

Kathryn Lueders
Program Manager

National Aeronautics and
Space Administration



COMMERCIAL CREW



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Commercial Crew Program Status to the NASA Advisory Council





Agenda



- **Agenda**

- **CCP Status**
 - Program Progress
 - Timeline to the International Space Station
 - Risks
- **Boeing OFT/CFT Mission Status**
- **SpaceX Demo-1 Highlights/Demo-2 Status**
- **Space Act Agreement Status**
 - Blue Origin Status
 - Sierra Nevada Corporation Status
- **Enabling Commercial Space**
- **Summary**



Program Progress



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

- **Mission planning and preparations for seven CCP missions are in work (one mission has been completed and flight data is currently being assessed)**
 - Targeted Work To Dates For Boeing:
 - Orbital Flight Test (uncrewed flight to ISS) - August 2019
 - Crewed Flight Test (crewed flight to ISS) - Late 2019
 - Targeted Work To Dates For SpaceX:
 - Demo Mission-1 (uncrewed flight to ISS) - March 2-8, 2018 **COMPLETED**
 - Demo Mission-2 (crewed flight to ISS) - Date Under Review
- **Space hardware manufacturing, testing and qualification are underway**
- **Both providers are making tangible progress toward missions to the International Space Station**
- **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





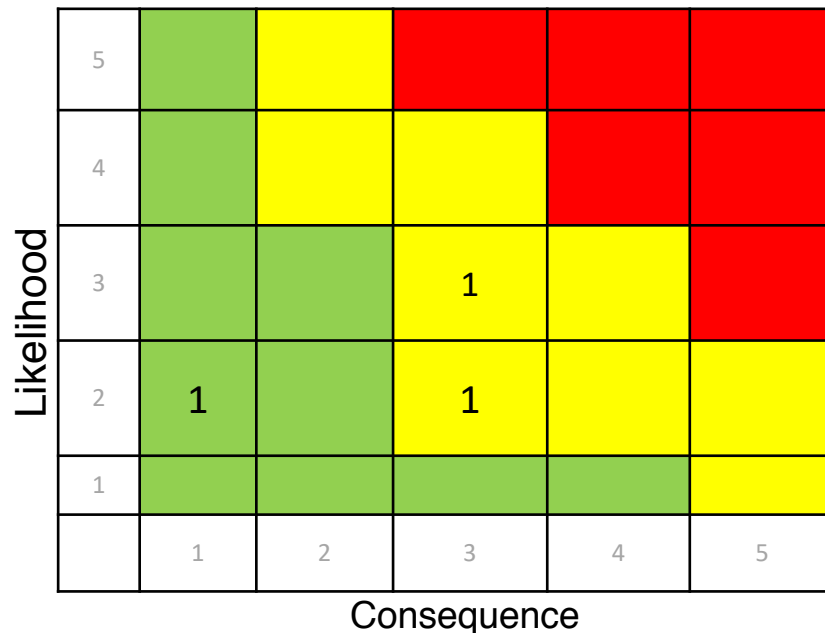
CCP Top Programmatic Risks



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

LxC	Trend	Risk Title	Risk ID Number	Office
3x3	D	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 3/28/2019





CCP Top Program Safety Risks



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
As of 3/28/2019

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



Boeing OFT/CFT Mission Status





Boeing Accomplishments



Design, Development, Test and Evaluation

- **System Level**

- Structural Test Article (STA) testing completed
- STA test reports in work

- **Subsystem Level**

- Parachute System Qualification Testing near complete (4/5 complete)
 - Remaining test planned for late spring
- Parachute Compartment Reliability Testing underway (2/6 complete)
 - Remaining 4 tests planned thru summer
- Service Module Hot Fire testing resuming after new valves installed
 - Remaining Tests: Low altitude abort/nominal mission sequences
- NDS Shock test offline series complete

- **Joint Tests and analysis with ISS**

- Joint testing and analysis required for ISS integration is progressing
- Completed Joint Tests:
 - JT 4/5/9b Integrated Software Stage Test complete
 - JT 4/5/9b Integrated Software Stage final regression test complete
 - JT 8 Phase 1: NDS bond and leak test complete (SC#3)
 - JT 9a Regression Test complete
- Remaining Joint Tests:
 - JT 8 Phase 2: NDS Interface Acceptance test SC #3
 - JT 9c C2V2 RF Interface test: CST-100 Encryption verification test
 - JT 10 Crew Equipment Interface Test (CEIT) SC #3
 - JT 11 Microbial and Fungal Sampling SC #3
 - JT 13 ISS/CST-100 Flight Article Validation Test SC #3

SC2 in ELS



Parachute Reliability Dart Test

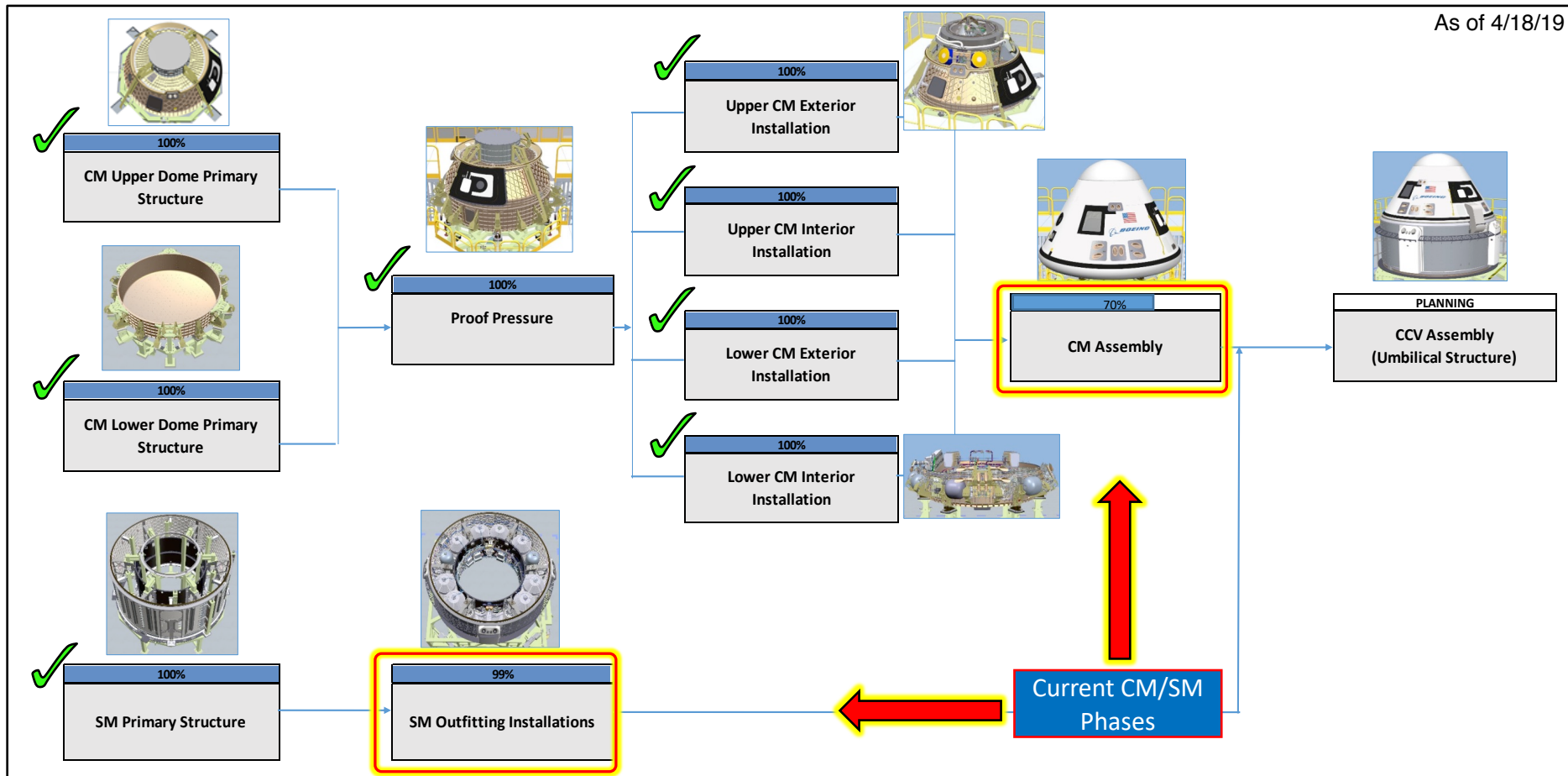


Boeing OFT Spacecraft Production Status



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

As of 4/18/19



- **SC#3 Status:** Currently, in the final stages of CM Assembly prior to mate CM/SM mate for final CCV acceptance testing
 - SM-3 near complete and ready for mate to CM
 - Progressing towards CM/SM mate early summer



Boeing CFT Vehicle Status



Spacecraft #2 (SC#2): Environmental Qualification Test (EQT)

• SC#2 EQT Campaign Complete

- ✓ Pre-Environmental Performance test complete
- ✓ Nominal Ascent Acoustics test complete
- ✓ Abort Acoustics test complete
- ✓ Thermal Vacuum balance tests complete
- ✓ EMI/EMC testing complete
- ✓ Post- Environmental Performance testing complete
- ✓ SC#2 shipped back to KSC for refurbishment
- ✓ SM Coolant Loop Tvac regression testing complete
- ✓ SM#2 shipped back to KSC for refurbishment



EMI/EMC Testing



Boeing CFT Spacecraft Production Status



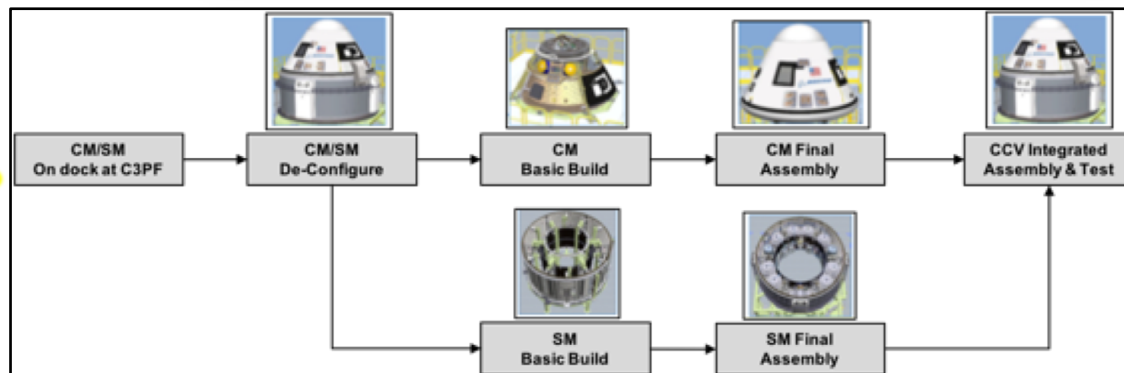
Spacecraft #2 (SC#2): Environmental Qualification Test (EQT) complete

- **SC#2 refurbishment flow underway in preparation for CFT mission**
 - SC#2 received C3PF in Florida and moved into production footprint
 - Hardware removal disposition process and footprint established
 - TPS Tile carrier panels/covers removed
 - CM Hatch access established
 - Power-up/offload gasses completed
 - Forward heat shield removed
 - Backshells removed



Thermal Vacuum Test

Boeing Tiger Team formed to establish SC#2 refurbishment plan





Boeing Launch Vehicle Production Status



- **Launch Vehicle Build Progress**

- **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 Nov 12/6/18

Atlas V Booster Arrival

- AV-080 Booster horizontal processing complete – Ready to stack
 - AV-080 Centaur stacked and mated to LVA and ISA – Ready to mate to Booster



- **Atlas V (AV-082) CFT Launch Vehicle**

- **Booster**
 - Production complete
 - Prep for shipment to CCAFS early summer 2019
 - **Centaur**
 - Production complete
 - Prep for shipment to CCAFS early summer 2019
 - **Launch Vehicle Adapter**
 - In work on remaining Aeroskirt and Truss activities
 - Prep for shipment to CCAFS early summer 2019



Atlas V Booster AV-080 (OFT)



Boeing Operations Status



- **Simulations/Exercises**

- **DoD Human Spaceflight Support Office Joint Tactical Exercise**

- Water Rescue Training USAF Det 3 & 920th RW, CCP, FOD

- **Joint Ascent Simulations with ULA and NASA**

- Completed OFT Integrated Crew Exercise (ICE) #1
 - Completed On-Pad Crew Emergency Egress Testing
 - Completed OFT ICE #2
 - OFT Final Mission Dress Rehearsal (MDR) planned for mid-summer
 - OFT Wet Dress Rehearsal Planned (WDR) just prior to launch



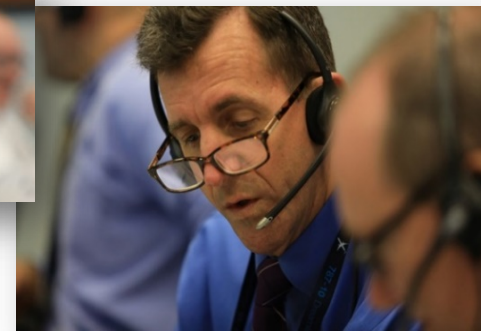
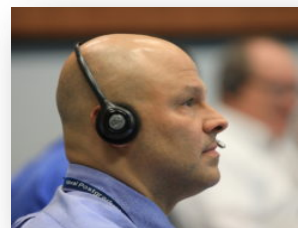
Water Rescue Exercise

- **Boeing Simulations**

- Completed OFT Systems Rehearsal #1 (On-Orbit)
 - Completed OFT Systems Rehearsal #2 (On-Orbit)
 - OFT Systems Rehearsal #3 (Un-dock) planned for late spring
 - OFT MDR Pt A (Ascent to Dock) planned for early summer

- **Boeing and NASA ISSP Joint Simulations**

- Completed (4) generic Joint Rendezvous docking simulations with ISS
 - Five (5) Mission specific Joint Rendezvous, Docking, and Departure simulations planned for spring through launch



*OFT Simulation ICE #2
NASA & Boeing Participants*

- **Boeing Landing Simulations**

- Completed field equipment integration & training at WSMR site
 - Completed Landing Recovery Team Paper Sim #5 & 6
 - Completed Landing Systems Rehearsal #1
 - Completed OFT Landing Systems Rehearsal #2 (Early Return)
 - OFT MDR Pt B (Undock to Landing) planned for early summer



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



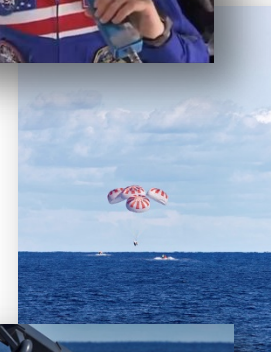
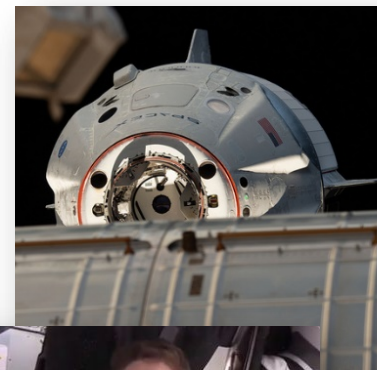


Demo-1 Mission Status

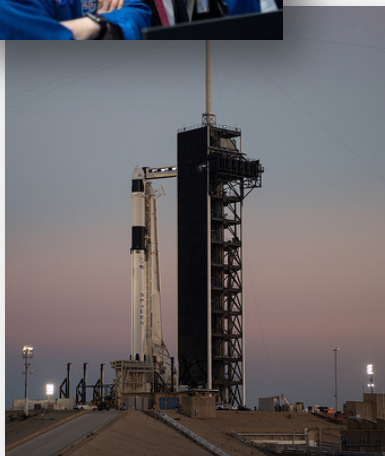


- **Demo-1 launched March 2, 2019 at 2:49 a.m. EST**
- **Crew Dragon soft docked to ISS Harmony module March 3 at 5:51 a.m. with a hard dock at 6:02 a.m.**

- NASA astronaut Anne McClain, David Saint-Jacques of the Canadian Space Agency and Russian cosmonaut, and Expedition 58 commander, Oleg Kononenko opened the hatch between the Crew Dragon and the International Space Station at 8:07 a.m. EST
- Cargo - more than 400 pounds of crew supplies and special equipment to ISS
- Passengers - an anthropomorphic test device named Ripley outfitted with sensors to provide data about effects on humans traveling in Crew Dragon and a plush “Earth” zero-g indicator
- Firsts - first autonomous docking of any U.S. spacecraft to the ISS and the first use of the international docking standard to build the station’s international docking adapter and the Crew Dragon’s docking adapter



- **Hatch was closed March 7 at 12:25 p.m. EST**
- **Undocked March 8 at 2:32 a.m. EST**
- **Deorbit burn March 8 at 7:53 a.m. EST**
- **Splashdown occurred March 8 in the Atlantic Ocean off the Florida coast at 8:45 a.m. EST**





Dragon Static Fire Test Anomaly Recovery



- **Static Fire objectives:**
 - Draco check prior to In-Flight Abort Test (IFA)
 - Demonstrate integrated system Super Draco performance
- Firing of 12x service section Dracos was successfully performed
- Anomaly occurred during activation of the SuperDraco system, prior to SuperDraco firing
- Test site was fully cleared and all safety protocol was followed
- Anomaly did not result in any injuries
- NASA teams were observing the test live from SpaceX control room
- SpaceX also immediately informed NASA management of the anomaly and has continued to communicate with and include NASA teams daily throughout the investigation
- Both NASA and SpaceX immediately executed mishap plans per agency/company guidelines
- SpaceX has continued to communicate with NASA on daily basis
- Early efforts focused on site-safing, data collection/reduction, and development of the anomaly timeline
- Early NASA contributions included site inspection assets including UAV/drone flights and on-site vehicles
- SpaceX is leading anomaly investigation with active NASA participation
- Schedule replanning is underway for IFA, Demo-2 and Crew-1 schedule
- **SpaceX has multiple capsules in build for the Dragon fleet and will advance assignments of capsules to specific missions.**
 - Capsule previously intended for Demo-2 (SN 205) for will be used for IFA and the capsule intended for Crew-1 (SN 206) will be used for Demo-2, etc.
 - SpaceX is optimizing hardware configuration for each spacecraft based on intended use for those test flights

Static Fire Test Setup, April 20

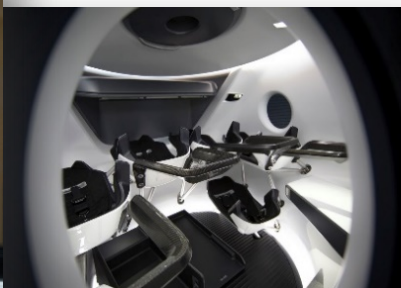




Demo-2 Vehicle Status



DM-2 Crew Watch DM-1 Ascent



Crew Dragon Interior

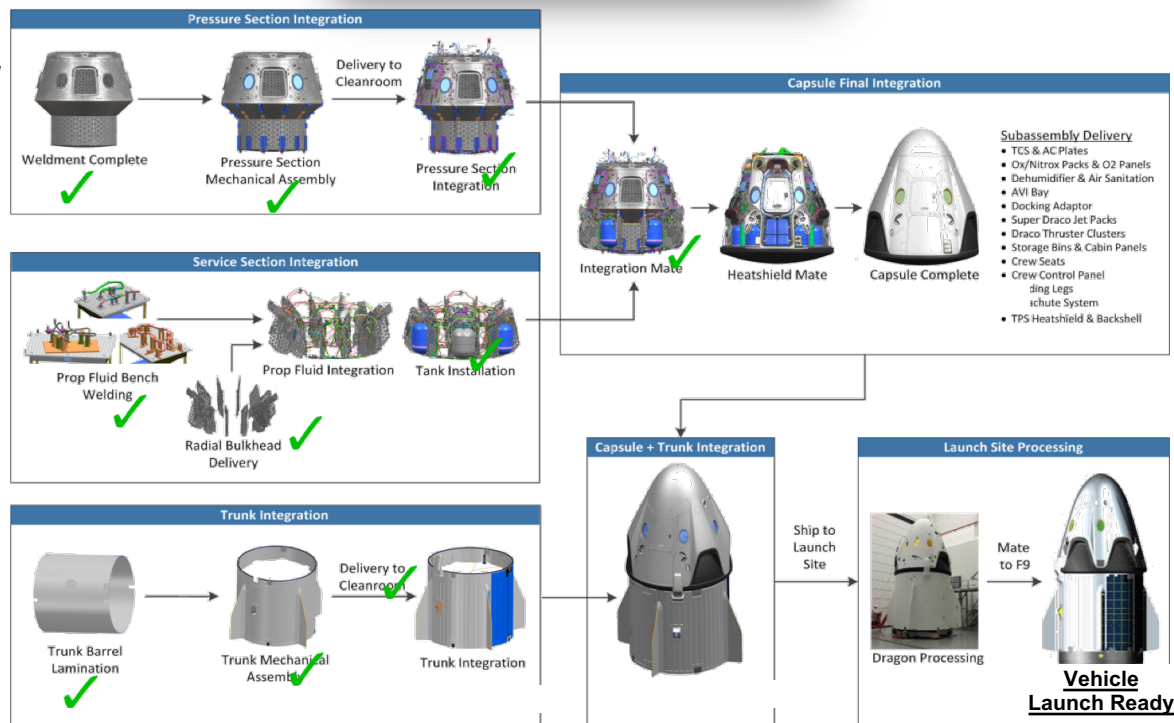


Crew Dragon Displays

Demo-2 Dragon

All Demo-2 Dragon dates under review

- Exterior TCS proof and leak testing complete
- Cabin Fans installed
- ECLSS components installed
- Propulsion System tanks installed
- Pneumatic panels and accumulators installed
- SuperDraco jetpacks installed
- Forward Bulkhead Dracos installed
- Docking System installed
- Primary heatshield and nosecone in final stages of assembly
- Trunk Mechanical Assembly delivered to Integration for Solar Array and Radiator installation





Crew-1 Vehicle Status



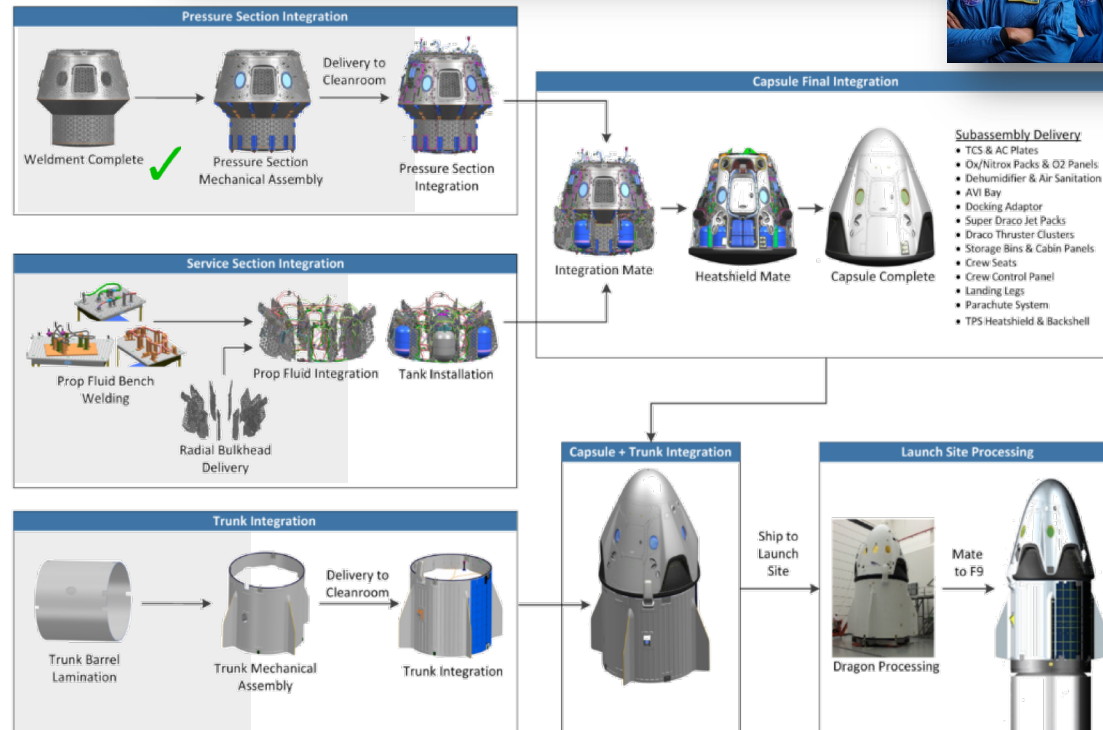
Crew-1 Dragon

All Crew-1 Dragon dates are under review

- Capsule in Main Building Clean Room
- TCS Lines and cold plate installation underway
- Prop component installation underway
- Trunk mechanical assembly started



SpaceX Meets Crew Members





SpaceX Operations Status



- **Simulations/Exercises/Training**

- Demo-2 Crew has 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



Crew Training



- **Crew Operations & 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

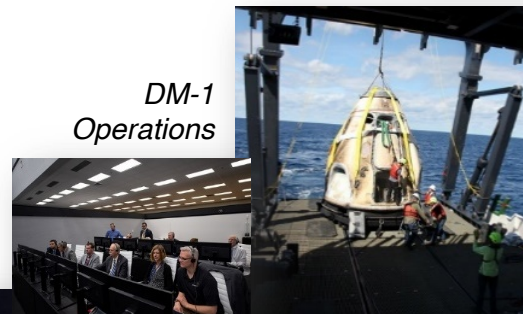
- **Full-scale Medical Triage Exercise**

- NASA medical, Decon team, DoD DET-3, NASA helo, SpaceX closeout team participation

- **Demo-1 Launch, Flight Operations, Recovery Training**

- Integrated SpaceX / NASA mission console support
- Go Searcher recovery ship for capsule recovery
- Go Navigator recovery ship for NASA observers, PAO

*DM-1
Operations*





Space Act Agreements





Blue Origin Status



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

- **Recent Progress**

- Milestone 6 Review complete Nov 2018
 - Launch site overview, Blue Moon and New Glenn updates

- **Latest Technical Exchanges**

- Parachute modeling
- Tank manufacturing
- Composite materials
- Battery technologies

- **Look Ahead**

- New Shepard NASA support for acoustics testing
- Milestone 7 Review: New Glenn development update

New Glenn



Blue Moon

New Shepard



New Shepard NS-10





Sierra Nevada Corporation Status



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

- **Recent Progress**

- Uncrewed Dream Chaser CDR complete Oct 2018
- Dream Chaser Body Assembly completing fabrication at Lockheed Martin Plant 4, slated for delivery to SNC Jul 2019
- RCS thruster testing ongoing thru summer 2019

- **Look Ahead**

- Milestones 42 & 43 Review: Dream Chaser RCS development testing and aerodynamic database review

*RCS Thruster
Testing*



*Dream Chaser Body
Assembly*



ETA Drop Test



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)
- National Reconnaissance Office (NRO)

- **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 phases of flight
- Independent investigation authority
- Update to executive order for contingency operations

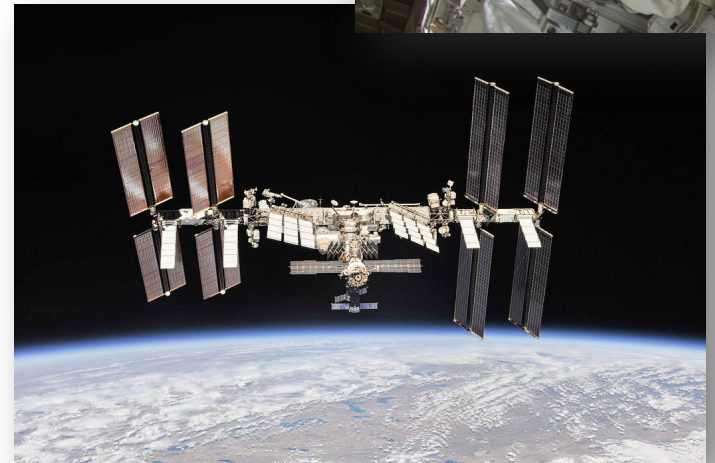
- **Spectrum Usage**

- 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**
 - SpaceX Demonstration Mission-1 flight data is being assessed
 - Program is supporting SpaceX test anomaly investigation
 - 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 crewed missions to the International Space Station**
- **CCP has robust and efficient processes for certification, including addressing waivers and deviations**
 - There is progress in burn-down of key certification products
- **Crew members have been assigned to missions**
- **Inter-agency work 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*

