LUNAR WATER REQUIREMENTS FOR CISLUNAR TRANSPORTATION

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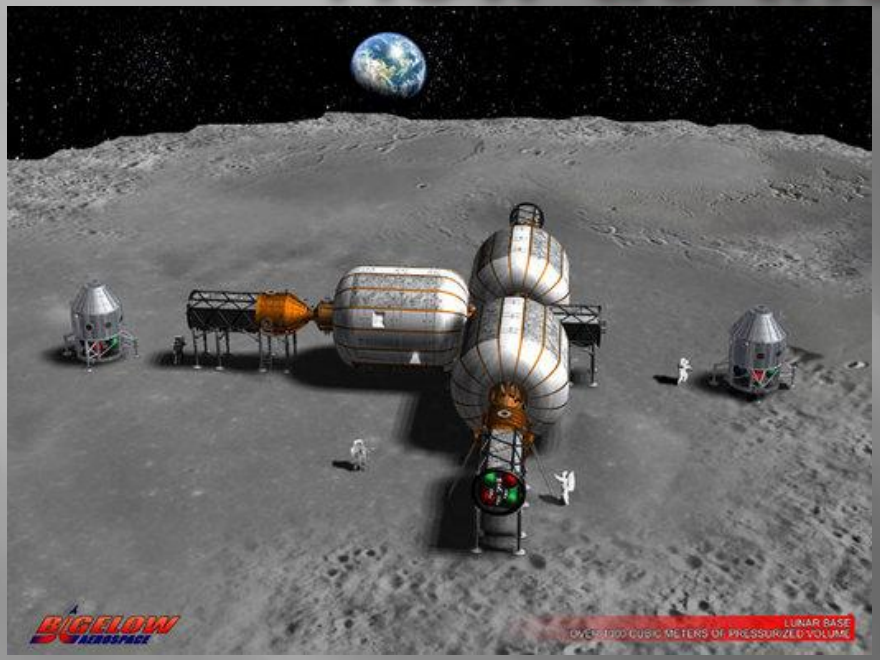
Lunar Water Requirements for Cislunar Transportation

- Lunar Development Plans
- Reusable Cislunar Transportation Architecture
- RCTA Systems
- Propellant Requirements
- Water Production Requirements

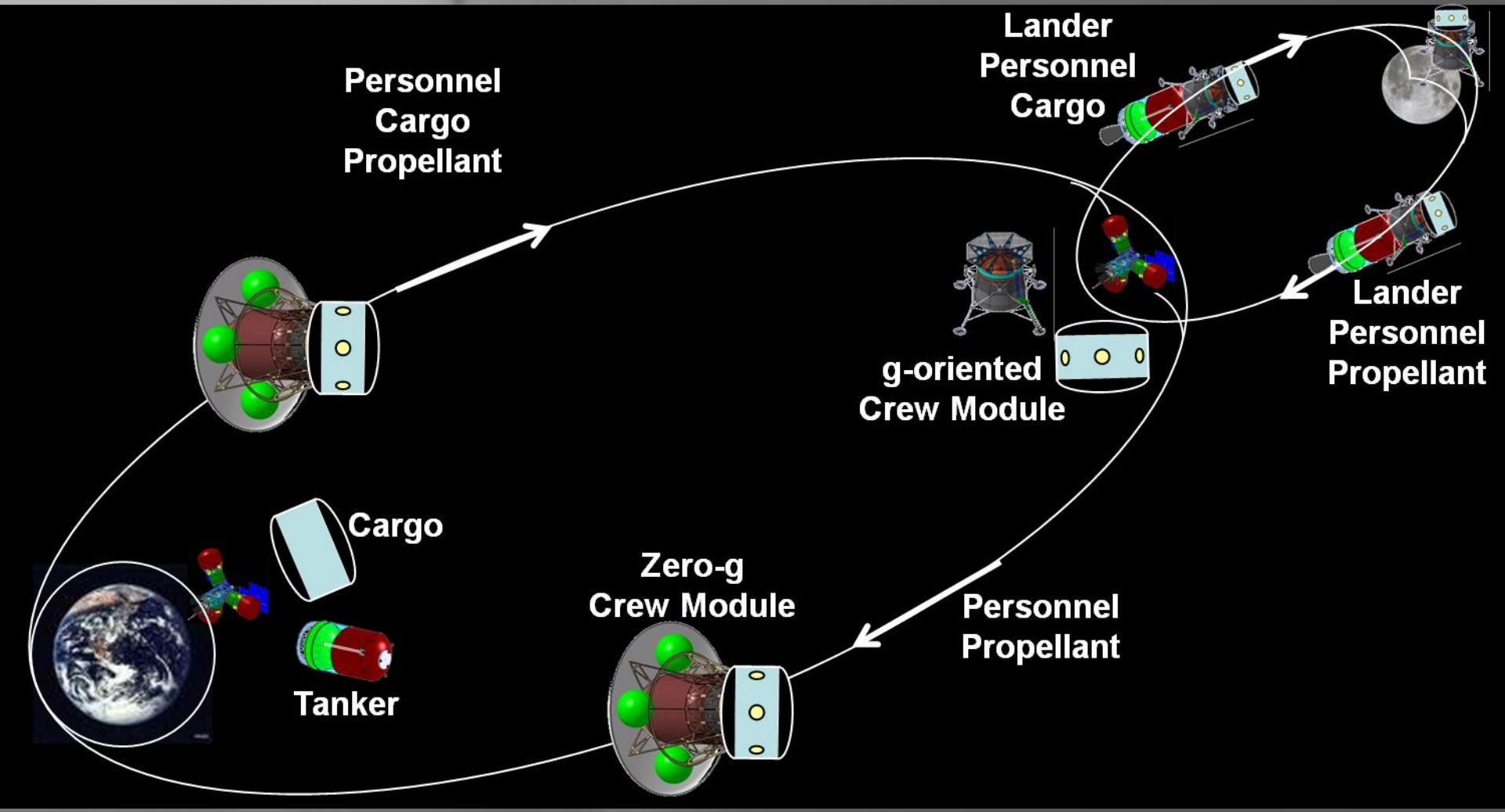
Lunar Development Plans: How do they get there?



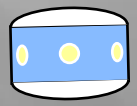
- Bigelow Lunar Base
- Follows LEO Complex
- Lease to national agencies
- 12 – 18 person occupancy

- Shackleton Energy Company
- 12 – 18 person crew
- One-way deploy mission
- Water export for propellant

A Reusable Cislunar Transportation Architecture

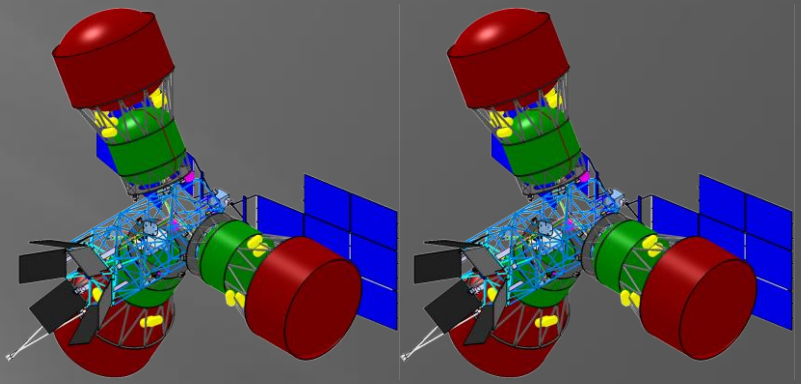


Reusable Cislunar Transportation Architecture Systems

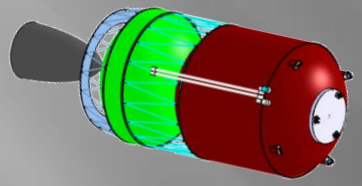


Personnel Modules
0-g and g-oriented

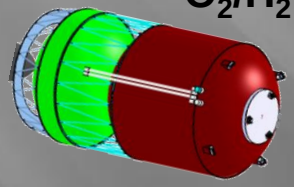
ETO
Propellant Carrier



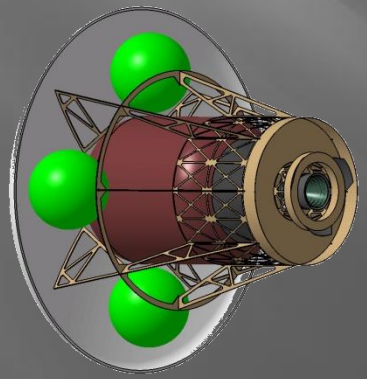
Modular Propellant Depots



Reusable Circumlunar Transfer Vehicle
EML1 to Perilune delivery
O_2/H_2



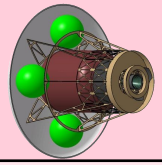
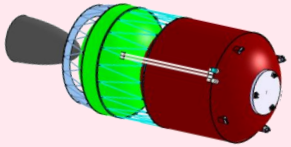
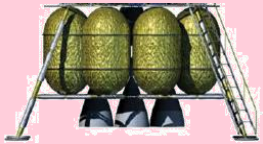
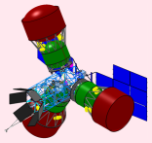
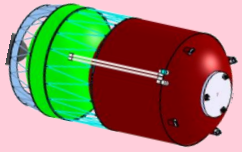
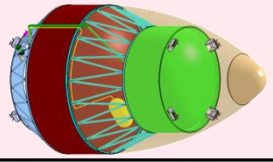
Propellant Tanker



Reusable Aerocapture Transfer Vehicle
GTO and/or GEO delivery
O_2/H_2

Lunar Lander
Perilune to Surface
O_2/H_2

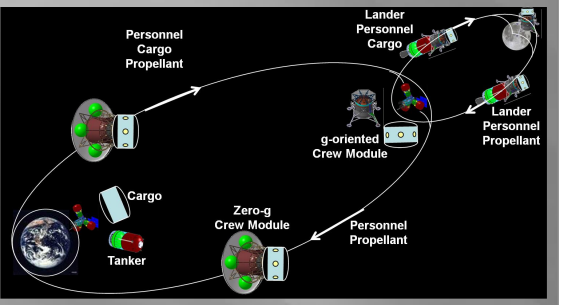
RCTA System Masses

Systems		Inert Mass (kg)	Propellant Capacity (kg)
RATV		6,665	46,142
RCTV		3,301	18,706
RLL		12,479	49,917
Propellant Depots		20,000	81,600
Propellant Tanker		3,000	22,000
Propellant Carrier		6,400	25,600

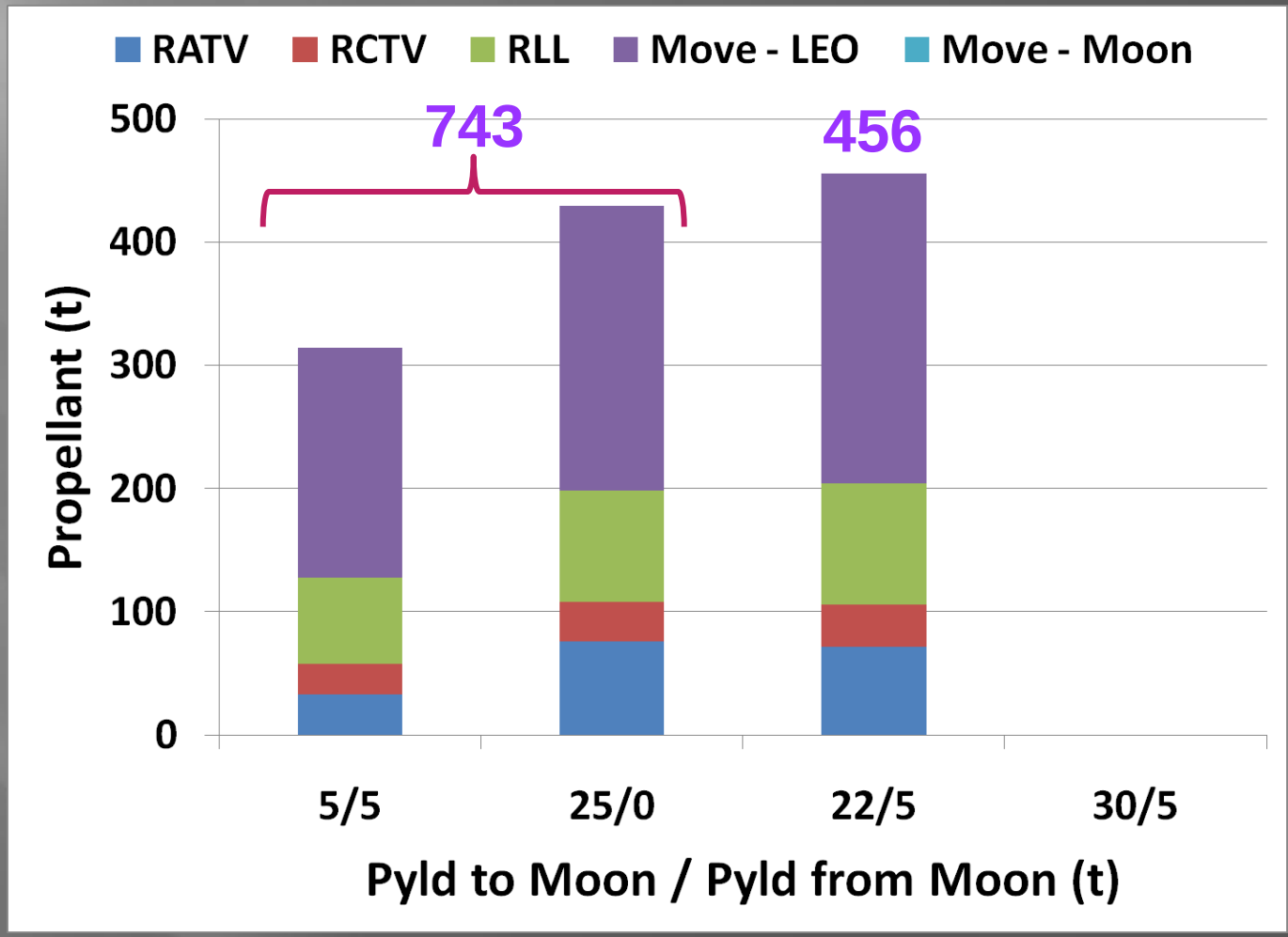
Annual Lunar Mission Model

- 2 crew rotations
  - 5 t crew module roundtrip
- 2 cargo deliveries to surface
  - 22, 25 or 30 t
  - 0 t payload on return legs
- Crew & cargo separate or together
- As-needed propellant delivery to EML1

LEO Propellant Requirements: 100% Earth Supplied

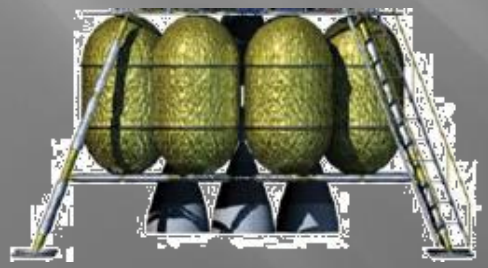


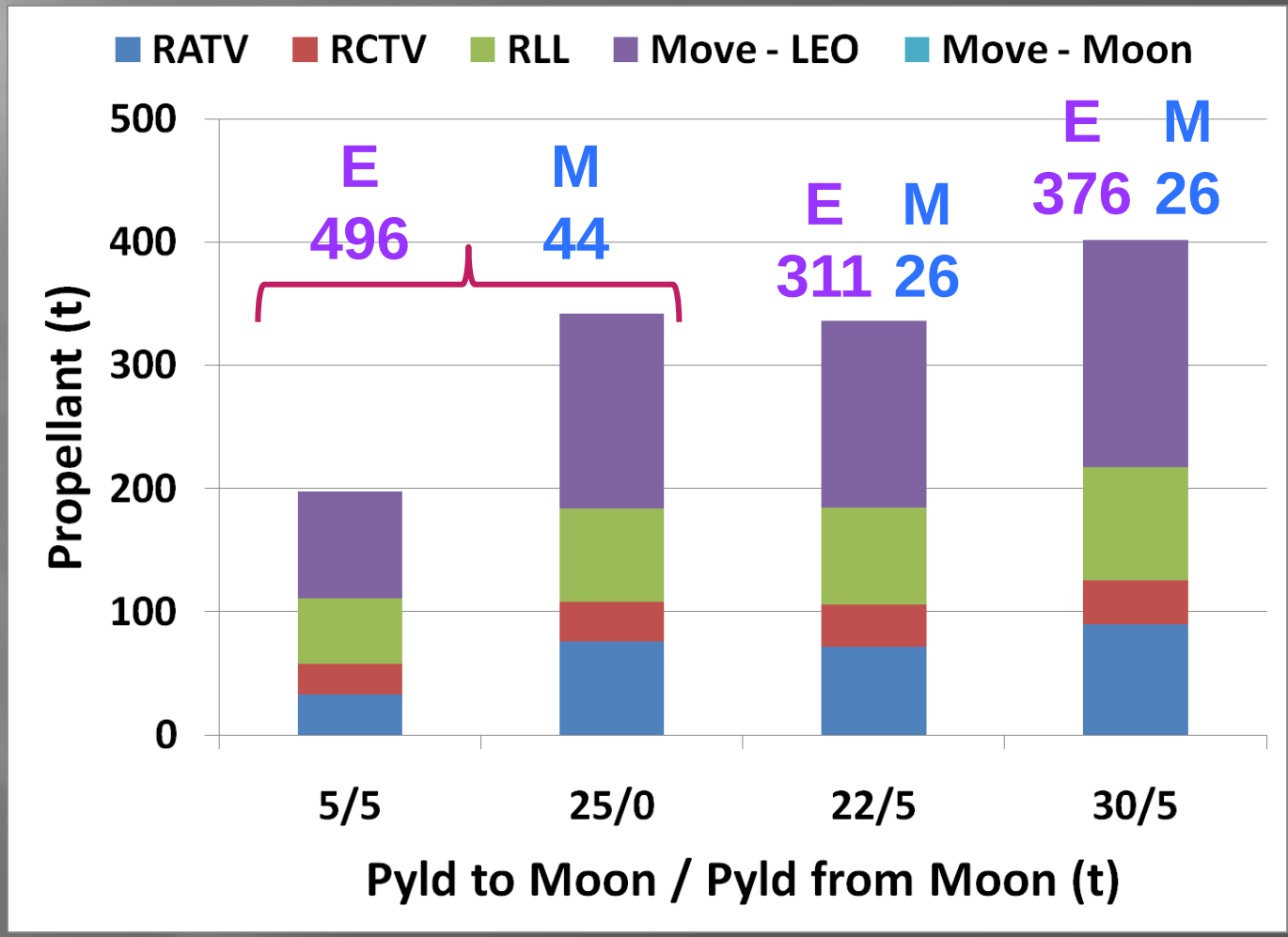
All Propellant Launched from Earth



Lunar Propellant Requirements: Step 1: RLL Ascent

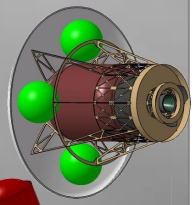
ISRU for
Moon Departure

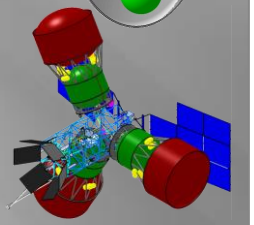




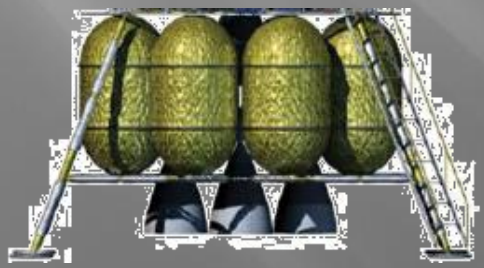
Lunar Propellant Requirements: Step 2: RLL Up and RATV Return

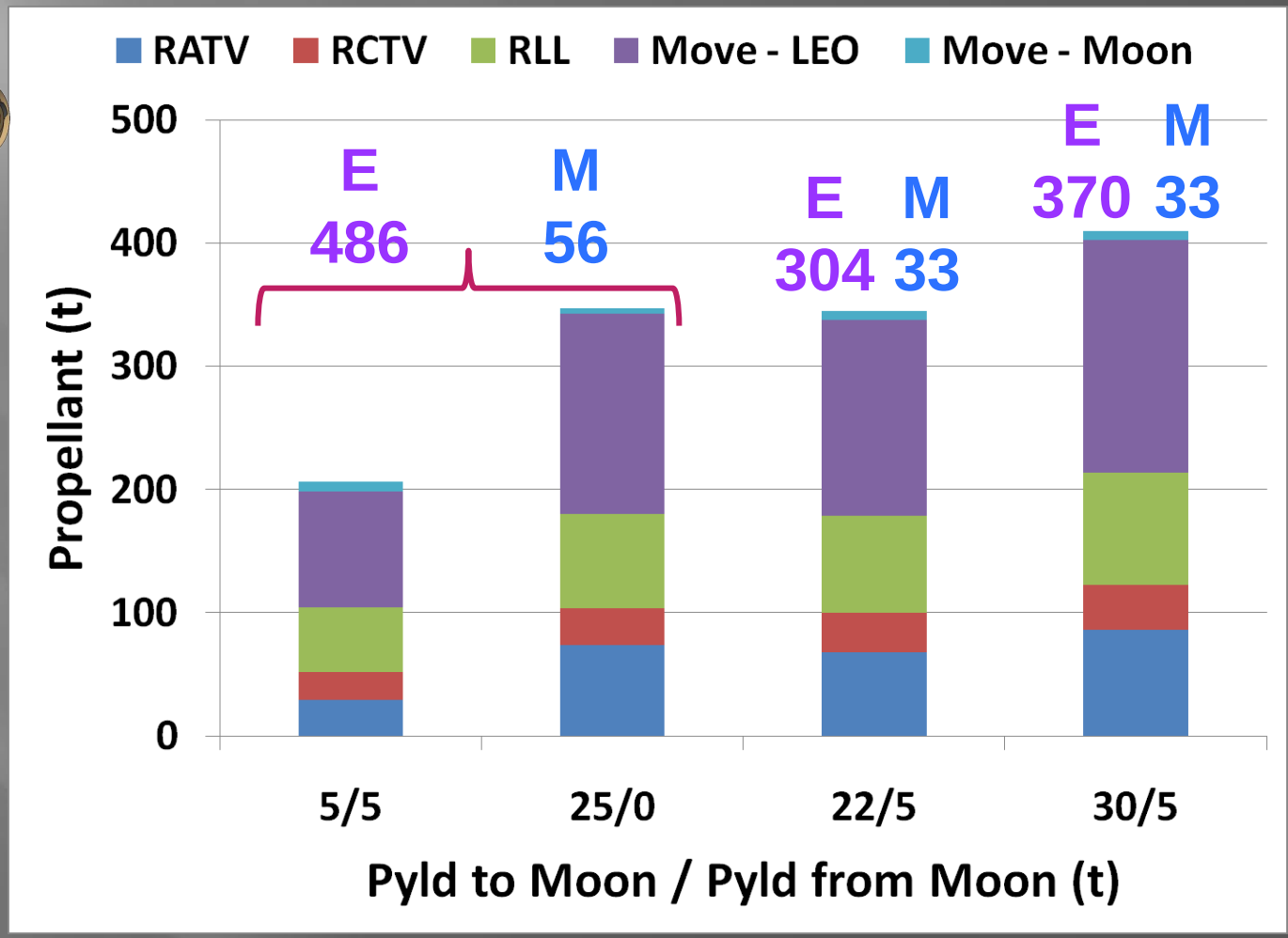
ISRU for Return to LEO





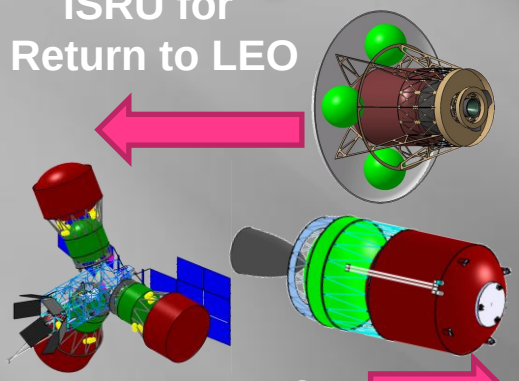
ISRU for Moon Departure





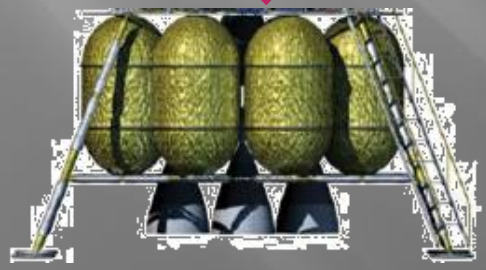
Lunar Propellant Requirements: Step 3: RLL, RCTV, RATV Return

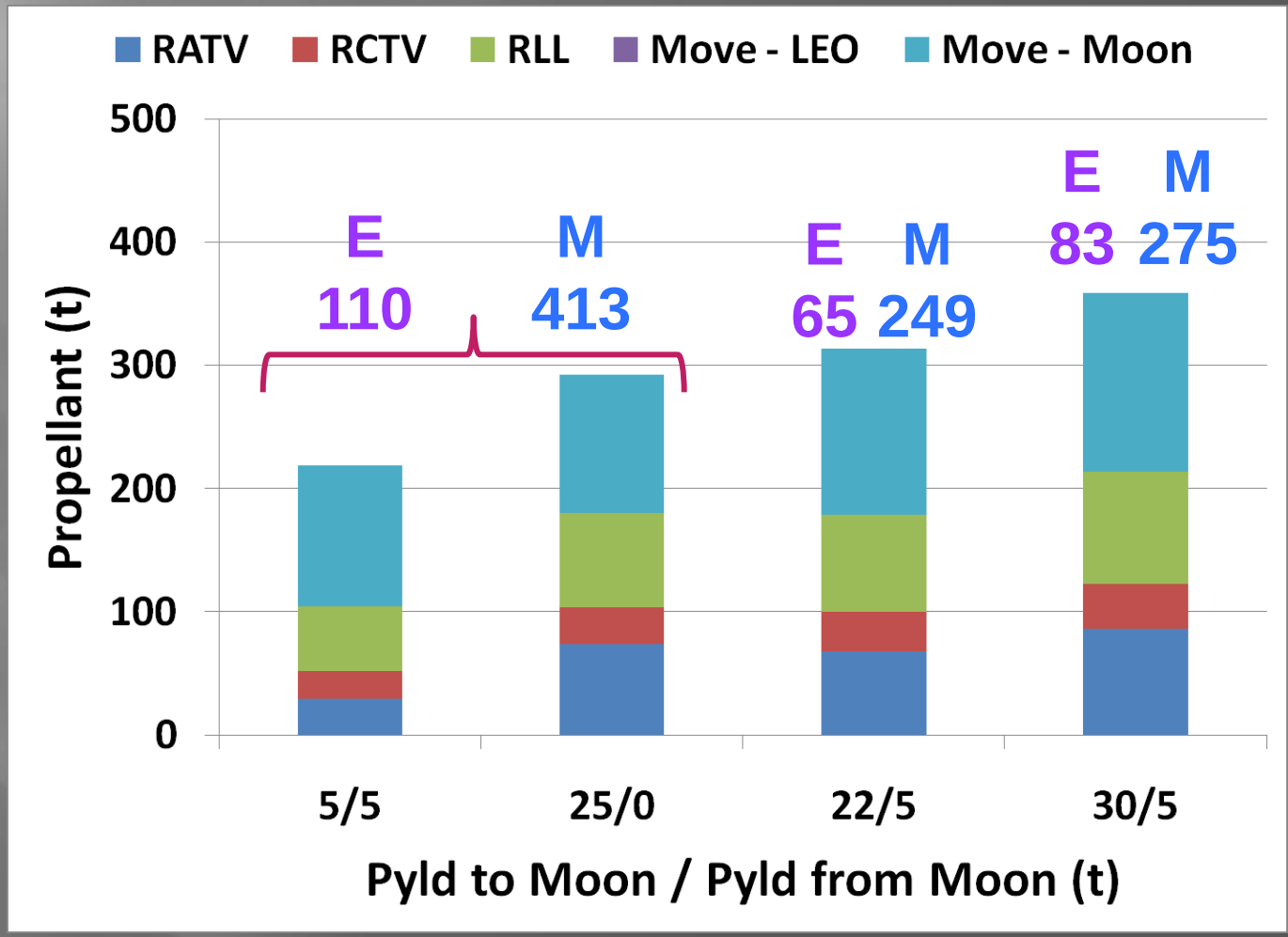
ISRU for Return to LEO



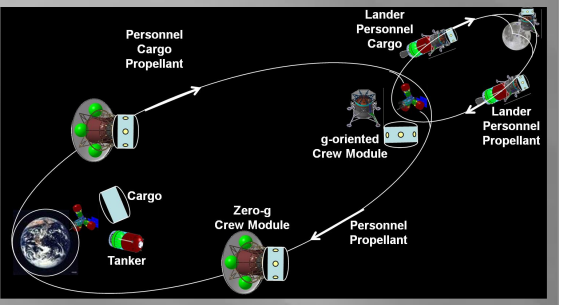
ISRU for EML1 to Moon & Back

ISRU for Moon Landing & Departure

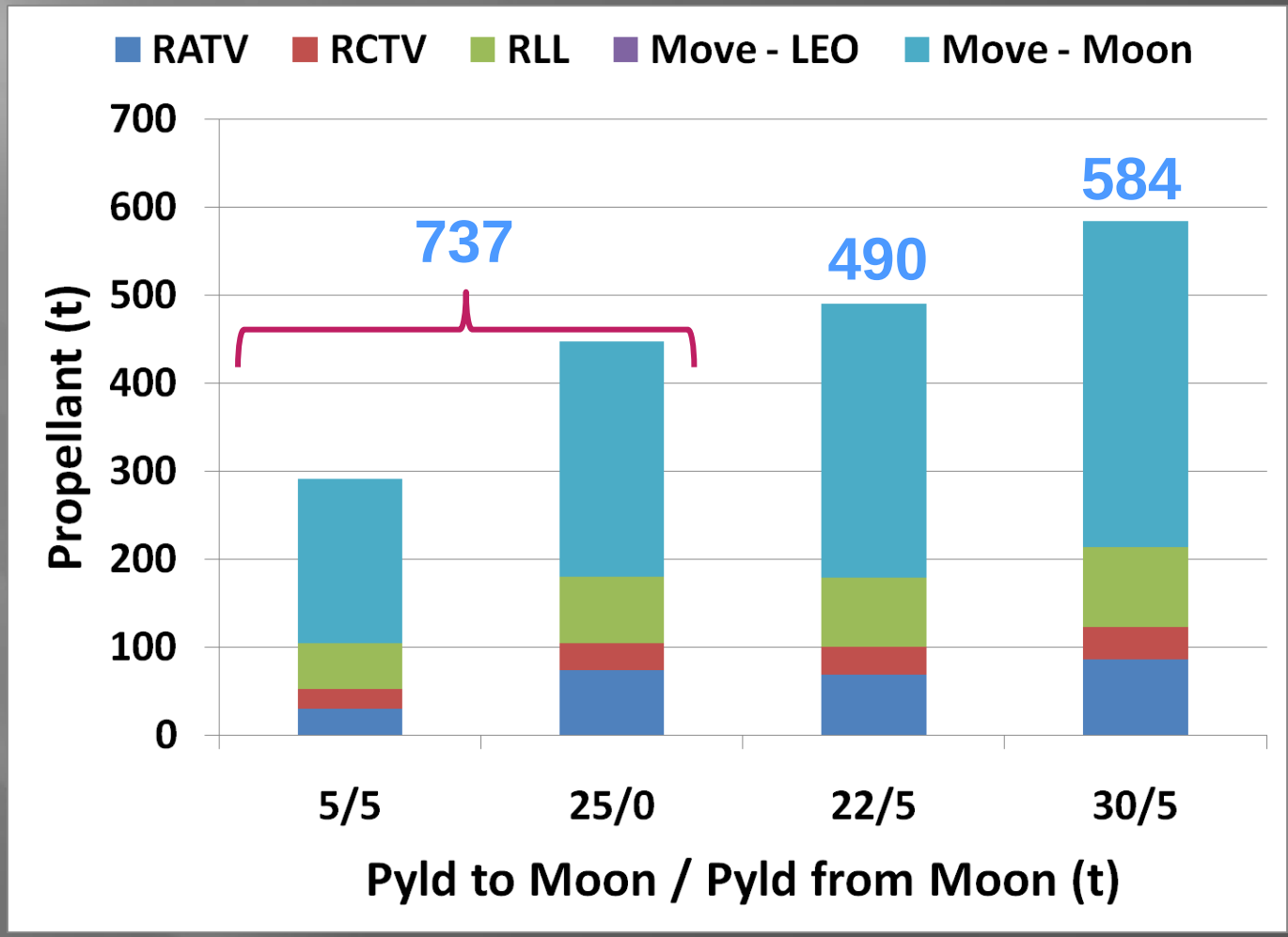




Lunar Propellant Requirements: Step 4: 100% Lunar Propellant



All Propellant Produced on Moon

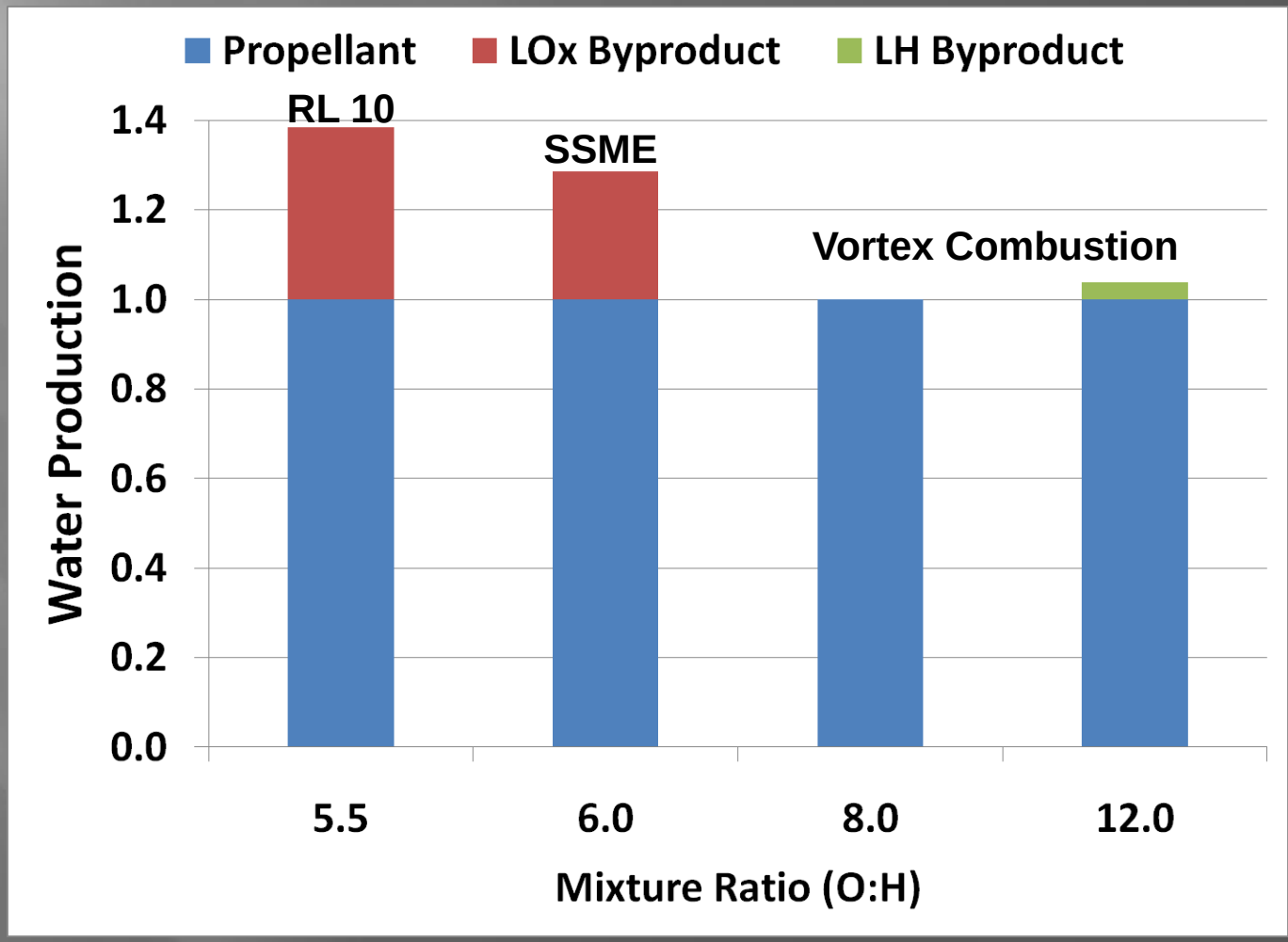


Propellant Mixture Ratio Drives Lunar Water Production

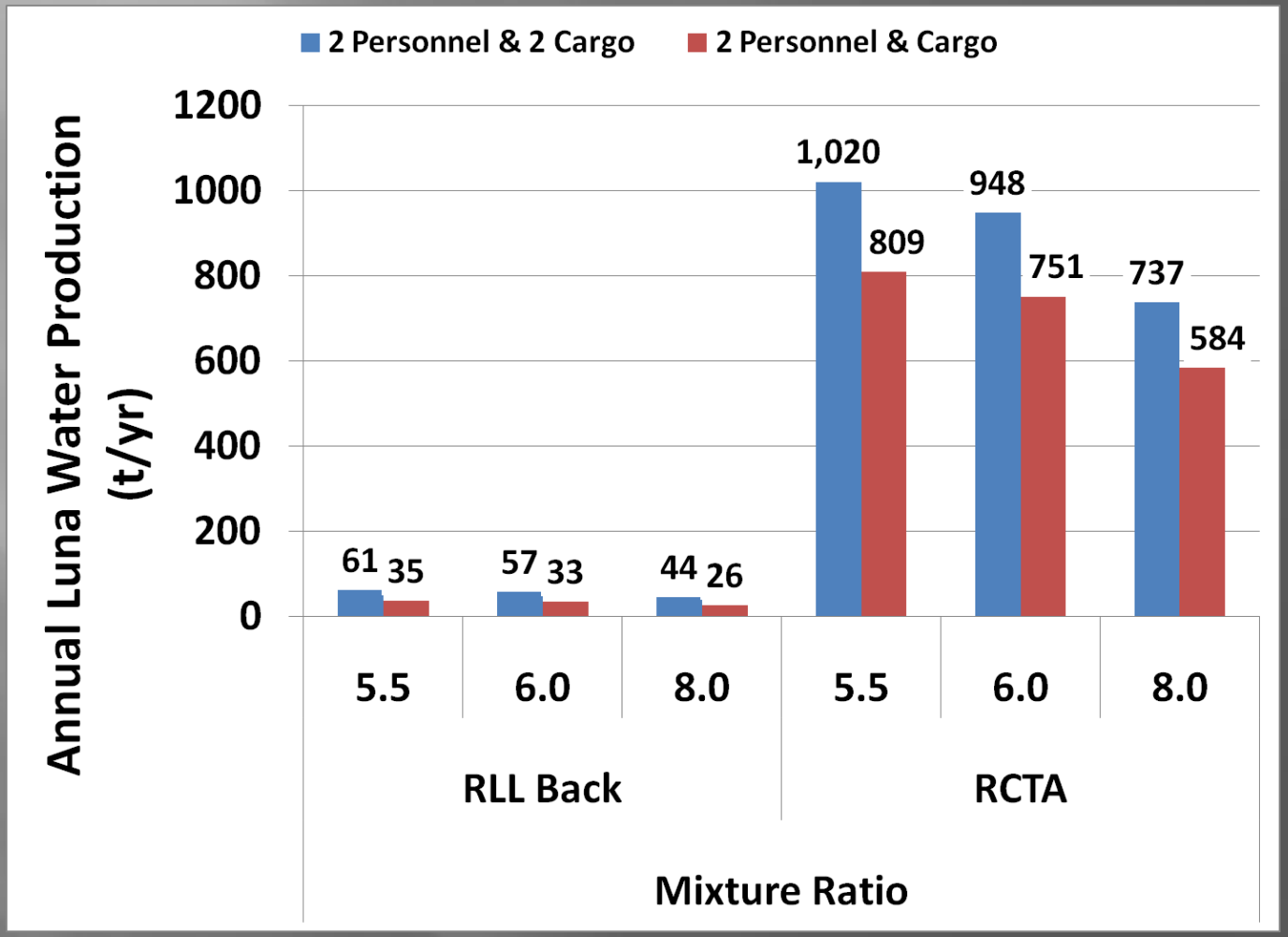
SSME

RL 10

Vortex Combustion



Production Impacts: MR & Logistics Approach



Lunar Water Requirements for Cislunar Transportation

- 61 to 1020 t water per year if 2 crew & 2 cargo
- 17 to 283 t LOx byproduct per year
- 20% reduction if crew & cargo together
- 30% reduction if 8:1 MR rocket engines

Study Assumptions

Specific Impulse (all mixture ratios)	450 sec
Mixture Ratio (O/H)	5.5
Crew Module	5 t
LEO to EML1 dV	3.35 km/s
EML1 to LEO dV	0.55 km/s
EML1 to/from circumlunar dV	0.63 km/s
RLL descent & landing dV	2.53 km/s
RLL ascent dV	2.43 km/s
RATV propellant fraction	0.874
RATV aerobrake fraction	0.30
RCTV propellant fraction	0.85
RLL propellant fraction	0.8
Propellant margin	10%
Inert mass margin	30%
Propellant loss per transfer	10%
Cargo capacity with Earth propellant only	25 t