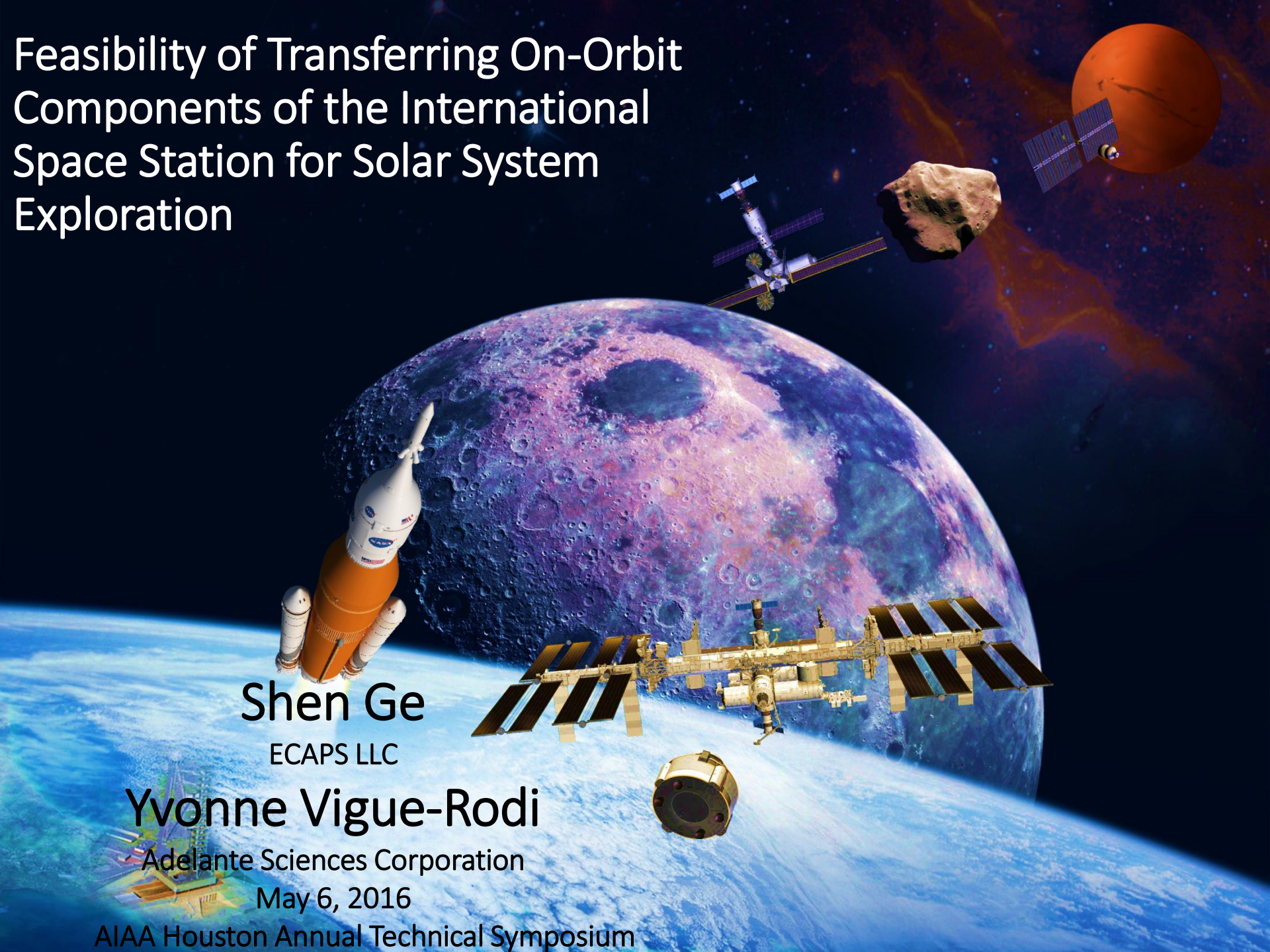
Feasibility of Transferring On-Orbit Components of the International Space Station for Solar System Exploration



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May 6, 2016

AIAA Houston Annual Technical Symposium

Outline

- Problem Statement
- Assumptions
- Why go to the moon?
- International Space Station
- How do we get there?
- Alternative Propulsion Systems
- Closing Thoughts

Problem Statement

- Context:
  - The International Space Station is in operation and will be decommissioned by 2024.
- Problem:
  - Explore whether the ISS can be reused for a space station near the moon.
- Approach:
  - Separate and transfer US portion of ISS components to a lunar orbit.

Assumptions

- ISS will be decommissioned in 2024
- A human habitat at lunar orbit or Earth-moon Lagrange point is the next human spaceflight target
- ISS components at such locations can be maintained autonomously prior to human arrival and provide a habitat for emergency rescue purposes
- ISS components can be equipped with science payloads to survey the moon

Why go to lunar orbit?

- Establish a robotic and human space station or space stations near the moon as a platform for
  - Future manned or robotic lunar surface scientific, exploration, and mining missions
  - Supply depot for exploration missions beyond the moon.
  - Research laboratory on lunar materials
  - Scientific observation, especially on the far side of the moon and the polar regions

Science

- Search for water at poles
- Identify minerals
- Map gravity field and topography
- Detect charged particles of exosphere

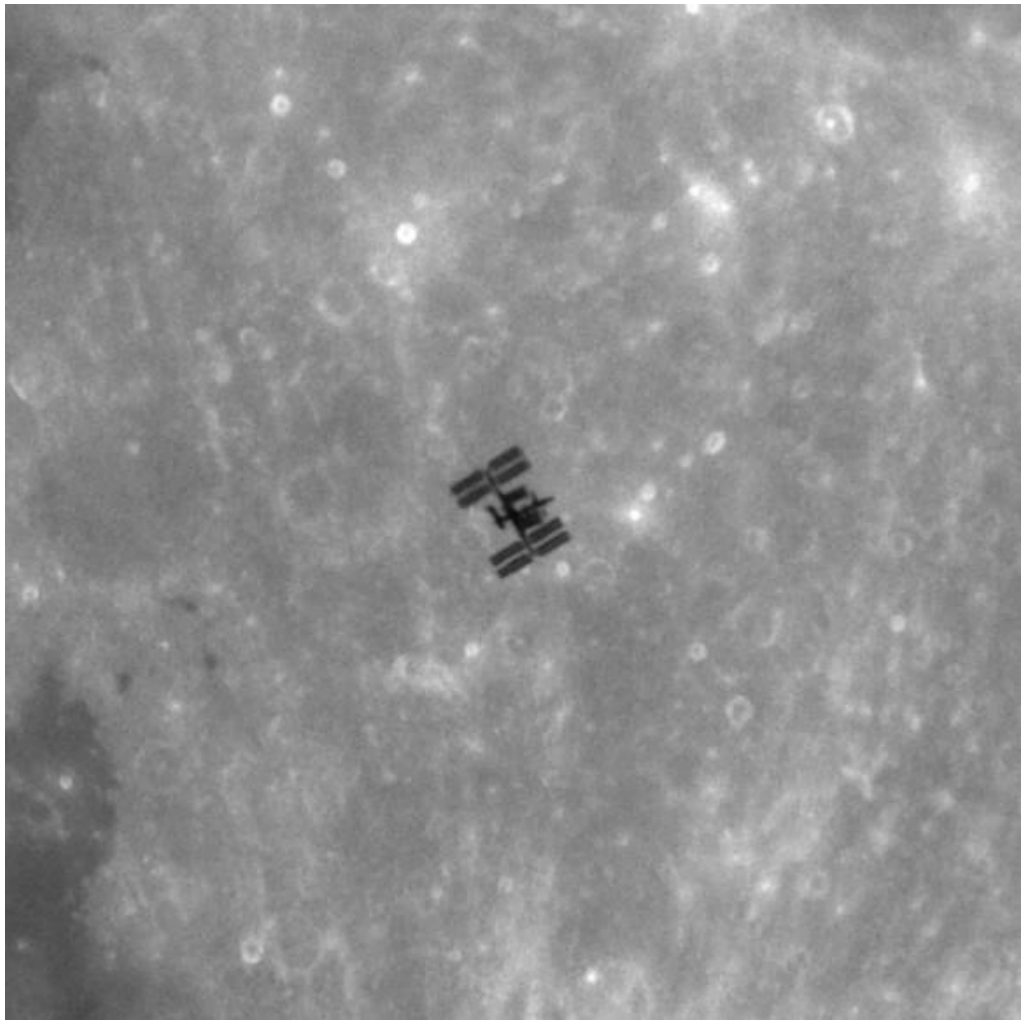
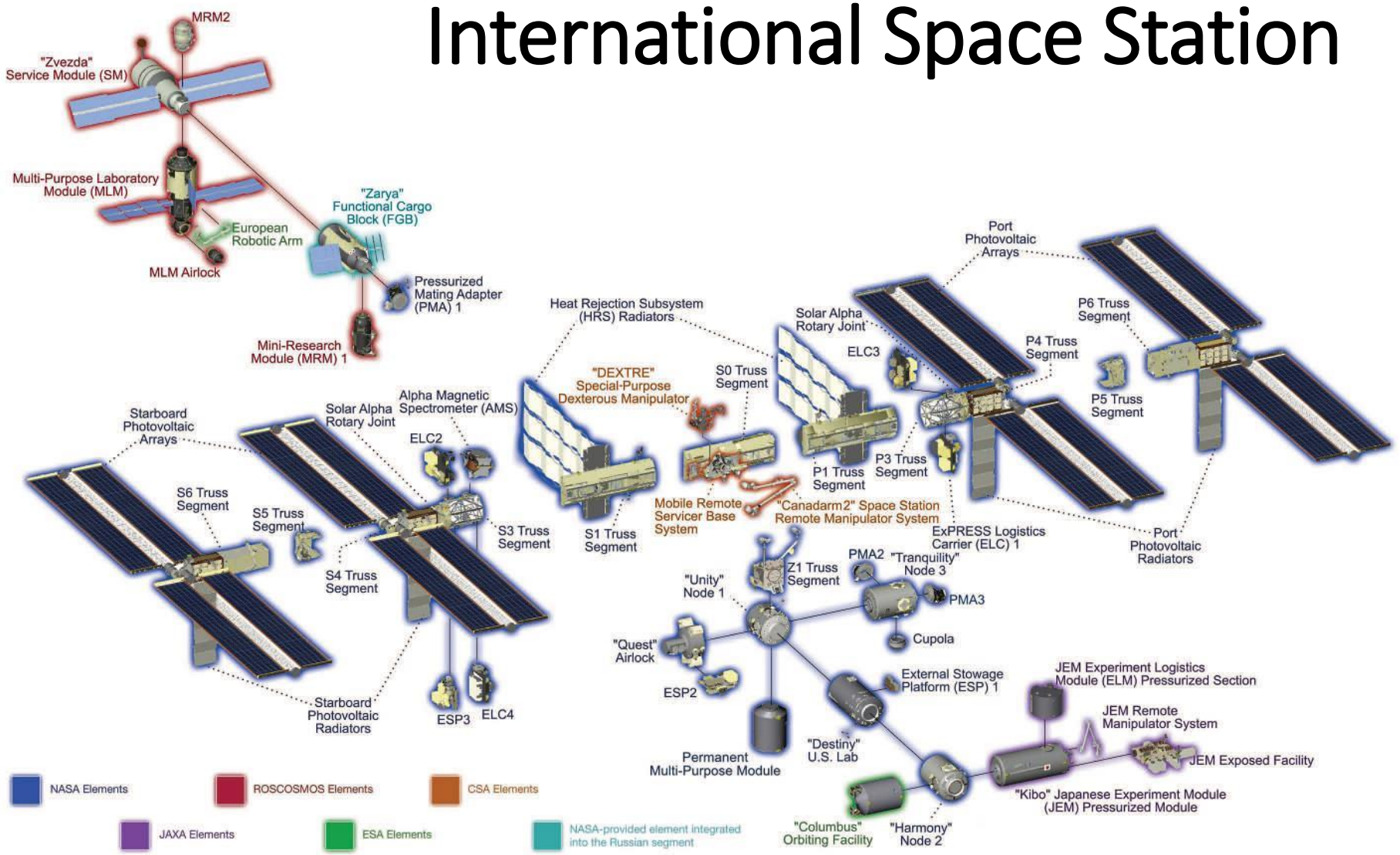


Image Credit: http://www.universetoday.com/82013/international-space-station-on-the-moon/

What ISS components are we using?

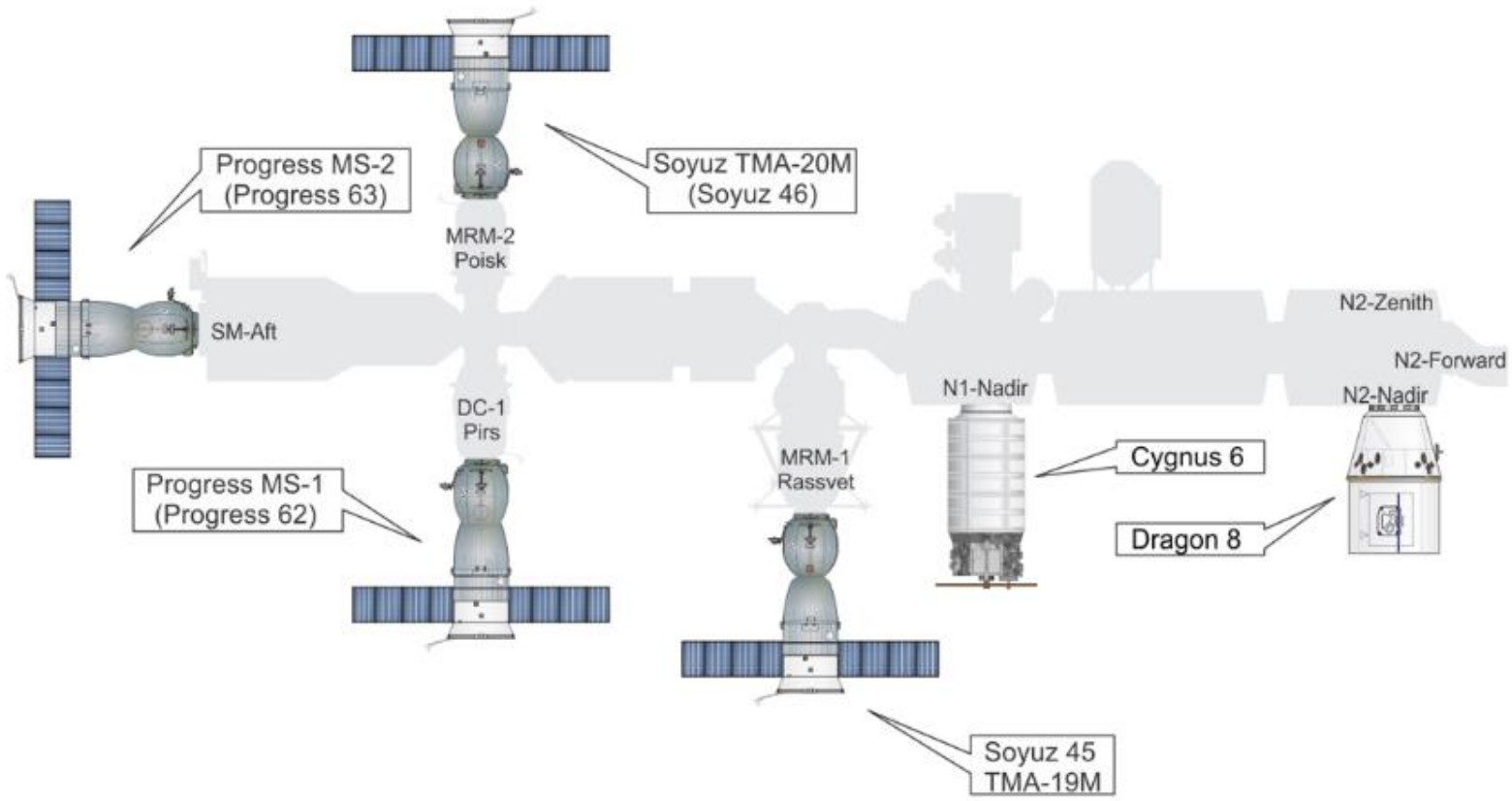
- Unity (Node 1)
- Tranquility (Node 3)
- Cupola
- Destiny US Lab
- Permanent Multi-purpose Module
- Harmony (Node 2)

International Space Station



Reference: www.StellarPlanet.co.uk

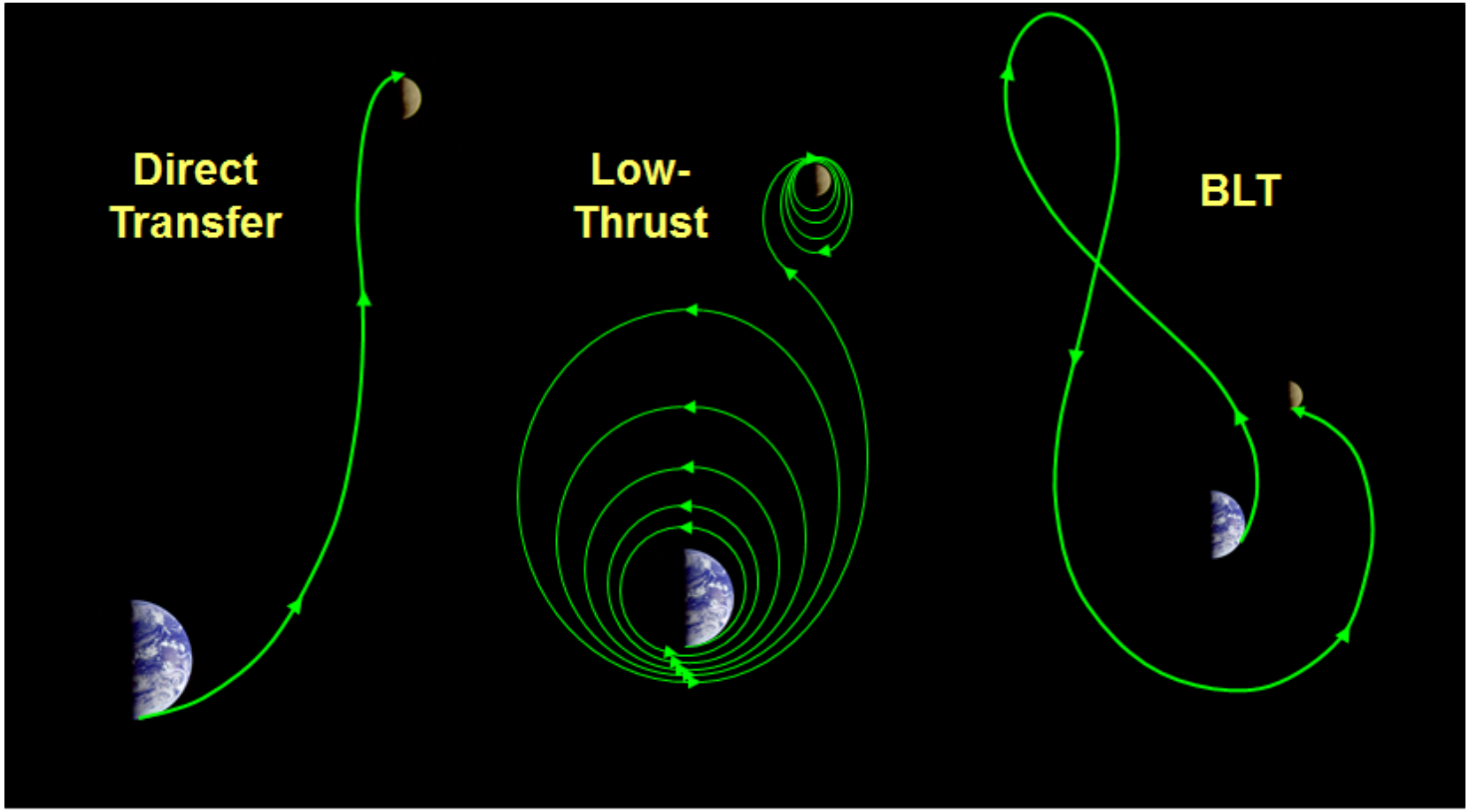
Visiting Vehicles Docked to ISS



Six Visiting Vehicles at ISS - 10 April 2016

HistoricSpacecraft.com

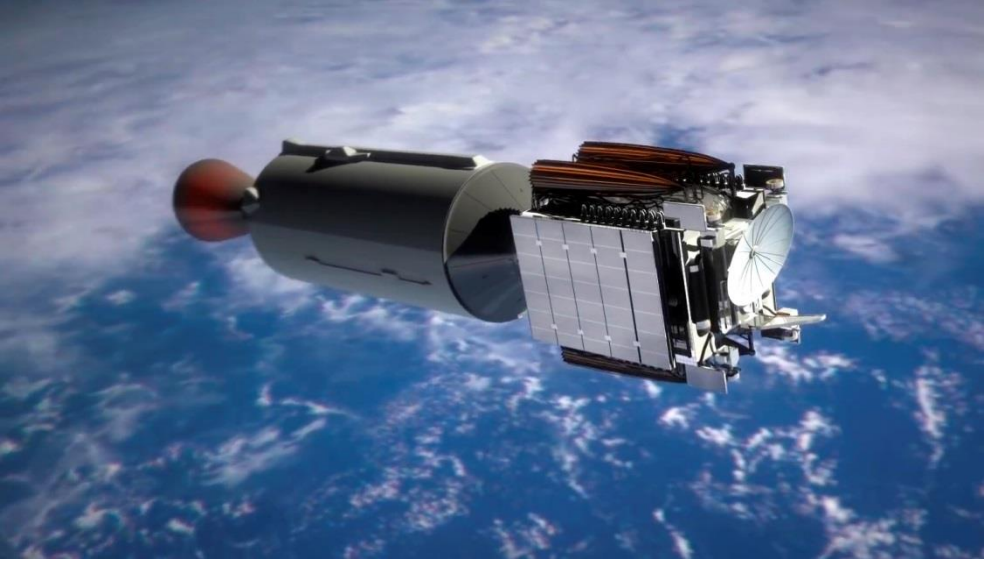
How do we get there?



What type of trajectory is best?

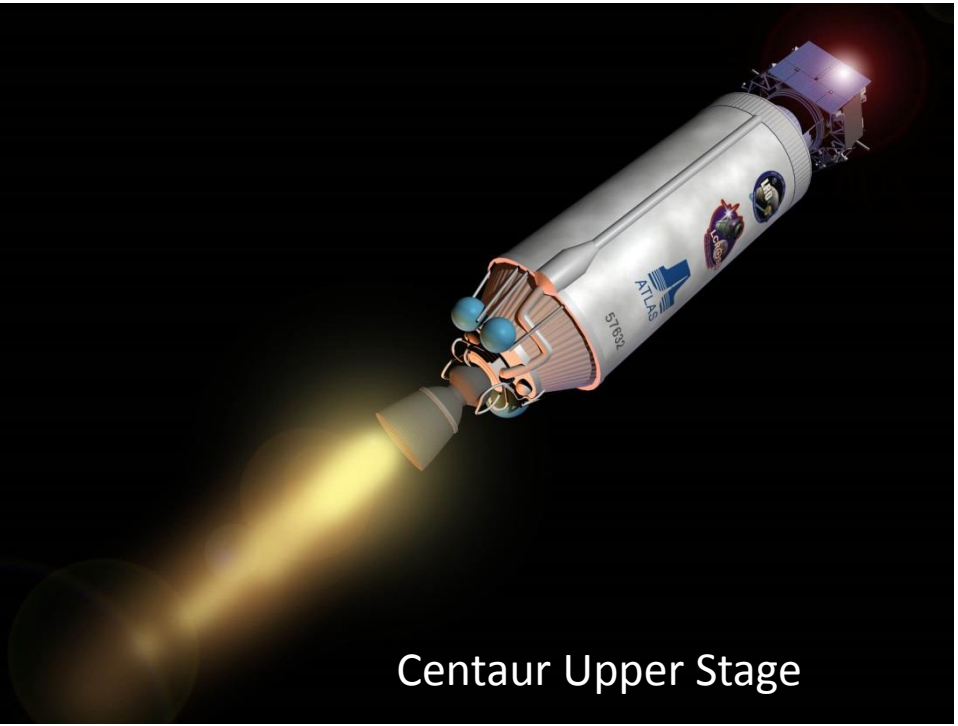
Transfer Type	Earth Injection ΔV (km/s)	Moon Insertion ΔV (km/s)	Total ΔV (km/s)
Minimum	3.099	0.622	3.721
BLT	3.235	0.644	3.879
Belbruno/Miller	3.187	0.651	3.838
Biparabolic	3.232	0.714	3.946
Hohmann	3.140	0.819	3.959

What engines should we use?



SpaceX Falcon 9 Full Thrust 2nd Stage

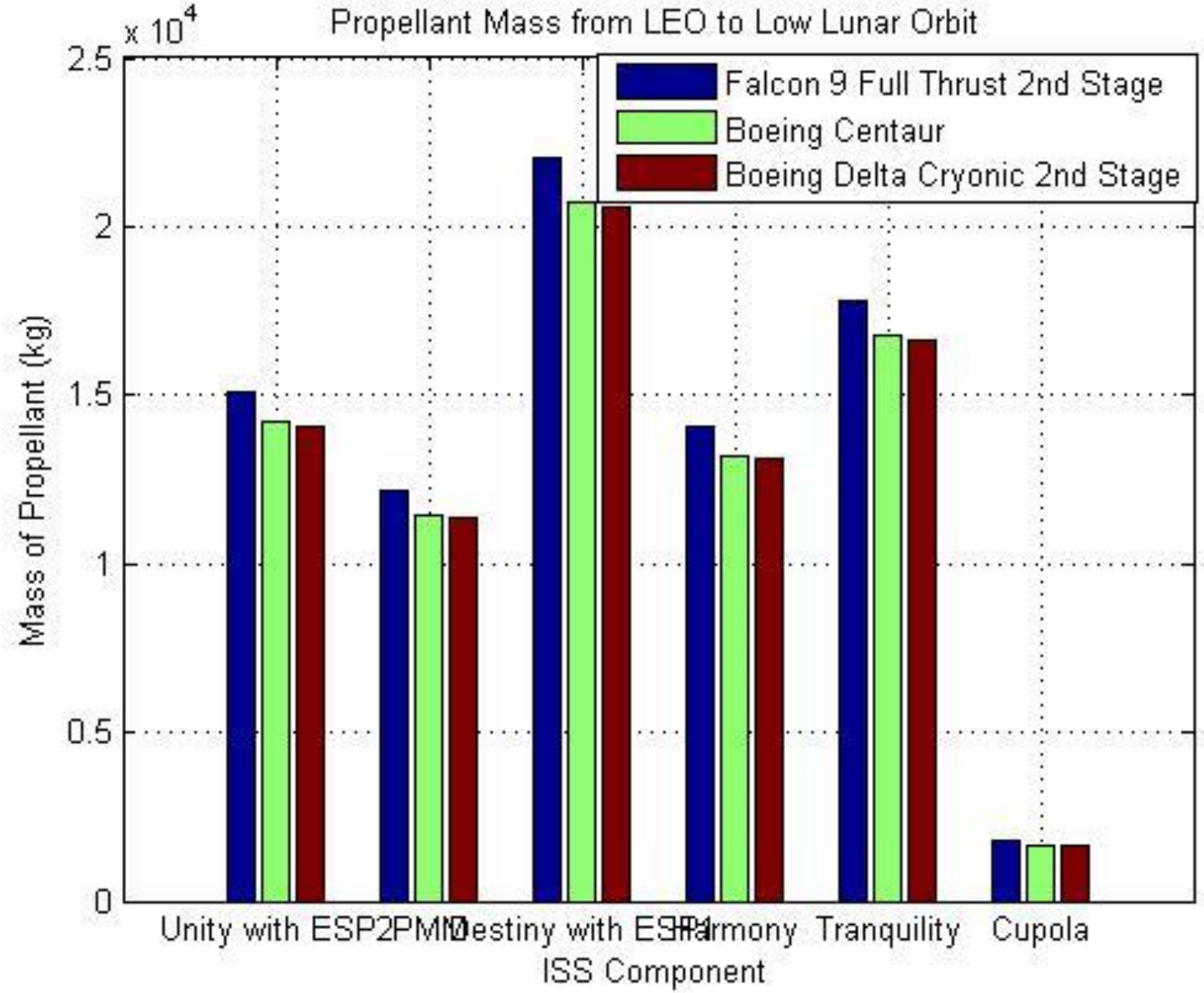
Delta Cryogenic Second Stage (DCSS)



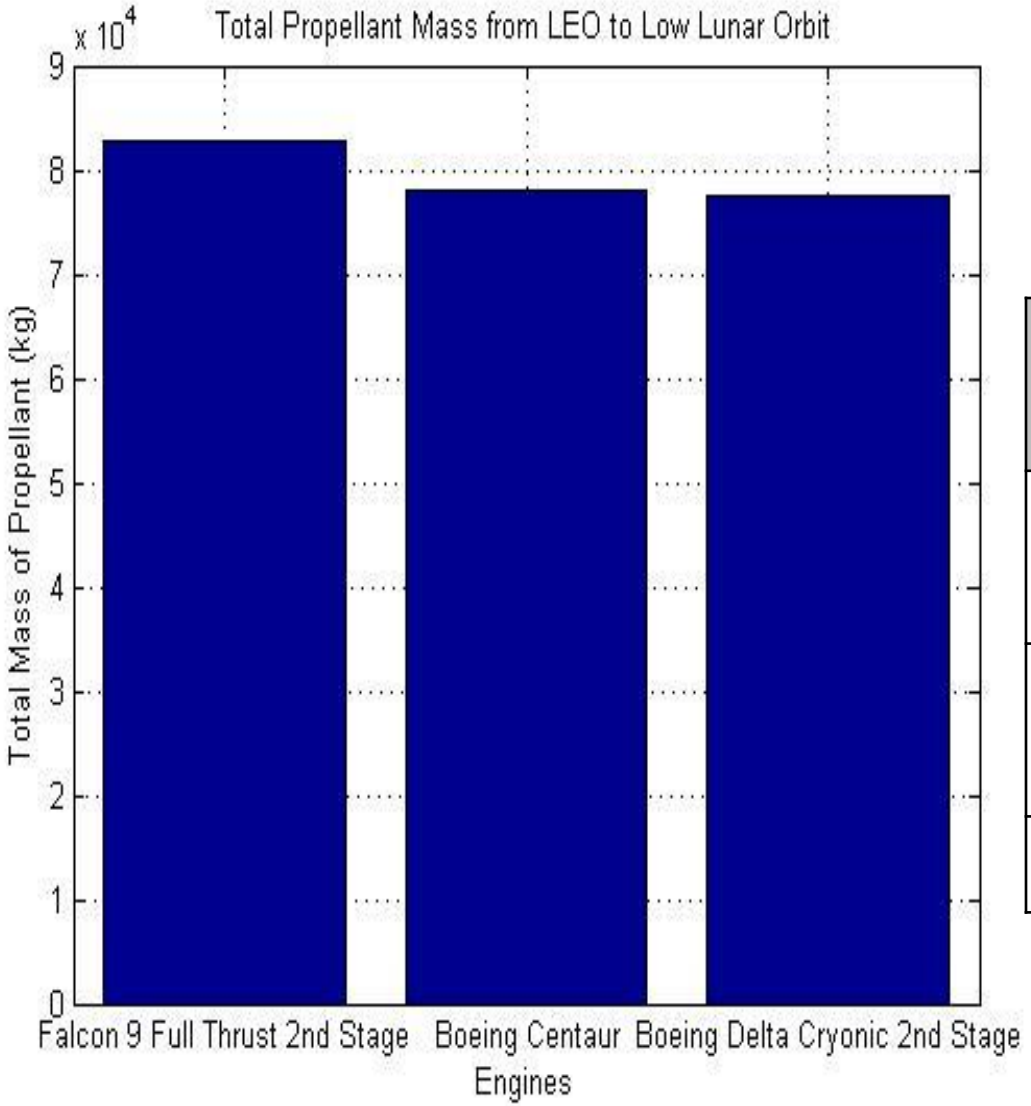
Centaur Upper Stage

Image Credits: NASA, SpaceX, Boeing

How much propellant to reach there?



Which engine should we use?



Rocket	Thrust (kN)	Isp (s)
Falcon9 Dual	934	348
Centaur Dual	198.4	450.5
DCSS	110.1	462

Manned Missions

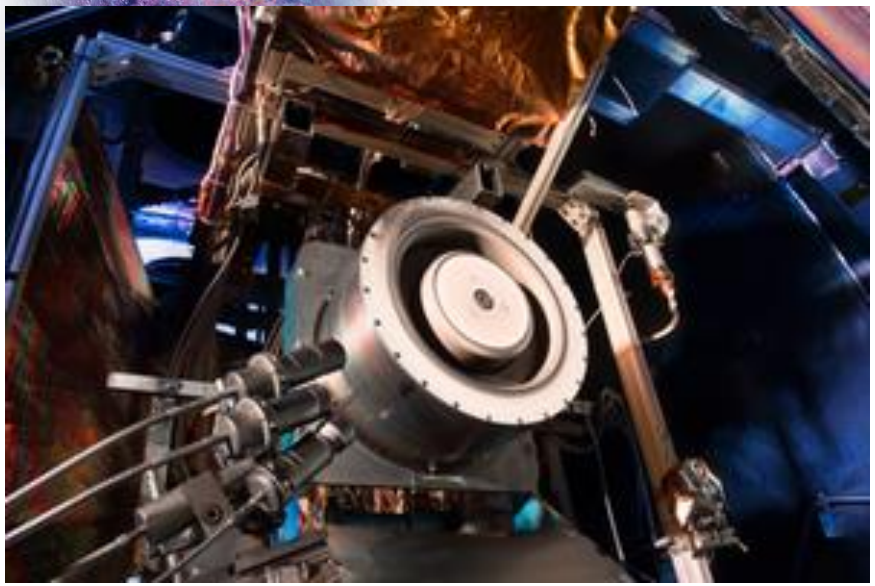
Manned Lunar Mission

2025 - ∞

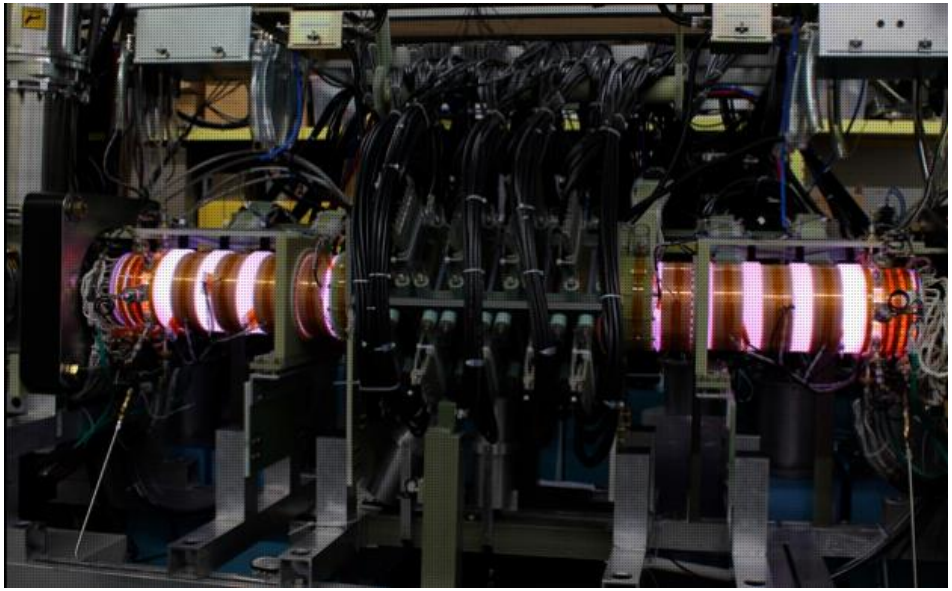
Apollo Program

1961 Oct – 1972 Dec

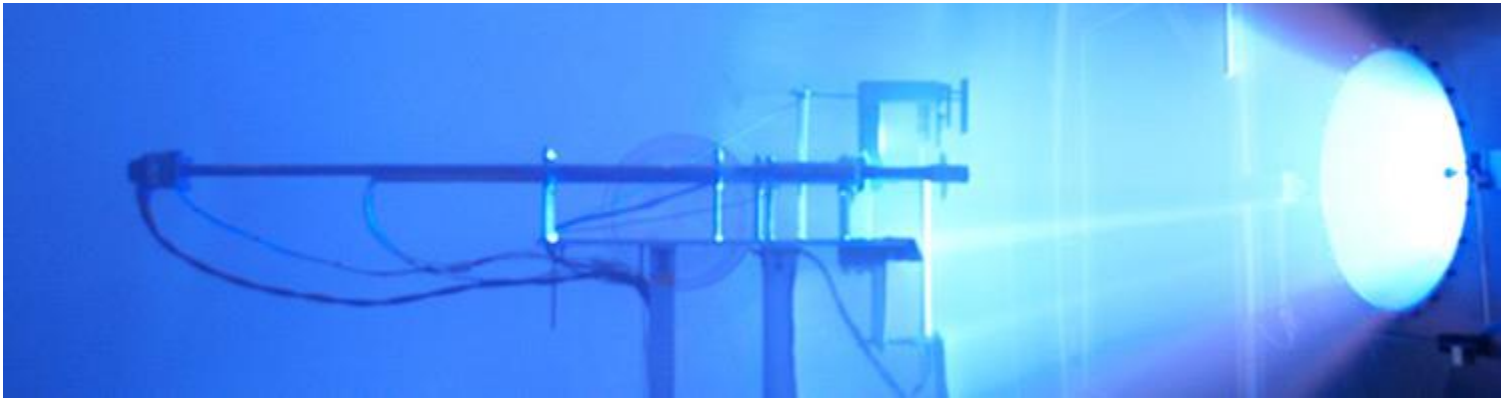
Future Propulsion Systems



Aerojet Rocketdyne's
Solar Electric Propulsion (SEP)



Helion Energy's Fusion Engine



Ad Astra's Variable Specific Impulse Magnetoplasma Rocket (VASIMR)

Image Credits: NASA, Helion Energy, Ad Astra

Closing Thoughts

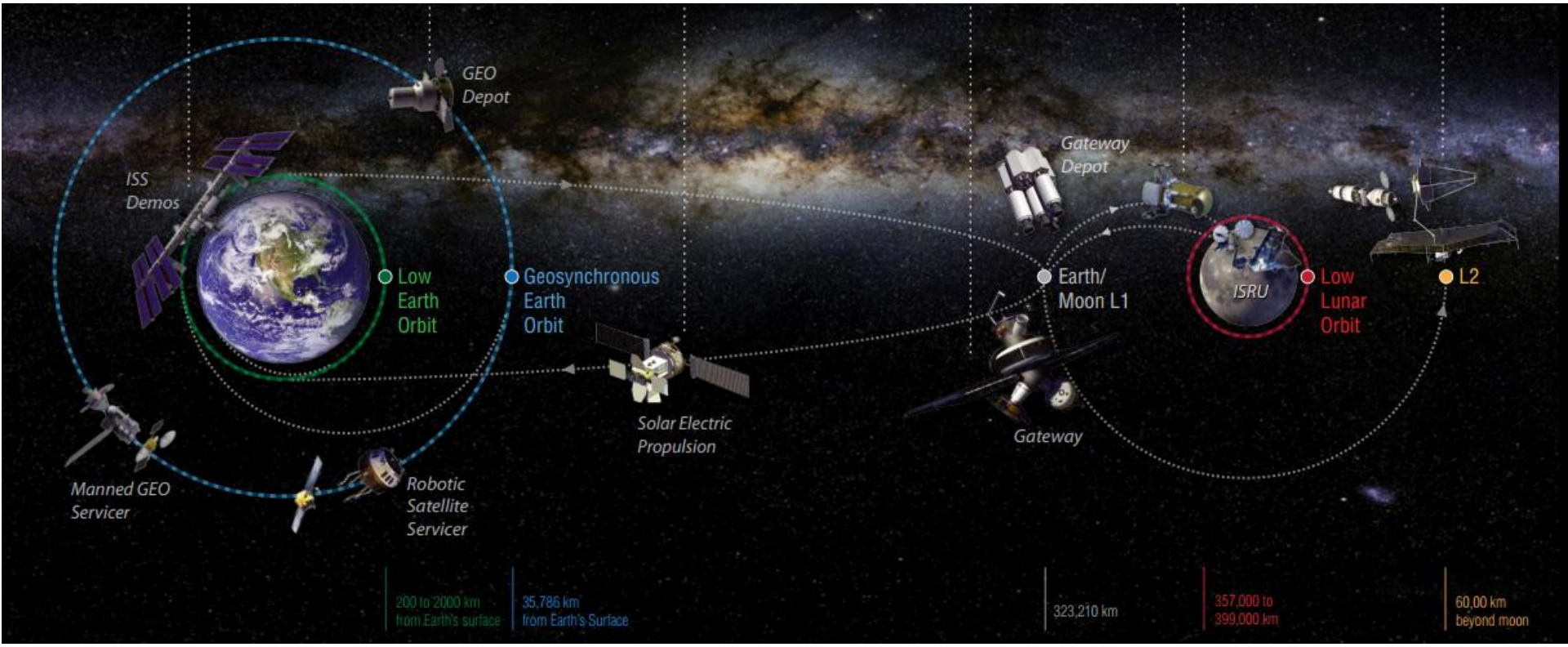


Image Credit: http://www.spudislunarresources.com/

Repurposing the ISS for a low lunar orbit space station 1) reuses the ISS components and 2) reduces cost significantly for future lunar missions and those beyond the moon.

References

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