Permanent Infrastructure – Space Elevators as Transformational Capability!

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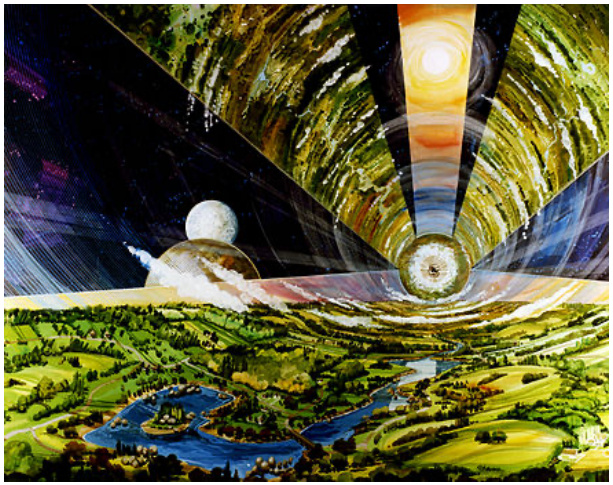
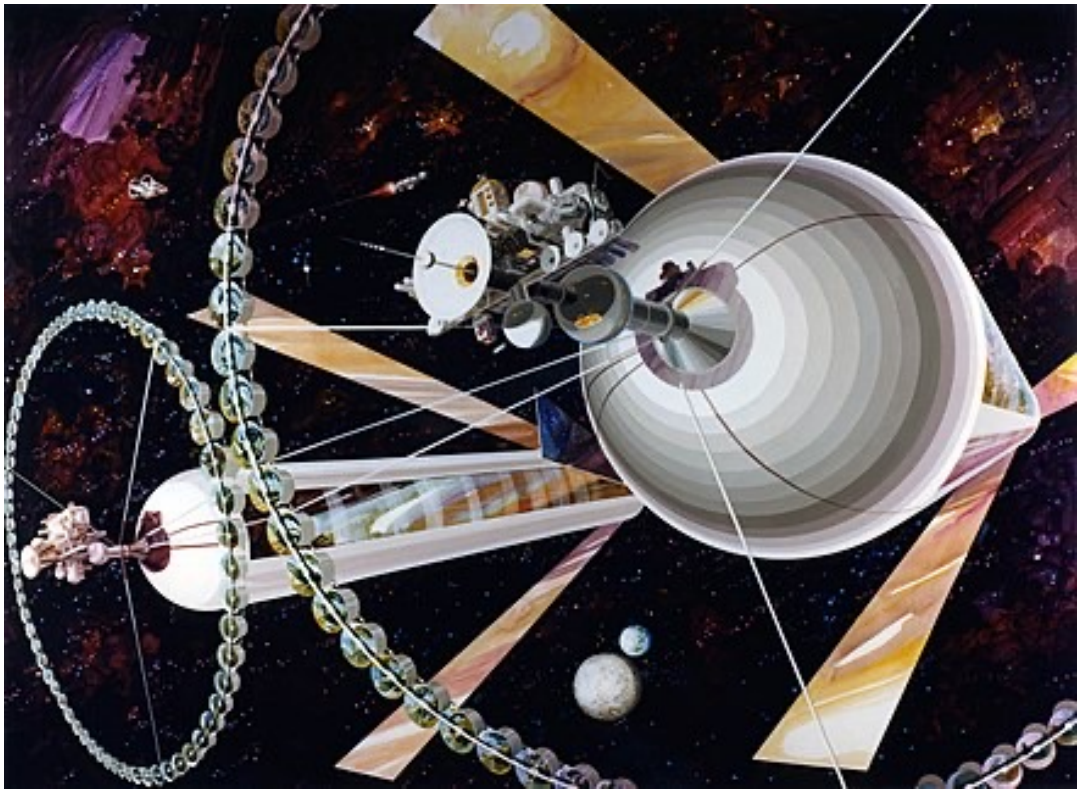
Space Elevator Track,
2022 International Space Development Conference
Washington DC

Art by
A. Stanton

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.”



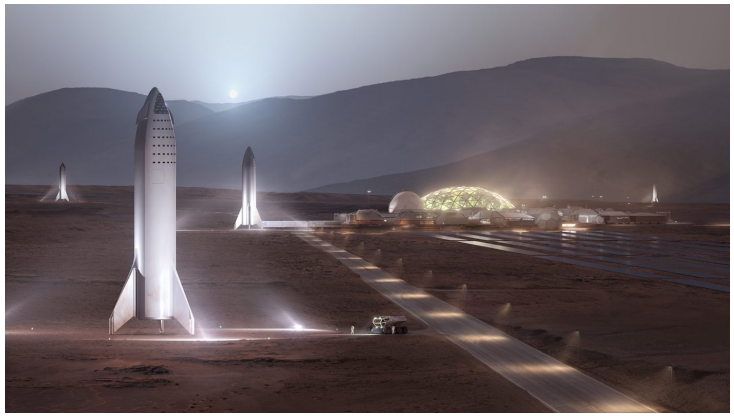


But, who asks how much mass
Is required at the altitude of the Moon?

How about 10,500,000 tonnes?

Living and working in thriving communities beyond Earth – NSS

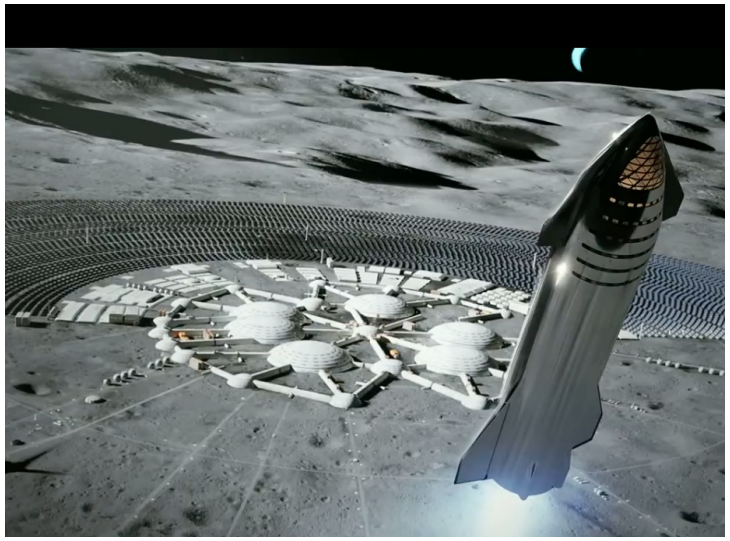
Dream Big!
But How much mass to Orbit?

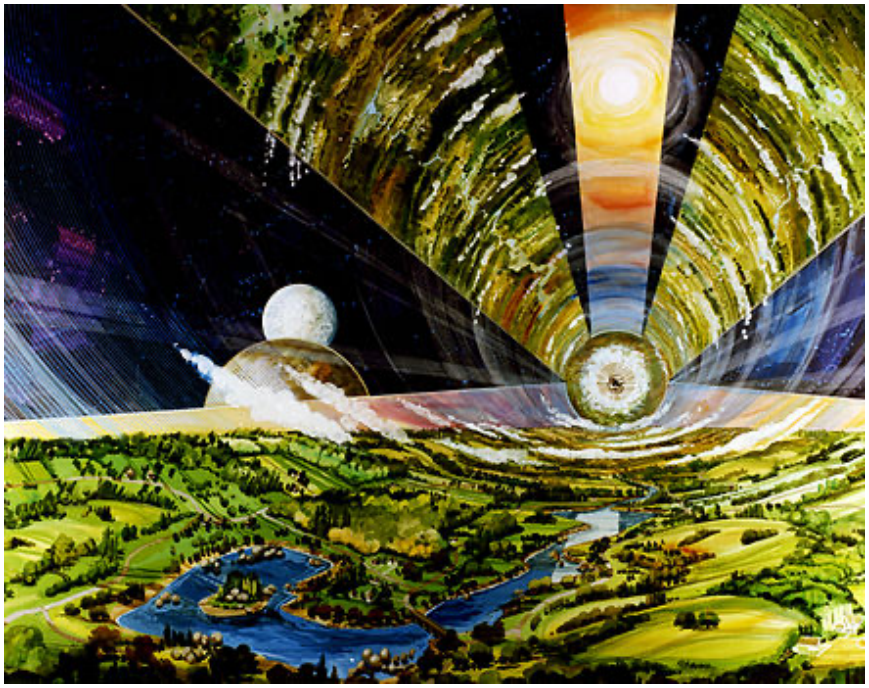


Images from SpaceX website

Images by NASA and Rick Guidice

Image from Blue Origin website



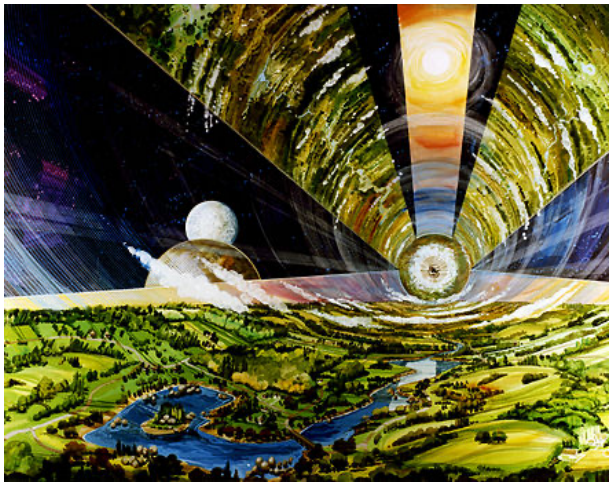


O'Neill's Vision

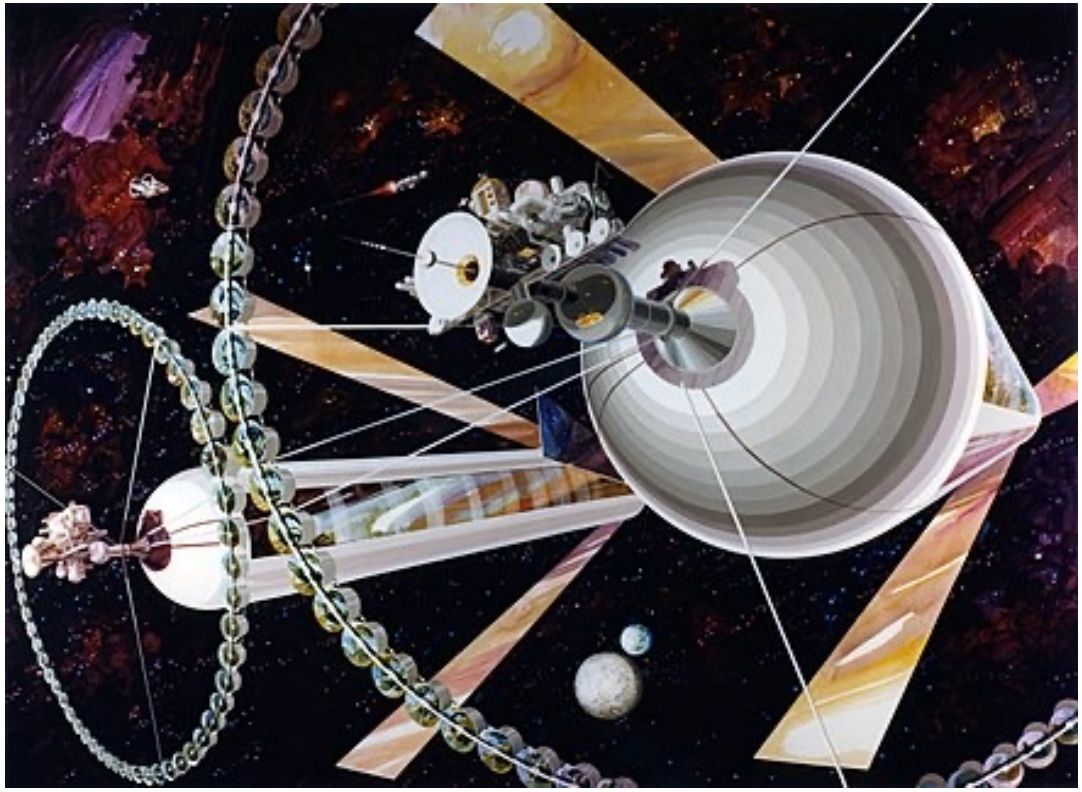
High-Frontier, Human Colonies in Space
Gerard K. O'Neill book in 1976 – Rotating Cylinders

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.

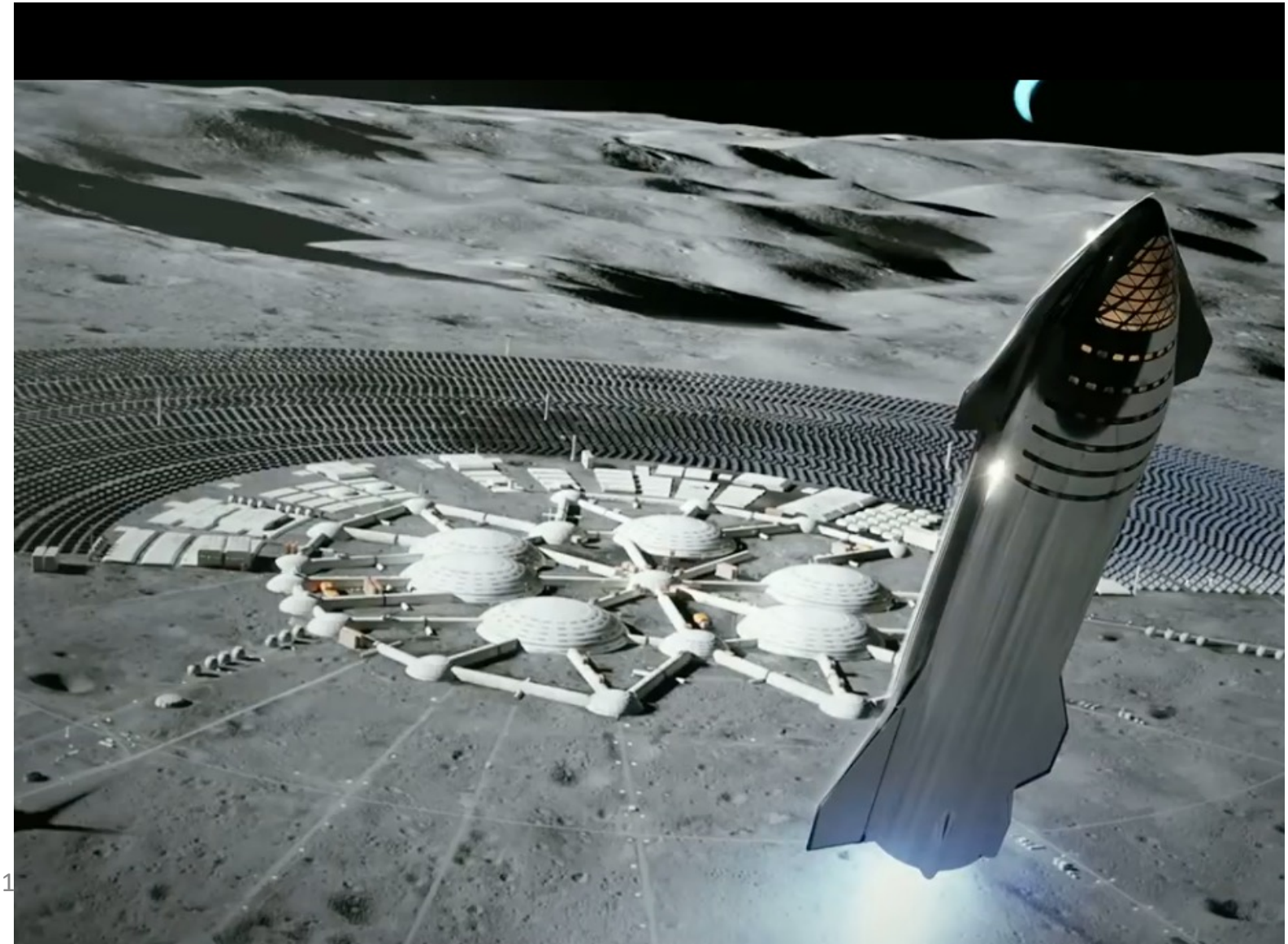


10,500,000 tonnes to L-5,
for several million people

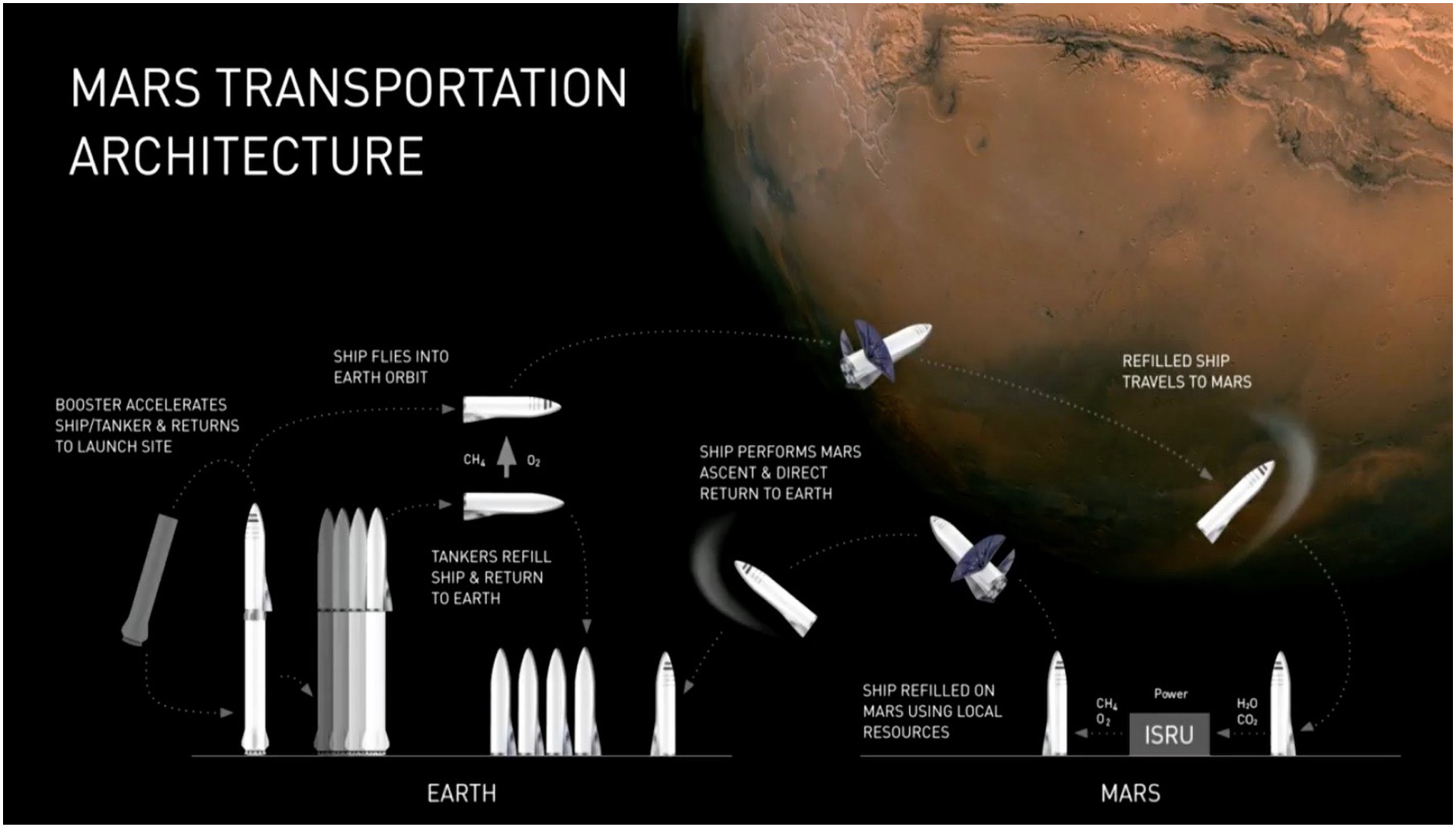


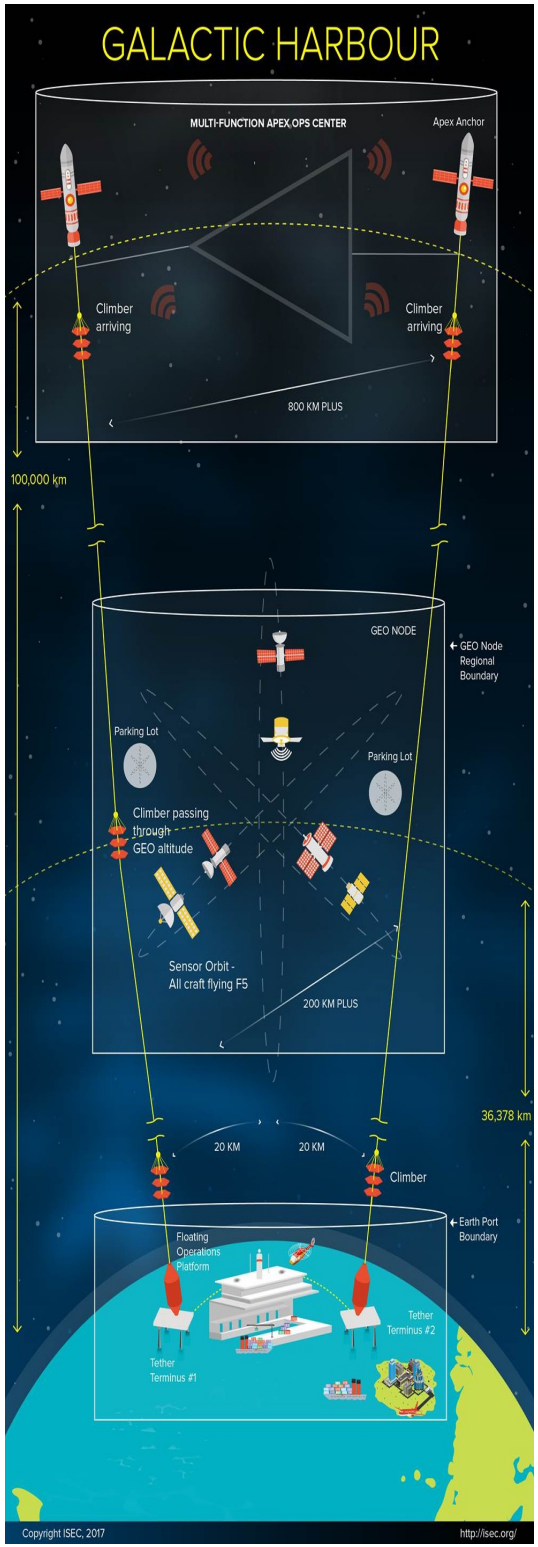
Images by NASA and Rick Guidice

Lunar Village



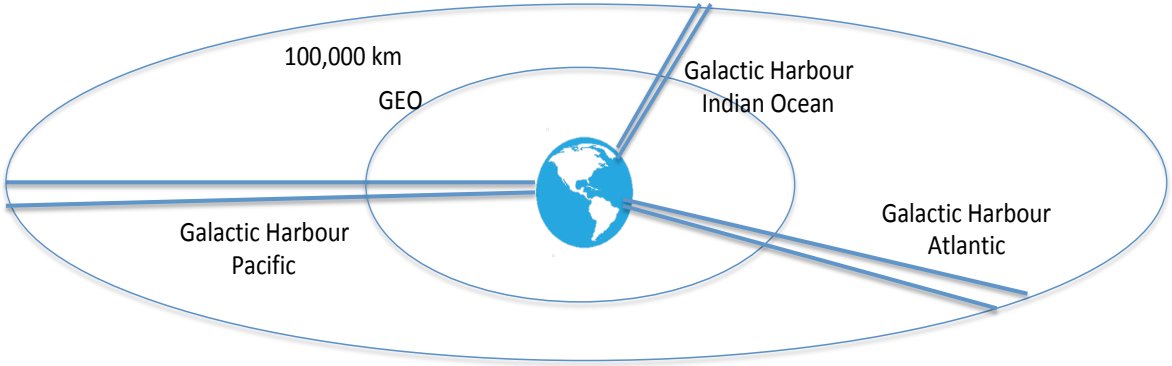
SpaceX Systems Approach to Mars





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 Beat the Rocket Equation
We Enable Dreams

*(30,000 tonnes/yr vs. approx.. rockets' 26,000 tonnes over 65 years)

Permanent Infrastructure – Space Elevators as a Transformational Capability

2:00 Welcome and Overview. Peter Swan (Galactic Harbour Associates)
2:05 Modern Day Space Elevator Transforming Space Access. Peter Swan (ISEC)
2:20 Reversing Global Warming Made Possible by Space Elevators. Jerry Eddy (ISEC)
2:35 Designing a 20-tonnes Space Elevator Climber - A Starting Point. Larry Bartoszek (Bartoszek Engineering)

3:00 NASA Space Settlement Contest Presentation
3:15 Study of Direct, Planetary Insertion Orbits from Space Elevators. Gene Luevano (Arizona State University)
3.25 How Will the Space Elevator Ascend the Tether? Dennis Wright (ISEC)
3.40 The Transformational Impact of Infrastructure and How a Space Elevator would Impact Space Development. Kevin Barry (LightBridge Strategic Consulting)

4:00 Start NOW - Development of Space Elevator Transportation Infrastructure. Michael Fitzgerald (Galactic Harbour Associates)

4:15 Panel: Transformational Infrastructure Scenario. What can be achieved while saving the atmosphere and aggressively moving off-planet with 30,000 tonnes per year delivered by the Green Road to Space. Moderator: Michael Fitzgerald (Galactic Harbour Associates)

Modern Day Space Elevator
Transforming Space Access

Peter A. Swan, Ph.D.
SenVP, Galactic Harbour Assoc.
President, International Space Elevator Consortium
Member, International Academy of Astronautics
Member NSS, FBIS, FAIAA

The term “A Modern Day Space Elevator” has evolved from a dream to a scientific engineering reality. The four major thrusts for the present Modern Day Space Elevator are:

- Space Elevators are ready to enter Engineering Development (Phase Two of development)
- Space Elevators are the Green Road to Space
- Space Elevators can join advanced rockets inside a Dual Space Access Architecture
- Space Elevator’s major strength as a permanent transportation infrastructure is movement of massive cargo to GEO and beyond enabling new enterprises along the way.

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A. Stanton

Space Elevator Vision 2038 Timeline

New Vision: *Space Elevators are the Green Road to Space while they enable humanity's most important missions by moving massive tonnage to GEO and beyond. This is accomplished safely, routinely, inexpensively, daily, and they are environmentally neutral.*

Approach: A permanent Dual Space Access Architecture relies on Space Elevator traditional strengths such as inexpensive, safe, daily, routine, with special characteristic of Earth friendly, and its ability to avoid the rocket equation. The rockets are complementary and cooperative to Space Elevators.

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, environmentally friendly, and inexpensive departures towards mission destinations

Transformational Characteristics

The transformation of space access will be similar to moving from small boats crossing a large river to a permanent infrastructure called a bridge moving traffic daily, routinely, safely, inexpensively, and with little environmental impact. Permanent transportation infrastructures called space elevators will enable missions by leveraging their strengths:

- Daily, routinely, safely, inexpensively
- Massive movement (30,000 tonnes/yr vs. approx.. rockets' 26,000 tonnes over 65 years)
- High velocity (starting at 7.76 km/sec at 100,000 altitude enables rapid transits)
- Green Road to Space ensures environmentally neutral operations
- Transforming the economics towards an infrastructure with access to more valuable, lucrative, stable and reliable investments.

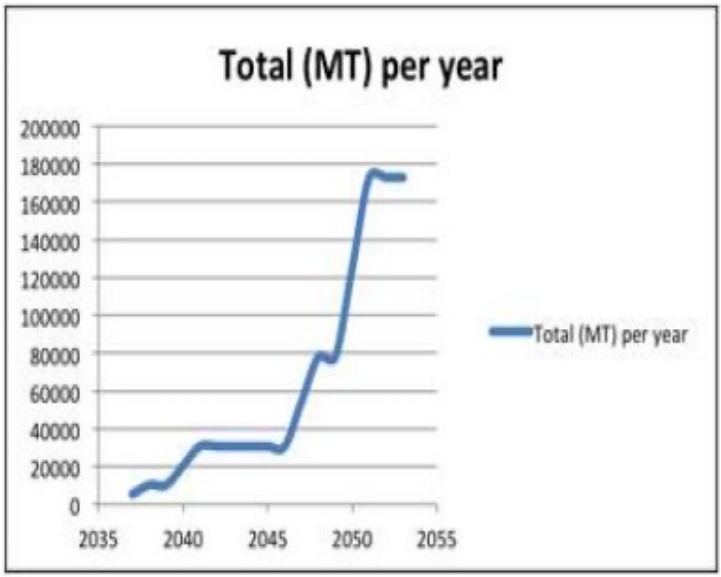
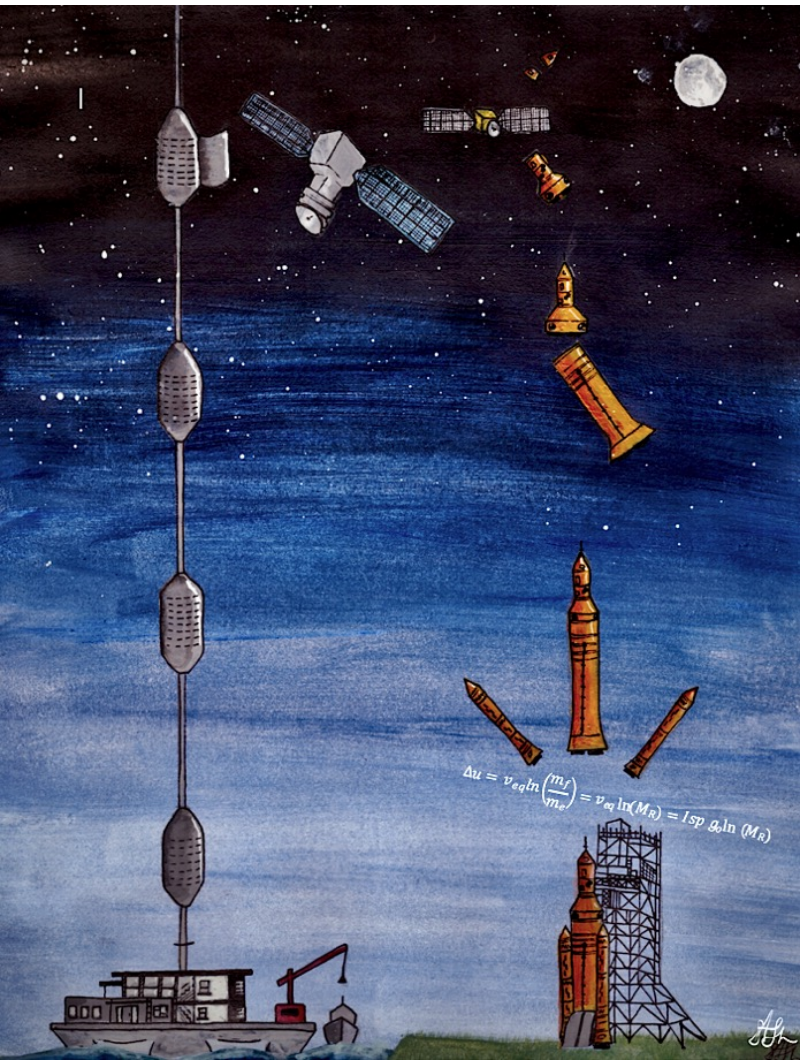


Figure 88. Massive Cargo Movement by Space Elevators (Swan "Dual Space Access Strategy Minimizes the Rocket Equation," Space Renaissance International 3rd World Congress 2021 – Congress Theses, Final Resolution and Papers. Pg 254-255.)

Dual Space Access Architecture

Rockets to Open up the Moon and Mars with Space Elevators to supply and grow the colonies. In addition, Rockets would delivery prototypes and initial operational Space Solar Power Satellites, while Space Elevators would fill out the constellations with the heavy lifting.

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

Collaboration and Cooperation

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

ISEC

7.76 km/sec

Apex Anchor

Tether

Geostationary Node

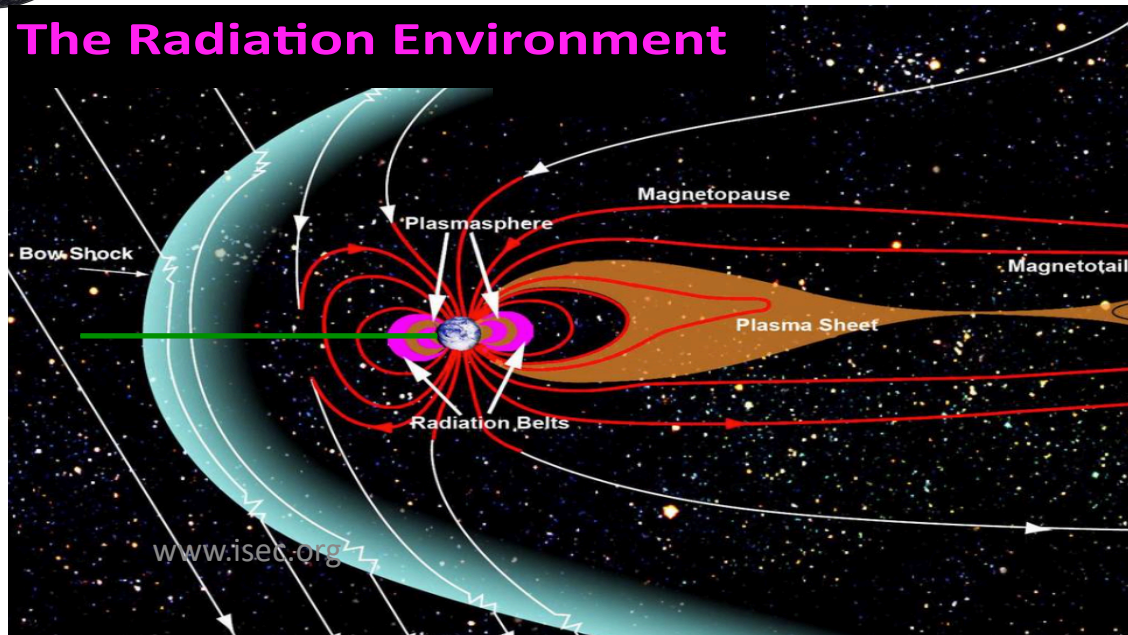
Climber

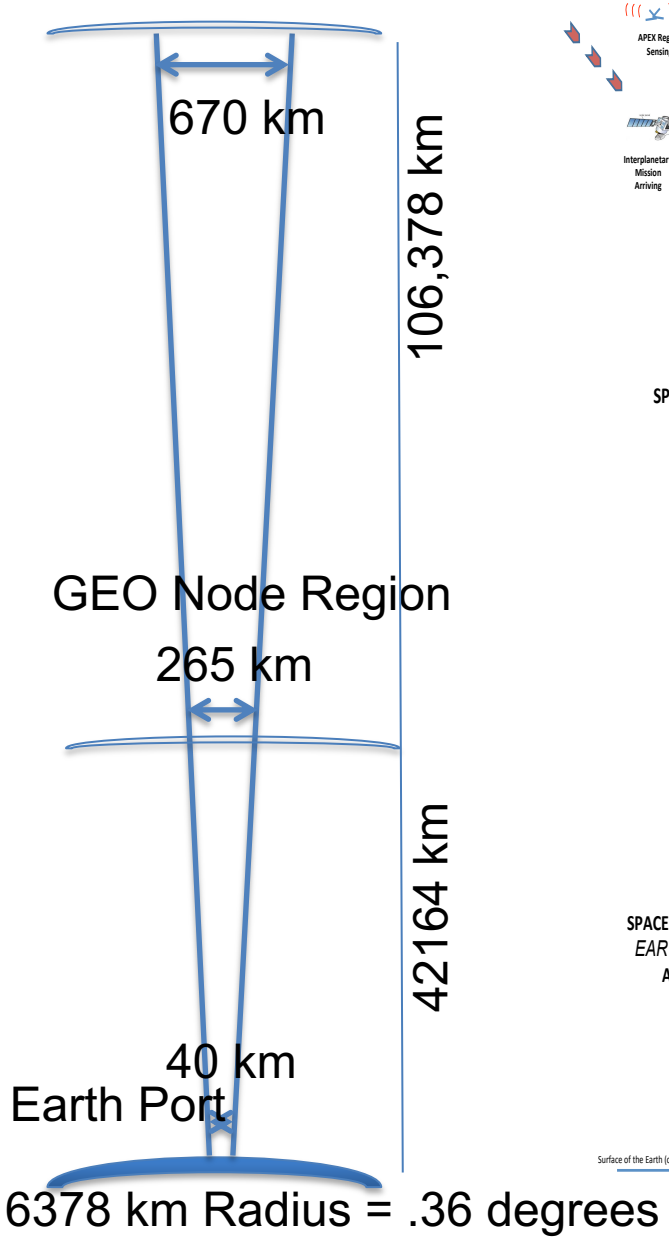
Marine Node

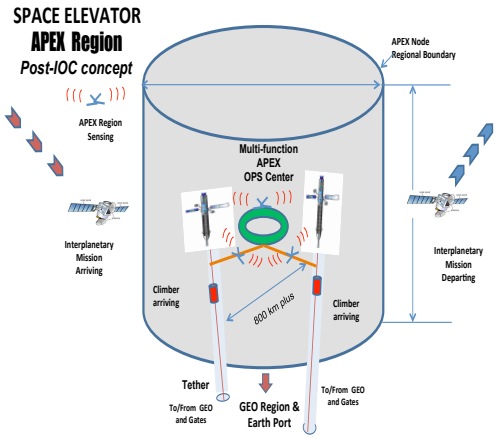
Diameter of earth 12,742 km

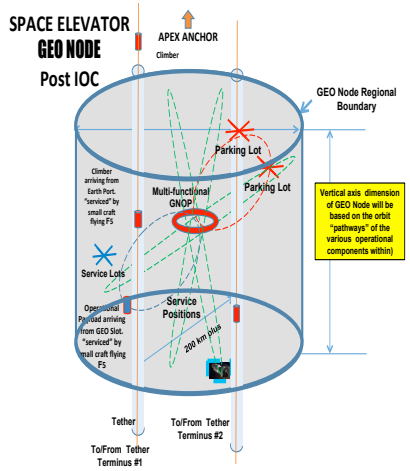
Tether length 100,000 km

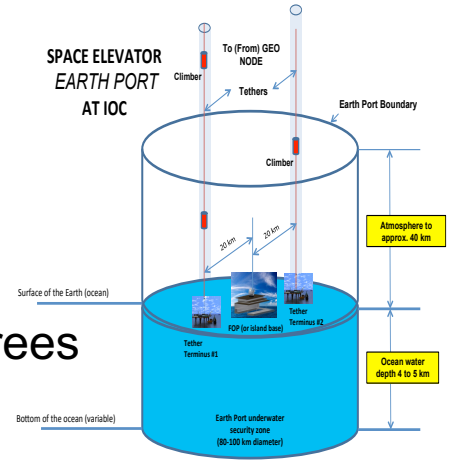
The Space Elevator











- Galactic Harbour includes two Space Elevators radially extending from Ocean surface to Apex Anchor for a permanent space access infrastructure.
- One reusable tether climber lift-off per day
- Three Regions, Earth Port – GEO – Apex Anchor, where commercial ventures will grow

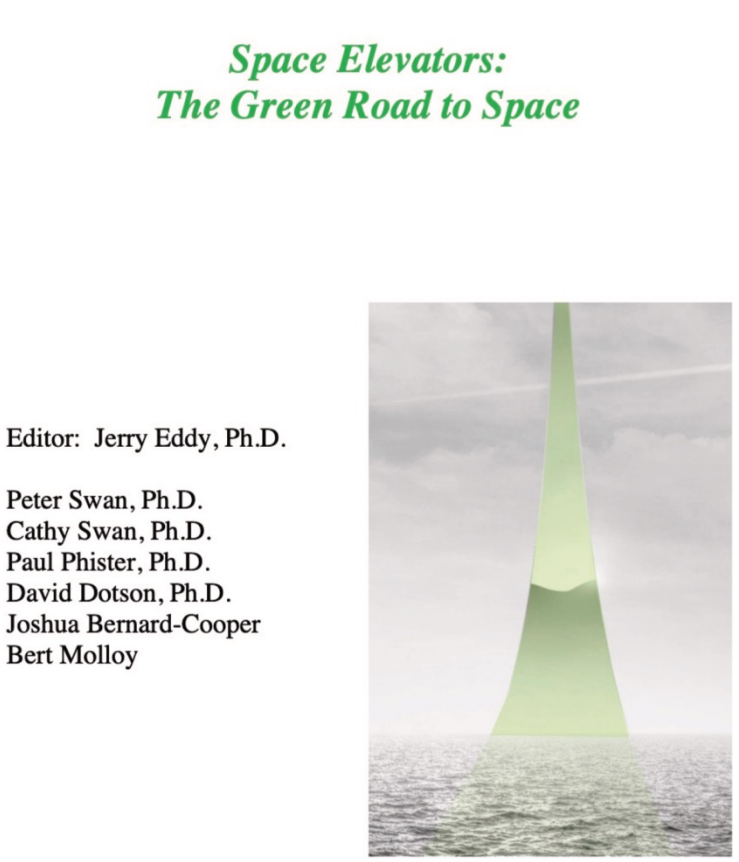
Characteristics of Transportation Infrastructure

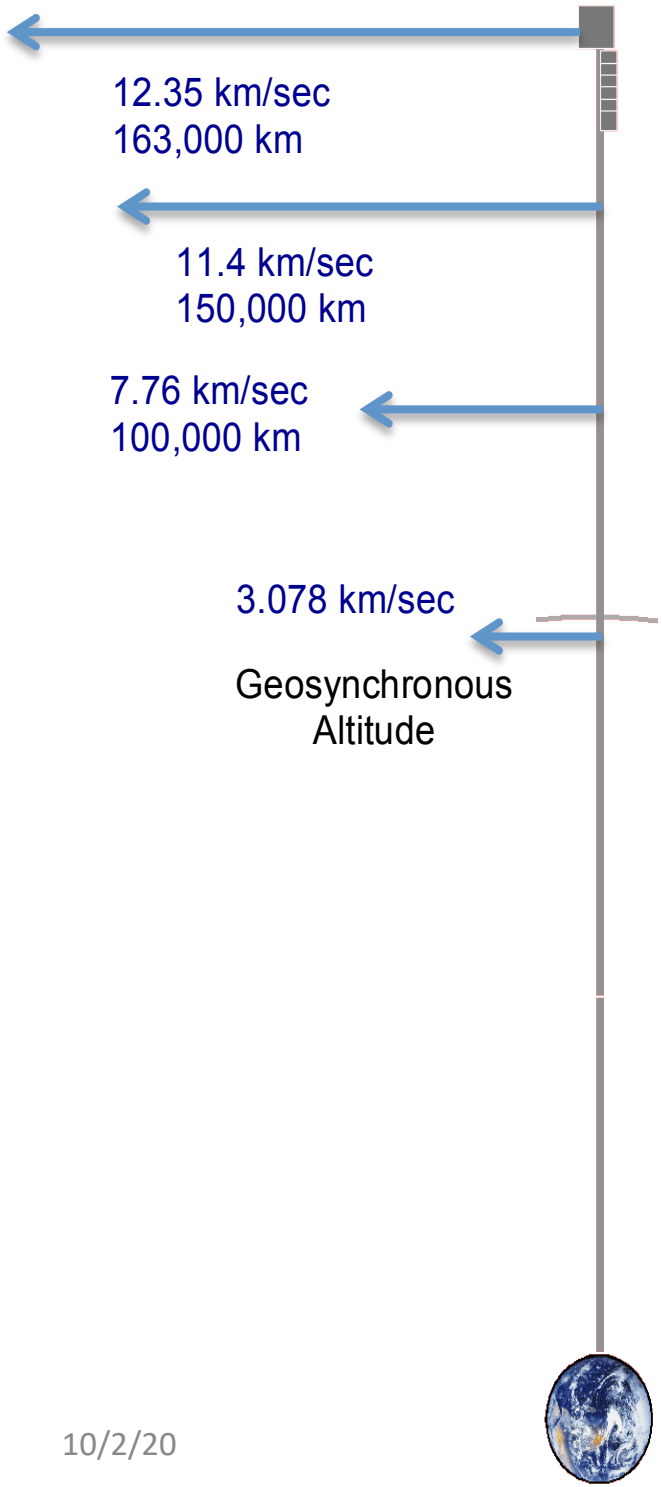
- Revolutionarily inexpensive to GEO [$100/kg to GEO]
- Commercial development similar to bridge building
- Routine [daily launches]
- Safe [no chemical explosions from propulsion]
- Permanent infrastructure 24/7/365/50 yrs. [bridge similarities]
- Massive loads with daily launches per elevator (30,000 tonnes per year to GEO & beyond (early operations))
- No shake-rattle-roll during launch
- "Big Green Machine" Little impact on global environment
- No consumption of fossil fuel.
- Does not leave space debris in orbit

Beats the Gravity Well in an environmentally 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 (25,000 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





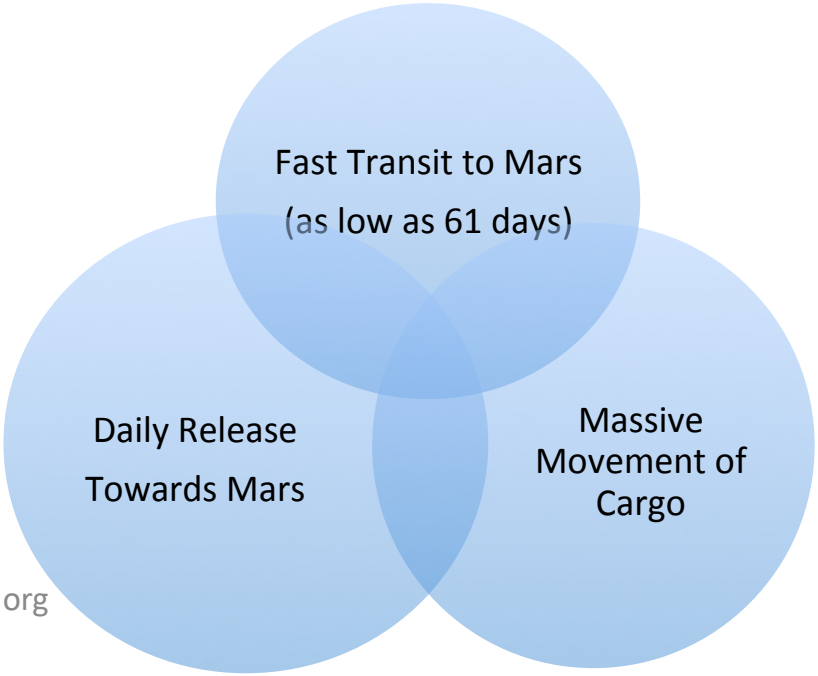
Revolution Coming

- This new vision of Galactic Harbour architectures will change the "thinking" for off-planet migration – How fast can we go?
- At 100,000 km altitude, there is no significant gravity pull to limit departures
- At 100,000 km altitude, there is tremendous velocity (7.76 km/sec) enabling beyond Mars
- With longer Space Elevators, the whole solar system opens up and even escape from the sun is possible (without thrusting from rocket fuel).

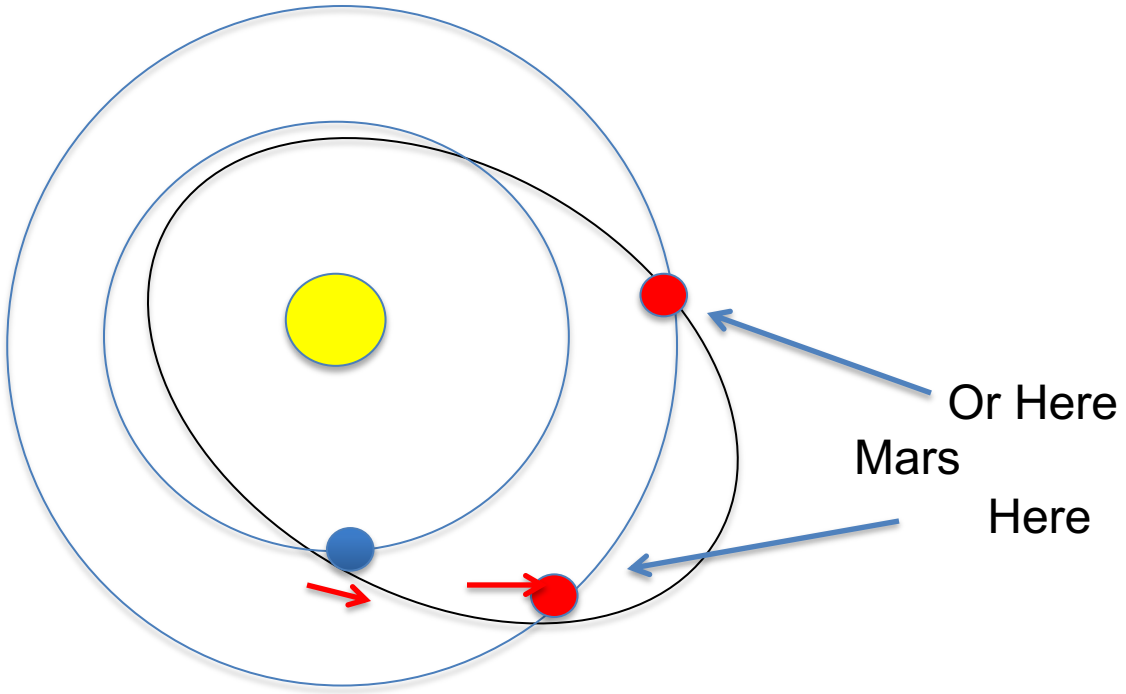
Enable Interplanetary Mission Support

The unique characteristic of Space Elevators is a rapidly moving Apex Anchor (7.76 km/sec) enabling 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 between 80 to 100 days)
- Release every day towards Mars (no waiting for 26 month window)
- Massive tonnage of mission support equipment (170,000 tonnes per year with a mature system)

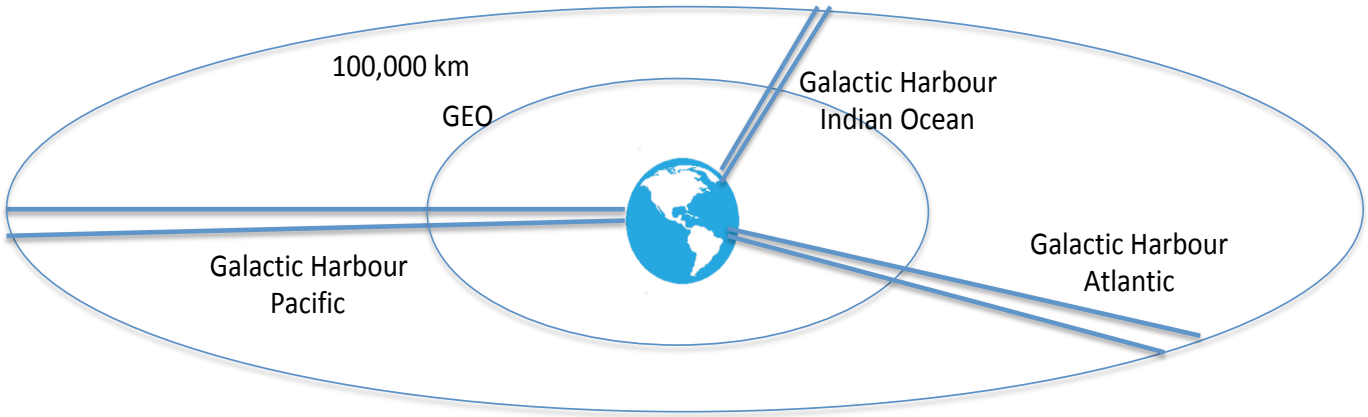


Case One: Fastest Approach



Concept: Our spacecraft enters the ellipse, “not at perigee,” but on the side of the ellipse centered as one foci at the Sun and outer portion matching Earth and Mars locations.

Vision of Galactic Harbours



Note: humanity has orbited only 26,000 tonnes so far (estimate)

Three Galactic Harbours

– 7 Climbers a week/SE

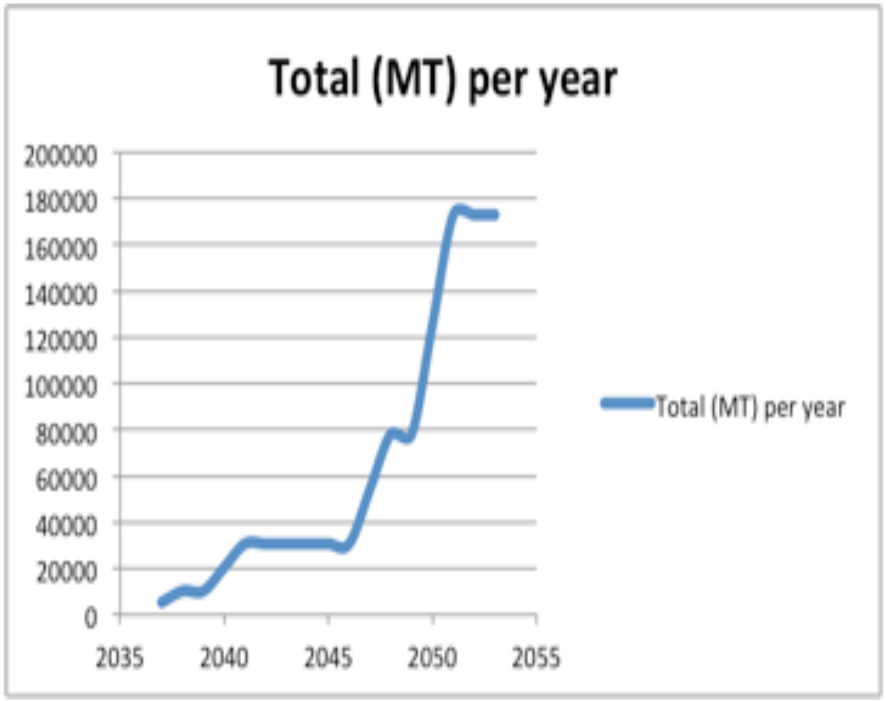
– 14 tonnes each, x2 x3

= 30,660 tonnes/yr to GEO and beyond

- growing to 79 tonnes each, x2 x3

= 173,010 tonnes/yr

- Future > 500,000 tonnes/yr



Visions of Many Demand Space Elevators Start NOW!

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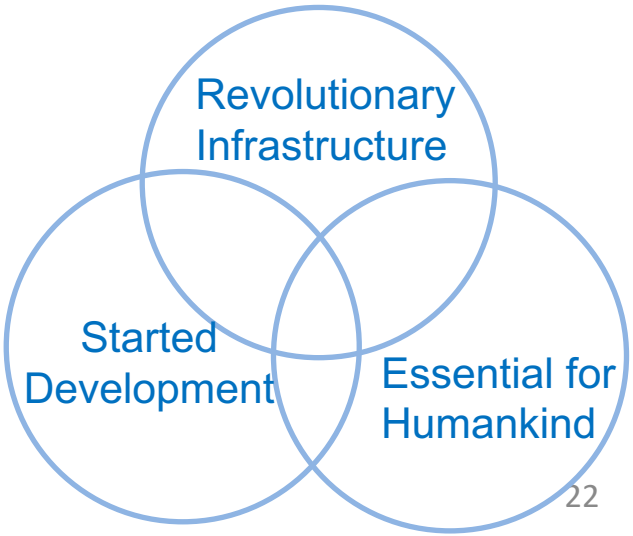
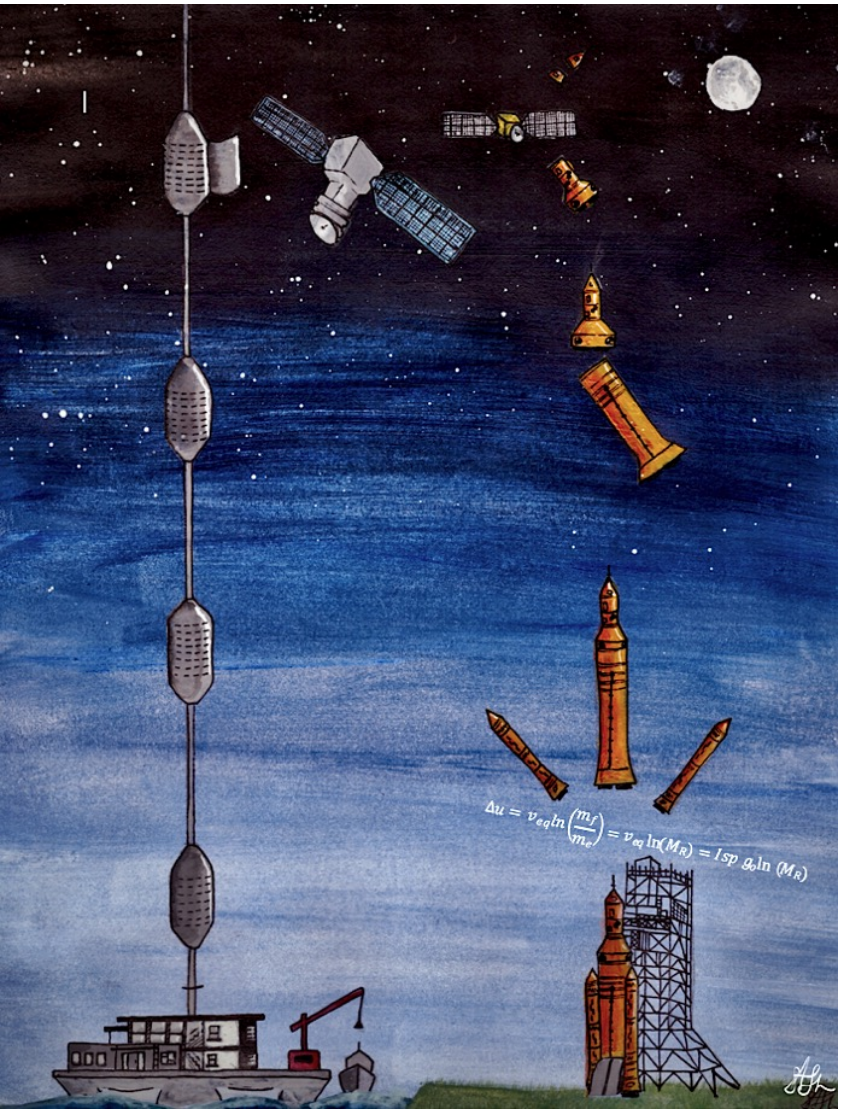
- Space Elevators can Enable the needs and visions of many!
- They provide massive cargos to GEO and beyond
- Space Elevators are the Green Road to Space
- Dual Space Access Strategy is a collaborative approach
- A testing and demonstration development program for Space Elevators has started



Why Space Elevators? Because we Must!



- Fulfills the Dreams of Many
- Raises Massive Cargo using Solar Energy
  - Green Road to Space
  - Permanent Infrastructure for GEO & Beyond
  - Daily, Routine, Safe, and Inexpensive
  - Early Operations: 30,000 tonnes per year
- Space Elevators are a Simple Elegant Solution to the Rocket Equation. - They avoid it!

Final Thought

Space Elevators could be the story of this century. Reliable, safe, environmentally friendly, inexpensive, and efficient access to space. This transportation capability is close at hand – Probably within 15 years. Space access paired with rockets! The Galactic Harbour opens the road; it opens the Heavens; it opens the way.

with the final realization:

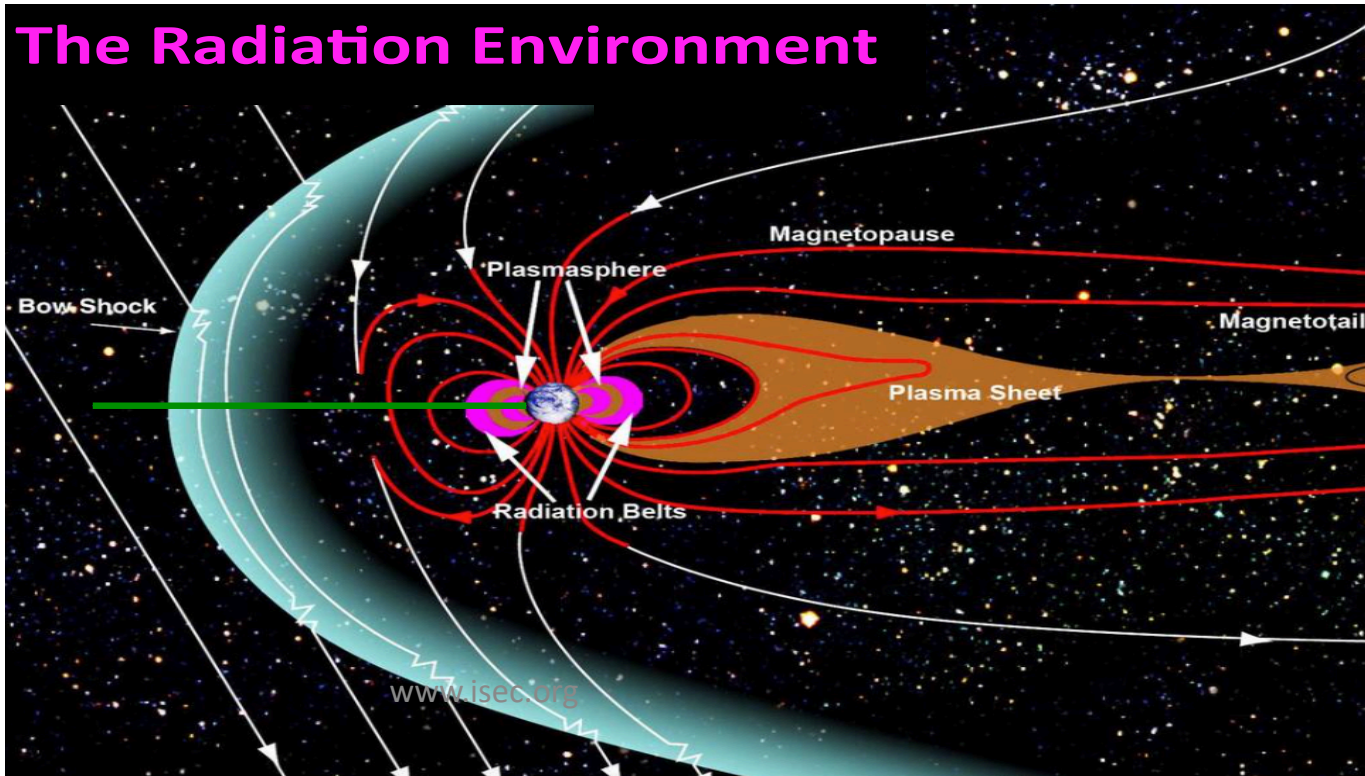
The Space Elevator is Closer than you Think!

How the Space Elevator Grew into a Galactic Harbour?

Backup Charts

Earth Radius
6,378 Km

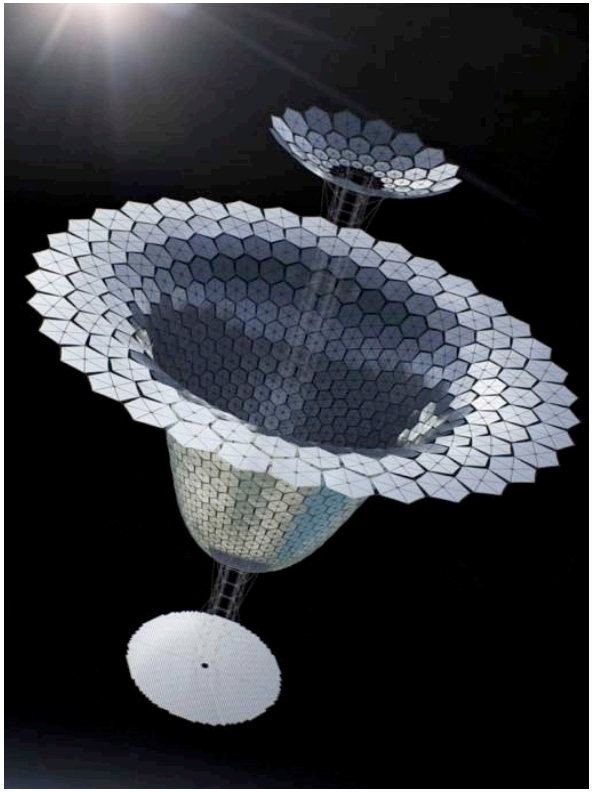
Space
Elevator
100,000 km
In green



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.

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

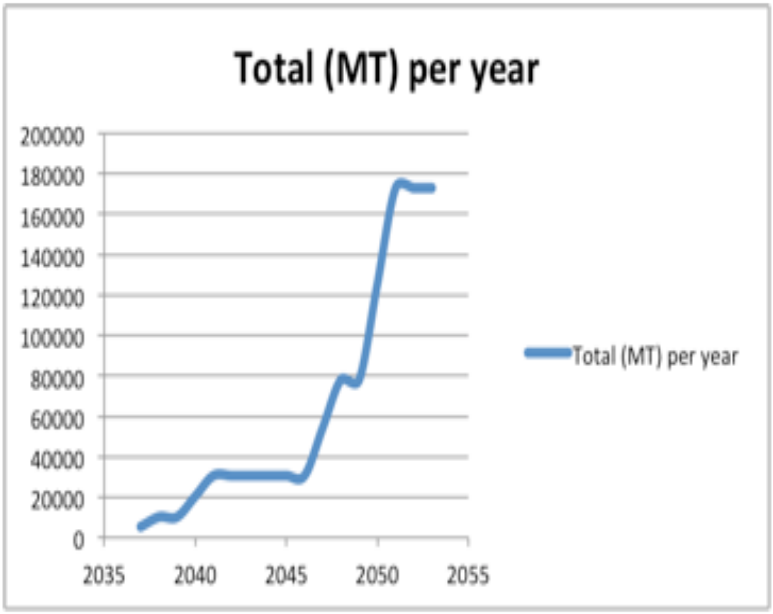
Type of Systems	*Orbit*	*Mass*	*Mass on pad*
		Tonnes	tonnes
Space Stations	LEO	431	10775
Earth Orbiting Sat's 2020	LEO, MEO, GEO	3220	80500
past satellites deorbited	LEO, MEO, GEO	1000	25000
Interplanetary	Solar System	100	5000
Lunar spacecraft	to the Moon	94	4700
Human to LEO	LEO	535	13375
Apollo Capsule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

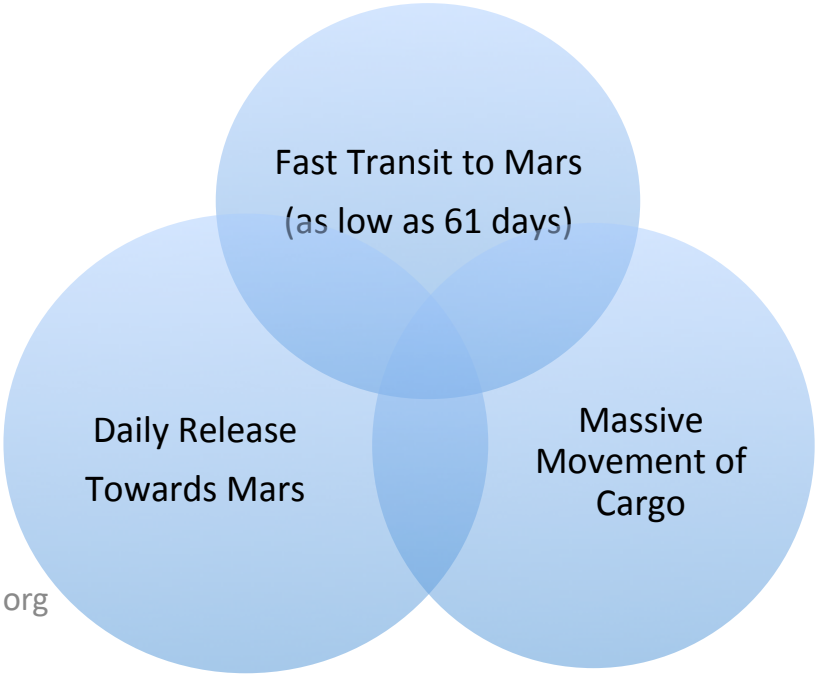
Space Elevator expected
movement of mass
Initial Operations Capability (30,000 tonnes/yr)
Full Operations Capability (170,000 tonnes/yr)



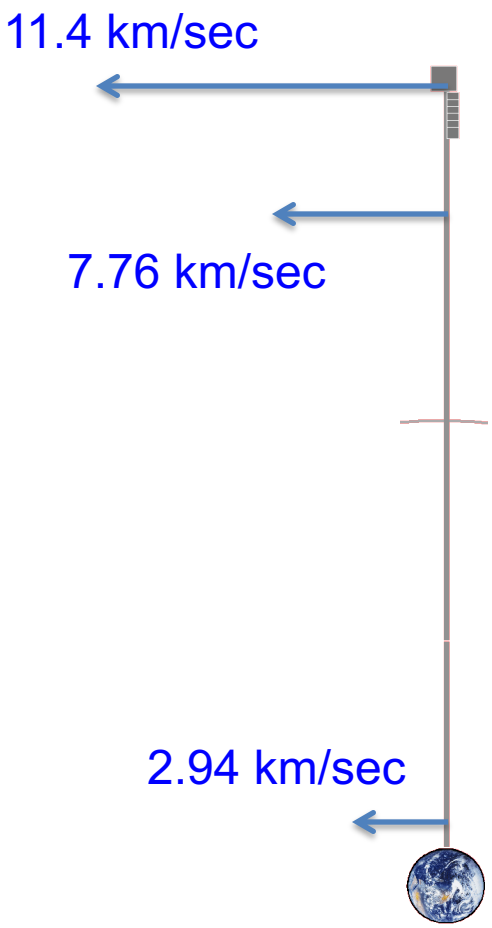
Special Strengths
A New Concept

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



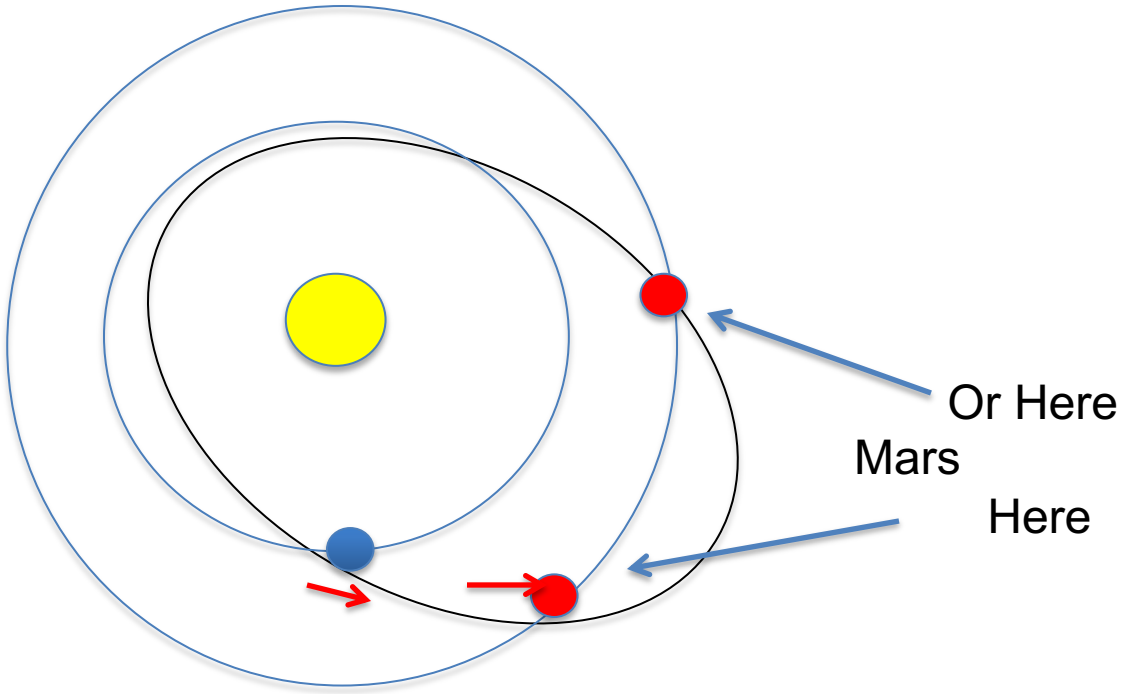
Three Release Locations

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

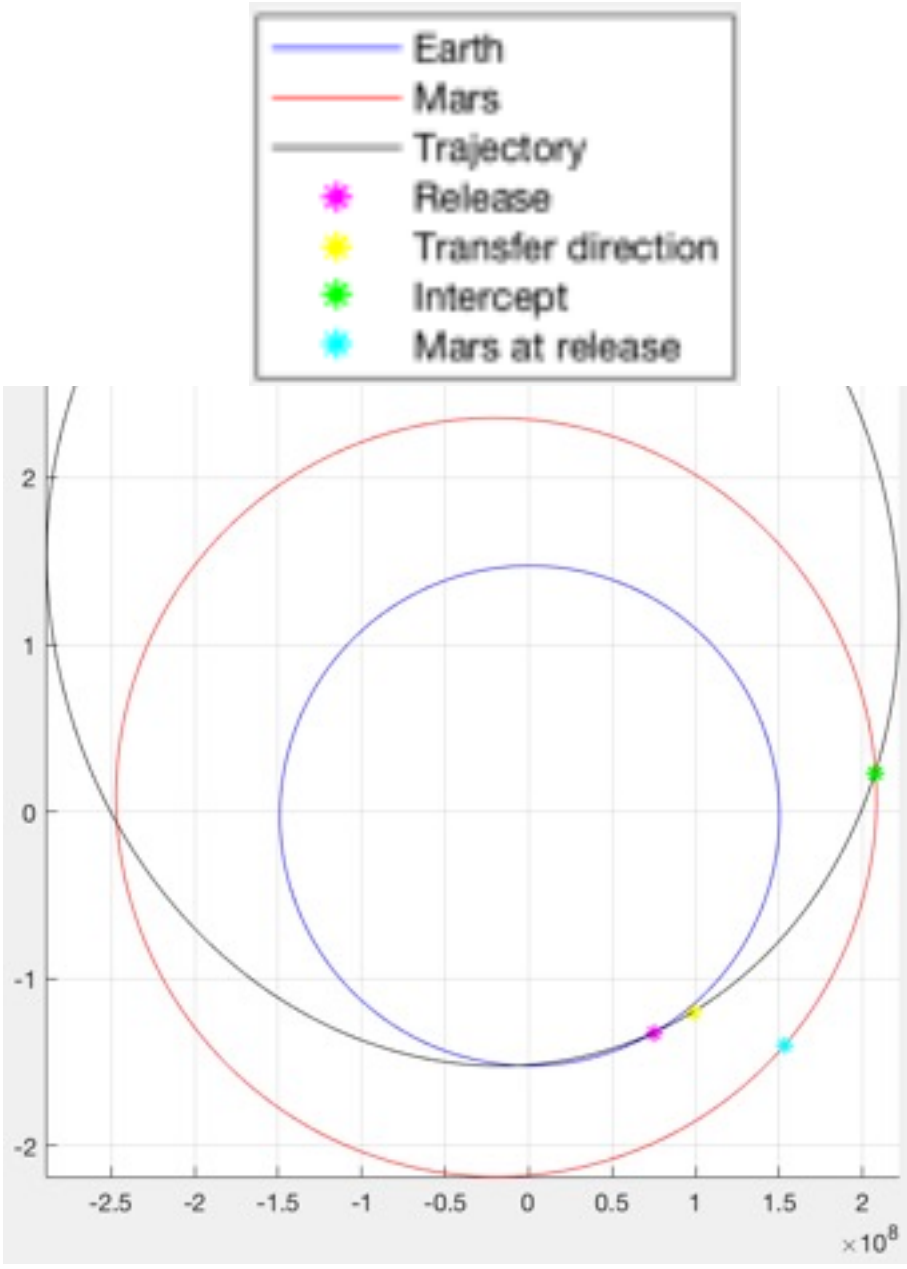


Concept: Our spacecraft enter the ellipse “not at perigee”
Ellipse is created by a velocity vector with one foci at the Sun
A later portion of the ellipse coincides with Mars with a rendezvous vector

Remarkable Infrastructure Support to Interplanetary Research from ASU

- To Mars in 76 days
- Weekly departures
- High speed transit
- Massive movement of payloads
- Each Payload has a rocket and fuel to slow down at Mars

Will Enable Mission Support for Interplanetary Flight



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 for Interplantary Transportation
when departing from Galactic Harbour Apex Anchor

Bus Schedule to Mars

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	
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Bus Schedule, from Apex Anchor 2035

Date	Departure	Destination	Flight Time	Arrival	Comments
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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
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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	

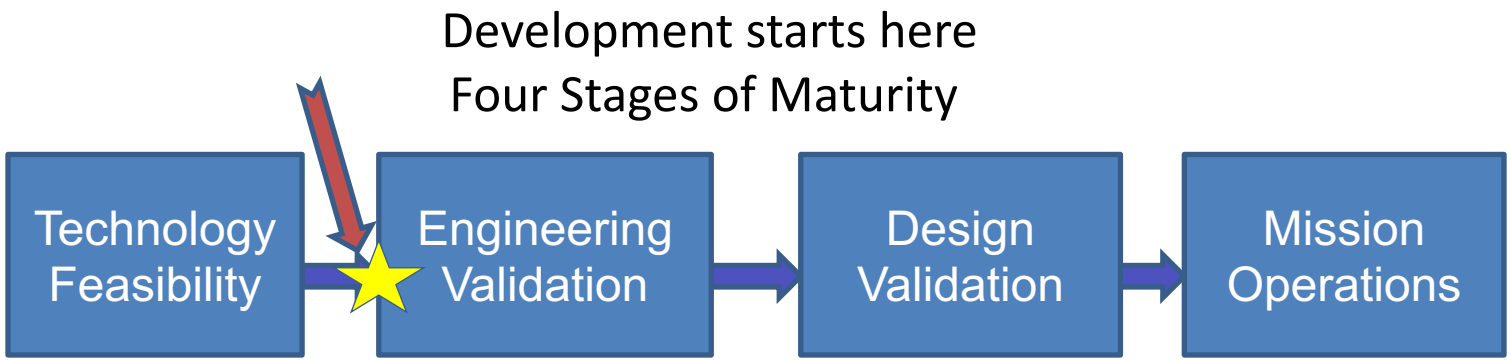
Bus Schedule, from Apex Anchor 2035

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

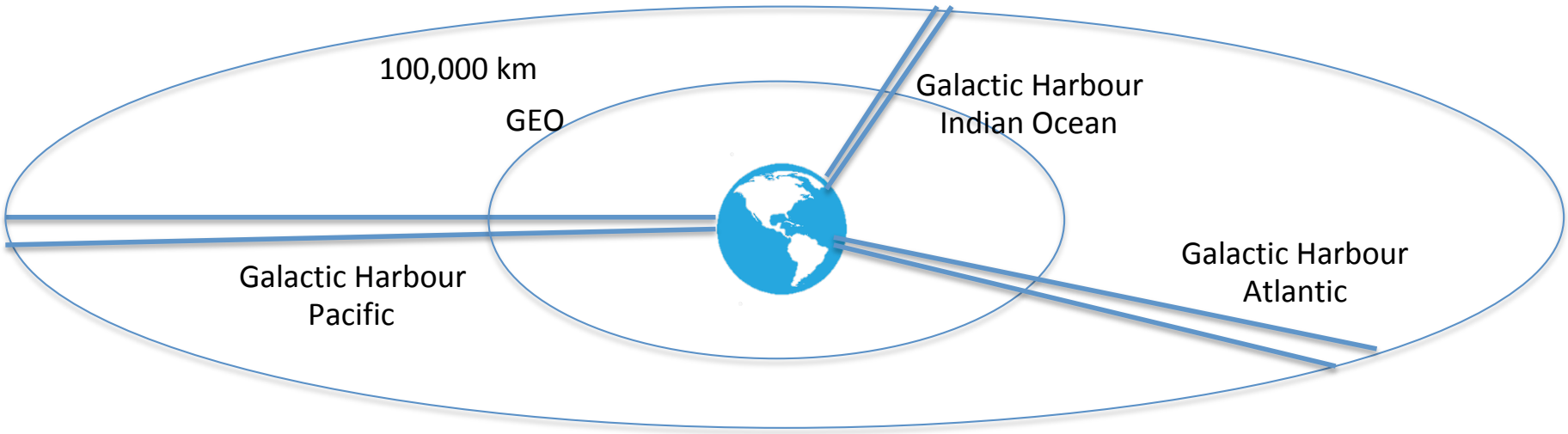
Date	Departure	Destination	Flight Time	Arrival	Comments
every day	Indian #1	Moon	14 hours	+ 14 hours	
every day	Indian #2	Moon	14 hours	+ 14 hours	
every day	Pacific #1	Moon	14 hours	+ 14 hours	Fast
every day	Pacific #2	Moon	14 hours	+ 14 hours	
every day	Atlantic #1	Moon	14 hours	+ 14 hours	
every day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

The Space Elevator has Entered Engineering Validation!



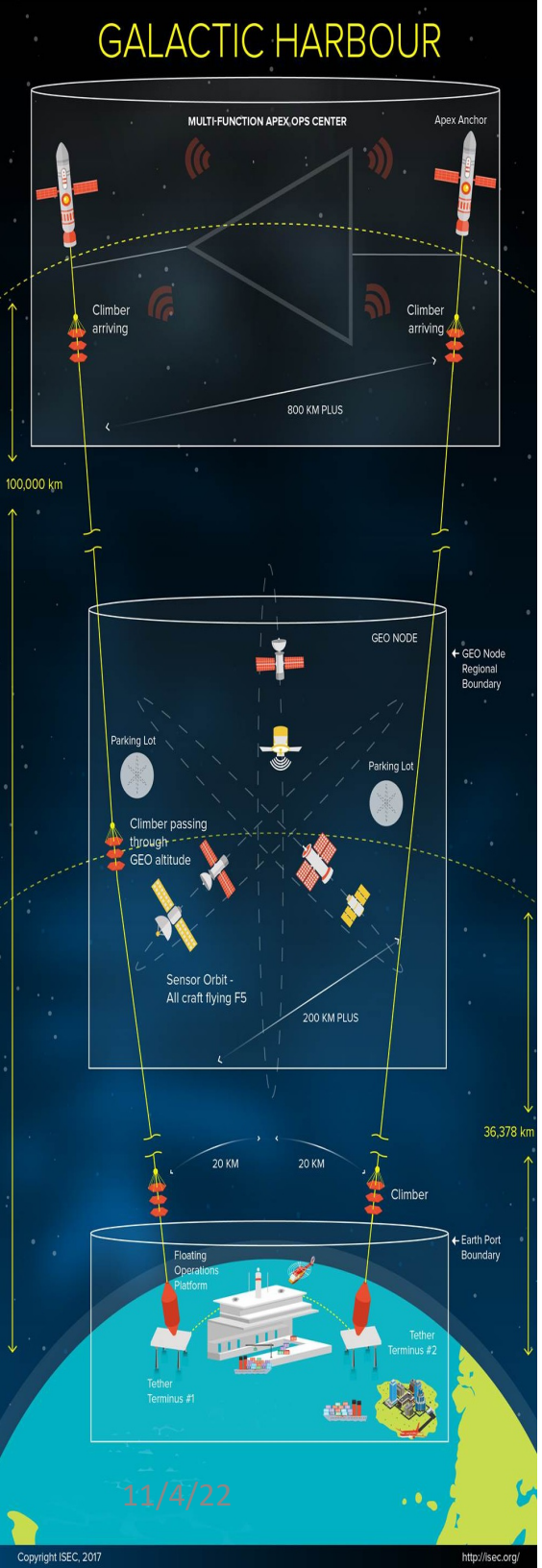
1. The ISEC team has been assessing the technology feasibility situation since 2008.
2. Recently the team has begun an open dialog with members of industry, academia, and others who could be the deliverers of developmental solutions.
3. Industry (especially) will show how the needed technologies are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

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?

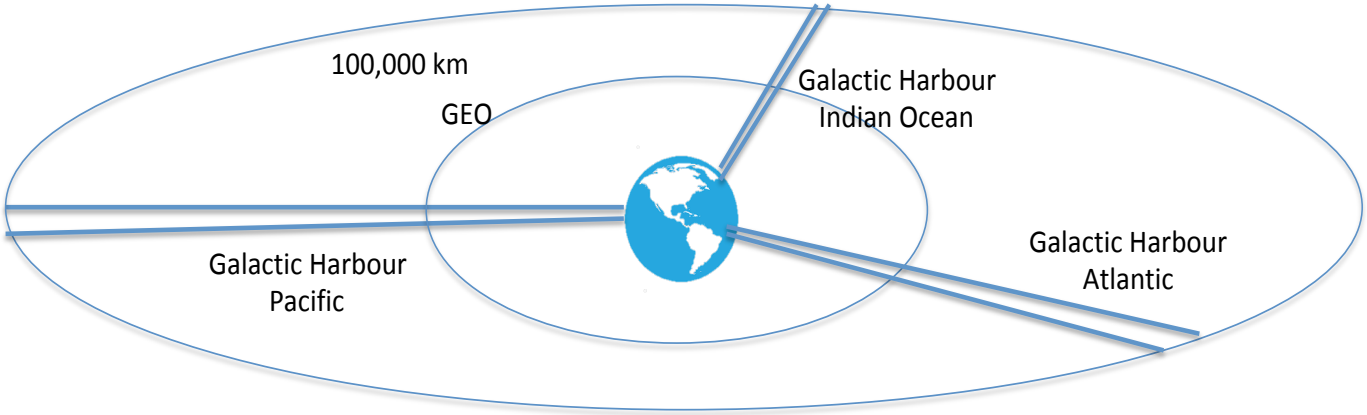
61 days

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

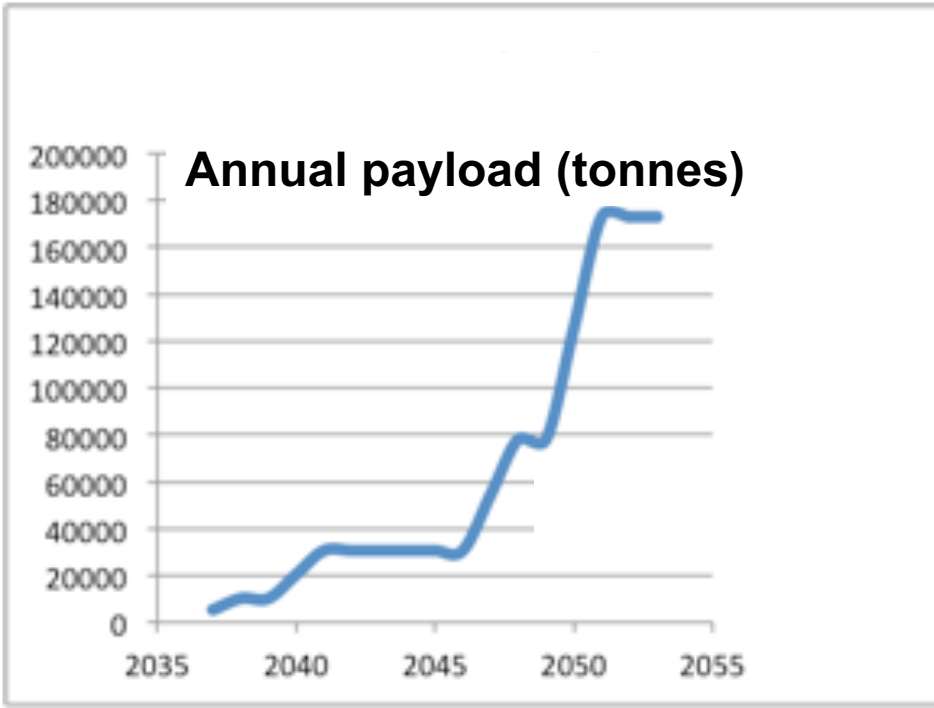
– 7 climbers a week/elevator

– 14 tonnes each, x2 x3

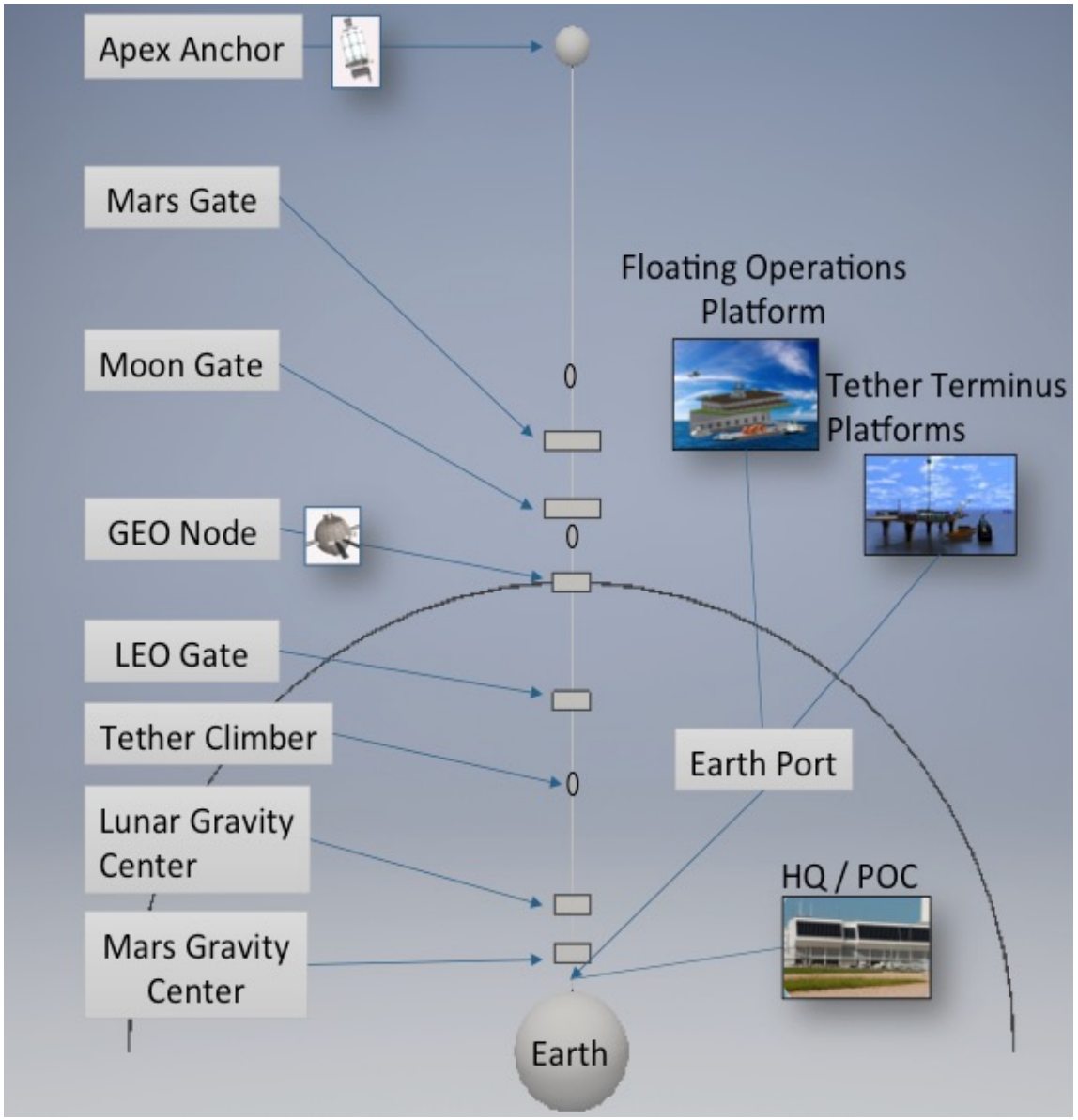
or 30,000 tonnes/yr

– expanding to 80 tonnes each

or 170,000 tonnes/yr



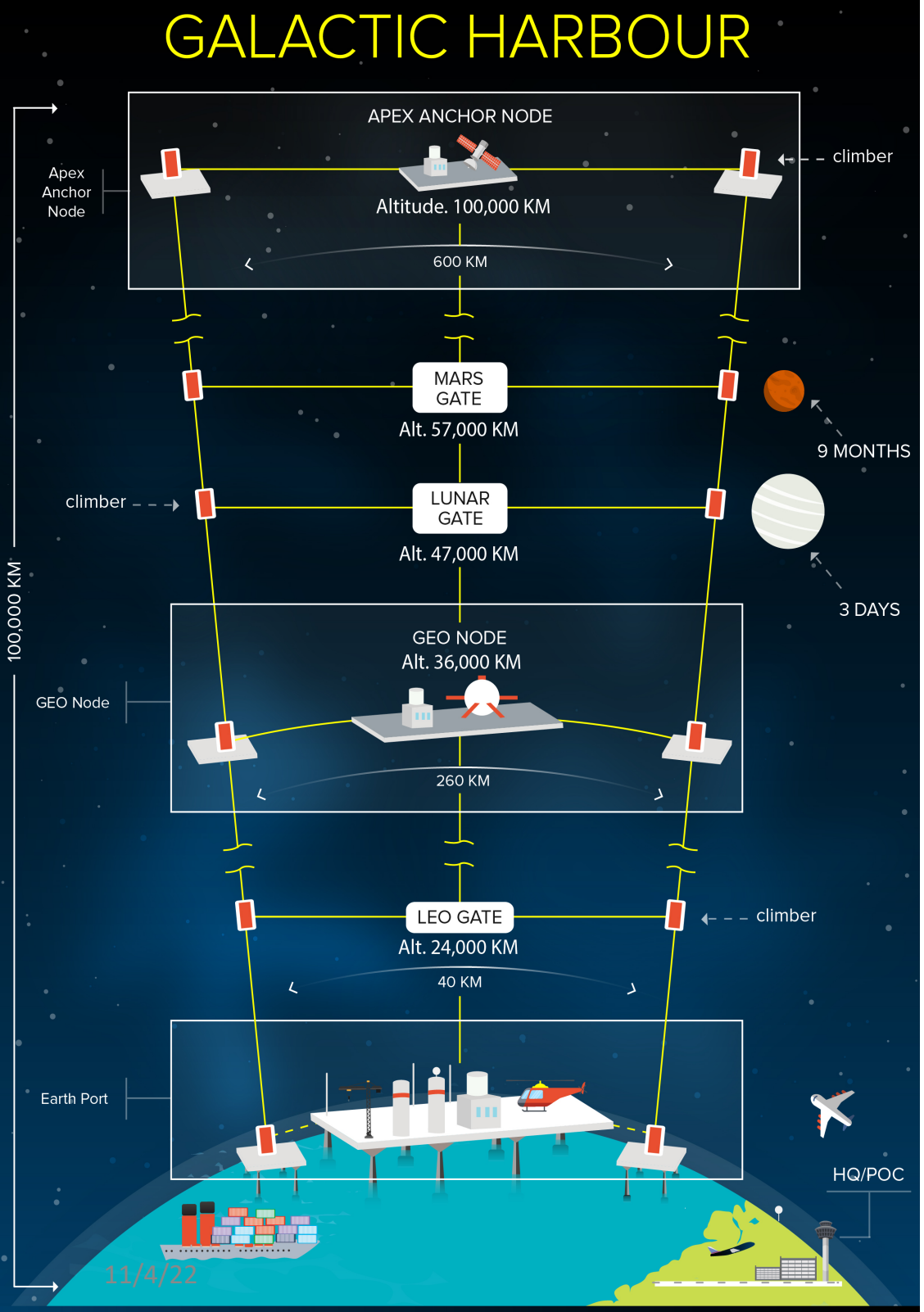
Lexicon for a Space Elevator



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

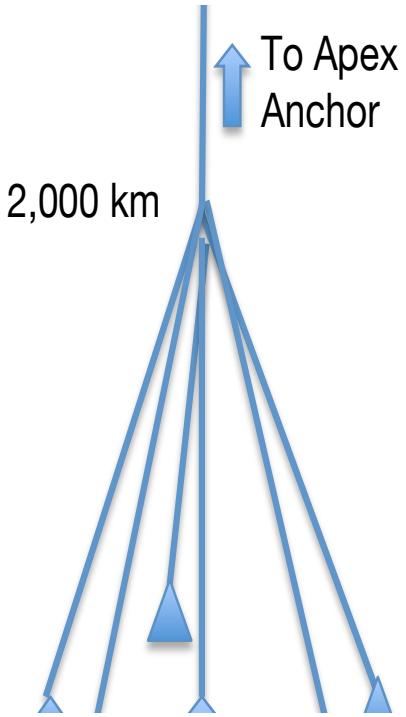
Two Reports and seven pg summary in “Start Now” work book.

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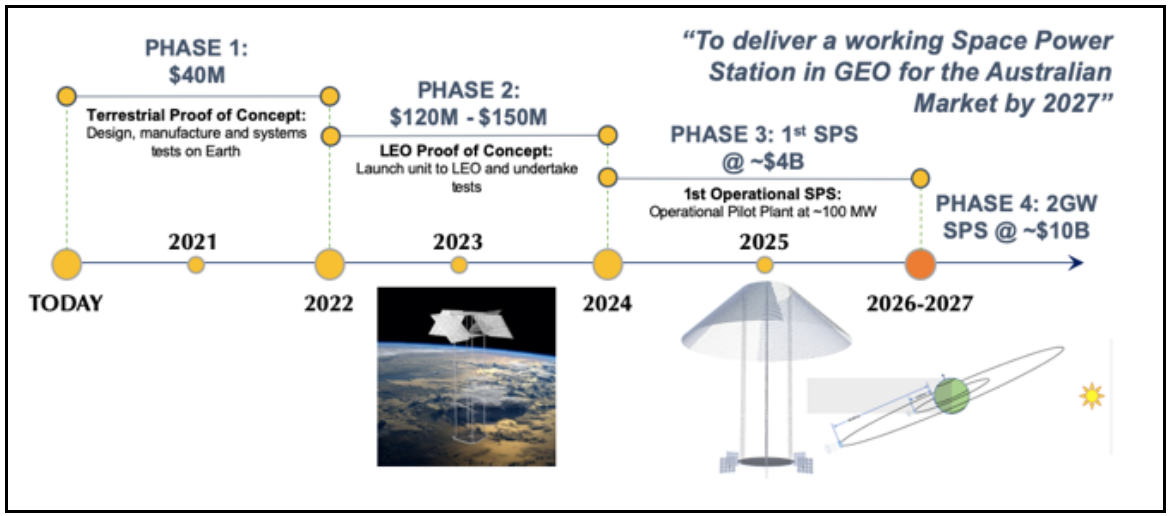
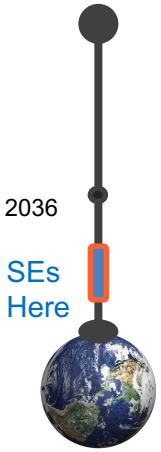
2019	The Road to the Space Elevator Era - IAA IAA = International Academy of Astronautics (https://iaaspace.org)
2014	Space Elevators: An Assessment of the Technological Feasibility and the Way Forward - IAA
2014	The Space Elevator Construction Concept – Obayashi Corporation (https://www.obayashi.co.jp/en/news/detail/the_space_elevator_construction_concept.html)

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.



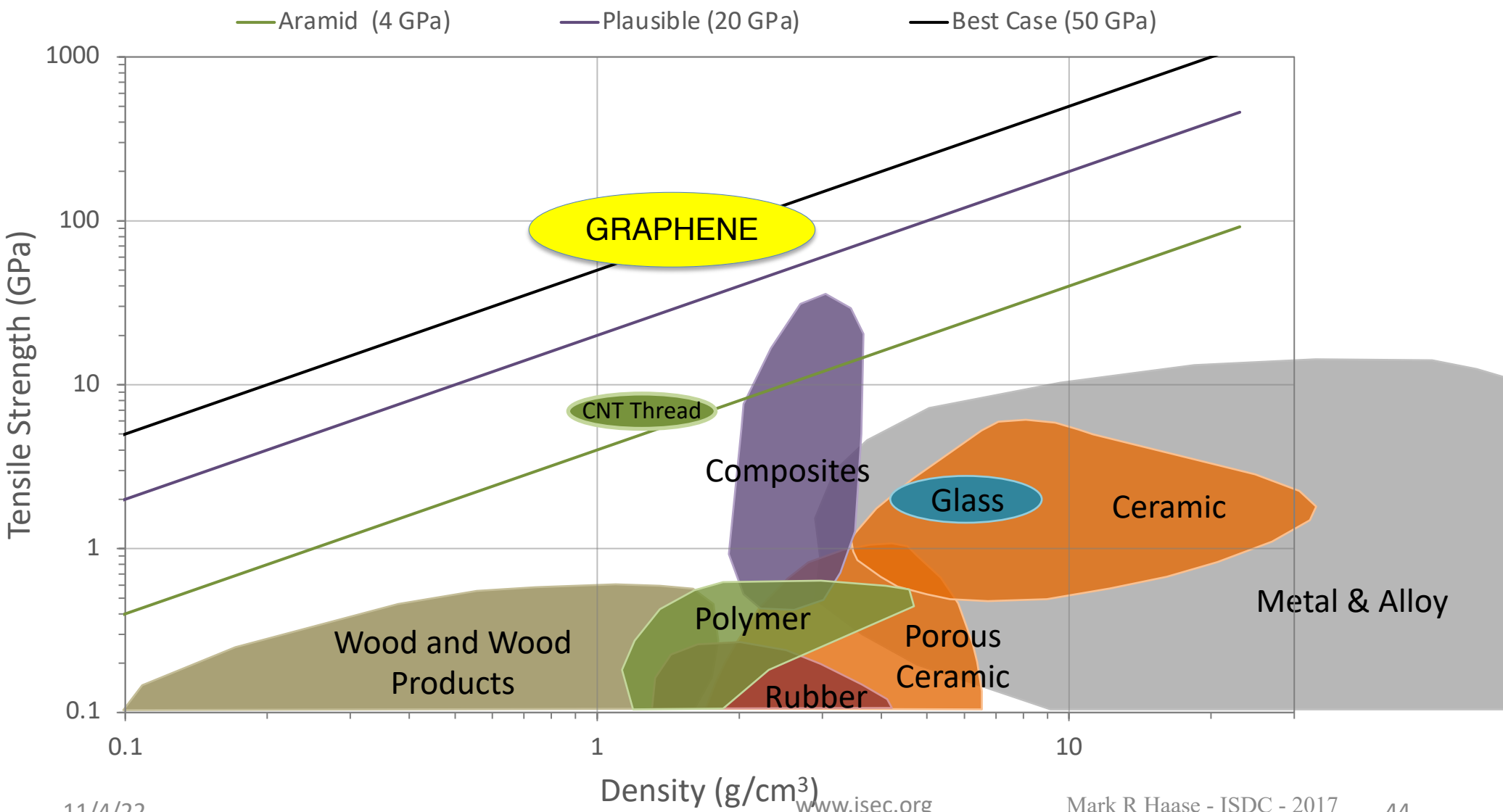


Space elevators are needed for high-throughput, massive hardware deployment.

- 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

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.

Bus Schedule to Mars

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

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every day	Atlantic #2	Moon	14 hours	+ 14 hours	

How did we get here?

- Dr. Brad Edwards and NASA NAIC Phase One & Two
  - We can do it today [CNT's have promise]
  - NASA's Cenntineanal Challenges
- International Space Elevator Consortium
  - Technical Conferences and Year Long Studies
- International Academy of Astronautics
  - Conferences with technical sessions
  - Two major studies (4 year – 30 + space professionals each)
- Obayashi Corporation
  - Major Study shows People and Space Solar Power by 2050
  - Continuous support on parallel efforts

SE History

- Original thoughts: Jacob's Ladder, Jack and the Beanstalk.
- Engineering Concepts: Tsiolkovsky-1895 Artsutanov-1960, Isaacs-1966, Pearson-1975
- NASA Conference: 1998 Smitherman
- Engineering Concept: in 2000, Edwards proposed, as a NASA Innovative Research project, that it could be accomplished with a new material, carbon nano-tubes.
- Global Feasibility Analysis: IAA Study on Feasibility of Space Elevators published, 2013.
- Construction Concept: Obayashi Corporation presents new concept

Conferences & Competitions

- ***The Space Elevator*** – Dr. Edwards 2002
- International Space Elevator Conference [2002, 03, 04]
- Space Exploration/Space Elevator Workshops [2005, 07]
- NASA Centennial Challenges [Power Beaming and Strong Tether – 2005, 06, 07, and 09]
- Japan Space Elevator Technical & Engineering Competition [JSEA 2009, 10, 11, 12, 13]
- International Astronautical Congress Sessions on Space Elevators e.g. [annually from 2004 through 2019]
- International Space Elevator Conferences [annually from 2008 through 2019] with robotic climber competitions in parallel
- EuSpEC, European Space Elevator Challenge [2011, 12, 13]
- BEST Regional Robotics Competitions [2012]
- FIRST Regional Robotics Tether Climber Competitions [2012, 13]

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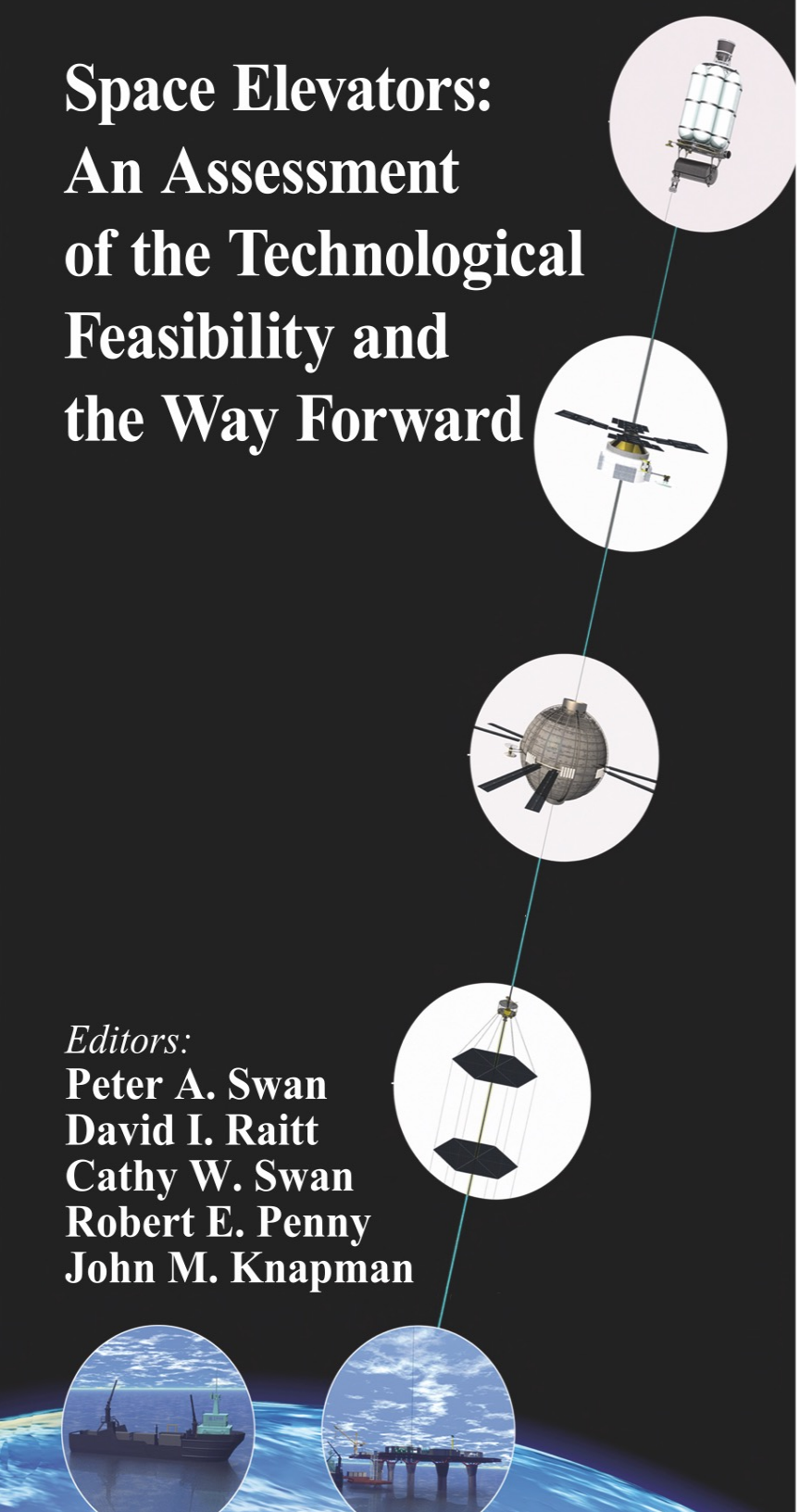
Ten Videos Explaining Modern Day Space Elevators

Modern Space Elevator Explanations	***Speaker***
Why Space Elevators and Customer Demands/Visions?	Pete Swan
Architectural Features of Galactic Harbours	Michael Fitzgerald
Green Road to Space Leads to Environmentally Friendly Lifts	Jerry Eddy
Space Solar Power Enabled by Space Elevators	David Dotson
Economic Benefits of Space Elevators	Kevin Barry
Graphene is Last Puzzle for Development	Adrian Nixon
Dual Space Access Architecture – Complementary to Rockets	Pete Swan
Tremendous Body of Knowledge about Space Elevators	Dennis Wright
Permanent Space Access Infrastructure - Global Transportation Intermodalism	Vern Hall

All videos at: https://www.isec.org/ready-to-go

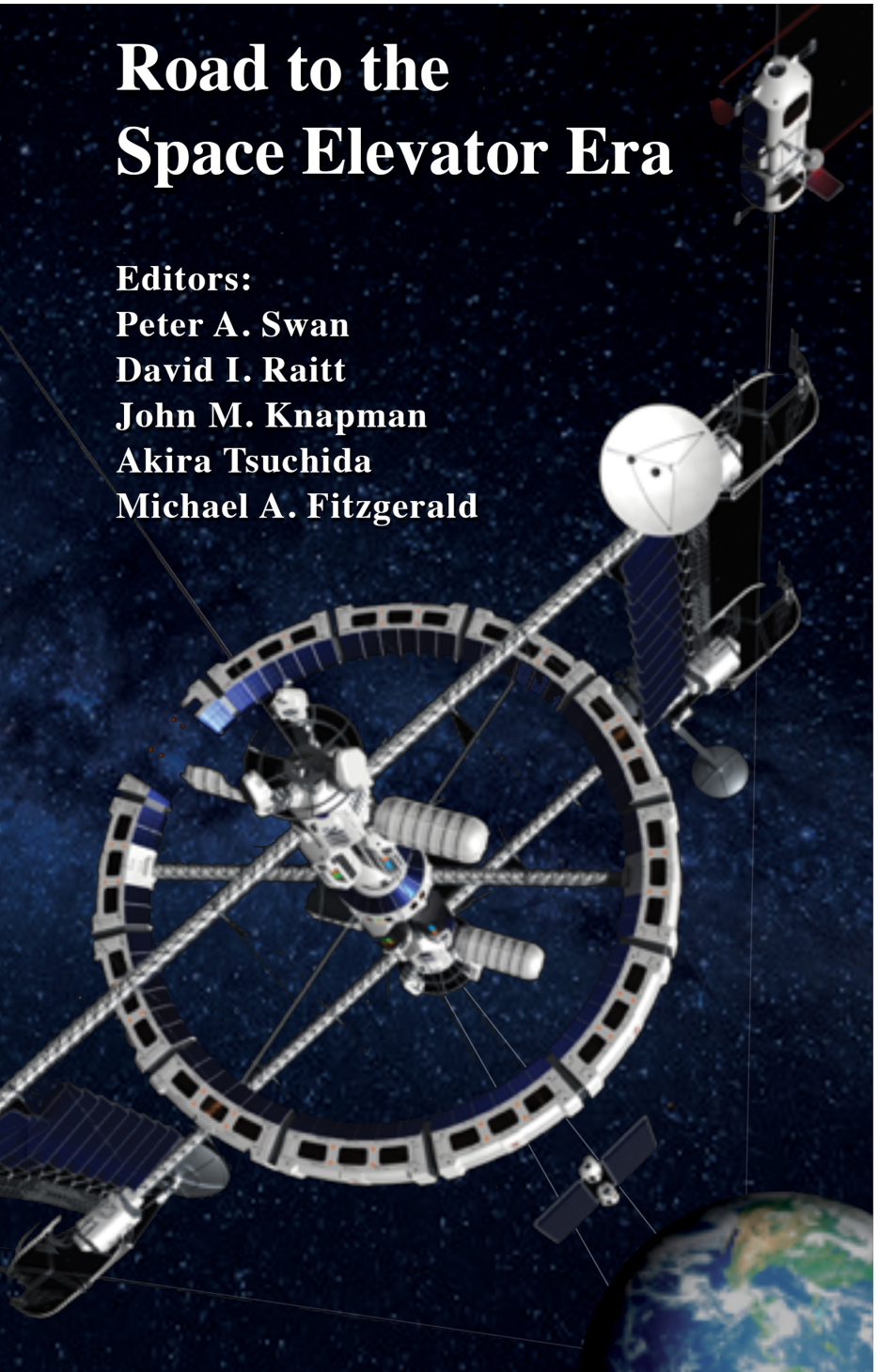
Several more videos and podcasts are or will be up on site.



International Academy of Astronautics

- IAA four year study
- 45 space experts
- Started at Edwards' architecture
- 350 page major study report
- Conclusion:

The Space Elevator Seems Feasible



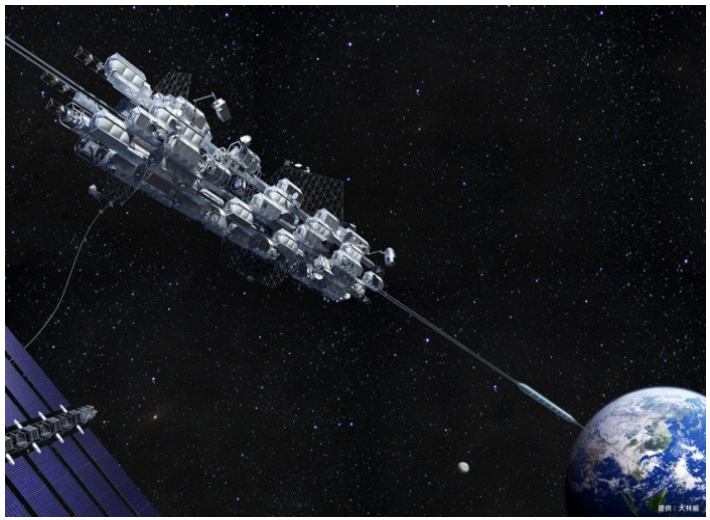
International Academy of Astronautics

- IAA four year study
- 30 + space experts
- Parallel with ISEC
- 200 page major study report
- Conclusion:

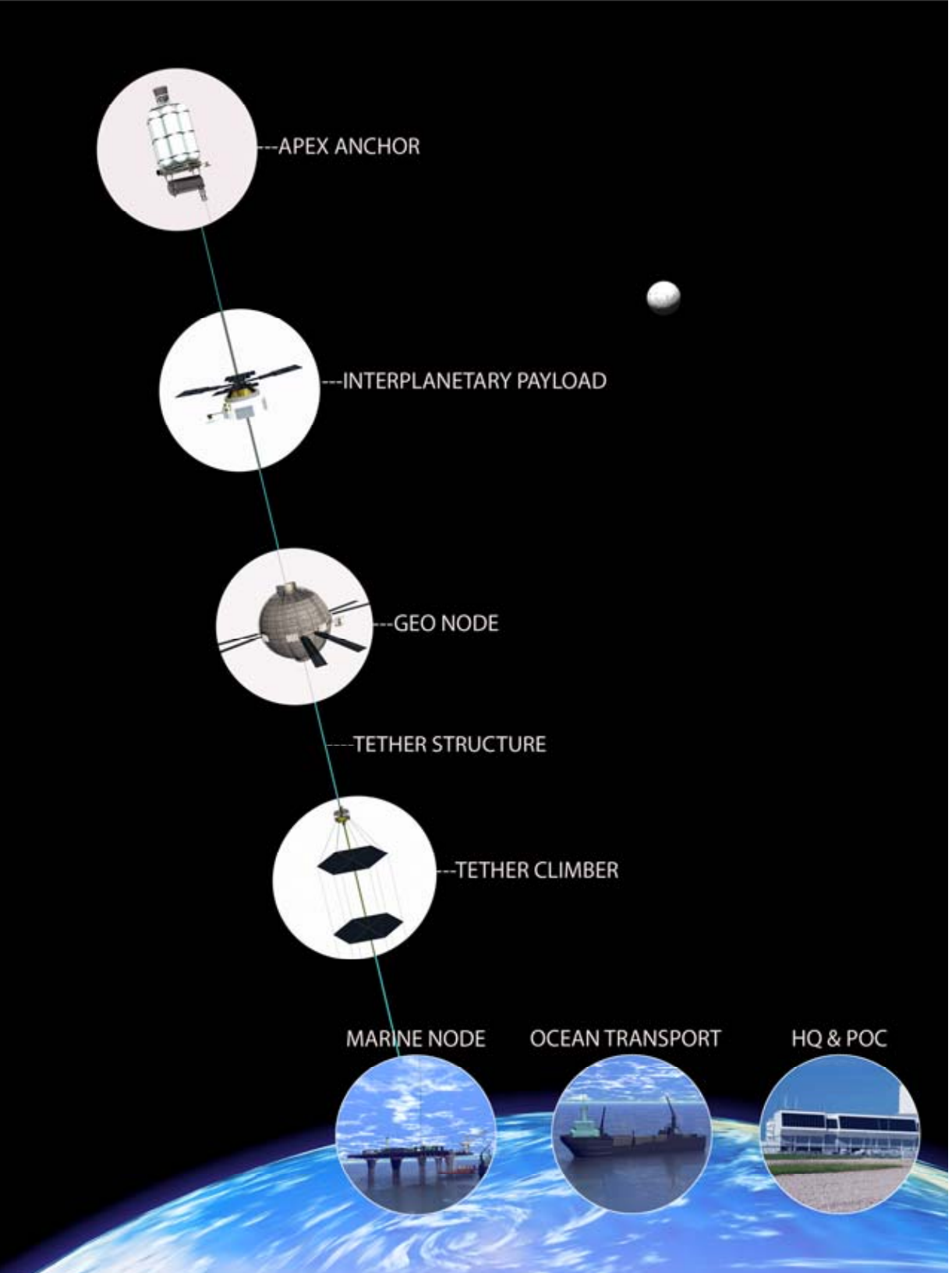
Technologies are beyond Preliminary Readiness Assessment

Obayashi Model Overview - Tether

Mass of cable	20 tons (Total 6,820 tons)
Cable length	96,000 km
Tensile strength	150 GPa (=115 MYuri*)
Safety factor	2 per cable (total 2 cables)
Cable taper ratio	1.0 (earth): 2.6 (GEO):2.0 (space)
Mass ratio of cable to counter-weight	1 (cable) : 0.92 (counter-weight)
Mass of the first reinforcement climber	440 kg per cable
Ratio of reinforcement	0.0115
Times of reinforcement	510



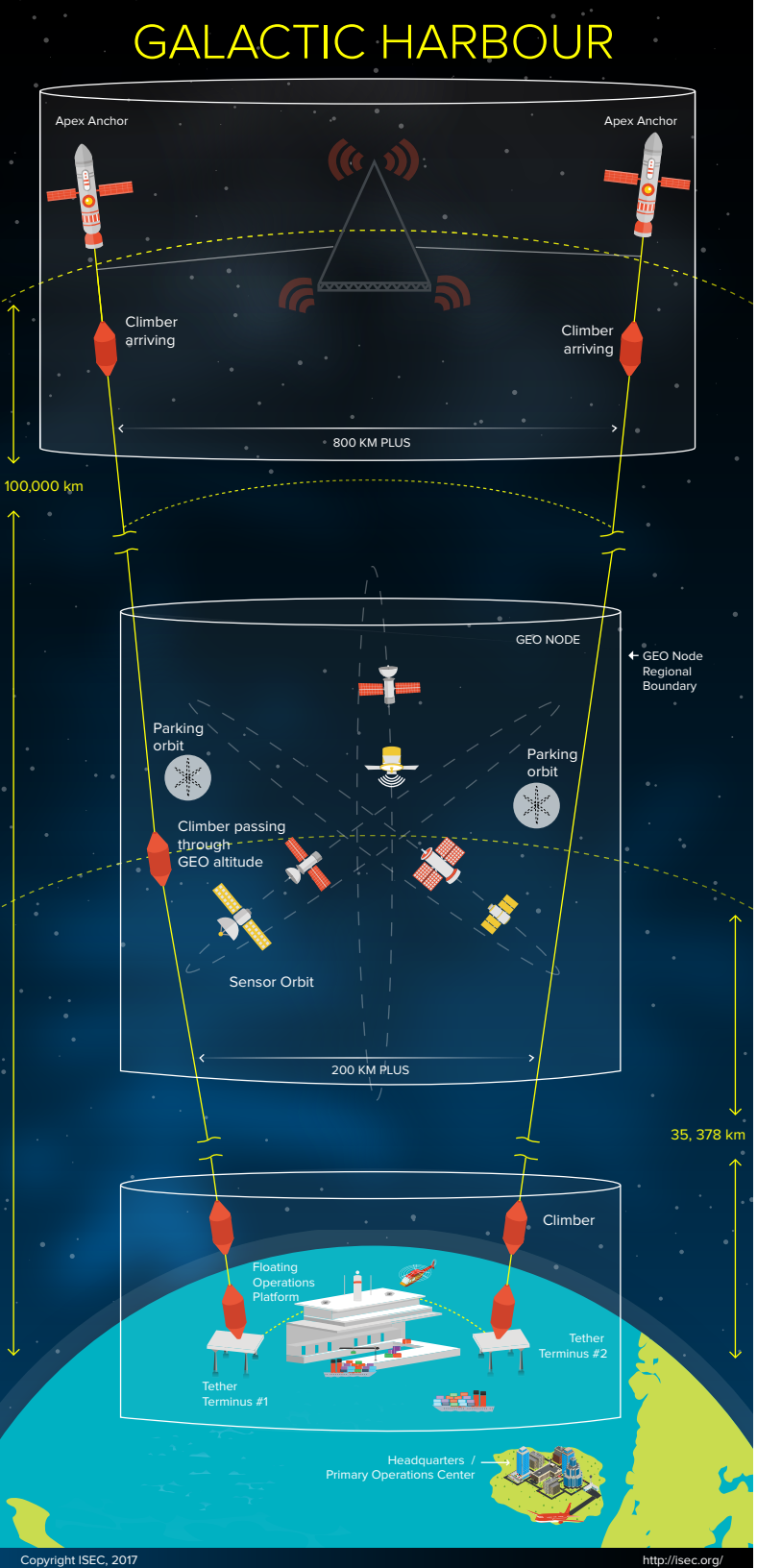
Myuri: specific strength = Tensile strength, Gpa/ Density of CNT, g/cc



What it did Look Like

- Headquarters
- Earth Port
- Tether Climbers
- Geosynchronous Station
- Interplanetary Payloads
- Apex Anchor

chasedesignstudios.com



Vision of the Future

Galactic Harbour

Galactic Harbours will Unify Transportation and Enterprises Throughout the Regions.

The Galactic Harbour is the unification of Transportation and Enterprise

The Main Message

Space Elevator Transportation System is the 'main channel' in the Galactic Harbour.

- *GEO Node*
- *Earth Port*
- *Apex Region*
- *Climbers*
- *Tethers*
- *HQ & Ops Center*

Businesses flourish as part of the Space Elevator Enterprise System

- *Business support to Operational Satellites*
- *Interplanetary Efforts within reach*
- *Power and Products delivered to Earth*
- *Research*

Why you should join ISEC?

- Fund research into the development of Space Elevator
- Spread the word that Space Elevators are “Real”
- Help recognize the fact that Space Elevators Will make Earth a “space faring civilization.”
- Help provide transportation infrastructure that will enable true entrepreneurial enterprises in space and beyond
- ISEC website has many ties to information

David Letterman’s Top Five Reasons (sorry-stole this approach)

5] You want to know where your mother’s yarn has gone.

#4] Bragging rights – be the first on your block to be a card carrying member

#3] Great Pick-up lines at Cocktail Party

#2] Develops your unassailable credibility as a rocket scientist

And, the number one reason to join ISEC is:

#1] Self-Satisfaction at furthering space exploration Priceless!

www.isec.org

Join us for the
Space Elevator Conference

Presented by the
International Space Elevator Consortium

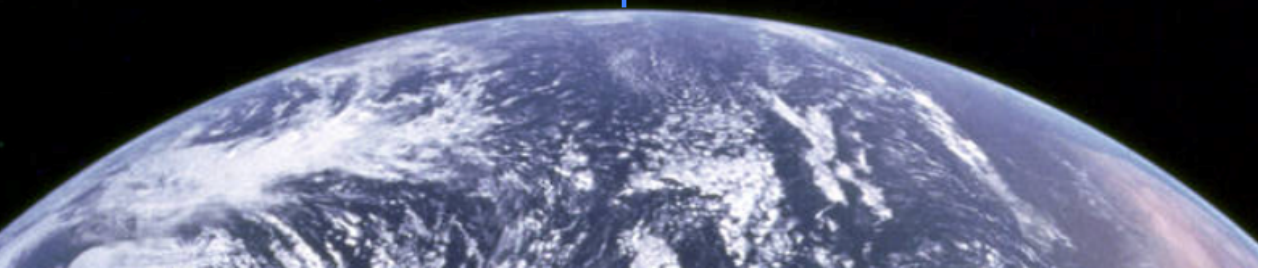
Museum of Flight
Seattle, WA, USA
August 16-18, 2019

Go to:
www.isec.org/sec

Robotics Climber Competition
And Family Science Fest
Held on
August 17th

Come see why the Space Elevator is "Closer than you think!"

Questions?
info@isec.org



Seattle in mid - August is exciting

Final Thought

Space Elevators could be the story of this century. Reliable, safe, and efficient access to space. This transportation capability is close at hand – Probably within 25 years. Space access without rockets! The Galactic Harbour opens the road; it opens the Heavens; it opens the way.

with the final realization:

The Space Elevator is Closer than you Think!