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National Aeronautics and
Space Administration

COMMERCIAL CREW

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Commercial Crew Program Status to the NASA Advisory Council

COMMERCIAL CREW PROGRAM

Agenda

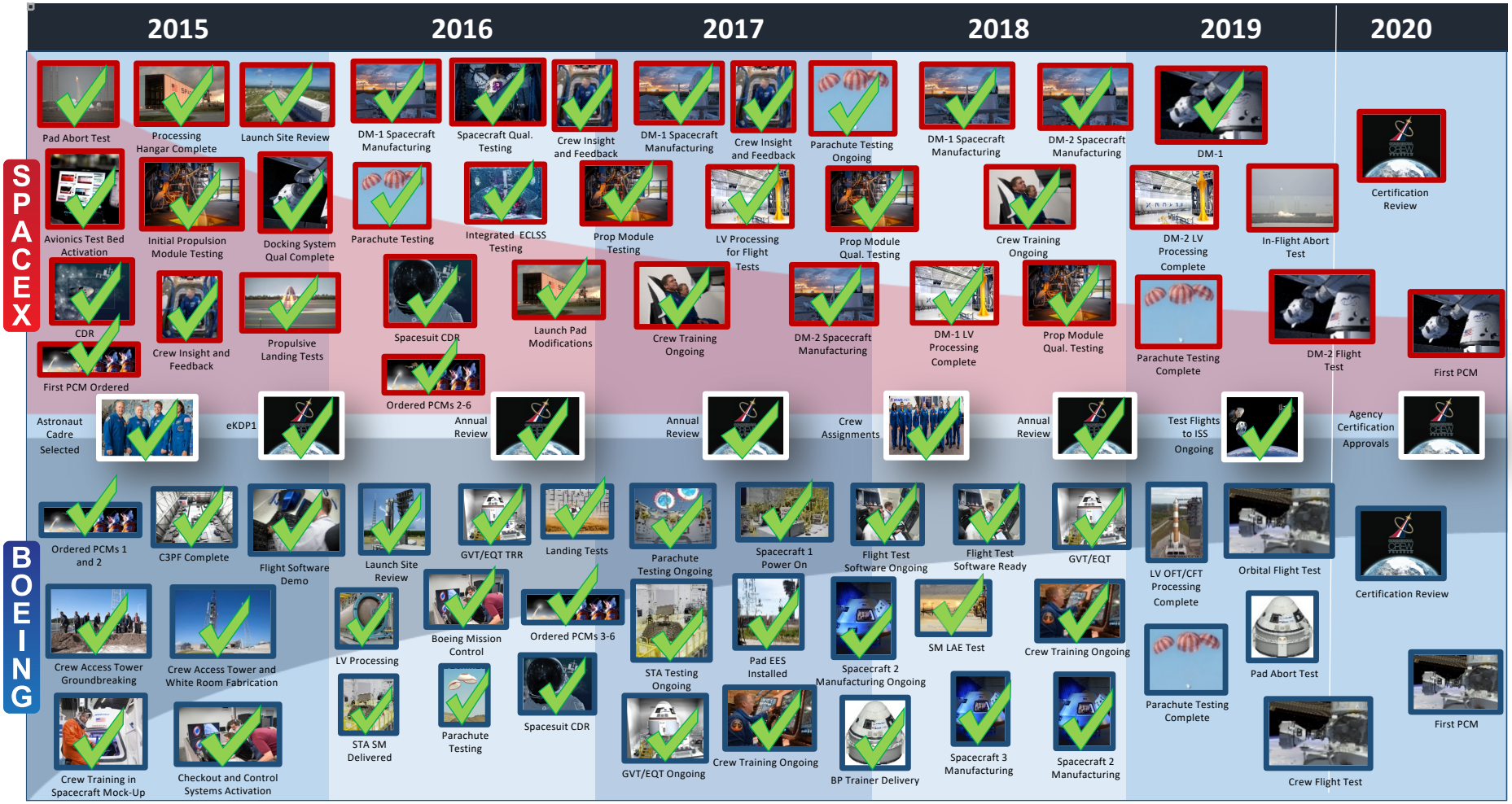
- **Agenda**
  - **Commercial Crew Status**
    - Program Progress
    - Timeline to the International Space Station
  - **Boeing PAT/OFT/CFT Mission Status**
  - **SpaceX IFAT/Demo-2 Mission Status**
  - **Enabling Commercial Spaceflight**
  - **Space Act Agreement Status**
    - Blue Origin
    - Sierra Nevada Corporation
  - **Summary**

Program Progress

Commercial Crew has made significant progress over the last quarter, notably:

- (**Mission planning and preparations for CCP missions continue:**
  - Official Launch Dates
    - December 17, 2019: Boeing Orbital Flight Test (uncrewed demo)
    - Under Review: SpaceX Demo Mission 2 (crewed demo)
    - Under Review: Boeing Crewed Flight Test (crewed demo)
- (**Space hardware manufacturing, testing and qualification continue**
- (**Both providers are making tangible progress toward flights to the International Space Station**
- (**Continued engagement from CCP as the providers perform critical test and verification events**
- (**CCP continues the burn down of key certification products for both Boeing and SpaceX**
  - Progress for each is included in provider-specific sections of this briefing

Timeline to the International Space Station



Last Updated
Oct 2019

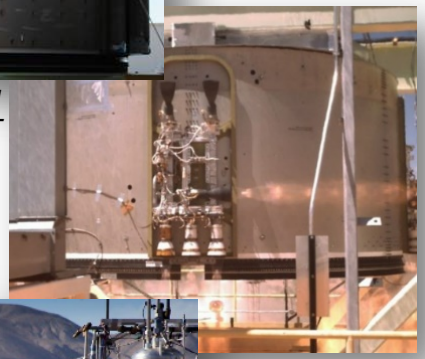
Boeing PAT/OFT/CFT Mission Status

Boeing Pad Abort Test Status

Pad Abort Test (PAT) Trending to Early November Launch Readiness - Target Date 11/4/19

- **Purpose is to validate end-to-end performance and functionality of the Launch Abort System**
- **Test Summary**
  - Mode Ia Abort from pad abort conditions
  - Test Location: White Sands Missile Range (WSMR)
  - Vehicle Configuration:
    - Spacecraft-1 CM and SM
    - ULA-delivered flight-like LVA including updated abort vent doors
  - CCP to support from WSMR and from MCC-H
- **Status**
  - PAT predicted performance delivered 7/31/19, showing margin against Commercial Crew Pad Abort requirement
    - NASA GNC IV&V shows good agreement with Boeing results
  - LVA abort vent door test successfully completed 8/15/19
  - CM/SM Mate Complete 9/18/19
  - SC1 CCV Power-up Complete 9/21/19
  - Set-Up for MMH Prop Loading 10/19/19
  - Test Readiness Review 10/28/19

Spacecraft being readied for PAT



Testing on Starliner's in-space maneuvering and launch abort systems

Boeing Orbital Flight Test Status

Orbital Flight Test (OFT) Trending to Mid-December Launch Readiness - Target Date 12/17/19

- **Spacecraft #3**
  - CM/SM mate complete 10/17/19
  - CM Integrated Avionics Acceptance testing complete
    - Boeing Integrated Propulsion Control R&R and regression testing complete
    - Prop regulator rebuild and retest complete
    - Final CM build and RF testing completed prior to CM/SM mate
  - Preparations for final CCV acceptance testing in work
  - Final close-outs in work
- **Atlas V (AV-080) OFT Launch Vehicle**
  - Booster, Centaur and Launch Vehicle Adapter (LVA) production complete
    - Centaur: Arrived at CCAFS on 10/18/18
    - LVA: Arrived at CCAFS on 11/12/18
    - Booster: Arrived at CCAFS on 12/6/18
  - AV-080 Booster horizontal processing complete – Ready to stack
  - AV-080 Centaur stacked and mated to LVA and ISA – Ready to mate to Booster
- **System Level-Subsystem Level Testing**
  - Structural Test Article (STA) testing completed
  - Environmental Qualification Testing (EQT) completed
  - Parachute System Qualification Testing (PSQT) 5/5 completed
  - Service Module Hotfire 2.0 Testing completed
    - Low Altitude Abort and Nominal Mission sequences
  - Parachute Compartment Reliability Testing underway (3/6 completed)
    - Remaining 3 tests planned throughout the fall
- **OFT Joint Tests and Analysis with ISS Remaining**
  - JA 9 Clearance During Docking/Mated Ops (SC# 3) Final As-Built compare NET 10/28/19
  - JT 10 Crew Equipment Interface Test (CEIT) (SC #3)
  - JT 11 Microbial and Fungal Sampling (SC #3)
  - JT 12 Closed Hatch Off Gassing (SC #3)

Spacecraft #3 in final prep

Atlas V Booster AV-080

Boeing Crew Flight Test Status

Crew Flight Test (CFT) Trending to Early 2020 Launch Readiness

- **Spacecraft #2 - CM/SM Basic Build In-work**

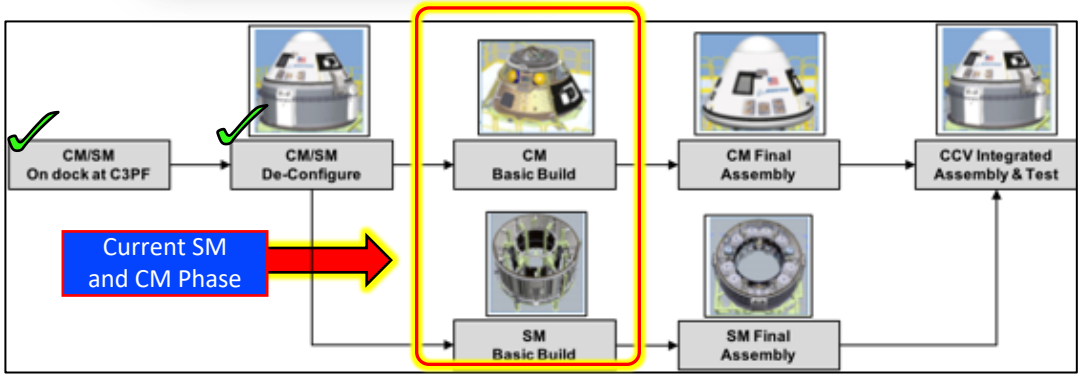
  Completed
  - Upper dome/lower dome mated 10/22/2019
  - Docking System Latch Actuator Installation
  - Atmosphere Revitalization System (ARS) component assembly build-up
  - NAFION assembly and installation
  - Removal of Orbital Maneuvering And Control (OMAC) Isolation Valves
  - Active Thermal Control System (ATCS) Check valve test
  - Flexhose precision cleaning
  - Crew suited training activities ongoing

  Remaining
  - Harness High Potential and Continuity Tests
  - LRS Panel buildup
  - PCS Panel buildup
  - Command Valve Panel rework
  - ATCS assembly/bellows rework
  - Doghouse reaction control system isolation valve inspection
  - Three way valve installation
  - OMAC bracket modification

Spacecraft #2

CFT suited crew training

- **Atlas V (AV-082) Launch Vehicle**
  - Booster
    - Production complete
    - Arrived CCAFS on 6/1/19
  - Centaur
    - Production complete
    - Arrived CCAFS on 6/1/19
  - Launch Vehicle Adapter
    - In work on remaining Aeroskirt/Truss manufacturing and assembly activities
    - Prep for shipment to CCAFS fall/winter 2019



Boeing Operations Status

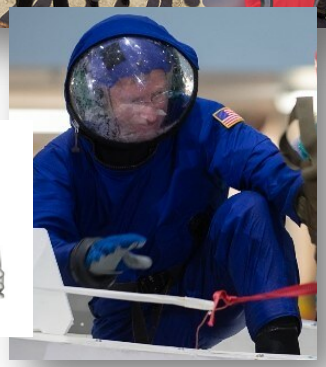
Simulations, Exercises and Training

- **DoD Human Spaceflight Support Office Joint Tactical Exercise**
  - Water Rescue Training USAF Det 3 and 920th Rescue Wing, CCP, FOD
- **Joint Ascent Simulations with ULA and NASA**
  - OFT Integrated Crew Exercise (ICE) #1
  - On-Pad Crew Emergency Egress testing
  - OFT ICE #2
  - OFT Final Mission Dress Rehearsal (MDR) planned just prior to launch
  - OFT Wet Dress Rehearsal Planned (WDR) just prior to launch
- **Boeing OFT Simulations Completed**
  - Systems Rehearsal #1a and 1b (On-Orbit & Un-dock to Landing)
  - Systems Rehearsal #2 (On-Orbit)
  - Systems Rehearsal #3 (Un-dock to Landing)
  - MDR Pt A (Ascent to Dock)
- **Boeing and NASA ISSP Joint Simulations**
  - Six (6) Joint Rendezvous docking simulations with ISS
  - Two (2) Undocking sims with ISS
  - Three (3) Mission specific Joint Rendezvous, Docking, and Departure simulations planned prior to launch
- **Boeing Landing Simulations**
  - Field equipment integration and training at WSMR site
  - Landing Recovery Team Paper Sim #5 and 6
  - Landing Systems Rehearsal #1
  - OFT Landing Systems Rehearsal #2 (Early Return)
  - OFT Landing Site and Systems Stand Alone Rehearsal
  - OFT MDR Pt B (Undock to Landing) planned for fall/ winter 2019

Water rescue contingency training

NASA/Boeing landing exercise

Boeing/David Clark spacesuit



Airstream/Boeing crew transport

SpaceX IFAT/Demo-2 Mission Status

Dragon Static Fire Anomaly Investigation

SpaceX encountered an anomaly during attempted static fire testing of the SuperDraco propulsion system on 4/20/19 resulting in the loss of the vehicle

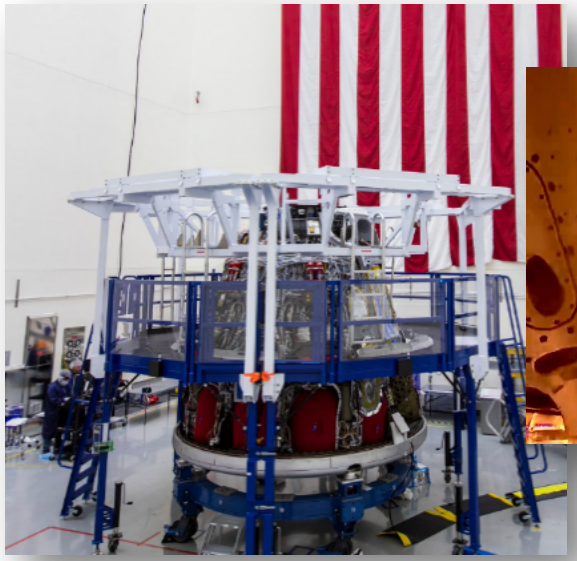
- **A formal investigation was begun, which included NASA participation**
- **Fault tree disposition is nearly complete**
- **The SpaceX static fire anomaly investigation team briefed NASA leadership on progress 8/15/19**
- **Anomaly associated corrective actions and design changes were identified and already being implemented by SpaceX**
- **Prior to the IFAT Anomaly SpaceX was already planning to make a few changes between DM-1 and DM-2**
  - Design changes on the low-flow side of the propulsion system were approved on 6/20/19
  - Changes on the high-flow side of the system are finalized, with ground-testing nearly complete
  - Hardware modifications installed August/September
  - Static Fire and IFAT capsule shipped to KSC on 9/25/19
  - Static Fire Test Readiness Review conducted on 10/21/19 with a delta TRR on 10/26 to discuss prop module testing
  - Static fire test NET 11/2/19
- **NASA plans to ensure that the necessary hazards and controls resulting from all changes get incorporated into the prop system hazard reports prior to approving them for Phase III (DM-2)**
  - Team is coordinating verification evidence product impacts and constraints with the respective requirement owners

DM-1 Dragon on test-stand prior to anomaly

SpaceX In-Flight Abort Vehicle Status

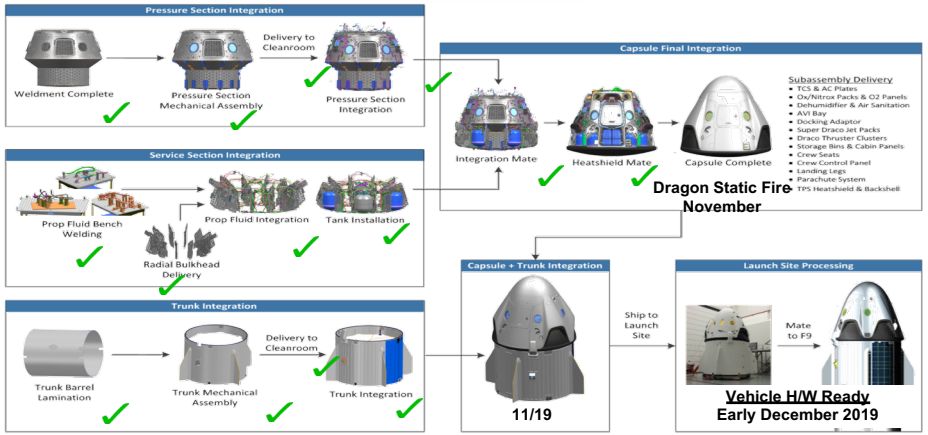
In-Flight Abort Test (IFAT) Trending to Early December Launch Readiness - Targeted after CRS 19

- **Focus on integration of the updated propulsion system and pressure system integration**
- **Test Summary**
  - Launch from LC-39A at KSC
  - S1B escape mode initiated at ~88s MET
  - Test article consists of:
    - F9 Block 5 4th flight booster and interstage
    - F9 Block 5 2nd stage with MVacD simulator (no engine)
    - Stage extension, trunk, and Dragon Capsule 205 incorporating SuperDraco propulsion system updates since static fire anomaly
  - IFAT F9 Static Fire and IFAT will be dry-runs for Demo 2+ ops support teams including exercising crew timeline
- **Status**
  - IFAT trunk shipped to CCAFS 8/16/19
  - IFAT Capsule shipped to CCAFS 9/27/19
    - Open installation work transferred to CCAFS (final harnessing, pod panels, nosecone)
  - 1st stage refurbishment completed in Hawthorne shipped to CCAFS 9/22/19
  - 2nd stage proof/tanking testing complete, awaiting shipment to CCAFS
  - Re-baseline NASA/SpaceX IFAT TIM conducted 9/25/19



IFAT spacecraft

Testing the upgraded launch escape system



SpaceX Demo-2 Vehicle Status

Demo-2 Currently Trending to First Quarter 2020 Launch Readiness

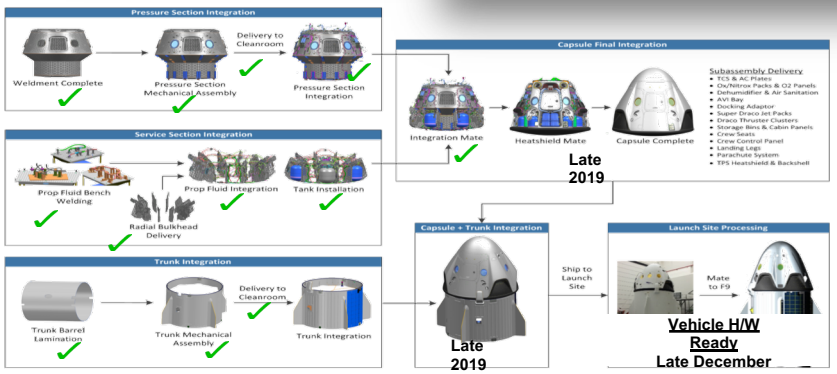
- **Dragon Spacecraft**
  - Docking Adapter installed
  - SuperDraco ATP complete
  - Trunk structure is complete
  - Avionics and system checkouts in-work to test integrated systems
  - Heat Shield build is complete
  - Expected to ship to KSC in early December

- **Falcon 9 Launch Vehicle**
  - 1st Stage shipped to McGregor and stage testing completed
  - Static fire test 8/29/19
  - Decision reached regarding MVacD upper stage engine configuration
    - Upper stage shipment to McGregor in October/November
    - Upper stage testing in November and ship to CCAFS in time for launch readiness review

- **Spacesuit production of primary suits nearing completion**
  - Backup suit production in work

Administrator Jim Bridenstine and Elon Musk with DM-2 spacecraft and spacesuits

DM-2 suited crew training



SpaceX Operations Status

Simulations, Exercises and Training

- Demo-2 Crew completed Crew Training Events
  - Integrated Cabin Review Demonstrations in the Buck (Part 1)
  - Integrated Cabin Review Demonstrations in the Buck (Part 2)
- Developed the CCP Mission Support Team Training Plan
- Conducted training for Mission Support Team via Joint Simulations and Mission Management Team Simulations
  - Part of the Mission Management Team Sims and Joint Simulations with SpaceX
  - Conducted SpX CRS-14 and SpX CRS-15 Flight Shadowing Training exercises in MCC-X, LLCC, MCC-H and Hangar AE locations
  - Completed training exercises for two F9 missions supported by LSP team at Hangar AE

Nominal and contingency crew training exercises

- **Joint SpaceX and NASA demonstrations on Go Searcher**
  - Starting condition: Capsule on the recovery boat and ready for crew egress
  - Nominal Runs: Practiced crew egress, medical evaluation and crew transportation to the handover airport (Skid Strip CCAFS)
  - Contingency Runs: Practiced declaring a medical emergency, executed crew egress, contingency medical care, Helo landing, Helo loading, Helo takeoff and transfer at Dedicated Medical Care Facility
- **Crew Operations and LC39A**
  - Successful dry-run of Day of Launch Closeout Crew Procedures with representative crew members, space suits and transportation vehicles
  - GO Searcher spacecraft recovery vessel sea trials for Demo-1
- **Day of Launch Crew Ops Dry-Run**
  - Completed a high-fidelity demonstration of select pre-launch activities
  - Large scale coordination of Transport, Security and Safety assets
  - Exercise communication infrastructure
  - Introduce full Closeout Team to Ops
- **Full-scale Medical Triage Exercise**
  - NASA medical, Decon team, DoD DET-3, NASA helo, SpaceX closeout team participation

Joint NASA, SpaceX, DoD shipboard exercises

Enabling Commercial Spaceflight

Executing Mission Requirements Through Inter-Agency Agreements and Collaboration

- **Federal Aviation Administration (FAA) and Department of Commerce (DOC)**
  - Mission licensing: launch, re-entry, launch site and operator
  - Air Traffic Management - public health and safety
  - Jurisdiction and authority during different phases of flight
  - Third-party indemnification
  - Cross waivers for government payloads/property
- **Department of Defense (DoD)**
  - U.S. Air Force Detachment 3 Partnership
  - U.S. Air Force Eastern Range
  - Launch and Entry Steering Group
- **National Oceanic and Atmospheric Administration (NOAA)**
  - SARSAT - Search and Rescue Satellite Aided Tracking
- **Federal Communications Commission (FCC) and National Telecommunications and Information Administration (NTIA)**
  - Spectrum usage and authorization
  - Ensuring secure communication pathway availability
- **National Transportation and Safety Board (NTSB)**
  - Independent investigation authority

Space Act Agreements

Blue Origin Status

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

- **Recent Progress**
  - Parachute, structures, and mission operations TIMs
- **Latest Technical Exchanges**
  - Launch vehicle technical TIMs, documentation requests
  - Space Shuttle historical technical reports
- **Look Ahead**
  - KSC structures technical interaction
  - SAA Milestone 8 Review

New Glenn

New Shepard

New Shepard NS-10

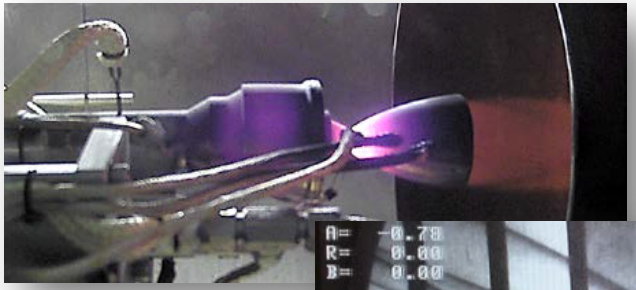
Sierra Nevada Corporation Status

Commercial Crew Integrated Capabilities (CCiCap) Space Act Agreement (SAA)

- **Recent Progress**
  - Milestones 42 and 43 Review Complete 6/19
    - Dream Chaser RCS development testing and aerodynamic database review
  - RCS thruster testing ongoing thru fall 2019
  - Ames TPS Arc-Jet testing and aero wind tunnel testing continue into 2020
  - SNC commits to Tail #2 (2nd vehicle), ready for services early 2023

- **Look Ahead**
  - Delivery of Dream Chaser Tail #1 Body Assembly to SNC from Lockheed Martin late Sep 2019
  - Assembly Integration and Test beginning mid-Oct 2019 at Louisville facility
  - Milestone 44: Lessons Learned for Crew Transportation TIM Feb 2020
  - Uncrewed Dream Chaser and Cargo Module ship to Plumbrook Q2 2021
  - 1st uncrewed Launch Q4 2021 aboard ULA Vulcan

Dream Chaser Cargo Module fabrication



RCS Thruster testing

Wind tunnel testing

Dream Chaser body assembly

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 spaceflight systems**
  - Risks are being identified and important design challenges are being addressed
  - A substantial amount of hardware is in development, test and qualification by both providers
  - NASA is engaged in meaningful insight
- **Both providers are making tangible progress toward test flights and post certification missions to the International Space Station**
- **CCP has a robust and efficient processes for certification, including addressing waivers and deviations**
  - There is progress in burn-down of key certification products
- **Crew members are training for specific missions**
- **Inter-agency collaboration continues to help enable the success of the commercial spaceflight industry**
- **There is significant work ahead for crewed flight**

Boeing CST-100 Starliner

SpaceX Crew Dragon

NASA