

SPACE COMMERCIALIZATION

NEAR TERM RECOMENDATION
FOR EXPLORATION AND SPACE HABITATION
Commercial Space Telecon Sep. 10, 2014



Space Propulsion Synergy Team
AIAA 50th Joint Propulsion Conference
AIAA-2014-3648 July 29, 2014



Discussion Topics:

- Introduction
- Emerging Opportunities
- Partnerships
- Evolving Infrastructure
- Technology needs
- Near term focus
- Benefits
- Consequences
- Conclusions/Recommendations



Introduction

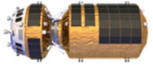
- Exploration and the habitation of space is the ultimate goal for the future but something needs to happen sooner that can provide direct benefits to the people on earth
- Currently the progress in developing the infrastructure needed for Space exploration is too slow to capture and sustain public interest and political support
- A better approach is to let commercial business and profit drive the infrastructure development



Emerging Business Opportunities



Producing materials in microgravity



Satellite servicing



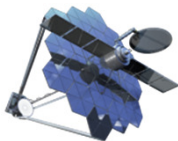
Space tourism



Providing propellants on-orbit



Processing resources on the Moon- ISRU



Space Based Solar Power



Partnerships



- Partnerships are essential to reduce cost and for space flight to be affordable
- Government agencies need to work together both foreign and domestic and share resources
- As more capabilities evolve commercialization opportunities will increase; partnering and sharing assets will reduce cost and increase customers
- An international governing body is desperately needed to control and establish standards and common interfaces to maximize use of these capabilities globally



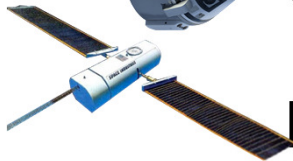
Evolving Infrastructure



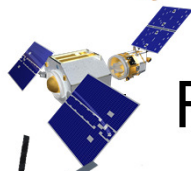
Ground operating facilities



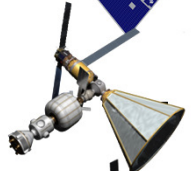
Cargo and crew delivery systems



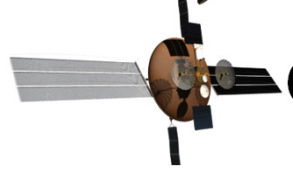
Microgravity research and manufacturing



Robotic and human servicing vehicles



Propellant depots



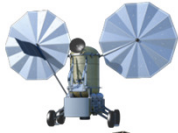
Orbital transfer vehicles



Space habitat



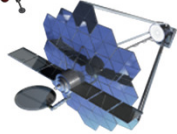
Evolving Infrastructure (cont.)



Lunar landers and rovers



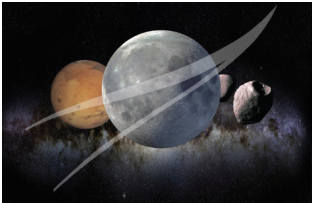
Lunar regolith processors



Solar power satellites



Lunar base



Commercial Space Infrastructure

Opportunities

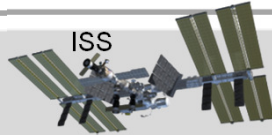
2010

2015

2020

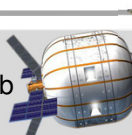
2025

Microgravity
Production

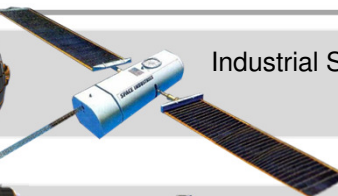


ISS

Inflatable Hab



Industrial Space Facility

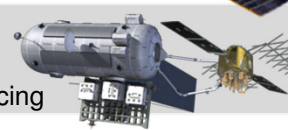
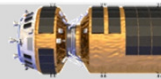


Satellite
Servicing

ISS Testing



Robotic Sat. Servicing



Crewed GEO Servicing

Tourism

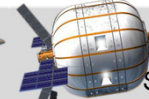
Sub-Orbital Tours



Orbital Tours



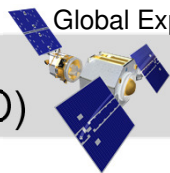
Space Hotel



Lunar Tours



Propellant
Supply (LEO)



Global Express

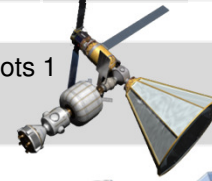


ISS Testing



Prop Module

Depots 1

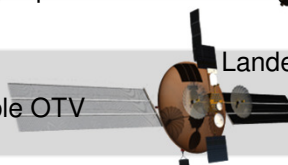


Depots 2



ISRU
(Cis-Lunar)

Reusable OTV



Lander/Rover Prospector

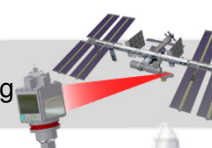


ISRU
Production
Facility

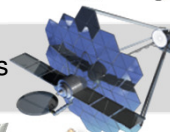


SBSP

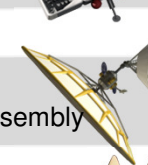
ISS Testing



Demos



Assembly



PWR Production



Atlas 5



Delta IV Heavy



Falcon 9



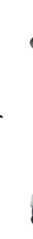
Antares



Falcon 9R



Falcon Heavy



Crew

Future RLV

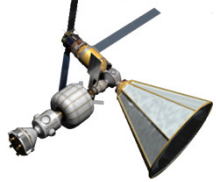


Future RLV Heavy





Technology Needs



Propellant storage and transfer



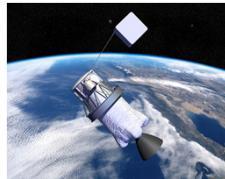
Solar power collection and transmission



Reusable launch and space vehicles



Improved propulsion systems



Note: Near term technology development should be targeted on risk mitigation and reduced operating cost to help the commercial business grow



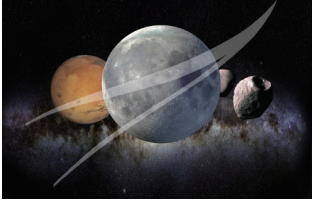
Near Term Focus

- Start with existing capabilities
- Modernize the ground support infrastructure for more efficient operations
- Capitalize on opportunities that have been demonstrated and have a market
- Build both commercial and global partnerships
- Establish an international governing body to oversee the infrastructure development and provide technical and legal standards so more customers can use it



Benefits

- Early commercial space activities can provide improved pharmaceuticals and materials, better satellite upkeep, space debris maintenance, space tourism, etc.
- As the commercial space business grows jobs will increase and the economy will benefit
- Longer benefits will include propellant depots, mining resources and beaming solar power to earth
- The resulting infrastructure will support exploration and eventual habitation of space



Consequences

- The consequences for not being aggressive and having a strong leadership in space can be very severe:
 - loss of jobs and revenue from the space market
 - more dependence on others for space services
 - less active voice in global space activities
 - no control over others dominating space for their own purposes
 - less ability to add our values and national interest for a fair enterprise and peaceful exploration of space



An Analysis and Review of Measures and Relationships in Space Transportation Affordability

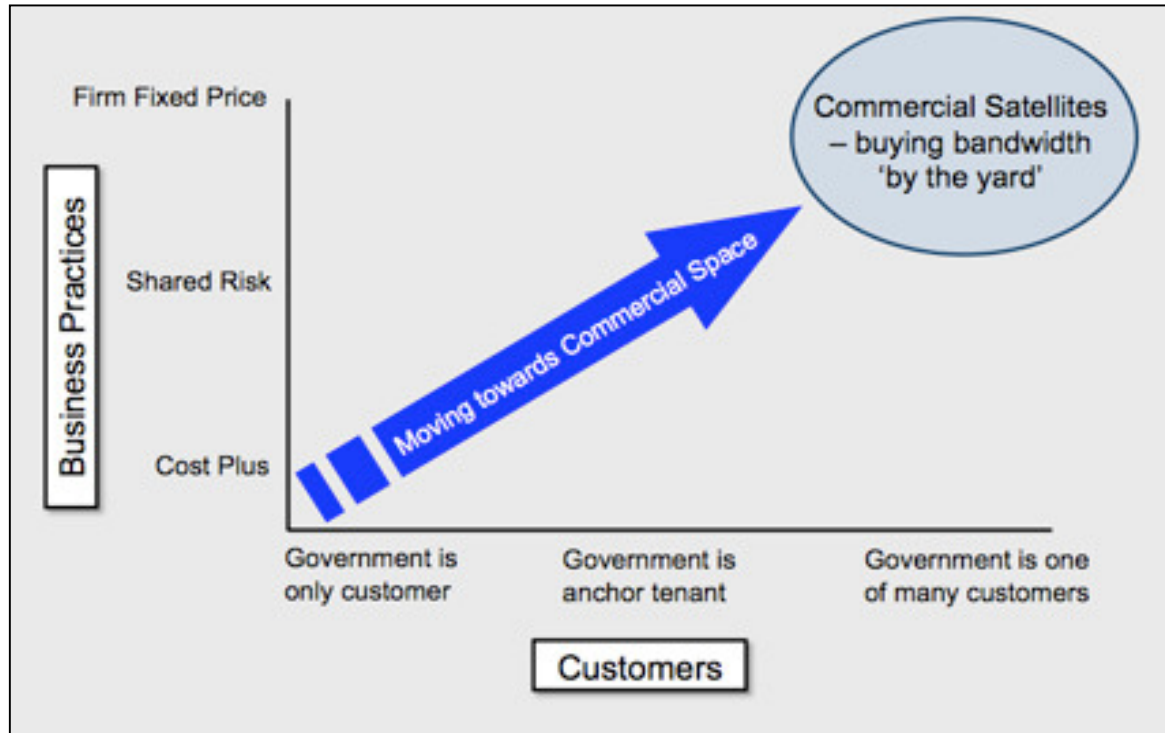


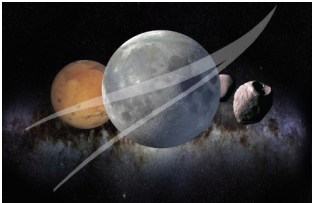
Figure 5: What is “commercial” space to NASA?

- Emerging / commercial space of great interest
- Visually, a spectrum of being more or less commercial
- Can compare two or more players as being more or less commercial
- Commercial is not about just being private sector; it’s much more



Conclusions

- Shifting the focus of space development from total government control to more commercial involvement provides opportunities for entrepreneurs and businesses to make money in space
- It will grow a space infrastructure that can be used by multiple customers world wide and benefit humans on earth
- As it grows and more people use it, space transportation cost will drop creating more opportunities and capabilities that can be used jointly by all to explore space a lot cheaper and probably a lot sooner than current plans



Evolving Infrastructure

A Compelling case for developing Cis-lunar space Next and soon:

Realize Economic, National Security, and Scientific advantage for the United States and our partners



Full utilization and servicing of ISS in concert with International partners and commercial providers prepare for exploration beyond Low Earth Orbit



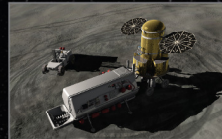
Propellant depots increase payload capability of current and future Launch Vehicles and refueling of reusable In-space Transportation



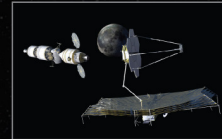
Hybrid reusable transportation infrastructure support for EML1/L2, crew and cargo for Lunar exploration, and Satellite deployment & servicing



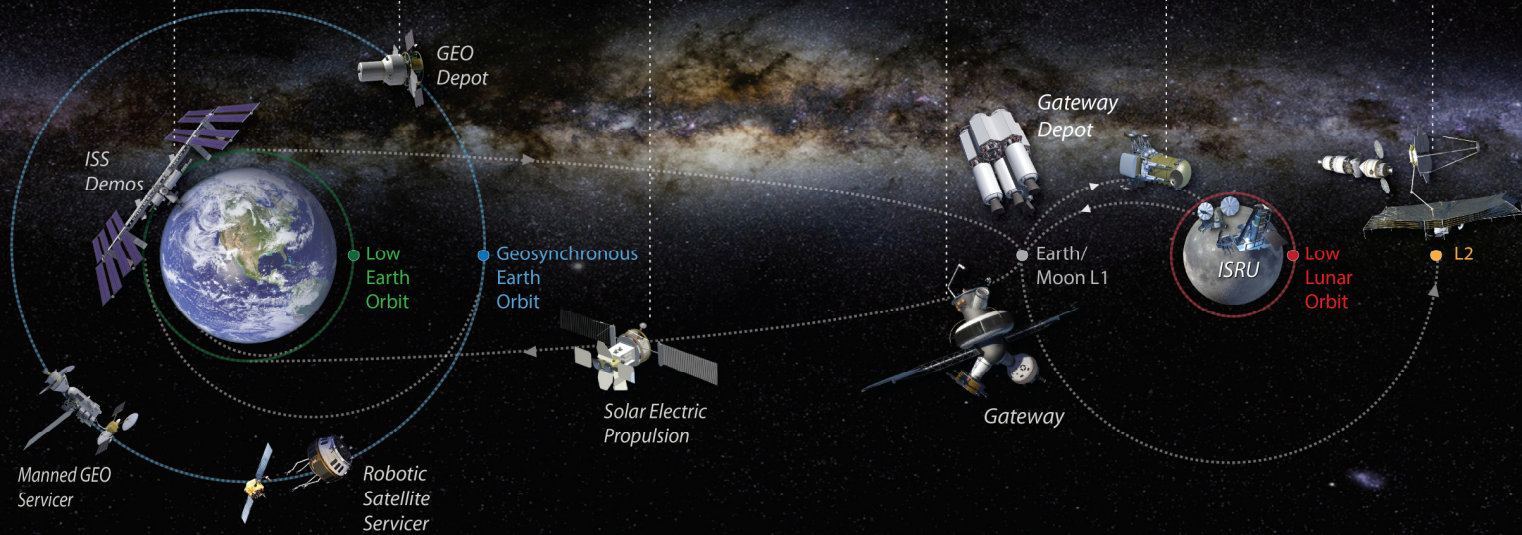
L1/L2 Gateway transportation node location for propellant depot and access to and from the Lunar surface



Lunar In-situ Resources Utilization produces water for rocket propellants and for sustaining surface operations with air and water



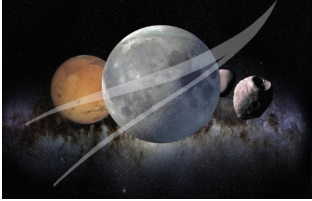
Construction and servicing of advanced telescopes and other In-space assets



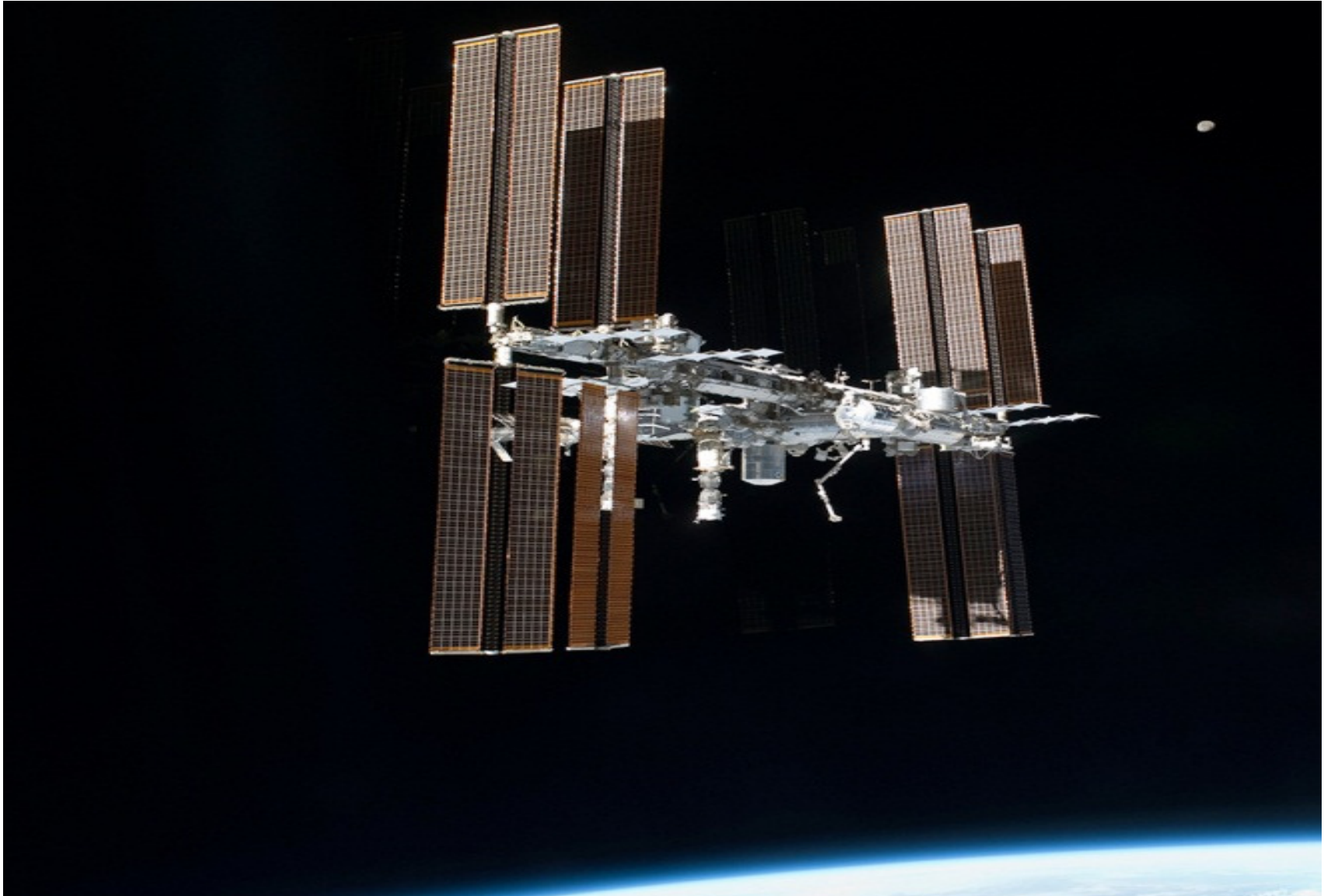


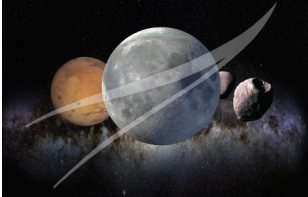
Recommendations

- Continue to educate the public on the direct benefits from an aggressive space program and the dire consequences of not being aggressive and the lack of leadership
- Start now to bolster commercialization of space
- Identify and demonstrate technologies that can be used to reduce risks and costs of space commercialization
- Establish an international governing body that can oversee space development that provides standards and commonality in design to maximize the use of the capabilities for all

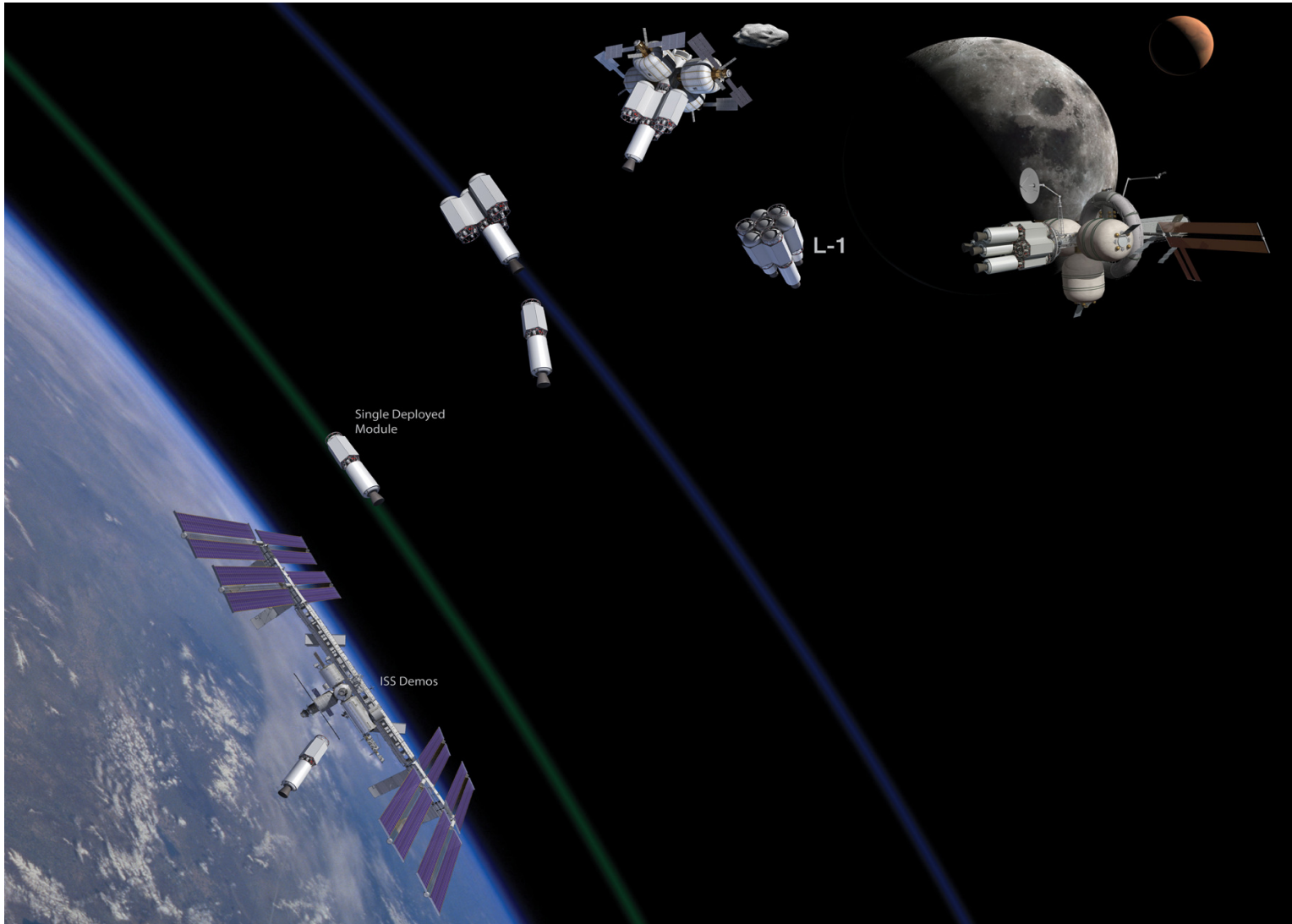


International Space Station



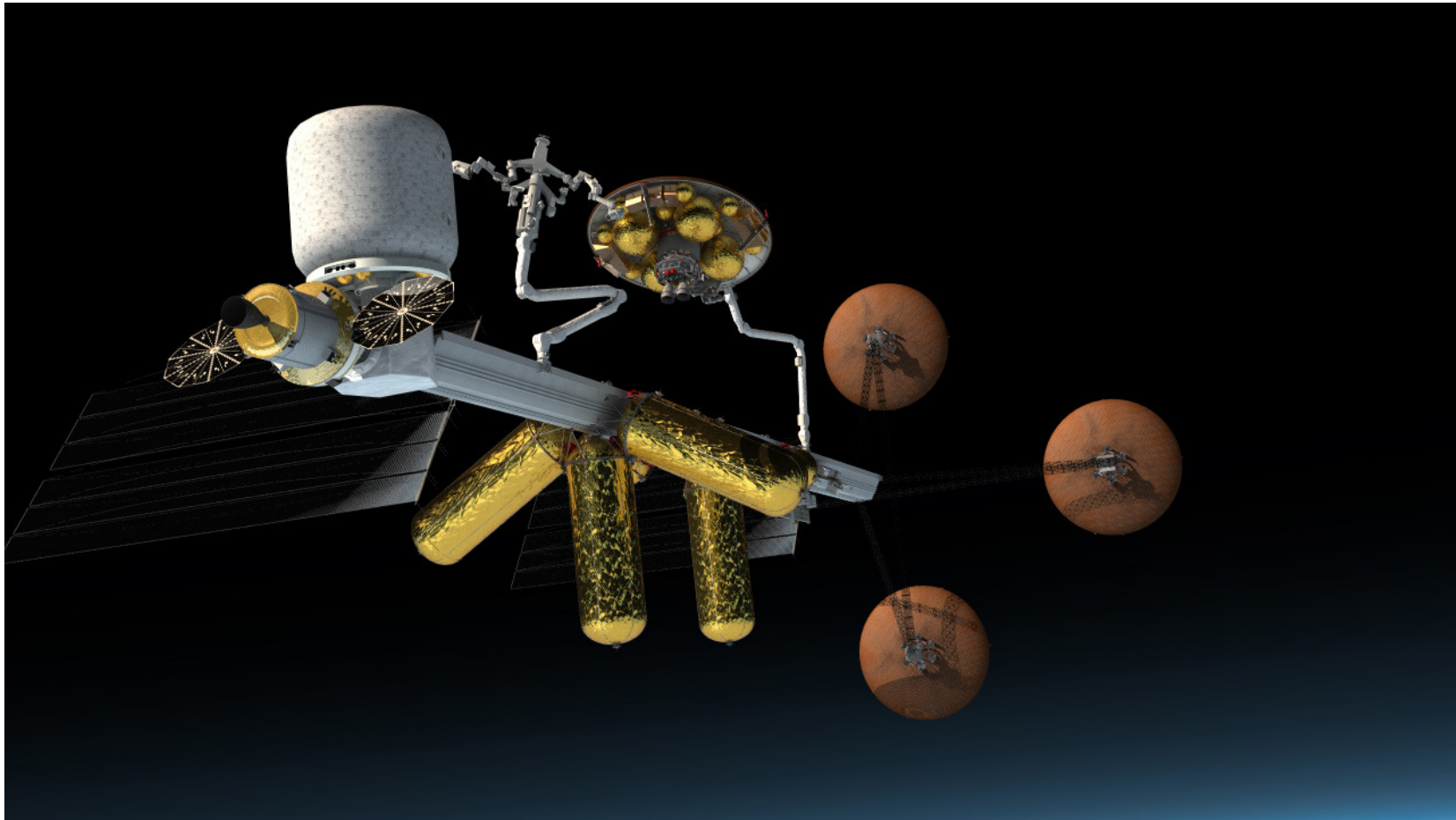


Tank Farm Evolution





Propellant Depot



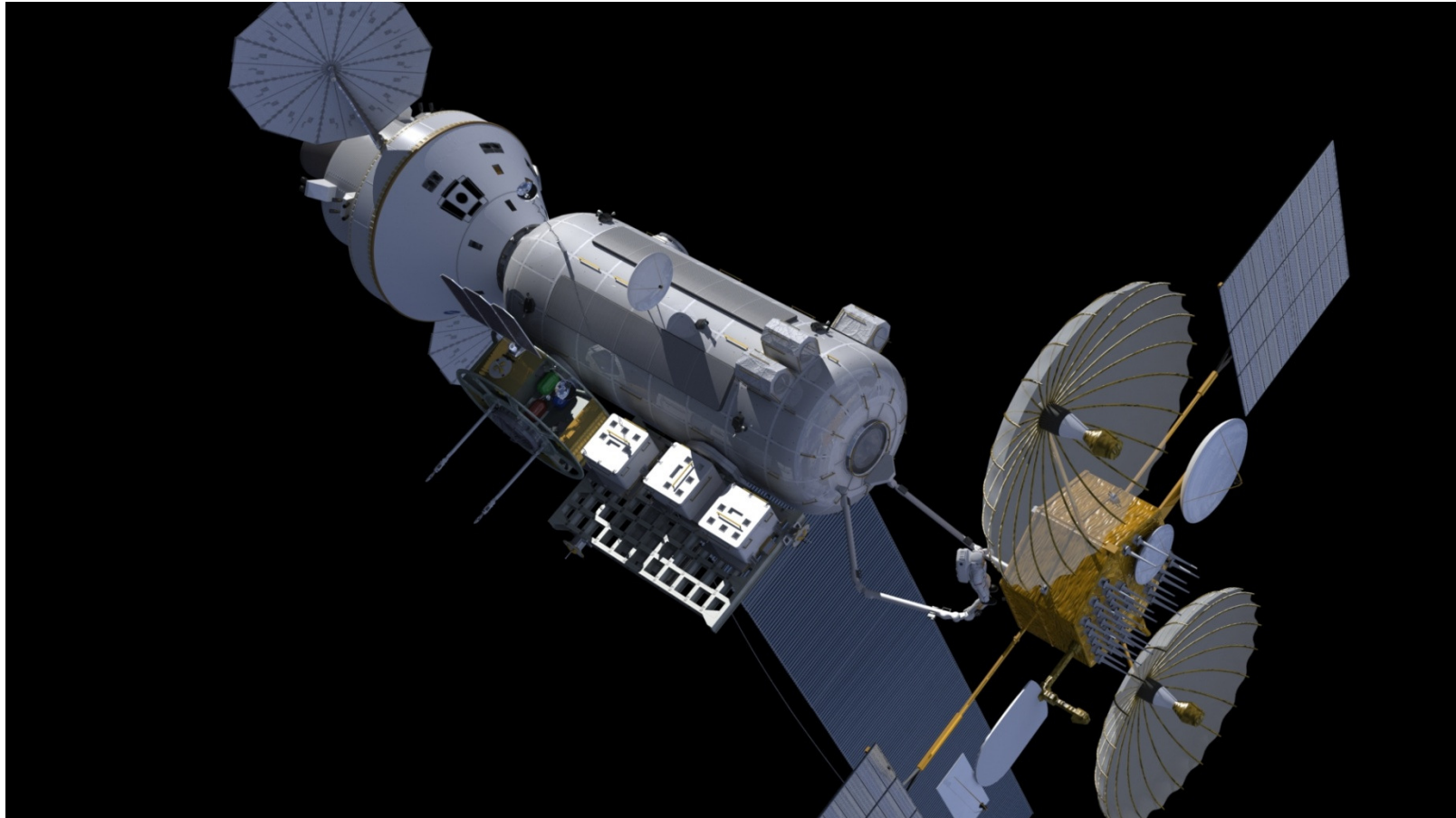


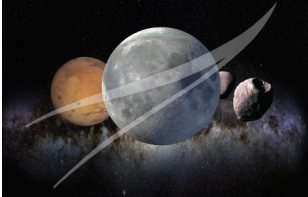
HYBRID Orbital Transfer Vehicle





Space GEO Habitat





ISRU Evolution

Phase 1



Atlas V 531 Falcon 9 Taurus II EELV Heavy



Google Challenge early flights establish Ground-truth using existing LV assets

Phase 2



Shuttle Derived SLS 70mt 130mt Super Heavy SLS



Full scale production uses SLS heavy



Launch Adaptor Commonality

