Visions of Many Demand Space Elevators Start NOW!

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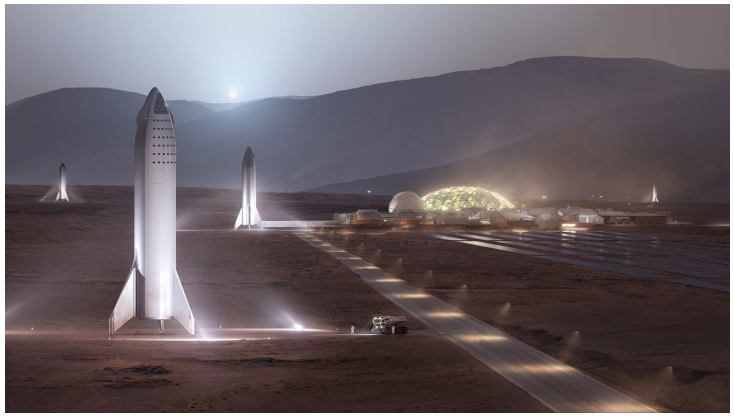
Art by
A. Stanton

Living and working in thriving communities beyond Earth – NSS

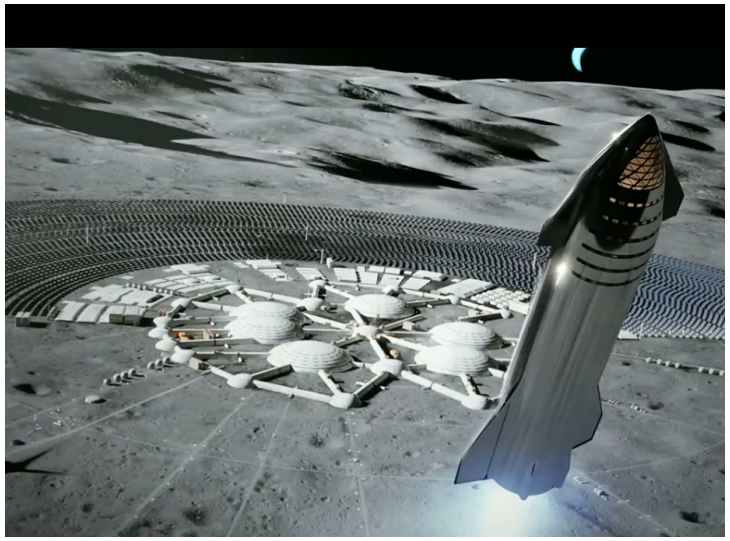
Dream Big!
But How much mass to Orbit?

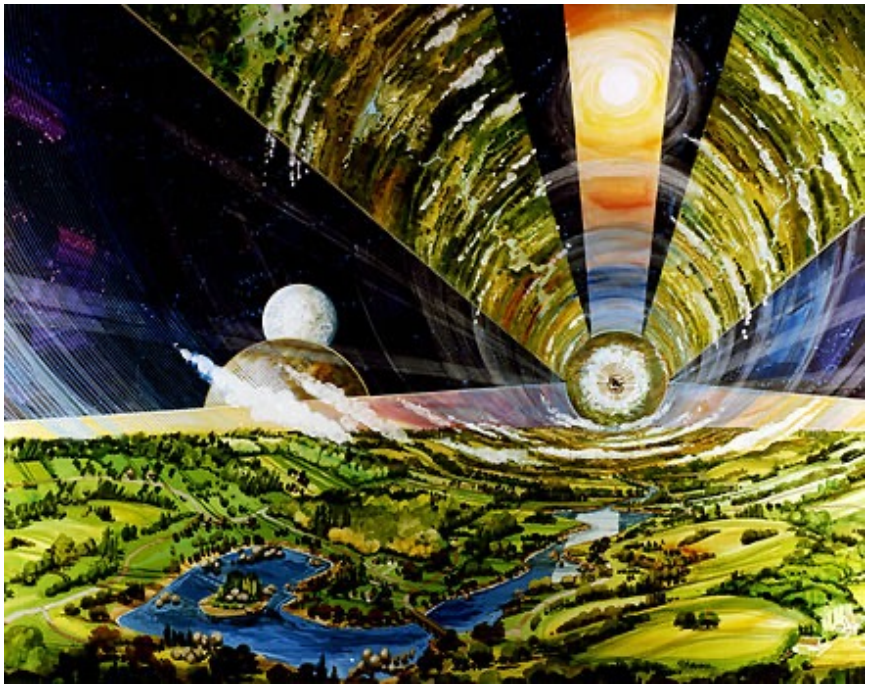


Images from SpaceX website

Images by NASA and Rick Guidice

Image from Blue Origin website





NSS Vision

- NSS Vision: “People living and working in thriving communities beyond the Earth, and the use of the vast resources of space for the dramatic betterment of humanity.”
- NSS Mission: “to promote social, economic, technological, and political change in order to expand civilization beyond Earth, to settle space and to use the resulting resources to build a hopeful and prosperous future for humanity.”

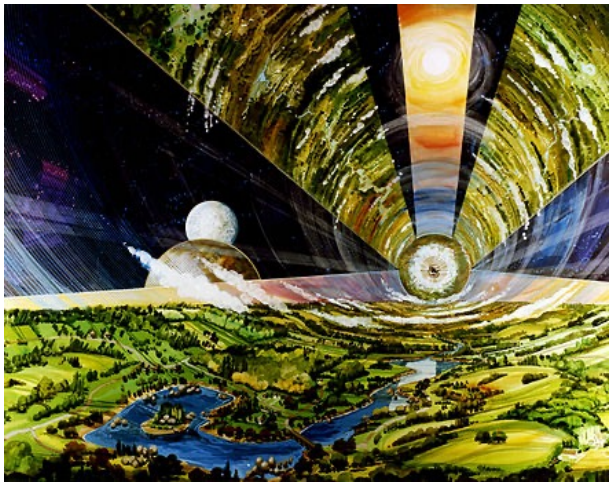
As the NSS merged from the National Space Institute and the L-5 Society, the vision is historic.

O'Neill's Vision

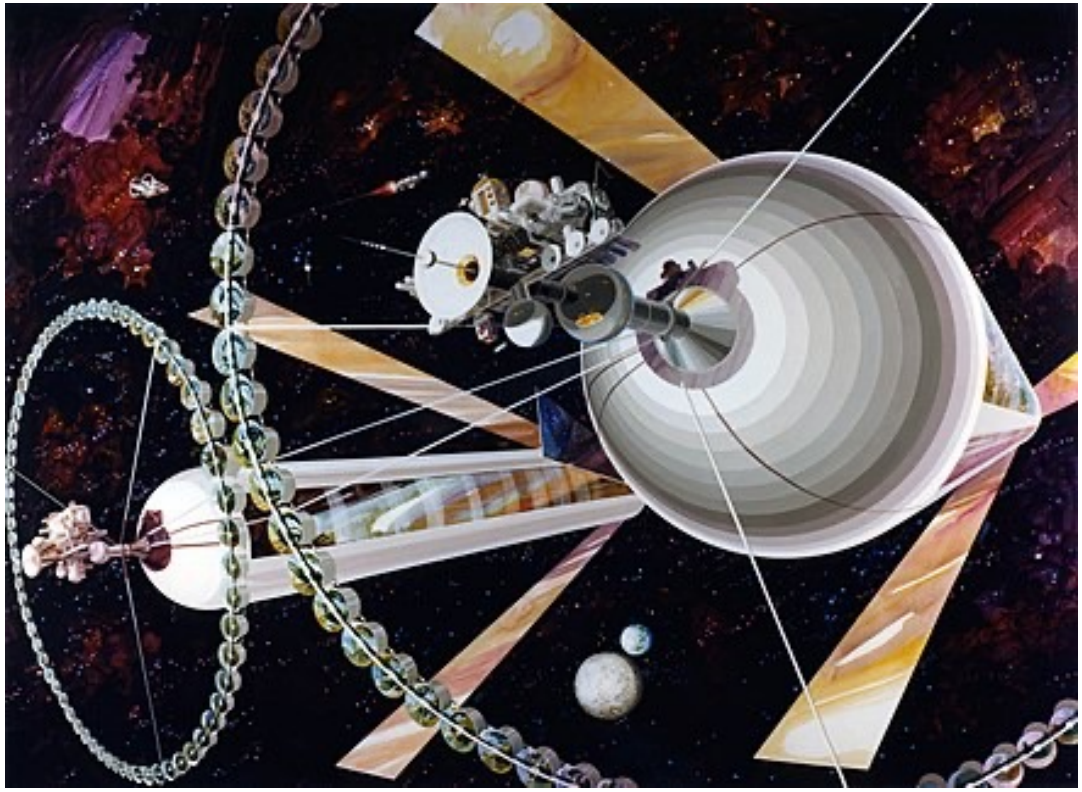
High-Frontier, Human Colonies in Space
Gerard K. O'Neill book in 1976 – Rotating Cylinders

His paper finally appeared in the September 1974 issue of *Physics Today*. In it, he argued that building space colonies would solve several important problems: It is important to realize the enormous power of the space-colonization technique. If we begin to use it soon enough, and if we employ it wisely, at least five of the most serious problems now facing the world can be solved without recourse to repression:

1. bringing every human being up to a living standard now enjoyed only by the most fortunate;
2. protecting the biosphere from damage caused by transportation and industrial pollution;
3. finding high quality living space for a world population that is doubling every 35 years;
4. finding clean, practical energy sources;
5. preventing overload of Earth's heat balance.

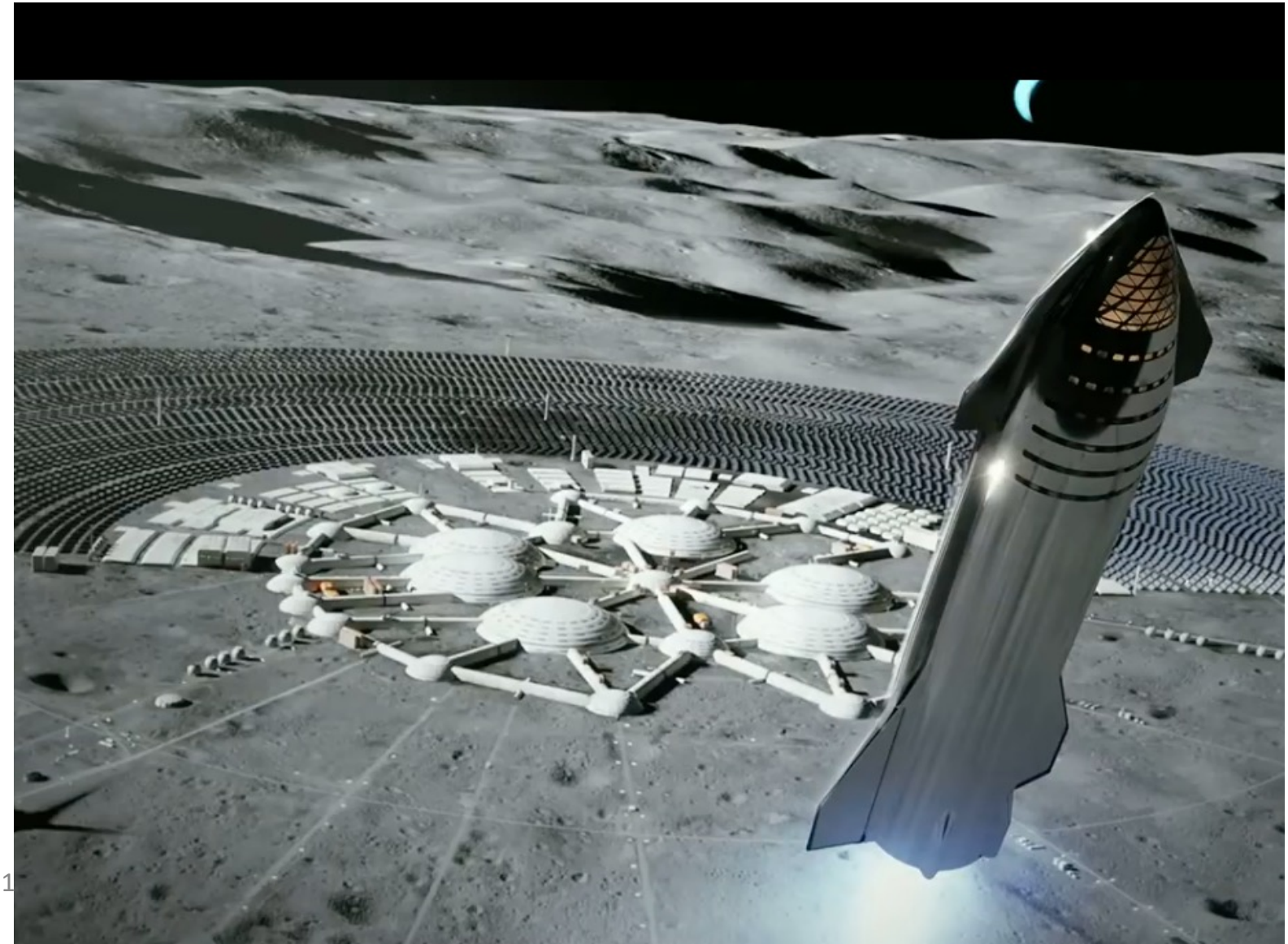


10,500,000 tonnes to L-5,
for several million people

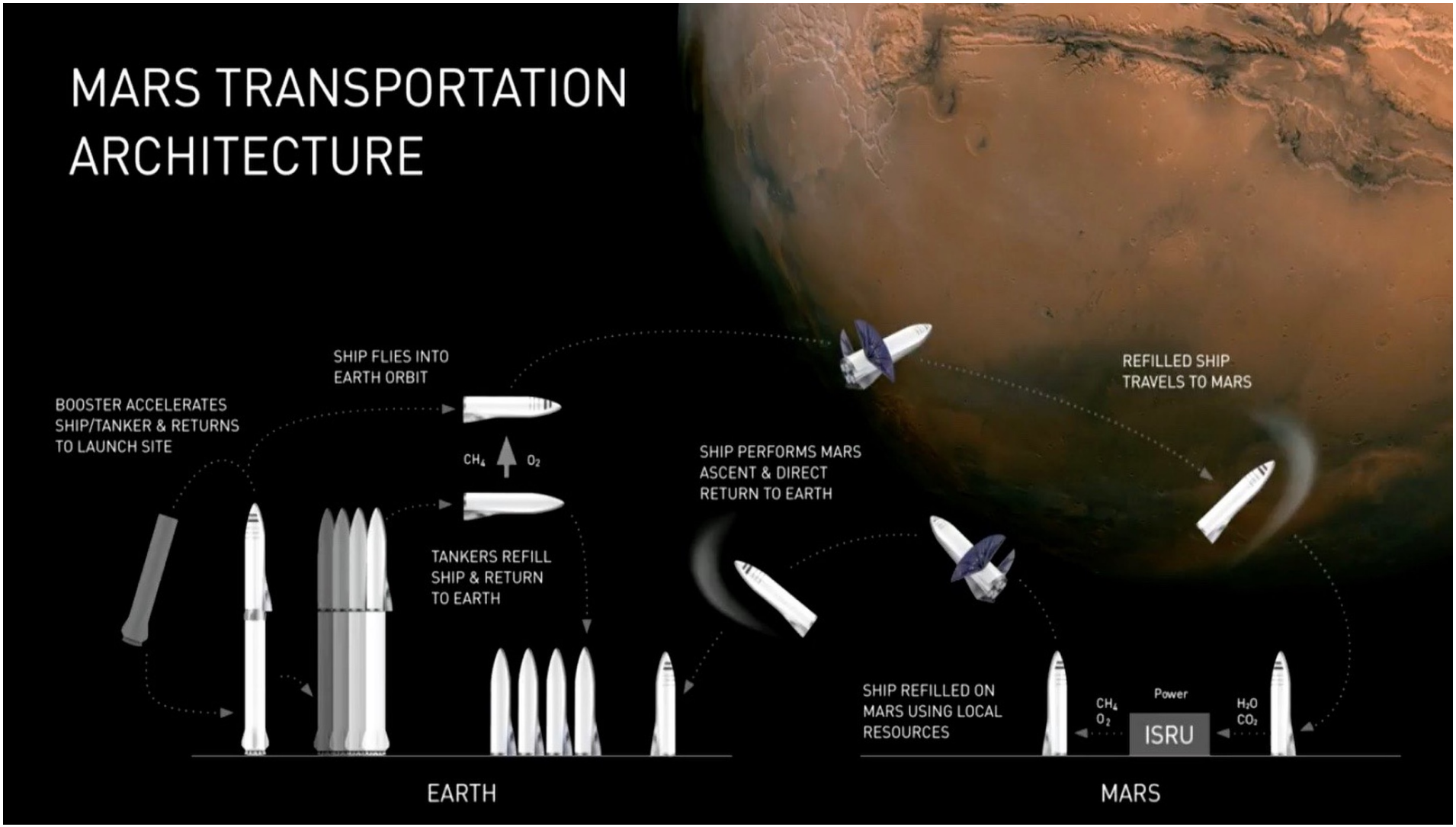


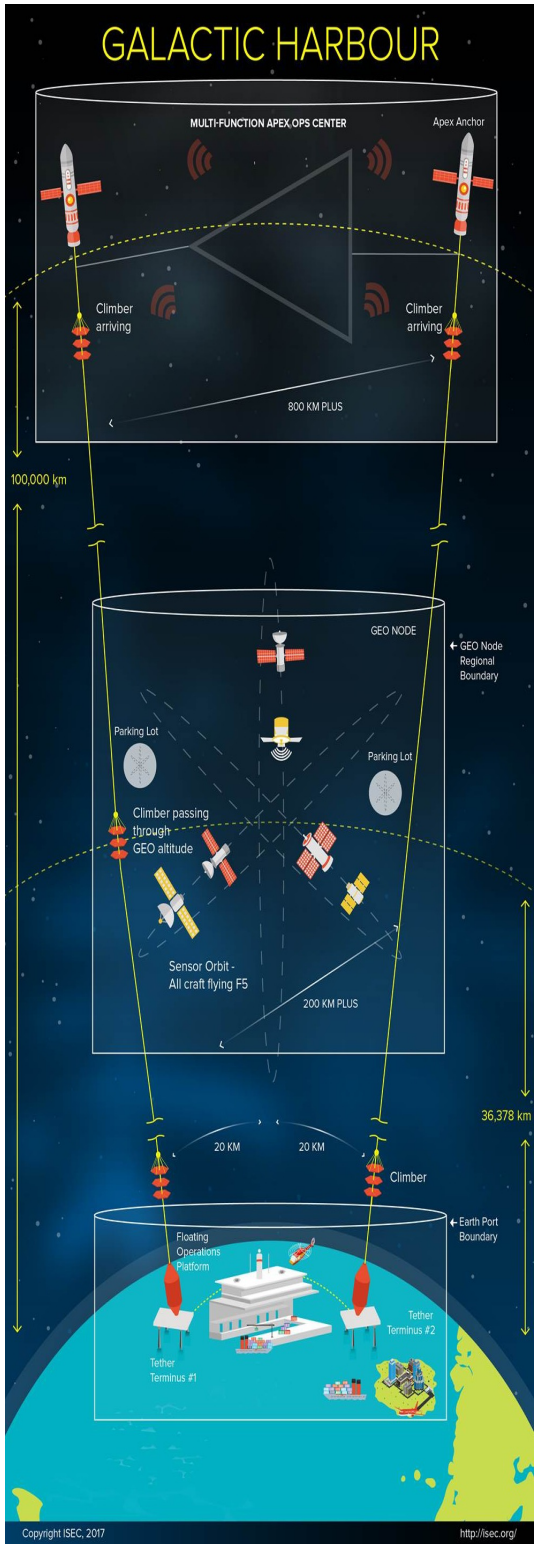
Images by NASA and Rick Guidice

Lunar Village



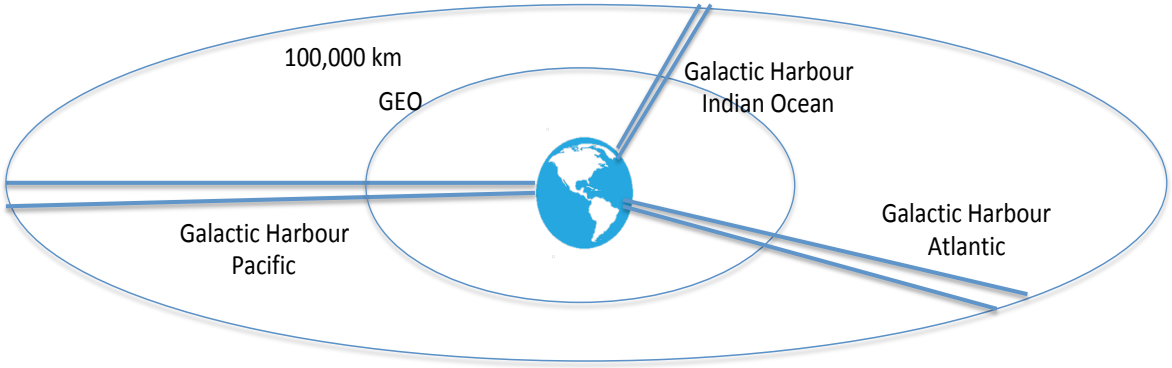
SpaceX Systems Approach to Mars





Vision of Space Elevators & Galactic Harbours

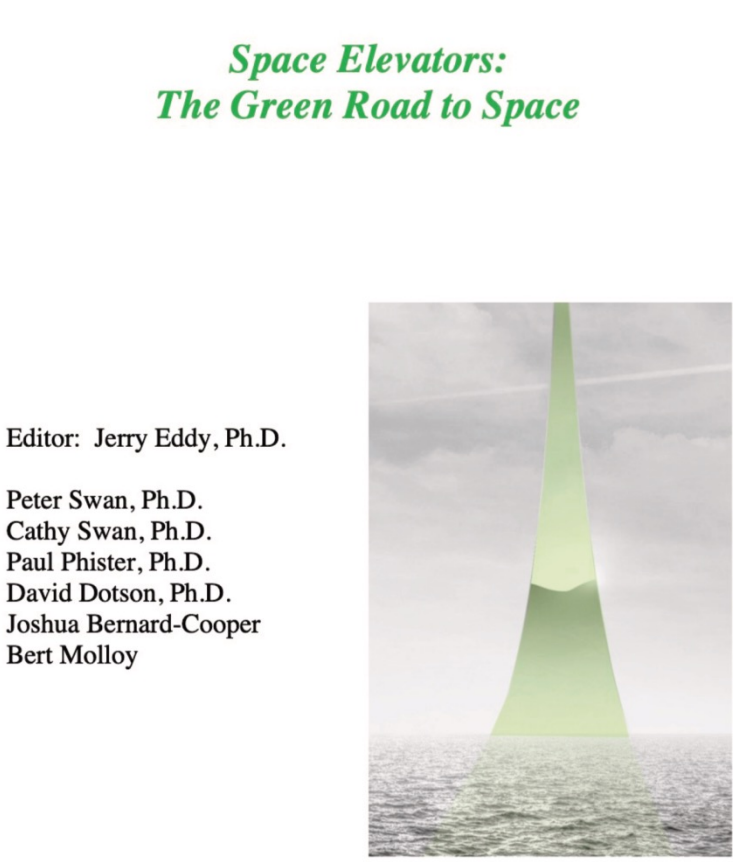
A Green Road to Space



Massive tonnage raised by electricity to GEO and beyond, daily, routinely, inexpensively, safely, and in an Earth Friendly manner.

Space Elevators are the Green Road to Space

- 18-month study at www.isec.org (pdf free)
  - Electricity from the Sun's energy raises cargo from the ocean's surface to GEO
  - Massive cargo delivered to GEO and beyond enables Earth-friendly missions such as Space Solar Power
- A robust permanent transportation infrastructure
  - Moving more cargo in a year (30,000 tonnes) to GEO and beyond (at Initial Operational Capability) than humanity has placed in orbit since 1957 (22,000 tonnes)
- Enables Space Solar Power requires -- To supply 12% of the global electrical demand in 2060 while stopping global warming



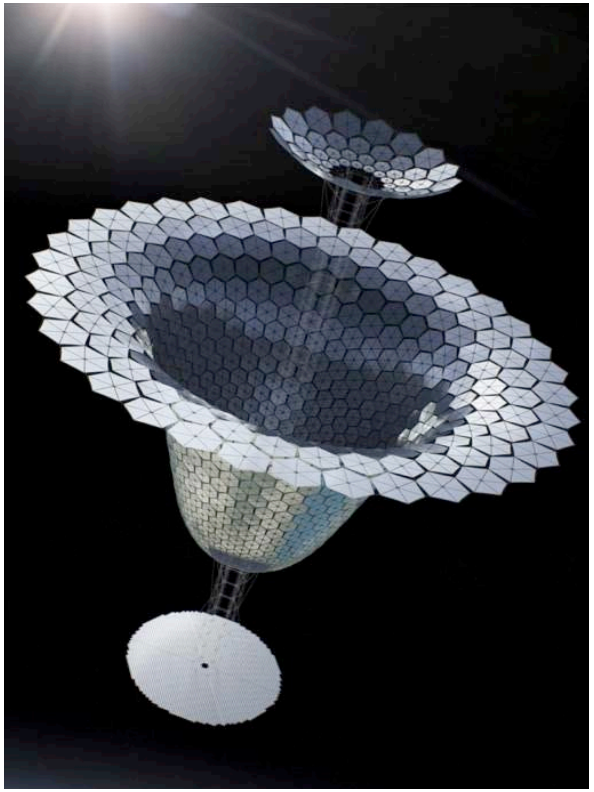
Download www.isec.org

ISEC

Glaser's Vision
Space Solar Power

- "Space solar power can solve our energy and greenhouse gas emissions problems. Not just help, not just take a step in the right direction, but solve."
- Promise: Eliminate 100's (1,000's?) of Coal Burning Plants by providing 12% of 2060 Earth's population.
- "I need 5,000,000 tonnes."*

Mankins, John, The Case for Space Solar Power, Virginia Edition Publishing Co. Dec 2013.
*Private conversation with Dr. Peter Swan Oct 2019



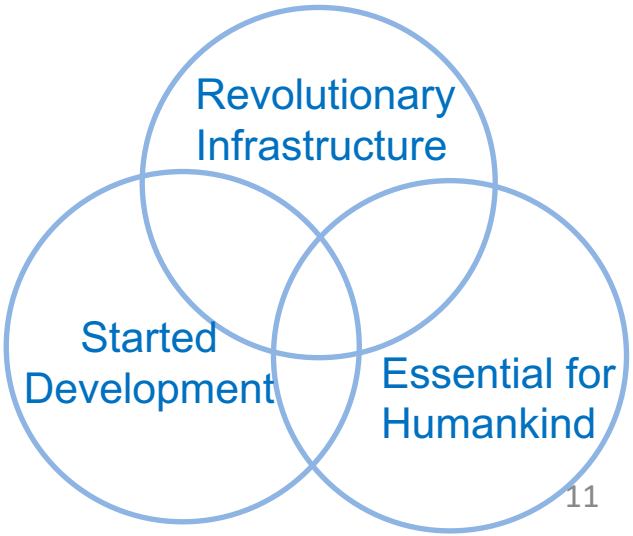
Each Alpha Mark IIIA is 9,800 tonnes (to GEO)
For output of 2 Gwatt continuous

Note: several other designs are lighter, but produce less energy.

Visions of Many Demand Space Elevators Start NOW!

Art by
A. Stanton

- Space Elevators can Enable the needs and visions of many!
- They provide massive cargos to GEO and beyond
- SE are the Green Road to Space
- Dual Space Access Strategy is a collaborative approach
- A testing and demonstration development program for Space Elevators has started



Reference Missions:

- Space Solar Power – 5,000,000 tonnes to GEO for 12% of Global Electrical need***
- Moon Village – 500,000 MT* - European "togetherness" towards a Moon Village suggests a massive support effort required.
- SpaceX Colony – 1,000,000 MT** – Mr. Musk has stated that he needs that amount of mission support on Mars.
- L-5 O'Neill Colony – 10,500,000 tonnes

* Estimate in Study Report "Space Elevators are the Transportation Story of the 21st Century
** Elon Musk, 21 July 2019, CBS Sunday Morning Interview
***Mankins, John, conversation with P. Swan

Massive Movement

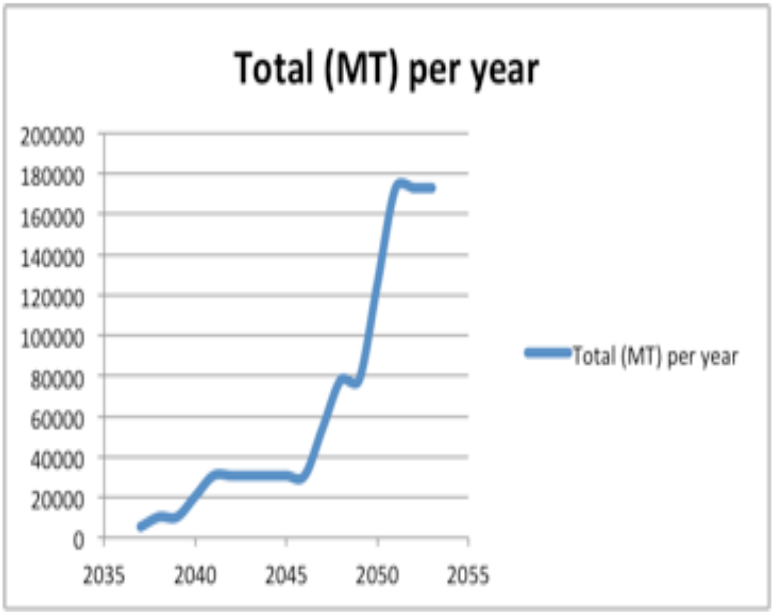
Type of Systems	*Orbit*	*Mass*	*Mass on pad*
		Tonnes	tonnes
Space Stations	LEO	431	10775
Earth Orbiting Sat's 2020	LEO, MEO, GEO	3220	80500
past satellites deorbited	LEO, MEO, GEO	1000	25000
Interplanetary	Solar System	100	5000
Lunar spacecraft	to the Moon	94	4700
Human to LEO	LEO	535	13375
Apollo Capsule to Moon	Lunar	336	16800
Space Shuttle*	LEO	16500	412500
Totals		22,216	568,650

Note: Leo is 4% of launch pad mass
GEO, Interplanetary, Lunar 2% of pad
*Shuttle launch vehicle reached orbit as an operational satellite

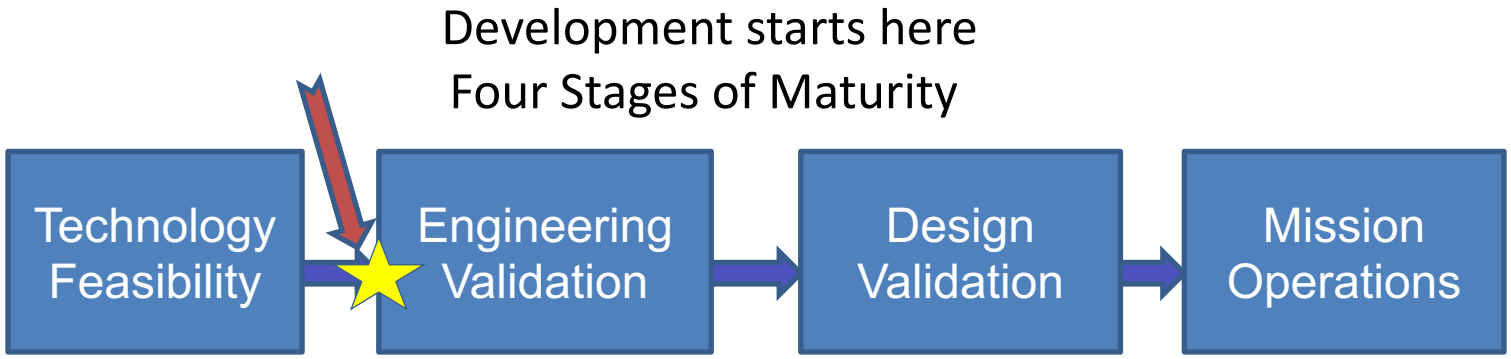
Historic Movement (1957 – 2020)

22,216 tonnes between 1957 and 2020.

Space Elevator expected
movement of mass
Initial Operations Capability (30,000 tonnes/yr)
Full Operations Capability (170,000 tonnes/yr)



The Space Elevator has Entered Engineering Validation!

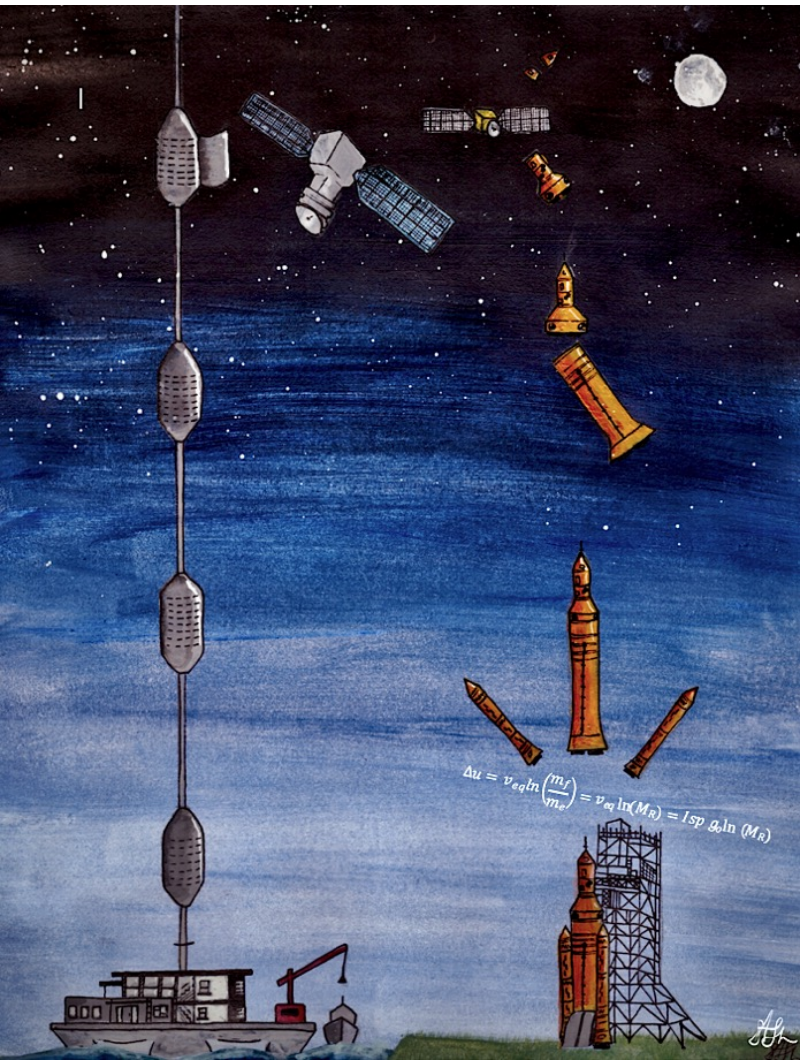


1. The ISEC team has been assessing the technology feasibility situation since 2008.
2. Recently the team has begun an open dialog with members of industry, academia, and others who could be the deliverers of developmental solutions.
3. Industry (especially) will show how the needed technologies are being matured and when they could be dependably available.
4. These readiness assessments were the Phase One exit criteria.

Dual Space Access Architecture

Rockets to Open up the Moon and Mars with Space Elevators to supply and grow the colonies.

Image by Amelia Stanton



Combination of delivery approaches: Will greatly enhance the missions of the future. Maturing customer demand for huge masses to support important missions will make the value of space elevators obvious.

Rocket Strengths: (1) Operational today with future growth, (2) rockets reach multiple orbits, and (3) rapid movement through the radiation belts

Space Elevator Strengths: As permanent infrastructure they lead to daily, routine, massive, environmentally friendly, and inexpensive departures towards mission destinations

Minimizing the Rocket Equation Limitations

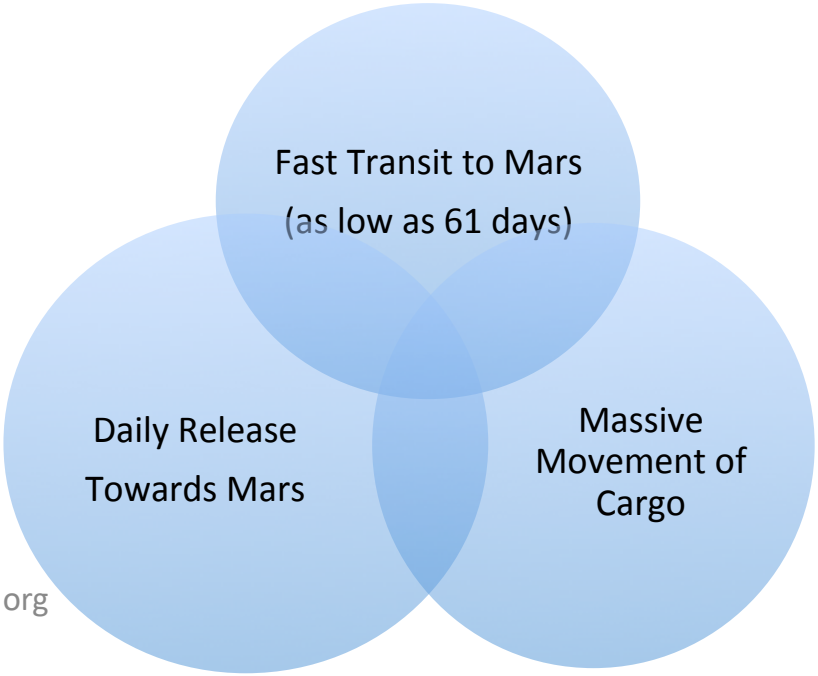
Space Elevator Strengths

- Routine [daily] access to space
- Revolutionarily inexpensive [<$100 per kg] to GEO and beyond
- Commercial infrastructure development similar to bridge building
- Permanent infrastructure [24/7/365/50 years]
- Massively re-usable, no consumption of fuels
- Environmentally sound/sustainable - will make Earth "greener"
- Safe (low risk) and reliable [no shake, rattle and roll of rocket liftoff]
- Low probability of creating orbital debris
- Redundant paths as multiple sets of Space Elevators become operational
- Massive loads per day [starts at 14 metric tons cargo loads]
- Opens up tremendous design opportunities for users
- Optimized for geostationary orbit altitude and beyond
- Co-orbits with GEO systems for easy integration

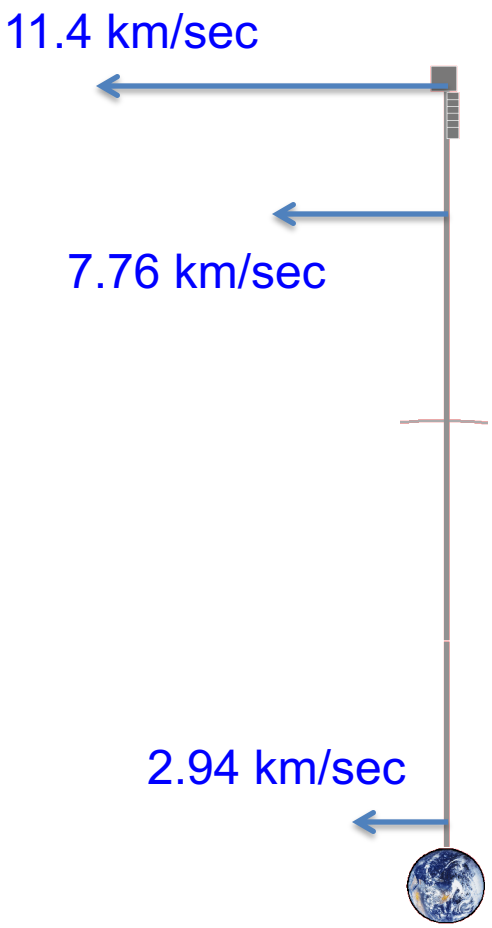
Special Strengths
A New Concept

The unique characteristics of Space Elevators with a rapidly moving Apex Anchor (7.76 km/sec) enable remarkable opportunities for off-planet missions. This combination of three major strengths will ensure constant support to missions beyond Geosynchronous altitude. Strengths:

- Rapid Transit to Mars (61 days best with many 80 to 100 days)
- Release every day towards Mars (no wait for 26 month)
- Massive movement of mission support equipment (170,000 tonnes per year when system mature)



Velocity at Sphere of Influence



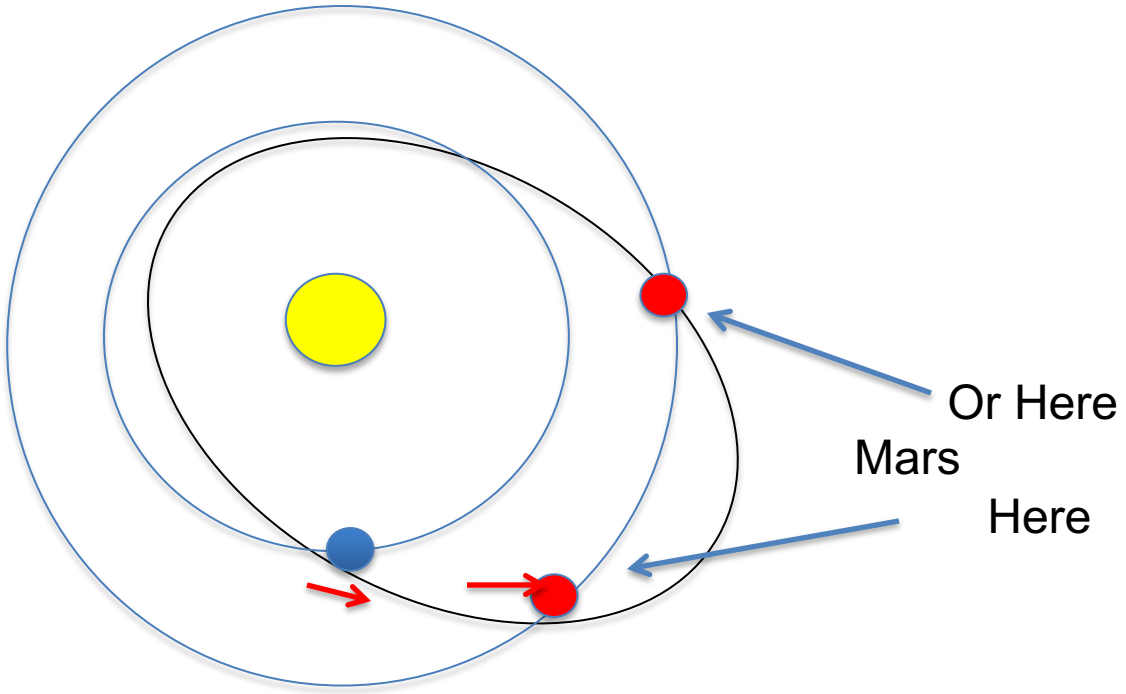
Three Release Locations

Traditional Hohmann Transfer (LEO)
Traditional Apex Anchor (100,000 km)
Optional Apex Anchor (150,000 km)

	Alititude (Km)	*Radius (Km)*	*Velocity (km/sec)*
Earth's surface	0	6378	0.465594
Geosynchronous	35,786	42,164	3.077972
Mars Gate	57,000	63,378	4.626594
Apex Anchor	100000	106,378	7.765594
Option Apex Anchor	150000	156378	11.415594

Every Day an Opportunity for Release

Case One: Fastest Approach



Concept: Our spacecraft enter the ellipse “not at perigee”
Ellipse is created by a velocity vector with one foci at the Sun
A later portion of the ellipse coincides with Mars with a rendezvous vector

This is the transportation story of the 21st century. Reliable, safe, and efficient access to space is close at hand. The Space Elevator is the Galactic Harbour, and an essential part of the global and interplanetary transportation infrastructure.

Bus Schedule to Mars

Bus Schedule for Interplantary Transportation
when departing from Galactic Harbour Apex Anchor

Bus Schedule, from Apex Anchor 2035

Date	Departure	Destination	Flight Time	Arrival	Comments
7/1/2035	Indian #1	Mars	87 days	9/26/2035	
7/1/2035	Pacific #1	Mars	86 days	9/25/2035	
7/1/2035	Pacific #2	Mars	84 days	9/22/2035	Fast

Bus Schedule, from Apex Anchor 2035

Date	Departure	Destination	Flight Time	Arrival	Comments
7/8/2035	Indian #1	Mars	81 days	4/14/2035	
7/8/2035	Indian #2	Mars	81 days	4/14/2035	
7/8/2035	Indian #1	Mars	80 days	4/13/2035	Fast

Bus Schedule, from Apex Anchor 2035

Date	Departure	Destination	Flight Time	Arrival	Comments
7/15/2035	Indian #1	Mars	79 days	10/2/2035	
7/15/2035	Indian #1	Mars	79 days	10/2/2035	
7/15/2035	Indian #2	Mars	79 days	10/1/2035	
7/15/2035	Indian #2	Mars	79 days	10/1/2035	
7/15/2035	Pacific #1	Mars	78 days	9/30/2035	Fast
7/15/2035	Atlantic #1	Mars	190 days	1/21/2036	
7/15/2035	Atlantic #1	Mars	182 days	1/13/2036	
7/15/2035	Atlantic #2	Mars	173 days	1/4/2036	
7/15/2035	Atlantic #2	Mars	164 days	12/25/2035	
7/15/2035	Atlantic #1	Mars	154 days	12/15/2035	

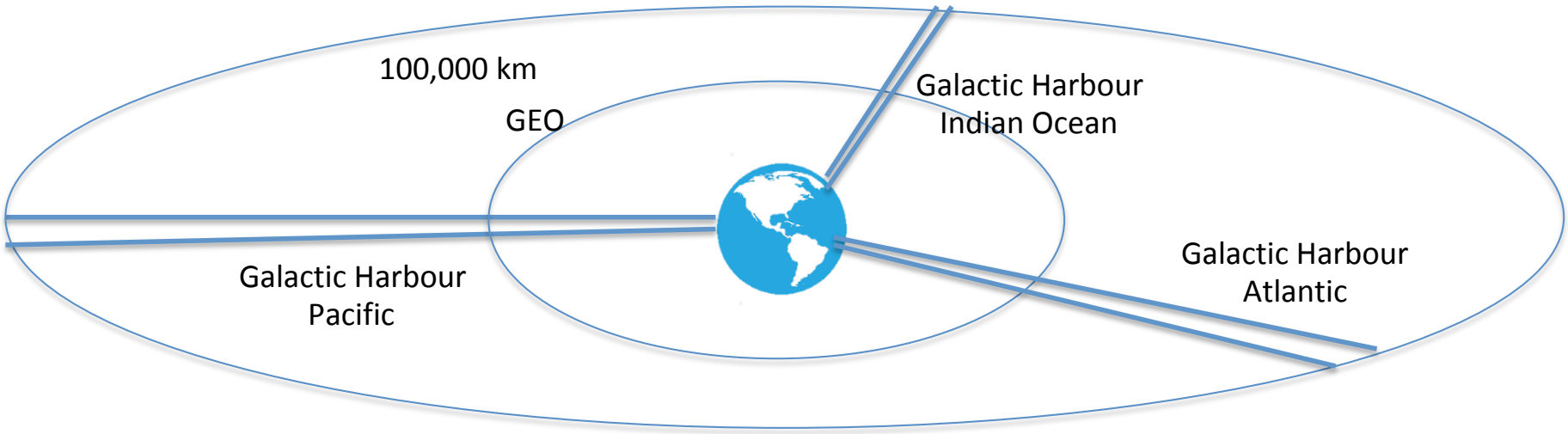
Bus Schedule, from Apex Anchor 2035

Date	Departure	Destination	Flight Time	Arrival	Comments
7/22/2035	Pacific #2	Mars	77 days	10/7/2035	Fastest
7/22/2035	Pacific #2	Mars	77 days	10/7/2035	Fastest
7/22/2035	Pacific #1	Mars	223 days	3/1/2036	

Bus Schedule, from Apex Anchor 2035 to Moon

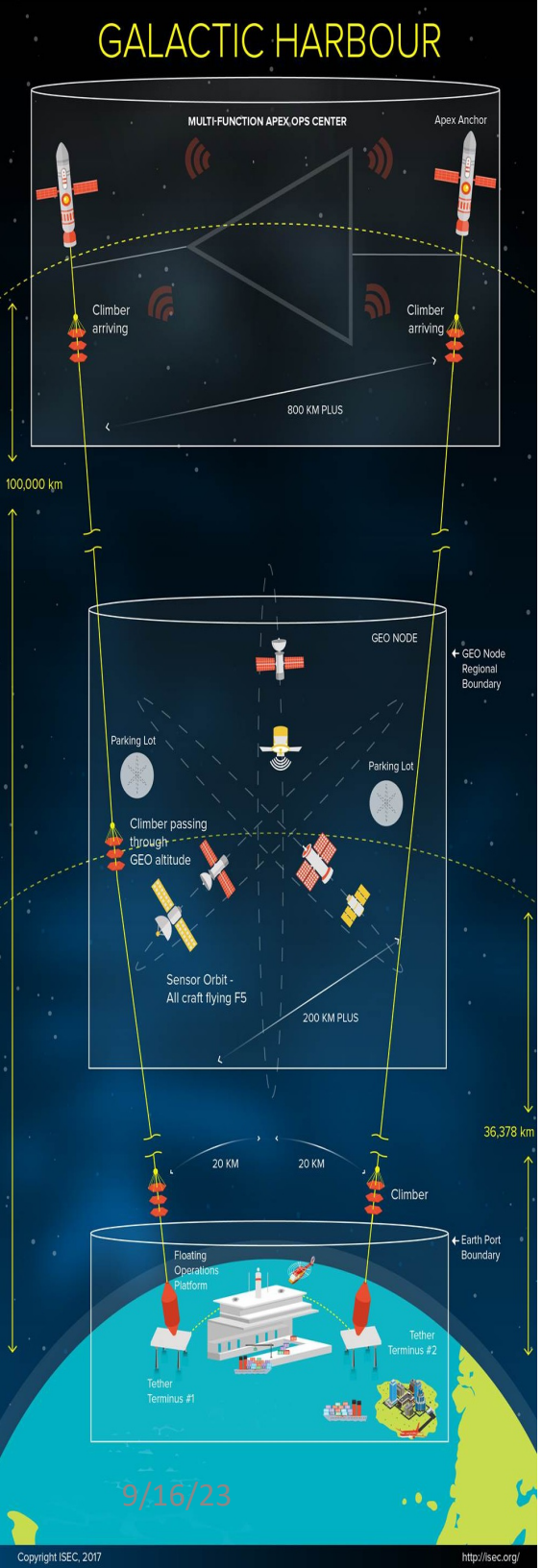
Date	Departure	Destination	Flight Time	Arrival	Comments
every day	Indian #1	Moon	14 hours	+ 14 hours	
every day	Indian #2	Moon	14 hours	+ 14 hours	
every day	Pacific #1	Moon	14 hours	+ 14 hours	Fast
every day	Pacific #2	Moon	14 hours	+ 14 hours	
every day	Atlantic #1	Moon	14 hours	+ 14 hours	
every day	Atlantic #2	Moon	14 hours	+ 14 hours	

Interplanetary Vision



Promise to Planetary Scientists: Any scientific payload mass
To any destination in the solar system with daily launches available.

Vision of the Future: On to Moon and Mars with Rockets
then Space Elevators to supply and buildup the colonies



Conclusions

Can we do daily lift-offs with a variety of flight times to Mars?

Of course!

What type of massive support is there

30,576 Tonnes per year (early years)

170,000 Tonnes per year (mature design)

What type of launch windows are there?

365 days a year

What is Fastest Transit Time to Mars?

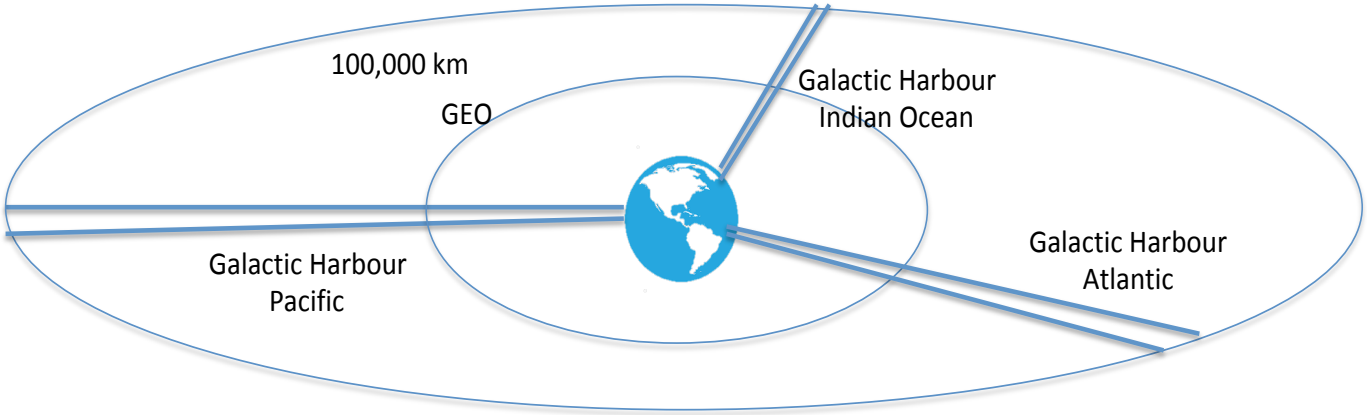
61 days

Reliable, daily, routine, safe and environmentally friendly movement off-planet towards the Moon Mars and asteroids.

Recommendations

- *Embrace vision of a Space Elevator will enable future dreams and visions by lifting mass with electricity.*
- *Recognizing the strengths of space elevators leads one to realize that Movement off-planet will only happen when space elevators are supplying mission support within a cooperative arrangement with the future rocket infrastructure.*
- *Initiate a program soonest – while developing a Space Elevator Institute immediately.*

Vision of Galactic Harbours – A Green Road to Space



Massive tonnage raised by electricity to GEO and beyond, daily, routinely, inexpensively, and safely

Three Galactic Harbours

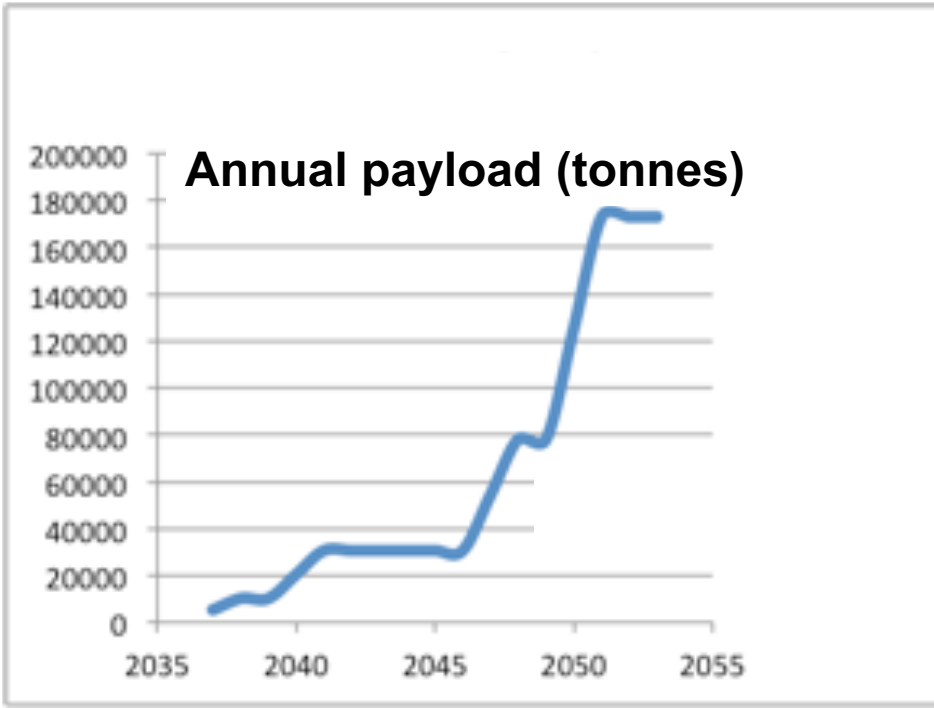
– 7 climbers a week/elevator

– 14 tonnes each, x2 x3

or 30,000 tonnes/yr

– expanding to 80 tonnes each

or 170,000 tonnes/yr

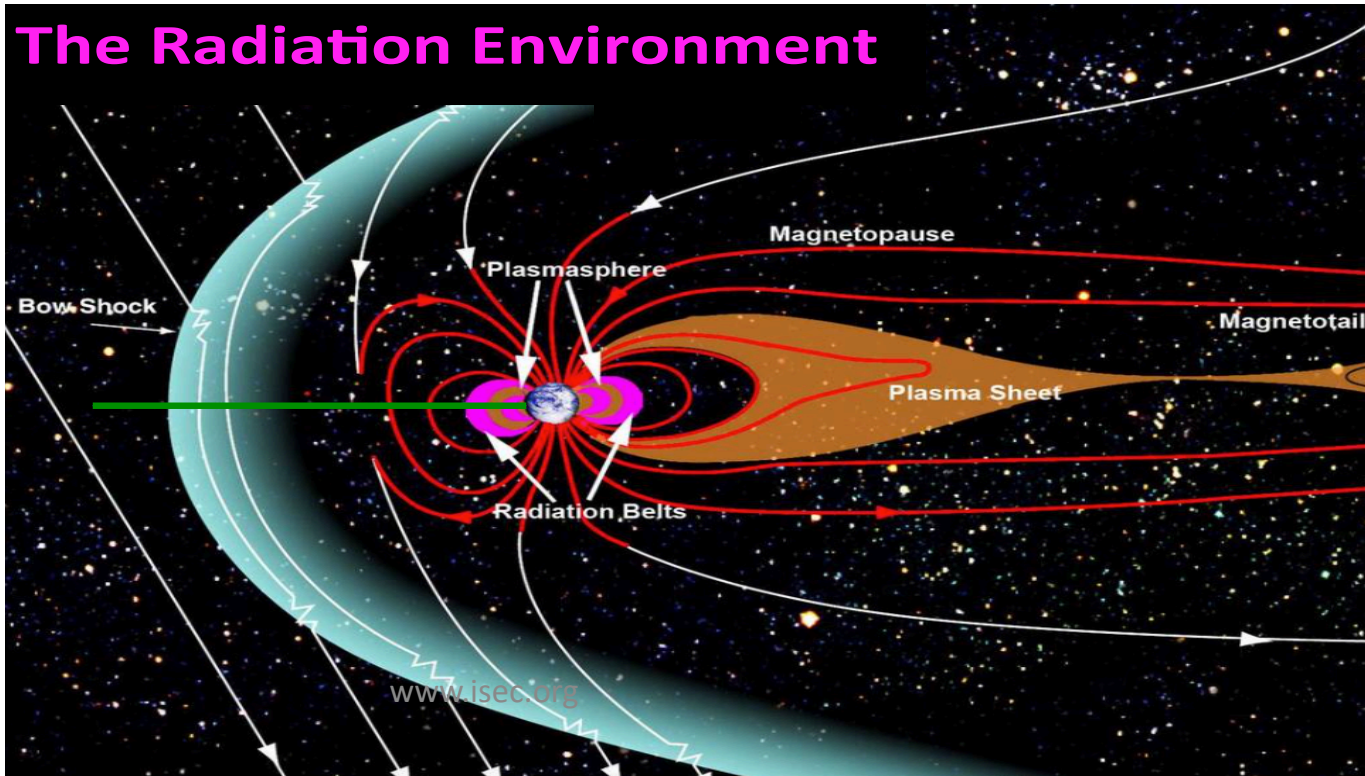


How the Space Elevator Grew into a Galactic Harbour?

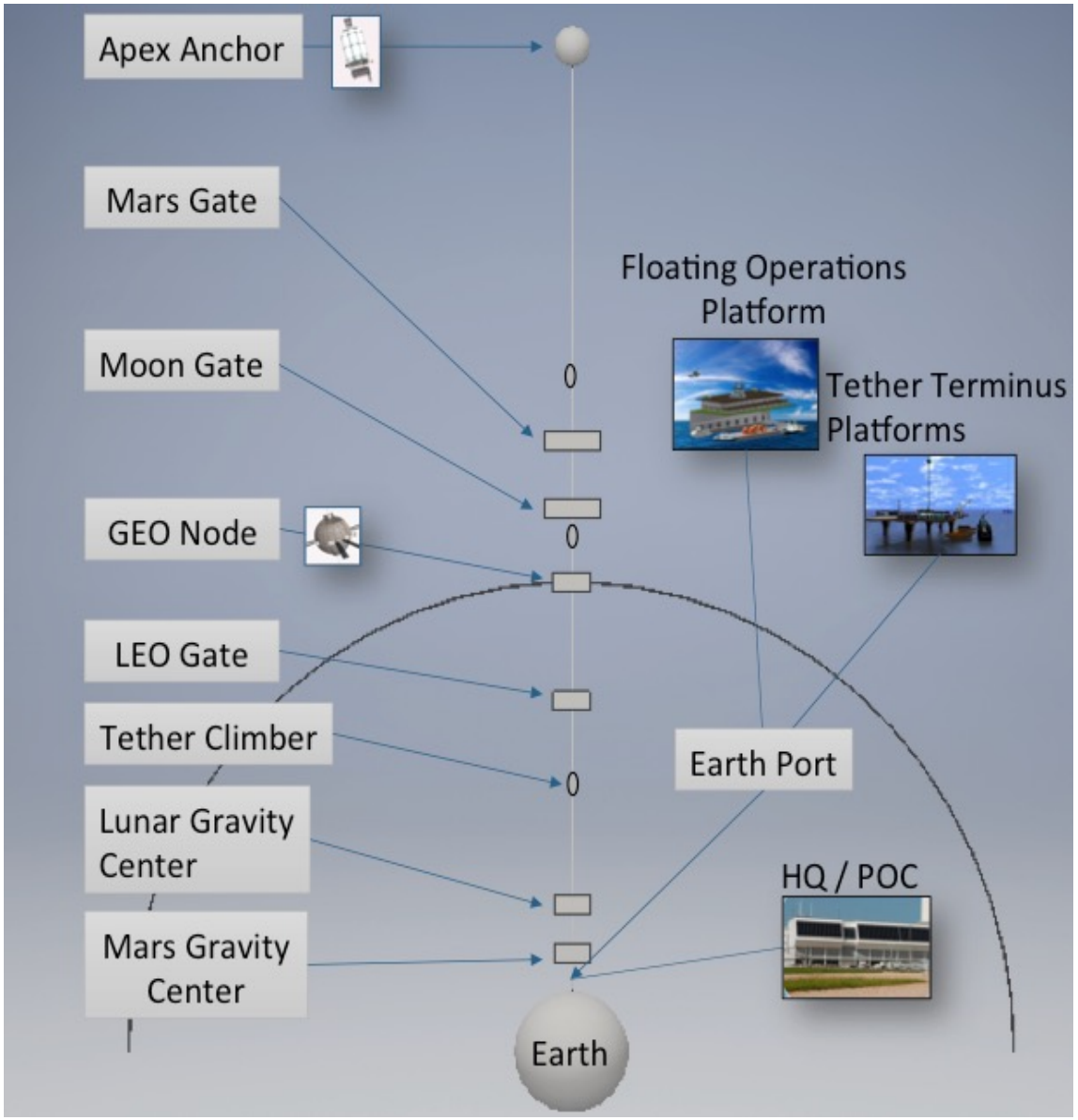
Backup Charts

Earth Radius
6,378 Km

Space
Elevator
100,000 km
In green



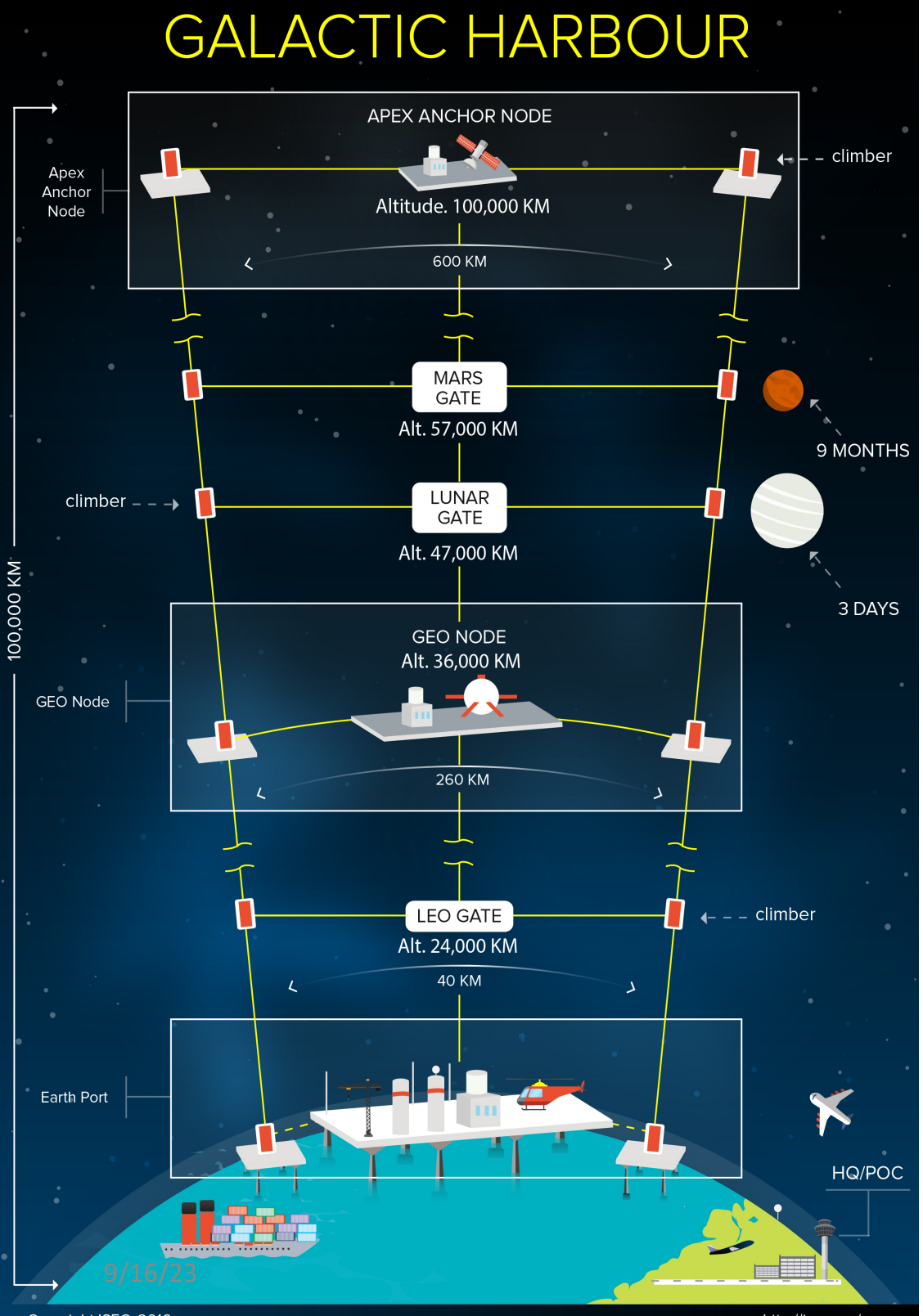
Lexicon for a Space Elevator



Apex Anchor Node
Mars Gate
Moon Gate
GEO Node
LEO Gate
Lunar Gravity Center
Mars Gravity Center
Tether Climbers
Tether Structure
Earth Port
- Earth Terminus
- Floating Operations Platform

Headquarters and Primary Operations Center (HQ&POC)

Major centers of activity
Locations on tether
Tether Material in development



Our Vision of Space Elevators is a Galactic Harbour

Galactic Harbour Mission Statement:

Importing needed commodities and exporting business and exploratory payloads.

Our "strategy" is to link the Space Elevator Transportation System to the Space Elevator Enterprise; within a Unifying Vision

... the Galactic Harbour.

Operating Safely in Debris Environment

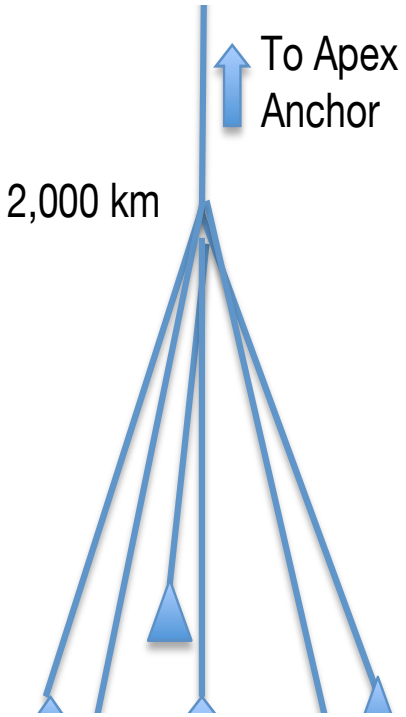
Two Reports and seven pg summary in “Start Now” work book.

- 2010 "Space Elevator Survivability, Space Debris Mitigation."
- 2020 "Today's Space Elevator Assured Survivability Approach for Space Debris.”

"Space debris mitigation is an engineering and management problem with definable quantities such as density of debris and lengths/widths of targets." Space Debris is NOT a show stopper!

Three parallel Activities.

- Passive – multi-leg, tether design,
- Active – move tether, protection, repair climber
- Collaboration – knowledge sharing, active involvement in tracking, coordinate with owners,



ISEC Studies

2021	Design Considerations for the Space Elevator Climber-Tether Interface - in progress
2021	Space Elevators are the Green Road to Space
2020	Space Elevators are the Transportation Story of the 21st Century
2020	Today's Space Elevator Assured Survivability Approach for Space Debris
2019	Today's Space Elevator, Status as of Fall 2019
2018	Design Considerations for a Multi-Stage Space Elevator
2017	Design Considerations for a Software Space Elevator Simulator
2016	Design Considerations for Space Elevator Apex Anchor and GEO Node
2015	Design Considerations for a Space Elevator Earth Port
2014	Space Elevator Architectures and Roadmaps
2013	Design Considerations for a Space Elevator Tether Climber
2012	Space Elevator Concept of Operations
2010	Space Elevator Survivability, Space Debris Mitigation

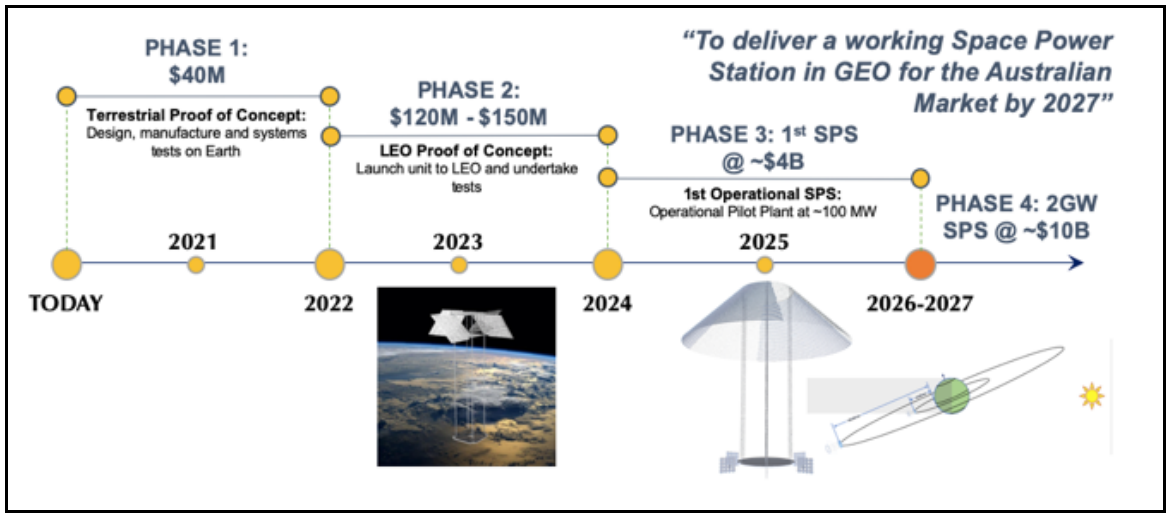
Completed studies on www.isec.org in pdf format are free

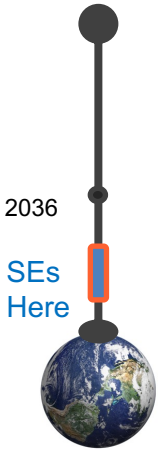
	Other Study Reports
2019	The Road to the Space Elevator Era - IAA IAA = International Academy of Astronautics (https://iaaspace.org)
2014	Space Elevators: An Assessment of the Technological Feasibility and the Way Forward - IAA
2014	The Space Elevator Construction Concept – Obayashi Corporation (https://www.obayashi.co.jp/en/news/detail/the_space_elevator_construction_concept.html)

Rockets to initiate SSP's prototypes with Space Elevators to supply and grow the Constellation.

Likely and possible for rockets to deploy the first SPS systems.

- Incredibly useful earth-to-orbit systems for deploying new space technologies, opening up new activities
- Deliver the initial prototypes to LEO for testing and the initial GEO production satellites for operational testing.





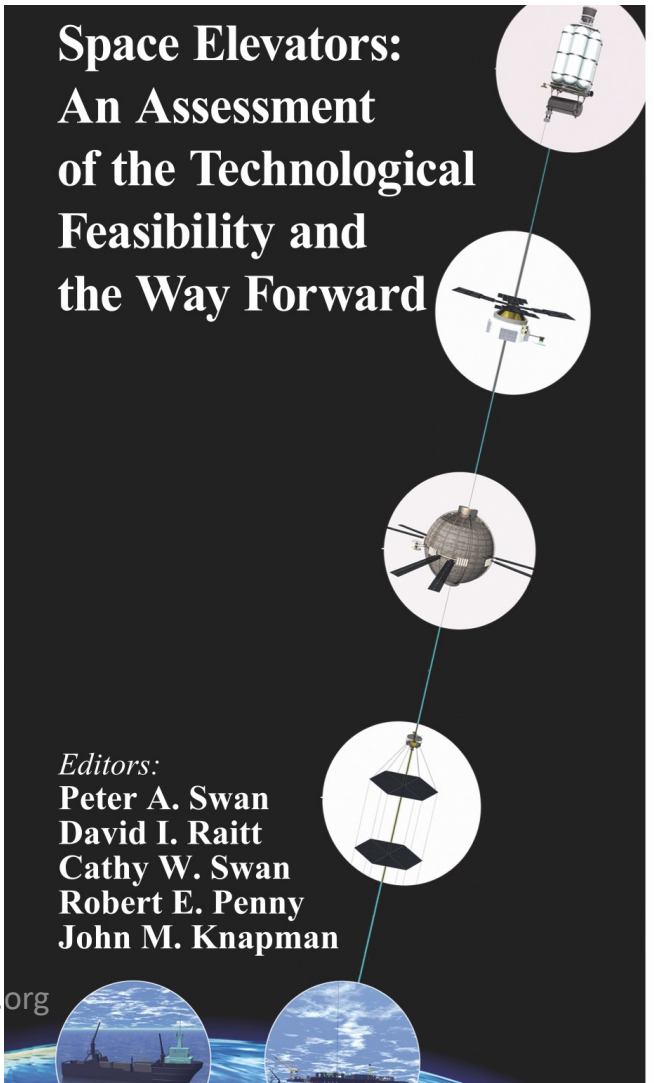
Space elevators are needed for high-throughput, massive hardware deployment.

- Consistent, continuous movement of freight to GEO and beyond
- Enable space technology deployment at scale for high impact
- Fills out the constellations by moving massive amounts of cargo

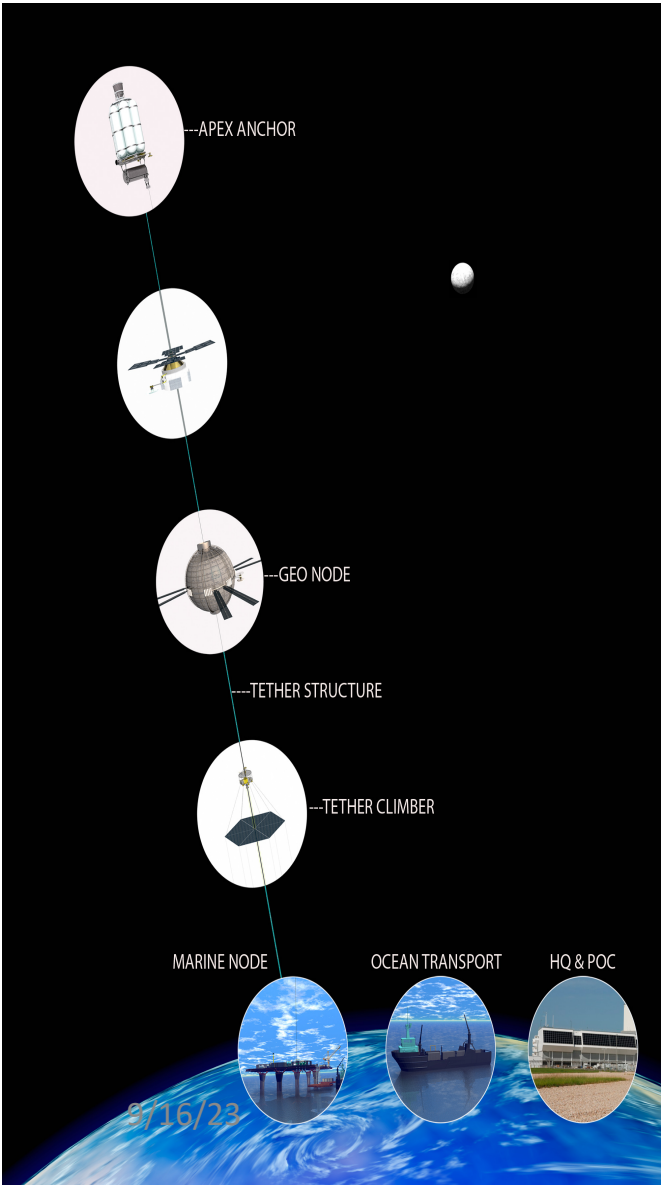
IAA Studies on Space Elevators

IAA Study One (2014) – Feasibility?
Conclusion: Space Elevators
Seem Feasible

IAA Study Two (2019) How To? Maturity?:
Road to the Space Elevator Era
Many global experts evaluating
critical technologies



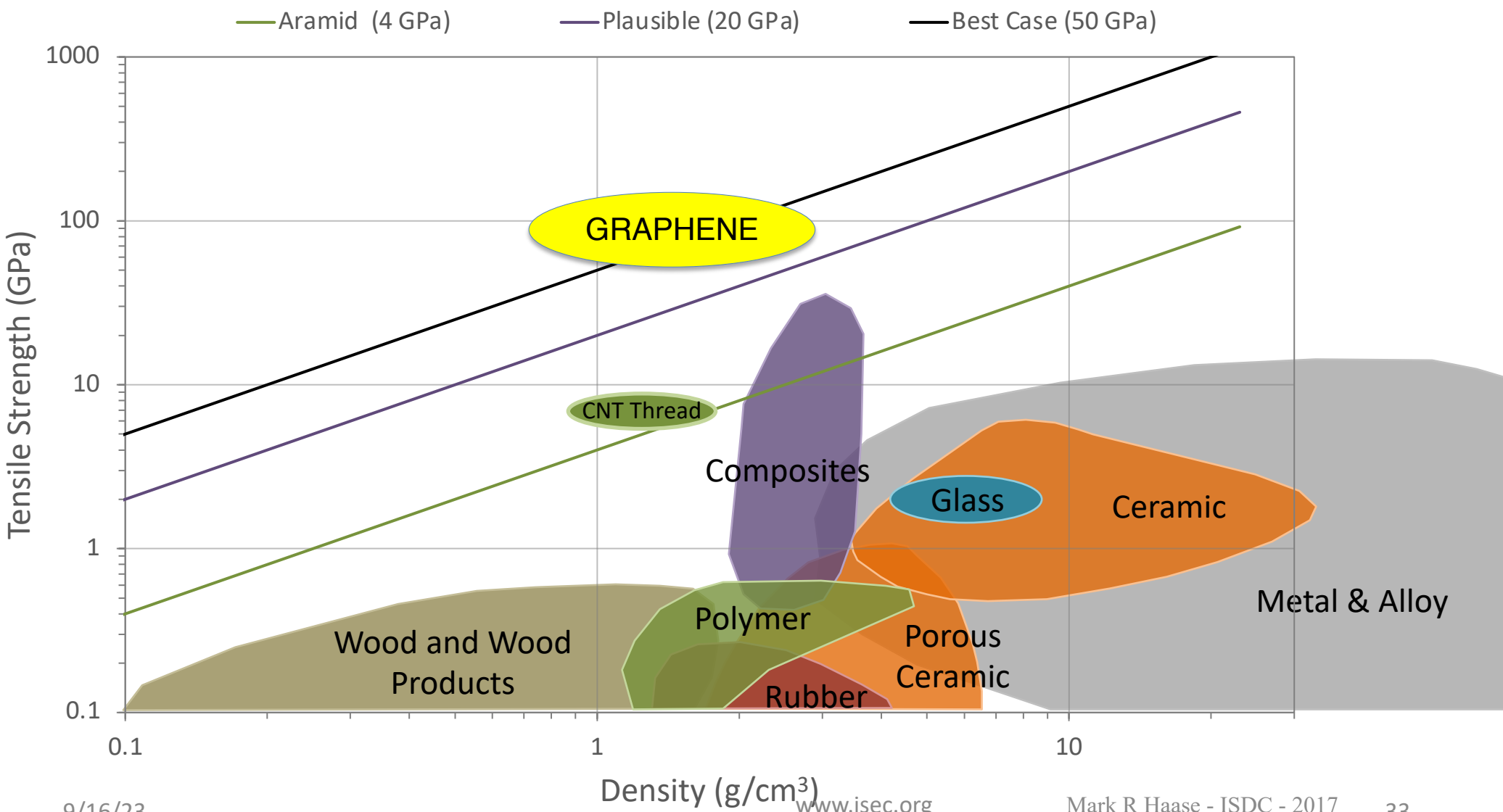
Second Modern Day Space Elevator International Academy of Astronautics (2013)



- Length: 100,000 km, anchored to floating Earth terminus, with a Marine Node connected to a large Apex Anchor.
- Ribbon: Width-One meter, curved;
- Design: Woven with multiple strands and curved;
- Material-Carbon Nano-Tubes with 25-35 MYuri at 1.3 gm/cm3
- Cargo: 14 metric ton payloads without humans [tether climber 6 MT]
- Loading: Seven concurrent payloads on the ribbon
- Power Source: Solar power after 1st 40 km
- Marine Node: Ocean going oil platform or retired aircraft carrier
- First 40 kms: box protection with power from an ultra-light cable.
- Alternant: High Stage One at 40 km altitude
- Apex Anchor: Based upon deployment satellite (with thrusters)
- Operations Date: The space elevator can, and will, be produced in the near future. [2035 operations start]
- Construction Strategy: The first space elevator will be built from GEO; then, once the gravity well has been overcome it will be replicated from the ground up.
- Architecture: Baseline is one replicating space elevator [used to produce all others] and then pairs sold to operating companies. Initial concept: three pairs operating around the world.
- Price: $ 13 billion for first pair, after replicator space elevator.
- Cost per kg: $ 500 USD

Tether candidate materials

YES: Graphene is strong enough to be a candidate tether material



Is a tether made from single crystal graphene feasible?

Current commercial nanoplate graphene cannot be used to make a tether.

However, 500mm of single crystal graphene has been made 13 years after graphene first isolated.

Layered single crystal graphene is yet to be made but we know how to do this and the material is already being called Nixene

YES

Graphene tether material really is possible within our lifetimes.