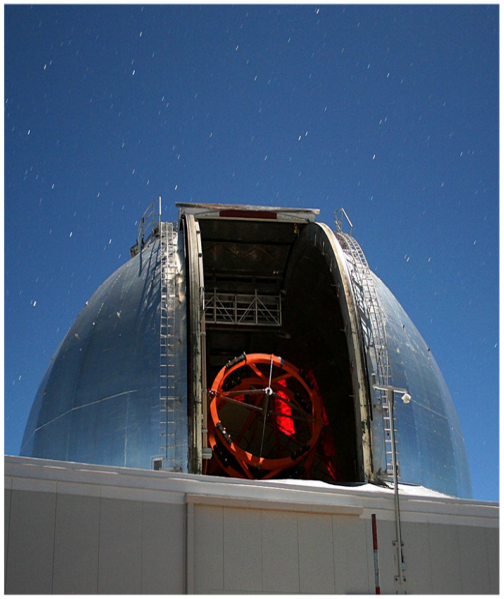
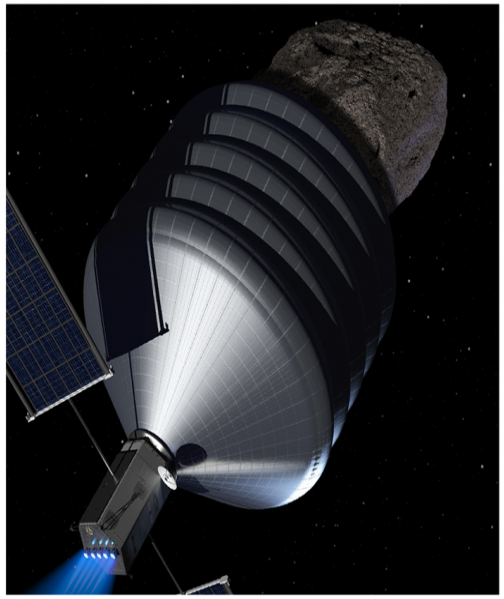
Asteroid Redirect Mission and Human Exploration

Michele Gates

Human Exploration and Operations Mission Directorate

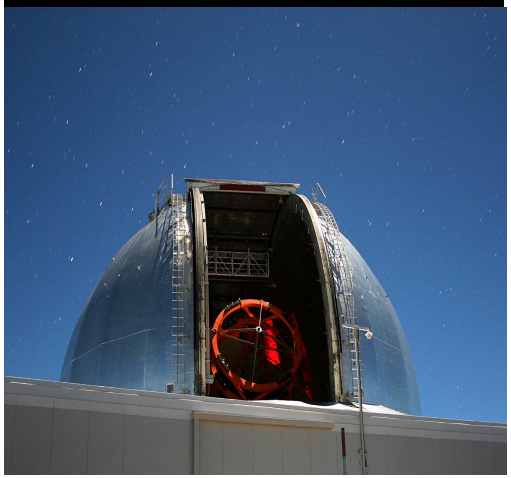



Leveraging Capabilities for an Asteroid Mission

- **NASA is aligning key activities in Science, Space Technology, and Human Exploration and Operations Mission Directorates**
  - Asteroid identification and characterization efforts for target selection
  - Solar electric propulsion for transport to and return of the target asteroid
  - Autonomous guidance and control for proximity operations and capture
  - Orion and Space Launch System (SLS) missions for asteroid rendezvous
  - Technologies for astronaut extra-vehicular activities
- **Each individual activity provides an important capability in its own right for human and robotic exploration**
- **We are working to utilize all of these activities to**
  - Identify and redirect a small asteroid to a stable orbit in the lunar vicinity; and
  - Investigate and return samples with our astronauts using the Orion and SLS assets.
- **The FY14 budget supports continued advancement of the important individual elements and furthers the definition of the overall potential mission.**

Overall Mission Consists of Three Main Segments

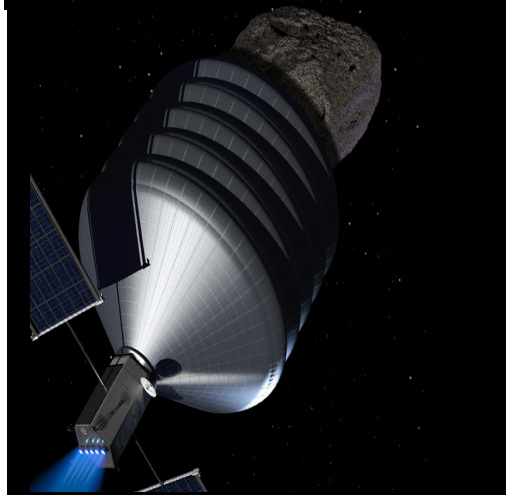
Identify



Asteroid Identification Segment:

Ground and space based NEA target detection, characterization and selection

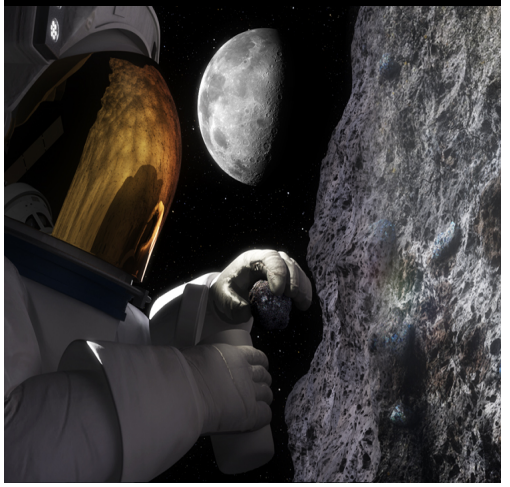
Redirect



Asteroid Redirection Segment:

Solar electric propulsion (SEP) based robotic asteroid redirect to trans-lunar space

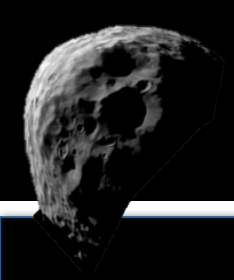
Explore

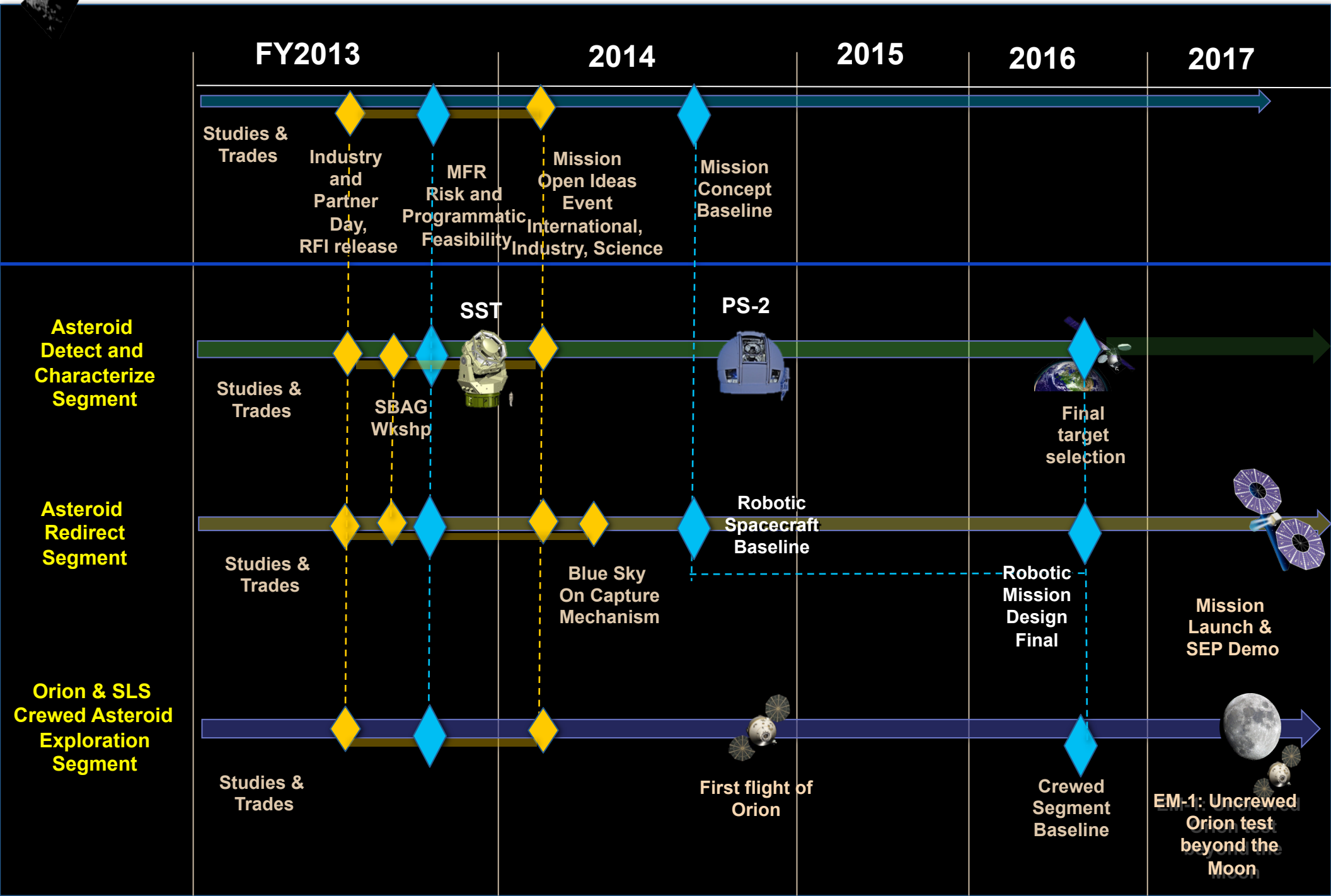


Asteroid Crewed Exploration Segment:

Orion and SLS based crewed rendezvous and sampling mission to the relocated asteroid

Decision & Engagement Strategy

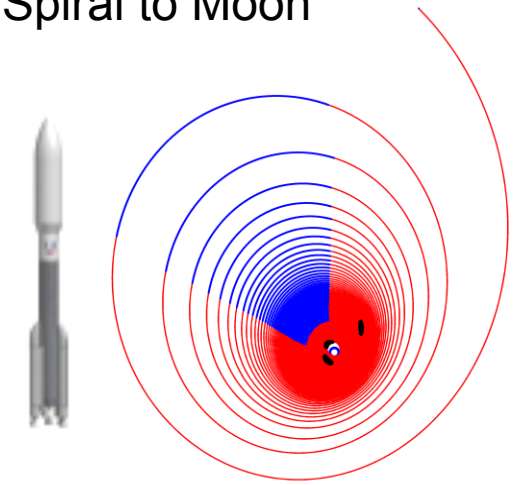




Reference Robotic Mission Design Executive Summary

1. Launch (2 Options)

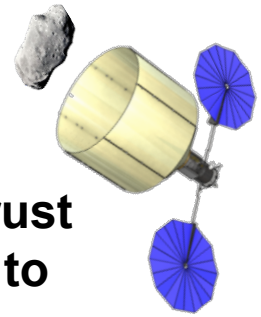
1a. *Atlas V* – Low Thrust Spiral to Moon



1b. *SLS or Falcon Heavy* – Direct Launch to Moon or to Asteroid

2. Lunar Flyby to Escape
(If Needed)

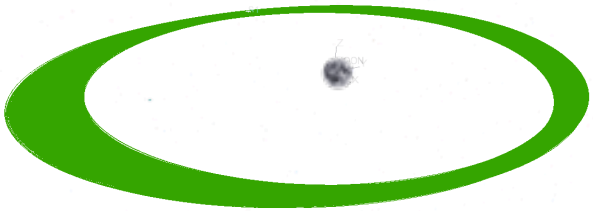
3. Low Thrust Trajectory to Asteroid

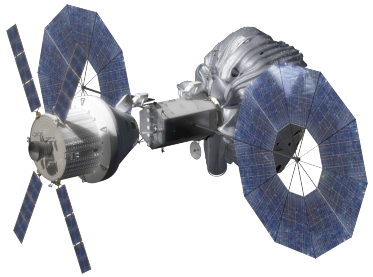


4. Low Thrust Trajectory with Asteroid to Earth-Moon System

5. Lunar Flyby to Capture

6. Low Thrust Trajectory to Storage Orbit

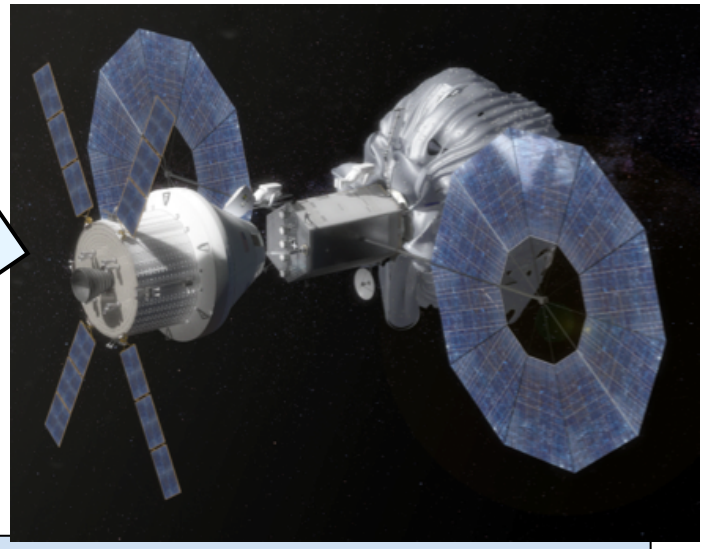




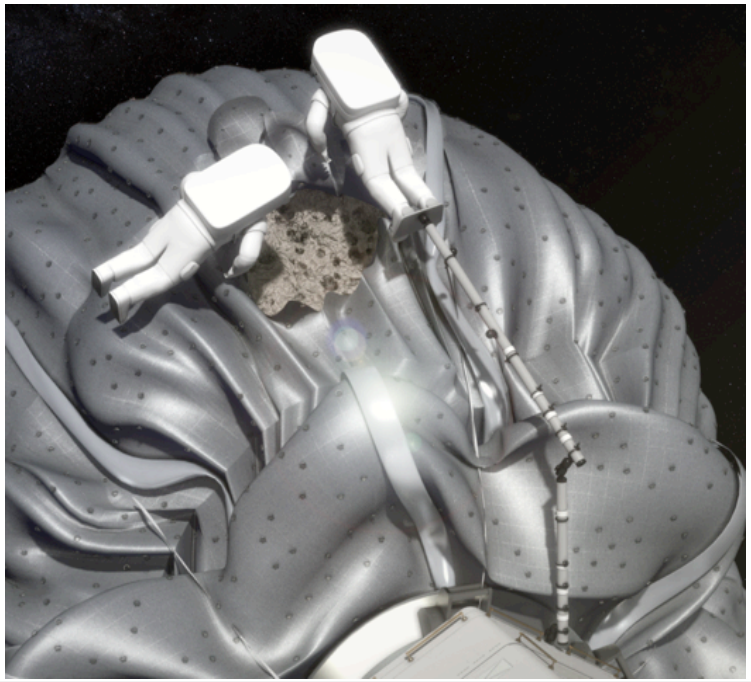
7. Orion Rendezvous

Explore: Orion Mission Overview

Deliver Crew in Orion



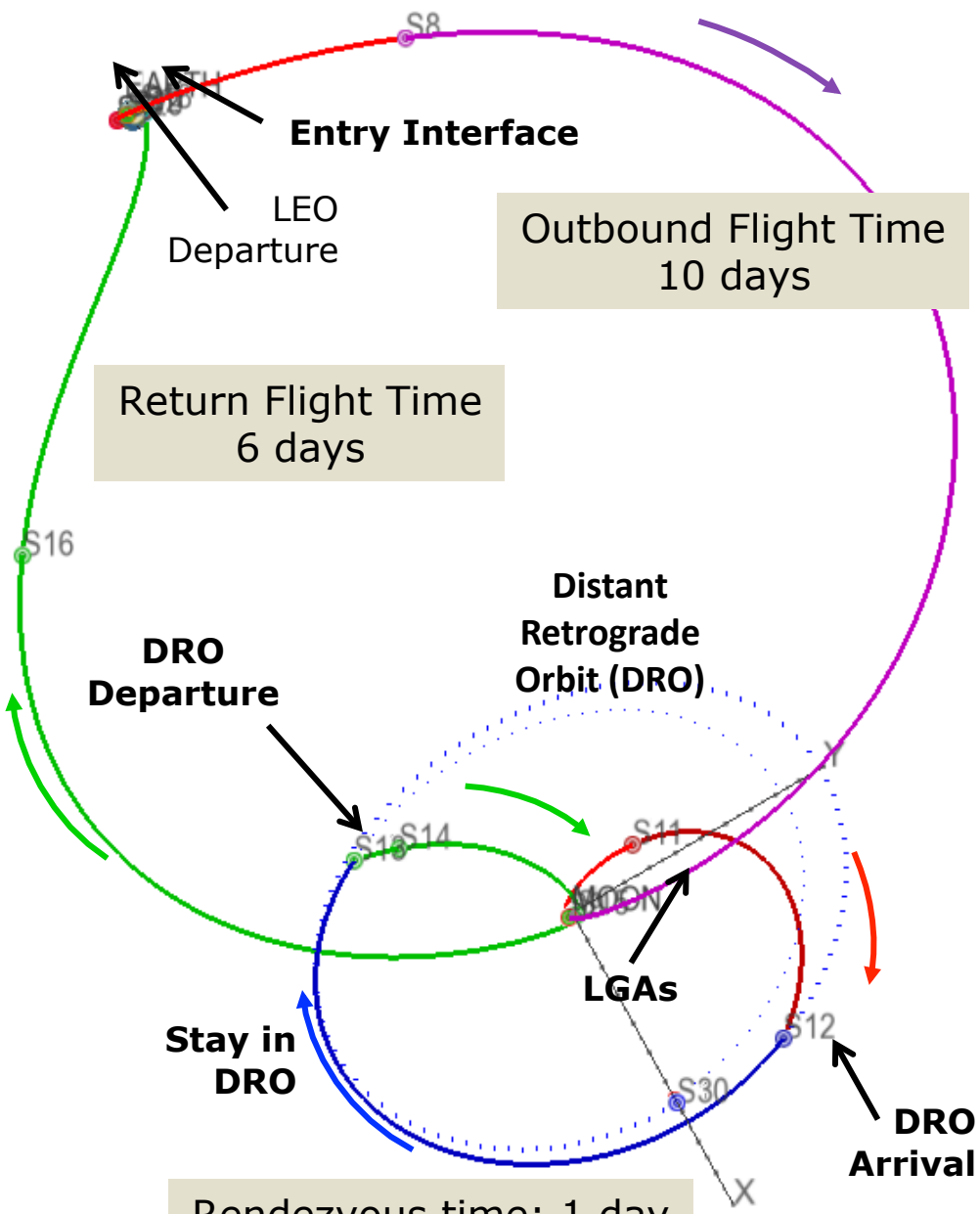
Attach Orion to robotic spacecraft



Perform Extra- Vehicular Activity (EVA) to retrieve asteroid samples

Return crew safely to Earth with asteroid samples in Orion

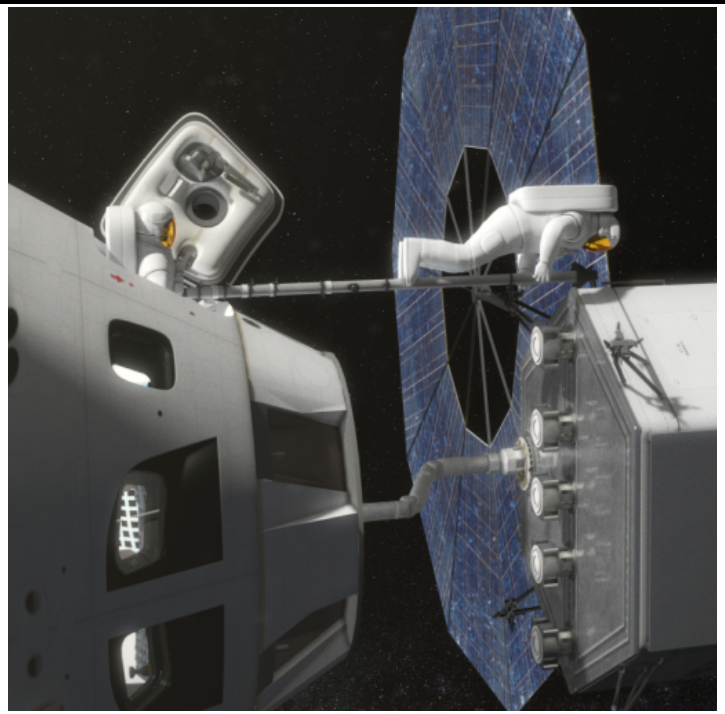
Nominal Orion Mission Summary

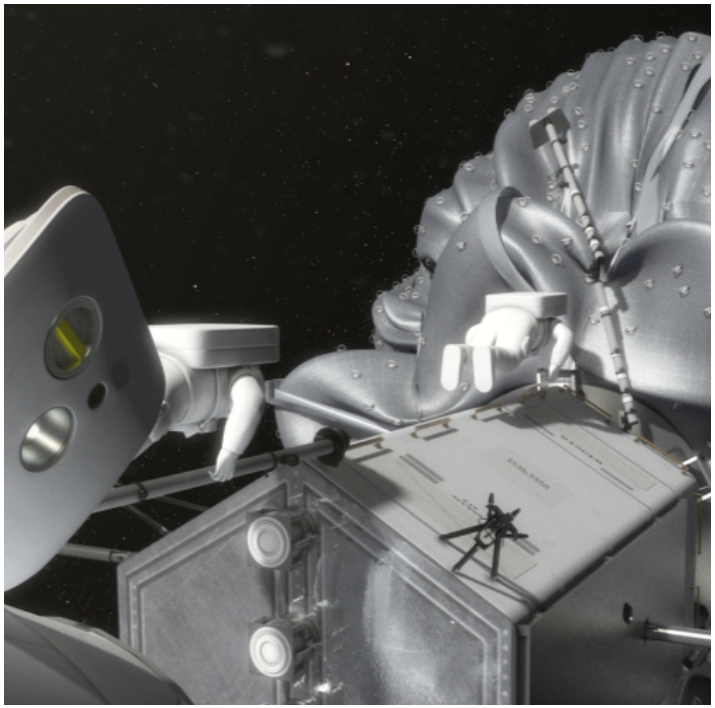


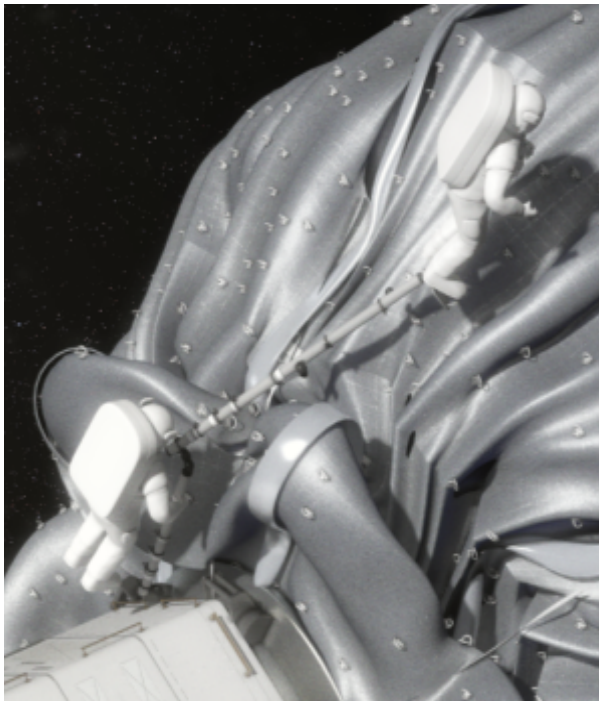
- **Outbound**
  - **Flight Day 1 – Launch/Trans Lunar Injection**
  - **FD2-FD5 – Outbound Trans-Lunar Cruise**
  - **Flight Day 6 – Lunar Gravity Assist (LGA)**
  - **FD7-FD9 – Post LGA to DRO Cruise**
- **Joint Operations with Robotic Spacecraft**
  - **Flight Day 10 – Rendezvous/Grapple**
  - **Flight Day 11 – EVA #1**
  - **Flight Day 12 – Suit Refurbishment, EVA #2 Prep**
  - **Flight Day 13 – EVA #2**
  - **Flight Day 14 – Contingency Day/Departure Prep**
  - **Flight Day 15 – Departure from DRO**
- **Inbound**
  - **Flight Day 16 – DRO to Lunar Cruise**
  - **Flight Day 17 – Lunar Gravity Assist**
  - **FD18-FD21 – Inbound Trans-Lunar Cruise**
  - **Flight Day 22 – Earth Entry and Recovery**

Note: Mission Duration Varies From 22-25 Days

Notional EVA Operations From Orion





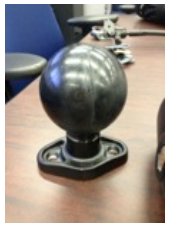


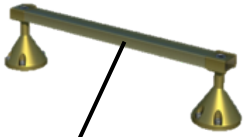
- Two EVAs executed from Orion
- Crew translates from Orion to robotic spacecraft
- EVA Tool box prepositioned on robotic spacecraft
- Telescoping booms pre-stowed on robotic spacecraft
- Crewmember stabilized on portable foot restraint for worksite
- Loops available on capture mechanism for additional stabilization

Notional Design for EVA: Robotic Spacecraft

Translation Boom and Attach Hardware

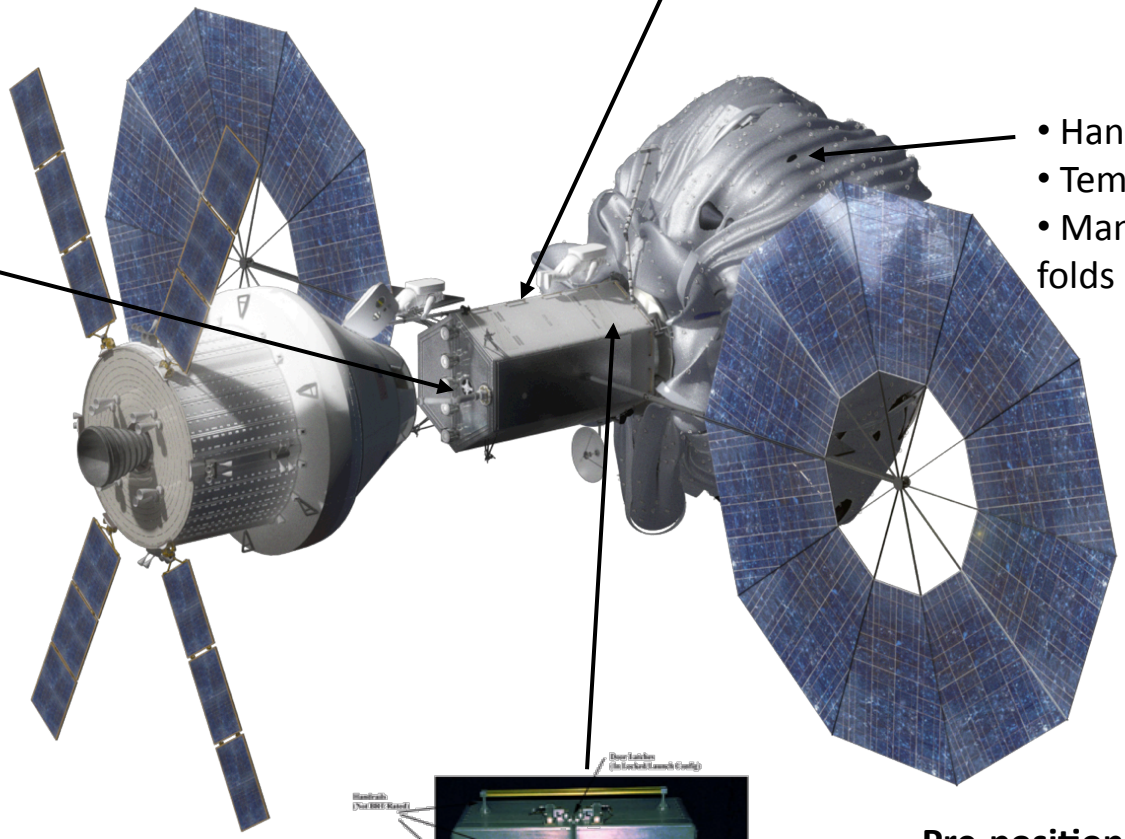
- Translation from Orion to spacecraft
- Translation from spacecraft to capture device bag for asteroid access





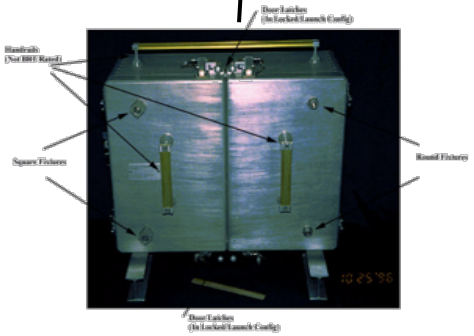
Hand Rails

- Translation path from aft end of spacecraft to capture device
- Ring of hand rails around spacecraft near capture device



EVA Tether Points

- Hand-over-hand translation
- Temporary restraint of tools
- Management of loose fabric folds



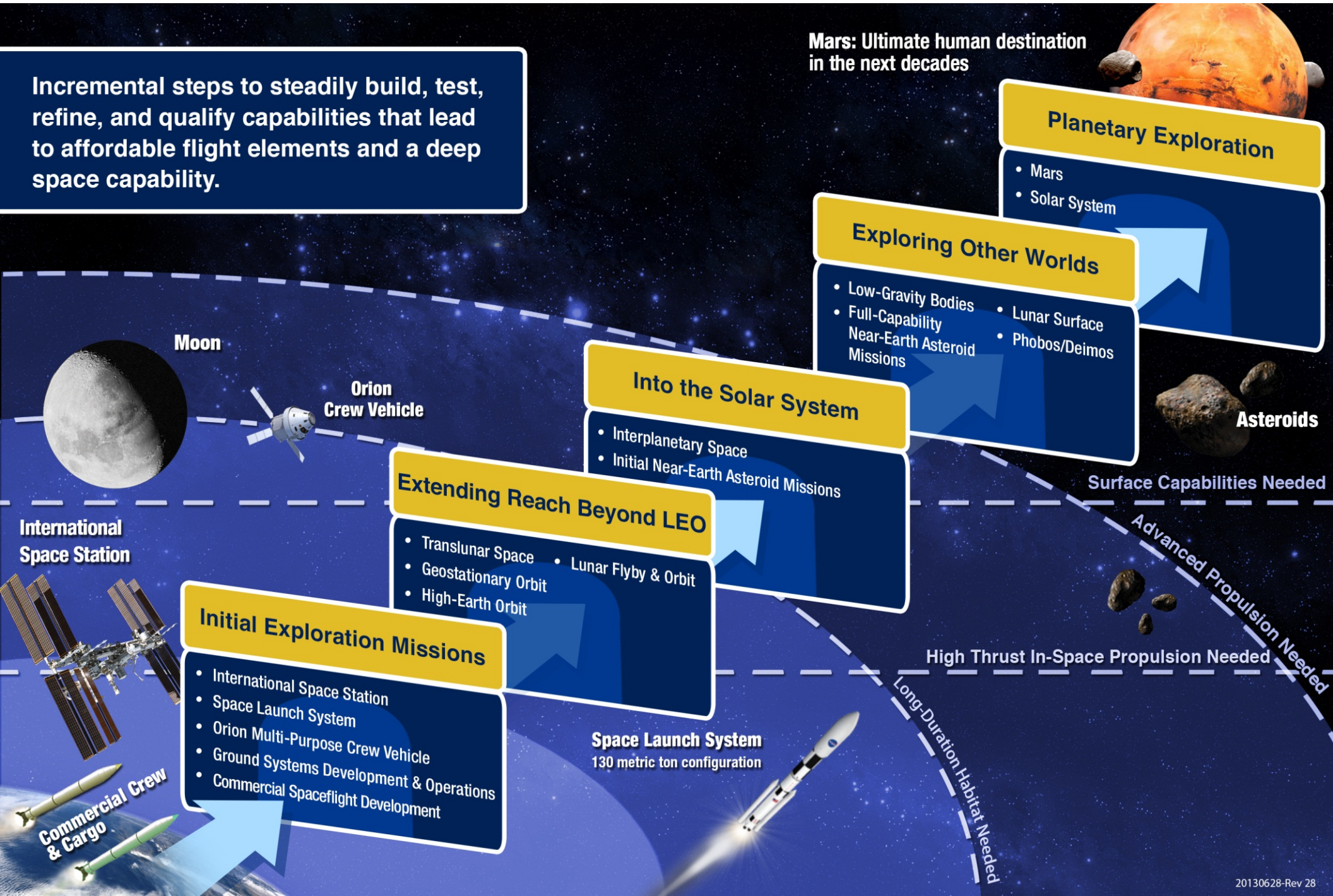
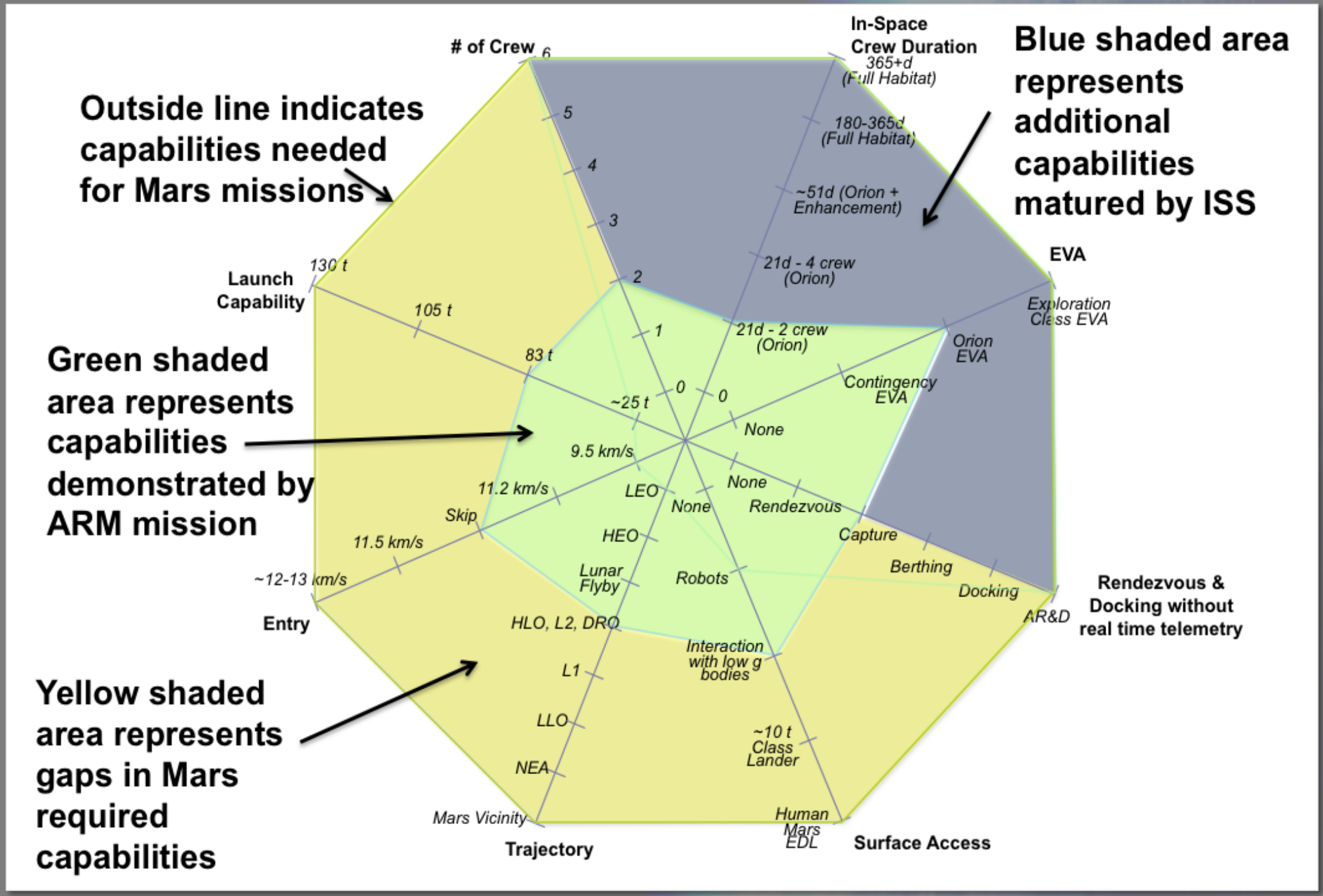
Pre-positioned EVA Items

- Tool box to offset mass in Orion
- Two additional translation booms

Asteroid Mission Supports Long-Term Human Mars Exploration Strategy

- Demonstration of Core Capabilities for deep space missions:
  - Block 1 SLS, Orion
  - 40kW Solar Electric Propulsion System
  - EVA, rendezvous, proximity operations, docking or grapple, deep space navigation and communications
  - Human operations and risk management beyond low earth orbit
  - Sample acquisition, caching, storage operations, and crew transfer operations for future Lunar/Mars sample return missions
- Demonstrates ability to work and interact with a small planetary body:
  - Systems for instrument placement, sample acquisition, material handling, and testing
  - Understanding of mechanical properties, environment, and mitigation of hazards

Capability Driven Framework



Mars Exploration Capability Build-Up Using Asteroid Redirect Mission and ISS