Risk in Off Earth Mining Financial Models

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Software
Forex, Capital Mkts
Risk Management
Uber for satellites in GTOs

Satellite Tug raising to GEO, but:

- Direct from polar mine (no depot)
- Grab satellite in GTO (customers)

Satellite design & launch unchanged (almost).

Partial raise extends station keeping lifetime.

Optimize satellites over time.

No “Chicken & Egg” / “Stag Hunt” dilemma.

My goal: consider including GTOs as a reference market along with LEO, GEO, EML1, …
GTOs: customers right now – how big?

- FAA: 120 mt commercial separation mass
- 1,500 m/s to raise
- 60 mt low Isp bi-propellant
- @ $11,250/kg SpaceX
  
  = $675 M/year
Used:
- Mining Model
- Finance Model

Applied to GTO impulse

Kornuta 2019
Commercial Lunar Propellant Architecture
A Collaborative Study of Lunar Propellant Production

CLPA: 40 authors, 25 orgs, economic model
CLPA implies GTO return is better than LEO

Major revenue & cost driver is burn ratio to move mass

Sell 1 unit in:
- LEO: $`
- GTO $$

6 unit mine can deliver:
- LEO: 1 unit
- GTO: 2 units

Get paid for 60, deliver 45

\[ \$GTO = 2 \times 2 \times \frac{4}{3} = 5\frac{1}{3} \times \$LEO \]
Practical Trajectories

NASAs General Mission Analysis Tool & Satellite operators:

- Tug trans Earth injection into Sat launch inclination
- Sat launches to tug line of nodes (not for eclipse)
- Sat waits on tug rendezvous (not raise ASAP)

Same launch procedures

Different optimality / price tradeoff

Everything has to align, but not all at the same time!
CLPA Model + Your Estimates = IRR%

2D sensitivity:

- Achievable GTO $/kg
- Burn ratio you believe
- Internal Rate of Return
- Discount Funding
- Discount Risk
  - EML1 LH2LOX or LOX

Lower Earth launch costs erode revenue.
GTO Impulse… a benchmark market?

I hope I’ve shown:

• There is a current market; $675M/year.
• CLPA mining and economic model imply GTO delivery more lucrative than LEO.
• Trajectory, engineering, satellite operations imply can be provided by lunar propellant.
• GTOs should be a benchmark like LEO, GEO, EML1, etc.

Do come talk to me for more details… (...lunar LOX...)

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Tug mass & delta-v budget → Burn Ratio

To GTOs:
5,500 → 4,400 m/s
Nominal → super² synchronous

Inert Mass Fractions:
Lower: 12%, 16%
Upper: 10%, 13½%, 4%

How light can we go?

Reader selects what is reasonable
Just LOX?

Useable Propellant

LEO Propellant

GTO Impulse

EML1 Propellant

“Waste” LOX

30% of mine output, 80% of propellant mass

Best Product for the mine = best for customer?