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Environmentally Conscious Space Travel

Scooby Doo

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"The dinosaurs became extinct because they didn't have a space program. And if we become extinct because we don't have a space program, it'll serve us right!"

- Larry Niven

The Current Method:

- Modern rocket launches and proper use solid and liquid fuel
  - Majority of a launches fuel is burned during its time within earth's atmosphere
  - Based on the laws of physics, out of the atmosphere if mass is expelled backwards the rocket itself will thrust forward
- Environmental impact aside, this method has cost up to $44,000 per kilogram (Pegasus rockets in 2006) [source]
- Space exploration corporations, both public and private, have not deviated from the standard code of getting into space

Image sources: [1] [2]

Problems:

- By a chemical reaction, chlorine (Cl) breaks down ozone (O_3), allowing a more intense rays from the sun to enter the earth's atmosphere [noaa]
- Black Carbon particles are a pure form of carbon found in rocket fuel that is a bi-product of the launch [source]
  - This form of carbon does not decompose and it a strong thermal conductor
  - The sun heats up these black carbon particles which constantly give off heat and contribution to greenhouse effect [source]
- As of right now, manned and unmanned space launches are extremely expensive which does not mix well with NASA's extremely small budget

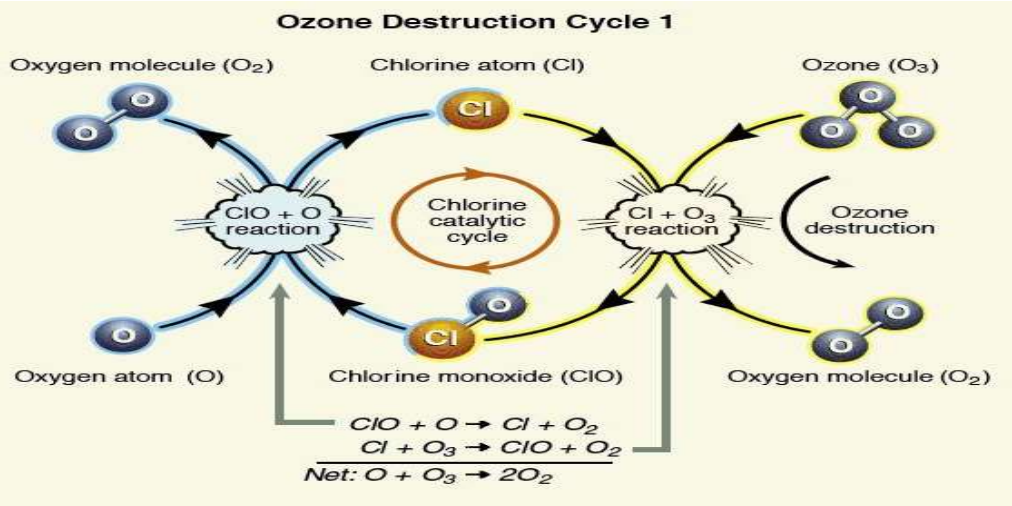

Image Source: [1] [2]

Alternative Methods:

- Space Elevator
  - A connected elevator from earth to a space station in geosynchronous orbit
- Reusable boosters (Space-X, Blue Origin)
  - Boosters that can fall back to earth after launch and be reused for other probes and manned missions
- NASA “Green Propulsion Infusion”
  - Hydroxyl Ammonium Nitrate based fuel that has less harmful environmental effects

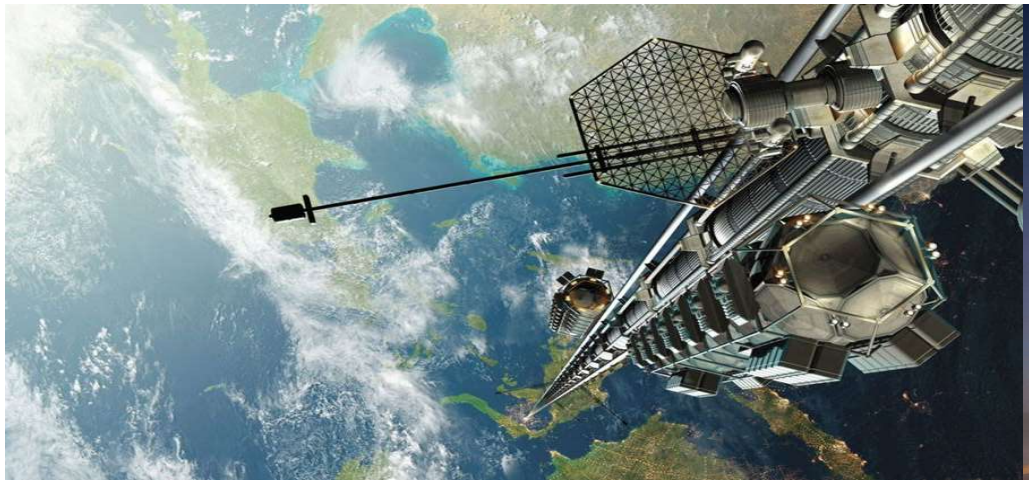

Image Source: [1] [2]

But how does a space elevator really work???

See video attached

https://www.youtube.com/watch?v=6Ddl55DCh-c

Space Elevator:

- Pros:
  - Significantly long term cost decrease [source]
    - Initial investment for construction of elevator is extremely high but assuming space exploration continues will yield high payoffs
  - Eliminates the need for fuel
  - Given the advancements and abilities of NASA and other private space companies, creating such mechanical phenomenon is possible [source]

- Cons
  - Given NASA's small budget, the initial investment of the development is colossal [budget source]
  - tether technology (*Pugno*)
  - Ownership of space elevator

Image source: [1]

Verdict:

- Technology will eventually get there - just not there now to make a commitment toward the investment
- Materials such as graphene, and crystal nanotubes will eventually be developed in a large enough quantity to put toward a space elevator (*Pugno*)
- Since the space elevator is in orbit, its would need an Asteroid redirect program to avoid collisions that would overall break the elevator itself (*Perek*)

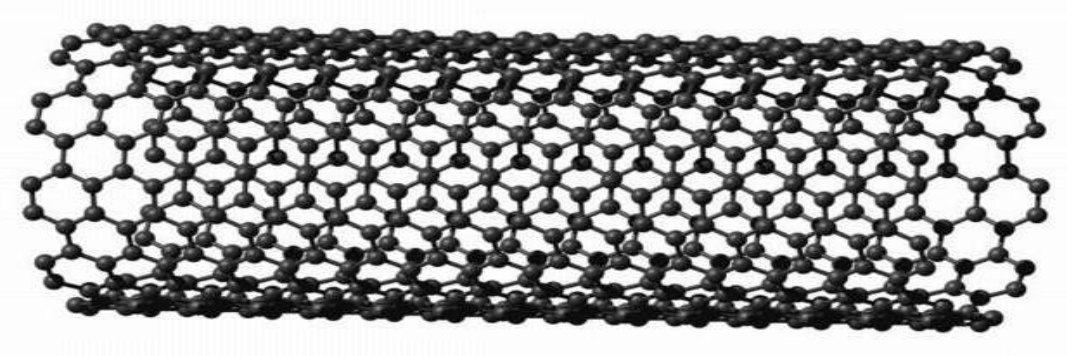

Image Source: [1]

But it may not be the best choice yet...

Reusable Booster Rockets:

- Blue Origin, SpaceX
- Cut down manufacturing waste
- Cost efficient
- Has been done

TECHNICAL OVERVIEW

HEIGHT	MASS	PAYLOAD TO LEO	PAYLOAD TO MARS
70 m 229.6 ft	549,054 kg 1,207,920 lb	22,800 kg 50,265 lb	4,020 kg 8,860lb
DIAMETER	**STAGES**	**PAYLOAD TO GTO**	
3.7 m 12 ft	2	8,300 kg 18,300 lb	

Image and Data Source: [1] [2]

Reusable Rockets:

- Pros:
  - Although initial research and investments are large, alike the space elevator, reusable boosters have an exceptionally large payoff [source] (*Shapiro*)
  - The reusable rockets are proven concept & working [source]
  - Each rocket that is reused contributes to less waste
- Cons
  - Using reusable rockets does not contribute to pollution as an alternative, but also does nothing to prevent it

Image and Data Source: [1]

Verdict:

- Cost efficient
- More environmentally friendly
- Little to no downsides
- Already being used

Despite a few mishaps…

Image Source: [1]

NASA Green Propulsion infusion:

- Hydroxyl ammonium Nitrate based *(NASA, Green Propellant)*
  - Fuel decomposes into mainly water and hydrogen which are more environmentally sound
  - Yields same thrust powers as regular fuel
- Improves flight handling of vehicles based on material characteristics *(NASA, Green Propellant)*

Image Source: [1]

Why should we change?

- We shouldn't explore other planets at the expense of our own (we do live here)
- Space launch alternatives are both ecologically conscious and cost-efficient
  - If space travel does not shift toward a more conscious effort, along with other sources of pollution, space travel will be to find new planets
- Yes- the technology is yet to be engineered- however research in space leads to innovations on the ground, and anyways:

Image Source: [1]

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No one said rocket science is easy.

Questions?

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