



Commercial Crew Program Status

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Agenda



- Commercial Crew Program (CCP) Highlights and Progress
- CCP Top Program Risks
- Boeing Summary
- SpaceX Summary
- Sierra Nevada Corp. Summary
- Blue Origin Summary
- Mishap Coordination
- Summary



Highlights



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

- **Continue to burn down key certification products with the providers**
- Over 90% of the alternate standards are completed
- Over 60% of the variances are completed
- Over 60% of the Phase 2 hazard reports are completed

- **Eight CCP missions now in process:**
- For SpaceX:
 - August 2017: Flight to ISS Without Crew (Demo Mission 1)
 - November 2017: Flight to ISS with crew (Demo-2)
 - PCM-1 awarded November 2015; Completed two milestones to date
 - PCM-2 awarded July 2016; Completed one milestone to date
- For Boeing:
 - June 2018: Orbital Flight Test (unmanned demo)
 - August 2018: Crewed Flight Test (demo)
 - PCM-1 awarded May 2015; Completed four milestones to date
 - PCM-2 awarded in December 2015; Completed two milestones to date



Program Progress



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

- **Awarded Post Certification Missions 1 & 2 for both providers**
- Developed procurement strategies for the remaining PCMs
- **Certification and CoFR planning and execution**
- Updated and approved program Certification and CoFR plans
- Developed and gained approval of strategy and Cert CoFR statements through the agency stakeholders
- **Evolved Risk Management process to delineate crew safety risks**
- **Partnered a MOA with four NASA centers for consistent and stable Engineering support**
- **Obtained Government Astronaut legislative change**
- **Started engaging with International Partners**
- **Negotiated spectrum usage with the FCC and DOD**
- **Successfully implemented and completed Cross-Center supervisory pilot program**



CCP Top Programmatic Risks

10/27/16



LxC	Trend	Risk Title	Risk ID Number	Office
4x5	NC	Requirement Changes	CCP-PCI-2015-3	PC&I
5x4	NC	DOD Search and Rescue Posture	CCP-GMO-2015-3	GMO
4x4	NC	Ammonia Emergency Response	CCP-SC-2016-3	SC
3x5	NC	Ability to Close the LOC Gap	CCP-SEI-2015-1	SE&I
3x4	NC	DoD Search and Rescue Training	CCP-GMO-2015-4	GMO
		Schedule		

Likelihood	5				1	
	4				1	1
	3				1	1
	2					
	1					
		1	2		4	5
Consequence						

NOTE: “Programmatic” risks include cost, schedule and technical consequences



CCP Top Program Safety Risks

10/27/27



LxC	Trend	Risk Title	Risk ID Number	Office
3x5	NC	Ability to Close the LOC Gap	CCP-SEI-2015-1	SE&I

Likelihood	5					
	4					
	3					1
	2					
	1					
		1	2		4	5
		Consequence				



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

Ground and Operations Segment

Mature design and processes through use of proven Boeing production techniques

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

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

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



Boeing Accomplishments



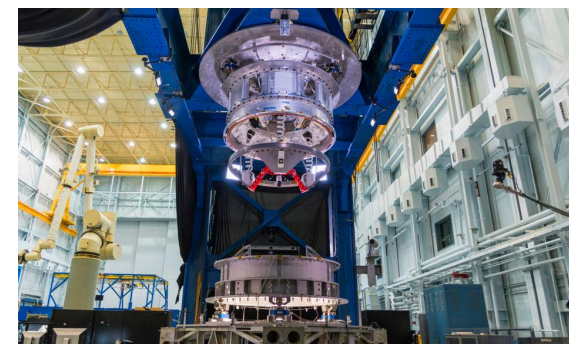
- **Design**
- Heat Exchanger delta CDR complete
- Ascent & Entry Suit CDR: Nov 15

Demonstration & Test

- Wind Tunnel Testing of Launch Vehicle Adapter skirt design tested
- International Docking Adapter and NASA Docking System tested at Johnson Space Center
- Launch Abort Engines with new propellant valves hot-fire development testing complete
- RL10 hot-fire acceptance testing of OFT/CFT engines complete
- Landing airbag qualification testing at Langley Research Center complete
 - Additional tests scheduled to validate crew impacts
- Crew Module propellant tank qualification testing complete
- Arc Jet tests at Ames Research Center



Wind Tunnel Tests



Docking System Tests



Launch Abort Engine Tests



RL10 Acceptance Tests



Landing Airbag Tests



Boeing Accomplishments

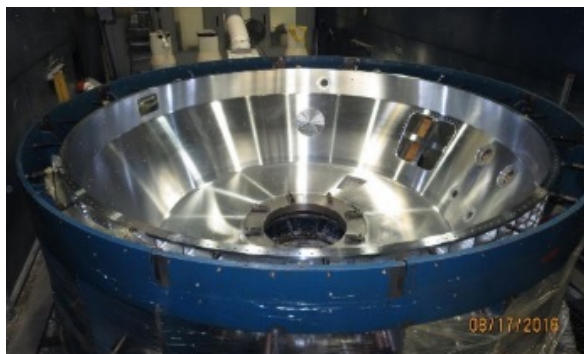


Production & Qualification

- Structural Test Article Crew Module testing targeted to begin in October
- Spacecraft 1 Crew Module upper and lower dome outfitting in work
- Spacecraft 1 Service Module structural panels at Kennedy Space Center
- Service Module Hot Fire test vehicle in production
- Spacecraft 2 and 3 progressing across supply base
- Crew Access Arm and White Room installed on Crew Access Tower at Cape Canaveral Air Force Station's Space Launch Complex-41

Facility Preparations

- Work progressing at White Sands Test Facility
- C3PF Hazardous Processing Facility build in work





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



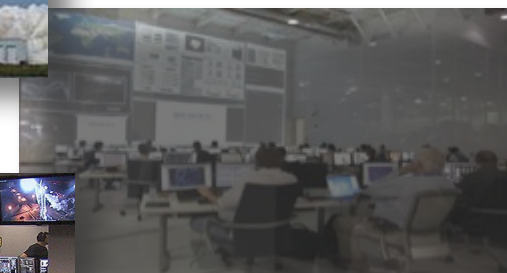
Falcon 9



Launch Control
Cape Canaveral, FL



Crew Dragon Vehicle



Mission Control
Hawthorne, CA



LC-39A
Kennedy Space Center, FL



SpaceX Accomplishments



Certification Products

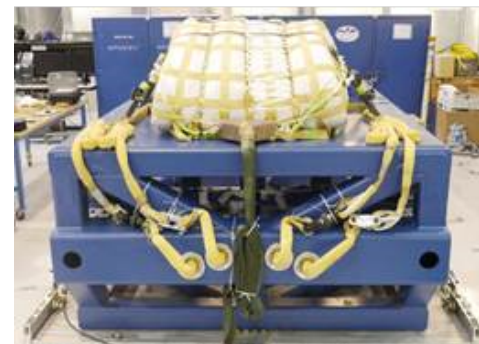
- Certification plan approved
- Alternate standards nearly 100% complete
- Verification Events closures in work
- Hazard analysis proceeding and on track for 100% delivery this quarter

Design

- Completed Delta Critical Design 2
- Drawing released for qualification space suit; suit is currently in test
- Dragon and Falcon 9 designs baselined and under formal change control
- LC-39A crew interface designs and demonstrations are on track for Launch Site Operational Readiness Review

Demonstration & Test

- Completed test series with initial Dragon propulsion test module
- Completed 6 full thrust F9 flights with load & go operations with densified propellants
- Completed 4 key parachute drop tests and on track to complete full test series
- Multiple Space Suite test units complete and on track for full qualification
- Multiple Environmental Control and Life Support System (ECLSS) test units complete and on track for full integrated test
- Qualification capsule first round structural testing complete and ongoing qualification on track
- Completed multiple propulsive landing tests



Parachute Test Weight Sled



Hardware In The Loop
Avionics Test Bed



Parachute Testing



SpaceX Accomplishments

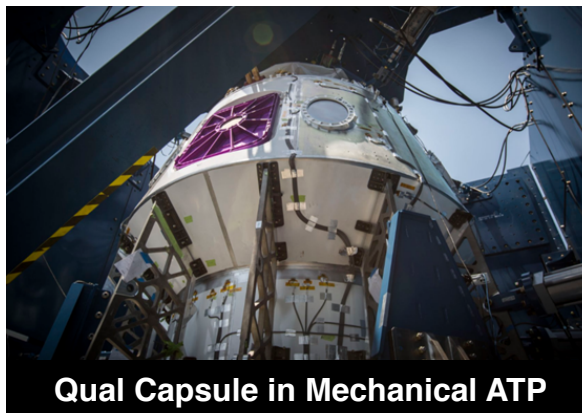


Production and Integration

- 4 Crew Dragon capsules in parallel production
- Qual test capsule weldment fabrication complete; outfitting for upcoming qual tests
- ECLSS test capsule weldment complete; multiple ECLSS components complete & installed
- Demo 1 capsule weldment complete; capsule in next stage of production
- Demo 2 capsule weldment in work
- Multiple components across Dragon, F9, and updated ground systems completed or entering into qualification phase and on track for implementation



LC-39A Hanger and activation



Qual Capsule in Mechanical ATP



Propulsive Landing Testing



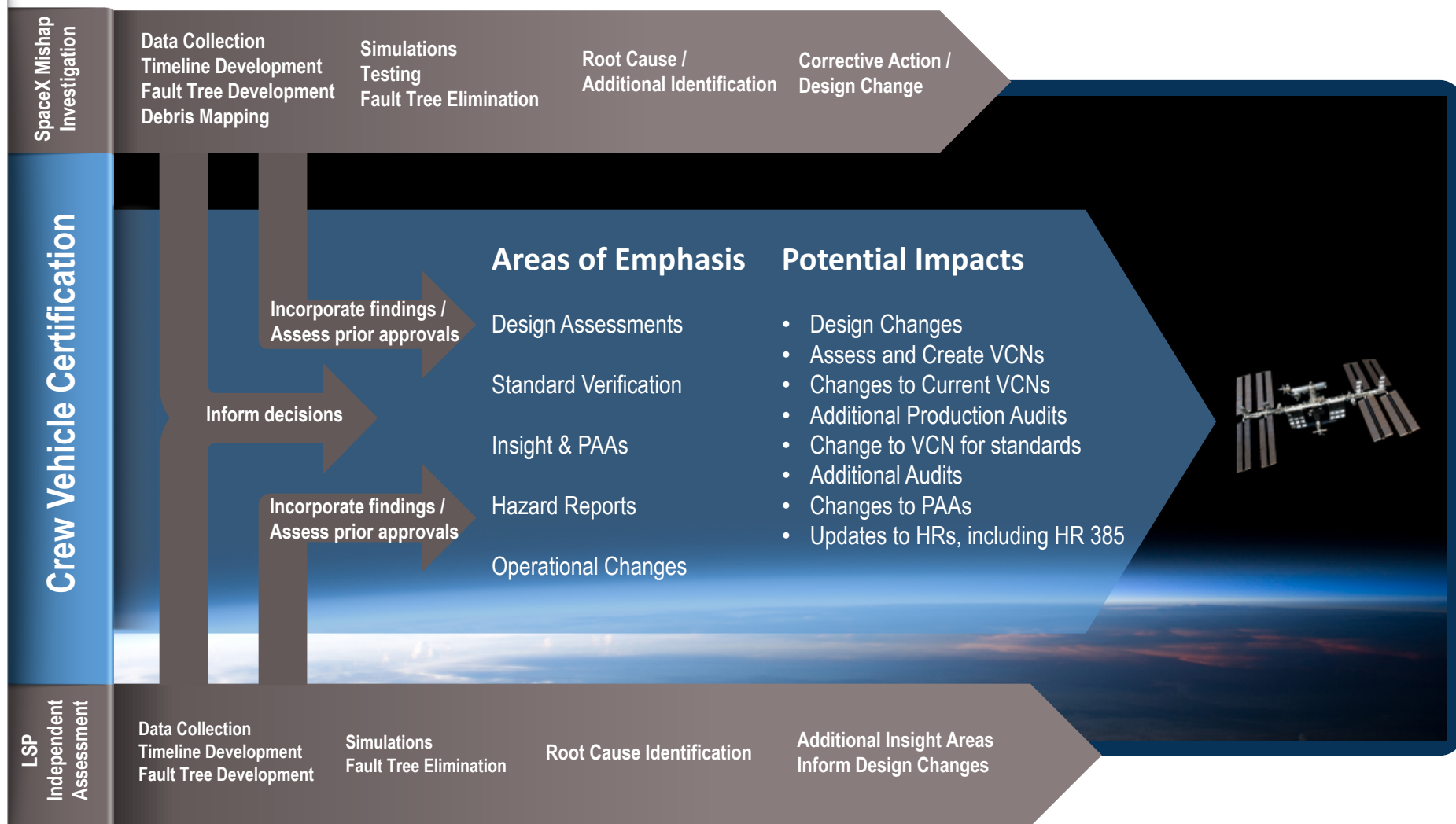
IDA Delivery



Radial Bulkheads



SpaceX Mishap Coordination





Sierra Nevada Corp. Accomplishments



Approach & Landing Test 2 (ALT-2) is CCIcap Milestone 4B and CRS2 Integration Milestone 5

- Full scale *Dream Chaser*® engineering test article (ETA) unpowered approach & landing test (ALT-2)
 - Ship to AFRC Q1 2017 for Range and Taxi Testing then Approach & Landing Test 2
 - Primary Objectives:
 - Collect subsonic aerodynamic data to validate wind tunnel and CFD aero results
 - Validation of spacecraft low-speed aerodynamic flying qualities – stability and control
 - Validate subsonic orbital vehicle flight software and GN&C functionality.



Key Dream Chaser test vehicle Activities, Q3-Q4 2016

- Successfully executed a large number of offline, on-vehicle and integrated tests in Louisville, CO facility to verify system design requirements and validate system function.
- Landing Gear tests identified nose/main landing gear (NLG/MLG) deploy sequence issue
- Remaining work planned in Colorado before Jan 2017 ship to AFRC/EAFB
 - Complete Landing Gear hydraulic system modifications and acceptance testing
 - Avionics Checkout with Flight Fault Tolerant Flight Computers using Flight Software ver. 3.0 (flight load)
 - Polarity Test, Multi-Actuator Test, pre-Ship Day-In-The-Life Test, Radar Altimeter installs, Flush Air Data System Checkout, Rollout Ground Resonance Test
 - Prep ETA for ship before Christmas, Ship to AFRC/EAFB 1st week January 2017



Execute Free Flight Test (ALT2) March 2017, complete milestone NLT Aug 2017 (current CCIcap 5-year period of performance).





Blue Origin Accomplishments



No Exchange of Funds Space Act Agreement

- Accomplishments
 - Held multiple TIMs
 - Astronaut Seat Design
 - Flame Diverters
 - Corrosion Control
 - Enterprise Software
 - NASA leadership invited to witness in-flight escape test
- Data Exchange
 - Various software requests and technical documentation exchange in work.
 - Manufacturing consulting request
- Look Ahead
 - Milestone Review #2, Progress Review of *New Shepard* Subscale Propellant Tank, scheduled for November 7 at Blue Origin's Kent, Washington facility
 - Continuing technical interchange



New Shepard in-flight escape test (October 5, 2016)



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

Both providers are providing increased insight opportunities for the NASA team

CCP has robust and efficient processes for certification including addressing waivers and deviations

In preparation for flight, there is significant work ahead

