

RLV-Compatible Orbital Propellant Depots

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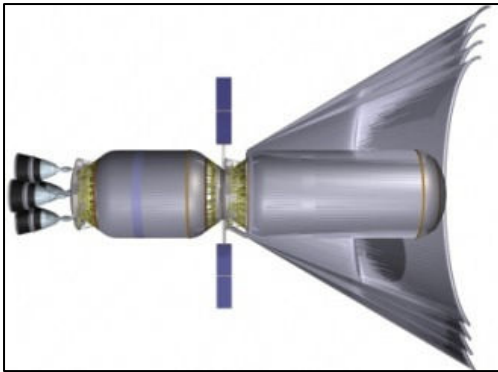


Depots as an Important Early RLV Market

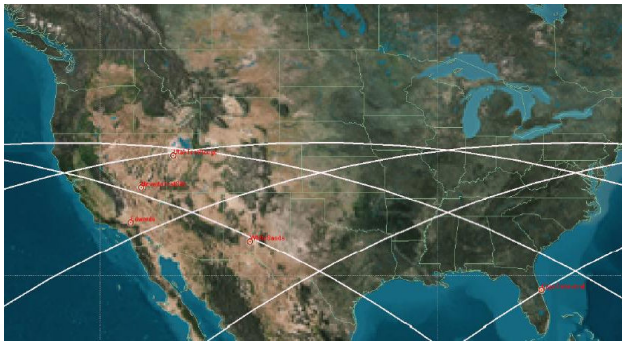
- RLVs are critical for low-cost LEO access.
- Business/Financing obstacles can be just as daunting as technical ones
 - So far, only Kistler raised enough money to have a chance to fail technically
 - No market has *demonstrated* adequate demand yet
 - RLVs need >25-50 flights/year
- Prediction: Realistic near-term RLVs will be <1 ton to LEO
- Ideal RLV payloads:
 - Finely divisible
 - Good demand elasticity
 - Easily produced w/ short lead times
 - Demonstrate sufficient demand before RLV available
- Propellants look interesting:
 - Just 1-2 GEO satellites per year would provide enough demand
 - Or one “Around the Moon” tourism flight per year



Location, Location, Location

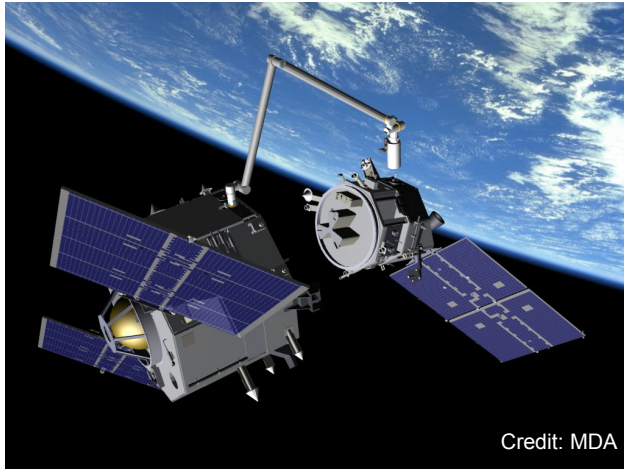


Dual Fluid Depot (Credit: ULA)

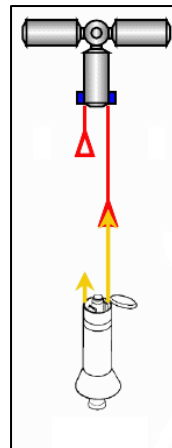
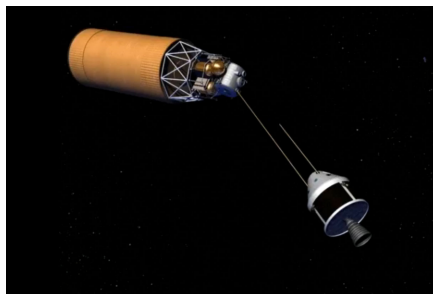


- Small Depots in LEO as well as BEO locations
 - RLVs most likely only able to reach LEO
 - Depots at both ends allows for smaller, single-launch depots to be used
 - More small LEO depots better than one big LEO depot
 - More frequent delivery opportunities
 - More frequent BEO launch windows
 - Use reusable tankers to transfer prop between LEO and BEO depots
- Resonant (Repeating Groundtrack) Orbits
 - At right combination of inclination and altitude, passes over same point at same time every day
 - Enables routine flight operations, simplifies single-orbit (or few orbit) rendezvous
 - Enables many launch sites to participate, not just one.
 - For many launch sites you get two daily launch and landing opportunities per depot
 - Multiple depots in the same inclination and altitude, but with different RAAN allows even more frequent flight opportunities

Reaching Out in New Ways



- Space Tugs
 - Early RLVs likely to be small (< 1 tonne to LEO)
 - Offload AR&D hardware to a reusable tug to improve payload fraction
 - Apogee tugs can enable RLV delivery to low altitudes, with tug providing boost to depot altitudes at lower cost
 - Common “dumb” interfaces make it easier for multiple players to compete for deliveries



- Boom Rendezvous with Depot
 - Initial connection point on an extendable boom, far from depot or tug
 - Like mid-air refueling
 - Greatly reduces odds of damaging depot accidentally by failed rendezvous
 - Potential large increase in AR&D reliability
 - Possibly simplifying some of the AR&D hardware and processes