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National Aeronautics and
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COMMERCIAL CREW





Agenda



- **Commercial Crew Program (CCP) Status**
 - Program Progress
 - Timeline to the International Space Station
- **Boeing Test Flight Status**
- **SpaceX Test Flight Status**
- **Space Act Agreement Status**
 - Blue Origin
 - Sierra Nevada Corporation
- **Enabling Commercial Space**
- **Summary**



Program Progress

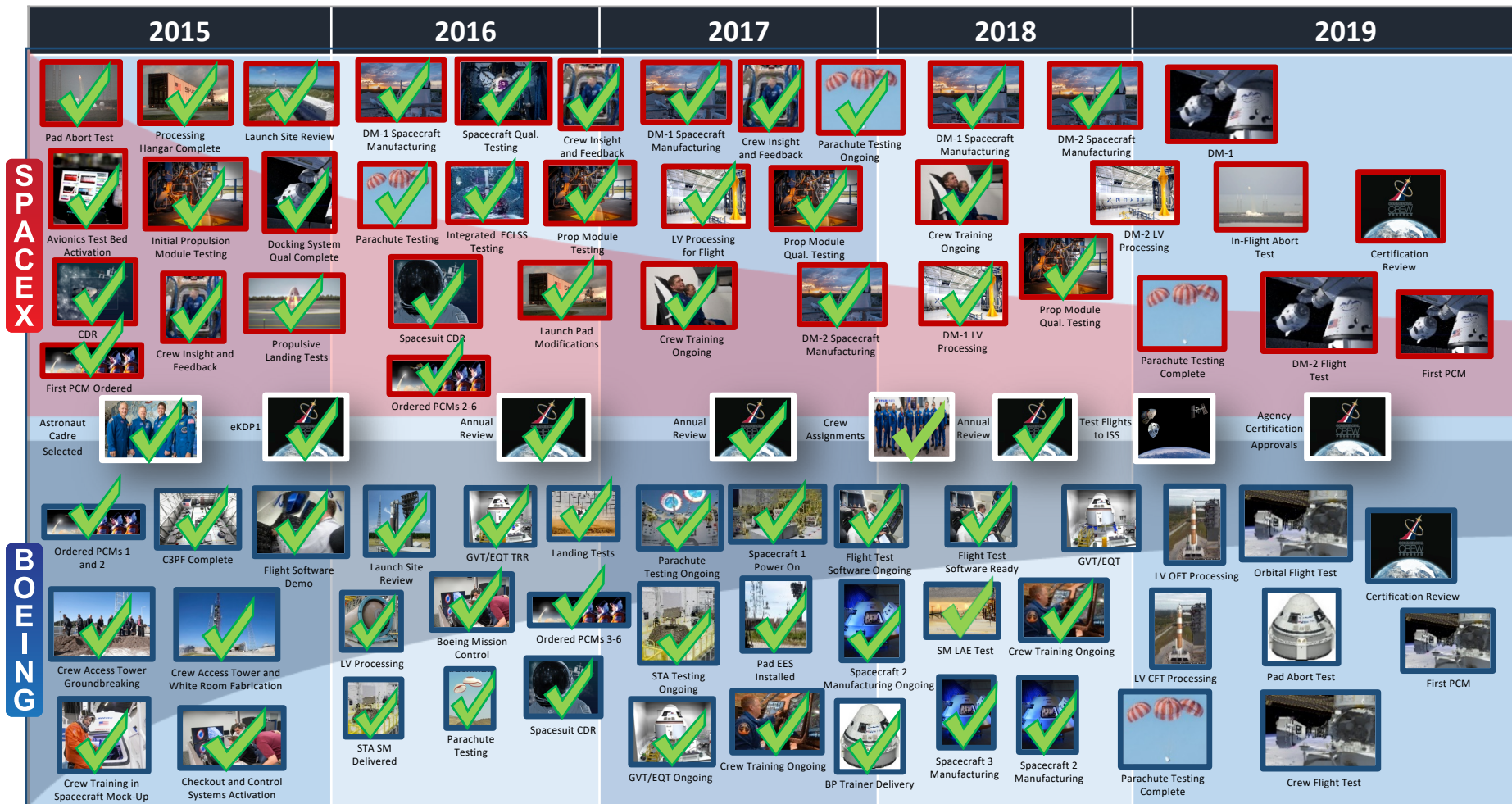


CCP has made significant progress over the last quarter

- **Mission planning and preparations for eight CCP missions are in work**
 - Boeing:
 - March 2019: Orbital Flight Test (uncrewed)
 - August 2019: Crewed Flight Test (with crew)
 - SpaceX:
 - January 7, 2019: Demo Mission 1 (uncrewed)
 - June 2019: Demo Mission 2 (with crew)
- **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 partner is included in provider-specific sections of this briefing



Timeline to the International Space Station



Last Updated Nov 2018



CCP Top Programmatic Risks

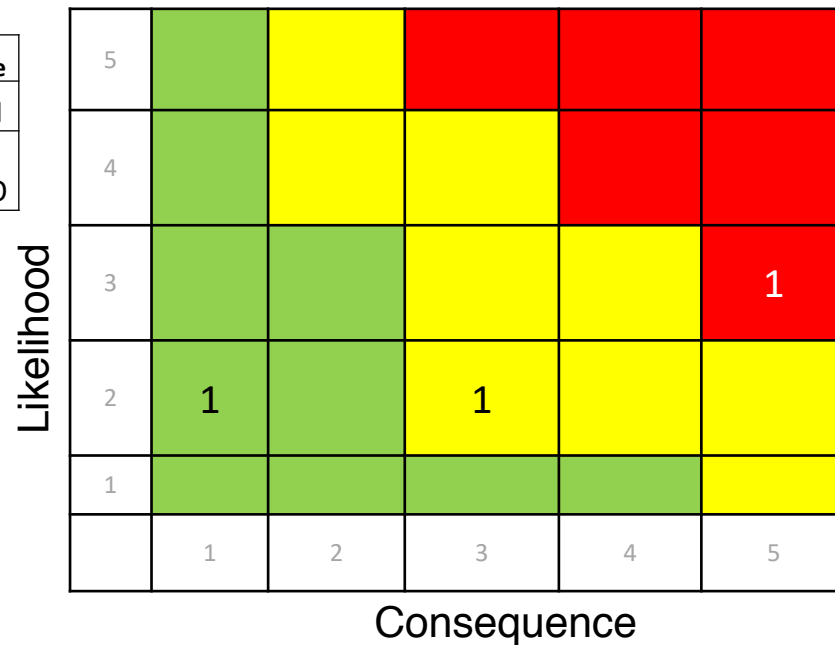


Programmatic Risk = Likelihood x (Highest of Non Safety Consequences (C, S, P))

LxC	Trend	Risk Title	Risk ID Number	Office
3x5	NC	Inability to Meet LOC	CCP-SEI-2015-1	SE&I
2x3	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

As of October 16, 2018





Boeing Test Flight Mission Status





Boeing Accomplishments



Design, Development, Test, and Evaluation

• System Level

- Structural Test Article (STA) campaign testing progressing towards closure at Huntington Beach, 13 of 15 tests completed
 - Shock Development test
 - Launch Vehicle Adapter Integrated Loads
 - On STA Sep-Bolt testing
 - Launch Vehicle Adapter Jettison test
 - Command Module Fixed Base Riser test series
 - Launch Vehicle Adapter Skirt Jettison test
 - Base Heat Shield Separation test
 - Forward Heat Shield/Parachute Impact test
- Remaining 2 STA test series:
 - Fixed Tunnel test series underway, Unit and Ascent Loads in work
 - Ascent Cover Separation offline test series in work

• Subsystem Level

- Land Landing Qualification Testing completed (all 14 tests)
- Parachute System Qualification Testing underway (3 of 5 completed)
- Parachute System Reliability Testing underway (1 of 6 completed)
- Service Module Hot Fire Low Altitude Abort firing commenced
 - Authority to proceed with valve design corrective action granted
- NASA Docking System Shock test series, planned to start in early 2019

• Completed Joint Tests with ISS

- Joint testing and analysis required for ISS integration is progressing
- Completed Joint Tests:
 - Command & Telemetry Routing test
 - CST-100 to C2V2 RF Interface Test
 - Power Quality and Electromagnetic Compatibility
 - CST-100 to NASA Docking System interface test



Fixed Tunnel Test:
Unit & Ascent Loads



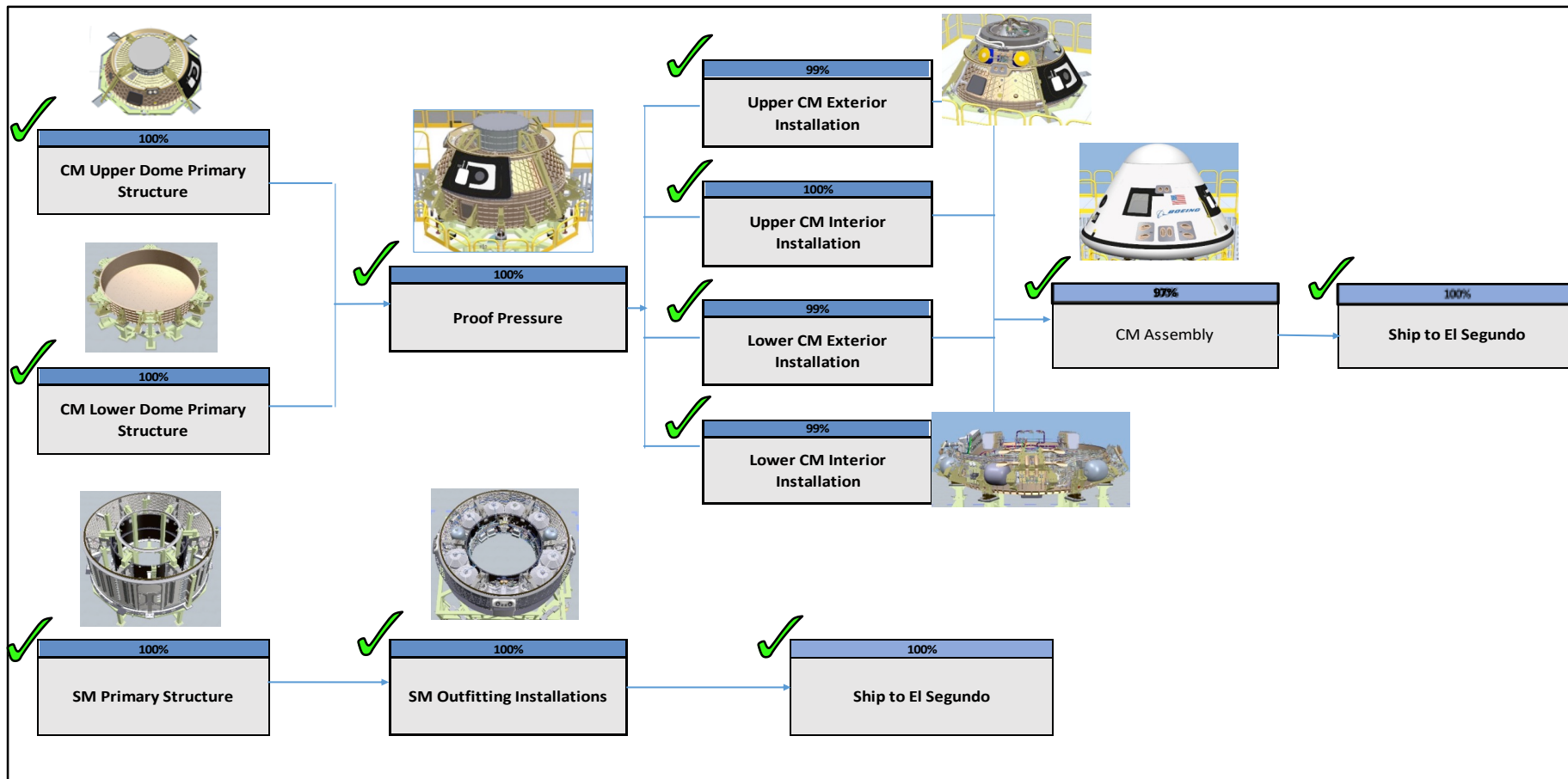
Low Altitude Abort Firing



Boeing CFT Spacecraft Production Status



Spacecraft #2 (SC#2): Environmental Qualification Test (EQT) vehicle and Crewed Flight Test (CFT) production build progress



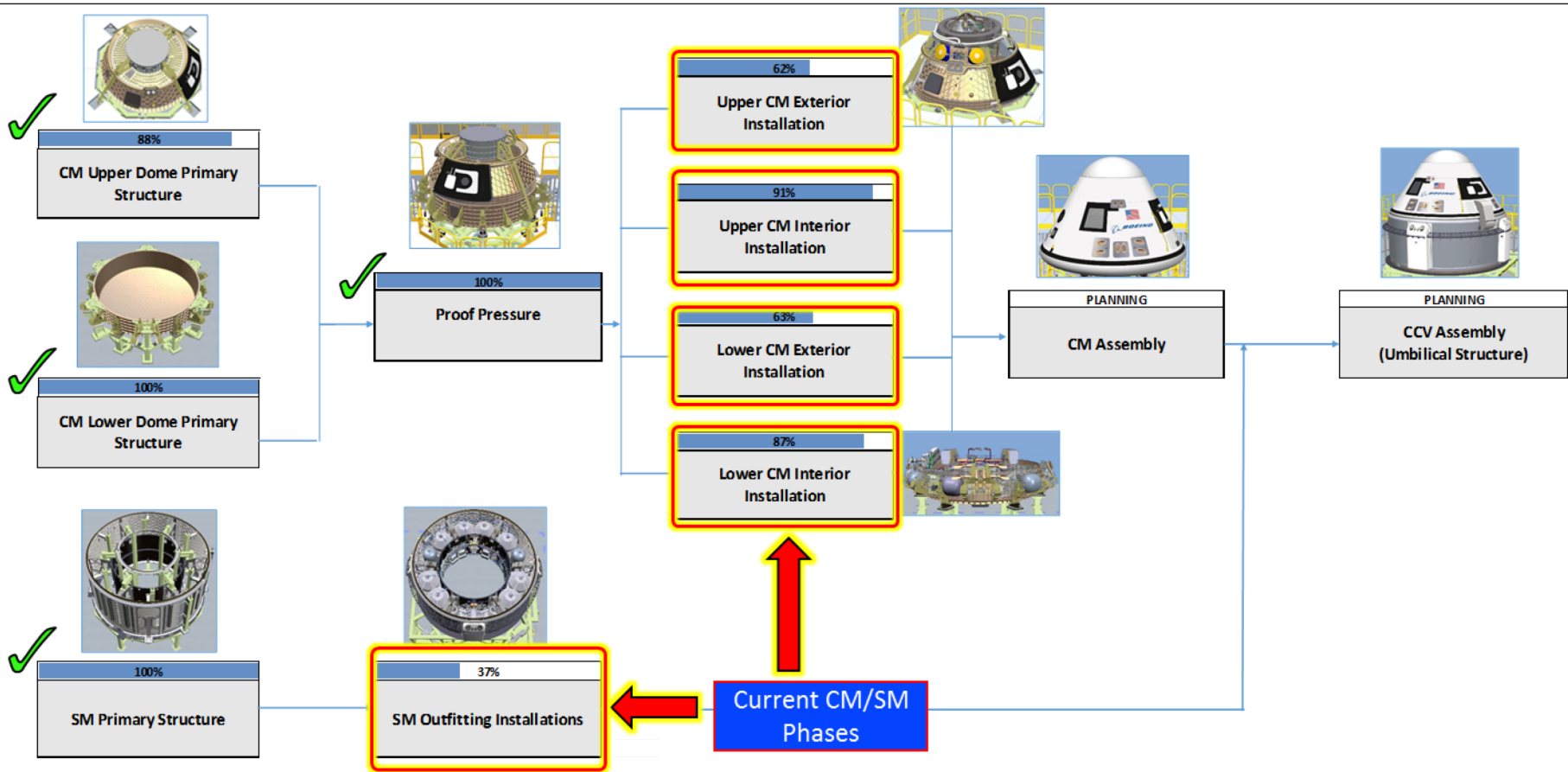
- **SC#2 Status: Currently, in the CM Assembly Phase and the SM Integrated Assembly**
 - EQT Service Module and Crew Module have shipped to El Segundo to support EQT testing



Boeing OFT Spacecraft Production Status



Spacecraft #3 (SC#3): Orbital Flight Test (OFT) production build progress



- **SC#3 Status: Currently, in the Upper Dome Assembly Phase, the Lower Dome Assembly Phase, and the Service Module Integrated Assembly**
 - Continuing with Upper and Lower Dome harness and sensor installations
 - Hatch installation and off-line panel build-up/tube welding in-work
 - Progressing towards Command Module/Service Module mate targeting early 2019



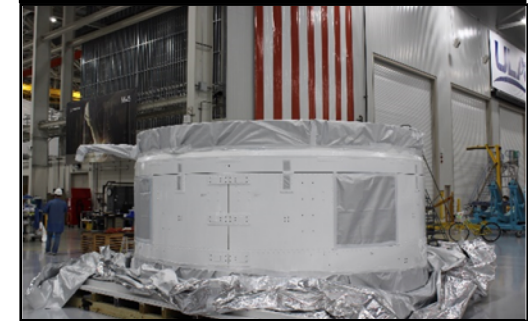
Boeing Launch Vehicle Production Status



- **Atlas V (AV-080) OFT Launch Vehicle**
 - Booster, Centaur, and Launch Vehicle Adapter nearing final build completion
 - Booster
 - RD-180 Engines installed and booster is scheduled to ship to Cape Canaveral Air Force Station in late November
 - Centaur
 - Production complete – Arrived at Cape Canaveral Air Force Station
 - Launch Vehicle Adapter
 - Production complete – Arrived at Cape Canaveral Air Force Station
- **Atlas V (AV-082) CFT Launch Vehicle**
 - Booster
 - Production near completion
 - Engine installation underway
 - Centaur
 - RL-10s and all feedlines are installed
 - Production complete targeted for late December
- **Cape Canaveral Space Launch Complex 41**
 - Crew Access Arm Common White Room Installed onto tower
 - Crew Access Arm functional testing completed



Atlas V Centaur, AV-080 (OFT)



Atlas V Adapter, AV-080 (OFT)



Common White Room



Boeing Operations Status



- **Flight Operations Reviews**
 - **ISSP Joint Flight Operations Review held**
 - Focused on Joint NASA ISS/Boeing Flight products used during rendezvous, departure and docked joint operations
 - **Boeing Mission Operations Flight Operations Review held**
 - Focused on Boeing Flight Operations products during pre-launch, launch, ascent and landing
 - **All Mission Operations products (Joint and Boeing) published**
 - Flight Rules, Launch Commit Criteria, Procedures, Ops Interface Plans, Flight Plans
- **Operations Training and Simulations**
 - **Joint Ascent Simulations with ULA and NASA**
 - OFT Integrated Crew Exercise prelaunch simulation completed
 - On-Pad Crew Emergency Egress testing completed
 - Atlas 5 Launch/Ground Team training completed for NASA CCP personnel
 - **Joint Simulations with ISS Program**
 - Three generic Joint Rendezvous and Docking simulations with ISS Program and Boeing completed
 - **Landing Simulations**
 - Landing and Recovery Team Paper simulations completed
 - Landing Systems Rehearsal completed
- **Crew Operations and SLC-41**
 - **Emergency Egress System validation test completed**
 - Evacuated 12 personnel from Crew Access Tower
 - Exercised Emergency Egress System with Crew
 - Performed crew handover operations at Triage Site 12 post evacuation from base of pad



OFT Simulation



Landing System Rehearsal



Egress System Validation



SpaceX Demo-1/Demo-2/Crew-1 Mission Status





SpaceX Accomplishments



- **Design, Development, Test, and Evaluation**
 - Dragon Development
 - Completed Draco/SuperDraco Validation Prop Module testing at McGregor
 - Completed Structural Qualification
 - Docking system tests complete
 - SpaceX Parachute Testing
 - 5 qualification tests completed in 2018
 - Spacesuit qualification complete
- **Design, Development, Test, and Evaluation (cont.)**
 - Falcon 9
 - Completed Vehicle Integration Review agreement for Block 5 configuration for human rating
 - Merlin 1D and MVAC qualification completed
 - LC-39A Crew Access Arm installed and Ground Operation review completed
 - Flight Software certification for Demo-1 approaching completion
 - Spacecraft Vehicle Hardware in the loop test complete
 - Stage Test with ISS completed
 - Both Dragon propulsion validation module completed
 - Qualification Test Reports of Crew Dragon and Falcon 9 hardware have been delivered for NASA review/approval
 - Completed all Demo 1 Joint SpaceX-NASA tests for software, docking, communications, equipment interface, and capsule environments



Demo 1 Thermal Vacuum Testing



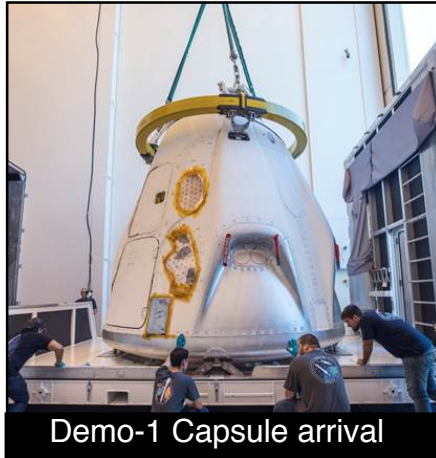
Propulsion Module Hotfire Testing



Demo 2 Crew Training



Demo-1 Vehicle Status



Demo-1 Capsule arrival



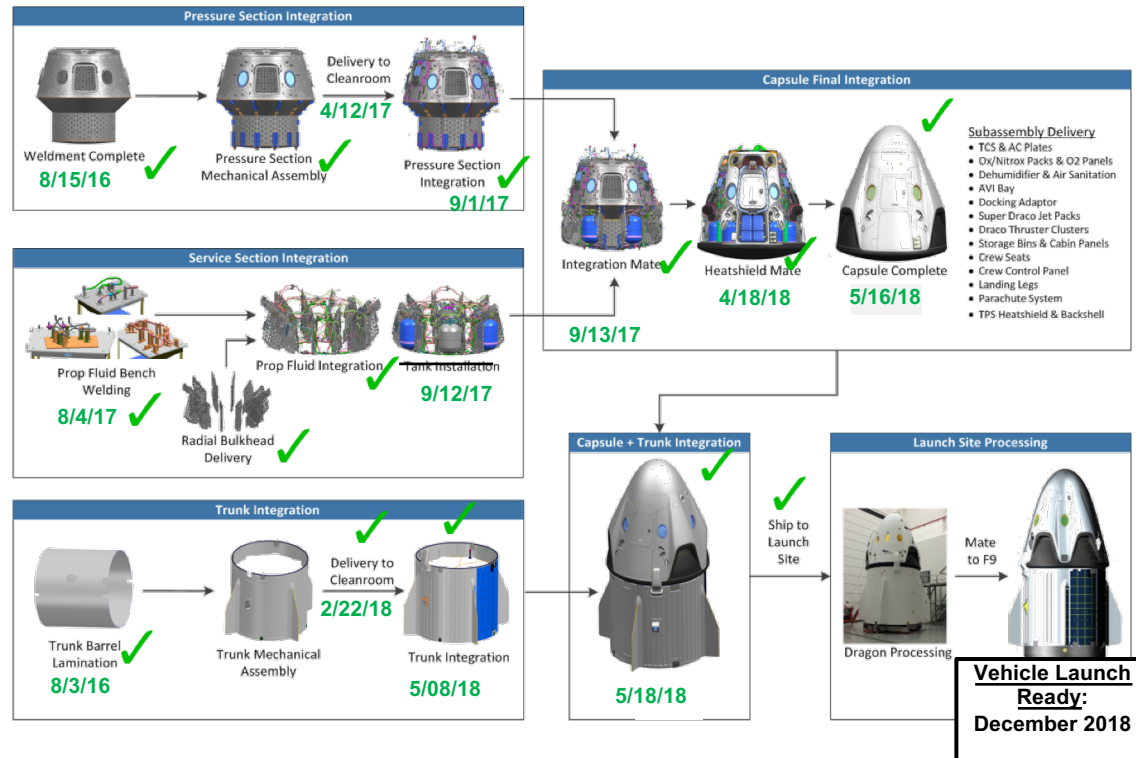
Demo-1 Capsule



Parachute Testing

Demo-1 Vehicle

- EMI, Tvac, and Acoustic tests completed successfully
- Capsule delivered to Cape and in final processing
- Heatshield mate complete
- Trunk solar array integration and proof loading complete
- Completed main and drogue parachute installation
- Completed interior closeout inspections
- Nose cone delivered to KSC and installed



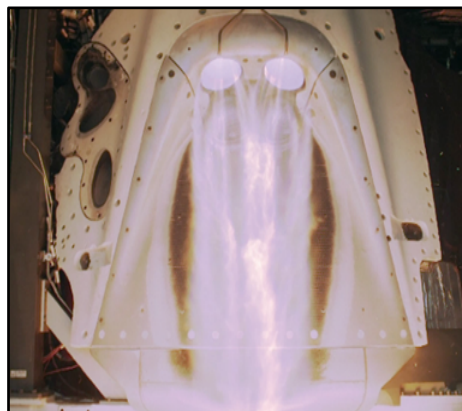


Demo-2 Vehicle Status



Demo-2 Dragon

- Started build on the first Demo-2 seats
- Completed all on-vehicle welds
- Pressure Section to the Service Section integration mate complete
- Ongoing vehicle integration in cleanroom
- Trunk primary structure complete
- Avionics Bay, components, and harnesses installed
 - Initial power up and testing complete
- 6 of 8 Super Draco's have been hot-fired at McGregor, Texas



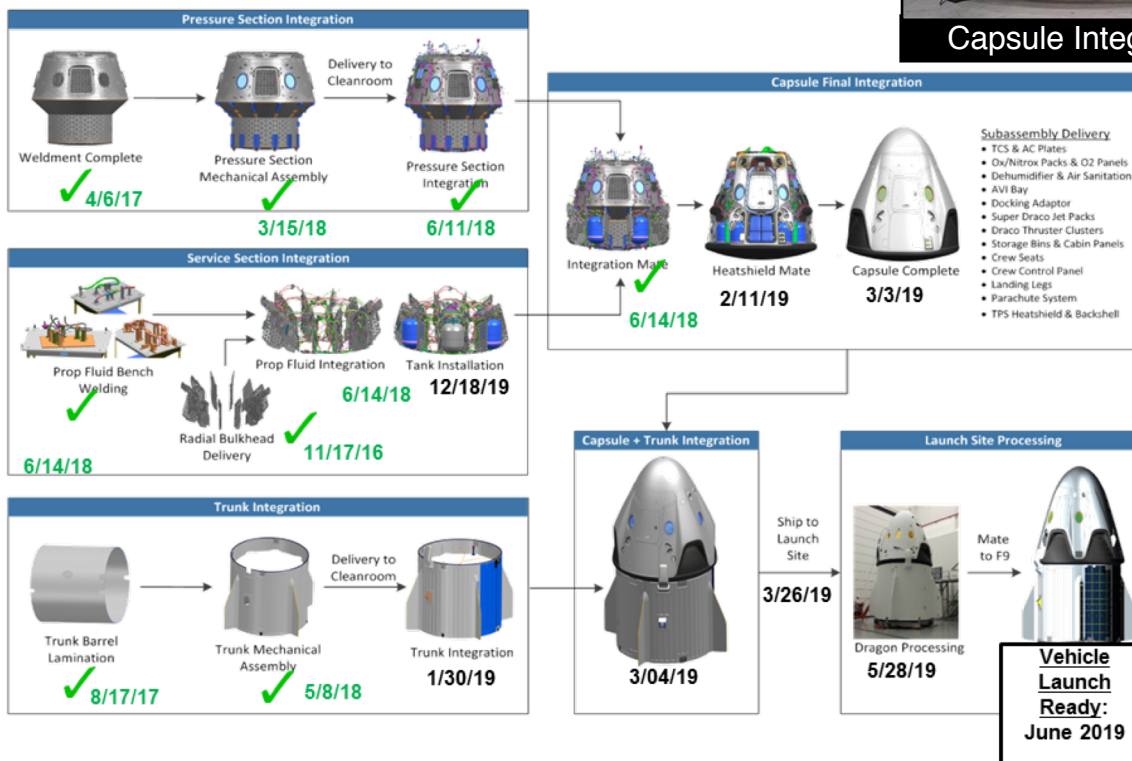
Pad Abort Module Sim



Demo-2 Trunk



Capsule Integration



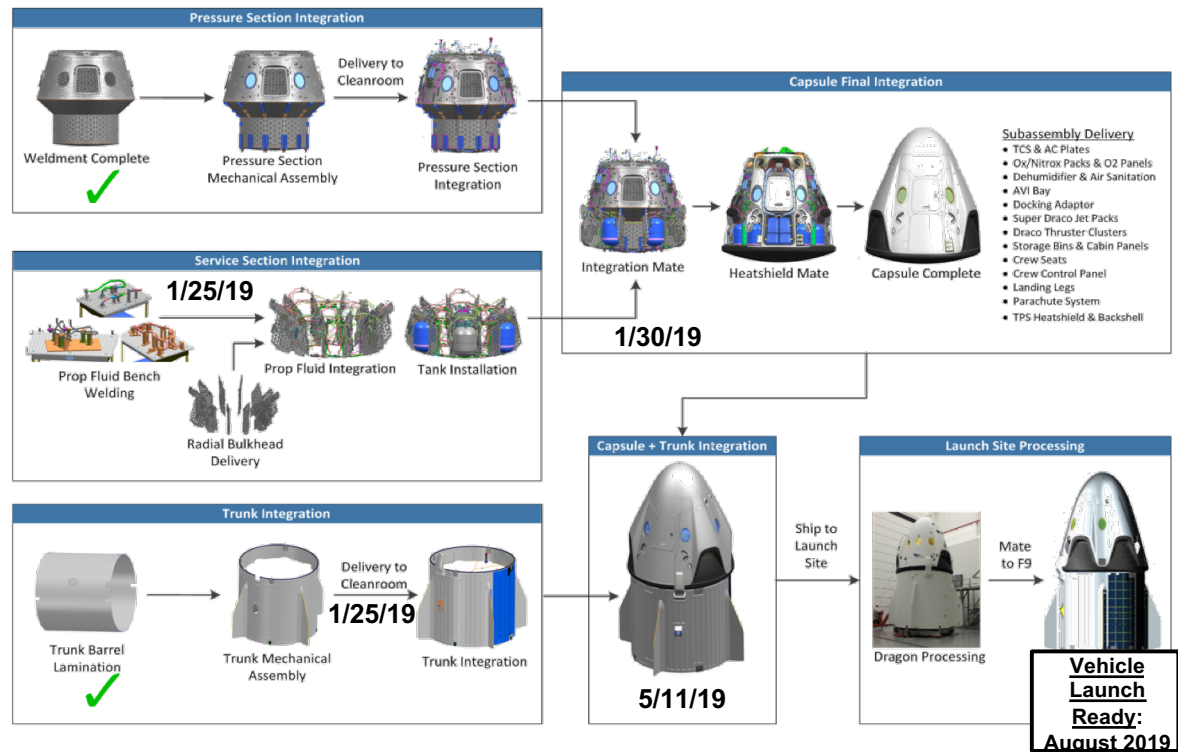


Crew-1 Vehicle Status



Crew-1 Dragon

- Capsule through mechanical assembly and structural ATP
 - Crew-1 capsule has completed ATP testing and is undergoing post-test inspections
- Prop Fluid Bench Welding has started and Radial Bulkheads have been delivered to the cleanroom





SpaceX Launch Vehicle & Pad 39A Status



- **Falcon 9**

- F9 1st Stage
 - Proof test complete
 - ATP stage firing complete
- F9 2nd Stage
 - Proof test complete
 - ATP Stage firing successfully occurred
- First F9 Block 5 flew on Bangabandhu mission

- **Pad 39A**

- Successful Crew Arm Seal testing
- Crew Access Arm Installation complete
- Delta Launch Site Operational Readiness Review complete



F9-55 Block 5 Launch



F9-60 Launch



LC-39A Crew Access Arm



SpaceX Operations Status



- **Operations**
 - Completed final Flight Operational Reviews
- **Operations Training and Simulations**
 - Finalized CCP Mission Support architecture and console support requirements for the Un-Crewed Flight Tests
 - Developed the CCP Mission Support Team Training Plan
 - Initiated training for Mission Support Team conducting Joint Simulations, Mission Management Team Simulations
 - Mission Management Team Sims and Joint Simulations with SpaceX
 - Conducted Flight Shadowing Training exercises onsite at SpaceX mission operation centers
 - Pre Launch and Post Landing Simulations completed
- **Crew Operations and LC39A**
 - Successful dry-run of Day of Launch Closeout Crew Procedures with representative crew members, spacesuits and transportation vehicles
 - Spacecraft recovery vessel currently in sea trials for Demo-1
 - Capsule recovery
 - Capsule crew egress verification complete



Joint Medical Triage and Medivac Exercise



Demo 2 Crew Training



Water Recovery Training



Space Act Agreements





Blue Origin Status



No Exchange of Funds Space Act Agreement

• Technical Exchanges

- Cryogenics and structures
- Design Reviews
- Launch Vehicle Materials

• Data Exchange

- Various software requests and technical documentation exchanges in work
- Historical Shuttle data and reports
- Trajectory software

• Look Ahead

- Milestone #6, Development Update of Ground and Mission Operations, late November 2018
- Continued Technical and Data Exchange
- Space Station Processing Facility tour



New Shepard



New Glenn



Commercial Crew Integrated Capabilities Space Act Agreement (no exchange of funds)

- **Milestone 4b, Engineering Test Article Flight Testing #2, NASA outbrief - December 2017 (test occurred on 11/11/2017)**
 - Successful uncrewed Dream Chaser engineering test article approach and landing test (ALT-2) at Edwards Air Force Base
 - ALT-2 performance was nominal for orbital vehicle
 - Lessons learned rolled into orbital vehicle design
- **Dream Chaser Orbital Vehicle Design and Development Activities**
 - Dream Chaser Cargo System design at CDR maturity level
 - Conducted systems level Delta CDR review with NASA Oct 29-30, 2018
 - DC-1 (Tail #1) delivery scheduled for March 2019
 - First Cargo Module delivery scheduled for May 2019
 - Dream Chaser Reaction Control System testing continues
 - Dream Chaser Aero Database updates incorporated into CDR design
 - Over 400 Flight Tiles delivered from NASA KSC
 - Multiple successful Cargo Demos performed with NASA
 - First launch late 2020 or early 2021
 - CCICap Milestone 41, summarizing Dream Chaser CDR design and bridge to crewed flight, was presented to NASA November 15, 2018



Dream Chaser ALT-2



DC Tail #1 OV Primary Structure
(LM Plant4 – Fort Worth)



Cargo Module and uncrewed Dream
Chaser Demonstrations



Enabling Commercial Space



- **CCP helps to facilitate Inter-Agency, Intergovernmental and International partnerships, agreements, and legislation with the strategic goal of enabling the commercial space industry**
 - Inter-Agency Collaboration
 - Department of Commerce (DOC)
 - Department of Defense (DoD)
 - Federal Aviation Administration (FAA)
 - Federal Communications Commission (FCC)
 - National Telecommunications and Information Administration (NTIA)
 - National Transportation and Safety Board (NTSB)
 - Legislation and Regulation
 - “Government Astronaut” classification
 - Mission licensing to include launch, re-entry, launch site and operator
 - Public health and safety protections
 - Jurisdiction and authority during different phases of flight
 - Independent investigation authority
 - Spectrum Usage
 - Ensure secure communication pathway availability
 - Liability and Insurance
 - Cross waivers
 - Financial responsibility
 - Third-party indemnification
 - Government property



ISS Crew EVA



International Space Station



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
- **Crew members have been assigned to missions**
- **Inter-agency work continues to enable the commercial spaceflight industry**
- **In preparation for flight, there is significant work ahead**



Boeing CST-100 Starliner



SpaceX Crew Dragon

