National Aeronautics and Space Administration

Future Human Exploration & Operations

Greg Williams
HEOMD Deputy AA for Policy & Plans
February 4, 2013

Overview

- Human Spaceflight Policy Goals
- A Capability-Driven Approach to the Future of Human Spaceflight
- Exploration Research on the International Space Station
- Exploration Systems Development
- Leveraging Commercial Spaceflight Development
- Advanced Exploration Systems and Technology Development
- Fostering International Collaboration in Human Exploration
- Summary
- Questions?

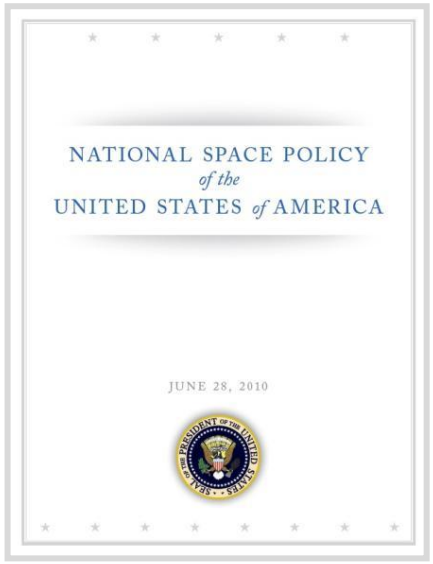
The NASA Authorization Act of 2010

- **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



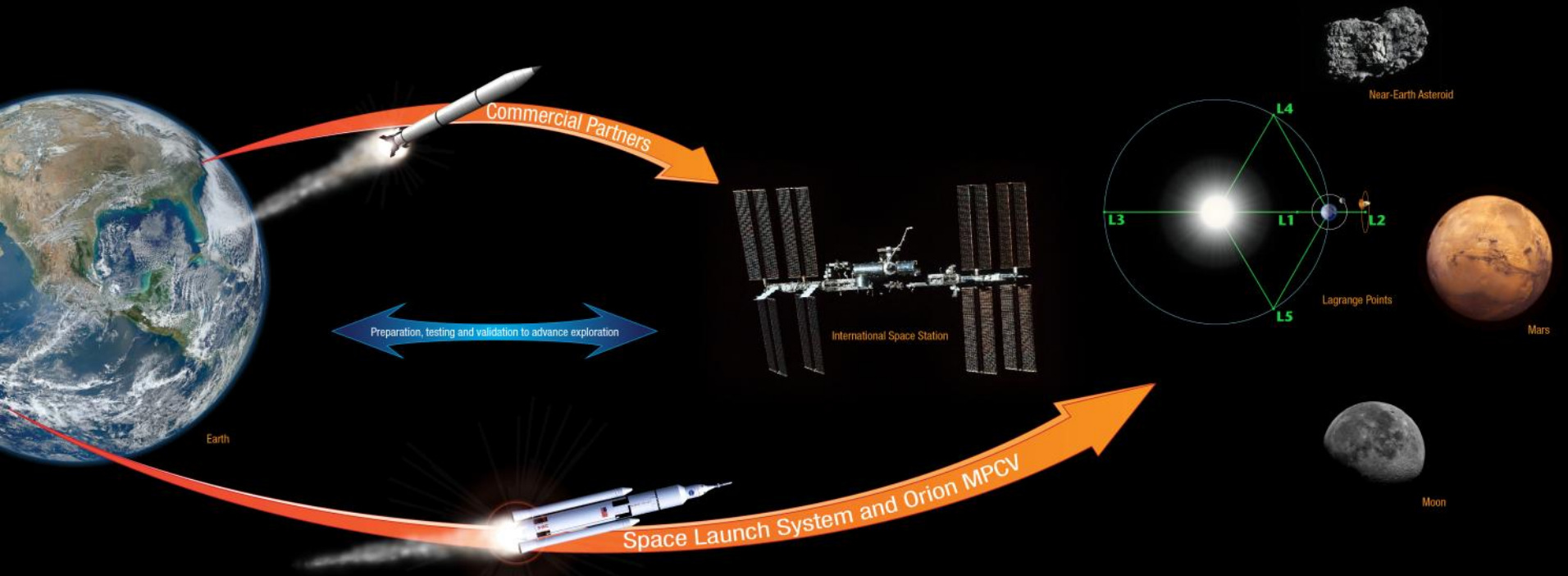

U. S. National Space Policy Guidelines on Human Space Flight

- 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.



The Future of American Human SPACEFLIGHT

National Aeronautics and Space Administration



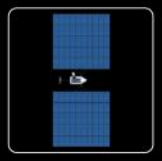
Human Spaceflight Capabilities


Mobile Extravehicular Activity and Robotic Platform


Deep Space Habitation


Advanced Spacesuits


Advanced Space Communication

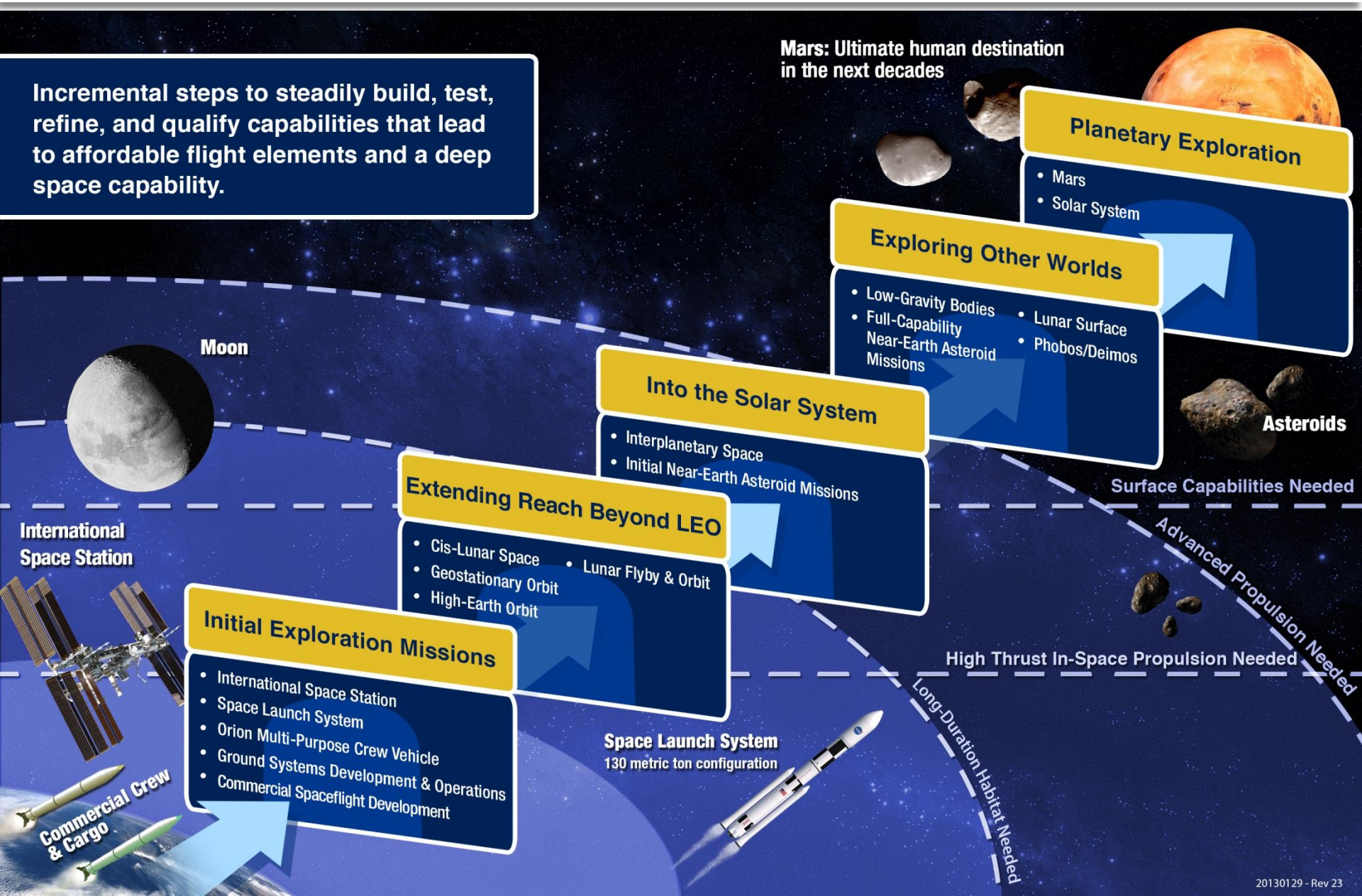

Advanced In-Space Propulsion


In Situ Resource Utilization


Human-Robotic Systems

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

Capability Driven Framework for Exploration



Identifying Future Exploration Mission Needs

Capability Driven Human Space Exploration

Human Exploration of Mars The "Horizon Destination"

Common Mission Needs Seeking Solutions

Low Earth Orbit Crew and Cargo Access	Human - Robotic Mission Ops	In-Space Propulsion	Adv. In-Space Propulsion	Deep Space Habitation	Ground Operations	High Reliability, Low Maintenance Systems
Beyond Earth Orbit Crew and Cargo Access	Robotic Precursor	EVA	Mobile EVA and Robotic Platform	Destination Systems	Autonomous Mission Operations	Crew Health & Protection

Technologies, Research, and Science

- OCT Technology Development Efforts
- Advanced Exploration Systems Projects
- HEO and SMD Cross Cutting Research & Science
- Human Exploration Specific Technologies

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

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.

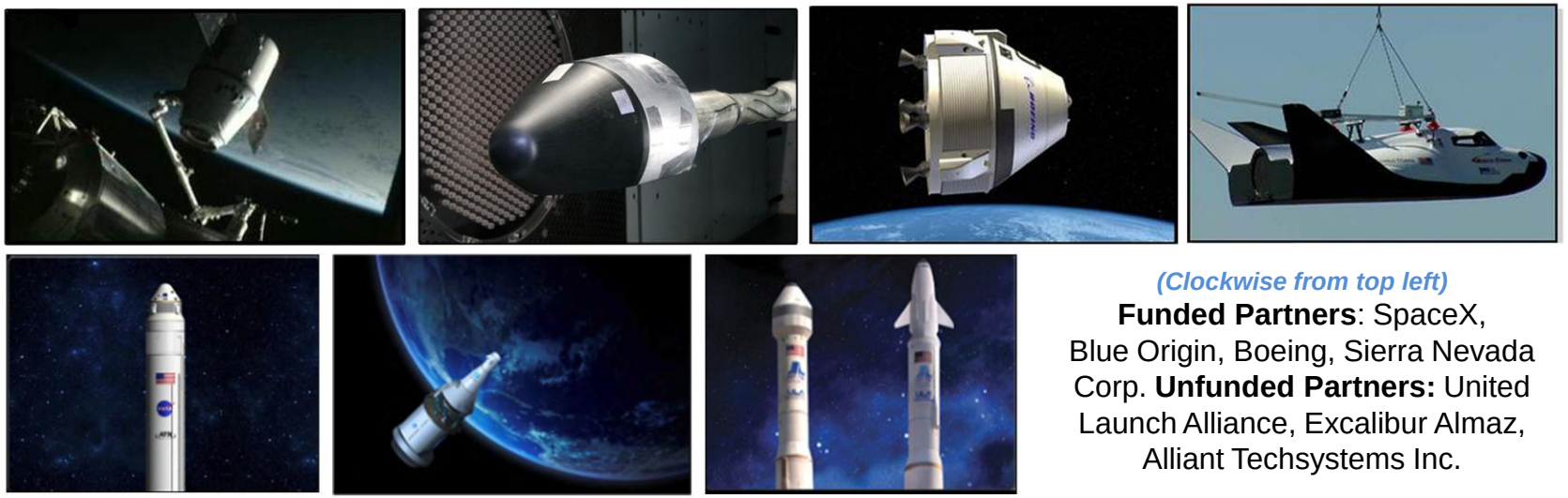
Commercial Spaceflight Development Partners

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.

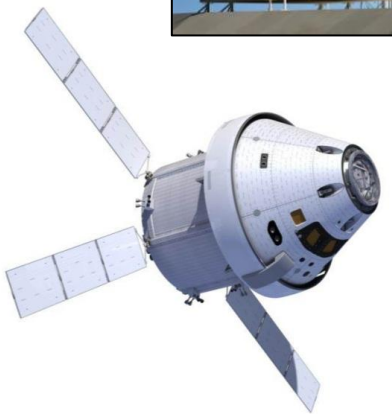
Exploration Systems Development

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



Advanced Exploration Systems Objectives

- **Advanced development of exploration systems to reduce risk, lower lifecycle cost, and validate operational concepts for future human missions beyond Earth orbit.**
- **Demonstrate prototype systems in ground test beds, field tests, underwater tests, and ISS flight experiments.**
- **Use and pioneer innovative approaches for affordable rapid systems development and provide hands-on experience for the NASA workforce.**
- **Maintain critical competencies at the NASA Centers and provide NASA personnel with opportunities to learn new and transform skills.**
- **Infuse new technologies developed by Space Technology Program into exploration missions.**
- **Support robotic missions of opportunity to characterize potential destinations for human exploration.**

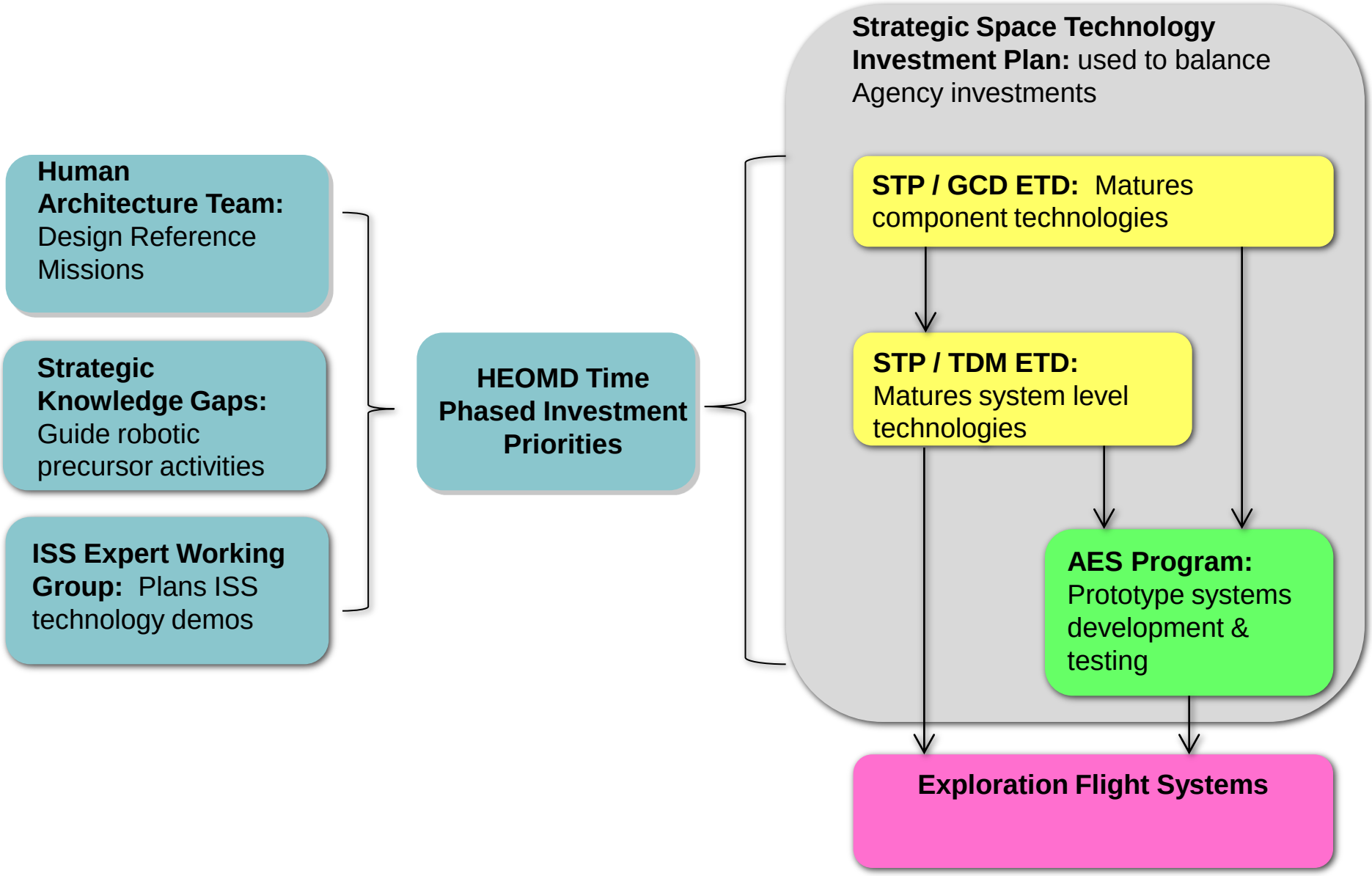
Advanced Exploration Systems

- **Crew Mobility Systems**
  - Systems to enable the crew to conduct “hands-on” surface exploration and in-space operations, including crew excursion vehicles, advanced space suits, and crew egress
- **Deep Space Habitation Systems**
  - Systems to enable the crew to live and work safely in deep space, including deep space habitats, reliable life support, radiation protection, and fire safety
- **Vehicle Systems**
  - Systems for in-space propulsion stages and small robotic landers, including nuclear propulsion, modular power systems, lander technology test beds, and autonomous precision landing
- **Operations**
  - Systems to enable more efficient mission and ground operations, including integrated testing, autonomous mission ops, integrated ground ops, and logistics reduction
- **Robotic Precursor Activities**
  - Acquire strategic knowledge on potential destinations for human exploration to inform systems development, including prospecting for lunar ice, characterizing the Mars surface radiation environment, radar imaging of NEAs, instrument development, and research and analysis

Suitport Concepts Testing

Morpheus Vertical Test Bed

Defining the Combined AES/STP Portfolio



Strategic Knowledge Gaps (SKGs)

- Strategic Knowledge Gaps will guide the planning of robotic precursor missions to gather crucial environmental data on the Moon, near-Earth asteroids, and Mars to support human exploration.

- **SKG Themes for the Moon**
  1. Understand the lunar resource potential
  2. Understand the lunar environment and its effects on human life
  3. Understand how to work and live on the lunar surface

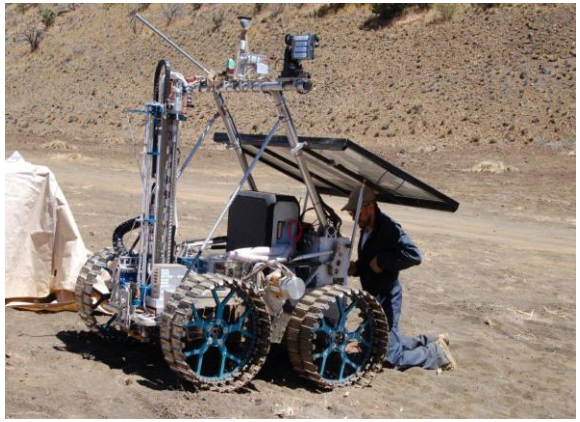
- **SKG Themes for Small Bodies (NEAs)**
  1. Human mission target identification
  2. Understand how to work on or interact with the Small Body surface
  3. Understand the Small Body environment and its potential risk/benefit to crew, systems, and operational assets.
  4. Understand the Small Body resource potential

- **SKG Themes for Mars**
  1. To achieve the goal of humans to Mars orbit: Upper atmospheric measurements & modeling
  2. To achieve the goal of humans to Mars surface: Lower atmospheric measurements, planetary protection, radiation, dust effects, atmospheric ISRU, landing site hazards
  3. To achieve the goal of humans to Phobos/Deimos: Surface science & operations
  4. To achieve the goal of sustained human presence at Mars: Water resources

AES Flight Experiments: Recent & in Development

- **ISS**
  - Additive Manufacturing (2014)
  - Autonomous Mission Operations (2014)
  - BEAM: Bigelow Expandable Activity Module (2015)
  - Delay Tolerant Networking (2012)
  - EVA Suit Demo (2019)
  - Medipix Radiation Sensors on ISS (2012)
  - OPALS: Optical Payload for Lasercom Science (2013)
  - Spacecraft Fire Safety (2015)
- **EFT-1**
  - Advanced Caution and Warning System (2014)
  - Radiation Environment Monitors (2014)
- **Mars**
  - Radiation Assessment Detector (2012)

- **Formulation**
  - GEO Hosted NEA Observation Instruments
  - RESOLVE Lunar Ice Prospecting Mission (2017)
  - EM-1 Secondary and Mars 2020



RESOLVE: Conducted field test in Hawaii of lunar ice prospecting experiment in partnership with Canadian Space Agency.

Radiation Protection: Demonstrated miniature radiation environment monitor and storm shelter concepts

International Collaboration is Essential

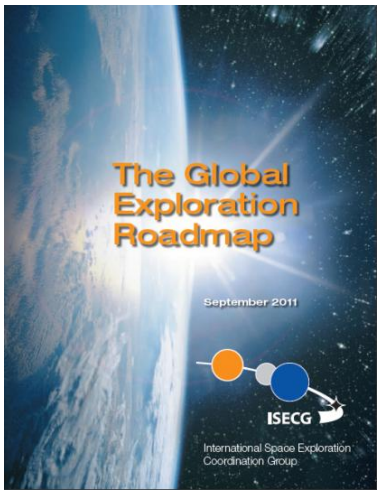
- **International Space Exploration Coordinating Group (ISECG) provides a venue for working in a non-binding, consensus-driven manner towards advancing a Global Exploration Strategy (GES)**

- **ISECG serves as a forum where interested agencies may coordinate on space exploration**
  - Provide a forum for discussion of interests, objectives and plans
  - Develop non-binding conceptual products to inform individual agency decision making

- **ISECG operating principles**
  - Open and inclusive
  - Flexible and evolutionary
  - Effective
  - Mutual interest

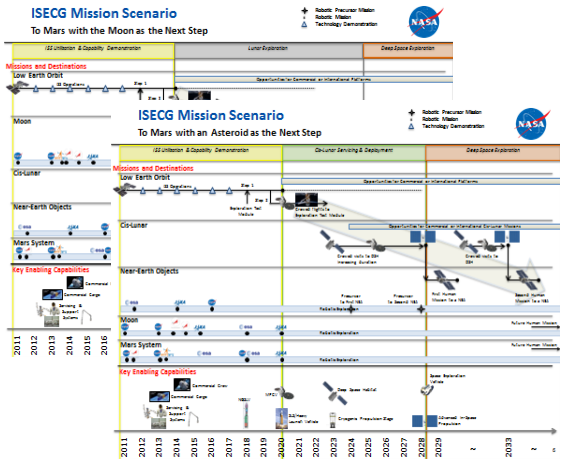
ISECG and the Global Exploration Roadmap

- **NASA has been a leader in the International Space Exploration Coordination Group (ISECG) effort to develop a Global Exploration Roadmap (GER)**
- **The non-binding GER enables agency discussions on important topics such as**
  - Common goals and objectives for exploration
  - Advancing long-range mission scenarios and architectures which lead to sustainable human missions to Mars
  - Opportunities for near-term coordination and cooperation on preparatory activities
- **Reflects consensus of 12 agencies that human exploration will be an international endeavor, with sustainable human missions to Mars as the common driving goal**
  - Reflects current policies and plans of participating agencies
  - Serving as a tool which supports individual agency stakeholder engagement
    - Industry, academia, government stakeholders, other
- **GER 2.0 is in development this calendar year**



GER Mission Scenarios

- **Mission scenarios are designed allow discussion of long-term strategies for Human Space Exploration, with sustainable Mars Exploration as the common goal**
  - Moon Next and Asteroid Next both considered valid steps to Mars and enable each partners interests to be discussed
  - Both build on MPCV, SLS, planned robotic missions

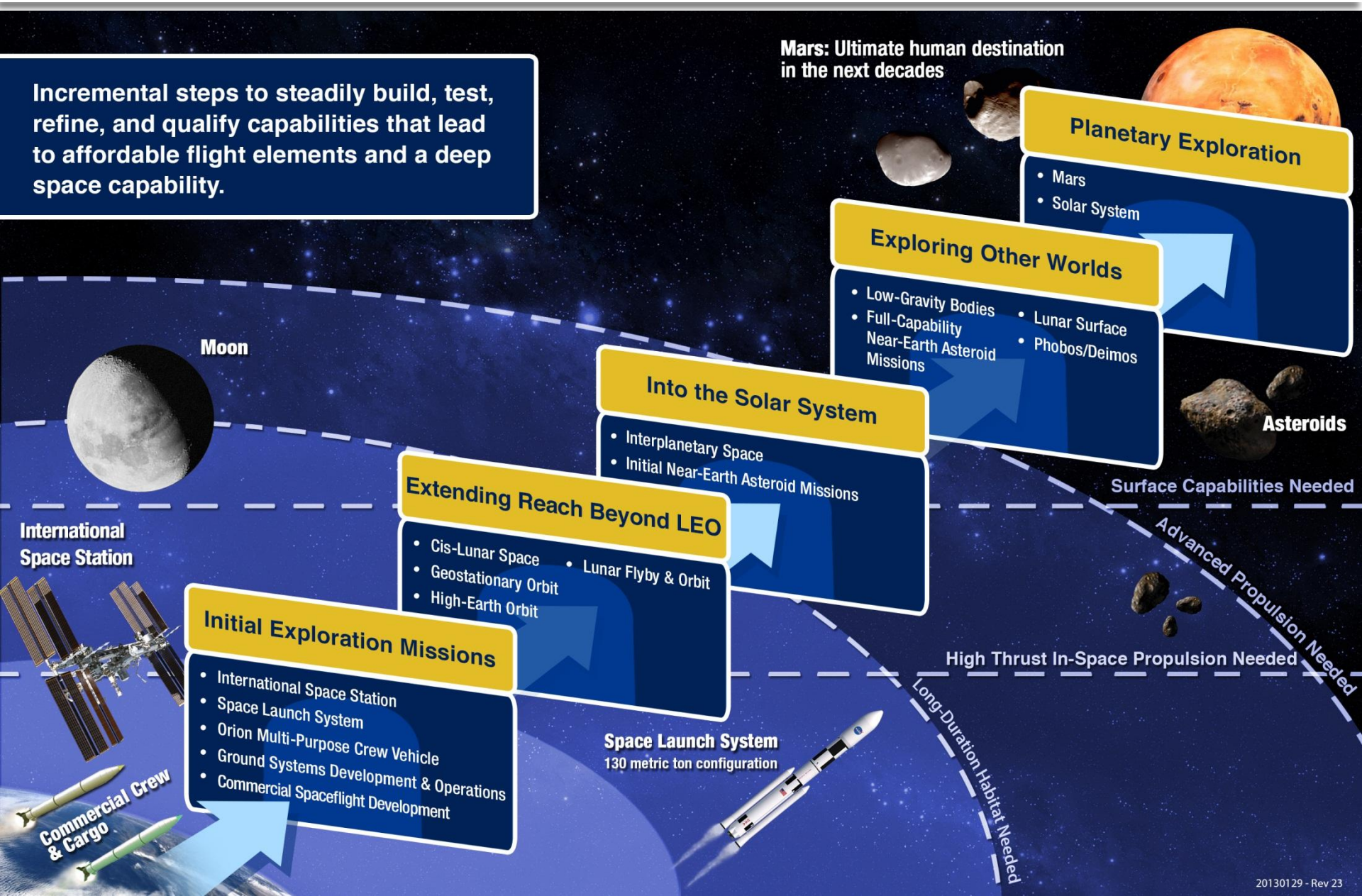


- **Principles guiding mission scenarios**
  - Meaningful roles for international participation
  - Realistic budget assumptions (affordability)
  - Step-wise evolution of critical capabilities necessary for executing increasingly complex exploration missions
    - Incorporating new technologies, as ready
  - Robustness to technical failures and partnership adjustments
  - Providing value to stakeholders, generating public benefit: science, education, technologies, economic expansion

Use of ISS to Prepare for International Exploration

- **All ISS partners are actively conducting exploration preparatory activities on the ISS to prepare for future roles**
  - Partners also looking for collaboration opportunities which maximize return on investment
- **Four main focus areas:**
  - **Exploration technology demonstrations**
    - On-orbit demonstration or validation of candidate technologies
  - **Demonstrating maturity and reliability of critical exploration systems, such as life support systems**
    - Driving evolution in capabilities supporting the ISS today to meet future challenges - high reliability, high efficiency, low mass, low power
  - **Human health management for long duration space travel**
    - Research to understand the main risks to human health and performance
    - Validation of strategies for keeping the crew healthy and productive
  - **Ops simulations and operations technique demonstrations**
    - Furthering our understanding of future operations challenges
    - One year expedition

Capability Driven Framework for Exploration



Looking Toward the Future

- Destinations for human exploration are ambitious and challenging: 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
- Research and technology breakthroughs aboard ISS will facilitate travel to destinations beyond low Earth orbit
- SLS and Orion will open up human exploration beyond Earth orbit
- We are laying the technological foundation for future exploration
- International collaboration will be essential

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