

CLDP Status to NASA Advisory Council (NAC)



**COMMERCIAL LEO
DEVELOPMENT
PROGRAM**

November 2023

Angela Hart
Manager, Commercial LEO
Development Program

Agenda



























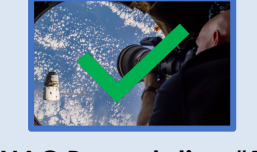





- **Phase 1 Commercial LEO Destinations (CLD)**
 - **Commercial Destinations Free Flyers (CDFF)**
 - **Axiom Commercial Destination on International Space Station (CDISS)**
 - **CLD Requirements Development**
 - **Commercial LEO Acquisition Strategy Plan**
- **Collaboration for Commercial Space Capabilities - 2 (CCSC-2)**
- **Private Astronaut Missions (PAM)**
- **Open work and Concerns**

Commercial LEO Destinations (CLDs)

Current Commercial LEO Destination Partners



Key Program Milestones

2020	2021	2022	2023
 <p>Program Established at JSC</p>	 <p>PAM #1 Mission Order Signed</p>  <p>Commercial Destination Free Flyers SAAs Solicitation & Awards</p>	 <p>Ax-1 Mission</p>  <p>RFI #1 Released CLD Requirements</p>  <p>PAM #2 Mission Order Signed #3 & #4 Solicitation Released</p>  <p>Industry Day #1 CLD Requirements</p>	 <p>Ax-2 Mission</p>  <p>CCSC-2 Solicitation & Awards</p>  <p>PAM #3 Mission Order Signed</p>  <p>RFI #2 Released CLD Requirements</p>  <p>PAM #4 Mission Order Signed</p>  <p>Industry Day #2 CLD Requirements</p>
 <p>Axiom Station Contract Signed</p>	 <p>PAM #2 Solicitation</p>  <p>CLD Phase 1 & 2 Strategy Industry Day</p>	 <p>SBIR Phase 1 Award</p>  <p>Axiom Station System Design Review</p>  <p>Starlab GWC Payload System Requirements Review</p>  <p>Orbital Reef System Definition Review</p>	 <p>RFI #3 Released CLD Requirements</p>  <p>Industry Day #3 CLD Requirements</p>  <p>Northrop Grumman & Starlab Teaming Agreement</p>  <p>Additional Milestones & Funding for CLDs</p>  <p>Axiom Station Modules 1 & 2 Fabrication Started</p>
 <p>PAM #1 Mission Solicitation</p>	 <p>NAC Presentation #1</p>	 <p>Northrop Grumman CDF-Level System Requirements Review</p>  <p>Northrop Grumman CDF-Level System Design Review</p>	 <p>Axiom Station Critical Design Review Started</p>  <p>Starlab System Design Review</p>  <p>Orbital Reef Core Module Structural Test</p>

2023 Accomplishments – CLD Partners



Nanoracks / Voyager as part of Starlab Station announced a trans-Atlantic Joint Venture with Airbus and teaming with Northrop Grumman

Orbital Reef and Sierra Space inflatable LIFE Habitat completes stress test at MSFC



Fabrication for primary structure for first two modules of the Axiom Space Station are underway at TASI.

Orbital Reef completed their Burst Test of the Sierra LIFE Module in Dec of 2022



Latest CLDs Developments (1)

Blue Origin:

- **October 2023:** Finalizing Window Demonstration test and Core Module Structural test. Final test reports in work.
- Updated commitment with SNC.

Northrop Grumman:

- NG termination by mutual consent for their Funded Space Act Agreement. This change will not affect their Unfunded Space Act Agreement.

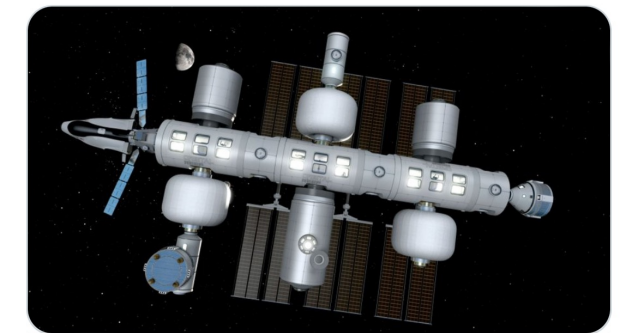
Nanoracks:

- Voyager Space/Nanoracks **announced teaming agreement** with Northrop Grumman along with Joint Venture.
 - [NASA Partners Combine Efforts for Low Earth Orbit Commercial Station - NASA](#)
 - [Voyager Space Announces Teaming Agreement with Northrop Grumman for the Starlab Space Station \(prnewswire.com\)](#)
- **June 2023:** Starlab System Readiness Review Milestone
- **October 2023:** Optical Link Demonstration Program Plan Validation Milestone; Starlab System Design Review Milestone and Alternative Urine Processor Demonstration Program Plan Validation Milestone



Follow ...

We're fully committed to working with NASA to ensure a continued human presence in low Earth orbit. @SierraSpaceCo is a big part of this effort and continues to provide deliverables for our NASA CLD Phase 1 contract. We're all in on CLD Phase 2.



11:55 AM · Oct 10, 2023 · 4,479 Views

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Latest CLDs Developments (2)

Axiom:

- Planned the **Axiom Hab 1 (first element)** subsystem CDRs with NASA.
- Fabrication for **primary structure for first two modules** underway at TASI.
- Long lead system procurements for **flight and development hardware** underway.
- Jointly **developing hazard reports and controls/mitigations** as per the standard design/ISS processes with NASA.
- Continue to work with NASA and other stakeholders to help **mature subsystems, safety, and concepts of operation** ahead of NASA CDR.
- Axiom Hab 1 hatches have been fabricated and tested and **prepared for delivery to TASI** to support Hab 1 pressure testing.



Axiom AI&T facility at the Houston Spaceport



Axiom Station attached to ISS

CLD Upcoming Activities

Axiom:

- CDR underway to conclude in **2024**
- Delivery of first 2 modules from TASI – **2024**
- Commissioning of the Axiom Assembly, Integration & Testing (AI&T) facility at the Houston Spaceport – **2024**
- Partnerships with University of Texas at El Paso (UTEP) and NASA/JSC are in work to support propulsion development and testing.
- Proposals for the Axiom Remote Manipulator (Axiom robotic arm) are being evaluated.

Blue Origin:

- ECLSS Tests, including Urine Water Recovery, Water Tank, Water Contaminant Oxidation, Trace Contaminant Control - **Q1 FY24**
- Full-Scale Burst Test for the LIFE module - **Q2 FY24**

Nanoracks:

- Commercial Business Model Review and Low Fidelity Mockup Milestone - **Q1 FY24**
- Starlab Architecture and Requirements Review Update Milestone - **Q1 FY24**

Requirements Development Status

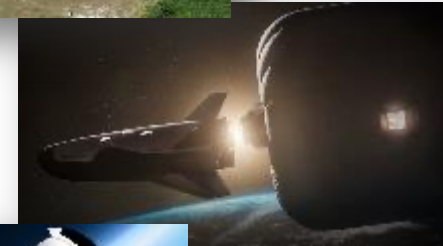
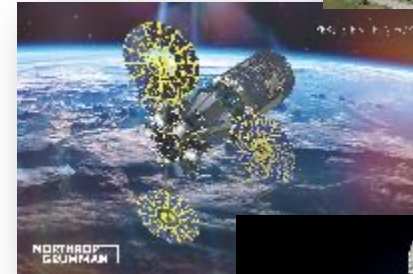
- **RFI #3 - Draft CLDP-REQ-1130** includes functional systems requirements and standards for destination and transportation services.
 - Released September 30th to industry; **Comments on the RFI were due on November 17.**
 - Does not include cargo or utilization requirements or verifications.
 - Key areas not included in this draft will be **updated in future revisions.**
- **Key questions being asked as part of RFI #3:**
 1. Are there any requirements or standards that are unclear, conflicting or ambiguous? If so, what are the recommended improvements?
 2. Other than the undeclared items, are there any requirements excluded that need to be addressed?
 3. Are there any requirements or standards that unreasonably restrict design or impact commercial development cost or schedule? If so, what are the recommended improvements?
 4. Do you have additional information you would like to share with NASA significant to the finalization of these requirements and standards?



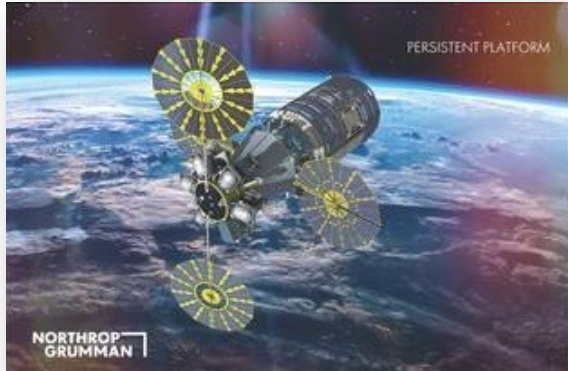
Collaborations for Commercial Space Capabilities

Collaborations for Commercial Space Capabilities - 2 (CCSC-2)

- **Second series of unfunded SAAs** with US industry to support the **development of new space capabilities** relevant to NASA's exploration strategy
- Partners receive **access to unique NASA know-how, data, and technical resources**, where available
- **7 competitively-selected SAAs were awarded in June 2023**
 - **Blue Origin**, Kent, WA
 - **Northrop Grumman Systems Corp.**, Dulles, VA
 - **Sierra Space Corp.**, Broomfield, CO
 - **Space Exploration Technologies Corp.**, Hawthorne, CA
 - **Special Aerospace Services**, Boulder, CO
 - **ThinkOrbital Inc.**, Lafayette, CO
 - **Vast Space LLC**, Long Beach, CA
- **NASA press release:**



CCSC2



Northrop Grumman – Crew tended Persistent Platform that works with NG’s CDFF and be used for other applications



Sierra Space - Pathfinder CLD with inflatable module and DreamChaser DC200 for crew and cargo



Blue Origin – New Glenn reusable launch system with crewed Space Vehicle, and in-space common bus



Special Aerospace Services – A robotic MMU-like system for external CLD ops instead of EVAs. Later versions can support suited crew.



SpaceX – Starship as a CLD (first with Dragon for crew and cargo, later as crewed sortible CLD). Related Dragon and Starlink upgrades.



ThinkOrbital – A system to robotically assemble and weld very large pressurizable modules for CLDs in-space



Vast Space – Single – module / launch CLDs with intent demonstrate spinning to generate partial gravity

Collaboration for Commercial Space Capabilities – Accomplishments and Upcoming Activities

7 CSCC2 Unfunded SAAs - Commercial LEO Development Program is teaming with Commercial Crew Program to provide **support for Destinations, In-space Capabilities and Transportation**

Blue Origin: 9/2023 – Supported Partner's Kickoff Meeting

Northrop Grumman: 9/2023 – Supported Partner's Kickoff Meeting

Sierra Space:

- 9/2023 – Supported Partner's Kickoff Meeting
- 9/2023 – Supported Partner's Milestone 1: Pathfinder System Req'ts Evaluation
- 10/2023 – Planning to support Partner's Milestone 2: Pathfinder Soft Goods Test and Payload Review

SpaceX:

- 11/2023 – Planning to support Partner's Kickoff Meeting
- 11/2023 – Planning to support Starship Test Flight 2

Special Aerospace Services: 9/2023 – Supported Partner's Kickoff Meeting

ThinkOrbital: 9/2023 - Supported Partner's Kickoff Meeting

Vast Space: 9/2023 - Supported Partner's Kickoff Meeting

Managing R&D efforts relevant to US commercial space flight industry

- 5 with U.S. Universities (NASA EPSCoR), and 2 with Small Businesses (NASA Ignite SBIR)



Sierra Space –
Dream Chaser and Pathfinder



SpaceX - Starship



Vast Space – Haven-1

Private Astronaut Missions

2023 Accomplishments – PAMs



**Axiom-2 Crew Mission
completed in May of 2023**



Marcus
Wandt

Michael
López-Alegría

Walter
Villadei

Alper
Gezeravci

**The Axiom-3 Crew was announced in
September of 2023
Axiom-4 Awarded**

Ax-3 Mission Summary

PAM/Launch Provider: Axiom Space on SpaceX Falcon 9 /Crew Dragon

Mission Duration: 16 Days, 14 Docked Days

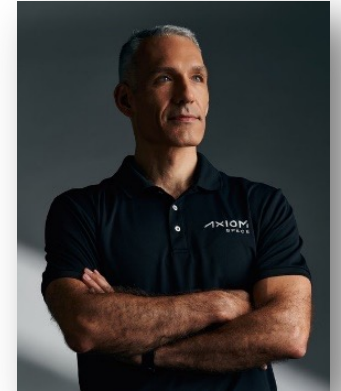
Launch Date: NET January 2024

Mission Overview & Status:

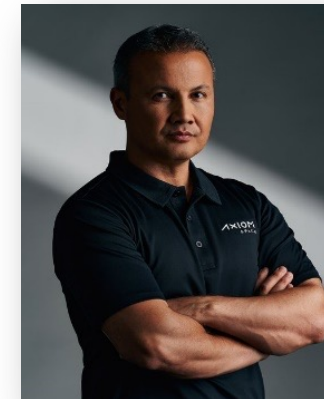
- Mission to include outreach, human research, technology demonstrations, Earth observation, and commercial activities.
- The prime crew consists of:
 - **PAM Commander:** Michael López-Alegría (2nd Mission as PAM Commander)
 - **Pilot:** Walter Villadei (Italy)
 - **Mission Specialists:** Alper Gezeravci (Türkiye) and Marcus Wandt (Sweden-ESA project astronaut)
- Vehicle Baseline Review was held on **May 4th**
- Crew Extreme Environment and Suitability Interviews **successfully completed**
- Crew training began on **June 20th**
- Discussions between Axiom and SpaceX for **potential use of SLC40 for PAM-3 launch**
 - SLC40 is not currently certified by NASA and will not be to support Ax-3 activities in January



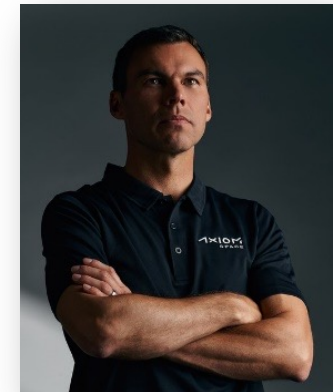
**Michael
López-Alegría**



Walter Villadei



**Alper
Gezeravci**



Marcus Wandt

Summary

How Can NAC Help?

- Continue to advocate for the importance of the Commercial LEO Development Program within the National Space Policy Community.
 - Advocacy for future regulatory framework is needed to support future success.
- In order to avoid a gap in LEO the program will need sustained budgetary support as CLD Partners begin to fully develop their designs.
 - Starting the Phase II certification is critical to maintaining industry capability and managing schedule risk





QUESTIONS

