National Aeronautics and Space Administration

Human Exploration & Operations

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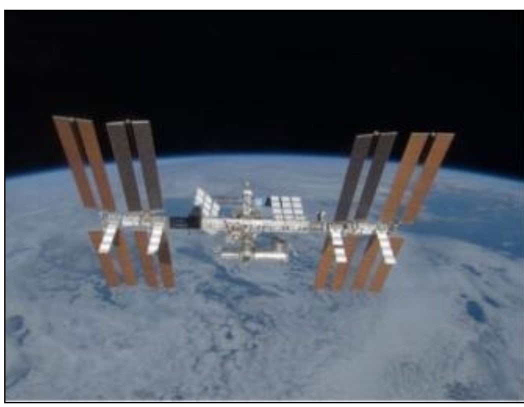
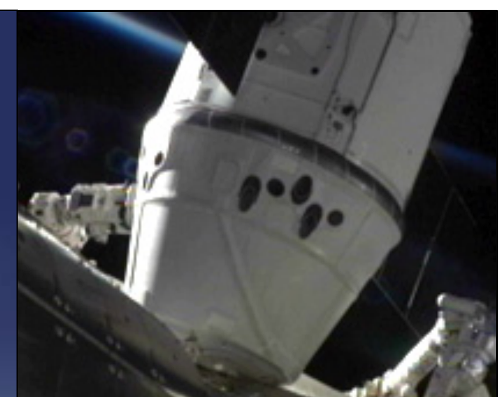
Overview

- Human Spaceflight Policy
- The Future of Human Spaceflight
- The International Space Station
- Commercial Spaceflight Development
- Exploration Systems Development
- Advanced Exploration Systems and Technology Development
- Space Life and Physical Sciences
- Space Communication and Navigation
- International Cooperation
- Inspiring STEM Leaders
- Summary
- Questions?

The NASA Authorization Act of 2010

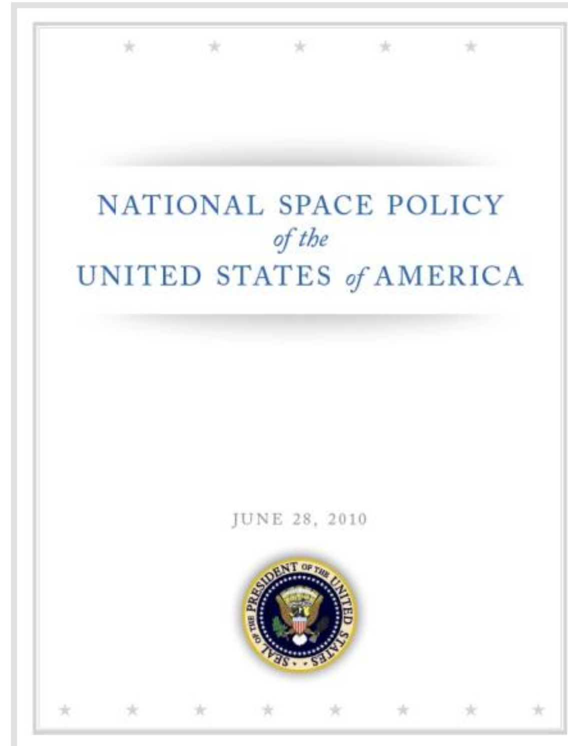
- **The U.S. Congress approved and President Obama signed the National Aeronautics and Space Administration Authorization Act of 2010**
  - Bipartisan support for human exploration beyond low Earth orbit
- **The law authorizes:**
  - Extension of the International Space Station until at least 2020
  - Support for a commercial space transportation industry
  - Development of a Multi-Purpose Crew Vehicle and heavy lift launch capabilities
  - A “flexible path” approach to space exploration opening up vast opportunities including near-Earth asteroids (NEA), the moon and Mars
  - New space technology investments to increase the capabilities beyond low Earth orbit



U. S. National Space Policy Goals

- Energize competitive domestic industries
- Expand international cooperation
- Strengthen stability in space
- Increase assurance and resilience of mission-essential functions
- Pursue human and robotic initiatives
- Improve space-based Earth and solar observation



"NASA has a key role in achieving the goals defined in the new policy. We are committed to working with other agencies, industry, and international partners to achieve national goals in exploration — human and robotic — and technology development that will ensure a robust future for the U.S. and our friends around the world."

— NASA Administrator Charles Bolden, June 28, 2010

U. S. National Space Policy Guidelines on Human Space Flight

- Set far-reaching exploration milestones. By 2025, begin ***crewed missions beyond the moon***, including sending humans to an asteroid. By the mid-2030s, send humans to orbit Mars and return them safely to Earth;
- Continue the ***operation of the International Space Station (ISS)***, in cooperation with its international partners, likely to 2020 or beyond, and expand efforts to: utilize the ISS for scientific, technological, commercial, diplomatic, and educational purposes; support activities requiring the unique attributes of humans in space; serve as a continuous human presence in Earth orbit; and support future objectives in human space exploration;
- Seek partnerships with the private sector to enable safe, reliable, and cost-effective ***commercial spaceflight capabilities and services*** for the transport of crew and cargo to and from the ISS;
- Conduct research and development in support of ***next-generation launch systems***, including new U.S. rocket engine technologies.


NATIONAL SPACE POLICY
of the
UNITED STATES *of* AMERICA

JUNE 28, 2010

The NASA Vision

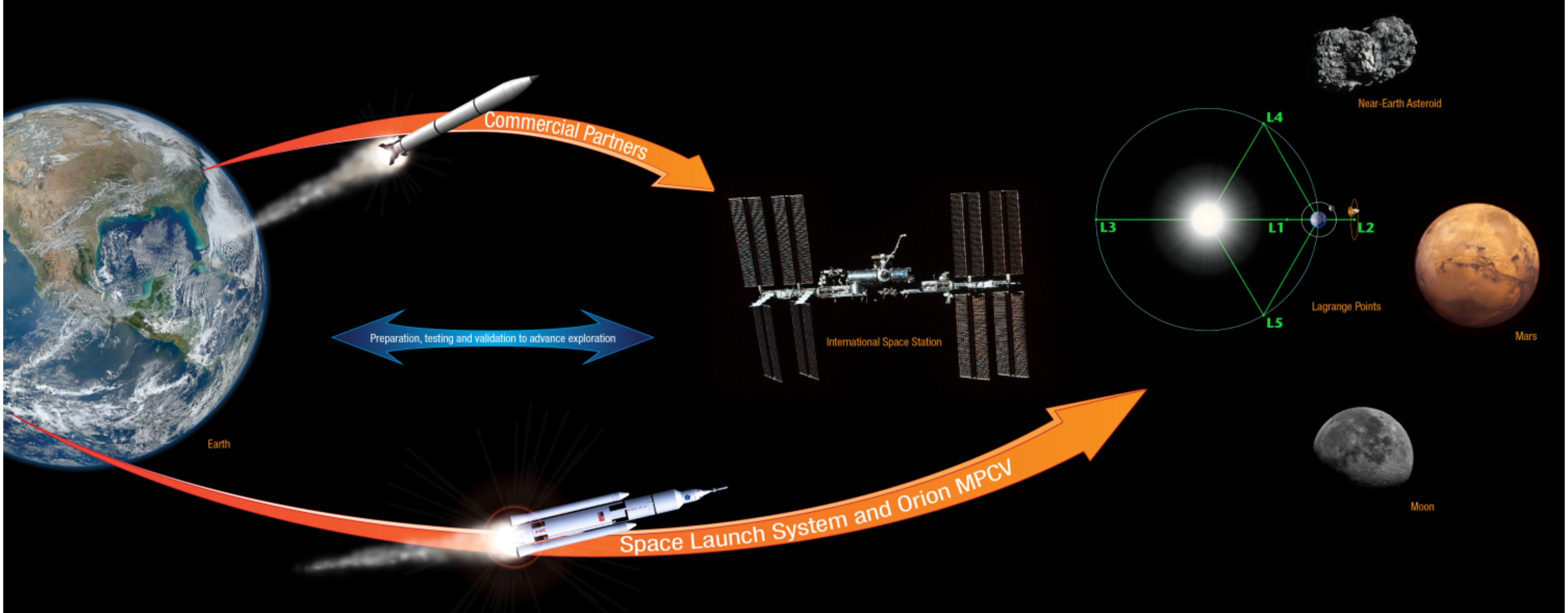
To reach for new heights and reveal the unknown, so that what we do and learn will benefit all humankind.

NASA Strategic Goals

1. Extend and sustain human activities across the solar system.
2. Expand scientific understanding of the Earth and the universe in which we live.
3. Create the innovative new space technologies for our exploration, science, and economic future.
4. Advance aeronautics research for societal benefit.
5. Enable program and institutional capabilities to conduct NASA's aeronautics and space activities.
6. Share NASA with the public, educators, and students to provide opportunities to participate in our mission, foster innovation, and contribute to a strong national economy.

The Future of American Human SPACEFLIGHT

National Aeronautics and Space Administration

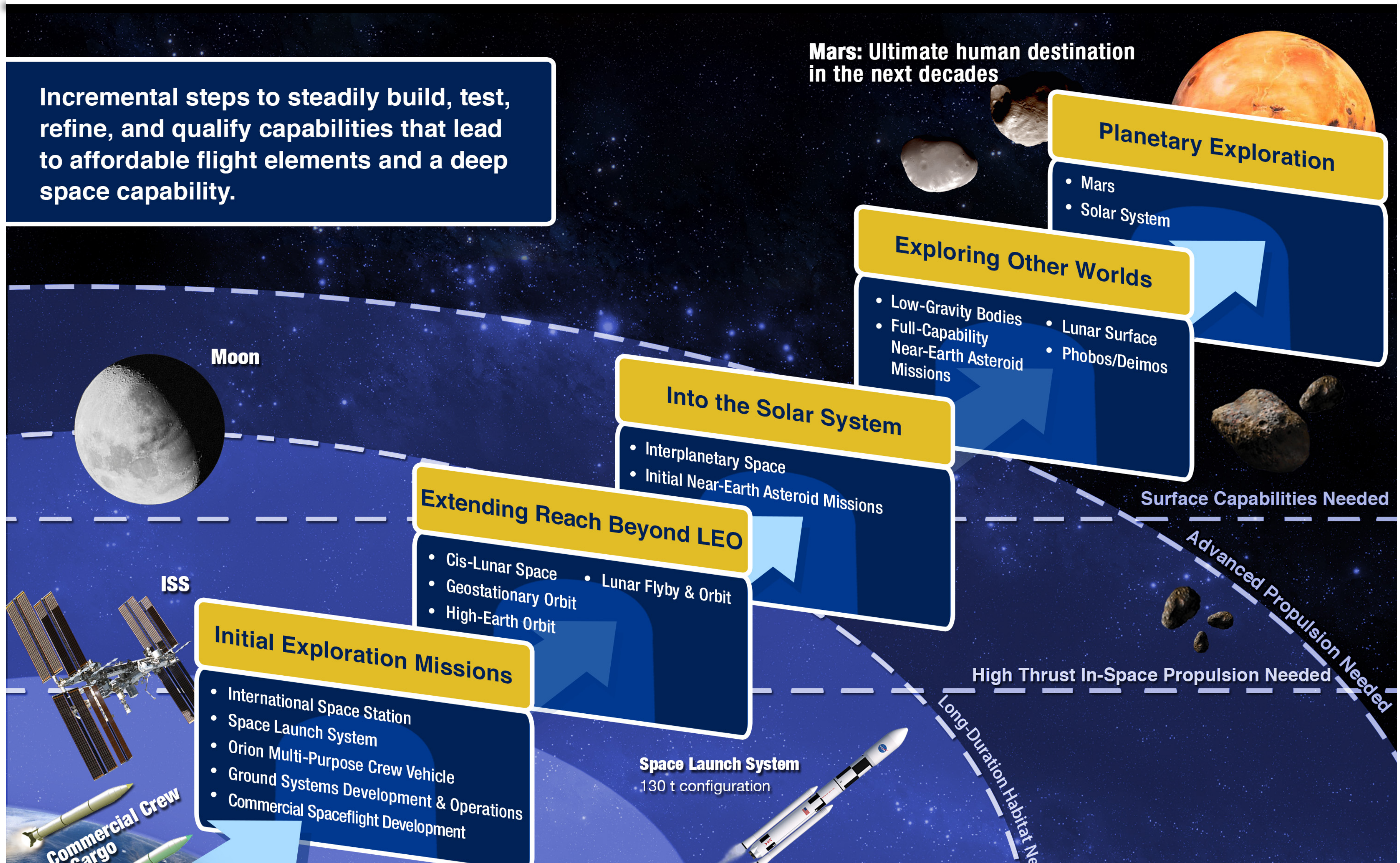


Human Spaceflight Capabilities

Mobile Extravehicular Activity and Robotic Platform | Deep Space Habitation | Advanced Spacesuits | Advanced Space Communication | Advanced In-Space Propulsion | In Situ Resource Utilization | Human-Robotic Systems

Visit the web interactive at www.nasa.gov/fhs

Capability Driven Human Space Exploration



The International Space Station

ISS is critical to our future in space

- ❑ Commercial space destination
- ❑ International collaboratory
- ❑ Exploration test bed

ISS – The World's Orbiting Laboratory

- **International Partnership**
- **Largest spacecraft ever built**
- **International crew**
- **International launch fleet**
- **Globally distributed operations**
- **12+ years of continuous human occupation (Nov. 2000 – today)**
- **Travels an equivalent distance to the Moon and back in about a day**
- **Manages 20 times as many signals as the Space Shuttle**
- **More than:**
  - 100 launches from four agencies to ISS; almost 20% of global launches
  - 165 spacewalks
  - 200 people from 15 countries

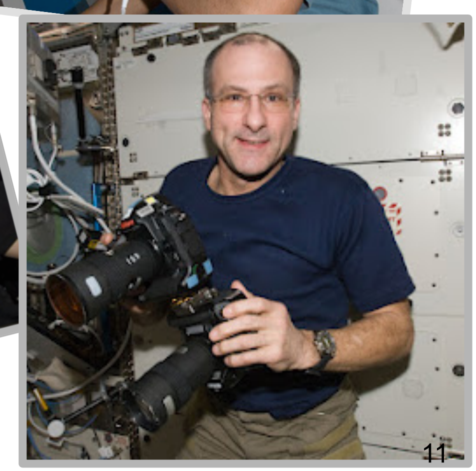
ISS as an Operations Test Bed for Exploration

Sustain Human Health and Performance
- Advanced health care & countermeasures
- Evolved crew accommodations
- Skills-based / onboard training tools
- International crew protocols

Ensure Systems Readiness
- Robotic designs, tools, & operations
- Extravehicular Activity (EVA) suit materials / components
- Hardware operating conditions
- System Demonstration/Qualification

Validate Operational Procedures
- Remote vehicle management
- Intermittent communications
- Autonomous crew operations
- In-space assembly
- EVA procedures

ISS Research and Developmental Technologies:
- Closed-loop life support
- Advanced monitoring and control
- In-space assembly
- Maintainability, supportability and logistics
- Solar panels and batteries
- EVA technologies
- Automated systems
- Exercise systems
- Medical care
- Food systems
- Communications



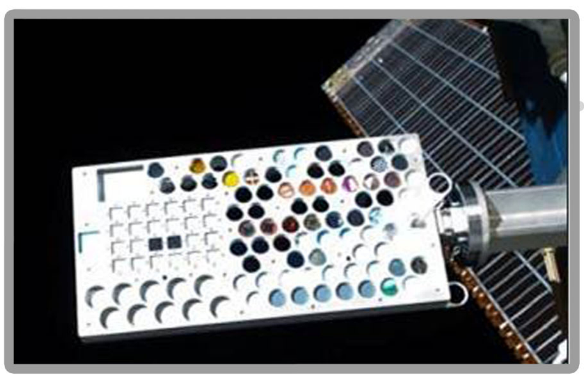
ISS Research and Technology Applications and Demonstration Testbed

Reaching Students.
Teaching 30+ million from ISS

Improving Life Support.
Water and air recycling on ISS

Observing Planet Earth.
Documenting global change and geographic events

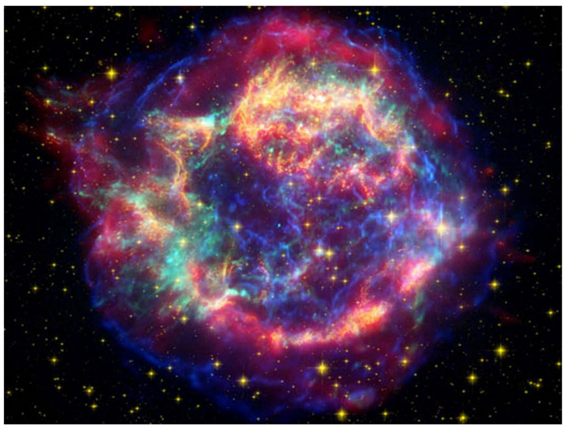
Improving Zero-G Health.
Bone loss prevention through exercise and space medicine

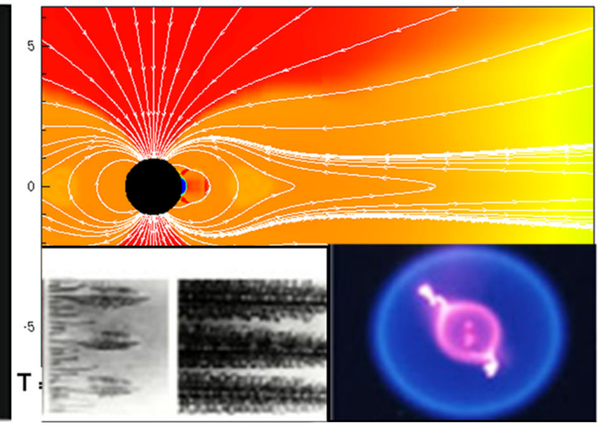


A Materials Testbed.
Improving satellite component development and spacecraft design

Space Life and Physical Sciences

Science knowledge and technology will improve our nation's competitiveness, education and the quality of life on Earth.





Space Life Sciences | **Human Research** | **Physical Sciences**

Uses the space environment to enhance understanding of the response of living organisms and biological processes to weightlessness.

Develops scientific and technological foundations for a safe, productive human presence in space for extended periods.

Conducts research in space to explore the processes that form materials and determine the performance of fluid, thermal and combustion systems.

Commercial Spaceflight Development

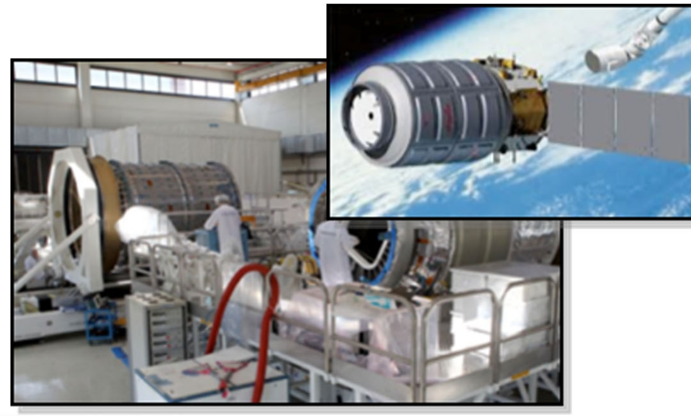
NASA's Commercial Crew and Cargo Program is investing financial and technical resources to stimulate efforts within the private sector to develop and demonstrate safe, reliable, and cost-effective commercial systems to transport crew and cargo to and from the International Space Station and low Earth orbit.

Commercial Spaceflight Development Partners

Cargo Transportation

< Space Exploration Technologies **(SpaceX)**

Orbital Sciences **(Orbital)** >



Commercial Crew Development

(Clockwise from top left)
Funded Partners: SpaceX, Blue Origin, Boeing, Sierra Nevada Corp. **Unfunded Partners:** United Launch Alliance, Excalibur Almaz, Alliant Techsystems Inc.

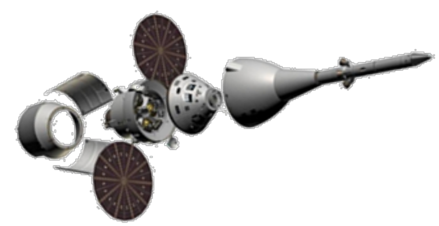
Exploration Systems Development

These programs will develop the launch and spaceflight vehicles that will provide the initial capability for crewed exploration missions beyond LEO.

- **Space Launch System (SLS) Program:**
  - Initial capability: 70 tonnes (t), 2017–2021
  - Evolved capability: 105 t and 130 t, post-2021

- **Orion Program**:
  - Initial test flight (no crew) on Delta IV in 2014 – vehicle assembly underway
  - First Orion/SLS (no crew) flight in 2017
  - First crewed Orion/SLS flight in 2021

- **Ground Systems Development and Operations (GSDO) Program:**
  - Developing launch site infrastructure to prepare, assemble, test, launch and recover the SLS and Orion flight systems

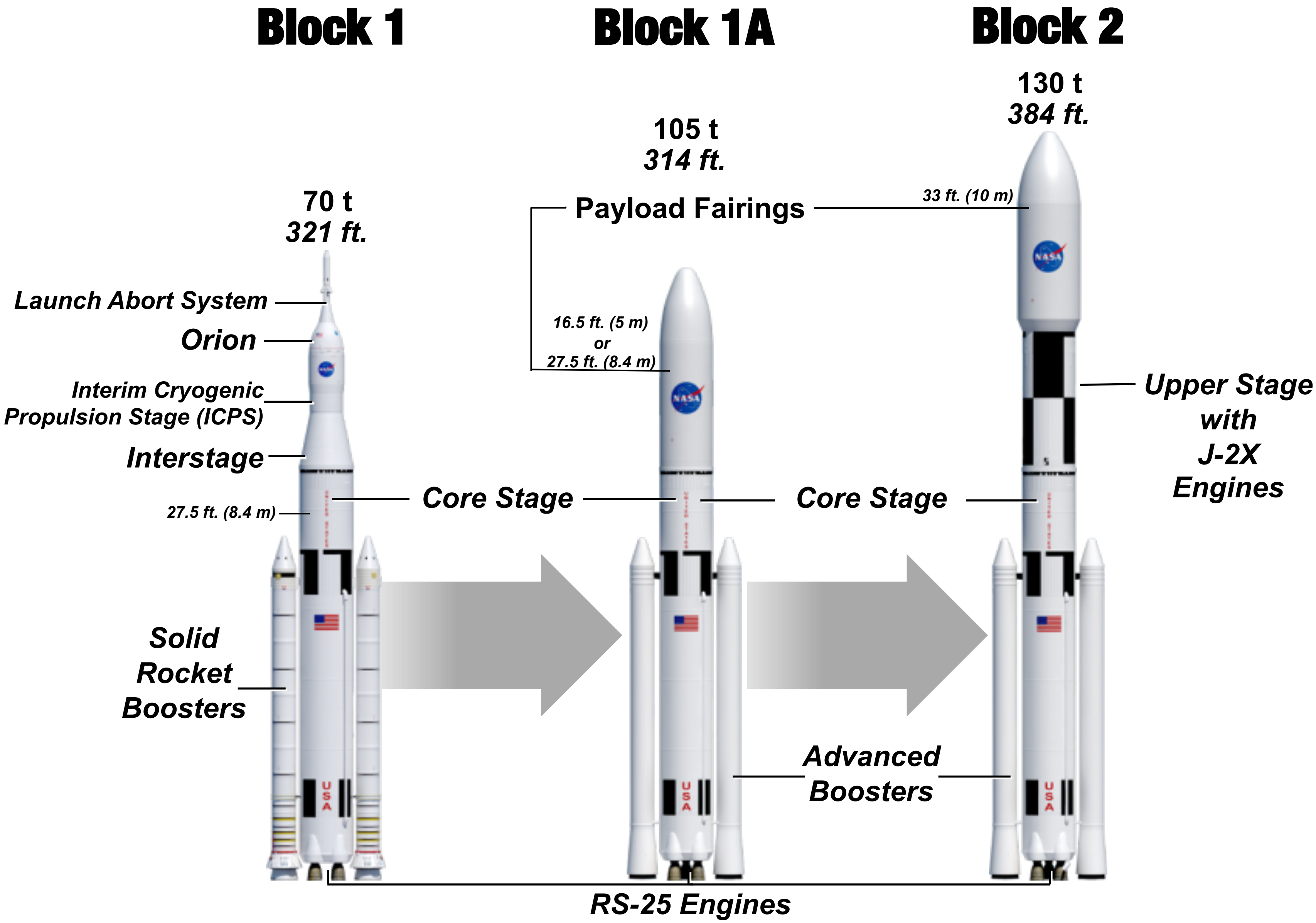


The Space Launch System (SLS)

- **Affordable & Sustainable**
  - Maximum use of common elements and existing assets, infrastructure, and workforce
  - Competitive opportunities for affordability insertion
- **Safe : Human Rated**
- **Initial capability: 70 tonnes (t), 2017–2021**
  - Serves as primary transportation for Orion and exploration missions
  - Provides back-up capability for crew/cargo to ISS
- **Evolved capability: 105 t and 130 t, post-2021**
  - Can enable scientific payloads with requirements beyond commercial lift capabilities
  - Modular and flexible, sized to mission requirements
- **Liquid hydrogen and liquid oxygen propulsion system**
  - RS-25 from the Space Shuttle Program for core stage
  - Upper Stage trades in work
- **Solid rocket boosters for the initial flights**
  - Competition for follow-on boosters based on performance requirements and affordability considerations

Initial 70 metric ton configuration

SLS Evolution and Block Upgrade Approach



SLS Hardware in Production and Testing in 2012

MPCV Stage Adapter Production
Major Tool and Machine, IN

Avionics Testbed
Marshall Space Flight Center, AL

J-2X Engine Testing
Stennis Space Center, MS

Booster Motor
Production and Firing
Promontory, UT

Core Stage Production
Michoud Assembly Facility, LA

Wind Tunnel Testing and Analysis
Langley Research Center, VA

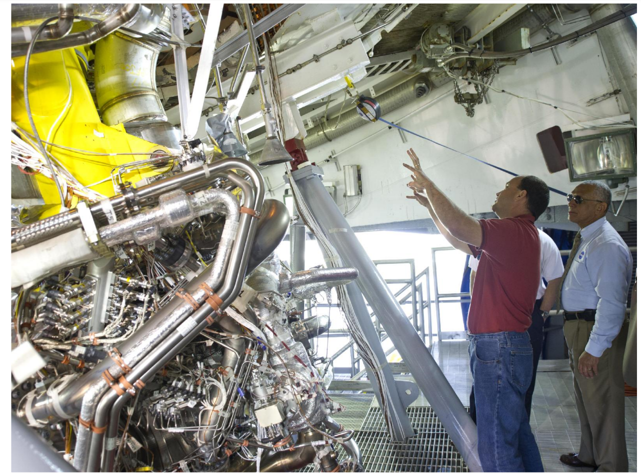
RS-25 Consolidation
Stennis Space Center, MS

Launch Complex 39B Preparation
Kennedy Space Center, FL

SLS Hardware

Stages Industry Day at Michoud Assembly Facility Nov 2011

SLS Nozzle Nose Rig



J-2X Upper Stage Engine at Stennis Space Center (SSC), April 2012

Solid Rocket Booster development motor test in Promontory, Utah, Sep 2011

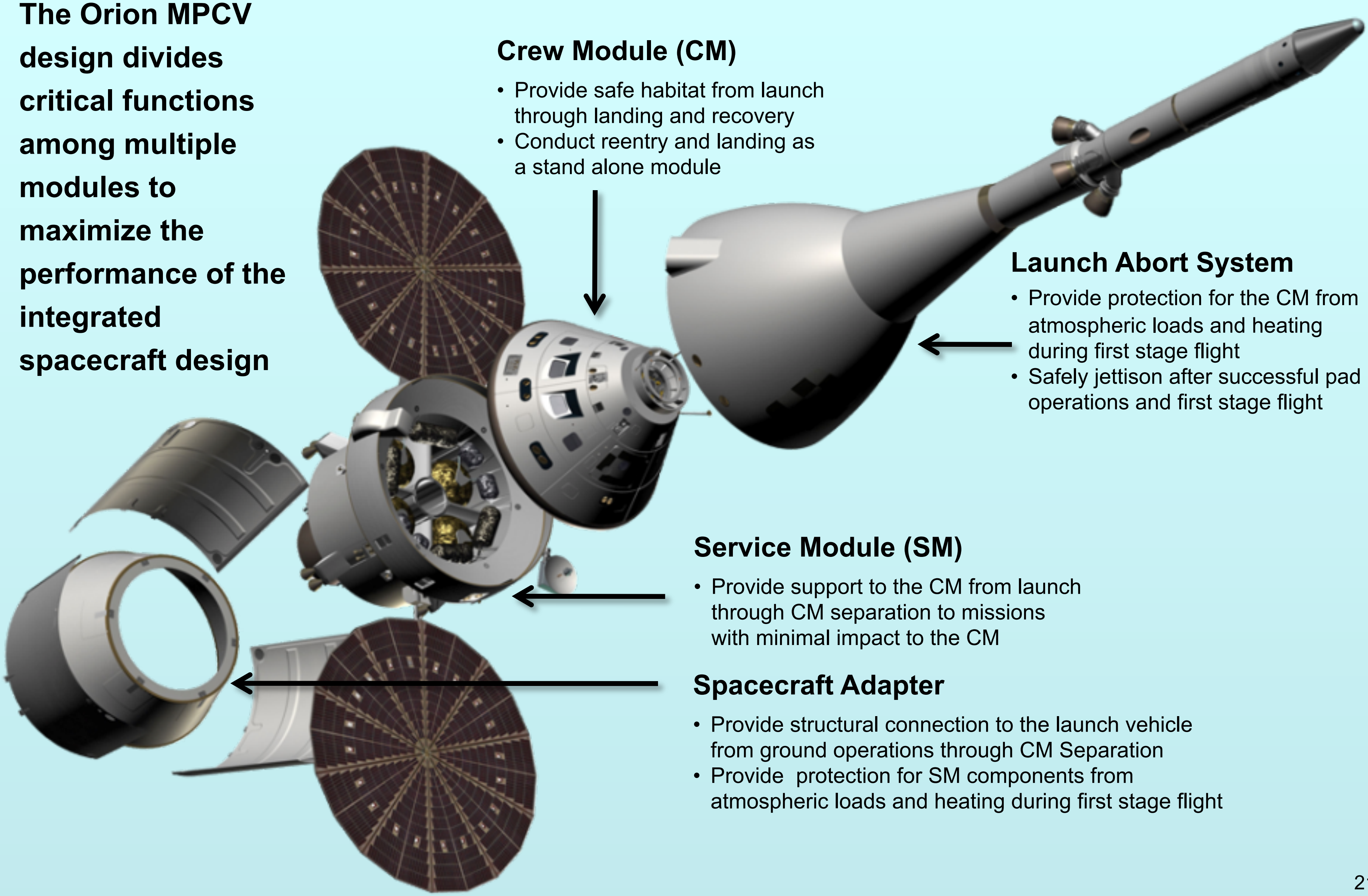
RS-25 Core Stage Engines Stored at SSC Jan 2012

Subscale Solid Rocket Motor firing at Marshall Space Flight Center, March 2012

J-2X Upper Stage Engine powerpack test at SSC Feb 2012

Orion MPCV Vehicle

The Orion MPCV design divides critical functions among multiple modules to maximize the performance of the integrated spacecraft design



Crew Module (CM)

- Provide safe habitat from launch through landing and recovery
- Conduct reentry and landing as a stand alone module

Launch Abort System

- Provide protection for the CM from atmospheric loads and heating during first stage flight
- Safely jettison after successful pad operations and first stage flight

Service Module (SM)

- Provide support to the CM from launch through CM separation to missions with minimal impact to the CM

Spacecraft Adapter

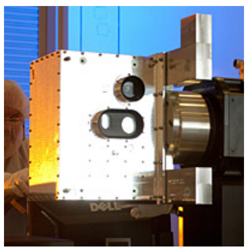
- Provide structural connection to the launch vehicle from ground operations through CM Separation
- Provide protection for SM components from atmospheric loads and heating during first stage flight

Orion Technology Advancements

Propulsion

Abort Motor, Attitude Control Motor, High Burn Rate Propellant for Solid Rocket Motors

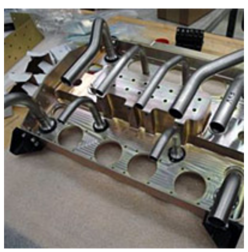
Benefits: High reliability launch abort, steerable solid rocket motors



Navigation

Atmospheric Skip Entry, Flash Lidar, Vision Navigation Sensors, Autonomous Rendezvous and Docking, Fast Acquisition GPS Receiver, High Density Camera Sensors

Benefits: Low cost, high reliability, autonomous docking



Life Support & Safety

Solid Amine Swing-Bed, Backup and Survival Systems, Closed Loop Life Support, Contingency Land Landing, Enhanced Waste Management, Environmental Control, Hazard Detection, Isolation and Recovery

Benefits: Low consumables, long mission duration, high reliability, low operations cost

Thermal Protection System

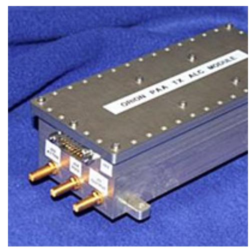
Ablative Heatshield with Composite Carrier Structure

Benefits: Low cost, high reliability, high energy (Beyond LEO) entry

Avionics

Algorithmic Autocode Generation, ARINC-653/ DO-178 Standard Operating System, Baseband Processor, High Speed/High Density Memory Devices, Honeywell HX5000 Northstar ASIC

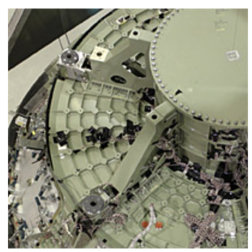
Benefits: Low cost, high performance, open architecture



Communications

Interoperable Communications, Communication Network Router Card, Digital Video Recorder, Phased Array Antennas

Benefits: Low cost, high reliability, open architecture



Structures

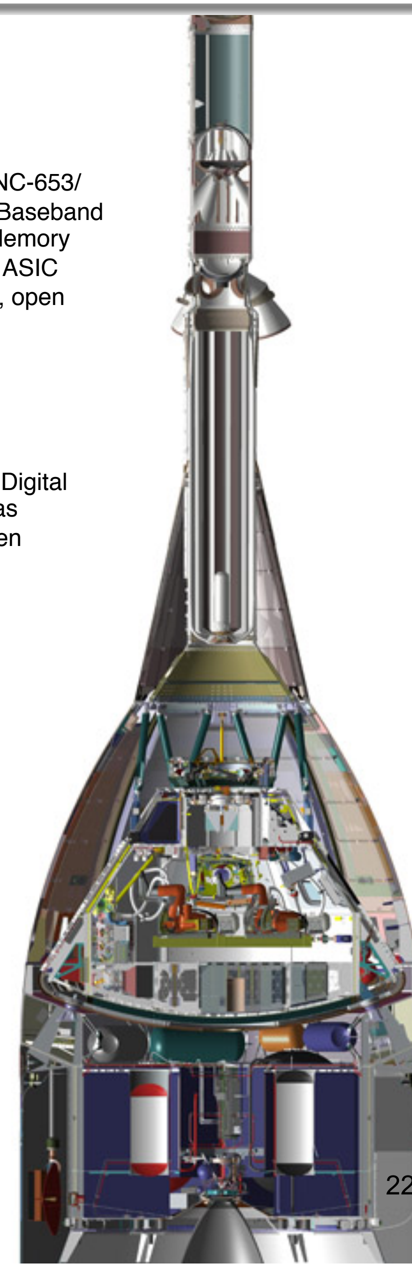
Composite Spacecraft Structures, Human Rated Spacecraft Primary Structures Development, Advanced Manufacturing

Benefits: Low cost, low mass

Power

High Energy Density Lithium Ion Batteries, Column Grid Array Packaging (CGA), Direct Energy Power Transfer System

Benefits: Low cost, high reliability, low mass, long mission duration



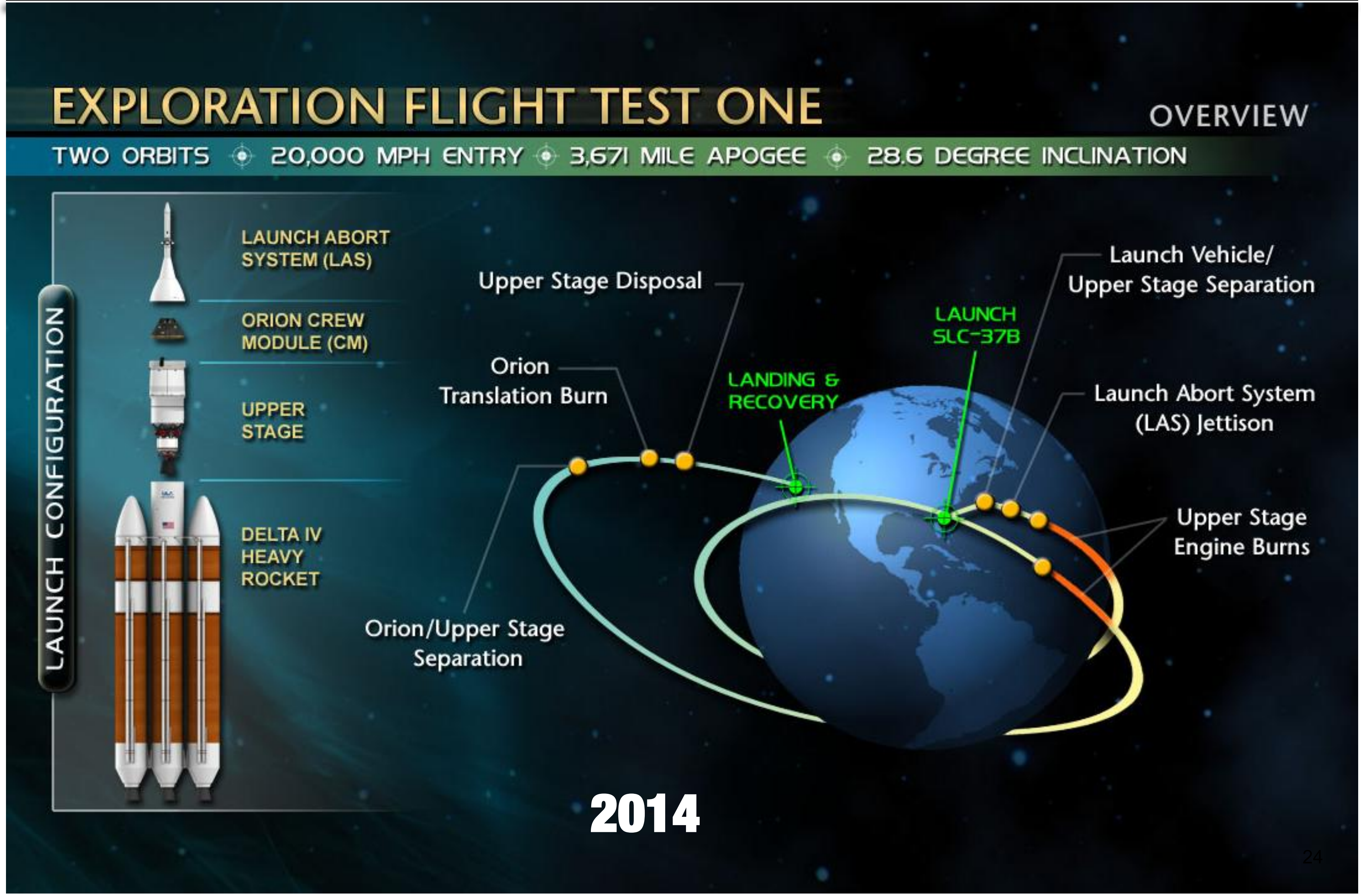
Orion Demonstration Tests Completed

- Launch Abort System
- Parachute Drop
- Water Drop

- Human Factors - Suit
- Acoustic Vibration
- Up-righting System

- Thermal Protection System
- Landing & Recovery
- Controls Evaluation

Exploration Flight Test – 1

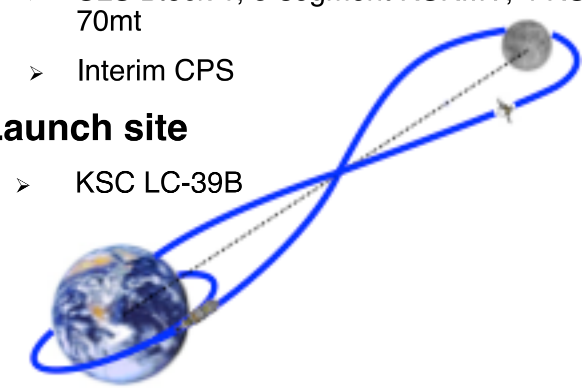


ESD Mission Overview

Exploration Mission One (EM-1)

First Uncrewed BEO Flight
2017

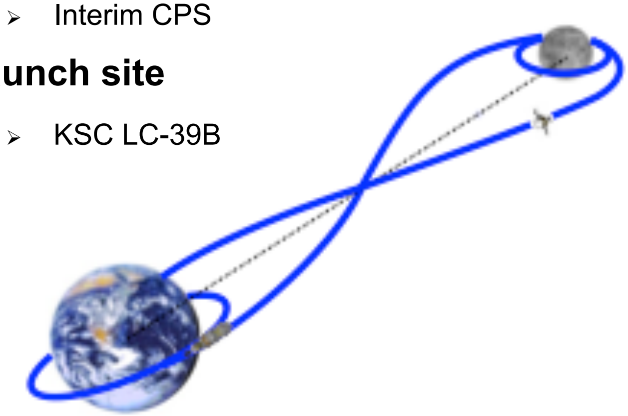
- **Mission objectives**
  - Demonstrate integrated spacecraft systems performance prior to crewed flight
  - Demonstrate high speed entry (~11 km/s) and TPS prior to crewed flight
- **Mission description**
  - Un-crewed circumlunar flight – free return trajectory
  - Mission duration ~7 days
- **Spacecraft configuration**
  - Orion Uncrewed
- **Launch vehicle configuration**
  - SLS Block 1, 5-segment RSRMV, 4 RS-25, 70mt
  - Interim CPS
- **Launch site**
  - KSC LC-39B



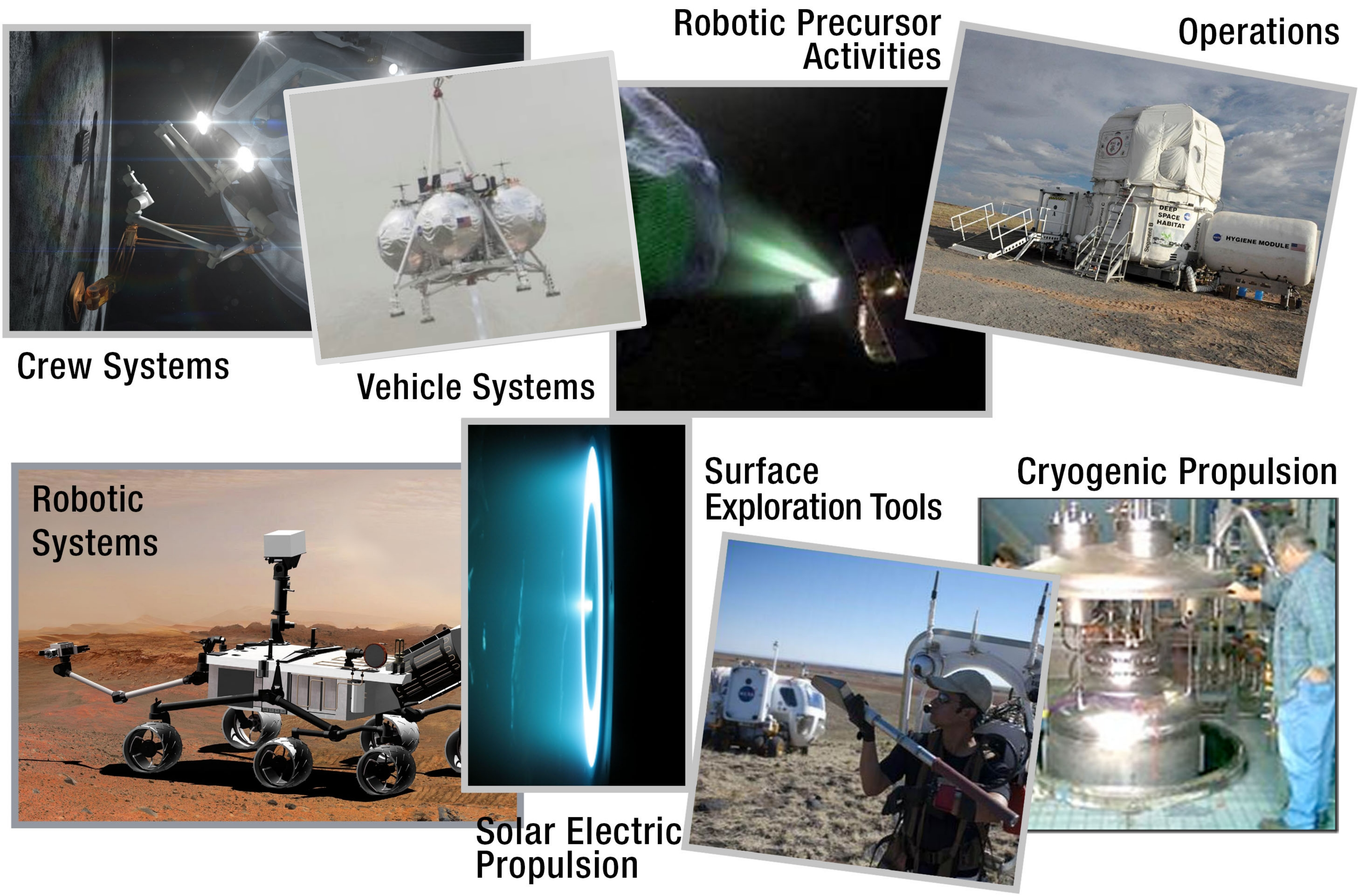
Exploration Mission Two (EM-2)

First Crewed BEO Flight
2021

- **Mission objectives**
  - Demonstrate crewed flight beyond LEO
- **Mission description**
  - Crewed lunar orbit-capable, or other destinations
  - Mission duration 10-14 days
- **Spacecraft configuration**
  - Orion Crewed
- **Launch vehicle configuration**
  - SLS Block, 5-segment RSRMV, 4 RS-25, 70mt
  - Interim CPS
- **Launch site**
  - KSC LC-39B



Advanced Exploration Systems and Technology Development



Space Communications and Navigation (SCaN)

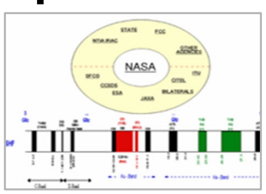
Deep Space Network
- Global tracking stations to provide tracking, telemetry and command, navigation data for spacecraft beyond LEO
- Solar system radar to determine NEO orbits

Tracking and Data Relay Satellite System
- Procuring replacement satellites

Near Earth Network
- Global tracking stations to support near Earth spacecraft
- Tracking, telemetry and command to support mission operations

Space Network
- Operations and maintenance
- Network sustaining engineering
- Network upgrades

Spectrum Management



- Management of Federal regulations for RF spectrum for NASA
- International coordination of spectrum allocation

Systems Planning

- Technology development
- Data Standards
- Search and Rescue technology

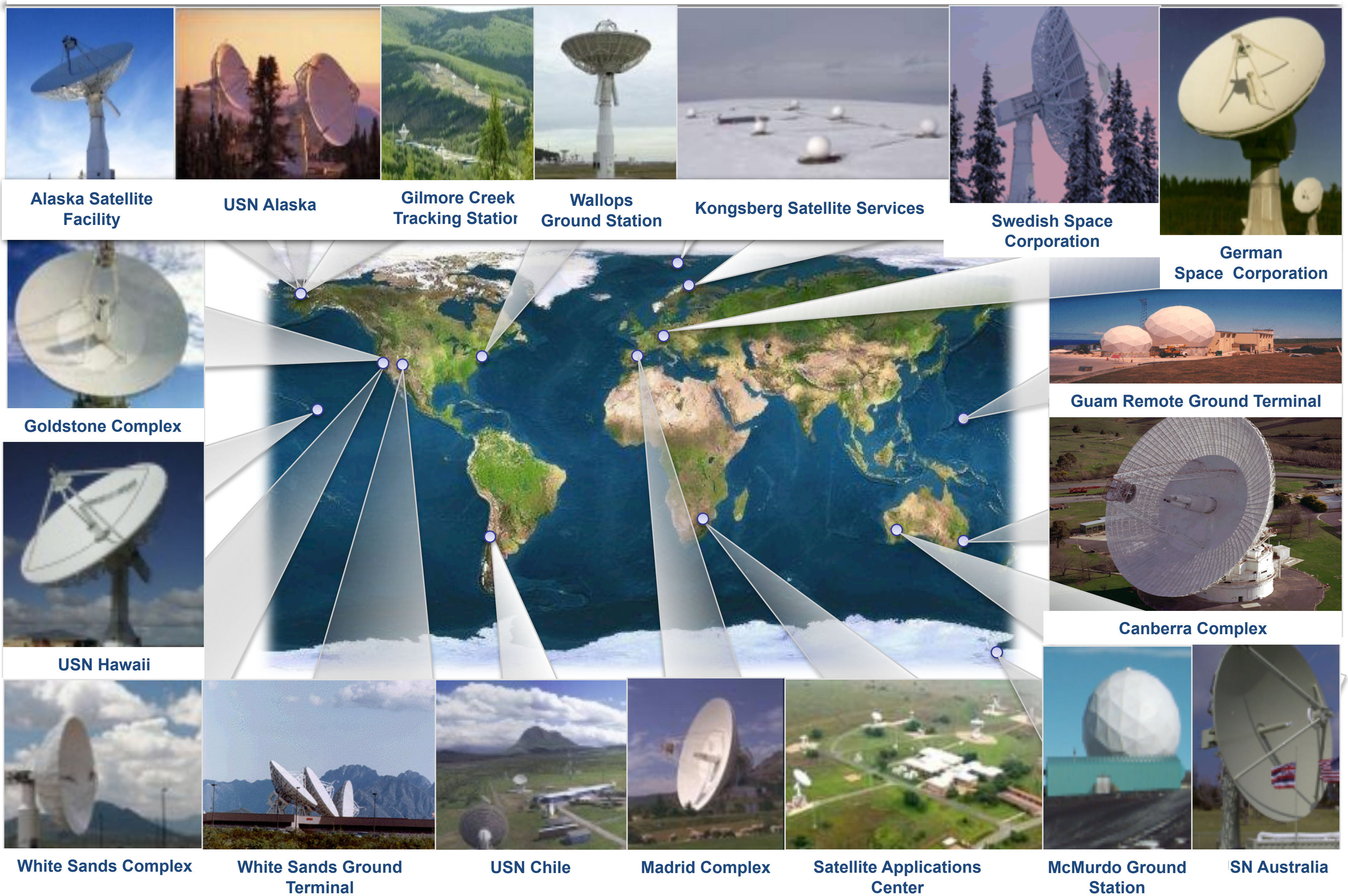
Systems Engineering

- Architecture development

Policy and Strategic Communications

- Federal and international coordination of Positioning, Navigation and Timing policy
- Succession planning

Space Communication and Navigation Networks



International Cooperation is Vital

INTERNATIONAL SPACE STATION

ISECG

CCSDS
Consultative Committee for Space Data Systems

UK SPACE
asi
cnes
ROSCOSMOS
CSIRO
NASA
DLR
KARI
JAXA
isro
esa

COSPAR
COMMITTEE ON SPACE RESEARCH

SFCG

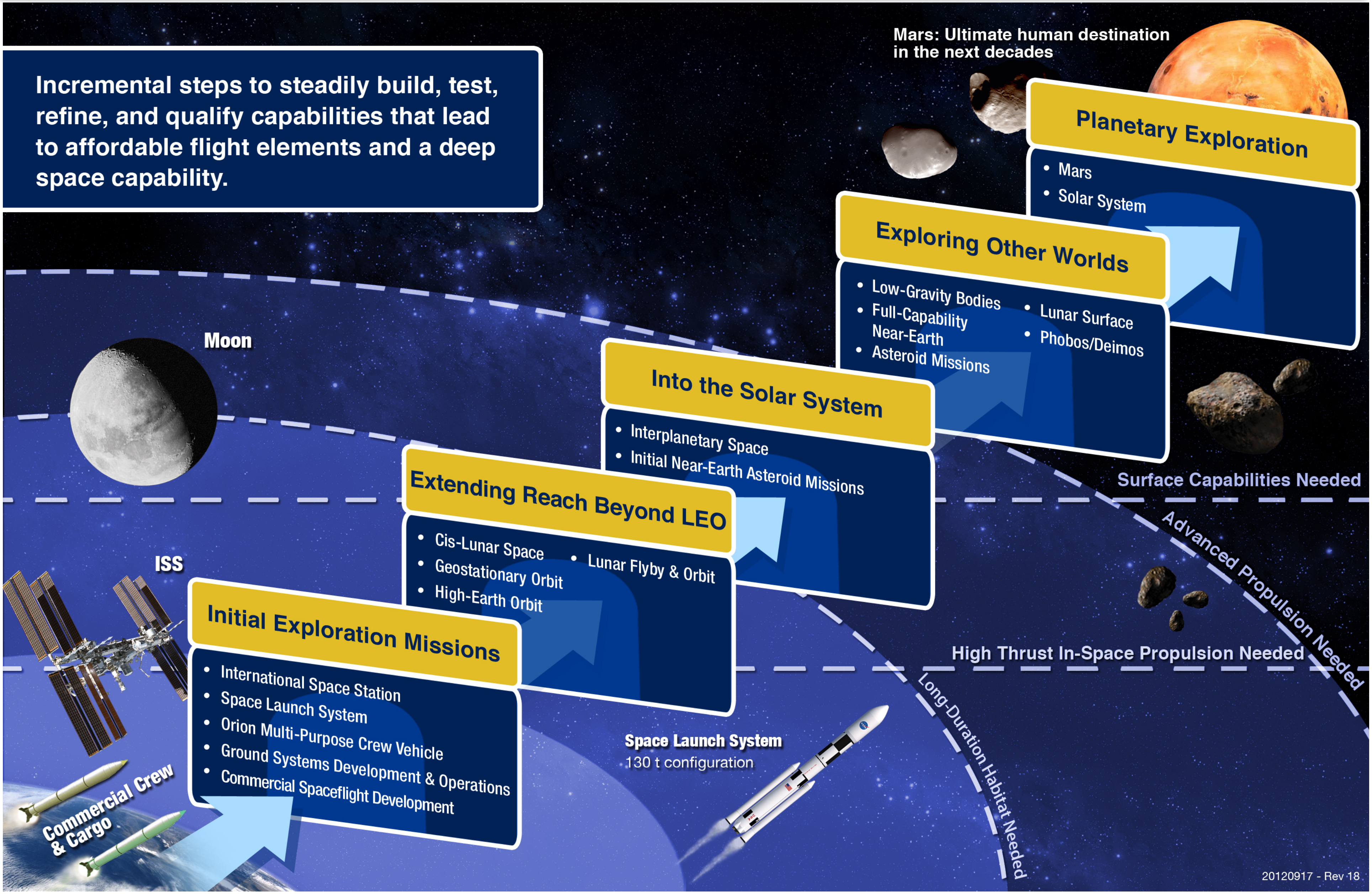
IOAG
Interagency Operations Advisory Group

Inspiring Future STEM Leaders

STEM

- **Educational Opportunities: www.nasa.gov/education**
- **Get Involved on NASA Social Media: www.nasa.gov/connect**

Capability Driven Human Space Exploration



Looking Toward the Future

- ISS will be the centerpiece of human spaceflight activities until at least 2020
- Research and technology breakthroughs aboard ISS will facilitate travel to destinations beyond low Earth orbit
- Destinations for human exploration remain ambitious: asteroids, the moon, Lagrange points, and ultimately, Mars
- A capability-driven human space exploration framework focuses on building, testing and refining core exploration capabilities that can be leveraged for multiple missions, rather than building destination-specific systems

QUESTIONS?

For the latest news about human space exploration:

www.nasa.gov/exploration

For more information about the Human Exploration and Operations Mission Directorate:

www.nasa.gov/directorates/heo

Backup

"Commercial" at NASA

Program Characteristic	Early Space Age Approach	Commercial-Oriented Approach
Owner	NASA	Industry
Contract Fee-Type	Cost Plus	Fixed Price
Contract Management	Prime Contractor	Public-Private Partnership
Customer(s)	NASA	Government and Non-Government
Funding for Capability Demonstration	NASA procures capability	NASA provides investment via milestone payments
NASA's Role in Capability Development	NASA defines "what" and "how"	NASA only defines "what" (Industry defines "how")
Requirements Definition	NASA defines detailed requirements	NASA defines top-level capabilities needed
Cost Structure	NASA incurs total cost	NASA and Industry cost share

Commercial Crew Approach

<u>Traditional NASA Development</u>

Goal: ISS Crew Mission

Extensive Government Involvement

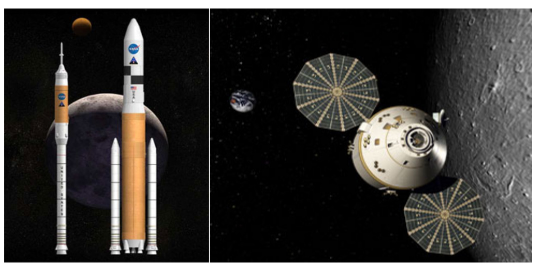
No Cost Sharing

Government Owns IP

Detailed Design Requirements

Unlimited Data and Lots of Deliverables

Higher Costs



<u>Non-Traditional Development</u>

Goal: Commercial Human Transport

Limited Government Involvement

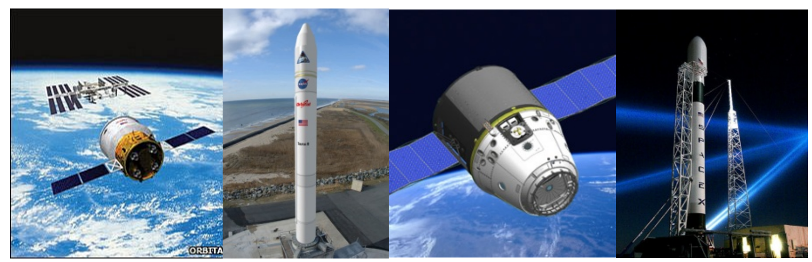
Cost Sharing

Commercial Partner Owns IP

Tailored Human-Rating Requirements

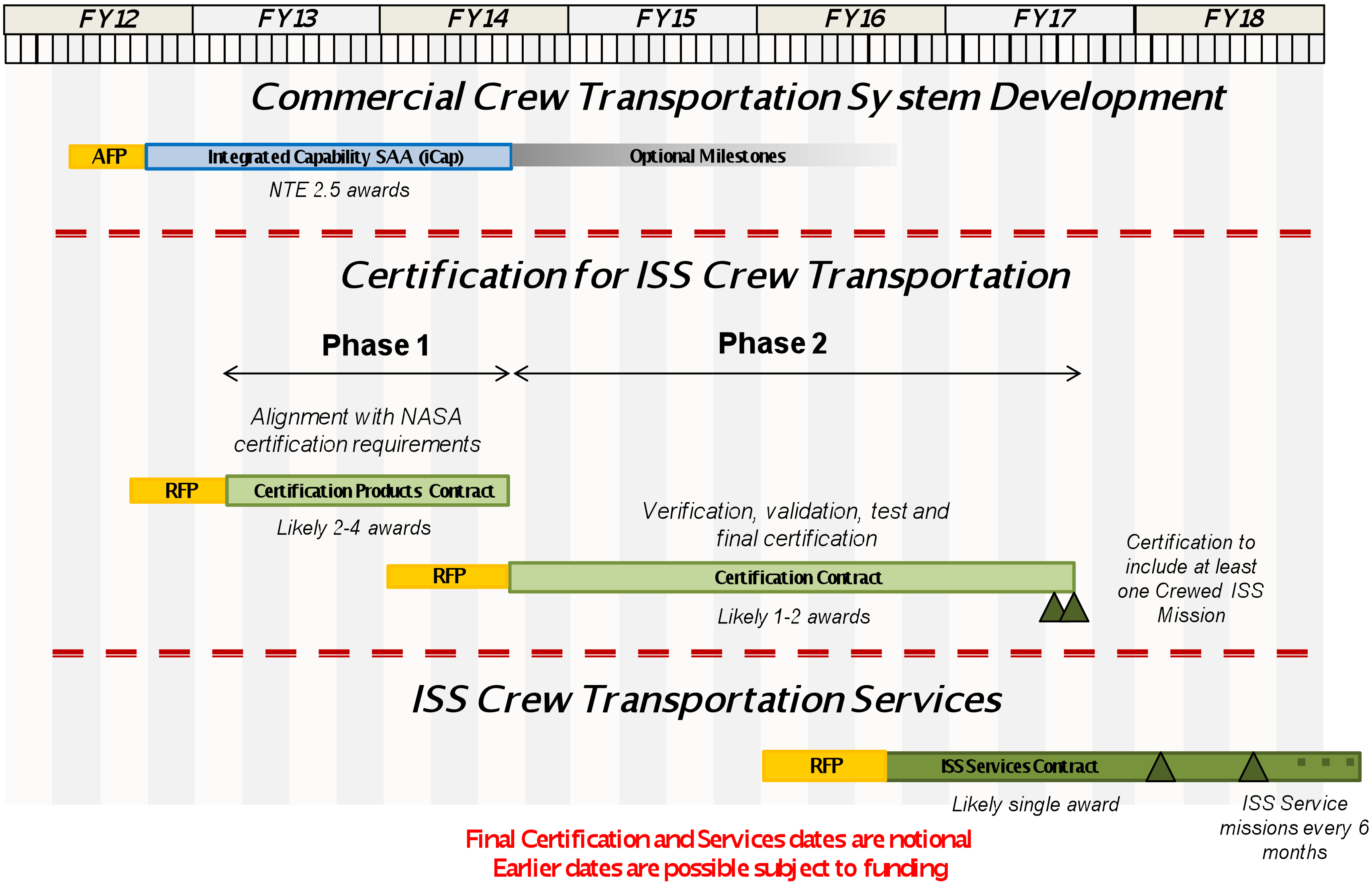
Pay-for-Performance Milestones

Lower Costs



NASA had clearly chosen a non-traditional development approach for the Commercial Crew Program.

Commercial Crew Program Roadmap



Relationship between CPC and Certification Contract