National Aeronautics and Space Administration

EXPLORE HUMANS *in* SPACE

HEO NAC

Commercialization of Low-Earth Orbit

Doug Comstock
October 2019

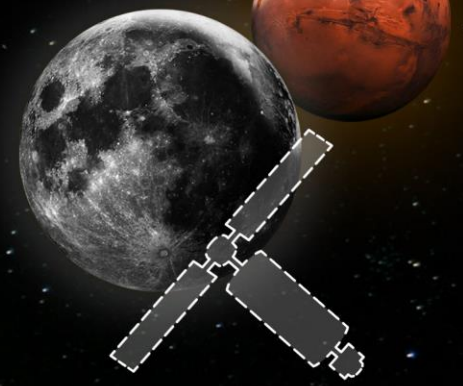
Goals for Human Spaceflight in LEO

- It is the sense of Congress that “an orderly transition for United States human space flight activities in low-Earth orbit from the current regime, that relies heavily on NASA sponsorship, to a regime where NASA is one of many customers of a low-Earth orbit commercial human space flight enterprise may be necessary.” *P.L. 115-10, NASA Transition Authorization Act of 2017*
- The President’s 2020 Budget: Drives toward a Vibrant, U.S.-Led Economy in Earth Orbit. The Budget provides funding for the International Space Station as well as for new commercial space capabilities that will facilitate a transition to a more robust and cost-effective approach to human space activities near the Earth. By 2025, the Budget envisions commercial capabilities on the International Space Station as well as new commercial facilities and platforms to continue the American presence in Earth orbit.
- Four goals from Oct 2018 NASA/Commerce/State report to the National Space Council: *Strategy for Human Spaceflight in LEO and Economic Growth in Space*
  1. To achieve a continuous U.S. presence in LEO – both with government astronauts and with private citizens – in order to support the utilization of space by U.S. citizens, companies, academia, and international partners and to maintain a permanent American foothold on the nearest part of the space frontier.
  2. To create a regulatory environment in LEO that enables American commercial activities to thrive.
  3. To conduct human spaceflight research in LEO that will advance the technology and systems required for long-duration spaceflight systems, including systems for interplanetary travel and permanent space habitation.
  4. To expand and extend commercial opportunity through international partnerships and engagement.

NASA's Vision for Economic Development in Low-Earth Orbit

LONG-TERM

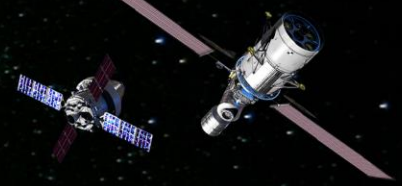
- Private sector owns and operates LEO destinations
- Industry activities including manufacturing, marketing, and entertainment thrive in LEO
- ISS assets are completely transitioned at end of life
- NASA purchases continued R&D Services from commercial providers at lower costs than on ISS
- NASA and International Partners are freed up to shift focus and resources towards exploration



FUTURE COMMERCIAL DESTINATIONS

MID-TERM

- NASA and commercial partners work together to develop and demonstrate new LEO destinations
- NASA continues to support R&D needs and ISS National Laboratory needs
- NASA incorporates International Partner commercial needs
- Phased transition from ISS to commercial platforms with attached and/or free flyers is initiated
- NASA and commercial partners work together to stimulate global demand and catalyze new markets

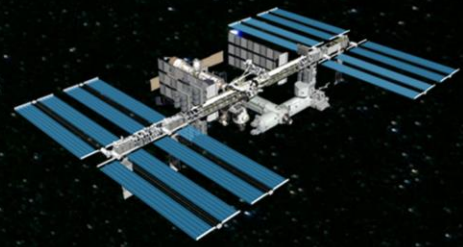


ARTEMIS MISSIONS

COMMERCIAL PARTNER SPACECRAFT

NEAR-TERM

- NASA documents and shares the agency's comprehensive approach for global commercial LEO development
- NASA continues to support R&D needs and ISS National Laboratory needs
- NASA leverages ISS capabilities to stimulate demand and catalyze new markets
- NASA collaborates with International Partners on new market development
- Commercial partners begin new activities in LEO

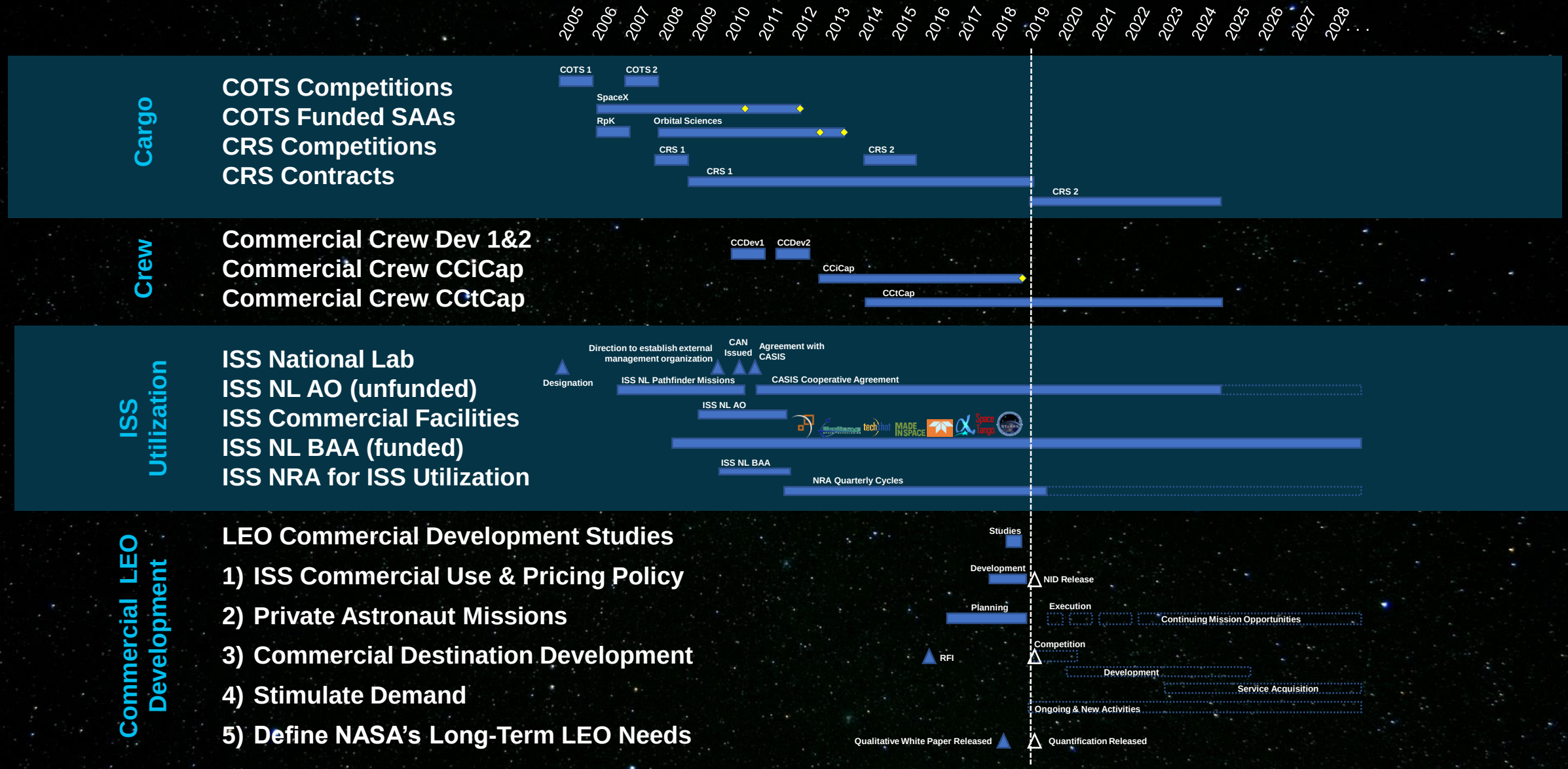


INTERNATIONAL SPACE STATION

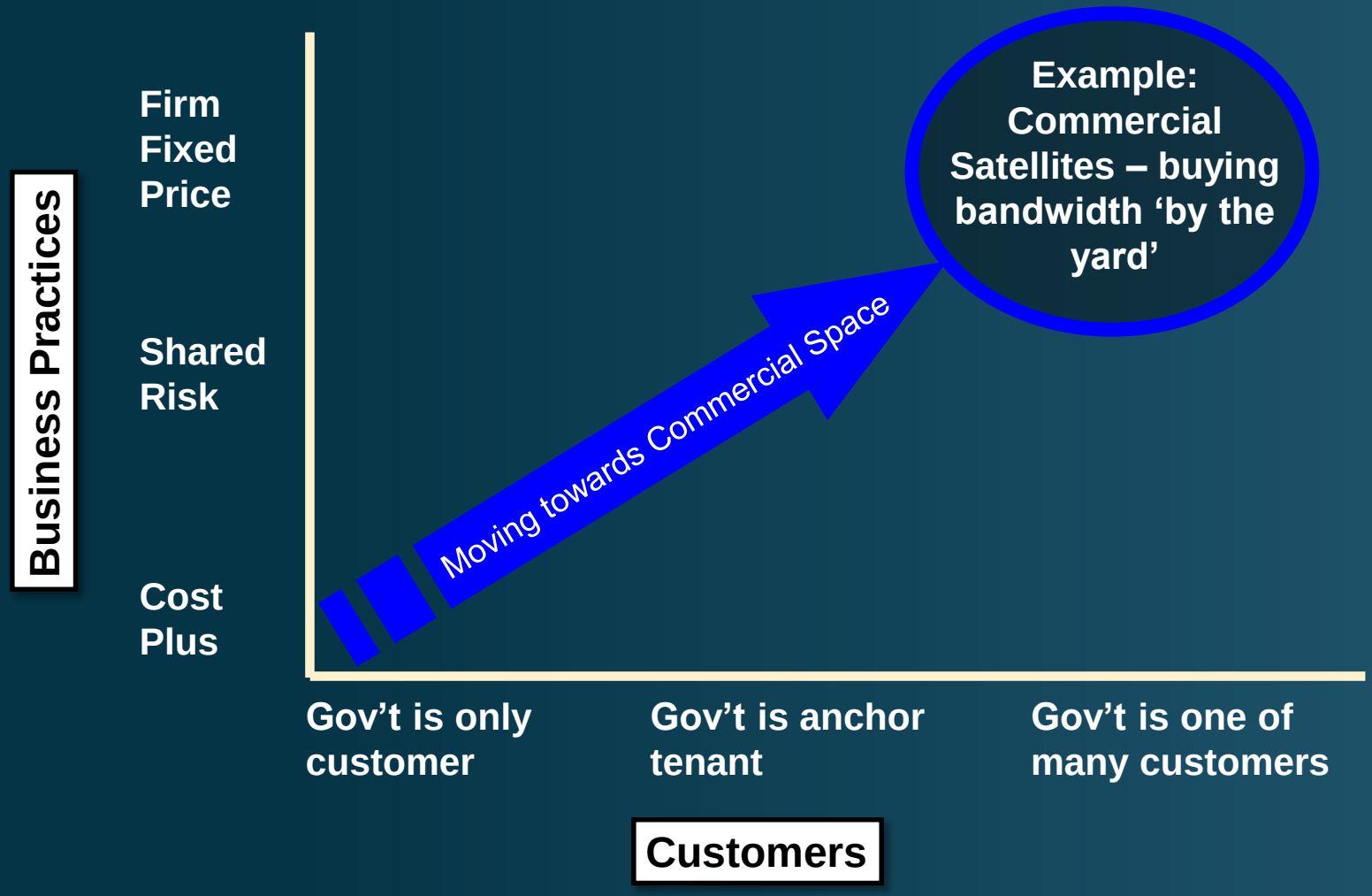
YOU ARE HERE

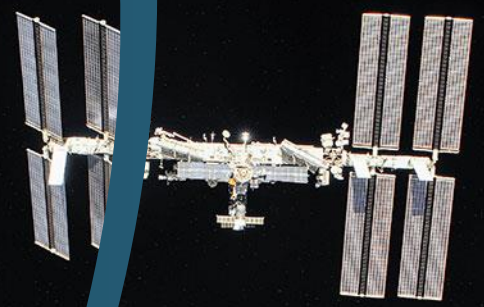
EXPLORE THE PLAN AT WWW.NASA.GOV/LEO-ECONOMY

Commercial LEO Development



What is Commercial Space?





A robust low-Earth orbit economy from which NASA can purchase services as one of many customers.

NASA Plan for Commercial LEO Development

NASA developed a five-point plan building on the work of the last two decades. This plan includes new policies, multiple solicitations, and new information that can be found on the Leo Economy website.

1. NASA established a commercial use and pricing policy for the International Space Station (ISS)
2. Enable flight of private astronauts to the ISS with the first mission as early as 2020
3. Initiate a process for developing commercial low-Earth orbit destinations
4. Seek out opportunities to stimulate scalable and sustainable demand for LEO destinations
5. Quantify the agency's long term needs in LEO

https://go.usa.gov/xym78

Commercial LEO Development Rollout

- NASA announced the agency's plans for commercial development of low-Earth orbit, including opening the International Space Station to expanded commercial activities on June 7, at Nasdaq in New York City.
- Key participants:
  - NASA CFO, Jeff DeWit
  - HEOMD AA, Bill Gerstenmaier
  - ISS Deputy Director, Robyn Gatens

- Reach of more than 700k from the three FB live
- More 80k+ viewers of the live press event on the NASA twitter feed
- Nearly 1,000 shares of the live press event on the NASA FB page

(1) ISS Commercial Use and Pricing Policy

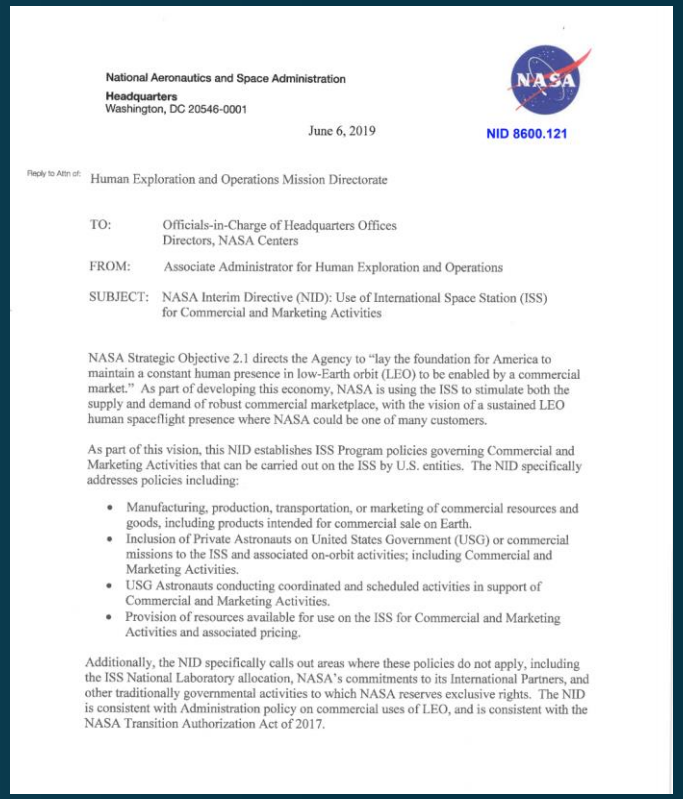
NASA released a NASA Interim Directive (NID) for Use of ISS for Commercial and Promotional Activities

Purpose: to clarify NASA's policy for expanded commercial use of ISS (within the agency's existing authorities) consistent with congressional and administration policy direction

Goal: enable commercial activities in low Earth orbit leading to sustainable LEO economy with NASA as one of many customers

Document includes:

- Requirements commercial and promotional activities must follow in order to be flown
- Pricing of NASA resources (reduced below actual cost to enable market development)
- Amount of NASA committed resources for commercial and promotional activities
- Limit of resources one commercial entity can acquire at a time



National Aeronautics and Space Administration
Headquarters
Washington, DC 20546-0001

June 6, 2019

NID 8600.121

Reply to Attn of: Human Exploration and Operations Mission Directorate

TO: Officials-in-Charge of Headquarters Offices
Directors, NASA Centers

FROM: Associate Administrator for Human Exploration and Operations

SUBJECT: NASA Interim Directive (NID): Use of International Space Station (ISS) for Commercial and Marketing Activities

NASA Strategic Objective 2.1 directs the Agency to "lay the foundation for America to maintain a constant human presence in low-Earth orbit (LEO) to be enabled by a commercial market." As part of developing this economy, NASA is using the ISS to stimulate both the supply and demand of robust commercial marketplace, with the vision of a sustained LEO human spaceflight presence where NASA could be one of many customers.

As part of this vision, this NID establishes ISS Program policies governing Commercial and Marketing Activities that can be carried out on the ISS by U.S. entities. The NID specifically addresses policies including:

- Manufacturing, production, transportation, or marketing of commercial resources and goods, including products intended for commercial sale on Earth.
- Inclusion of Private Astronauts on United States Government (USG) or commercial missions to the ISS and associated on-orbit activities; including Commercial and Marketing Activities.
- USG Astronauts conducting coordinated and scheduled activities in support of Commercial and Marketing Activities.
- Provision of resources available for use on the ISS for Commercial and Marketing Activities and associated pricing.

Additionally, the NID specifically calls out areas where these policies do not apply, including the ISS National Laboratory allocation, NASA's commitments to its International Partners, and other traditionally governmental activities to which NASA reserves exclusive rights. The NID is consistent with Administration policy on commercial uses of LEO, and is consistent with the NASA Transition Authorization Act of 2017.

https://go.usa.gov/xym7f

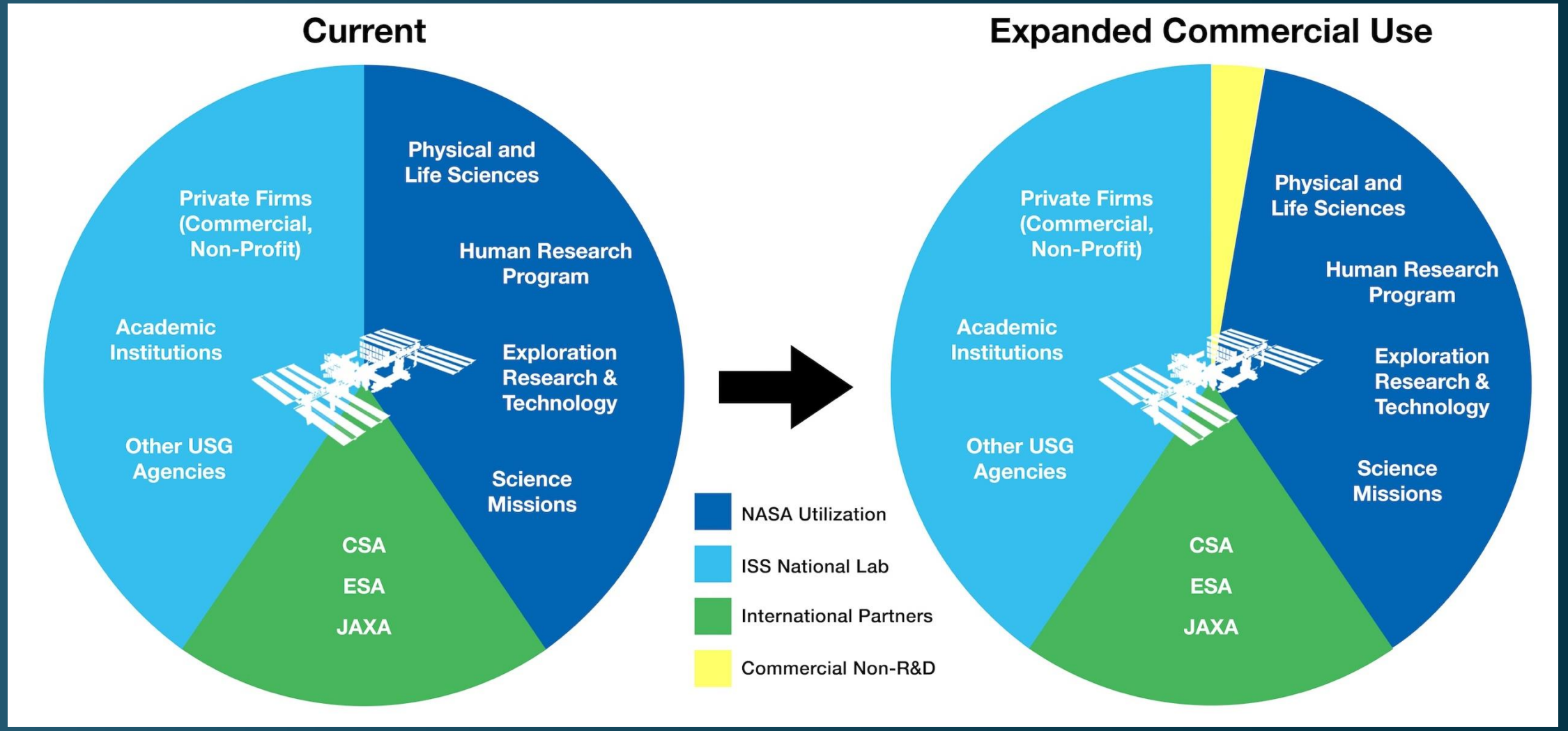
Commercial Use Policy Overview

Under the NASA Interim Directive on Use of International Space Station (ISS) for Commercial and Marketing Activities, U.S. Entities will have the ability to pursue:

- Manufacturing, production, transportation, or marketing of commercial resources and goods, including products intended for commercial sale on Earth
- Inclusion of private astronauts on USG or commercial missions to the International Space Station and associated on-orbit activities, including commercial and marketing activities
- U.S. government astronauts conducting coordinated and scheduled activities in support of commercial and marketing activities
- Purchase resources available for use on the International Space Station for commercial and marketing activities

Read more at nasa.gov/leo-econoy/commercial-use/.

Commercial Resource Allocation



Interim Pricing Policy

- **Purpose:** Establish prices to enable companies to reduce uncertainty and build business plans
- **Goal:** Estimate the market value of ISS resources such as upmass, downmass, trash, crew time, etc., and to enable reimbursement of commercial and promotional activities to be performed on the ISS (outside the R&D scope of ISS National Lab)
  - Since market value is unknown, pricing and purchasing (or lack of) will be monitored and evaluated periodically (~ 6 months initially)
  - Iterative process, expected to vary by market sector, document will be updated periodically as more information is gathered
  - Adjust prices as appropriate, with agility at the speed of industry
  - Expect overall process to take years over course of commercial LEO transition
- Starting with offering upmass, downmass, trash, and crew time waived to below the nominal cost to enable market development
  - Designed to not reveal any proprietary cost information for CRS or hardware providers
  - Reduced rates will allow reimbursement of costs while being sensitive to not stifling the potential emerging markets
- Initially offering 5% of NASA utilization resources for commercial and promotional activities
  - Limiting amount one company can acquire to allow multiple opportunities for any given resource
  - Does not affect resources or allocation set aside for the ISS National Lab

https://www.nasa.gov/leo-economy/commercial-use/pricing-policy

(2) Private Astronaut Missions

Historical Precedent

- Russia sold seats on Soyuz for 8 private astronaut missions of 7-13 days duration to the ISS between 2001-2009 for ~$25m-45m per mission, and has sold 1 seat to UAE Space Flight Participant (SFP) for flight in September 2019

Current NASA Plans

- NASA is planning to enable private astronaut missions to the ISS using vehicles developed by SpaceX and Boeing under NASA's commercial crew program (CCP)
  - Goal is all Commercial "Charter" Flight – Commercial Provider (CP) sells an entire mission to SFPs for sortie mission to ISS, independent of NASA's commercial crew program
  - Private companies may offer to fly NASA astronauts under these agreements
- Initial mission could potentially be as early as 2020
- NASA can accommodate up to 2 'sortie' flights to come to ISS per year
- NASA will encourage foreign governments to work through US companies
- NASA has released a new Focus Area 4 in the ISS Utilization NRA
  - Private Astronaut Missions to the International Space Station (ISS)

Benefits of Private Astronaut Missions

- Allow commercial industry to purchase commercial services and gain insight into the costs associated with owning and operating a platform in the future
- Reduce market risk to commercial LEO destination developers by demonstrating the market
- Expands range of commercial activities that can be performed on ISS
- Potential to increase flight rate and strengthen the market for commercial crew launch service providers
- Potential to increase available crew time on orbit for NASA, commercial, and other R&D activities

(3) Commercial LEO Destination Solicitations

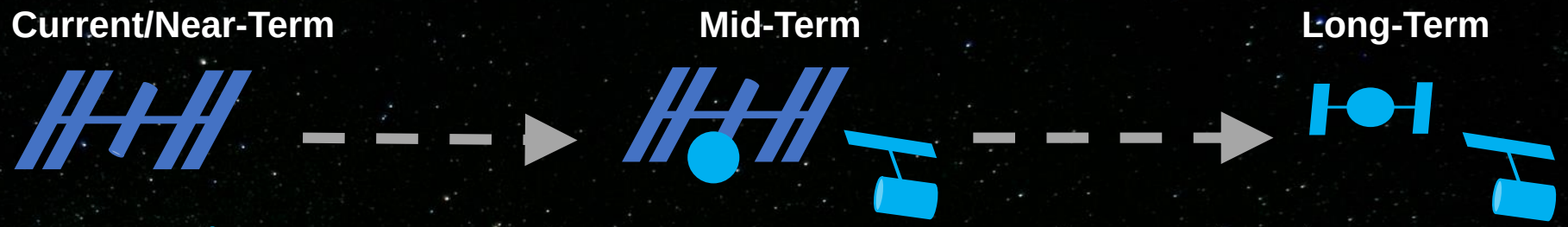
NASA Objectives – Move fast to:

- Partner with US industry to facilitate development of LEO Destinations that are safe, cost effective, and available for Government and other customers
- Enable the eventual purchase of commercial services to meet NASA's need for continued operations in LEO as one of many customers, once the capability is matured and available

Attributes

- Not taking delivery of hardware or services at this time, availability of initial services not anticipated for several years.
- Continue to let providers maintain as much ownership of their data and invention rights as possible
  - NASA does not need data other than for confirmation of milestone completion and safety/interfaces
- Treat the providers as **partners** and not suppliers
  - Minimal NASA oversight (insight only) with small team and avoidance of bureaucracy
  - Need maximum flexibility for industry to innovate
  - The company will be required to get significant non-NASA investment
  - NASA has a desire for significant non-government customers
- Minimize industry and investor uncertainty and reduce risk of commercial failure
- Performance-based milestones in order to obtain NASA funding

Notional LEO Destinations Roadmap



NextStep 2 BAA Appendix I

Sept 18, 2019 Proposals Received

ISS Port Path

Pre-Phase A Phases A-B — Concept Dev & Prelim. Design

Phase C-D — Final Design, Fabrication, Assembly, Integration, Test

Launch

Phase E — On-Orbit Demo(s)

Phase E cont. — Commercial Operations and Transition Planning

Commercial Ops — Free-Flying

Down-Select to assign priority for use of ISS Port

ISS Reconfiguration

NextStep 2 BAA Appendix K

October 3, 2019 Draft Solicitation

Portfolio Decision

Free Flyer Path

Selection

Pre-Phase A Phases A-B — Concept Dev & Prelim. Design

Phase C-D — Final Design, Fabrication, Assembly, Integration, Test

Launch

Phase E — On-Orbit Checkout

Phase E cont. — Commercial Operations

Service Acquisition Competitions

NASA Services Acquisition

ISS Research Acquisition

Incremental Research Element Services Purchases

ISS Transition

Ongoing use of Current ISS

NRA for Utilization

Definition

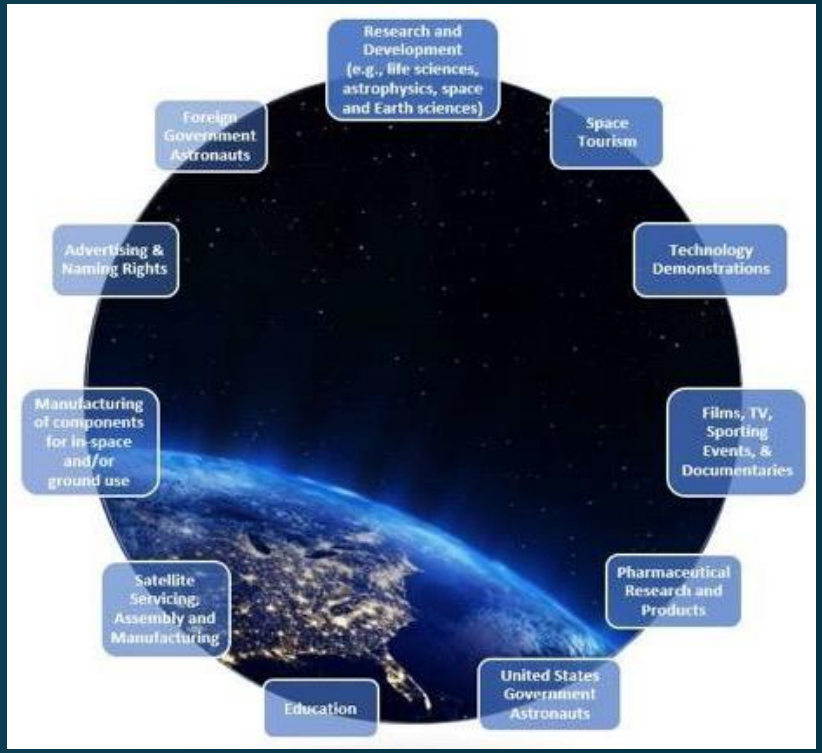
Commercial Destination Services Acquisition

Commercial Destination Services Purchase

Budget - LEO and Spaceflight Operations: Commercial LEO Development

($M)	2019	2020	2021	2022	2023	2024	Total FY19-24
Commercial LEO Development	$40.0	$150.0	$175.0	$200.0	$225.0	$225.0	$1,015
Up to 75% for supply	$30.0	$112.5	$131.3	$150.0	$168.8	$168.8	$761.3

- Assists commercial space industry to develop a sustained commercial low earth orbit presence.
- Continues transition of low Earth orbit human space flight operations to commercial partners.
- Encourages commercial development of platforms and capabilities for use by the private sector and NASA to enable a seamless transition from ISS.
- Increases efforts to develop a commercial space economy in LEO.



(4) Stimulate Sustainable Demand

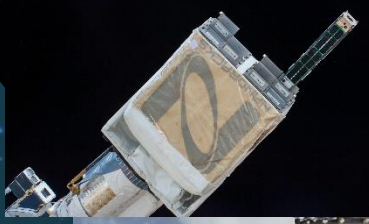
- **ISS National Lab accommodating many industry R&D projects**
  - Promising projects will transition from ISS NL post-R&D to enter production
- **In Space Manufacturing Projects underway (funded by ISS to date):**
  - Exotic Optical Fibers (3 projects) - 2 on NG-11 (April 2019)
    - 1 on SpX-16 (December 2018)
  - Bio-printing - on SpX-18 (July 2019)
  - Industrial Crystallization - NET SpX-20 (March 2020)
  - Super Alloy Casting - NET NG-12 (October 2019)
  - Ceramic Stereolithography - NET SpX-19 (December 2019)
- **New ISS Utilization NRA Thrust Areas now open for new projects leading to scalable, sustainable demand**
  - In-space manufacturing, regenerative medicine/bioengineering, other concepts
  - Commercial concepts to create “space lab” research capabilities that mirror ground lab capabilities
- **Intent is to continue building a pipeline of projects through ISS life, migrate successful projects to commercial lab(s) in LEO**

Stimulate Sustainable Demand (cont.)

- **New ISS commercial use policy coupled with Private Astronaut Missions**
  - Industry enabled to pursue new and emerging markets
  - ISS access will facilitate validation and enable growth of new and emerging markets
- **Seeking targeted studies to better understand real and perceived barriers of potential new market entrants, and to address broad ideas which could help stimulate demand (e.g. reducing launch cost, etc.)**
  - Plan to issue solicitation to gather industry ideas as Appendix J of the NextSTEP2 BAA
  - Synopsis released June 7, 2019, solicitation released July 3, 2019, proposals due October 16, 2019
- **Seeking to expand feeder pipeline of potential new entrants into use of LEO environment**
  - Planning to coordinate across microgravity access community to strengthen integration, simplify user access, and reduce real and perceived barriers to entry
    - Drop Towers
    - Parabolic and Suborbital Flights (e.g. Flight Opportunities Program)
    - ISS (e.g. SLPSRA and ISS National Lab)
  - Coordinate outreach with consistent messaging to magnify and expand awareness of potential benefits of microgravity research in industrial and academic research communities

Commercial Hardware on ISS

- NanoRacks: Internal & External platforms; sat deployers; airlock
- Teledyne Brown Engineering: MUSES External precision pointing platform
- Bigelow Aerospace: Expandable module
- Alpha Space: MISSE-FF External materials exposure platform
- BioServe: Space Biology platforms and services
- Space Tango: TangoLab space biology platforms
- Techshot: Bone densitometer, MVP centrifuge facility
- Made In Space: Additive Manufacturing Facility
- STaARS: Space biology platform
- Sierra Nevada Corp: Small mass measurement device



Commercial Research on ISS

(5) NASA's Long-Term LEO Forecast

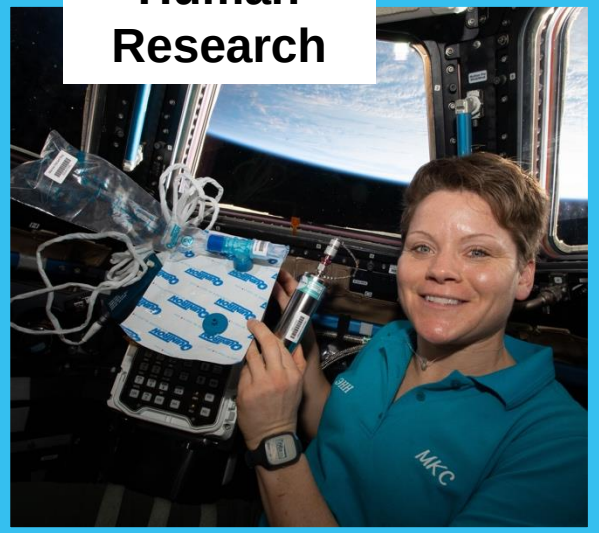
- **Purpose**: Define NASA's minimum long-term LEO requirements as basis for commercial destination providers business case assessments
- Helps the US portion of the ISS to transition away from direct federal funding
- White paper published last fall defined high-level NASA projected LEO needs but did not attempt to quantify
- NASA has updated this white paper to include a quantification of the demand forecast, representing the type and amount of services that NASA intends to purchase in the future when those services become commercially available

Forecasting Future NASA Demand in Low-Earth Orbit: Revision Two – Quantifying Demand (June 7, 2019)

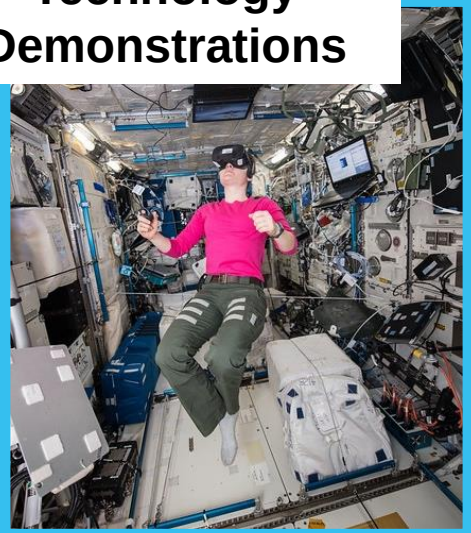
https://www.nasa.gov/sites/default/files/atoms/files/forecasting_future_nasa_demand_in_low-earth_orbit_revision_two_-_quantifying_demand.pdf

NASA's Future LEO Demand

Human Research



Technology Demonstrations



Crew Accommodations & Training

Science

Physical & Biological Research

National Lab Services

Status Summary

Overall Plan, NASA Demand Forecast, RFI on overall plan released June 7, 2019

- RFI Inputs received July 9, 2019, comments under assessment

NextSTEP-2 Broad Agency Announcement

Appendix I – Port Solicitation

- Solicitation released June 21, proposals received September 18, 2019

Appendix J – Demand Stimulation

- Solicitation released July 3, Proposals due October 16, 2019

Appendix K – Free Flyer

- Synopsis released July 16, Draft Solicitation to be released soon (today!)

ISS Utilization NRA

- Focus Area 1 – Manufacturing (multiple rounds, round 3 proposals due Nov 22)
- Focus Area 2 – Lab in Space (multiple rounds, round 3 proposals due Nov 22)
- Focus Area 3 – Commercial Activities (open)
- Focus Area 4 – Interest in Private Astronaut Missions (open)

Resources Available

Low-Earth Orbit Economy Resources

Request for Information (RFI)

- Plan for Commercial Low-Earth Orbit Development (June 7, 2019)

Document Releases

- NASA Plan for Commercial LEO Development: Summary and Near Term Implementation Plans (June 7, 2019)
- NASA Interim Directive: Use of International Space Station (ISS) for Commercial and Marketing Activities (memo signed by Bill Gerstenmaier, June 6, 2019)
- How to Get Your Commercial Activity on ISS (June 7, 2019)
- Forecasting Future NASA Demand in Low-Earth Orbit: Revision Two – Quantifying Demand (June 7, 2019)
- Low Earth Orbit Commercialization Study Results - Executive Summaries (June 7, 2019)

Related Previously Released Documents

- Low Earth Orbit Commercialization Study Results - One Page Summaries (May 20, 2019)
- Forecasting Future NASA Demand in Low-Earth Orbit (October 26, 2018)
- Strategy for Human Spaceflight in LEO and Economic Growth in Space (October 19, 2018)
- International Space Station Transition Planning (March 30, 2018)
- Economic Development of Low Earth Orbit (July 11, 2016)

Press Releases

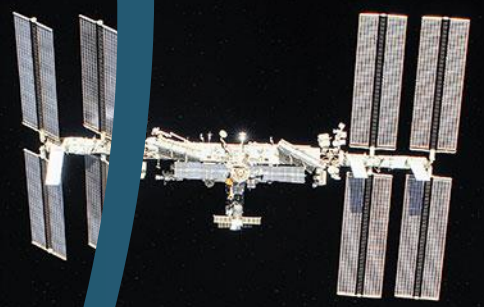
- NASA Opens International Space Station to New Commercial Opportunities, Private Astronauts (press release 19-044, June 7, 2019)

Related Previous Press Releases

- NASA Invests in Concepts for a Vibrant Future Commercial Space Economy (press release 18-071, August 8, 2018)

Opportunity Releases

- NextSTEP
  - Synopsis: FedBizOpps NextSTEP-2 Appendix I: Commercial Destination Development in LEO Using the ISS (Solicitation Number: NNH16ZCQ001K-CDISS; June 7, 2019)
  - Solicitation: FedBizOpps NextSTEP-2 Appendix I: Commercial Destination Development in LEO Using the ISS (Solicitation Number: NNH16ZCQ001K-CDISS; June 21, 2019)



https://www.nasa.gov/leo-economy/resources

National Aeronautics and Space Administration

Learn more at www.nasa.gov/leo-economy