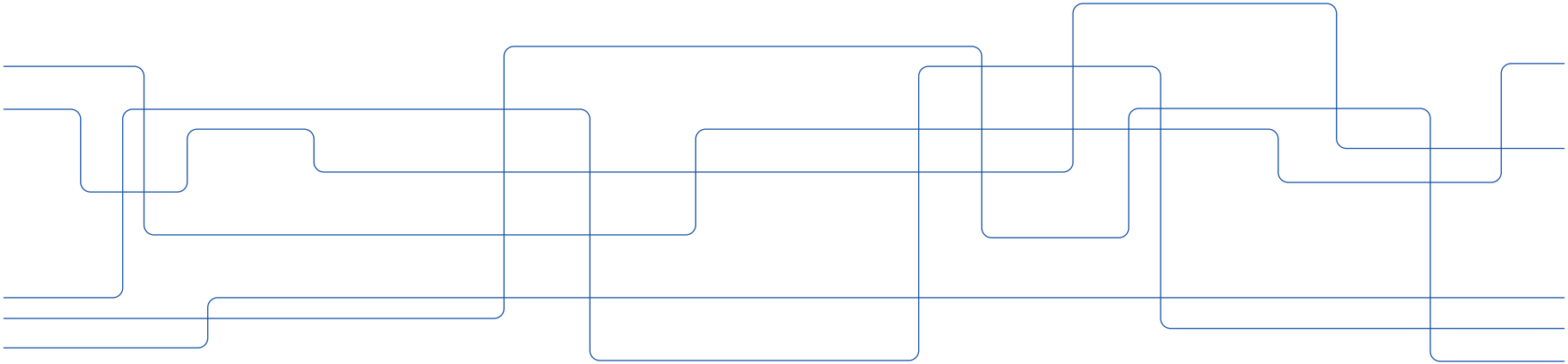
KTH ROYAL INSTITUTE OF TECHNOLOGY

# CISLUNAR ORBITAL TRANSPORTATION STUDY OF SPACE ELEVATOR APEX ANCHOR RELEASES

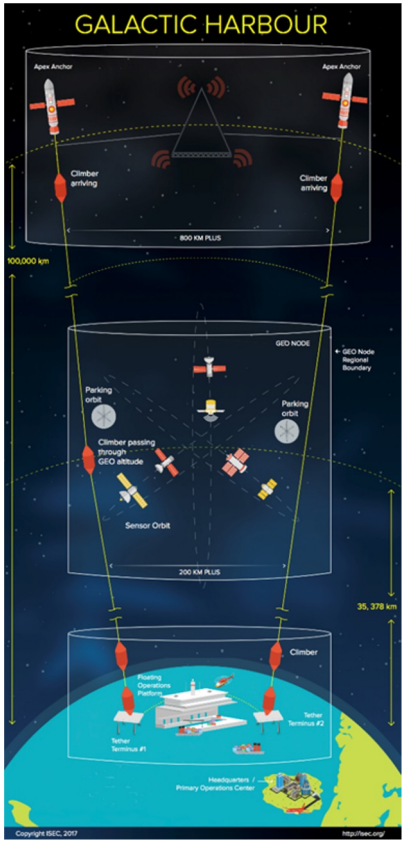


IAC 2022 D4.3 - Paris

By Daniel Griffin and Gunnar Tibert

# Summary of Research

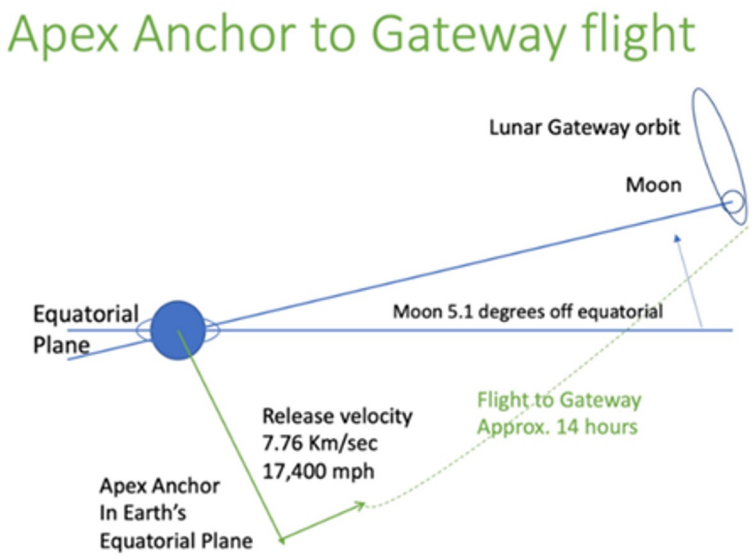
- As humankind expands further into space the safety, sustainability, and resource transportation requirements within CisLunar space will outpace the Tsiolkovsky rocket equation.
- Apex Anchor has enormous potential for Cislunar Space
- This presentation concludes six months of research and study.




Ref: ISEC Image

# Introduction

- Cislunar Space
- Space Elevator
  - *Apex Anchor*
- Tsiolkovsky rocket equation
- Mass Transportation
- Astronaut Safety




Ref: ISEC Image

# Tsiolkovsky Rocket Equation

- Natural restriction for rockets
- Minimal delivery percentages
- Environmental Impact
- Dual Space Access

$$\Delta v = v_e \ln \frac{m_0}{m_f} = I_{sp} g_0 \ln \frac{m_0}{m_f} \quad (1)$$

$\Delta v$ (Maximum change of velocity of the vehicle)
$m_0$ (Initial mass)
$m_f$ (Final mass)
$v_e$ (Effective exhaust velocity)
$I_{sp}$ (Specific impulse)
$g_0$ (Gravity)

Table 1: Launch Vehicle Delivery Percentages to GEO

| Launch Vehicle | Pad Mass | To LEO (with % of pad) | To GEO (est.) (with % of pad) | To Moon surface (with % of pad) |
|---|---|---|---|---|
| Atlas V | 590,000 | 18,500 (3%) | 7,000 (1.2%) | |
| Delta IV | 733,000 | 28,770 (3.9%) | 10,000 (1.4%) | |
| Falcon H | 1,420,000 | 63,000 (4.4%) | 26,000 (1.8%) | |
| Saturn V | 2,970,000 | 140,000 (4.7%) | | 16,000 – 0.5% |
| Average | | 4% of Pad Mass | 1.5% of Pad Mass | |

Note: Data from web varies greatly - these numbers are representative only, ref. ISEC working documents summarizing information on web. [2]

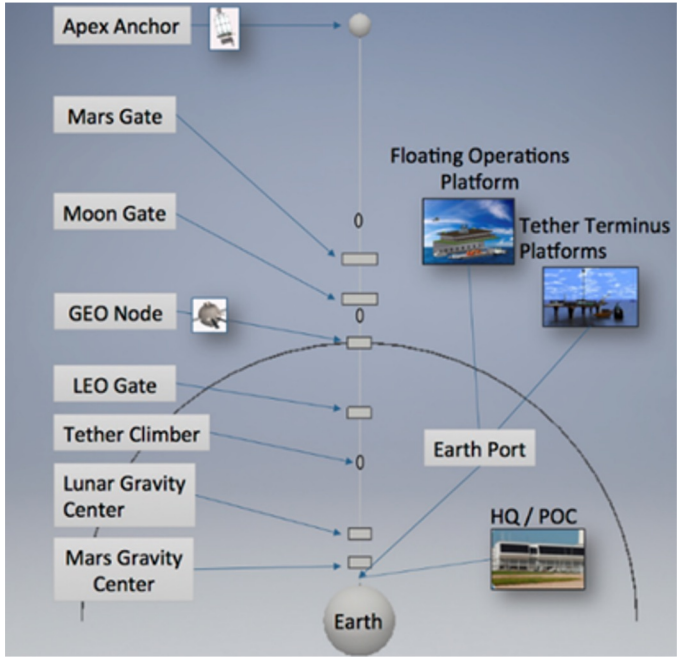
# Mass Transportation

- Mass sent to Space
  - *26,000 tonnes*
- Projected Projects
- The Space Elevator
- Travel times
  - *14 hours to moon*

Table 2: Projected Space Projects

| Project Name | Mass Required in Space (in tonnes) |
|---|---|
| Space Solar Power | 3,000,000 |
| Moon Village | 500,000 |
| SpaceX Colony | 1,000,000 |
| L-5 O'Neill Colony | 10,500,000 |
| L1 Sunshade System | 34,000,000 - 83,000,000 |

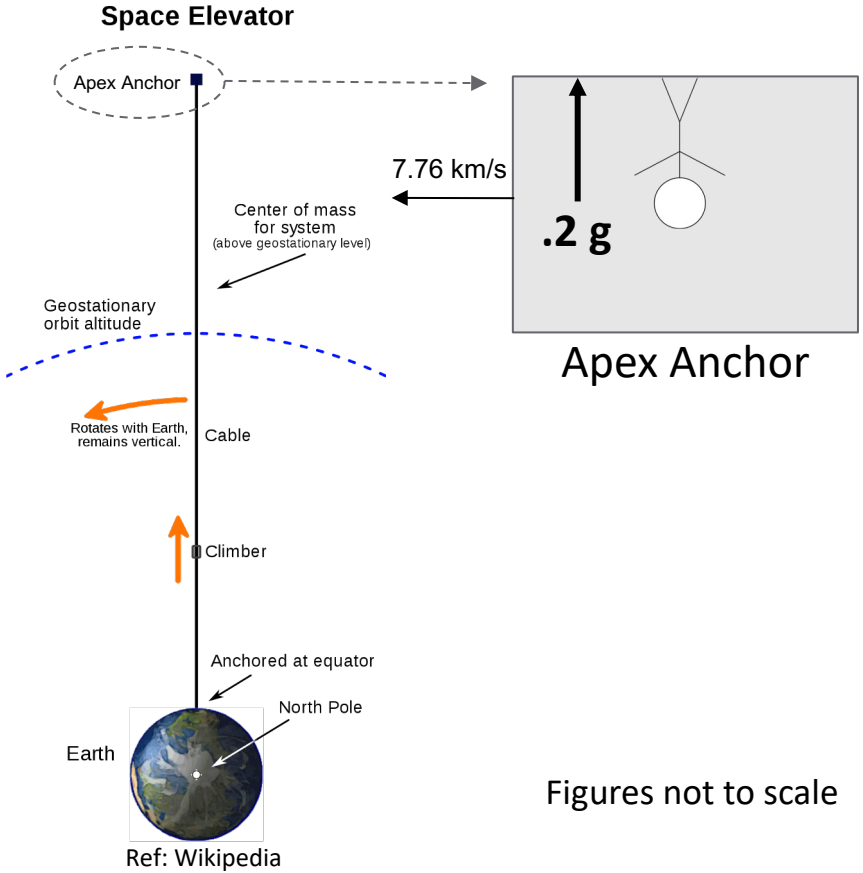
Mass in tonnes for potential projects in space. [8,9]




Ref: ISEC Image

# Apex Anchor

- Space Station
- Capabilities
  - *Storage*
  - *Assembly*
  - *Rescue Vehicle*
- .2 g of acceleration (local force)
- Missions
  - *Space Control Center*
  - *Emergency Astronaut Safety*

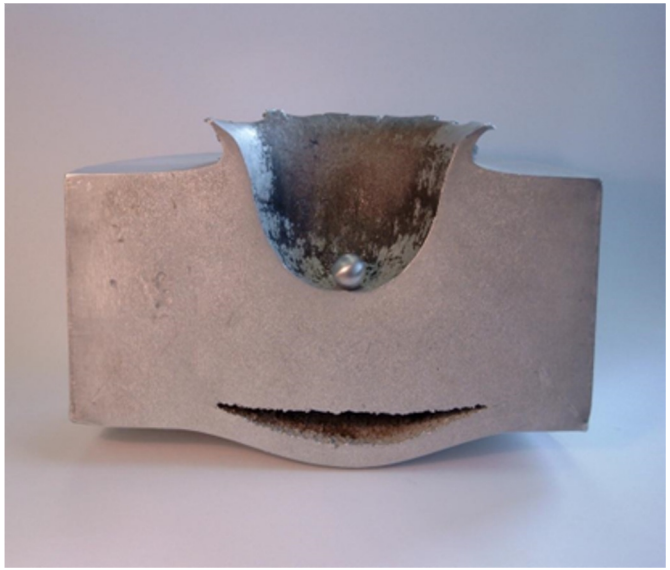



Ref: Wikipedia

Figures not to scale

# Astronaut Safety

- Delay of Resources
- Meteorites/Space Debris
- System failure of:
  - *Transportation*
    - *Rocket malfunction*
    - *Insufficient Fuel*
  - *Habitation unit*
    - *Power Outage*
    - *Oxygen Supply*
    - *Medical Emergencies*
- Habitation on and around the Moon



Ref: ESA Image

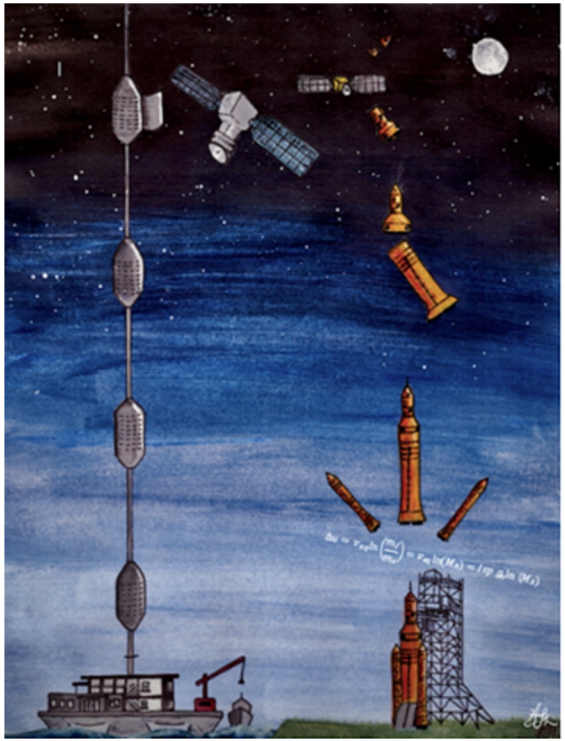
# Emergency Response from Transportation Hub

- Cislunar Emergency Response - Moon
  - *From Earth, Manned - 69 hours (Apollo 8)*
  - *From Earth, Unmanned - 35 hours (Luna 2)*
  - *Apex Anchor - 14 hours to moon*
- Cislunar Emergency Response - Other
- Emergency Aid

Ref: Moon Village Association

# Conclusion

- Tsiolkovsky rocket equation
- Mass Transportation
- Apex Anchor
- Astronaut Safety
- Emergency Response from Transportation Hub
- Dual Space Access



Ref: ISEC Image

# Thank you, Questions?

**Daniel Griffin**

*KTH Engineering Mechanics, Teknikringen 8, 11428 Stockholm, Sweden,*
dgriffin@kth.se

**Gunnar Tibert**

*KTH Engineering Mechanics, Teknikringen 8, 11428 Stockholm, Sweden,*
tibert@kth.se