



Space Exploration

# LEO Propellant Depot: A Future Opportunity?

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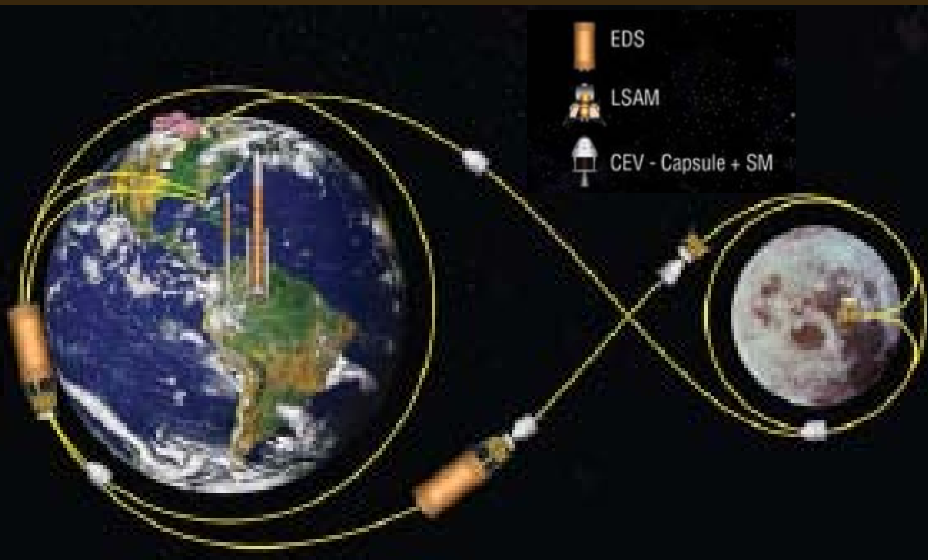
**Space Frontier Foundation**

**NewSpace 2007**

**July 18-21, 2007**

**Arlington, Virginia**

# The ESAS Recommended Architecture



- 1.5 Launch architecture: Ares I & V
- Earth orbit rendezvous: CEV to LSAM/EDS
- EDS performs Earth orbit insertion & circularization and TLI burns

- LSAM DS performs LOI with CEV and lunar descent and landing
- Lunar orbit rendezvous: LSAM AS to CEV
- LOx/LH in EDS and LSAM DS
- Lox/Methane in LSAM AS and CEV



Crew Exploration Vehicle



Exploration Departure Stage



CEV LV Upper Stage



Crew LV

Cargo LV



Lunar Heavy Cargo LV Upper Stage (EDS)

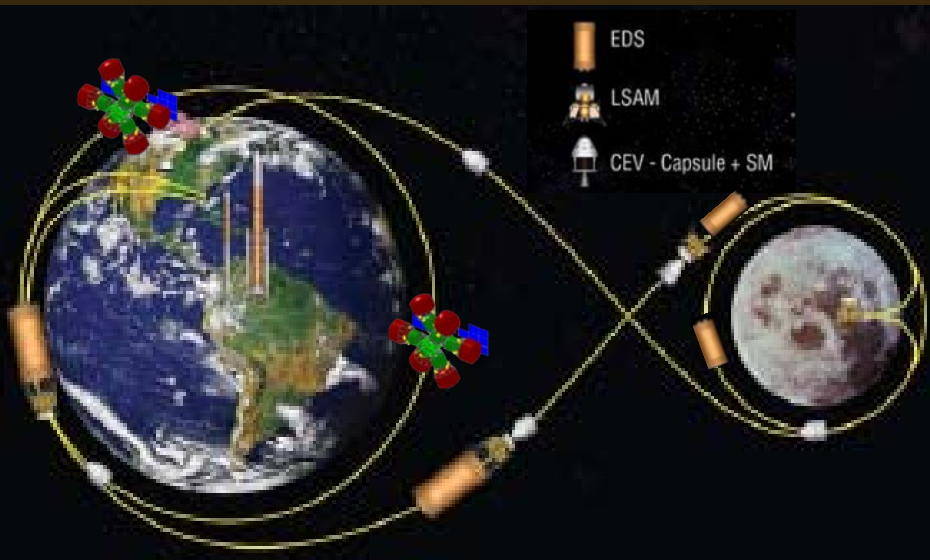


Lunar Surface Access Module

NASA's Exploration Architecture  
September, 2005

# Two LEO Propellant Depots

## Add Capability, Options and Resiliency



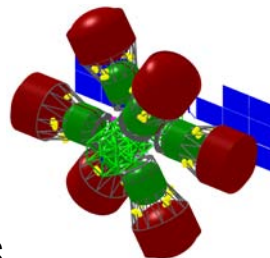
- 1.5 Launch or Single Launch architecture: Ares I & V or Ares V
- EDS & LSAM receive propellant in LEO
- Eliminates EDS & LSAM boil-off concerns
- Earth orbit rendezvous: EDS/LSAM to Depot; CEV to LSAM/EDS
- EDS performs Earth orbit insertion & circularization, TLI, and LOI burns



Crew Exploration Vehicle



Exploration Departure Stage



Lunar Surface Access Module

NASA's Exploration Architecture  
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CEV LV Upper Stage



Crew LV

Cargo LV



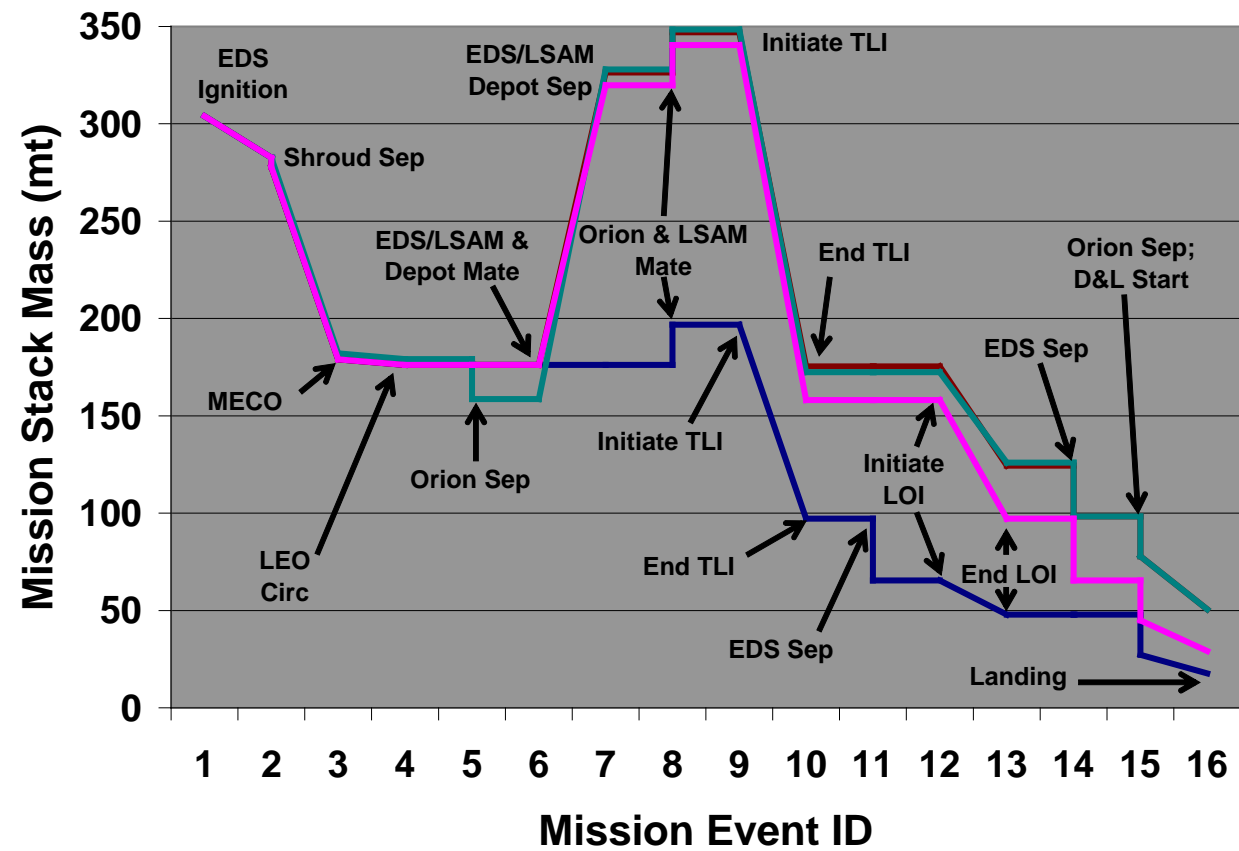
Lunar Heavy Cargo LV Upper Stage (EDS)

- LSAM DS performs **only** lunar descent and landing
- Lunar orbit rendezvous: LSAM AS to CEV
- LOx/LH in EDS and LSAM DS
- LOx/Methane in LSAM AS and CEV



# Lunar Missions Using Ares I and V or Ares V; with 51 t Landed with Depot vs. 18 t Without; or Two Sorties per Launch with Depot

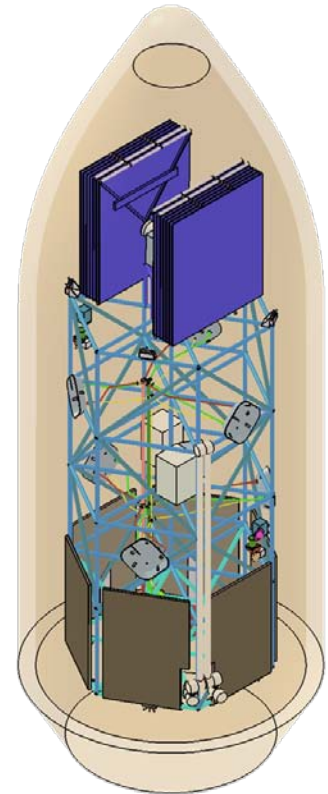
— ESAS 1.5   
 — ESAS 1.5 + Depot   
 — ESAS 1.0 + Depot   
 — ESAS 1.5 + Depot; No Extra Pyld



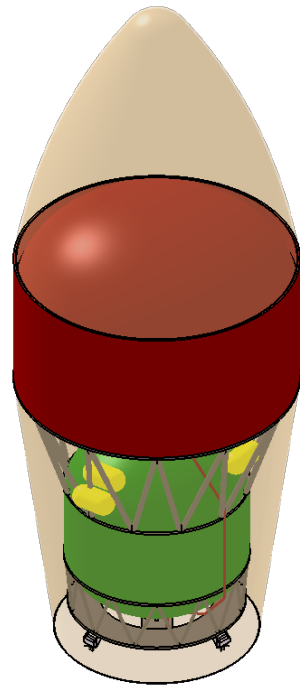
- EDS mods for propellant receipt and routing to Lander
- ARPO added to EDS
- Lander struts strengthened
- 6 t increase in Lander primary structure capability at launch
- ~25 t propellant offloaded from EDS for Ares V only
- No extra payload for two-sortie missions
- Lander has propellant for two-sortie missions

**150 - 175 mt Lox/LH transferred from depot to EDS and LSAM DS**

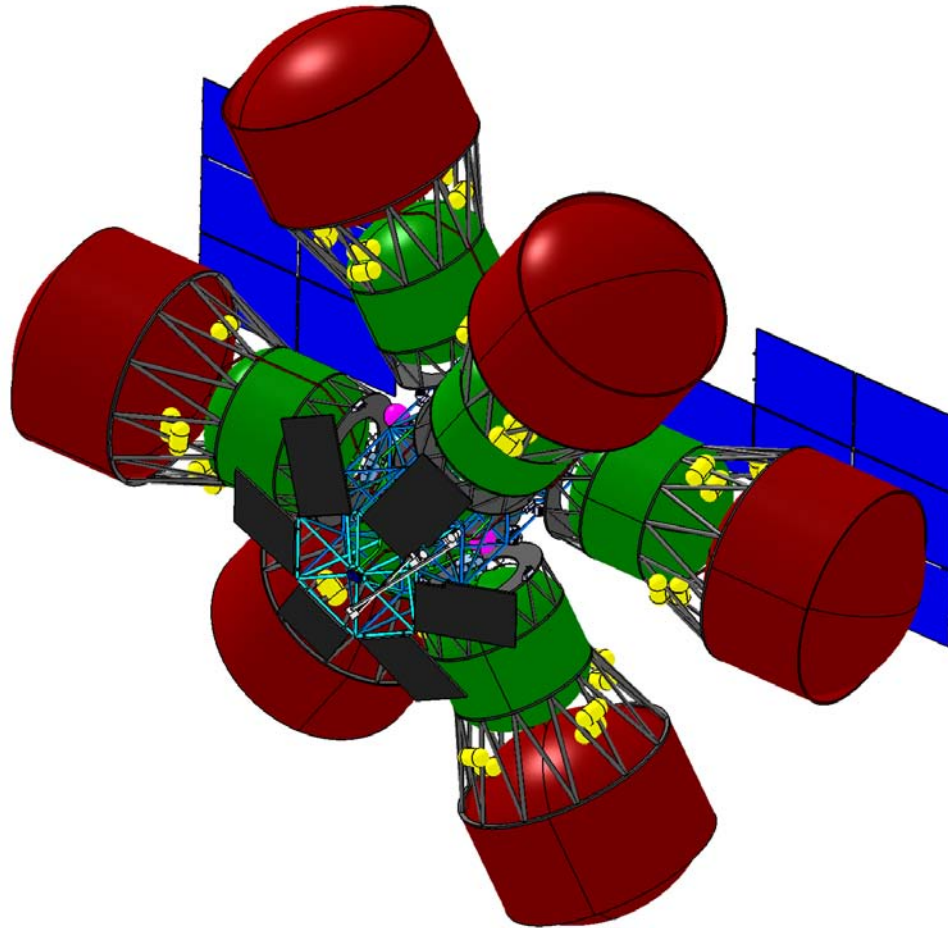
# A Propellant Depot System



**Truss in Launch Configuration**



**Tank Set in Launch Configuration**



**Assembled Propellant Depot in Orbit**

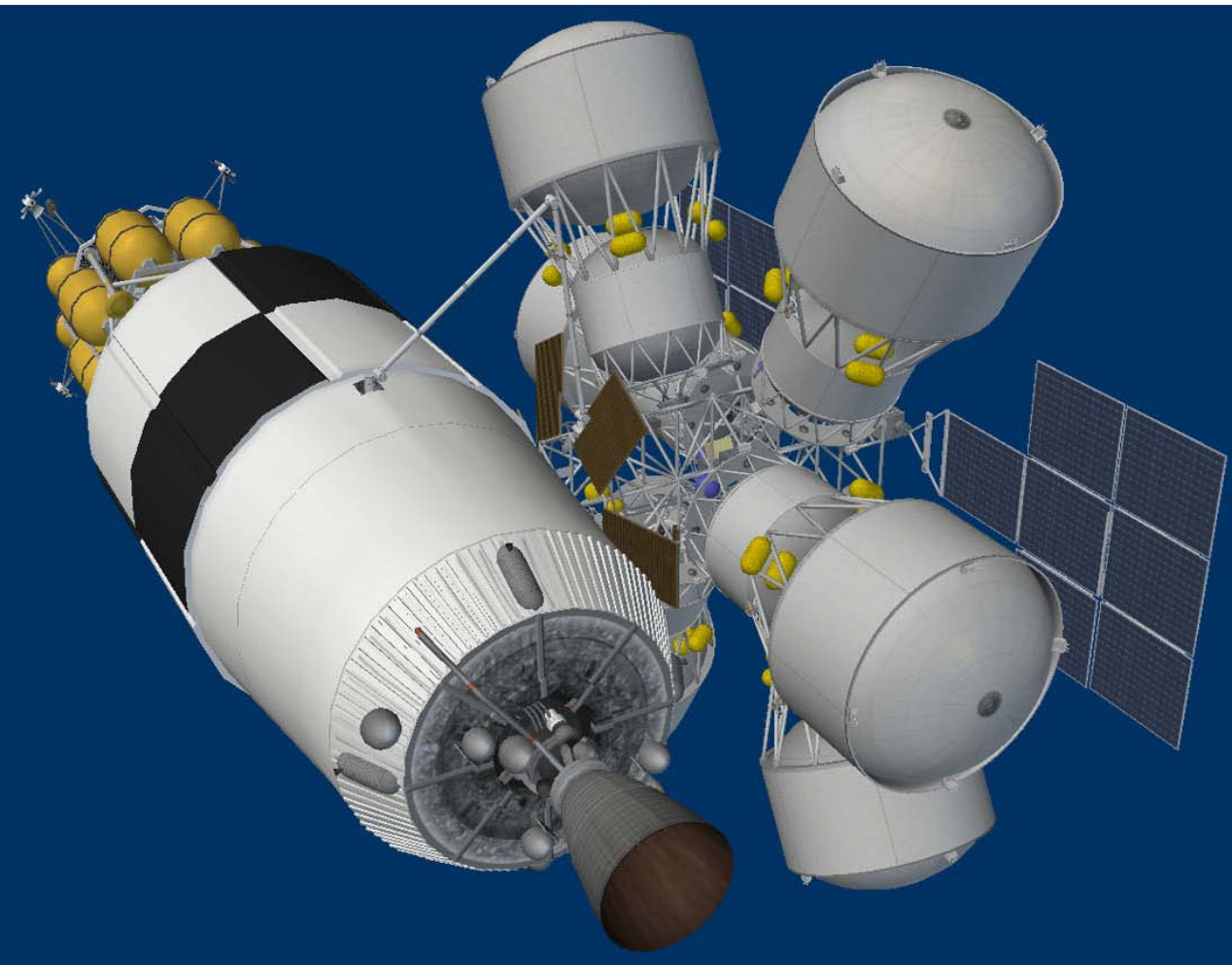


**Reusable Propellant Carrier**

# Business Case Constraints

- **\$10,000/kg value to NASA for propellant in LEO (Griffin)**
- **\$3,300 – 3,600/kg to 185 km x 28.5**
  - Space X Falcon 9 and Falcon 9 Heavy with 5.2 m shroud
  - Unit launch price based on gross mass to LEO
  - [www.spacex.com](http://www.spacex.com) (July 3, 2007)

# Refueling the EDS/Lander Vehicle from Depot



- LPD RMS berths EDS & LPD
- Single mating interface
- Transfer prior to Orion mate
- Lox and LH to EDS & Lander
- ~25 t transferred to Lander
- ~125 t transferred to EDS
- 2 depots for redundancy
- 12-month depot refill cycle