The Space Elevator

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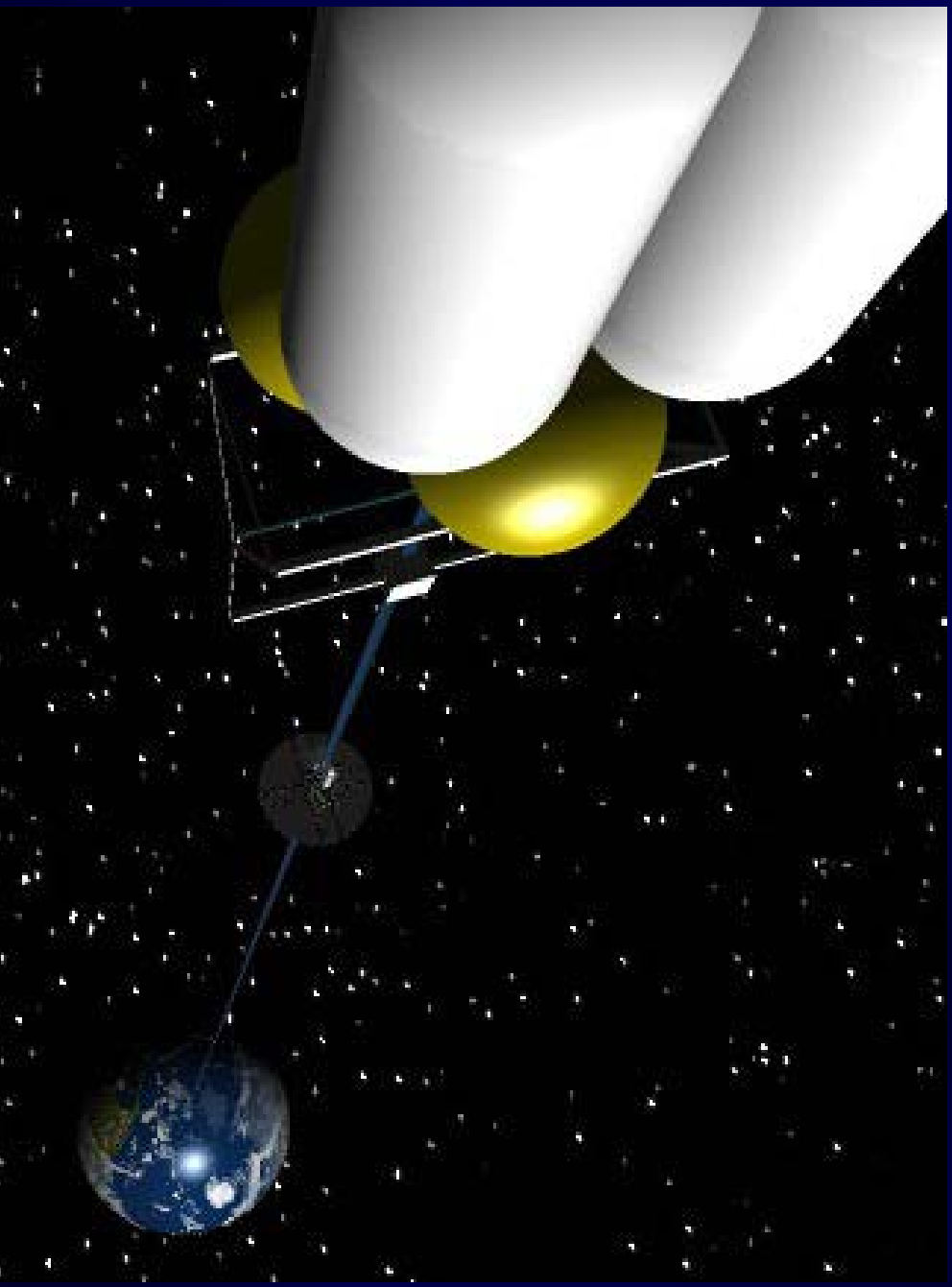
Funded by
NASA Institute for Advanced Concepts

For more information please see: www.niac.usra.edu or www.highliftsystems.com



Proposed System: Overview

- What is a space elevator?
- First, small elevator (20 ton capacity)
- One week ascent time to GEO
- Constructed with existing or near-term technology

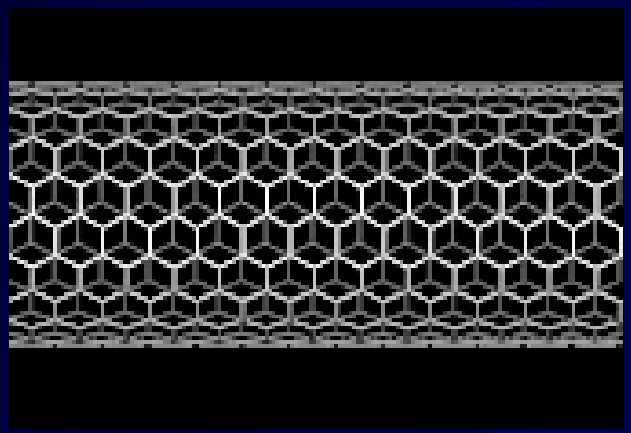
Why build it?

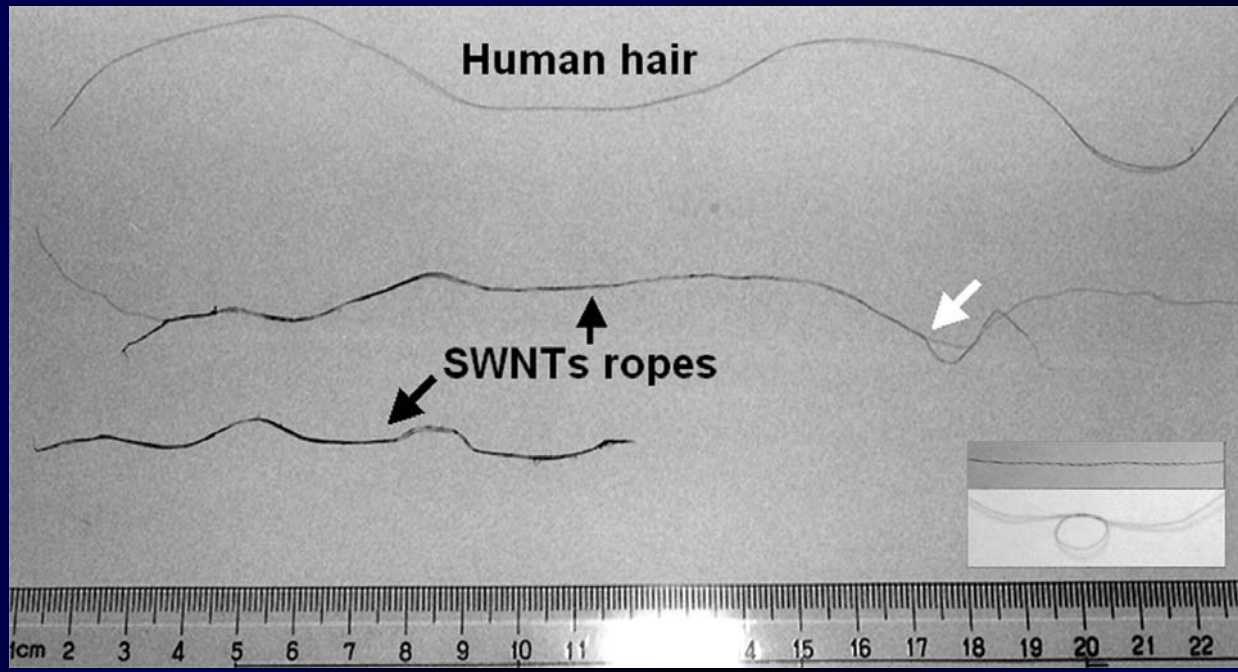
	Now	First Space Elevator
Cost(GEO)	$50,000/lb	$100/lb ($10/lb)
Capacity	4,000 lb/day ave.	12,000 lb/day
Usefulness	• Critical satellites for gov., large corp. and research	• Solar power satellites • Manufacturing • Space resources • Private environ monitoring • Tourism

The Original Problem:

The Cable

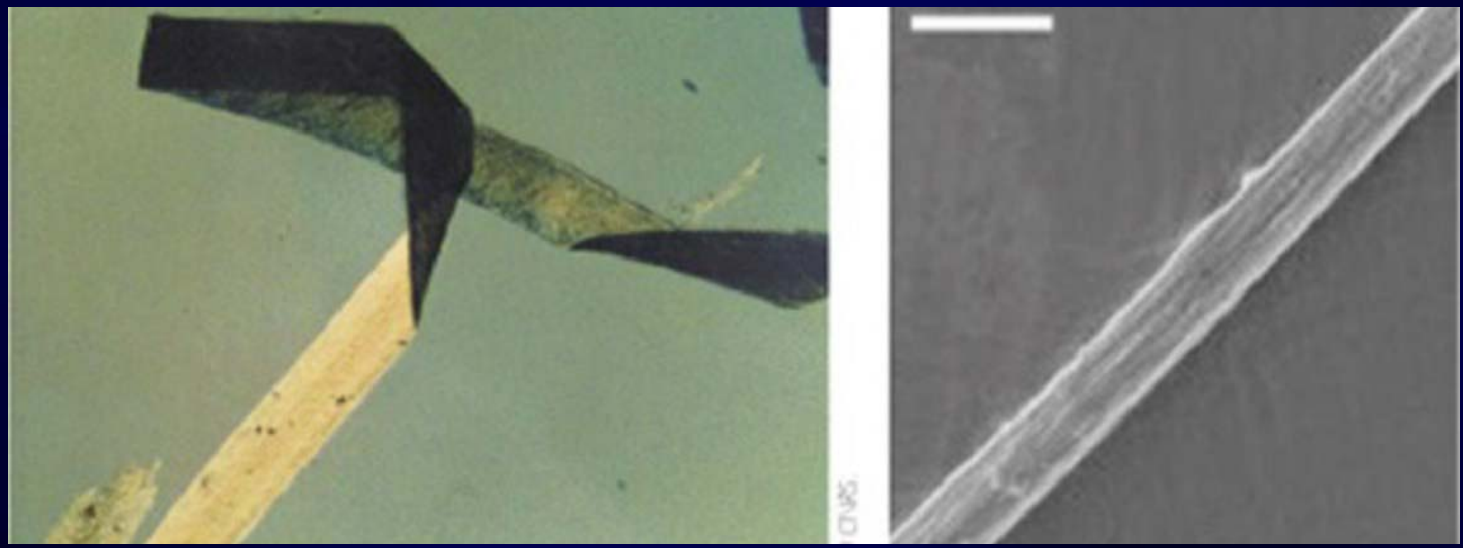
Carbon Nanotubes





- 100 times stronger than steel and 1/5 as heavy
- Production at 1 and 2 tons per week available in 2003

Carbon Nanotubes Composites

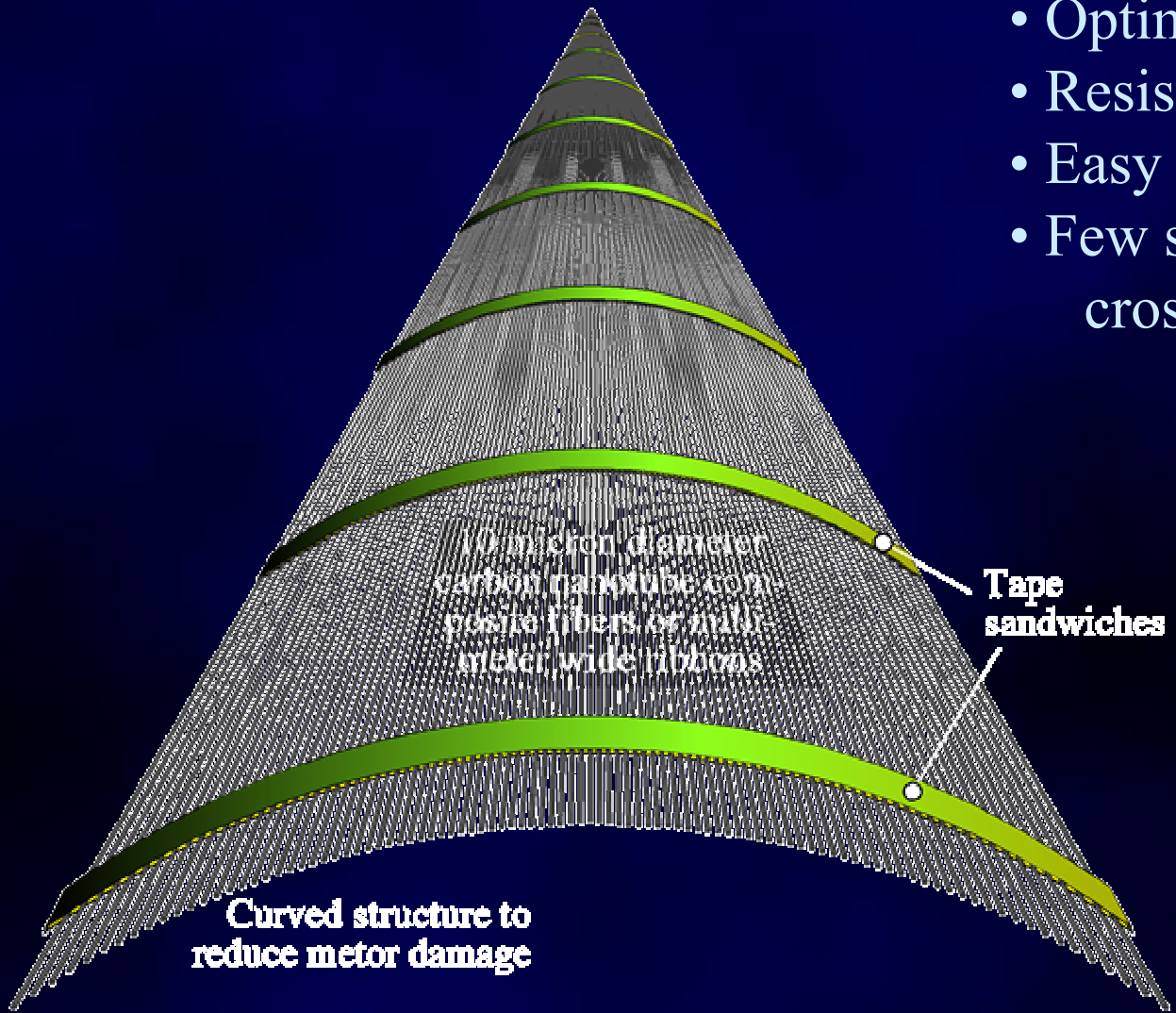


5km continuous 1% CNT composite fiber

- Dispersion, functionalization, incorporation
- Need 100GPa tensile strength (30 times steel)
- 1 to 3 years development

Ribbon Design

- Optimized strength to mass
- Resistant to meteors
- Easy to climb
- Few square millimeters cross section



The Rest of the Problems:

Deployment

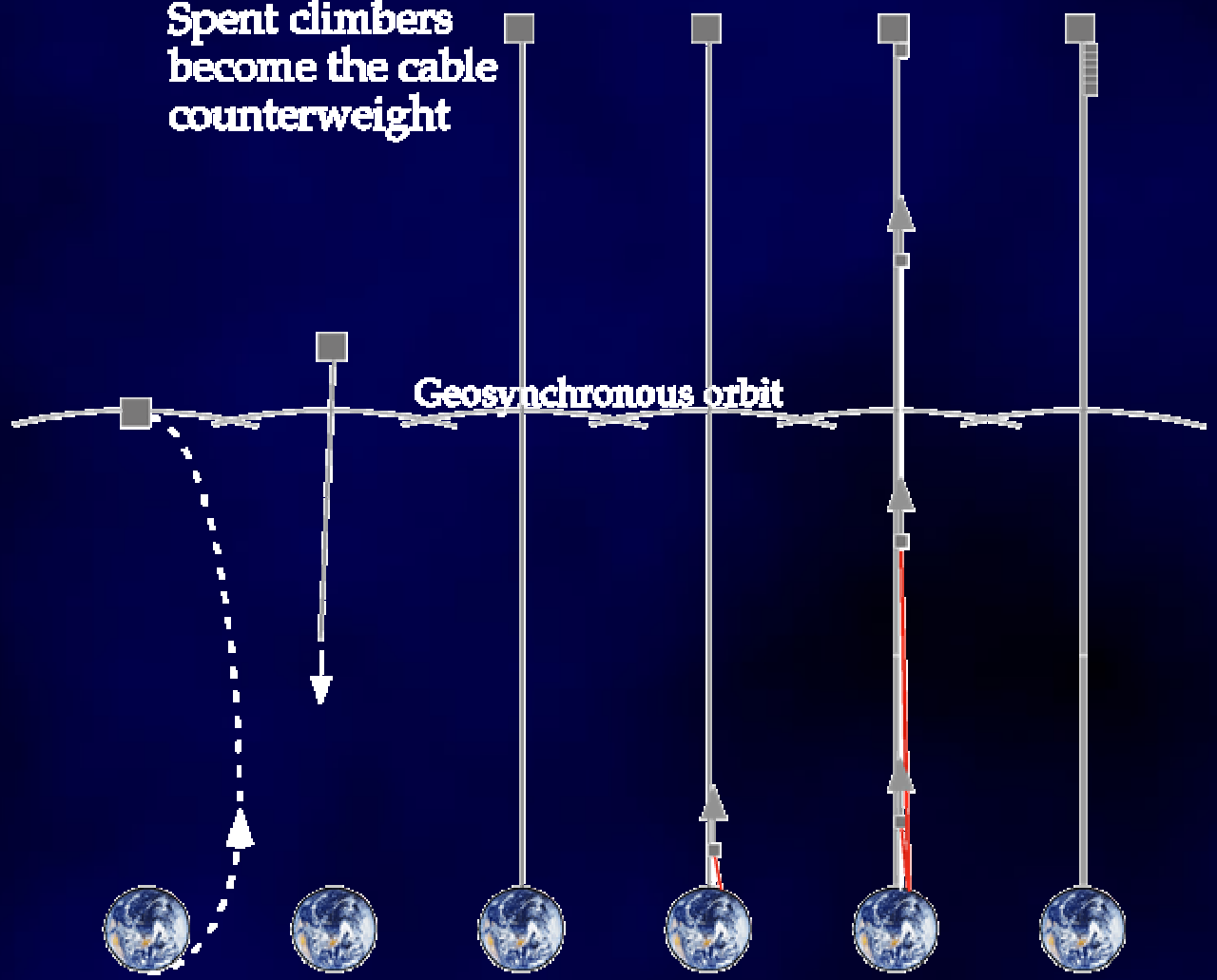
Climber

Power

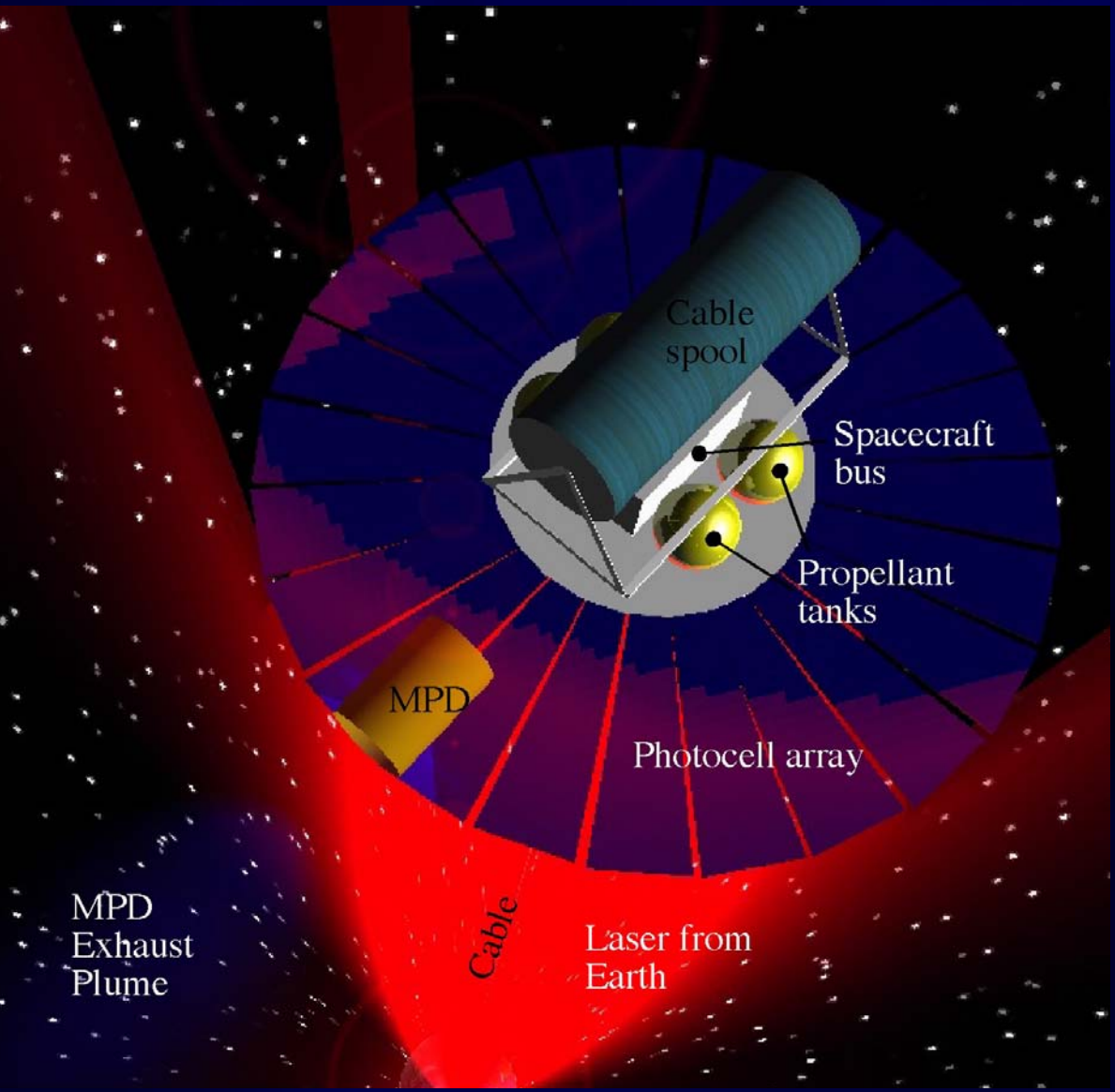
Anchor

etc.

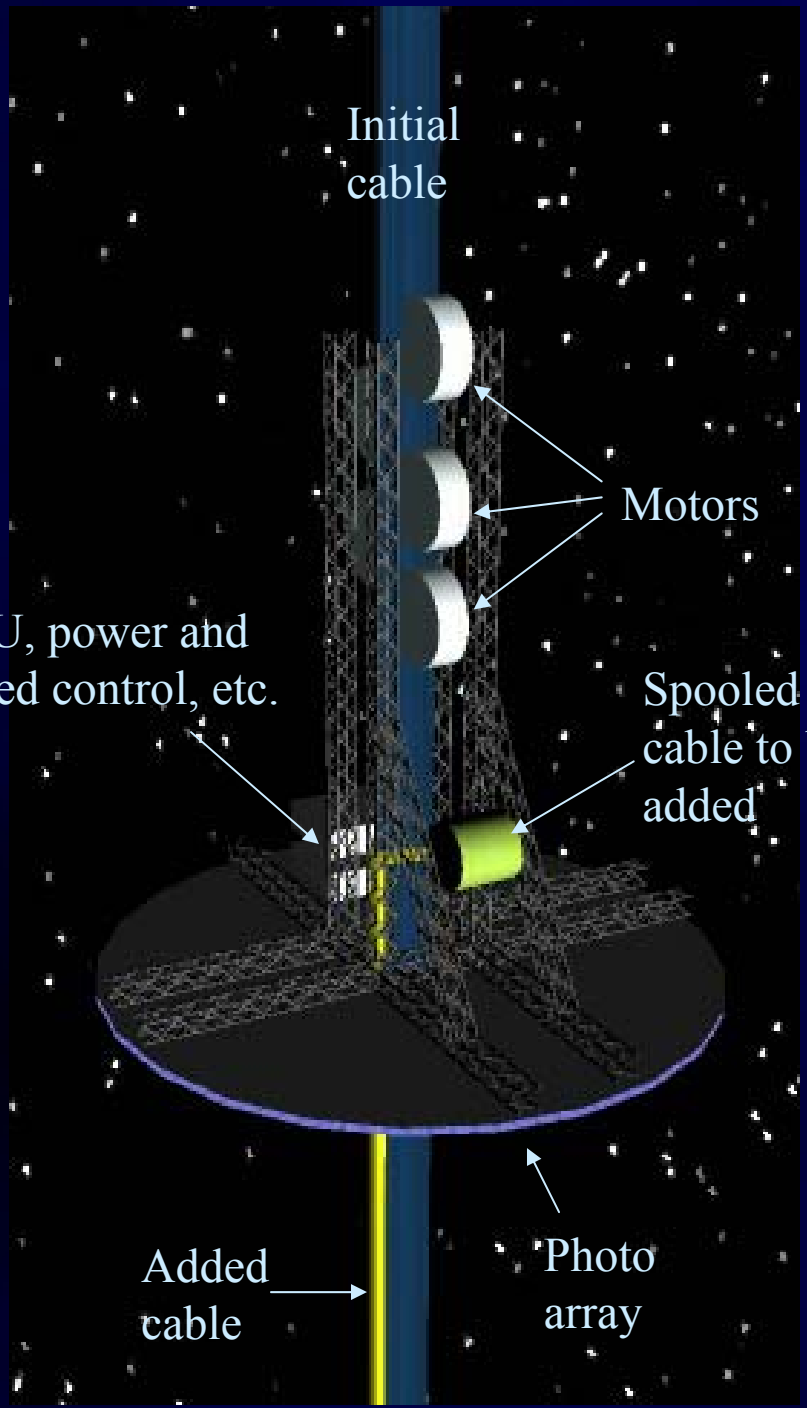
Deployment Overview



Initial Spacecraft



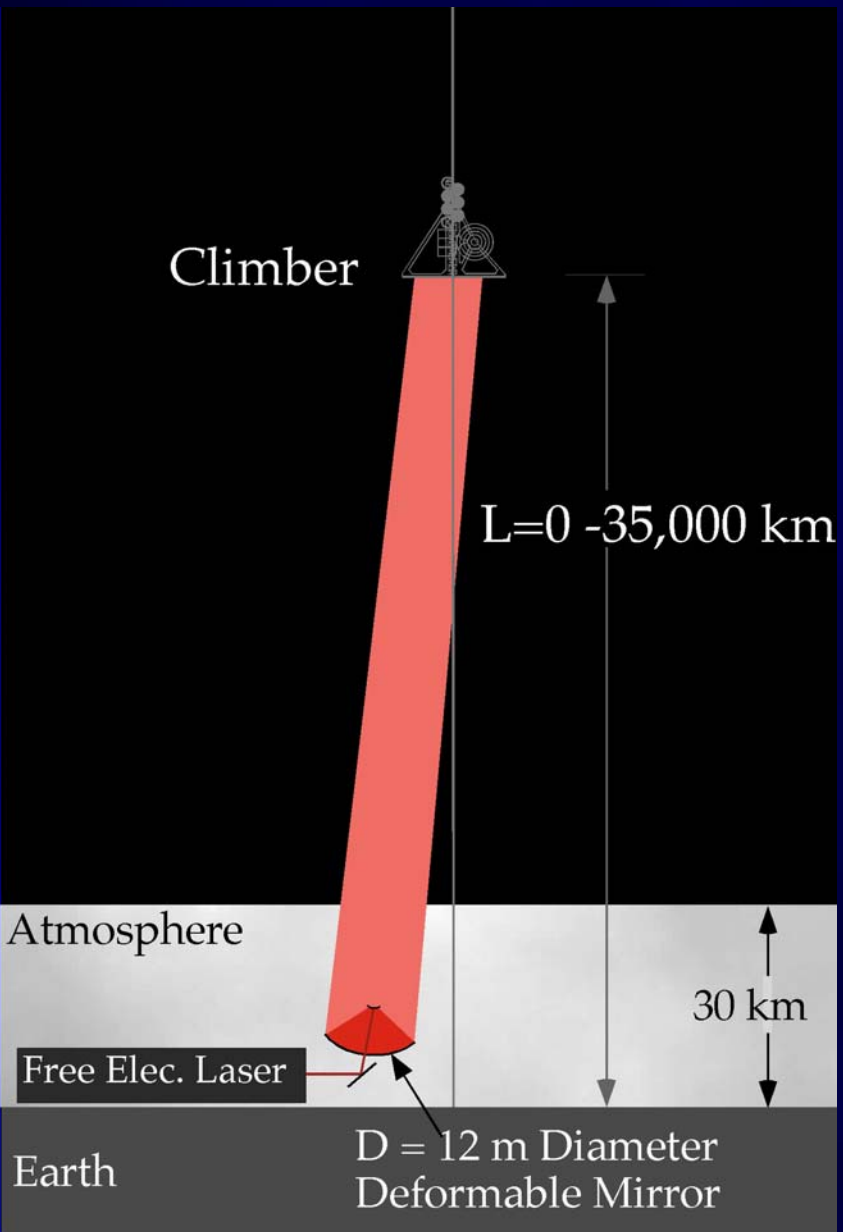
- Largest initial ribbon
- Minimum launch mass
- Minimal development



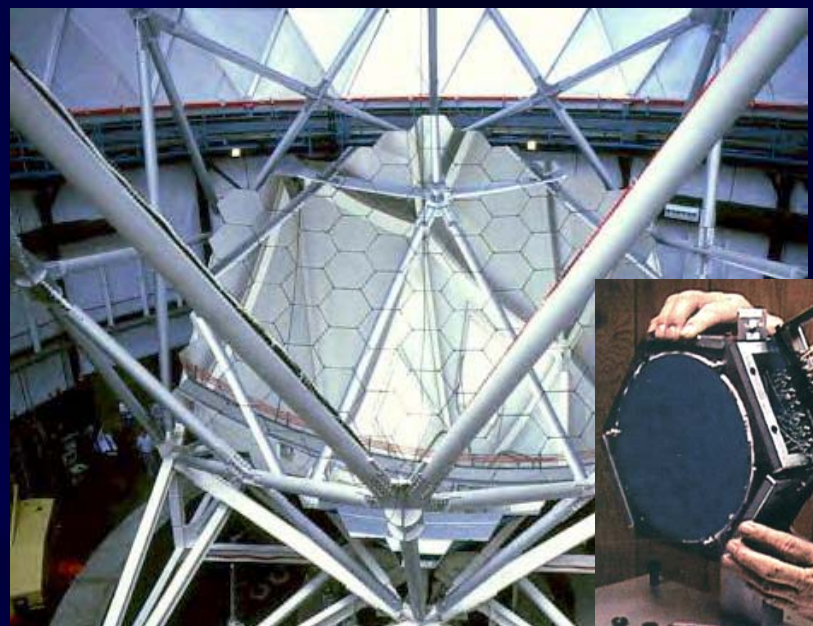
Climbers

- Simple
- Reliable
- Efficient
- Low mass to payload ratio

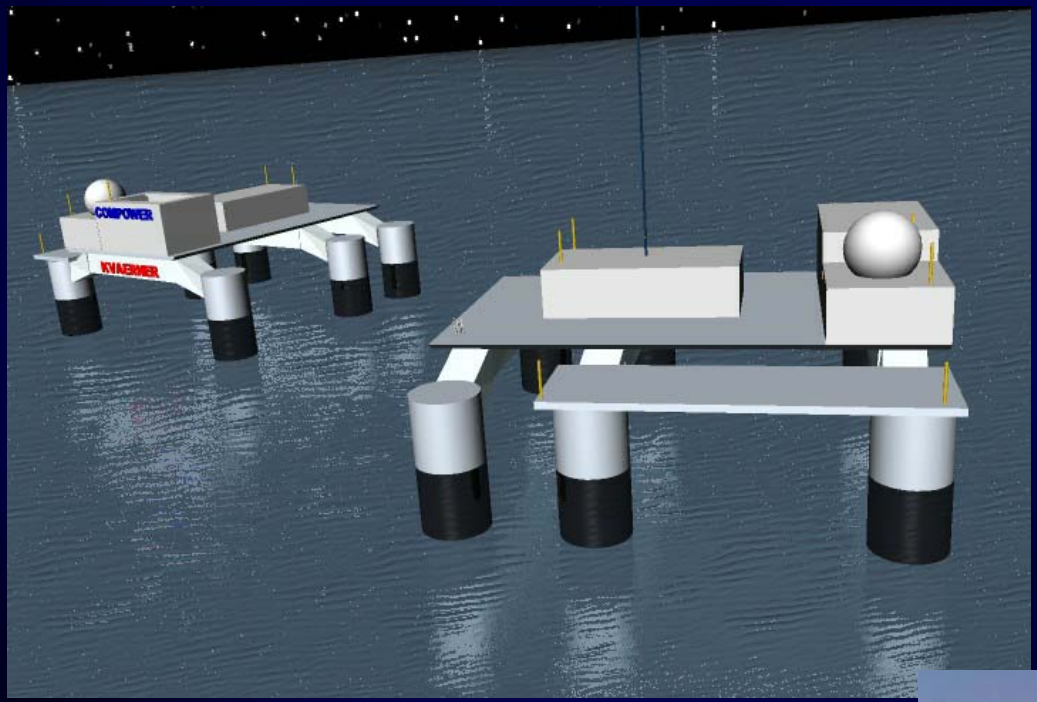
Power Beaming



- Minimal mass on climber
- High net power
- Low recurring cost
- Efficient



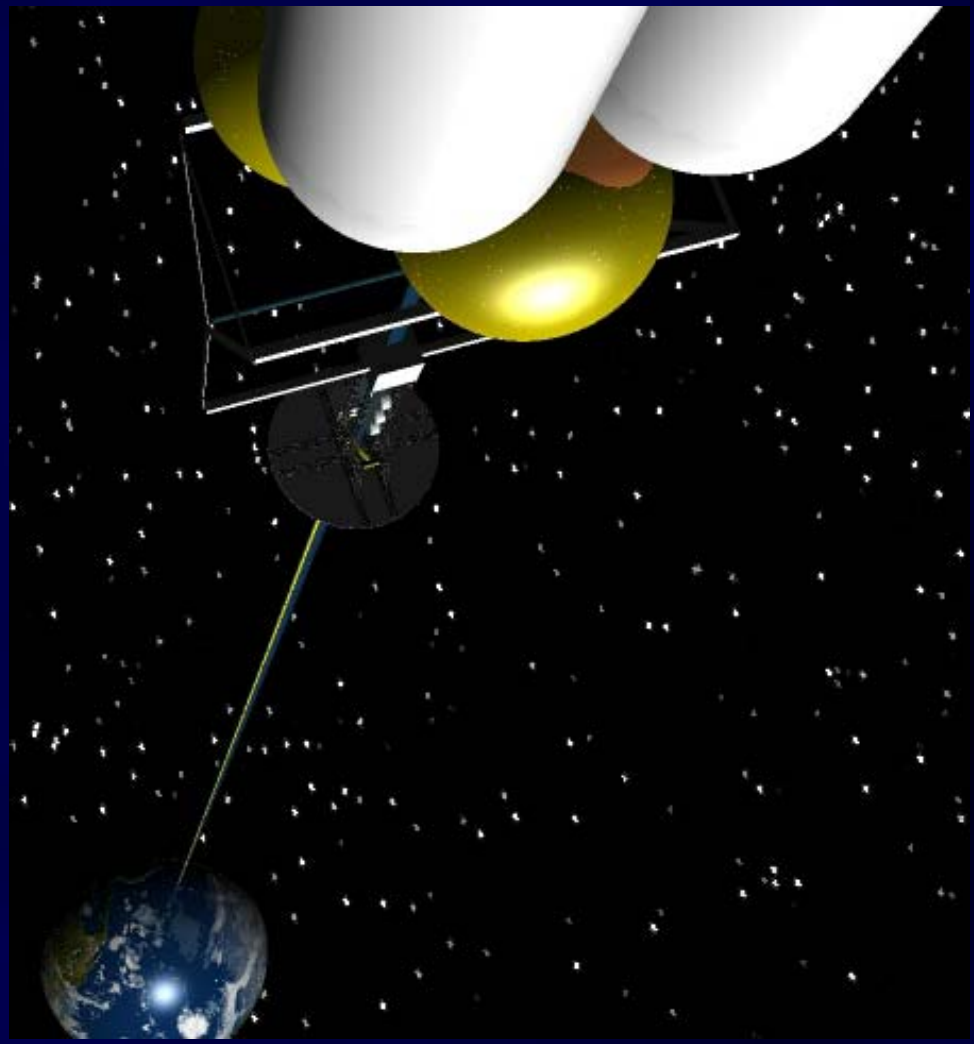
Anchor



- Mobile
- Ocean-going
- Existing technology
- Multi-purpose platform

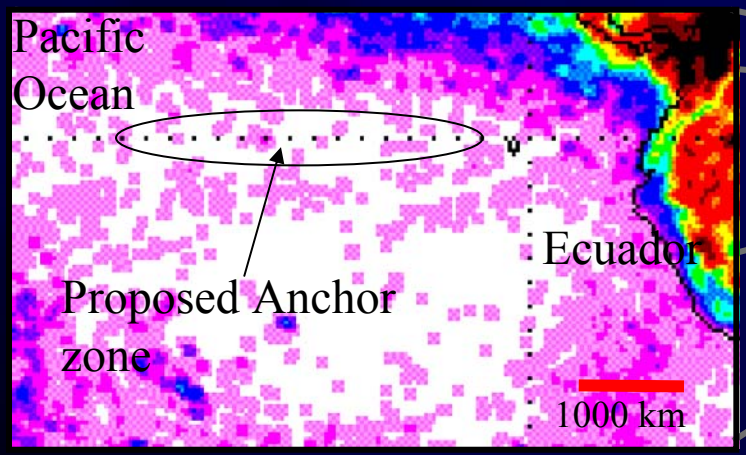
Sealaunch

Full Deployment

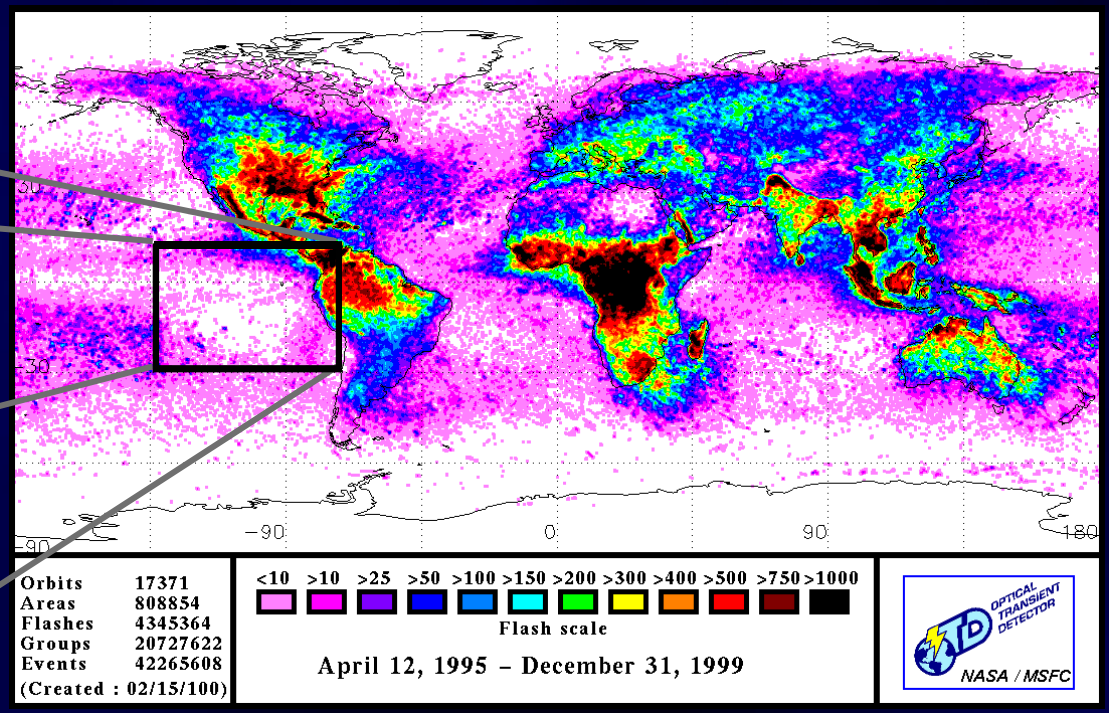


Operational Challenges

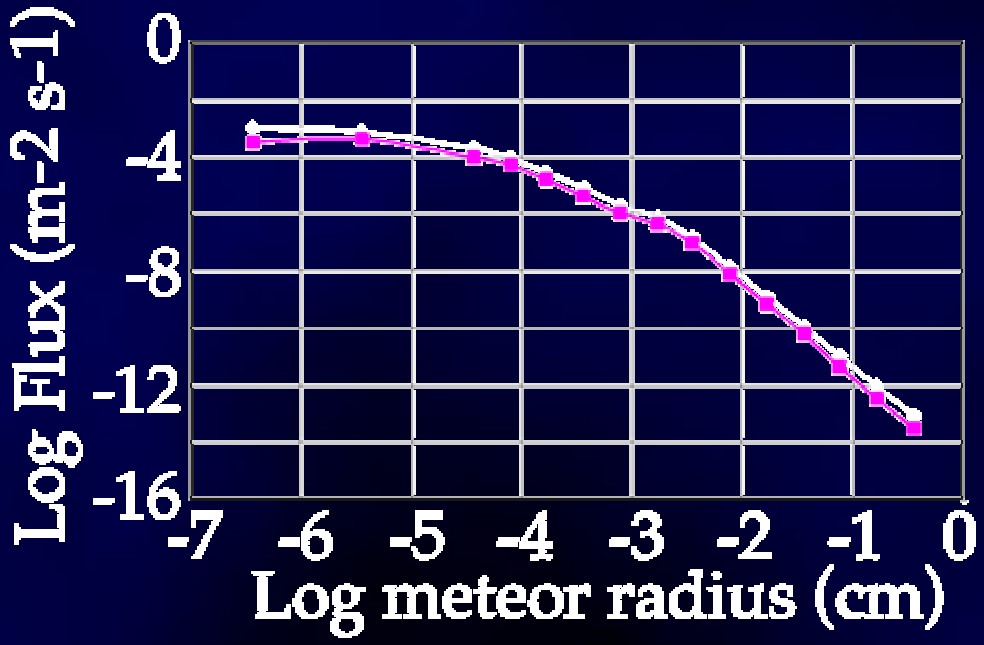
Lightning



Lightning rate: <10 km^{-2} year^{-1}

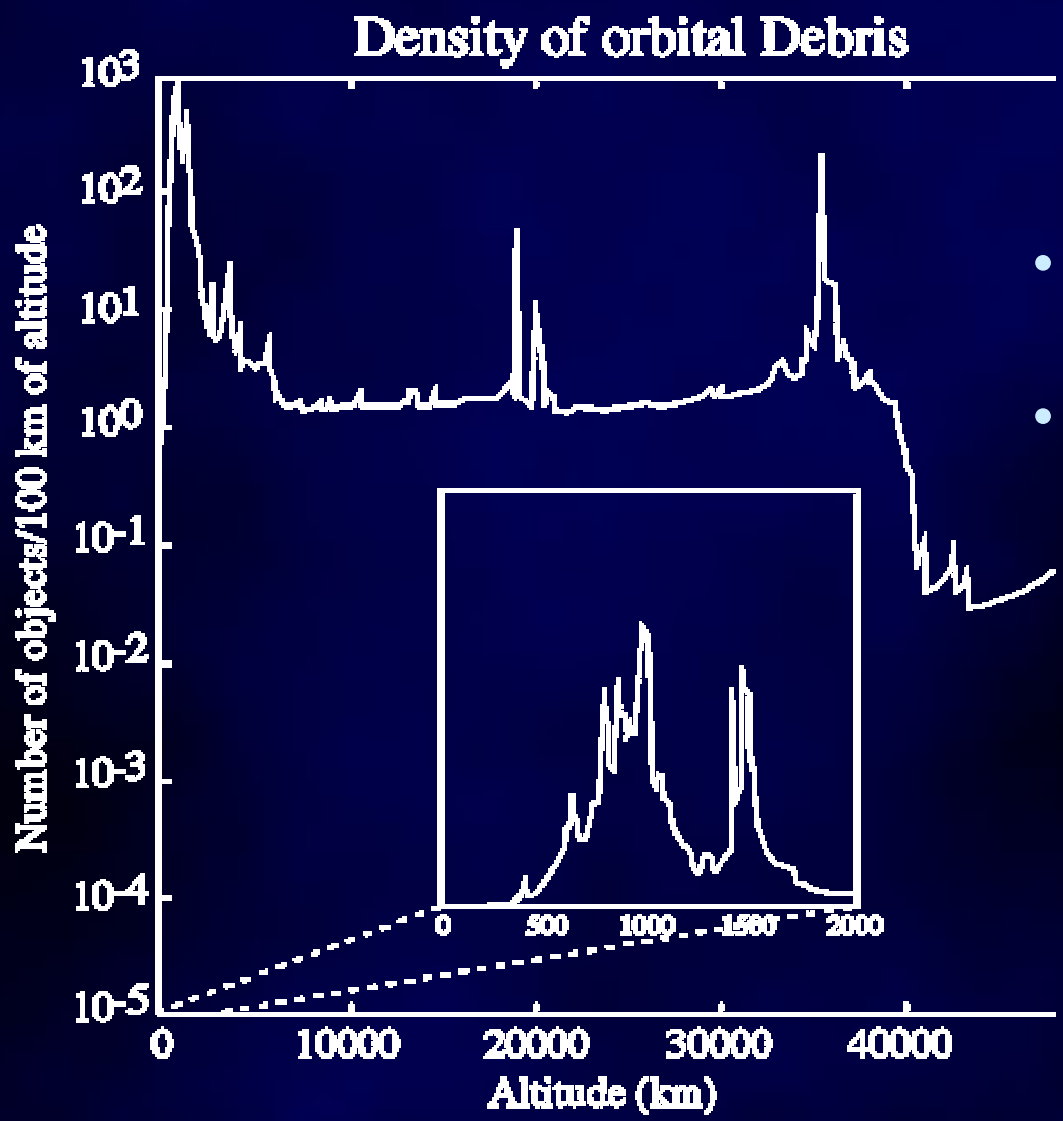


Meteors and Debris



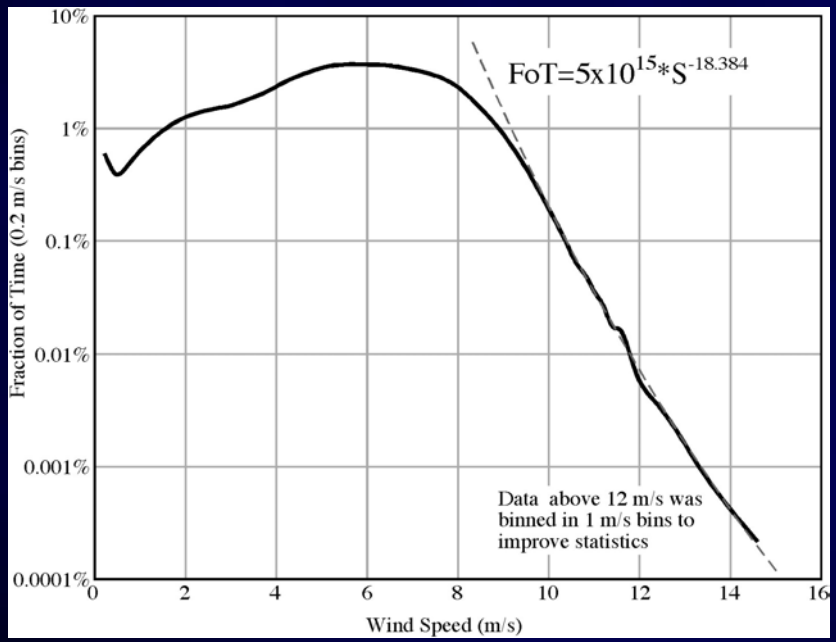
- A 20 cm wide cable will survive for 3 yrs
- A 1 m wide cable will survive for roughly 200 yrs

Orbital Objects and Debris

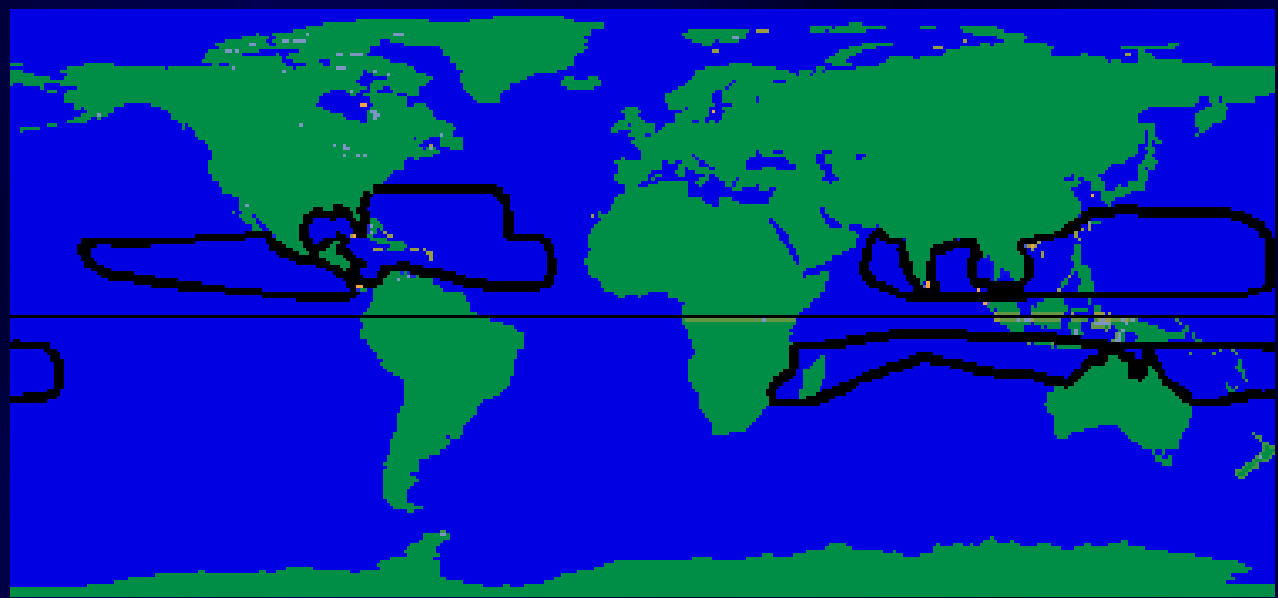


- 110,000 objects larger than 1 cm diameter
- Active avoidance required

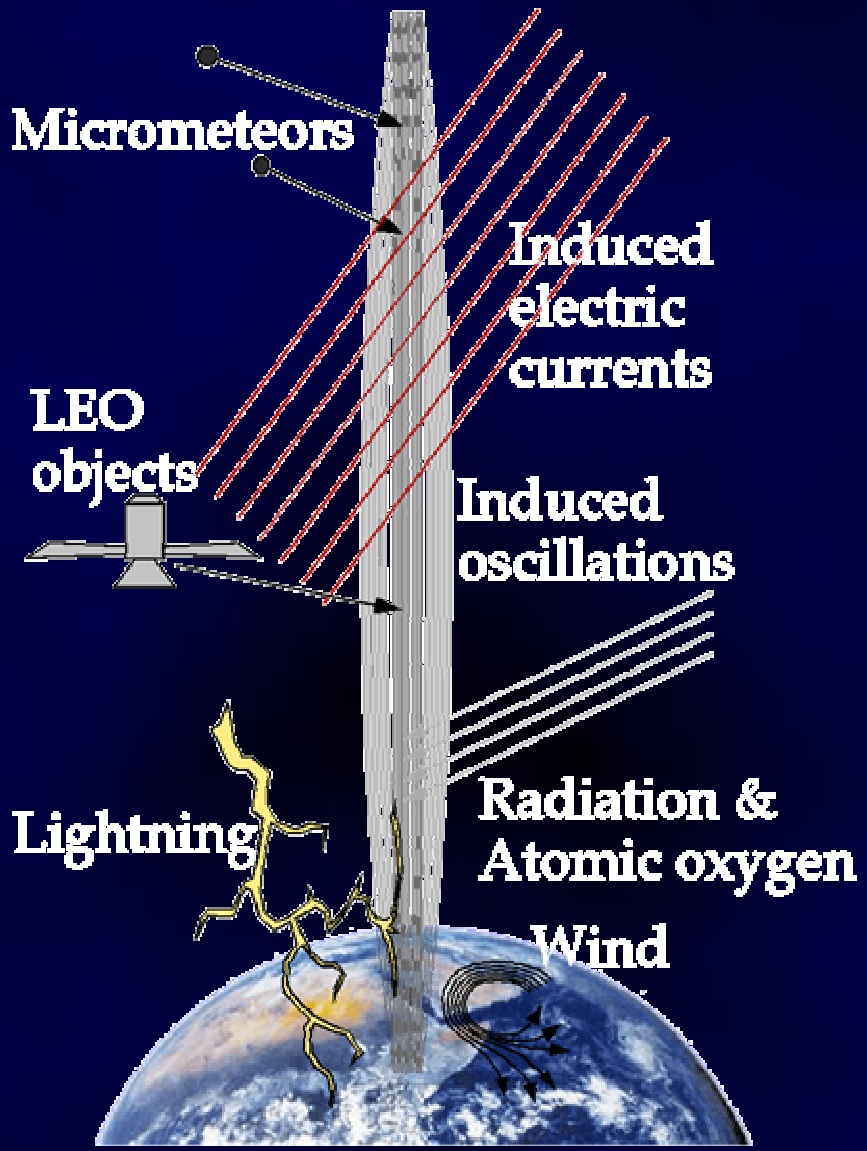
Wind Loading



- Proposed cable should be able to survive windspeeds up to 159 mph or a Category 5 hurricane
- Anchor location avoids hurricanes, jetstreams and high winds

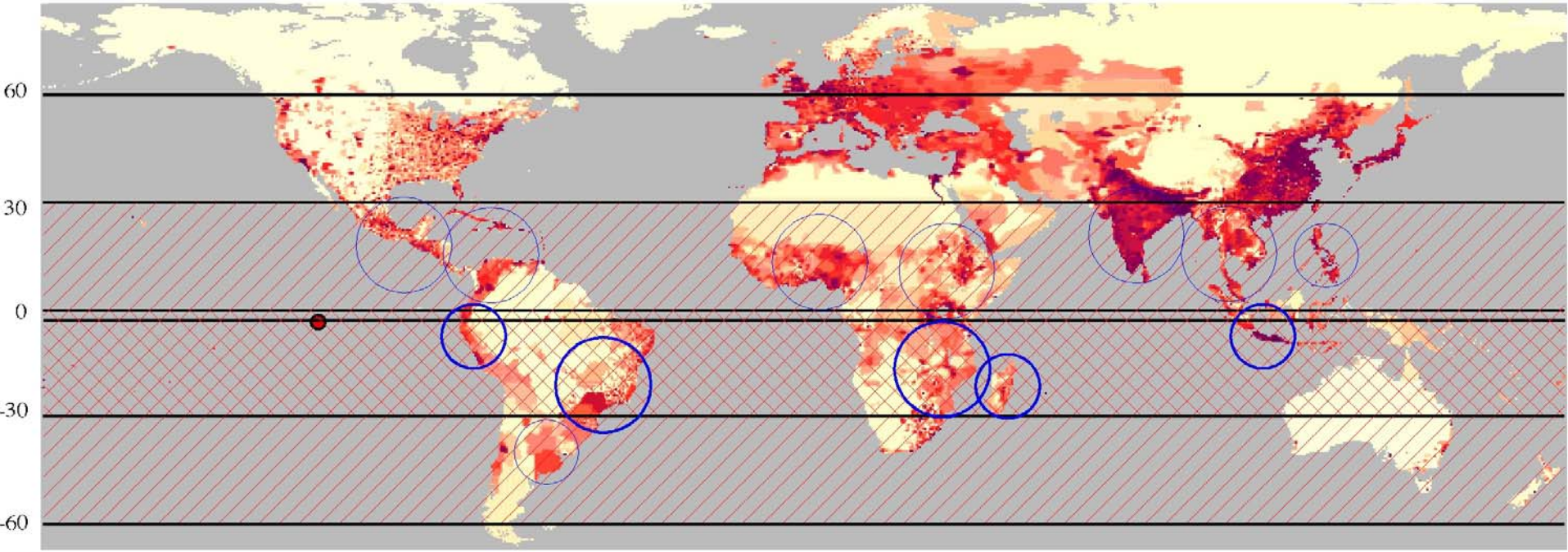


Murphy



- Environmental Impact - Ionosphere
- Malfunctioning climbers

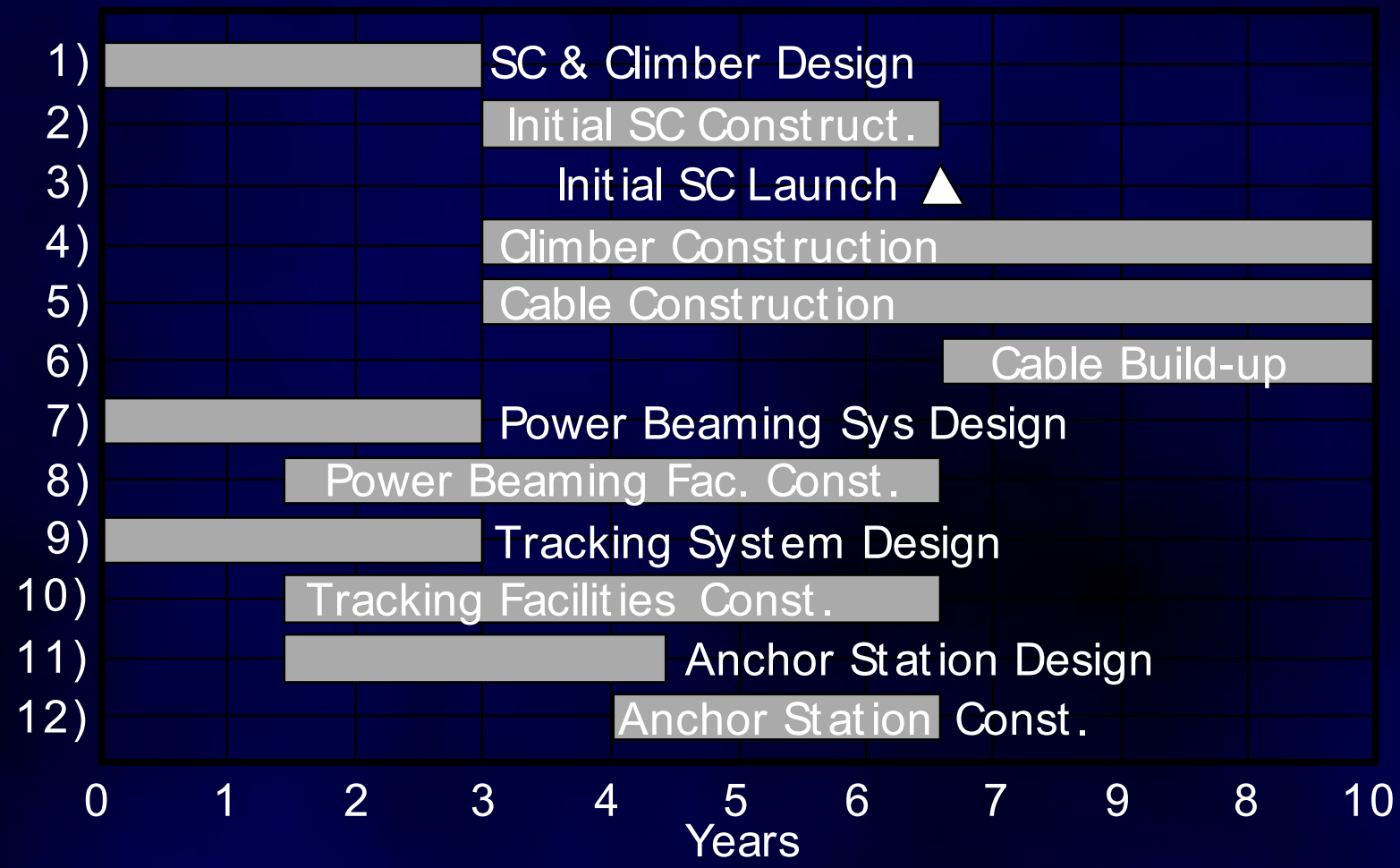
Severed Cables



- Infall scenario: break-up on re-entry
- Mechanical damage: minimal
- Lingering health risks: under investigation

Schedule and Cost

Schedule (Years 1-10)



Budget (Technical Costs)

Component	Cost Estimate
Launch costs to GEO	$1.02B
Cable production	$390M
Spacecraft	$507M
Climbers	$367M
Power beaming stations	$1.5B
Anchor station	$120M
Tracking facility	$500M
Other	$430M
Contingency (30%)	$1.44B
TOTAL	~$6.2B

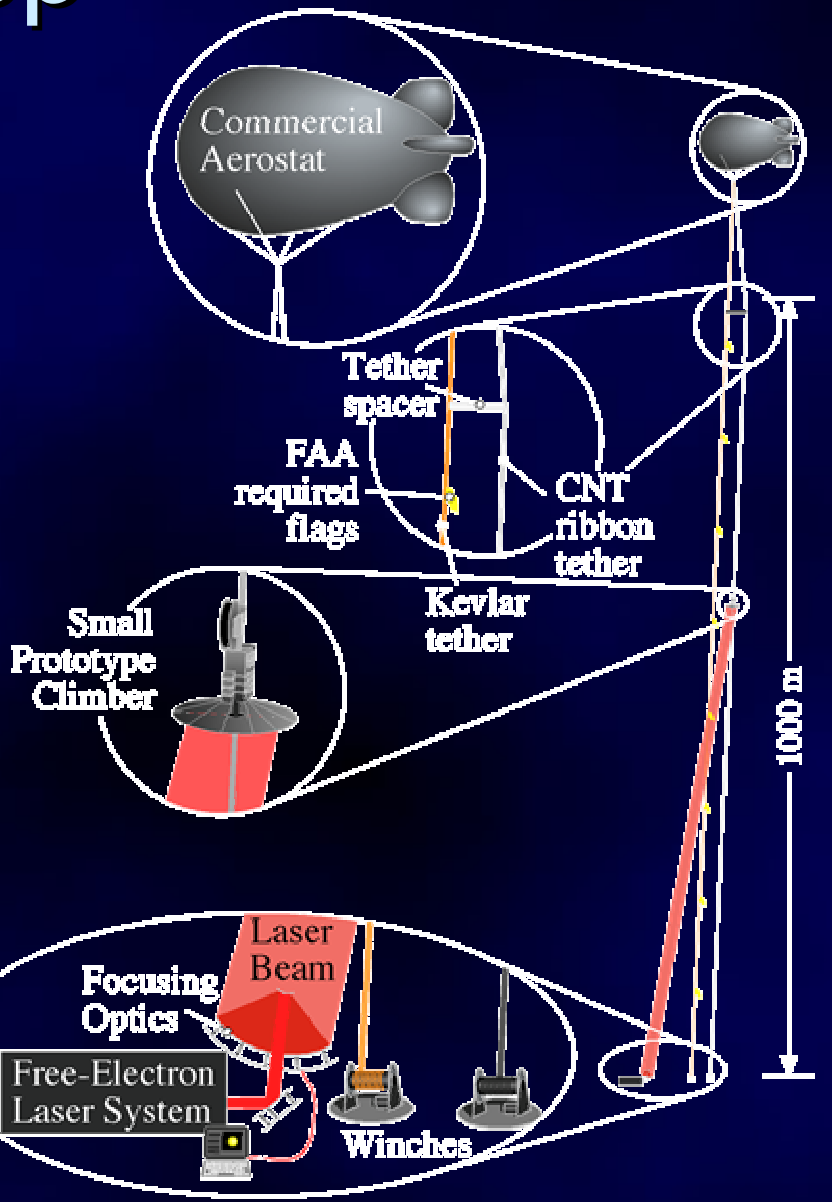
Recommend construction of a second cable for redundancy: $2B

The Bottom Line

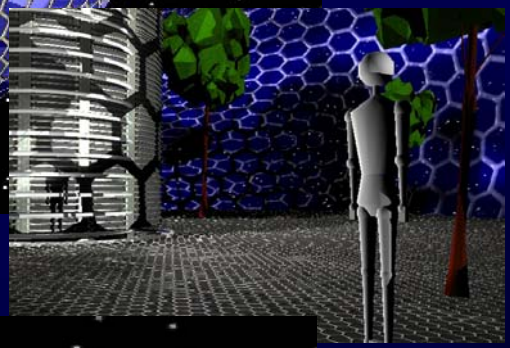
- Initial capital cost: $6.2B
- Operations cost: <$100M/yr, <$250/kg
- Ultimate operational costs: ~$10/kg
- SE Lift rate: 5000 kg/day
- Cost of additional cables or doubling the size of the first: $2B

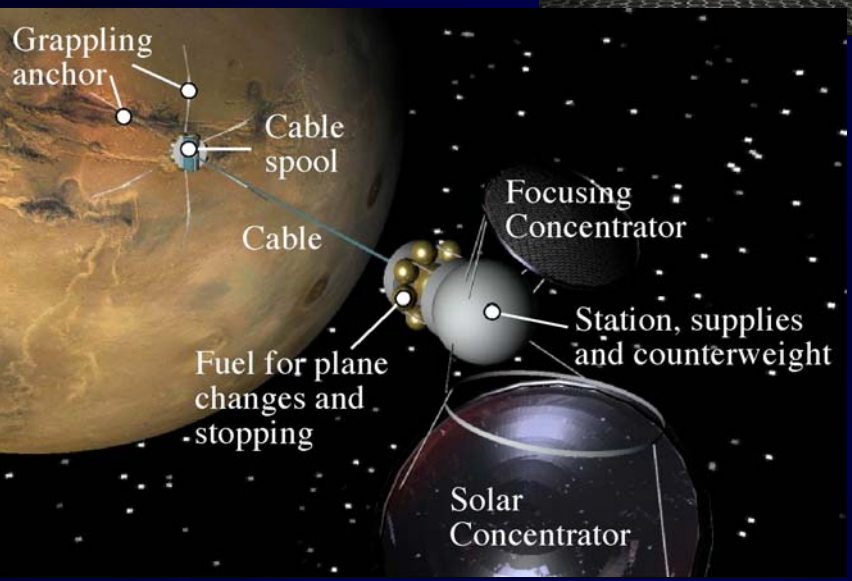
The Next Step

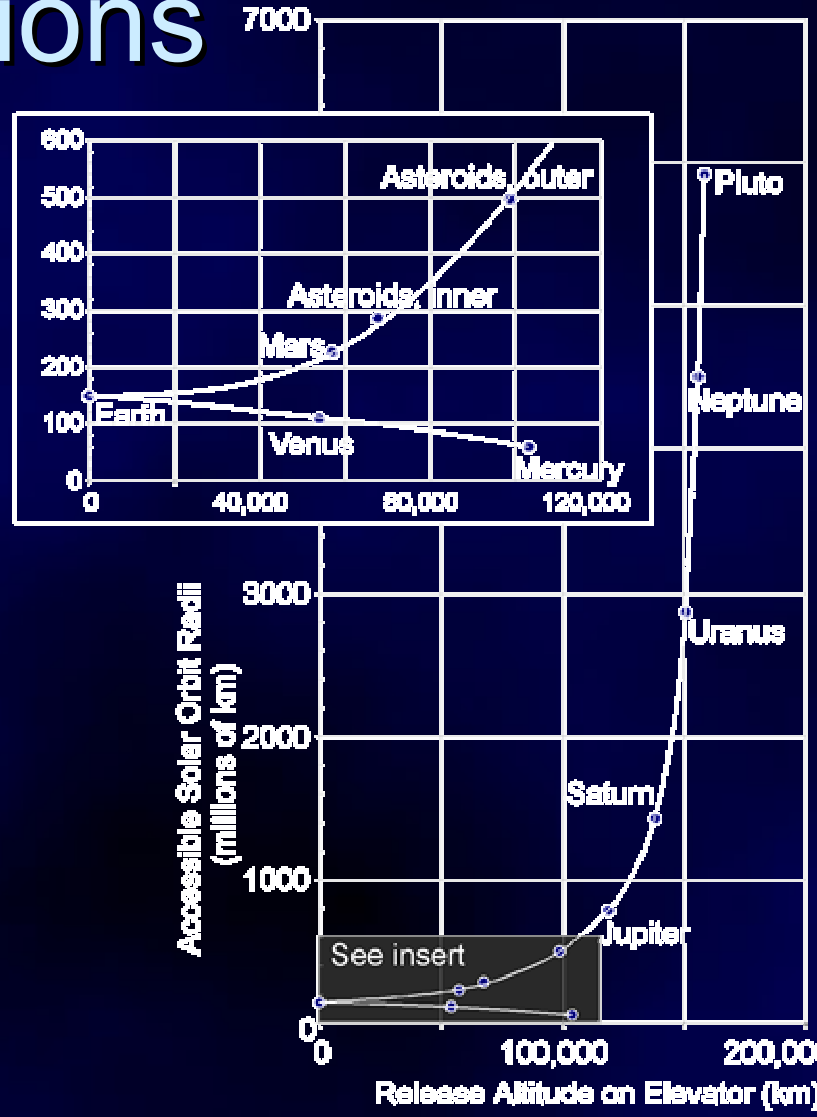
- Complete development effort:
  - -CNT composites
  - -Feasibility test
  - -Engineering studies
- Assemble management, engineering and construction teams

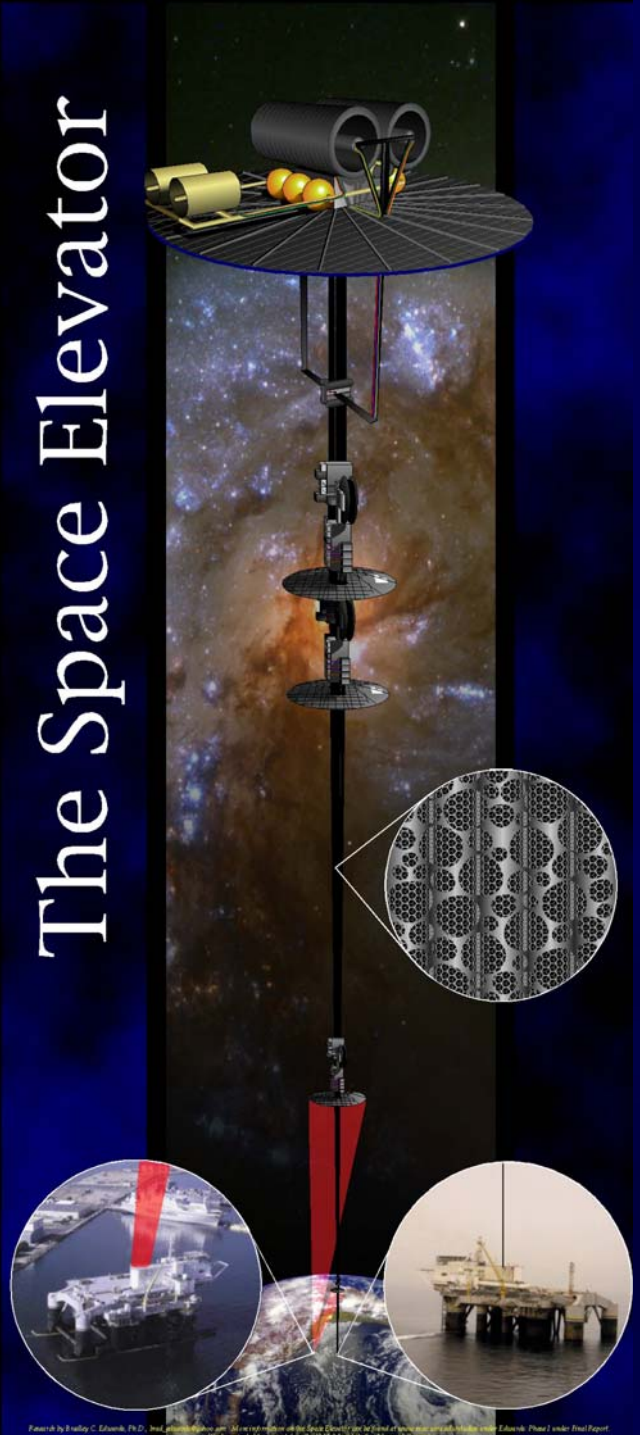


Applications









Summary

- The initial designs, construction and operational scenarios for the space elevator have been laid out.
- Two years of supported development yet required
- First space elevator (13,000 kg capacity, 5000 kg/day, $250/kg) can be operational in 11 years at a cost of <$10B

For more information and details please see:
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www.highliftsystems.com