Commercial Crew Program Status

Phil McAlister
NASA Headquarters
March 2, 2016

Agenda

- Commercial Crew Program (CCP) Highlights
- Milestone Status
- Space Act Agreement Summary
- CCP Top Program Risks
- Boeing Summary
- SpaceX Summary
- Special Topic: CCP Certification
- Summary

Advancing Human Spaceflight

The vision of commercial human spaceflight to low-Earth orbit is a robust, vibrant enterprise with many providers and a wide range of private and public users.
A successful human space transportation system will strengthen the International Space Station Program, allow NASA to focus on deep-space exploration, potentially reduce the cost of human access to space and significantly contribute to the national economy.

CCP Public Purpose

Support the development of non-NASA markets for commercial human transportation services to and from low-Earth orbit.

CCP NASA Purpose

Safe transport of NASA and NASA-sponsored astronauts to and from the station.

Highlights

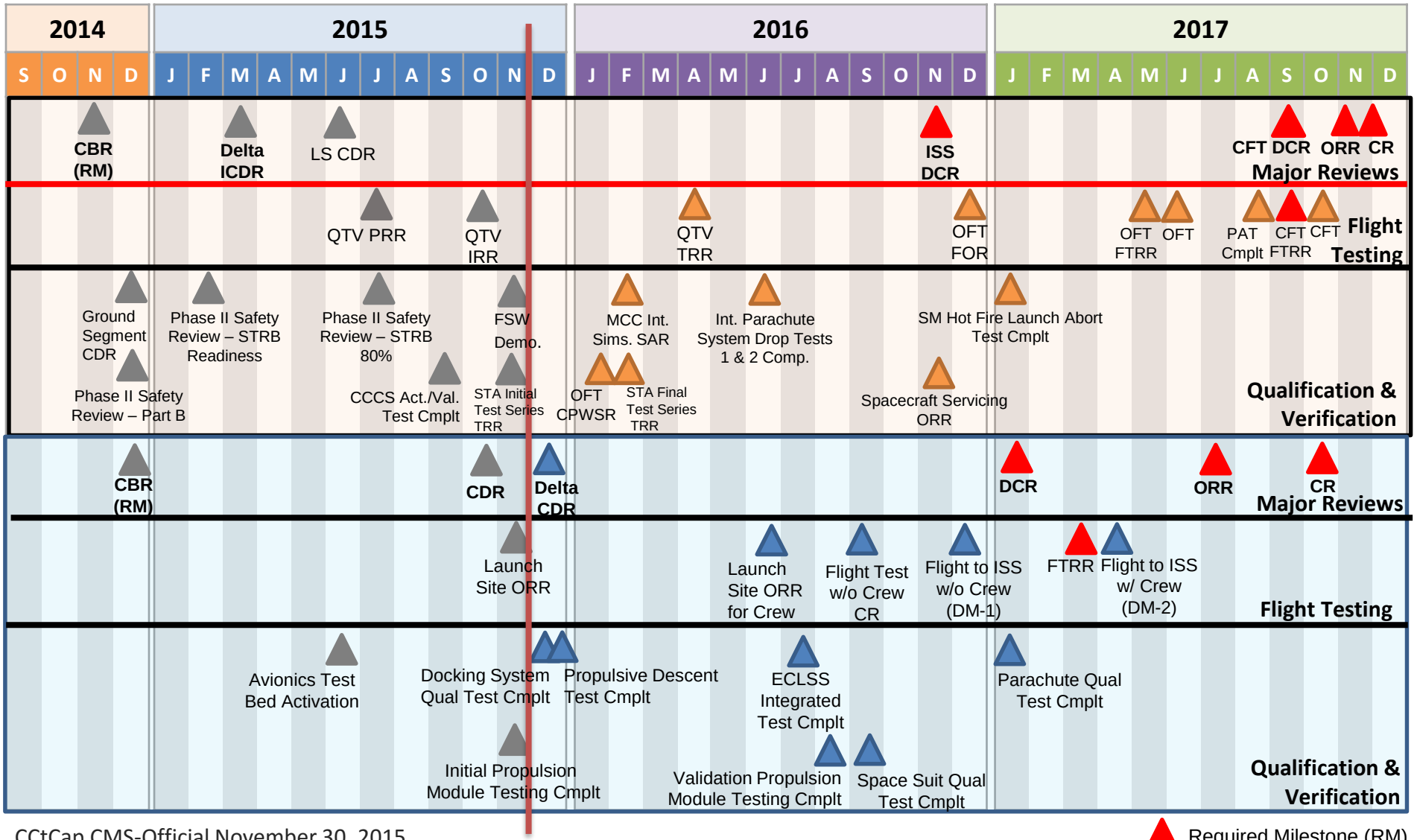
CCP has made significant progress over the last quarter, notably:

- **Continue to burn down key products with the providers**
  - Over 60% of the Alternate Standards have been dispositioned
  - Over 40% of the Variances have been dispositioned

- **Updated NASA Certification Plan and baselined the Certification of Flight Readiness (CoFR) Plan**

- **Awarded Post Certification Missions (PCMs)**
  - For SpaceX:
    - PCM-1 awarded November 2015; Completed one milestone to date
    - PCM-2 award expected in August 2016
  - For Boeing:
    - PCM-1 awarded May 2015; Completed three milestones to date
    - PCM-2 awarded in December 2015; Completed one milestone to date

CCtCap Combined Milestone Summary



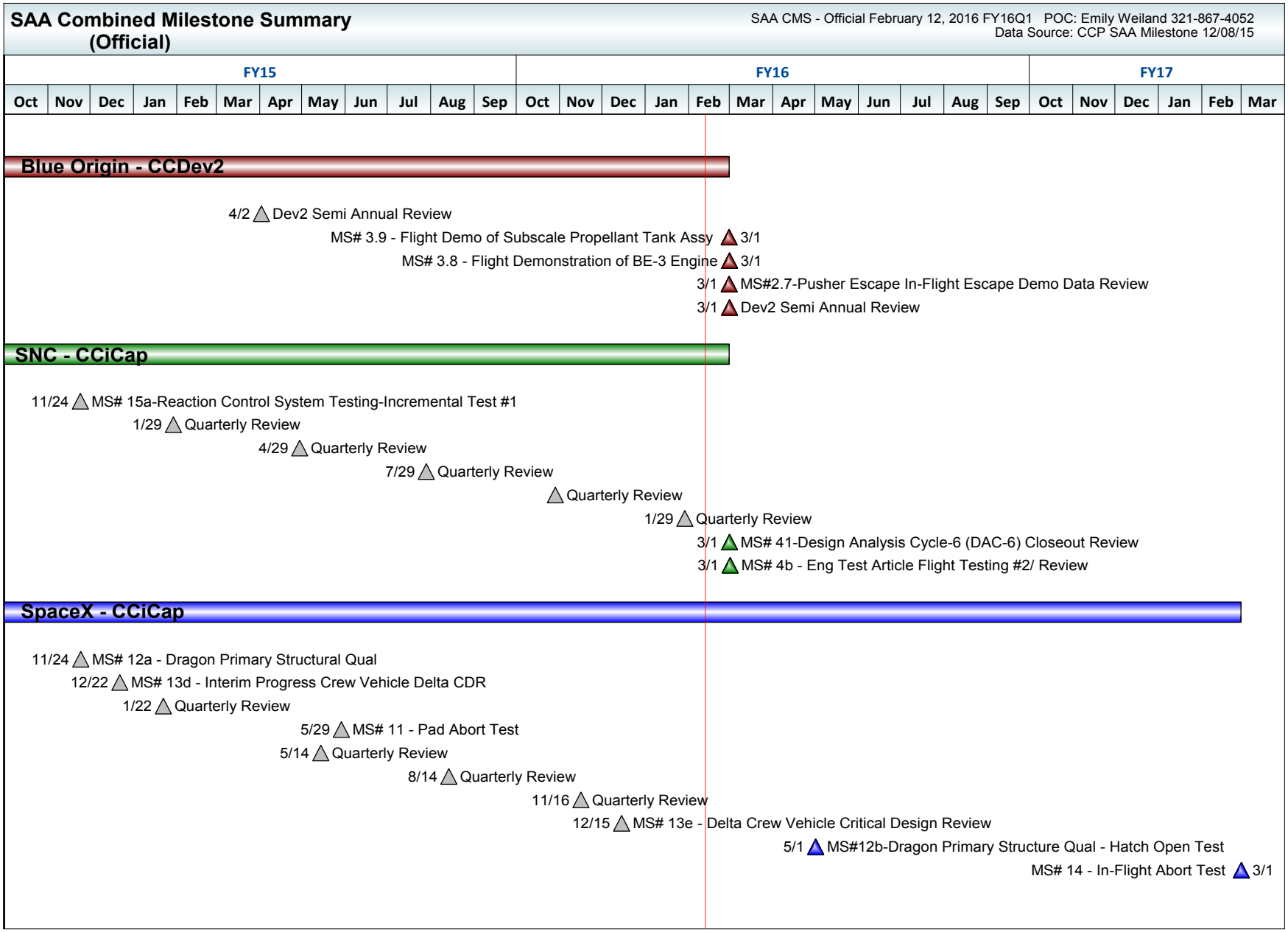
CCtCap CMS-Official November 30, 2015

Required Milestone (RM)

Boeing Milestone

SpaceX Milestone.

SAA Combined Milestone Summary



CCP Top Programmatic Risks 1/26/16

Program Control & Integration (PC&I)

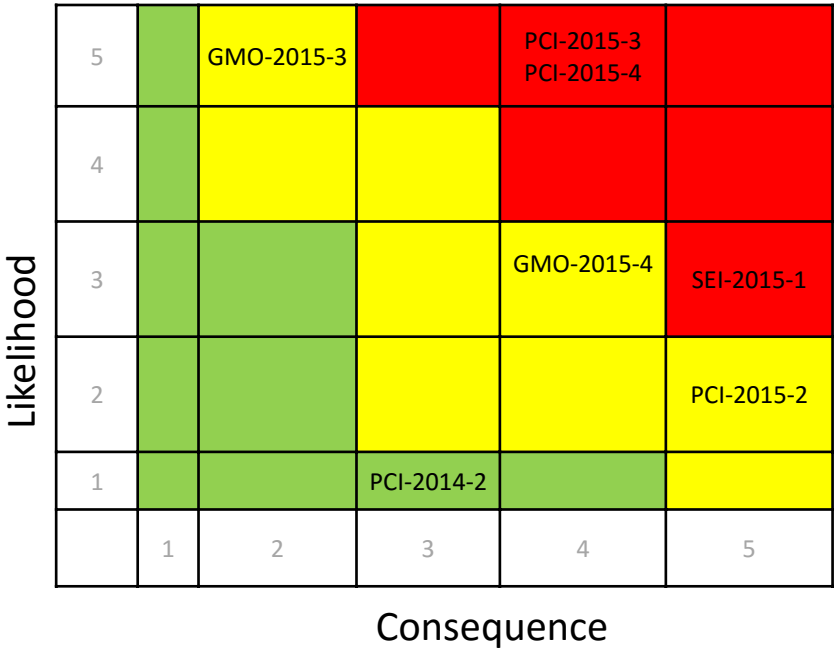
- Requirement Changes (PCI-2015-3)
- Additional Cost for IV&V (PCI-2015-4)
- Budget Uncertainty (PCI-2015-2)
- Maintaining knowledge and continuity with a skilled and stable Civil Service workforce (PCI-2014-2)

Systems Engineering & Integration (SE&I)

- Ability to Close the Loss of Crew Gap (SEI-2015-1)

Ground & Mission Operations (G&MO)

- DoD Search & Rescue Training Schedule (GMO-2015-4)
- Search and Rescue Posture (GMO-2015-3)



Boeing Architecture Description

Spacecraft Segment

Simplicity of design with high maturity through use of existing technologies within Boeing and from our key suppliers such as Aerojet Rocketdyne and General Dynamics

- Crew Module
- Service Module
- Flight Software

Launch Segment

Mature design through use of heritage design, production, and operations from our key supplier ULA

- Launch Vehicle
- Launch Control Complex
- Spacecraft / LV Integration
- Launch Pad
- Pad Test and Checkout
- Emergency Detection System

Ground and Operations Segment

Mature design and processes through use of proven Boeing production techniques

- Cargo Integration
- Landing and Recovery
- Network Services
- Assembly, Integration and Test Facility
- Landing Site Facilities

Mature mission operations through use of heritage mission support from our key supplier JSC/Flight Operations Directorate (FOD)

- Crew Training
- Mission Planning
- Mission Operations
- Mission Control Center
- Training Systems

Boeing Accomplishments

Significant progress made over last quarter:

- Crew Access Tower main column complete
- Crew Access Arm and White Room testing in work
- Passive Thermal and ECLSS CDRs completed
- Solar Array Delta CDR completed
- Structural Test Article production progressing to support testing
- Several component-level development and qualification tests completed
- New flight software released
- Emergency detection system risk reduction test completed
- Service Module hot fire test site in work
- Hardware delivery ramping up
- Alternate standards and variances approved by NASA
- Astronaut and flight crew teams performing mission simulations

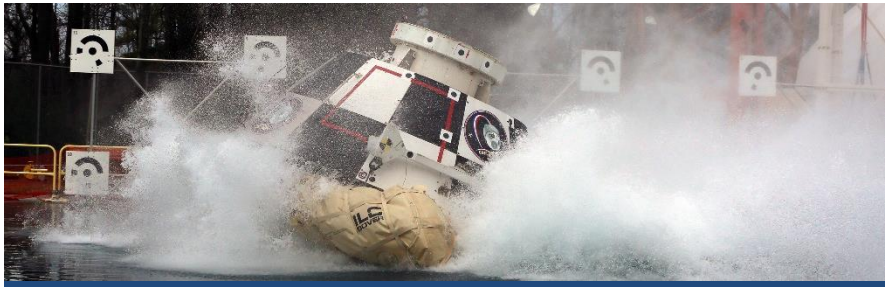
Crew Access Arm and White Room Testing

ECLSS CDR Passed

Crew Simulator Training Ongoing

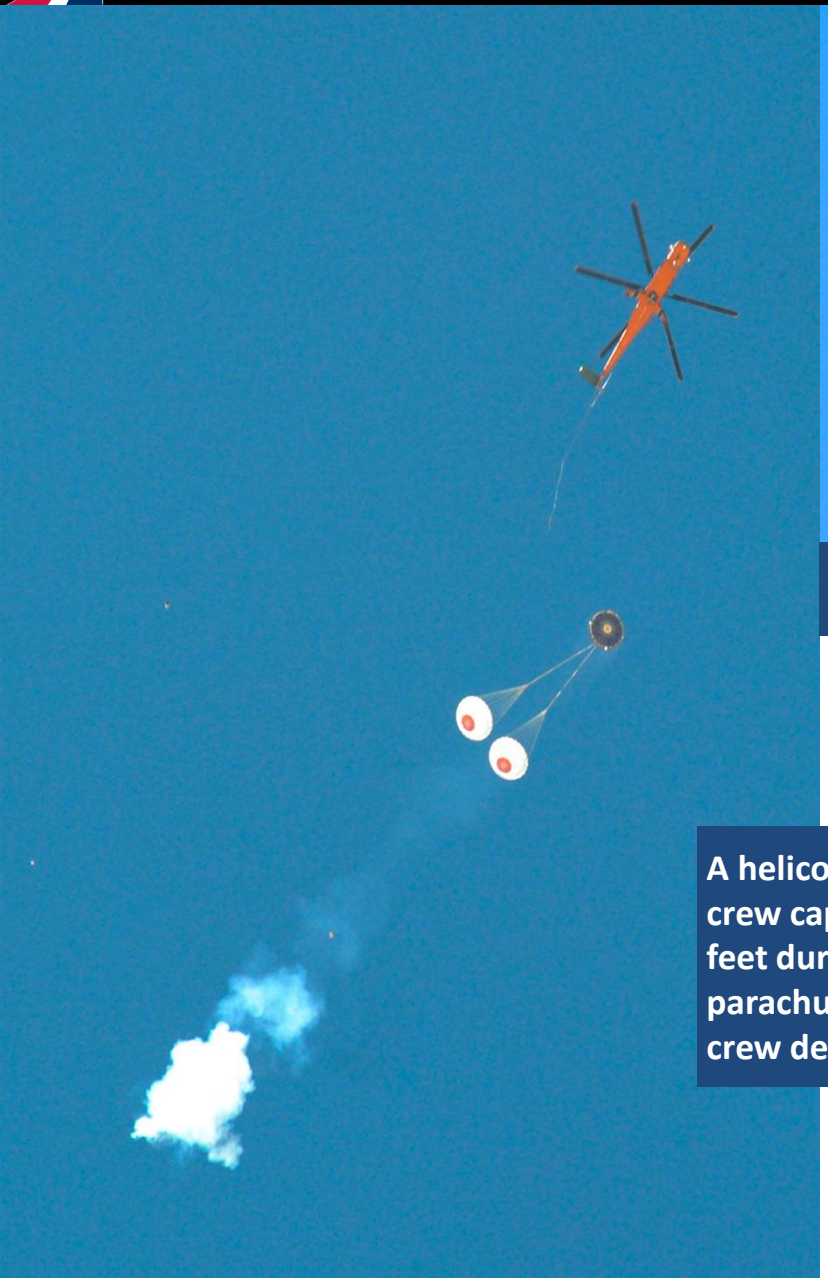
Structural Test Article Production Progressing

Crew Access Tower Main Column Complete

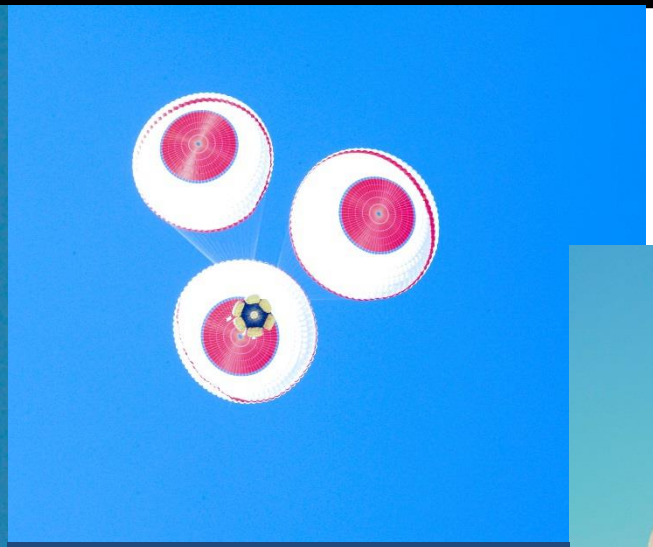


Air Bags Qualification Tested for Emergency Water Landings

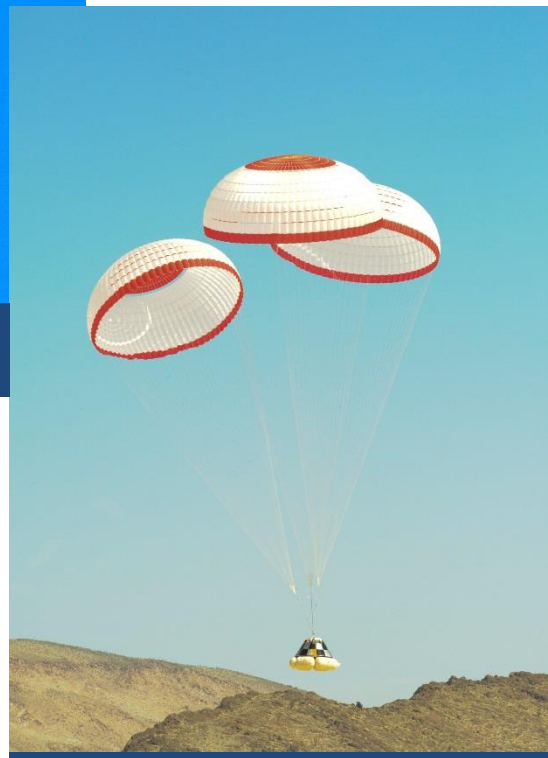
2 May 2012 Helicopter Drop Testing



A helicopter drops Boeing's CST 100 crew capsule from about 10,000 feet during the company's second parachute drop test for commercial crew development activities.



The main parachutes deploy



Boeing's CST 100 crew capsule floats to a landing above the Delmar Dry Lake Bed near Alamo, Nev,.

Image credits: Boeing

SpaceX System Description

- **Spacecraft Segment (Dragon)**
  - Crew Dragon
  - Trunk
  - Launch Abort System (internally integrated in Dragon)
- **Launch Segment (Falcon 9)**
  - Full thrust Merlin engines
  - Densified propellants (chilled LOX & RP-1)
  - Common First stage w/Falcon Heavy design
  - Autonomous Flight Termination System
  - Landing legs (stowed in ascent)
  - Stage separation system
- **Ground and Operation Segment**
  - Launch Operations System
    - Launch Pad (LC39A), Launch Pad facility, Ground SW, & Launch Control Center
  - Mission Operation System
    - MCC (Hawthorne) Crew Ops, Training & Sim, & Recovery

Crew Dragon Vehicle

Falcon 9

Mission Control
Hawthorne, CA

Launch Control
Cape Canaveral, FL

LC-39A
Kennedy Space Center, FL

SpaceX Accomplishments

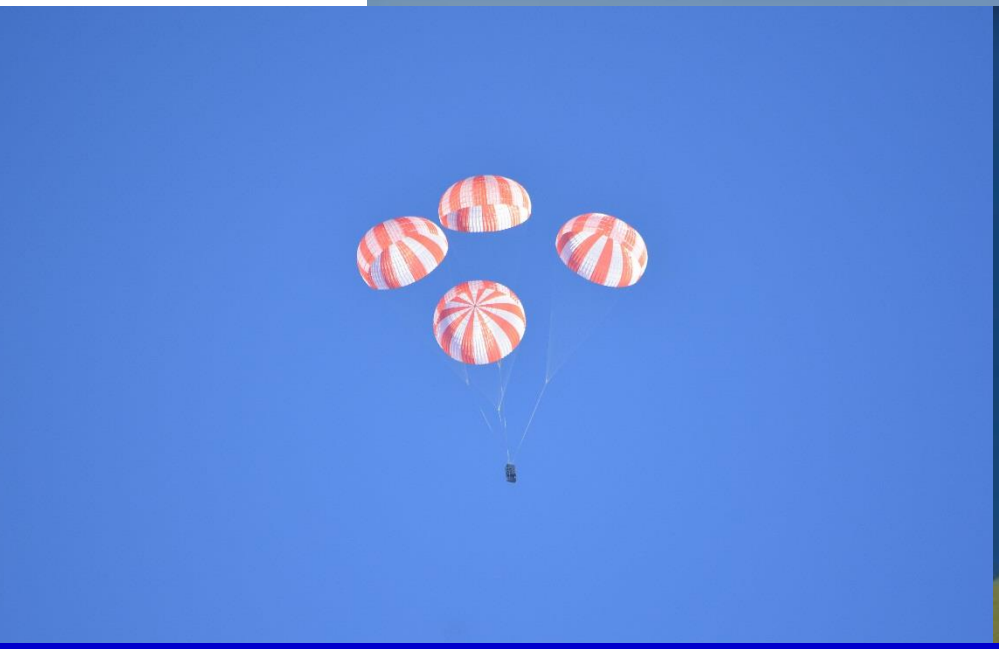
Parachute Mass simulator test

Propulsive landing test

Significant progress made over the last quarter:

- **Completed two Critical Design Reviews**
  - Dragon, F9, ground systems, and operations
  - SpaceX in the process of addressing all NASA comments to satisfaction
- **Propulsion System Testing**
  - Began Initial propulsive landing tests (Pad abort vehicle)
  - Propulsion system testing (SuperDraco Module)
- **Activated 39A launch site**
- **Good progress on space suit and helmet design**
- **Crew Module seats being modified to maximize crew safety**
- **Flew upgraded F9 that will carry crew**
- **Completed first 4-parachute test**
- **Qualification and production on key components**
  - Dragon vehicle structures are in production
  - Conducted Qualification testing of several F9 Systems and development testing of stage separation system to human standards
  - Completed Docking System Qualification
- **Approved alternate standards**
  - Software alternate standard approved
  - Avionics environmental testing alternate standard approved

SpaceX Crew Dragon Parachute Drop Test



January 27, 2016. Parachute drop test for SpaceX crew Dragon involving four red and white parachutes unfurled from a mass simulator high above the desert near Coolidge, Arizona.

Photo Credits SpaceX

NASA CCP Certification

- **CCP Certification/CoFR strives to achieve a balance of insight/oversight appropriate for shared government & industry accountability in establishing a safe, reliable, and cost-effective CTS**
  - The Industry Partner is responsible for the design, development, test and evaluation; culminating in their certification assertion of its CTS to transport crew to and from the ISS.
  - NASA CCP is accountable for **ensuring compliance** to CCP's human spaceflight requirements thru **evaluation and approval** of the Contractor's compliance evidence and execution of **NASA's insight** into the Contractor's solution in accordance with a risk based insight approach implemented under a shared assurance model.

Government / Industry Accountability

Allocation of Responsibilities

Activity	NASA	Industry
Establish Requirements	• Flow down and Tailor Agency Rqmts (Mission Rqmts, HRR, Standards) • Disposition Rqmts Variances	• Flow down of CCP Requirements and Tailoring; • Evaluate Rqmts Achievability
Manage Development Risk	• Development Oversight • Elevate Design and Development Risks from Insight	• Produce Mgmt Plans • Perform Risk Reduction Planning
Establish Cert Baseline	• IV&V • Accept Cert Compliance • Support Joint Test Planning • Accept Residual Risk	• Submit Cert Data Packages • Perform System Validation • Quantify Residual Risk (PSA, Reliability)
Validate Baseline Cert	• Quality Assurance Audits • Accept Problem Resolutions	• Accept Hardware • Problem Identification, Resolution, Corrective Actions
Assess Mission Readiness	• Accept Flight Certification and Residual Risk	• Compliance Evidence of Hardware/Team Readiness

Design Cert

Flight Cert

CTS Certified

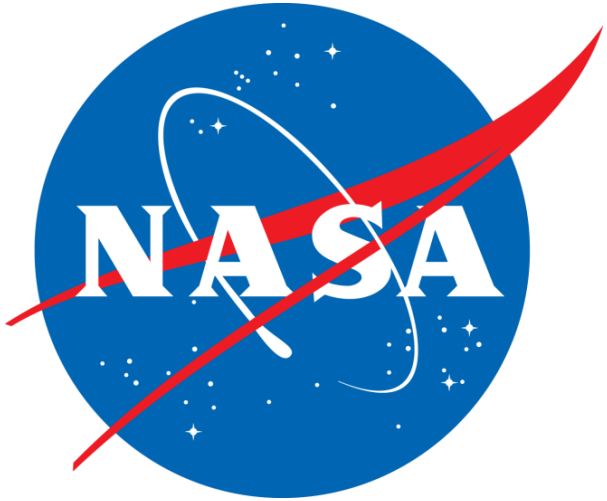
Flight Readiness Certification

By design, the CCP model allocates greater accountability to industry.

Summary

- **Boeing and SpaceX are advancing their design concepts**
  - Actively building and testing hardware to inform design
  - Engaging in meaningful insight with NASA
  - Addressing important design challenges
- **CCP has robust and efficient processes for certification including addressing waivers and deviations**
- **In preparation for flight, there is significant work ahead**





NASA