Propellant Depots and a Reusable Cislunar Transportation Architecture

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A Depot-Enabled Reusable Cislunar Architecture: Matched Impedance – What is Launched is Landed

Personnel Cargo Propellant Depot Tug

g-oriented Crew Module

Cargo

Zero-g Crew Module

Personnel Cargo

Lander Personnel Propellant

Personnel Propellant Depot Tug
LEO Depot Deployed
ARTV and DPM Deployed to LEO Depot

ARTV

DPM

DPM

Zero-g Crew Module

DPM
SRTV with g-Oriented Crew Module Deployed to EML1 Depot
Lunar Surface Shuttle Deployed to EML1

Personnel  
Cargo  
Propellant  
DPM

Personnel  
Cargo

DPM

LSS  
g-oriented  
Crew Module

Zero-g  
Crew Module

Personnel  
Propellant  
DPM

Lander  
Personnel  
Propellant

May 27-31, 2010
A Depot-Enabled Reusable Cislunar Architecture: Matched Impedance – What is Launched is Landed
Systems Comprising an Impedance Matched Cislunar Architecture

- Low-cost launch provider: Space X Falcon 9-3.6 shown
- Personnel Modules: 0-g and g oriented
- Propellant Carrier and Depot Propellant Module
- Space Transfer Stage: EML1 to Perilune delivery LOx/LH
- 2 Modular Propellant Depots
- Aerobraked Reusable Transfer Vehicle: GTO and/or GEO delivery LOx/LH
- Lunar Lander: Perilune to Surface LOx/LH
A LEO Propellant Depot Operational Concept: Missions Not Constrained by Launch Capability

Low-cost launch provider
Space X
Falcon 9-3.6 shown

Reenter & Reuse

Interplanetary Trajectories

Earth Orbit

Lunar Orbit

RPC

ARTV

EDS/LSAM
Operational Flexibility Enabled With ISRU

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<th>System</th>
<th>Case</th>
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- Lunar propellant can be provided for none, one, or all mission legs
- Selection is dependent on
  - Price at depot
  - Operational failures
  - Mission efficiency (prop/payload; prop needed/prop used)

\(^\d\) only applies when DPM not included in architecture
Architecture Propellant Requirements Defined by Source and Mission Type

- Stacked columns are propellant used to move payload
  - Blue is Earth-supplied; Green is Moon-supplied
- Stacked symbols are propellant required to conduct mission
  - Square is Earth-supplied; Round is Moon-supplied
- Constellation propellant used shown for comparison
- 100% Moon-supplied requires most total propellant

20 t to Moon  25 t from & 3 t to Moon  5 t Roundtrip LEO to Moon
What if DPM Deleted From Architecture?

- Lunar propellant can be provided for none, one, or all mission legs
- Selection can be dependent on
  - Price at depot
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Minor Propellant Reduction if DPM Deleted

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- Stacked symbols are propellant required to conduct mission
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- Constellation propellant used shown for comparison
- 100% Moon-supplied requires most propellant for out and back
What if SRTV Deleted From Architecture?

- Lunar propellant can be provided for none, one, or all mission legs
- Selection can be dependent on
  - Price at depot
  - Operational failures
  - Mission efficiency (prop/payload; prop needed/prop used)

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Significant Propellant Increase if SRTV Deleted

- Stacked columns are propellant used to move payload
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- Stacked symbols are propellant required to conduct mission
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- Constellation propellant used shown for comparison
- Propellant needs approximately double without SRTV
What if DPM and SRTV Deleted From Architecture?

- Lunar propellant can be provided for none, one, or all mission legs
- Selection can be dependent on
  - Price at depot
  - Operational failures
  - Mission efficiency (prop/payload; prop needed/prop used)

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Significant Propellant Increase if DPM & SRTV Deleted

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- Constellation propellant used shown for comparison
- Propellant needs approximately double without SRTV and DPM
Lunar Propellant @ < 80% ETO Propellant Cost Reduces Cost for all Missions

- 14% savings if E-to-M does not use DPM
- Roundtrip mission cost independent of DPM
- 8-9% savings for roundtrip missions if prop costs are equal
- 25% savings if M-to-E uses DPM
ARTV Gains 7100 kg if 3500 kg DPM Deleted

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50 t LEO and 70 t EML1 Depots Needed for 25 t Payload Reusable Cislunar Architecture

- SRTV is a critical architecture element
- ISRU reduces EML1 depot propellant needs ~25%
This Depot-Enabled Cislunar Architecture...

- Matches surface payload capability to ETO launch capability
- Uses path-specific transportation systems
- Employs reusable Space transportation systems
- Incorporates propellant depots at payload transfer nodes
- Shows SRTV is key to minimizing propellant use
- Needs lunar propellant costs to be <80% ETO propellant cost