In-Space *Power Forecast* for Lunar Power & Light

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Brad R. Blair

Founder and General Partner

NewSpace Analytics LLC

In-Space Power Forecast

- Power / energy to electrolyze water for space propellant (interpolation required)

power to electrolyze water (MWh)	*2010*	*2025*	*2040*	*2055*	*2070*	*year*
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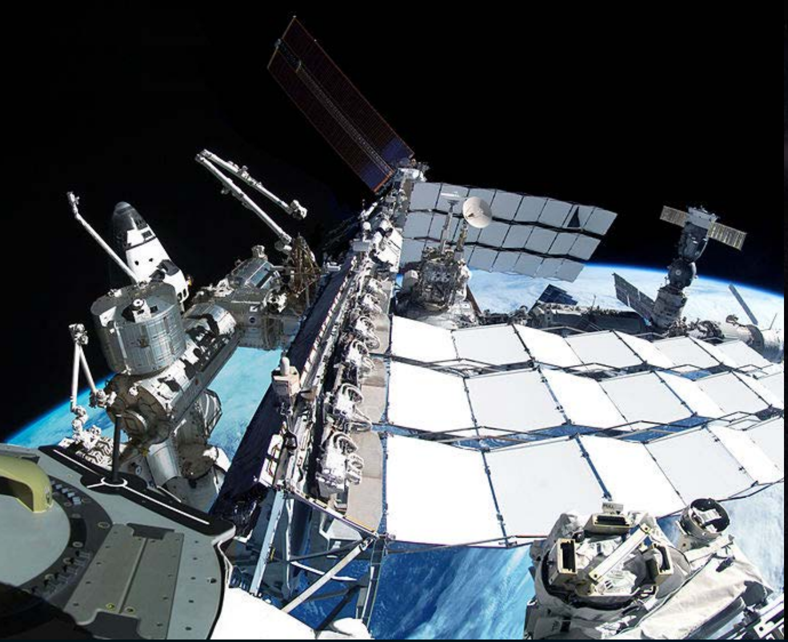
Overview

- Key Insight: ***Propellant*** requires ***Power***
- **Economic Framework** for space propellant
- **Prior Art**: Quantitative economic modeling of space resource supply & demand
- Location of primary **Space Power Markets**

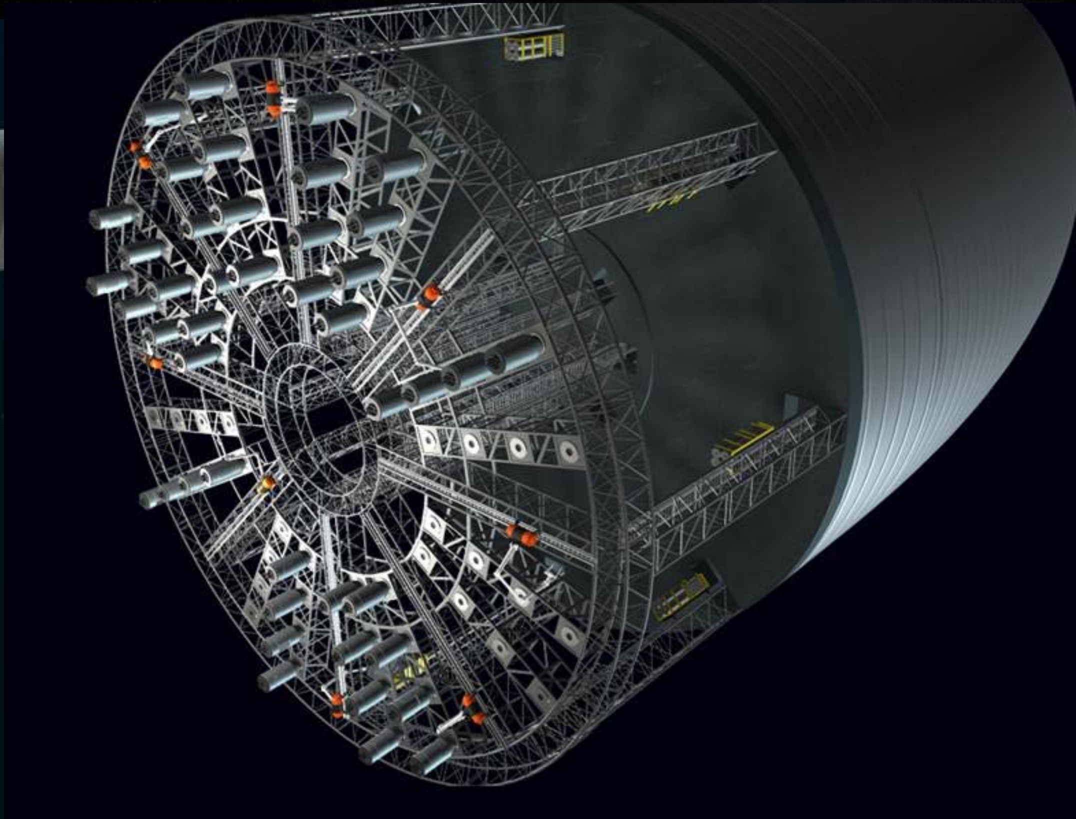
Who am I?

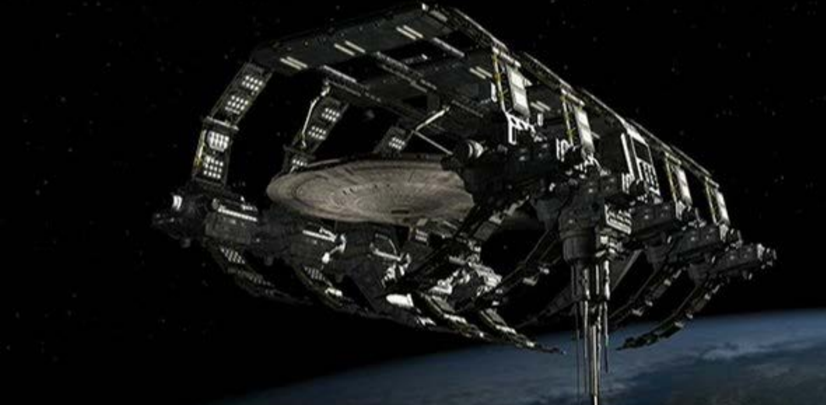
- 25 years ago I was writing about mine and equipment design for the moon
- 20 years ago I started my first private space startup (it failed - no market) and started a marketing campaign for LEDA bonds
- 15 years ago I published the first integrated lunar economic model as a phd econ student
- 10 years ago I was a consultant to Lockheed, Raytheon and Bechtel for a NASA return to the moon
- 5 years ago I worked to rebuild isdac and give it a biz model (sue for debris cleanup) and make an asteroid boulder grabber
- 0 today I am writing and publishing models about the growth of in space markets

FRAMEWORK FOR SPACE MINERAL & ENERGY RESOURCES

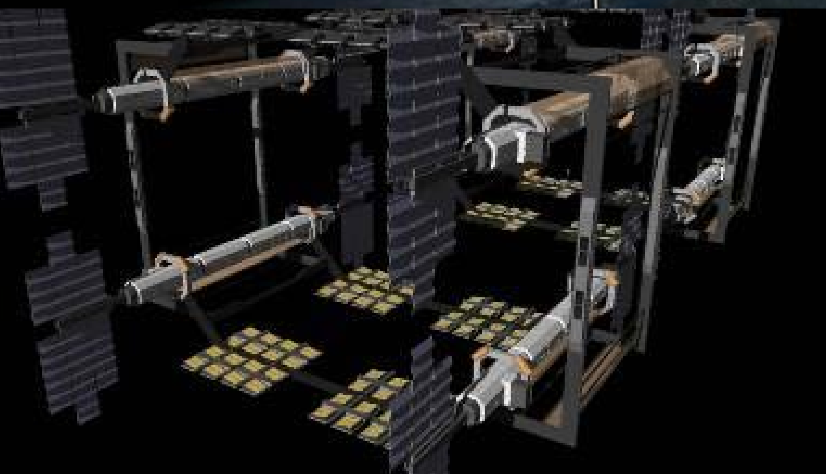


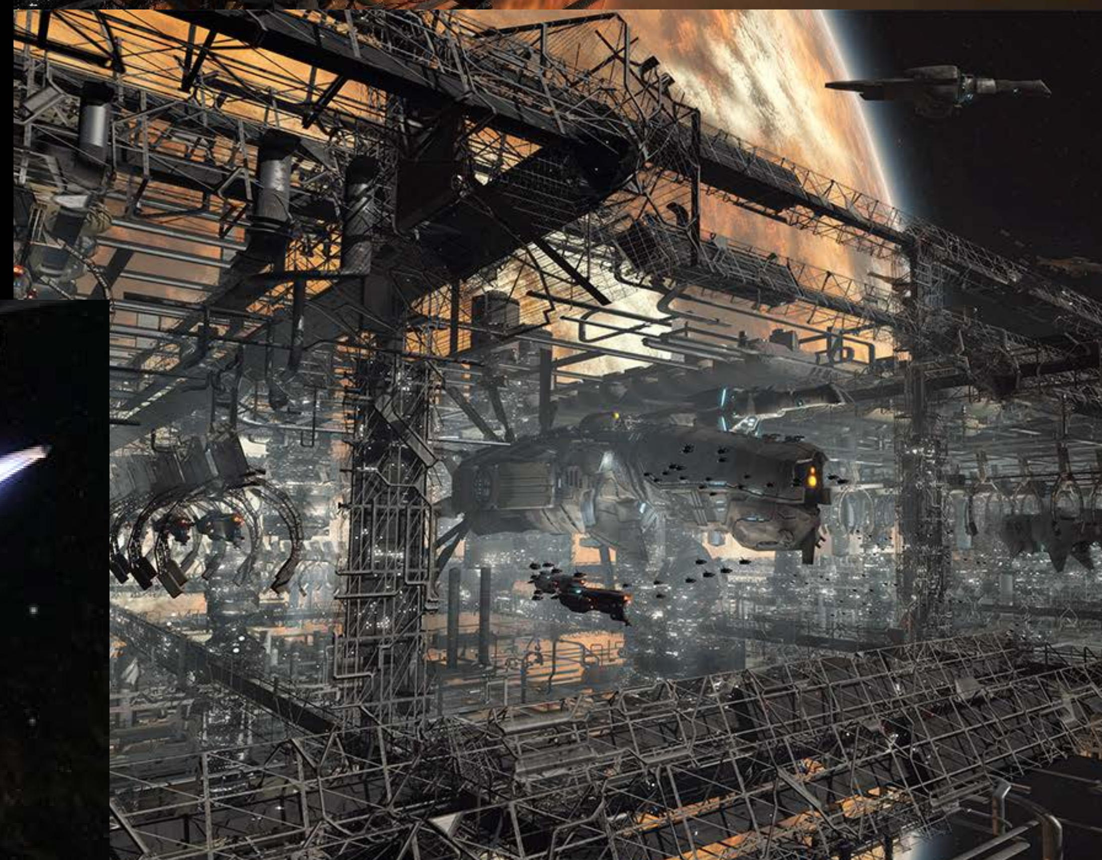

SETTLEMENT CONCEPT
BRYAN VERSTEEG
DEEPSPACEINDUSTRIES.COM

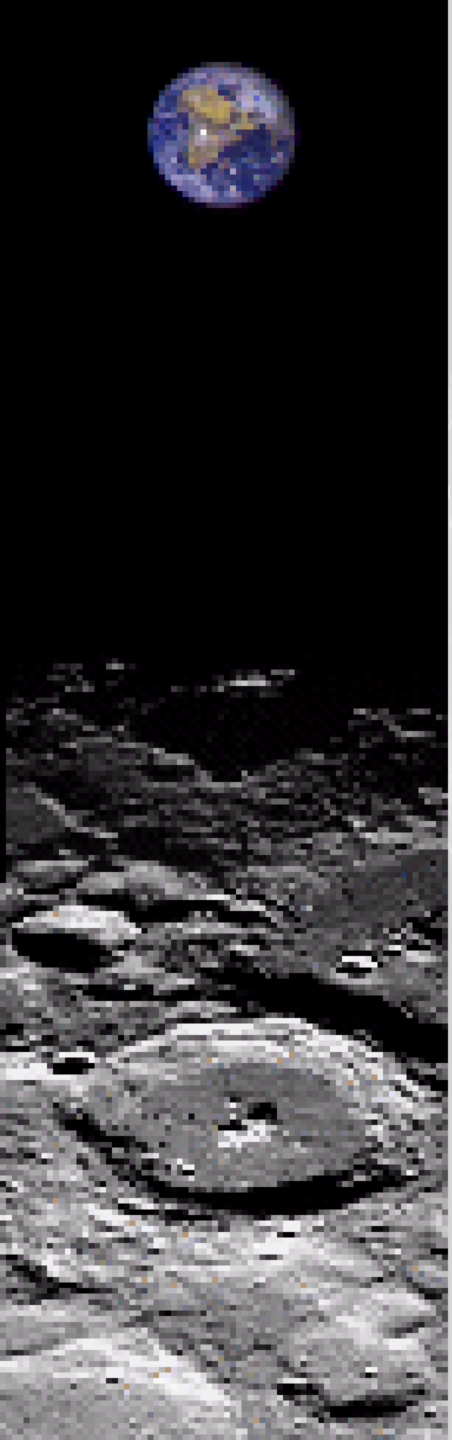





ANGELS FALL FIRST
war in heaven







The Case for Commercial Lunar Ice Mining

by

Brad R. Blair, Javier Diaz, Michael B. Duke,
Center for the Commercial Applications of Combustion in Space, Colorado School of Mines, Golden, Colorado

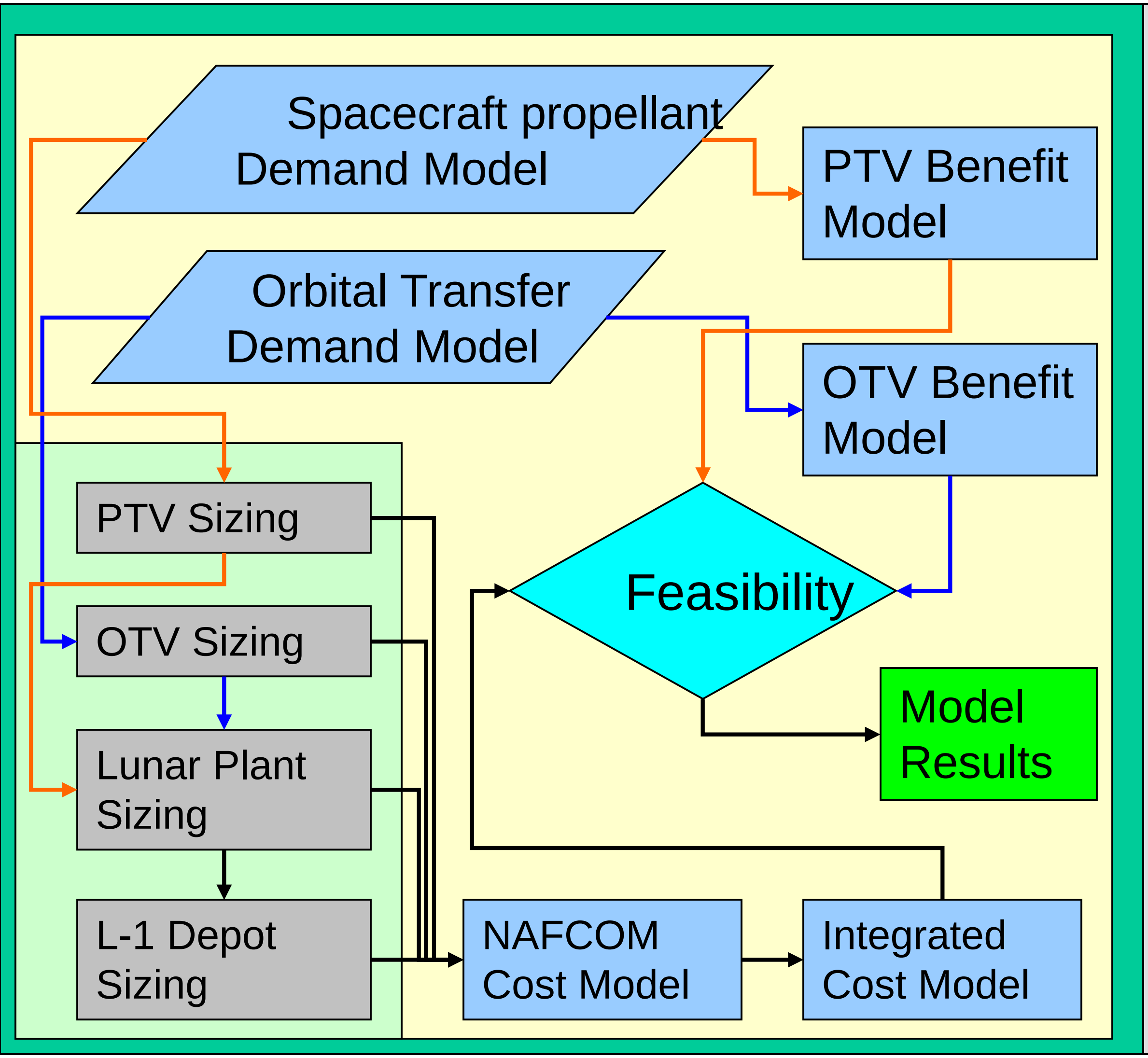
Elisabeth Lamassoure, Robert Easter,
Jet Propulsion Laboratory, Pasadena, California

Mark Oderman, Marc Vaucher
CSP Associates, Inc., Cambridge, Massachusetts

December, 2002

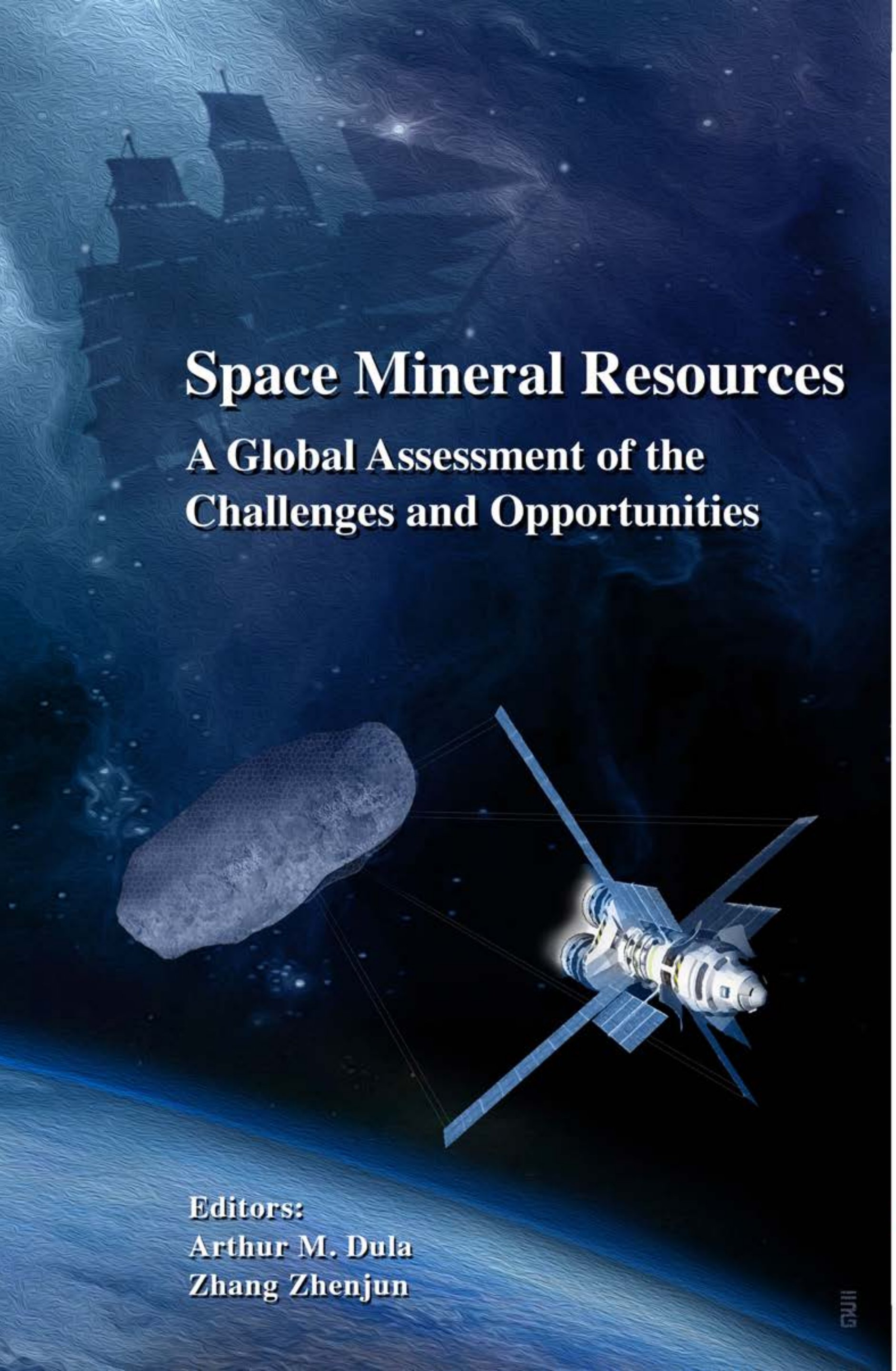
http://www.isruinfo.com//docs/LDEM_Draft4-updated.pdf

Functional Layout of Econ Models



- Model Structure
  - Architecture
  - Parametric sizing
  - Demand models
  - Cost model
  - Feasibility
- Goals of Modeling
  - Determine feasible conditions (Go / No Go)
  - Insight into critical assumptions
  - Insight into systems dynamics (sensitivity)
  - Identification of critical risk factors
  - Technology sensitivity analysis (investment prioritization)

IN-SPACE POWER DEMAND - ECONOMIC MODEL DEVELOPMENT



International Academy of Astronautics

Study Leadership:
Art Dula
Zhang Zhenjun

Secretariat:
Anat Friedman

Research Staff:
Brad Blair
Jason Juren

Editorial Staff:
Dr. Peter Swan
Roger Lenard
Dr. Cathy Swan
Shirazi Jaleel-Khan

https://www.amazon.com/Space-Mineral-Resources-Assessment-Opportunities-ebook/dp/B018OJD95Q

Space Mineral Resources

(IAA Cosmic Study 3.17)

Arthur M Dula

- Space lawyer and patent attorney
- Literary executor for Robert A. Heinlein
- Chairman and founder of Excalibur Almaz

Zhang Zhenjun

- Secretary General, China Institute of Space Law
- Founding Editor-in-Chief, China National Yearbook of Space Law Studies
- Resident Director, Chinese Society of Astronautics

Economic Assumptions

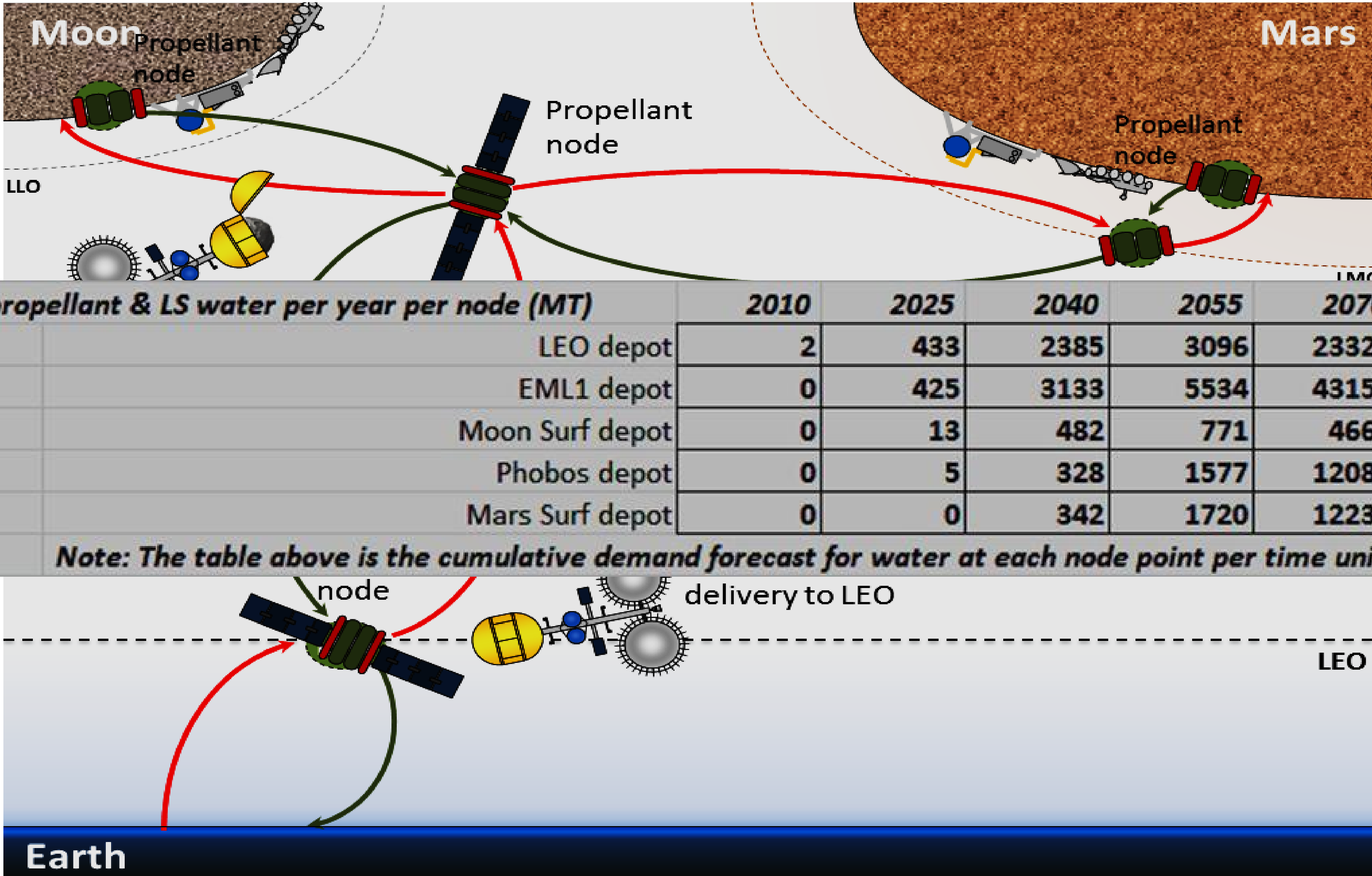
- Water is the "propellant of choice"
- Customers: Space propellant and consumables
- Population forecast = 10,000 people on Mars
- Estimated unit consumption *per human*
- Estimated in-space logistics flows
- Simple approximations are favored vs. high model fidelity (comprehensibility bias)

Mars Surface Population Forecast:

10,000 people by 2070

SMR-Space Infrastructure Forecast / In-Space Population Model					
year	2010	2025	2040	2055	2070
growth rate per period (specified)		15%	15%	15%	15%
number of people in space	6	49	397	3233	26304
population ratios through time		100%	100%	100%	100%
LEO outpost	100%	75%	55%	35%	30%
EML1 outpost		20%	20%	10%	10%
Moon Surf outpost		4%	17%	20%	20%
Phobos outpost		1%	3%	5%	5%
Mars Surf outpost			5%	30%	35%
in-space population distribution	2010	2025	2040	2055	2070
LEO outpost	6	37	218	1131	7891
EML1 outpost	0	10	79	323	2630
Moon Surf outpost	0	2	68	647	5261
Phobos outpost	0	0	12	162	1315
Mars Surf outpost	0	0	20	970	9206

Propellant Flow (quantity)



propellant & LS water per year per node (MT)	*2010*	*2025*	*2040*	*2055*	*2070*
LEO depot	2	433	2385	3096	23321
EML1 depot	0	425	3133	5534	43158
Moon Surf depot	0	13	482	771	4665
Phobos depot	0	5	328	1577	12084
Mars Surf depot	0	0	342	1720	12230

Note: The table above is the cumulative demand forecast for water at each node point per time unit

SPACE POWER DEMAND FORECAST

Quantitative Power Demand

- Note: This is only for electrolysis of water for propellant (quantity will increase with other products)

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CONCLUSIONS

NewSpace Analytics

Space Myths and Truth

MYTH

- High cost space access
- Lack of customers
- Extreme environments
- Technical failures
- Low systems reliability
- Slow advancement
- Money should be spent on the poor
- Human beings are meant to stay on earth

TRUTH

- Reusability lowers costs
- Humans will spend
- Enabling physics
- Rapid learning
- Failure is frequently rewarded
- TRL chasm of death
- Spinoffs also help the poor
- The dinosaurs were meant to stay here too