Commercial Space Division Programs

NASA Advisory Committee Meeting

November 2023

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Agenda

- Commercial Crew Program (CCP)
- Commercial LEO Development Program (Comm LEO)

  (detailed status to be presented by Angela Hart)
- Suborbital Crew (SubC)

Commercial Crew Program (CCP) Status

CCP Flight Accomplishments

CCP is proud to be a new chapter in human spaceflight

SPACEX

Demo-1
Launched 03/02/19
Landed 03/08/19

BOEING

OFT
Launched 12/20/19
Landed 12/22/19

SPACEX

Demo-2
Launched 05/30/20
Landed 08/02/20

SPACEX

Crew 1
Launched 11/15/20
Landed 05/02/21

SPACEX

Crew 2
Launched 04/23/21
Landed 11/09/21

SPACEX

Crew 3
Launched 11/10/21
Landed 05/06/22

SPACEX

Crew 4
Launched 04/27/22
Landed 10/14/22

BOEING

OFT-2
Launched 05/19/22
Landed 05/25/22

SPACEX

Crew 5
Launched 10/5/22
Landed 3/12/23

SPACEX

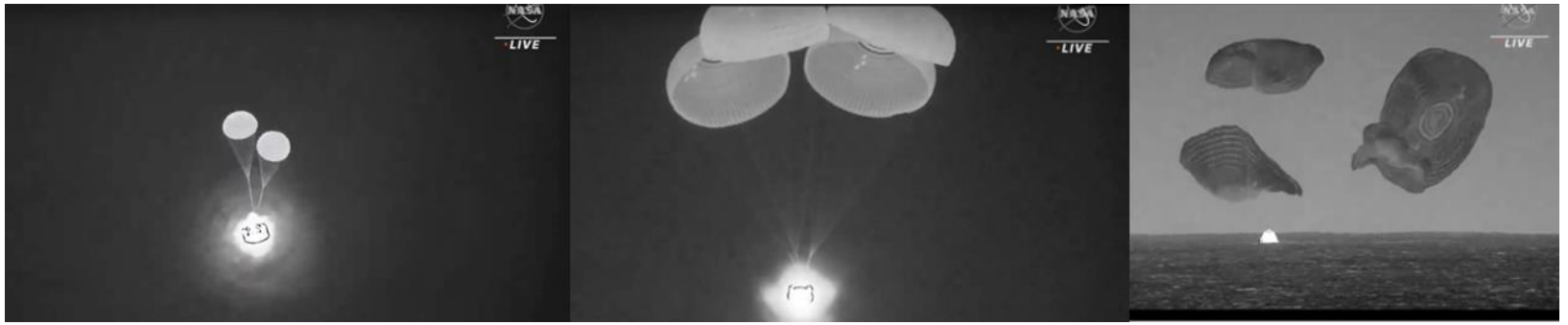
Crew 6
Launched 3/2/23
Landed 9/10/2023

SPACEX

Crew 7
Launched 8/27/2023
On-Orbit

Crew-6 Status

- Crew: Commander: Stephen Bowen (NASA); Pilot: Woody Hoburg (NASA); Mission Specialist: Sultan AlNeyadi (UAE) and Andrey Fedyaev (Roscosmos)
- Launched and docked to ISS on March 3, 2023
  - 186 days in space
  - Approximately 3000 orbits around Earth
- Undocked September 9, 2023 and splashed down September 10, 2023
  - Flew behind station and 20 km above to set up phasing for landing at Jacksonville, first time in the history of CCP.
- Sea States: 5 ft waves, winds 5 knots. Higher than past but within flight rules.



Crew-7 Status

- Launched August 26, 2023 and docked to ISS August 27, 2023
- Planned return NET early 2024 following a five-day handover with Crew-8
- Crew: Commander: Jasmin Moghbeli; Pilot: Andreas Mogensen (ESA); Mission Specialist: Satoshi Furukawa (JAXA) and Konstantin Borisov (Roscosmos)
- On July 25, NASA and SpaceX adjusted the launch date from NET 8/15 to allow SpaceX time to reconfigure the pad from a Falcon Heavy launch (EchoStar) to a Falcon 9 (Crew-7).
- Delayed one day out of an abundance of caution. Stood down at SpaceX's recommendation to ensure understood forced margin parameter on all valves for nominal and contingency scenarios.

Crew Flight Test (CFT) Status

- Crew: Barry “Butch” Wilmore, Suni Williams
  - Launch Vehicle: Atlas V
  - Starliner: Spacecraft 3 Calypso (previously flew OFT-1)
  - Dock to ISS for a minimum of 8 days
  - Landing: White Sands Missile Range
  - Fly a full mission profile, testing end-to-end capabilities of the Starliner system
- The CFT launch date is NET April 14, 2024. Backup dates of April 15th and 18th.
- All OFT-2 In-Flight Anomolies are now closed. 98% of the certification products required for the Crew Flight Test are complete. P213 Tape and parachute soft link joint issues continue remediation efforts.

- First American-made orbital crew capsule to land on land with crew
- First launch of crew from Cape Canaveral since 1968 (Apollo 7)

Other Misc CCP Activities

- Pad 40 crew launch capability

- Strengthened collaboration with the Comm LEO Program
- Collaborations for Commercial Space Capabilities-2
  - Blue Origin – Space Vehicle
  - Sierra Space – Crewed Dreamchaser
  - SpaceX – Dragon and Starship

- CCP Lessons Learned (see next slide)

CCP Lessons Learned

- **Items that were a success for CCP**

1. Mature, stable requirements and well-defined ISS interfaces led to stable design resulting in cost control.
2. Integrated vehicle and software testing including abort tests has been a key to success.
3. Streamlined board structure, flat organization, and well-sized workforce resulted in efficiency of communication and decision velocity.
4. Multi-center, flexible NASA team with strong Shuttle and ISS development experience that leveraged existing programs (e.g., LSP, CRS, and Orion)
5. Reduced number of Government Mandatory Inspection Points to focus on high-risk systems. CCP Product Assurance Actions evolved over time based on assessment of risk, hardware production, qualification, assembly, and acceptance testing.

- **Initial thoughts on where CCP could have improved in hindsight**

1. New NASA Technical Standards were challenging (e.g., Fracture Control, Mechanisms) to interpret, implement, and validate.
2. Parachute certification and testing was five decades removed from Apollo was more complex than envisioned.
3. Earlier NASA involvement in detailed component level design, detailed system design reviews and additional hardware and system level integrated testing could have identified problems earlier.
4. Spacecraft propellant systems due to combined ascent abort and on-orbit functions were much more complicated that originally envisioned.
5. Improved plans for reusability in the early phases of the Program.

Commercial LEO Development Program Status

(detailed status to be presented by Angela Hart)

COMMERCIAL LEO DEVELOPMENT PROGRAM

ISS-to-CLD Transition

2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031

Planned ISS Deorbit

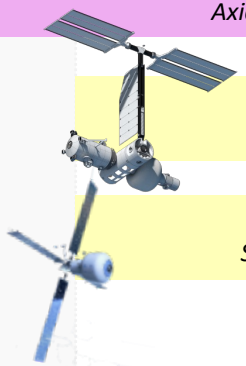
International Space Station (ISS) Operations

CLD Operations
overlapping ISS to CLD operations

CLD Phase 1: Design Maturation

Commercial Destinations for ISS (CDISS)
Axiom Space

2-year Option



Commercial Destinations Free Flyer (CDFF)
Orbital Reef - Blue Origin, Sierra Space

Commercial Destinations Free Flyer (CDFF)
Starlab - Nanoracks, Voyager Space, Airbus, Northrop Grumman

Collaborations for Commercial Space Capabilities (CCSC-2) – unfunded SAAs
Northrop Grumman, Blue Origin, Sierra Space, SpaceX, SAS, Think Orbital, Vast Space

CLD Phase 2: Certification and Services

NASA Certification of CLD(s) and Purchase Services
Full and open competition, one or more awards

Transition Challenges

- The timeline associated with completing CLD development prior to ISS retirement is a major schedule risk.

  NASA has a multi-pronged strategy to address this schedule risk:

  1. NASA is engaged with multiple CLD providers (3 funded partners and 4 unfunded partners). Having more than one company developing CLDs mitigates the risk of relying on a single provider and enables NASA to gain the benefits of competition.
  2. NASA's transition plan includes an overlap period between CLD operations and ISS end-of-life. Ideally, the overlap would be approximately two years, but less than that is certainly feasible, and this provides some schedule margin.
  3. If CLDs were not ready by the planned retirement of ISS at the end of 2030, NASA could request an extension in the operation of ISS (assuming the ISS was still healthy and safe at that time).
  4. If all the above mitigations fail, a temporary gap in the availability of a LEO destination would result, which could impact the achievement of commercialization objectives, as well as development activity for exploration beyond LEO.

Transition Challenges (2)

- In addition to all the normal technical challenges associated with developing a human spaceflight system, the CLD providers have the additional challenge of making the CLD work as a business.
- All of our CLD providers (funded and unfunded providers) are doing in-depth investigations into the business considerations of CLDs. Those investigations are all specific to the providers. They are dependent on the technical configuration of their CLD, the cost structure associated with that technical configuration, their pricing, their investment strategy, their corporate strategy and risk tolerance, and their customer capture strategy. All those things are integral to a business assessment, and they are all currently "in work".
- This is why NASA established the two-Phase strategy for CLDs. The current first phase was deliberately set up to enable our industry partners time to mature their technical and business considerations listed above. It also enables NASA to mature its technical and performance requirements, which are also "in work".
- These areas should be sufficiently mature by 2026 so that NASA can make an informed decision regarding Phase 2.

Suborbital Crew (SubC) Status

SubC Objectives

- **SubC engages industry partners in an innovative "Safety Case" approach to meet Agency objectives**

1. Fostering the development of commercial space through technical insight, engagement and advocacy for safe and reliable systems

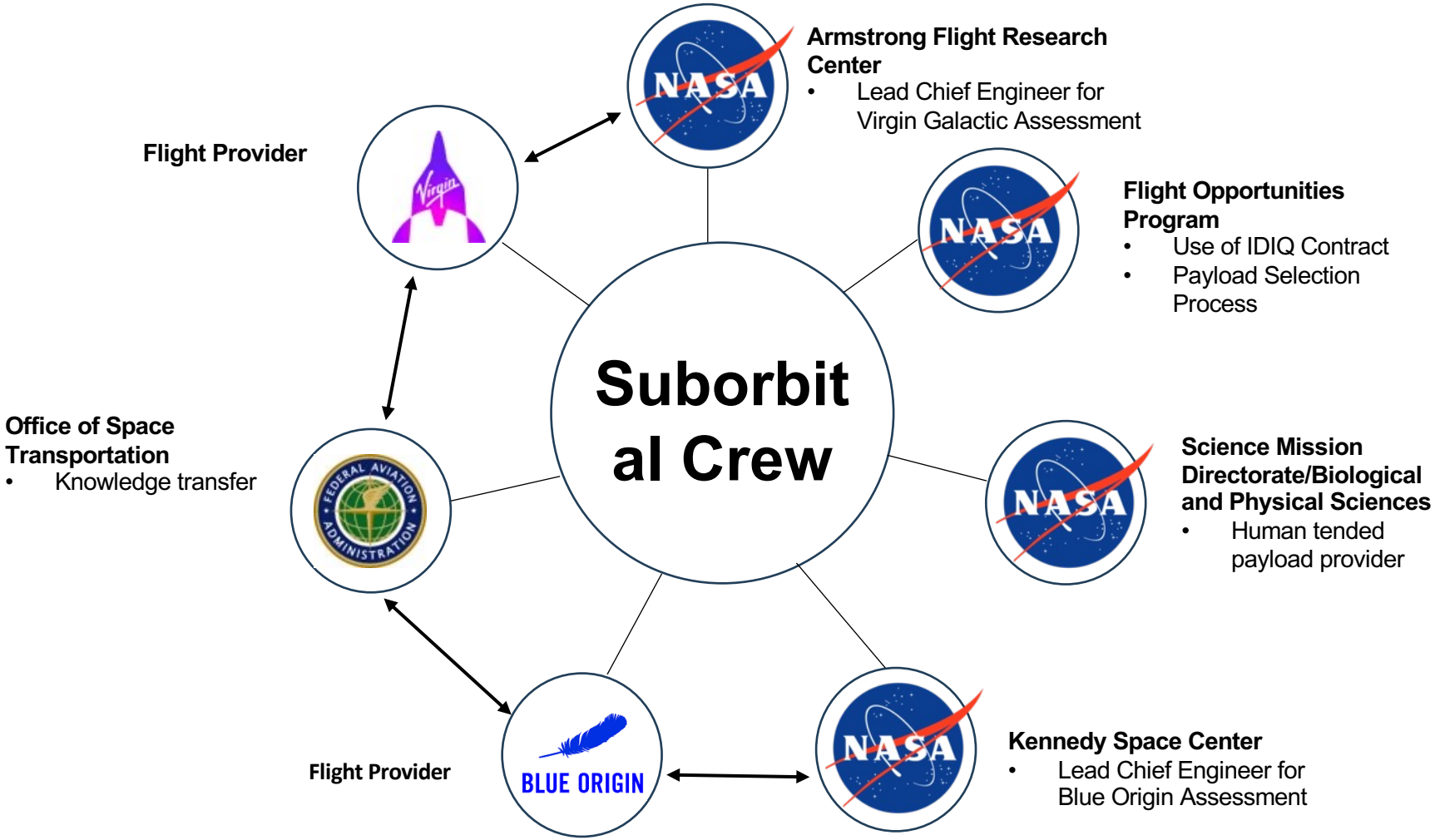
2. Partnering with the FAA on lessons learned and capabilities to ensure a streamlined transition to regulation of passenger safety in space

3. Expanding research platforms available to the Agency to support human tended research in micro gravity

Suborbital Crew Program

- SubC continues to engage Blue Origin and Virgin Galactic in an innovative “Safety Case” approach to meet Agency objectives
  - These objectives include expanding acceptable platforms available to Civil Servants to support human-tended research in microgravity
  - Partnering with the FAA on lessons learned and capabilities to ensure a streamlined transition to regulation of passenger safety in space
- SubC Safety Case approach utilizes an evidenced-based paradigm without specific direction or requirements
  - Safety Case approach relies on a Provider’s internal human certification process along with targeted engineering and safety reviews into higher risk systems to substantiate a recommendation to the Agency whether to allow Civil Servants to fly on their suborbital vehicles.

Suborbital Crew Big Picture



Potential Human-Tended Payloads

- SubC sent out a call for payload ideas on NASA@Work
  - 32 responses, including areas such as medical devices, medical capability, fluids, ECLSS, planetary imaging, communications, biology, physical and life sciences, etc.
- The SubC team and Flight Opportunities co-chaired a HQ workshop which provided the more than 35 attendees a top-level view of past, current, and future opportunities in human-tended suborbital technology development and testing
  - Over 60 ideas for human-tended payloads were collected
- Several research ideas submitted are good candidates for suborbital flights and are being evaluated further

- In-flight Testing of the NASA E-Nose, a Novel Technology for Non-invasive Medical Diagnostics in Space
- Goggle-Based Visual Field Device: To Detect and Monitor Severe Spaceflight Neuro-Ocular Syndrome (SANS)
- rHEALTH Awesome: Point-of-Care Diagnostics in Microgravity
- SKYE Sensor for Suborbital Flight
- Low-Power, Microgravity Air Quality Measurement System for Small Crew Cabin Environments
- Intravenous Fluid Generation (IVGen) Mini - Air Elimination from Potential Bad Bubbles Microgravity
- Inner Ear Fluid Research - Fluid Ear Research Novelty (FERN)
- In-Situ Preparation of Sample
- Seeing the Effects of Microgravity on Electrolysis Efficiency
- Wet Lab Feasibility Study
- Evaluation of a Bio-electrochemical Wastewater Recycling System in Microgravity
- CO2 Ice Nucleation From Direct Air Capture in Microgravity
- FLUTE: Fluidic Telescope Experiment
- Eclipse Run - Apogee in Umbra
- Lightweight Deployable Integrable Antenna (LiDIA)
- Intelligent Personal Astronaut Assistants

Summary

- CCP is delivering on its goal of safe, reliable and cost-effective transportation to and from ISS from the United States through a partnership with American private industry
- The Comm LEO Program continues to make good progress on development milestones, program requirements, and certification strategy.
- SubC represents a potential significant innovation for human spaceflight systems.