Commercial Crew Program (CCP)
NAC HEOMD Committee Status

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Purpose & Agenda

- **Purpose: To brief the NASA Advisory Council HEOMD Subcommittee on the latest status and technical progress for the CCP CCtCap and CCiCap contracts**
- **Agenda:**
  - **CCP Execution Status**
    - Program Progress
    - Milestone Summary
    - Top Risks
  - **CCtCap Status**
    - Boeing Commercial Provider Status
    - SpaceX Commercial Provider Status
  - **CCiCap Status**
    - Blue Origin Status
    - Sierra Nevada Status
  - **Summary**

Program Progress

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

- **Program's Annual Review is complete**
  - Significant technical issues resolution and risk mitigations continue as CCP progresses toward flight tests and crewed missions to the International Space Station
  - Awarded Post Certification Missions (PCMs) 3-6 to both Providers
  - Multiple spacecraft and qualification test articles are in production and testing simultaneously
- **Mission planning and preparations for eight CCP missions are in work:**
  - Official Dates For Boeing:
    - August 2018: Orbital Flight Test (unmanned demo)
    - November 2018: Crewed Flight Test (demo)
    - PCM-1 awarded May 2015; Completed four milestones to date
    - PCM-2 awarded in December 2015; Completed four milestones to date
  - Official Dates For SpaceX:
    - April 2018: Flight to ISS without crew (Demo Mission 1)
    - August 2018: Flight to ISS with crew (Demo Mission 2)
    - PCM-1 awarded November 2015; Completed three milestones to date
    - PCM-2 awarded July 2016; Completed two milestones to date

Program Progress Continued

- **Both providers are making tangible progress toward flight tests and crewed missions to the International Space Station**
- **Space hardware manufacturing, testing and qualification are underway**
- **Continued engagement as the providers perform critical test and verification events**
- **Continue to make progress in the burn down of key certification products with the providers**
  - Progress for each provider is included in provider-specific sections of this briefing

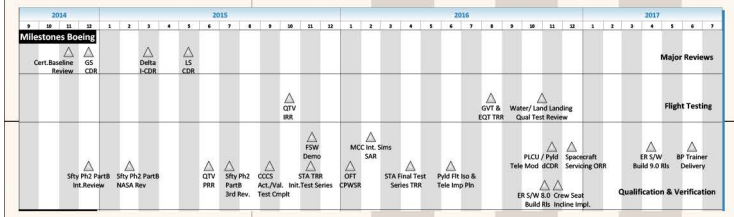
Commercial Crew & Cargo Processing Facility

Horizontal Integration Facility

CCtCap Combined Milestone Summary Official – FY17Q3

Sep'17 | Oct'17 | Nov'17 | Dec'17 | Jan'18 | Feb'18 | Mar'18 | Apr'18 | May'18 | Jun'18 | Jul'18 | Aug'18 | Sep'18 | Oct'18 | Nov'18 | Dec'18 | Jan'19 | Feb'19 | Mar'19

Milestones Boeing

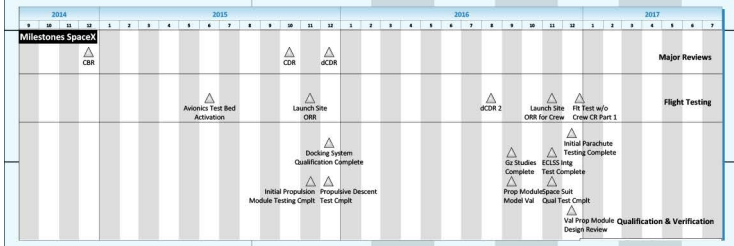


ISS DCR | CFT DCR | ORR | CR — Major Reviews

OFT FOR | OFT FTRR | OFT Launch | CFT FTRR | CFT Launch — Flight Testing

Int. Parachute Sys Drop Tests 1 & 2 Comp. | Crew Seat Incline Cmplt | PAD Abort Test Cmplt | PLCU Mod Install RR | AER Rack Design Review | SM Hot Fire Launch Abort Test Compl. | AER Stowage Rack Ready — Qualification & Verification

Milestones SpaceX



DCR | ORR | CR — Major Reviews

Flt Test w/o Crew CR Part 2 | Flight to ISS w/o Crew (Demo-1) | FTRR | Flight to ISS w/ Crew (Demo-2) — Flight Testing

Demo-1 Dragon Integr. ChkPt | Demo-1&2 Dragon Int. ChkPt | Intg.Sys.Review | Cert. ChkPt | Merlin Engine Qual CkPt | Validation Prop Module Testing Cmplt | Ph 2 Haz Rpt ChkPt | Parachute Qual Part1 | Parachute Qual Complete — Qualification & Verification

Required Milestone | Boeing Milestone | SpaceX Milestone

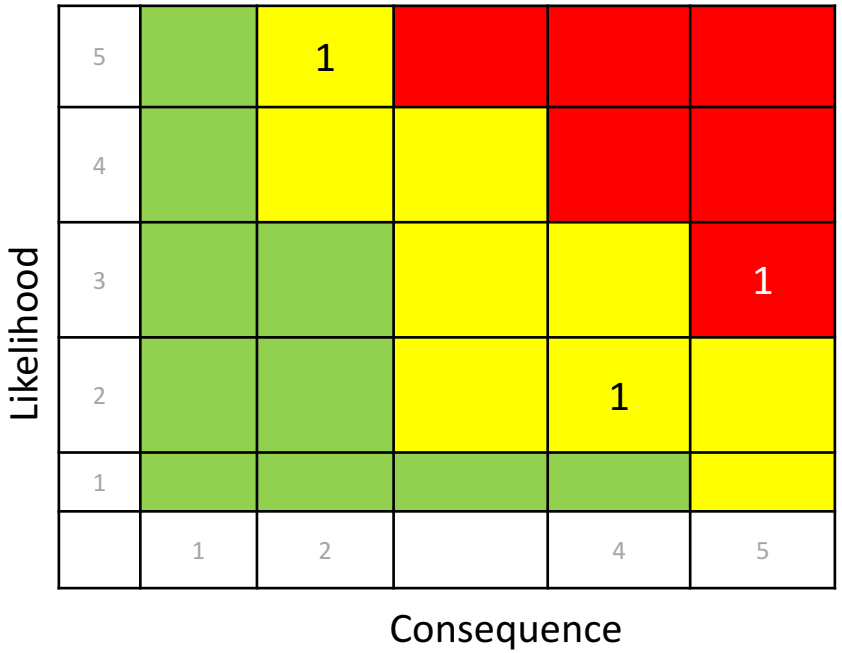
CCtCapCMS - Sep 1,2017
Data Source: Boeing FY17Q3 / SpaceX FY17Q3
POC: Debbie Cole, 321-867-0834

CCP Top Programmatic Risks 11/7/2017

Programmatic Risk = Likelihood x (Highest of Non Safety Consequences (C, S, P))

LxC	Trend	Risk Title	Risk ID Number	Office
3x5	NC	Inability to Meet LOC	CCP-SEI-2015-1	SE&I
5x2	New	Cost of Government Provided Services (ISS CR-15654)	CCP-GMO-2017-1	GMO
2x4	NC	DoD Search and Rescue Training Schedule	CCP-GMO-2015-4	GMO

Trend Key: NC = No Change, I = Increase in Risk, D = Decrease in Risk

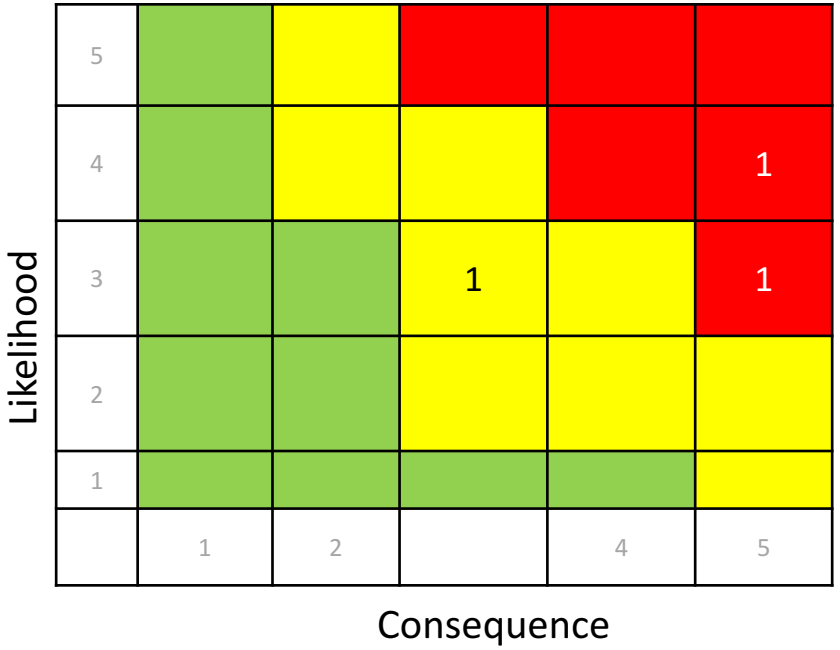


CCP Top Program Safety Risks 11/7/2017

Safety Risk = Safety Likelihood x (Highest of Safety Consequences (Sp, Sf, Se))

LxC	Trend	Risk Title	Risk ID Number	Office
4x5	NC	Inability to meet LOC	CCP-SEI-2015-1	SE&I
3x5	NC	Aborting into Sea States with Unsafe Rescue	CCP-GMO-2016-3	GMO
3x3	NC	Crew Entry Accelerations and Spaceflight Associated Neuro-ocular Syndrome (SANS) Exacerbations	CCP-IP-2016-3	IP

Trend Key: NC = No Change, I = Increase in Risk, D = Decrease in Risk



Boeing Commercial Provider Status

Boeing Accomplishments

- **Design, Demonstration, Test, and Evaluation**
  - Nine Land Landing Qualification Tests completed as of 9/28 (14 planned)
  - Parachute System Qualification Test #2 completed in October
  - Completed a joint orbital flight test, rendezvous and docking paper simulation with the ISS
  - Structural Test Article (STA) initial Shock Testing complete
    - Modal Testing completed in September
    - Launch Vehicle Adapter aeroskirt shipped to Huntington Beach to support future Jettison and Separation tests
  - Completed a crew emergency egress system demonstration
  - WSTF hot fire testing
    - First LAE acceptance hot fire test completed with pathfinder engine
      - LAE test sequence of shipsets (CFT, PCM's) and SMHF qual testing in work
    - Service Module Hot Fire test article shipped to WSTF
      - Cold flow testing in work
  - ISS DCR planning and execution continues
    - ULA Phase III progressing with first STRB completed in October
    - Partnered Spacecraft Phase III ground-rules with ISS and Boeing

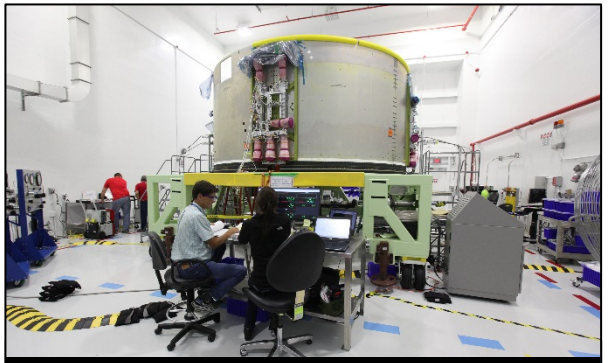
Land Landing Qualification Test

LC-41 Emergency Egress

STA in Modal Test Config

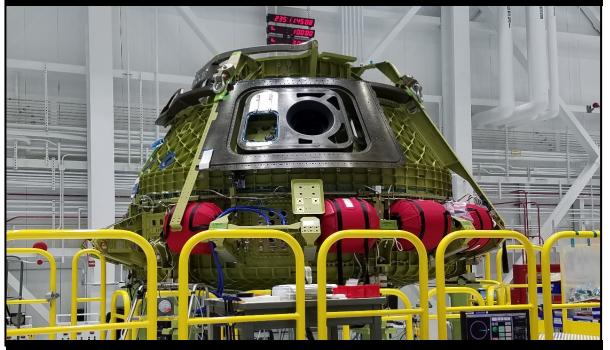
Boeing Accomplishments

- **Production & Operations**
  - Flight unit assembly on several key spacecraft structures and mechanisms
    - Service Module Hot Fire (SMHF) Test Article systems acceptance test complete
    - Spacecraft 1 (SC1) crew module upper and lower domes mated
      - Landing airbags integrated onto SC1 lower dome
      - Landing and Recovery System (LRS) pressure tank installation and leak tests complete
      - Pressure Control System (PCS) proof pressure test complete
    - Pad Abort Service Module 1 (SM1) Strong backs, bridge beams, isogrid panels, and radiator panels installed
    - Spacecraft 2 (SC2) upper dome bucket handle installed and IVA hatch installation in work to support proof pressure test
    - Spacecraft 3 (SC3) A-Frames installed on lower dome
    - ISS delivered 2 NDS flight units to Boeing
  - Atlas AV-080 OFT Launch Vehicle
    - Dual Engine Centaur (DEC) tank in high pressure test cell Booster RP-1 tank weld completed, in hydrostatic test
    - Booster LOX tank upper barrel in friction stir weld; lower barrel weld and x-ray complete
  - Operations training preparations
    - Boilerplate-3 delivered to NASA for future water rescue training
    - Crew training plan delivered, NASA review in work



Service Module Hot Fire Test Article

Spacecraft 1 Assembly



Spacecraft 1 Crew Module

SpaceX Commercial Provider Status

SpaceX Accomplishments

- **Design, Demonstration, Test, & Evaluation**
  - Dragon
    - Demo-1 capsule integration mate complete
    - Qualification module structural testing complete
    - Demo-1 schedule efficiencies implemented
    - Continuing maturation of displays & controls, crew interfaces and operations; began joint sims and training
    - Completed initial Dragon to C2V2 RF Interface Test (Joint Test 9a) with ISS
    - 8 parachute drop tests held to date
    - Validation propulsion module buildup and test facility upgrades in work
    - 2 Hardware-in-the-Loop (HITL) tables assembled in support of software testing
  - Falcon9
    - Merlin 1D and MVAC in qualification testing
    - Performing Block 5 CDR reviews
    - Continuing COPV 2.0 development and beginning qualification
  - Ground Systems (LC-39A)
    - Lightning tower upgrades complete
    - Crew access arm and white room installation planned for upcoming months
  - Certification Products
    - (30) VCNs have been approved:
      - (25) for SSP 50808 and (5) for CCP 1130

Parachute Test

Hardware-in-the-Loop Table

Merlin 1D Full Thrust Testing

SpaceX Accomplishments

- **Production & Operations**
  - Flight unit assembly on several key spacecraft structures and mechanisms
    - 3 Dragon Crew Modules in production:
      - Demo-1 service section integration complete and Demo-1 Avionics rack assembled
      - Demo-2 mechanical integration nearing completion
      - Crew-1 (PCM 1) weldment seeing significant progress
    - Demo-1, Demo-2 and IFAT trunks in production
  - Operations Training
    - Uncrewed
      - Completed first Demo-1 simulation
      - Launch operations continuing from LC-39A
    - Crewed
      - Supported Dragon Rescue Trainer DET-3 training
      - Buck mechanical assembly complete including all cabin panels, storage bins and seats


Dragon 2 Capsule


Rescue Trainer


Demo 2 Trunk


Crew 1 Weldment

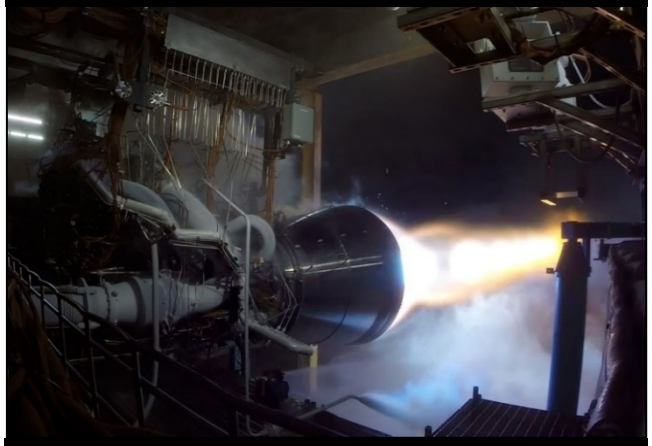

Cabin Mock Up

Blue Origin Accomplishments

Commercial Space Capabilities Collaboration (CSCC)
Space Act Agreement (SAA)

- **Technical Exchanges**
  - Launch Vehicle Structures and Materials
  - Reentry Aeroheating
  - Effects of Lightning on Launch Vehicle
  - Doppler Radar
  - Structural Loads
  - Milestone #4: November 2017
    - Progress Review of Rocket Propulsion Systems (Blue Origin Facility)
- **Data Exchange**
  - Various software requests and technical documentation exchanges in work
- **Look Ahead**
  - Milestone #5, May 2018
    - Development Update of Launch Site
  - Continued Technical and Data Exchange

BE-3 in Test Stand



BE-4 Test Fire

Sierra Nevada Corp. Accomplishments

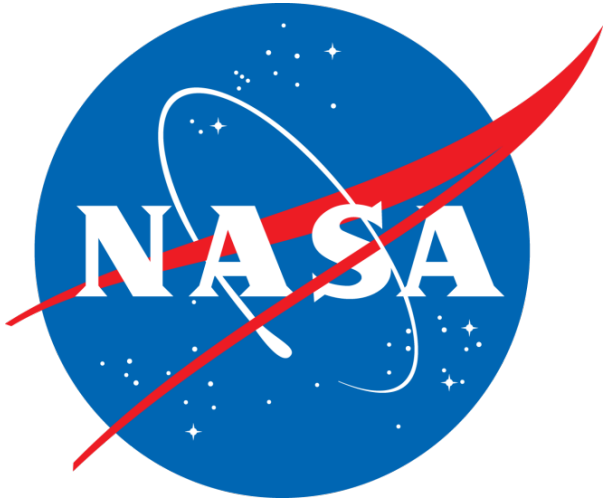
- **Successfully performed Full scale Dream Chaser engineering test article (ETA) unpowered approach & landing test (ALT-2) at Armstrong Flight Research Center - Edwards Air Force Base on 11 Nov. 2017**
  - ALT-2 Free-flight including detailed flight maneuvers was nominal
  - ETA landing and rollout were successful
  - SNC Post-flight data analysis is currently underway
  - CCiCap SAA Milestone 4b NASA outbrief scheduled for Dec. 2017
  - Several integrated tests performed to verify system design requirements and validate system functions in preparation for ALT-2 test
    - Day In The Life Test (final) – Aug. 2017
    - Combined Systems Test (final) – Aug. 2017
    - Captive Carry Test #1 & #2 – Aug./Sept. 2017

Dream Chaser ETA

CCP Summary

- **CCP continues to facilitate the development and certification of U.S. industry-based crew transportation systems**
- **Boeing and SpaceX are meeting contractual milestones and maturing their designs**
  - A significant amount of hardware is in development, test and qualification in preparation for upcoming missions
  - Risks are being identified and important design challenges are being addressed
  - NASA is engaged in meaningful insight
- **Both providers are making tangible progress toward flight tests and crewed missions to the International Space Station**
- **CCP has robust and efficient processes for certification including addressing waivers and deviations**
  - Progress is being made in the burn down of key certification products with the providers
- **In preparation for flight, there is significant work ahead**


NASA


NASA

Acronyms & Abbreviations

- ALT: Approach & Landing Test
- AoA: Angle of Attack
- ATCS: Active Thermal Control Subsystem
- BP: Boilerplate
- Calysto: Risk Management tool
- C3PF:Commercial Crew and Cargo Processing Facility
- CCiCap: Commercial Crew integrated Capability
- CCtCap: Commercial Crew transportation Capability
- CDR: Critical Design Review
- CFA: Computational Fluid Analysis
- CFT: Crewed Flight Test
- CM: Crew Module
- COPV: Composite Overwrap Pressure Vessel
- CPWSR: Configuration Performance & Weight Status Report
- CSCS: Contingency Spacecraft Crew Support?
- CTS: Crew Transportation System
- DCR: Design Certification Review
- DDT&E: Design, Development, Test & Evaluation
- Det3: (USAF) Detachment 3
- DM: Demonstration Mission
- ECLSS: Environmental Control and Life Support System
- ECM: Electro-Chemical Machining
- EDM: Electron Discharge Machining
- EDS: Emergency Detection System
- ETA: Engineering Test Article
- FHS: Forward Heat Shield
- FLT: Flight
- FOD: Flight Operations Directorate
- FTCR: Flight Test Certification Review
- GMO: Ground & Mission Operations
- HAR: Hazard Analysis Report
- HITL: Human in the Loop
- HR: Hazard Report
- HRCP: Human Rating Certification Package
- IDA: International Docking Adapter
- IFA: In-Flight Abort
- IV&V: Independent Verification & Validation
- JIRA: Project management software tool
- JPRCB: Joint Program Requirements Control Board
- JT: Joint Test
- LAE: Launch Abort Engine
- LLQTL Land Landing Qualification Test
- LOC: Loss of Crew
- LOM: Loss of Mission
- LSC: Linear Shaped Charge
- LSORR: Launch Site Operational Readiness Review
- LV: Launch Vehicle
- LVA: Launch Vehicle Adapter
- MIR: Mission Integration Review
- MMOD: Micrometeoroid and Orbital Debris
- MVac: Merlin Vacuum Engine
- NDS: NASA Docking System
- NBL: Neutral Buoyancy Lab
- NESC: NASA Engineering & Safety Center
- NLA: Non-Linear Aero
- OFT: Orbital Flight Test
- OMAC: Orbital Maneuvering and Attitude Control
- OML: Outer Mold Line
- ORDEM: Orbital Debris Engineering Model
- ORR: Operational Readiness Review
- PAA: Product Assurance Analysis
- PAFB: Patrick Air Force Base
- PAT: Pad Abort Test
- PC&I: Program Control & Integration
- PCB: Program Control Board
- PCDTV: Parachute Compartment Drop Test Vehicle
- PCM: Post Certification Mission
- PDR: Preliminary Design Review
- PnP: Probability of No Penetration
- PSA: Probabilistic Safety Analysis
- PJ: Para Jumpers
- RCS: Reaction Control System
- RT: Rescue Trainer
- SC: Spacecraft
- SE&I: Systems Engineering & Integration
- SM: Service Module
- SOW: Statement of Work
- STA: Structural Test Article
- STRB: Safety Technical Review Board
- SureSep: LVA Jettison System
- TIM: Technical Interchange Meeting
- TM3: Targeted Mass 3
- TPS: Thermal Protection System
- TTP: Tactics, Techniques, & Procedures
- TRR: Test Readiness Review
- UDA: Universal Docking Adapter
- ULA: United Launch Alliance
- USAF: US Air Force
- VBR: Vehicle Baseline Review
- VCN: Verification Closure Notice
- VE: Verification Event
- VIIP: Vision Impairment/Intracranial Pressure
- WSTF: White Sands Test Facility
- WTT: Wind Tunnel Testing