

Commercial LEO Development Program Overview for BPAC

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November 16, 2022



COMMERCIAL LEO
DEVELOPMENT
PROGRAM

Agenda

- COMMERCIAL LEO ECONOMY GOALS
- COMMERCIAL LEO DEVELOPMENT PROGRAM ROAD MAP
- COMMERCIAL LEO DESTINATIONS (CLDS)
 - ACQUISITION STRATEGY
 - REQUIREMENTS PLANNING
 - CLD PARTNERS
- PRIVATE ASTRONAUT MISSIONS
 - AX-1
 - FUTURE PAMs

Commercial LEO Economy Goals



1. Create a robust commercial LEO marketplace with commercially-owned and operated LEO destinations that are safe, reliable, cost-effective and allows NASA to be one of many customers in space.
2. Ensure NASA can meet its needs in Low-Earth orbit, as it transitions from International Space Station operations to new commercial LEO destinations.
3. Maintain a sustained presence in LEO and pre-eminent U.S. leadership in LEO.
4. Drive down costs through LEO commercialization so that NASA can free up resources to be used for future missions.
5. Utilize inventive, nontraditional agreements for acquiring commercial space goods and services to meet NASA requirements.

COMMERCIAL LEO DEVELOPMENT PROGRAM ROAD MAP

Near Term

Mid-Term

Far Term

International Space Station (ISS) Operations

Commercial LEO Destinations (CLDs) Development

CLD Operations

Phase 1: Early Design Maturation

Phase 2: Certification & Services

Design and Development

LEO economy developed by enabling a supply side and actively maturing a sustainable demand side

S
U
P
P
L
Y

Commercial Destinations
on ISS (CDISS)

Commercial Destinations
Free Flyer (CDFF)

D
E
M
A
N
D

Demand Stimulation (In-Space Manufacturing, R&D to Applications)

ISS National Lab/CASIS (Science, Applied R&D, Tech Dev, STEM)

Commercial Use of ISS (Commercial and Marketing Activities)

Private Astronaut Missions (Tourism)

Gov't LEO Requirements (Human Research, Life & Physical Sciences)

Transition

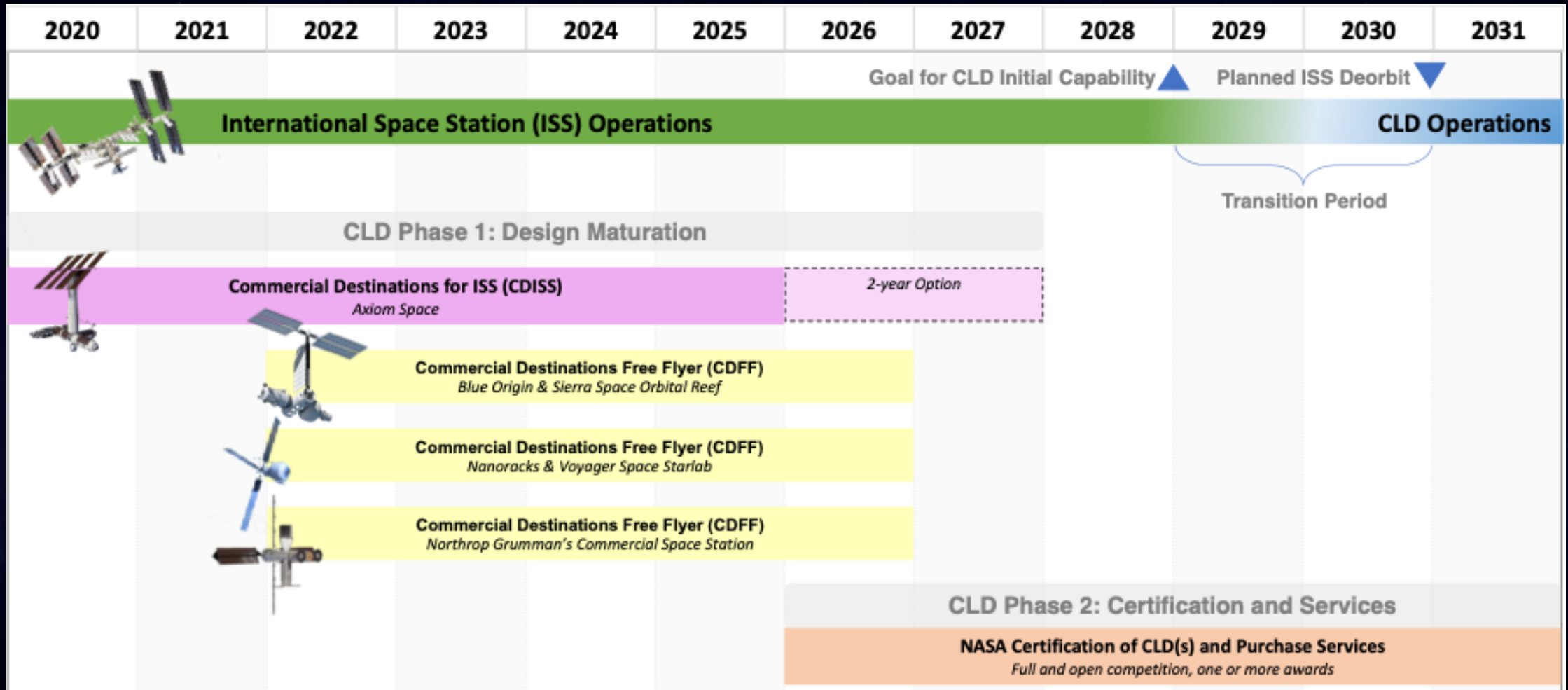
*Plan based on NASA
readiness,
maturation of
destinations, and
market demand*

End Goal

*Sustainable
Commercial
Operations with
multiple customers*

**Transition LEO Economy
Activities from ISS to
Commercial Destinations**

Acquisition Strategy



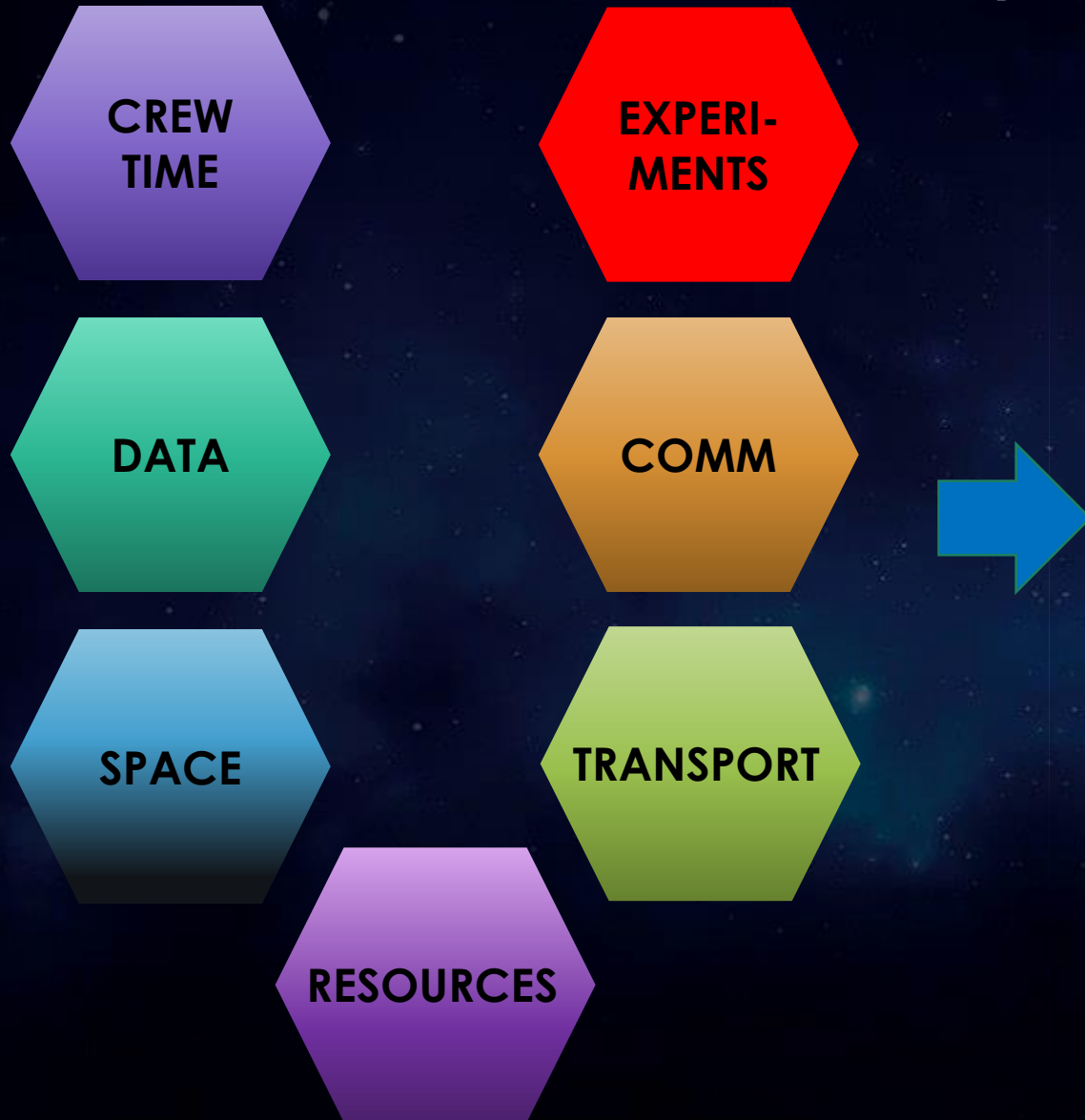
Crew Safety Requirements

- In May 2022, NASA released the first of several Request for Information (RFI) documents that contained draft crew safety requirements and a white paper documenting the agency's current assumptions and expectations on CLDs.
 - Ten (10) companies responded, including all four CLD partners.
 - Approximately 300 total comments were received.
 - The vast majority of the comments were questions, not comments. Respondents wanted more information, clarifications, and better/more definitions.
 - Industry feedback on key assumptions has been incorporated into the development of the detailed crew and vehicle requirements.
- Plans in work for 2023:
 - RFI-3: CLD Concept of Operations White Paper
 - Industry Workshops on Safety Approach and Certification Strategy
 - RFI-5: Transportation, Destination, and Services Requirements document

Service (Utilization) Requirements

- NASA has communicated to industry the agency's future needs in low-Earth orbit:
 - Continuous accommodations and training for at least two crew members
 - Conduct approximately 200 investigations annually
 - These were rough estimates and published in a White Paper in 2018 and updated in 2019
- NASA has been refining these estimates with all the NASA utilization communities (Human Health, Technology Demonstrations, Biological and Physical Sciences, Earth Science and Heliophysics) and the ISS National Lab.
 - Utilization needs include: crew time, number of experiments, data, communications, storage and volume, up/down mass, and other resources.
- In addition, NASA has identified a list of multi-user "core capabilities" needed for CLDs (e.g., gloveboxes, conditioned stowage, centrifuge, incubators, etc).
- Plans in work for 2023:
 - RFI-2: Multi-User Core Capabilities white paper
 - RFI-4: Service (Utilization) white paper
 - RFI-5: Transportation, Destination, and Services Requirements document

Service (Utilization) Requirements



Crew Time

- Average & Max Crew Time Hours

Experiments

- Average & Max number of experiments

Data

- Number of IT assets (e.g. computers or iPads)
- Digital Storage Capacity (terabytes)
- Data Transmission Rate (mbps)

Comm

- Lines for audio, video, imagery, data

Space

- Number of ISPR-Equivalent Racks
- Glovebox Equivalent
- Conditioned Stowage Volume

Transport

- Mass launch, return, and disposal

Resources

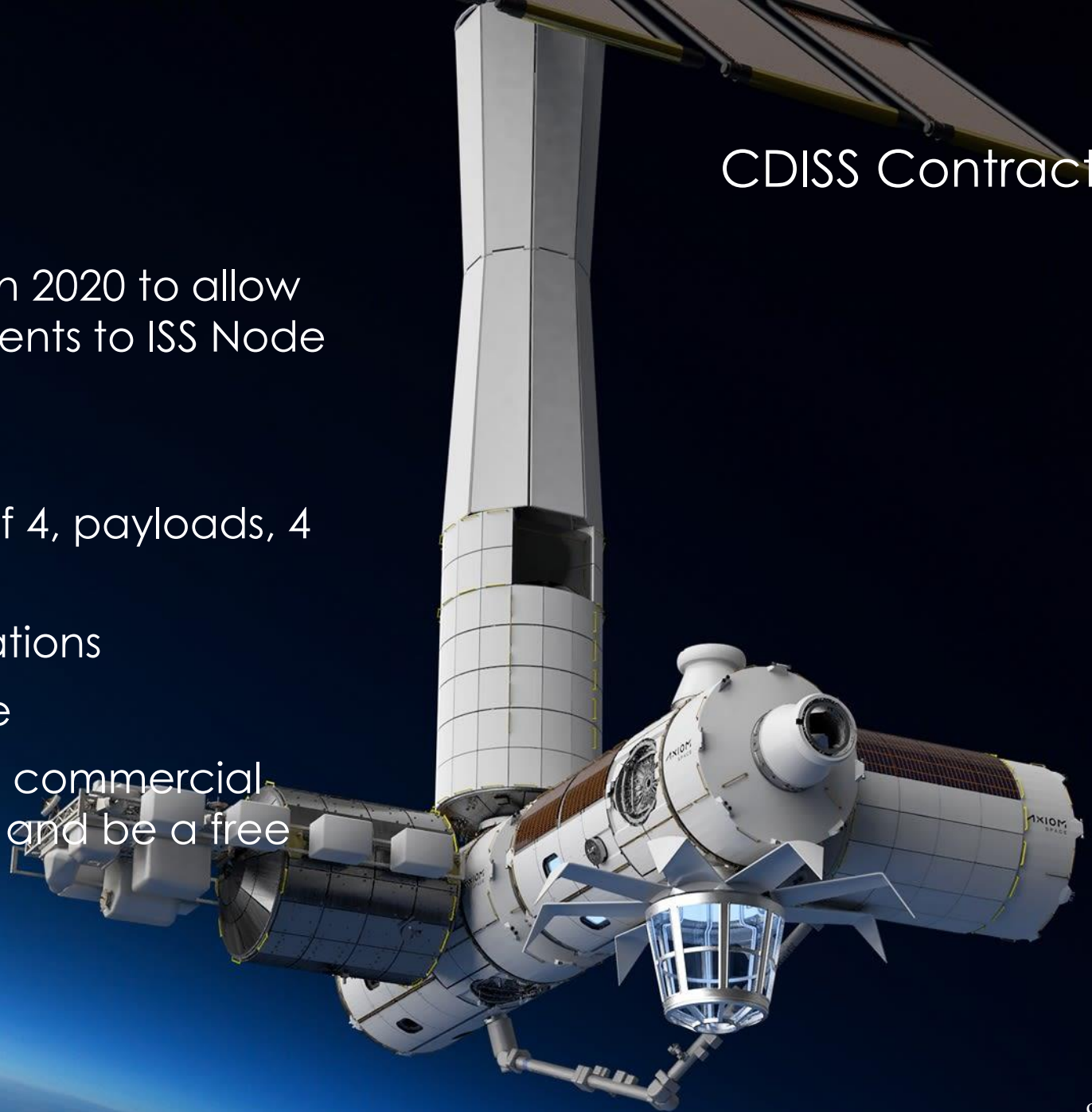
- Power Draw
- Supply Pantry
- Potable Water
- Thermal MTL/LTL
- Vacuum Vent



CDISS Contractor

- Axiom was awarded a contract in 2020 to allow attachment of Commercial Elements to ISS Node 2 Forward Port
- Launch schedule 2024 - 2027:
 - AxH1 accommodates crew of 4, payloads, 4 ports
 - AxH2 with same accommodations
 - AxPTM Power Thermal Module
- After launch of AxPTM, the Axiom commercial element would separate from ISS and be a free flyer

CDR Date:	2022-23
IOC Date:	2024
# of crew at IOC:	4



- Orbital Reef features:
 - Spacious modules with large Earth-facing windows
 - Scalable permanent presence
 - Baseline configuration offering 90% of ISS's volume, capacity for 10 astronauts, and multiple internal and external payloads
- Team:
 - Blue Origin – modules, New Glenn launch
 - Sierra Space – modules, Dream Chaser
 - Boeing – Science module, Starliner
 - Redwire Space – Deployed structure, R&D ops
 - Genesis Eng Services – Single Person Spacecraft
 - Arizona State Univ – R&D support and outreach



CDR Date:	2024
Baseline Config (BC) Date:	2027
# of crew at BC:	10



Nanoracks

LOCKHEED MARTIN



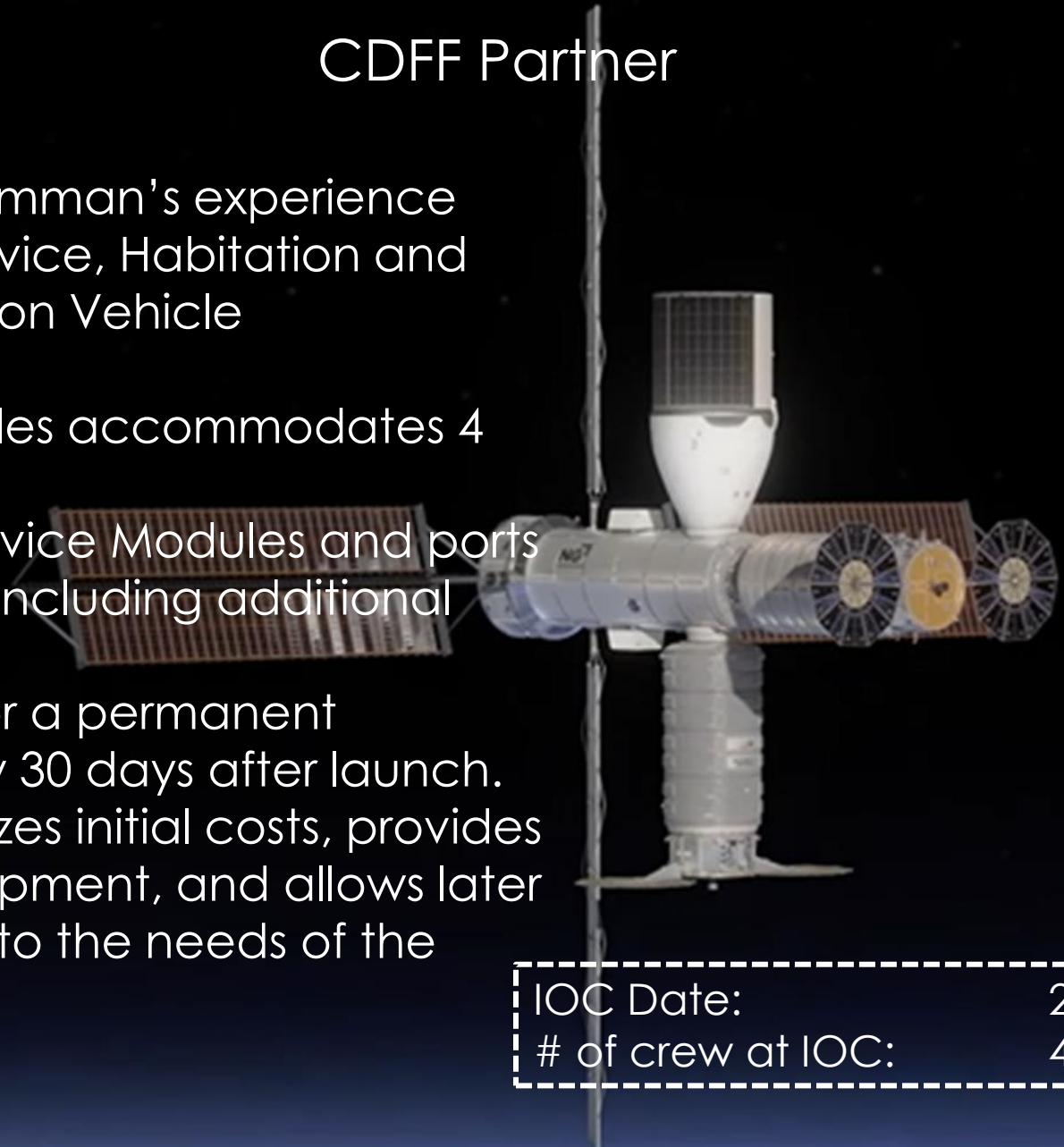
CDFF Partner

- Starlab consists of a large inflatable habitat and a metallic docking node, power and propulsion element, and external robotic arm
- Single launch in 2027
- Includes George Washington Carver (GWC) Science Park laboratory to host advanced research, science, and commercial capability
- The park features four main operational departments: biology lab, plant habitation lab, physical science and materials research lab, and open workbench area
- Spacious volume over 340 cubic meters

CDR Date:	2025
IOC Date:	2027
# of crew at IOC:	4

11/16/2022

- CLD concept builds on Northrop Grumman's experience from the Cygnus Cargo Resupply Service, Habitation and Logistics Outpost, and Mission Extension Vehicle
- Three-stage approach:
 - Stage 1 – Hab and Service Modules accommodates 4 crew, launched in 2029
 - Stage 2 – Additional Hab and Service Modules and ports
 - Stage 3 – Enhanced capabilities including additional labs
- NG Space Station (NGSS) provides for a permanent presence of four crew approximately 30 days after launch.
- Overlapping stage approach minimizes initial costs, provides revenue to offset subsequent development, and allows later capabilities to be added according to the needs of the emerging LEO market



IOC Date:	2Q 2029
# of crew at IOC:	4

AX-1 Private Astronaut Mission

- **Axiom Space on SpaceX Falcon 9 /Crew Dragon**
- **April 8 – 25, 2022**
- **The Axiom crew had a successful mission and completed all nominal mission objectives including:**
 - **Over two dozen ISS National Lab sponsored payloads**
 - **Over 50 live video events using NASA and ESA media assets**
 - **A multitude of educational outreach, commercial, and media activities.**
 - **20 commercial activities**
- **Nominal mission was extended to deconflict with a planned Russian EVA and await favorable return weather.**
- **Ax-1 returned hundreds of kilograms of NASA hardware, including conditioned science, an expended NORS tank, and EVA hardware for ground evaluation.**
- **Lessons Learned were compiled and incorporated into future PAM solicitations.**



Future Private Astronaut Missions

- **Axiom was selected for the second private astronaut mission, Ax-2, in December 2021**
 - **Mission Duration: 10-14 days**
 - **Launch Date: Mission is scheduled for Q2 2023**
 - **Axiom proposed a similar mission, objectives, and crew complement as Ax-1**
 - **AX-1 Lessons Learned have been incorporated into AX-2 contract**
- **Future Solicitation**
 - **Requirements were based on Ax-1 Lessons Learned**
 - **Request for Proposal (RFP) released on September 14th for the next two PAM flight opportunities, PAM-3 and PAM-4**
 - **Preproposal conference: Sept 16th**
 - **Proposal due: Oct 27th**
 - **Tentative award: Late 2022/Early 2023**

