Space Exploration Logistics Workshop

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Group G

Space Logistics Network Design

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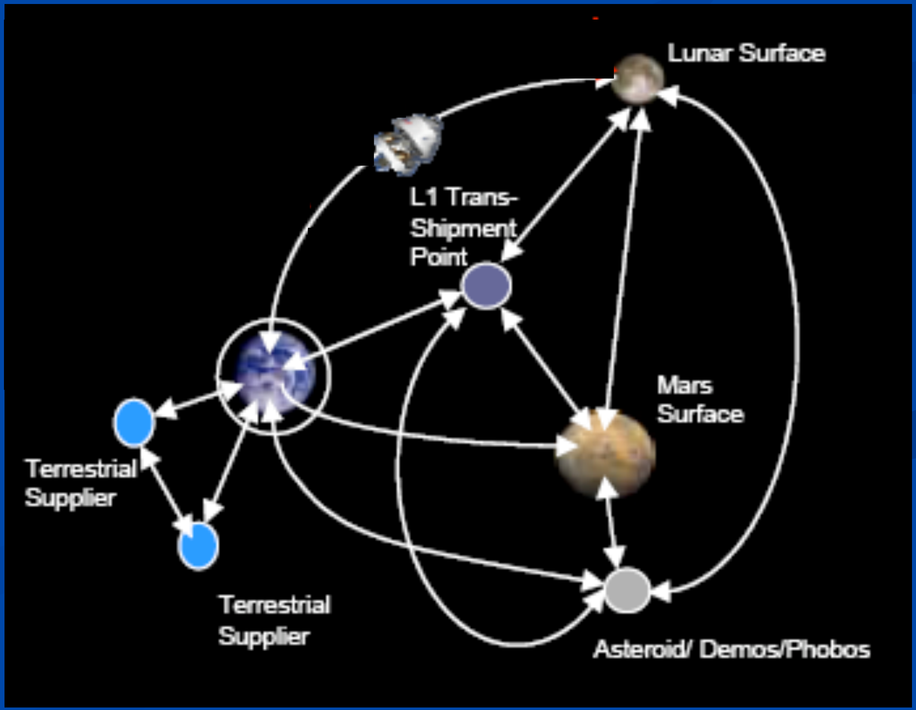

Session Overview

- Space Logistics Network Design Scope
  - The design of the network for space logistics creates a framework for modeling and evaluating different mission scenarios and identifying useful operational plans for execution
- Goals
  - Identify the impact of issues related to space logistics network design and how these issues impact each of the three different missions considered
    - What are the driving concerns in space logistics
    - Where do the differences between terrestrial and space logistics arise

Session Overview (cont.)

- Brainstorm relevant issues in space logistics network design
- Expand each issue to discuss
  - Predicted impact of an issue on the logistics network design
  - Potential mitigation of this issue
  - Methods of testing each issue to determine impact on logistics network design
  - Potential impact of an issue on other systems
- A brief review of the three different missions is listed at the end for reference

Discussion Points

- Fuel consideration
  - Pre-positioned propulsive elements (fuel stages)
  - In-space Re-fuelling
    - Pre-packaged fuel components vs. gas-station-like pumps
  - Tracking fuel availability for multiple non-consecutive burns
- Non-expendable vehicles
  - Cyclers and re-usable vehicles require different modeling assumptions
- Multiple time steps
  - Long time horizon and short time steps lead to large-scale problems → Benefits vs. Cost of employing multiple time steps
- Connection between surface logistics and in-space logistics
  - How do we interface the different network

Issues -
Short Lunar Mission

1. *Issue: ISRU*
   Predicted Impact: None
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems:
   Possible Solution(s):

2. *Issue: Reusability*
   Predicted Impact: None
   Potential Mitigation: Refine supply demand models
   Testing Methods: ISS data analysis, perform quality check on data models,
   Impact on Other Systems: Pervasive
   Possible Solution(s): what if analysis of data error

3. *Issue: Readiness Decay*
   Predicted Impact: Loss of required capability requiring a lunar abort and redesign
   Potential Mitigation: Reliability improvement/ system learning curves, improve robustness of transportation systems
   Testing Methods: What if scenarios…Evaluate unmanned elements kept in harsh environments for a period of time
   Impact on Other Systems:
   Possible Solution(s):Redundancy/Maintenance plan

Issues -
Long Lunar Mission

1. *Issue: ISRU*
   Predicted Impact: Lose capability of reusing expended elements
   Potential Mitigation:
   Testing Methods: Run scenarios with and without the capability to determine benefit of technology on architecture
   Impact on Other Systems: surface systems and propulsion systems
   Possible Solution(s): Include refueling capability and account for increased mass to surface required to develop ISRU facilities

2. *Issue: Reusability*
   Predicted Impact: Potential for a significant decrease in acquisition cost…potential increase in operations and maintenance costs
   Potential Mitigation: Build a number of units
   Testing Methods: Run with and without reusability capability
   Impact on Other Systems: Pervasive
   Possible Solution(s): Utilize what-if analysis to determine how extensively to employ reusability in the architecture

3. *Issue: Readiness Decay*
   Predicted Impact: Loss of required capability requiring lunar rescue/abort
   Potential Mitigation: Improve reliability and robustness of transportation systems. Utilize system learning curves
   Testing Methods: Evaluate unmanned elements kept in harsh environments for a period of time. Run what-if scenarios to define the impact of a launch
   Impact on Other Systems: Possible critical failure
   Possible Solution(s): Create redundancy in the solution and define a maintenance plan

Issues -
Mars Mission

1. *Issue: ISRU*
   *Predicted Impact: Lose capability of reusing expended elements **Same as Long lunar***
   Potential Mitigation:
   Testing Methods: Run scenarios with and without the capability to determine benefit of technology on architecture
   Impact on Other Systems: surface systems and propulsion systems
   Possible Solution(s): Include refueling capability and account for increased mass to surface required to develop ISRU facilities

2. *Issue: Reusability*
   Predicted Impact: Potential for a significant decrease in acquisition cost…increased operations and maintenance cost
   Potential Mitigation:
   Testing Methods:
   Impact on Other Systems: Pervasive
   Possible Solution(s): what if analysis of data error

3. *Issue: Readiness Decay*
   Predicted Impact: Loss of required capability creating a need for abort/contingency plans
   Potential Mitigation: Improve reliability and robustness of transportation systems. Utilize system learning curves
   Testing Methods: Evaluate unmanned elements kept in harsh environments for a period of time. Run what-if scenarios to define the impact of a launch
   Impact on Other Systems: Possible critical failure
   Possible Solution(s): Create redundancy in the solution and define a maintenance plan that was tested during lunar missions

Other Points not Developed

- Need for a robust logistics plan b/c of Murphy
- How does the requirements for manned space craft maintenance effect the logistics/vehicle decisions
- What if scenarios for maintenance—personal skills
- Earth departure stage depot at L1 creates a possible resource for future flights
- Need to list assumptions…not all assumptions that may be necessary are modeled
- Contingencies
- How to account for the need for redundancy/tendency to fail. Can it be more than a post-optimality what if analysis
  - Can we model a different level of repairability for different vehicles through what-if scenarios

- What adjustments to the network model need to be made for the learning curve