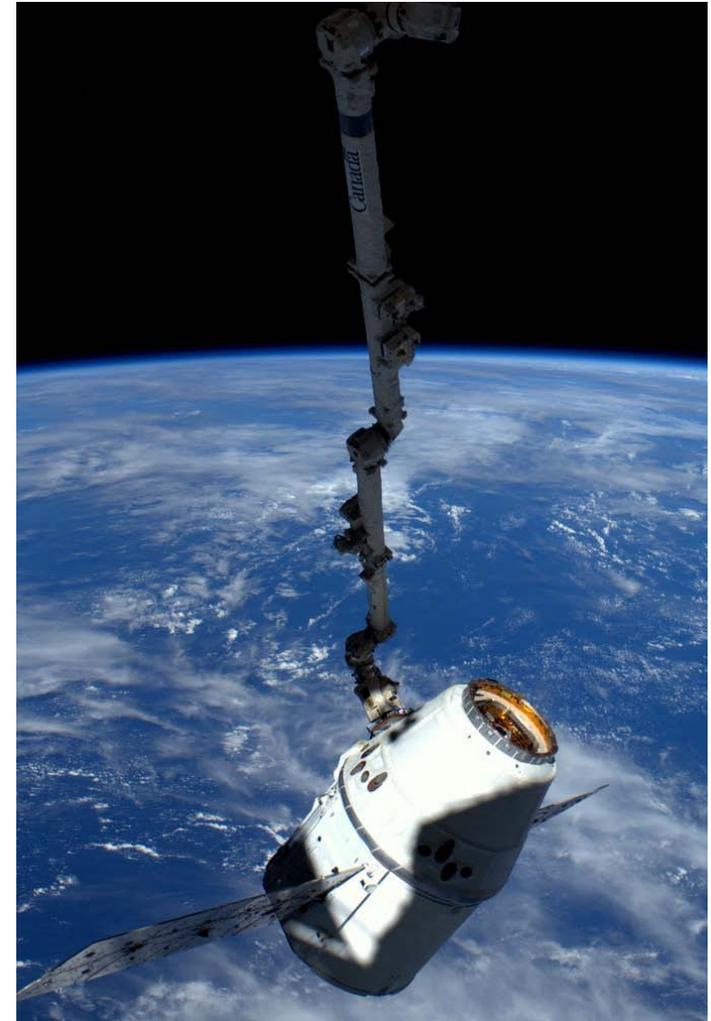


Credit: NASA

# 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**







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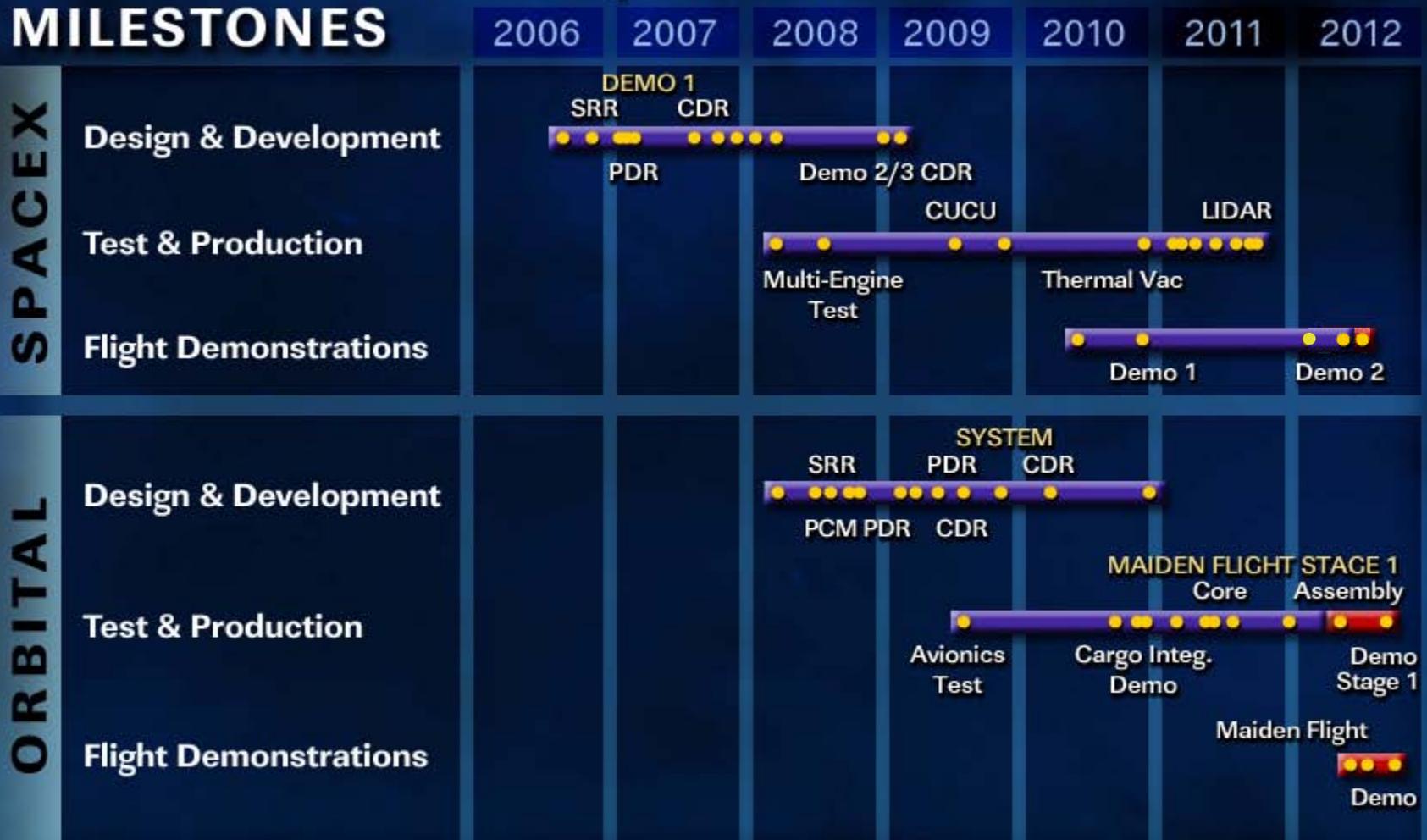# Dragon Structures, Post Flight Observations

- **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**