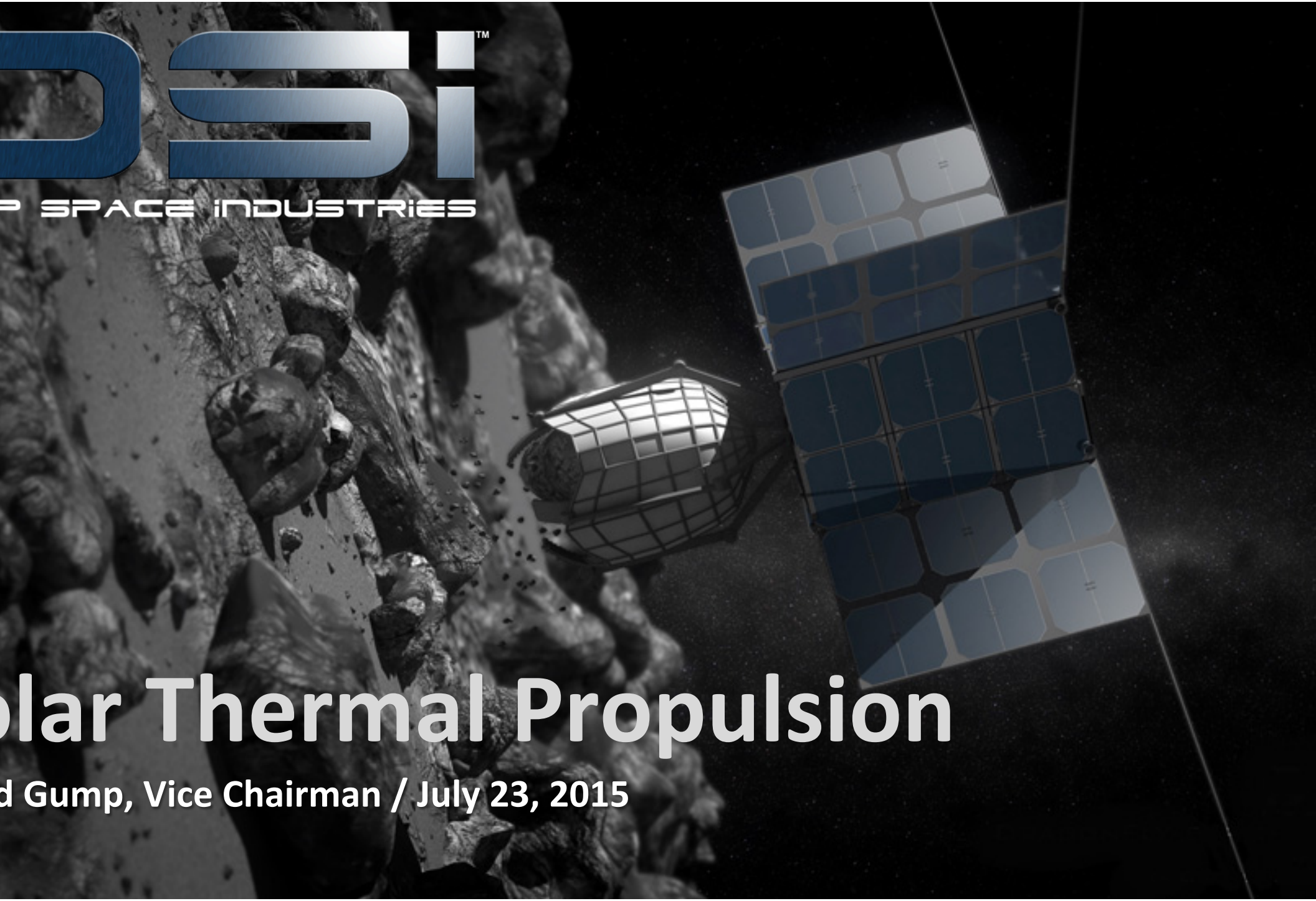


olar Thermal Propulsion

d Gump, Vice Chairman / July 23, 2015

new solar system compared to 1990s

ter everywhere

- Lunar poles
- Martian subsurface
- Mercury's poles
- **Near Earth Asteroids**

und-trip missions

- Reusable Mars mission elements
- Harvesting space resources

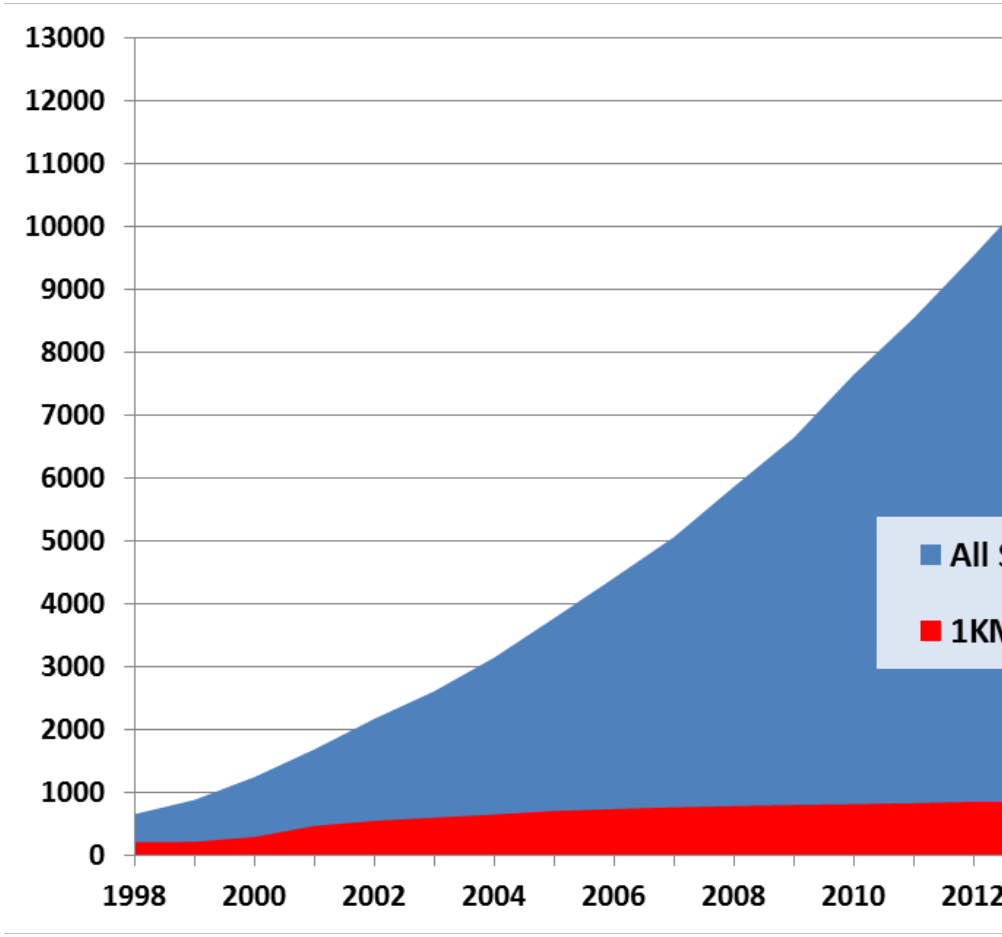
A portion of NEAS likely are dormant comets ***with >75% volati***

DSI™ DEEP SPACE INDUSTRIES

new NEA reality compared to 1990s

m curiosities
bundant resource

- 18% energetically closer than the Moon
- Some require only a few hundred m/s dV to deliver material to Earth orbit
- At Earth, they support both orbital commerce and expeditions



DEEP SPACE INDUSTRIES

teroid Redirect Mission study for NASA

erence Goal

- Create 1,000 tons of water/volatiles in HEEO
- Markets: GEO sat refueling, orbital transfer stages, Moon/Mars missio

ar Electric Propulsion case

- Return 10,000 tons regolith and extract 1,000 tons of volatiles

ar Thermal Propulsion case

- Process regolith remotely to extract 2,000 tons
- Use half for propulsion returning to HEEO

l's ARM study results

ar Electric case

- Required eight vehicles and **20 years**
- Low specific thrust engines required round trips of five to six years
- 300 tons regolith per vehicle/trip nets 30 tons water; **33 trips total**

ar Thermal case

- Required two vehicles and **six years**
- High specific thrust engines enable round trips in about three years
- 250 tons net water per vehicle per trip, **four trips total**

y Facts

ar Thermal Propulsion Scalability

ermal & optical power scales without significant component-level rede

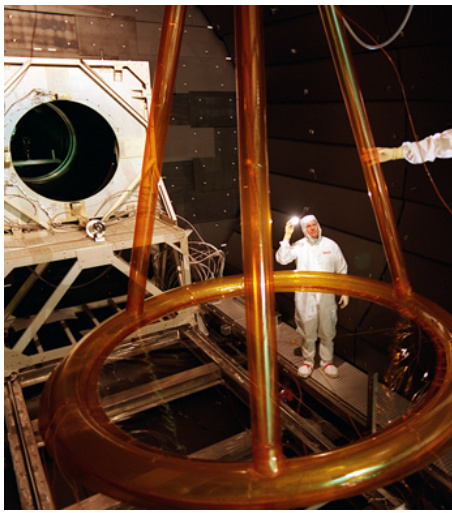
gher power = higher mass flow BUT same temperature

mpatible with water as propellant at high power

died in 1990s and earlier, not flown

rth launch, not space-sourced prop

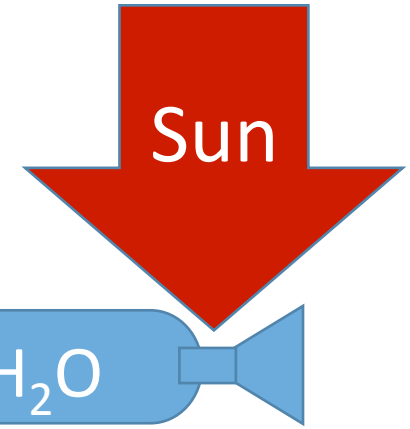
drogen or light gas in an Upper Stage



Inflatable truss for collector

ater for STP vs. Water into Cryogens

e simplest way
utilize NEA water
d sunlight



OR

1. Convert sunlight to electricity; lose 65% of energy during conversion
2. Bring mass required to electrolyze water into gaseous H and O
3. Convert more sunlight to electricity to run liquefaction step
4. Add substantial mass to rocket for insulation and continuous refrigeration two tanks instead of one tank
5. Use complex cryogenic thrusters

ars Missions

rs DRM 5.0: six to seven SLS launches in 26-month windo

- Initial Mass in LEO: 76% propellant
- Substitute IMLEO volatiles with NEA volatiles
- Switch to an achievable three to four SLS launches in 26 months
- NEA water enables more mass for greater safety/redundancy
- Example: two Mars ascent vehicles instead of a single point of failure

P Mars Mission Architecture

IEEO: 6.3 tons start mass

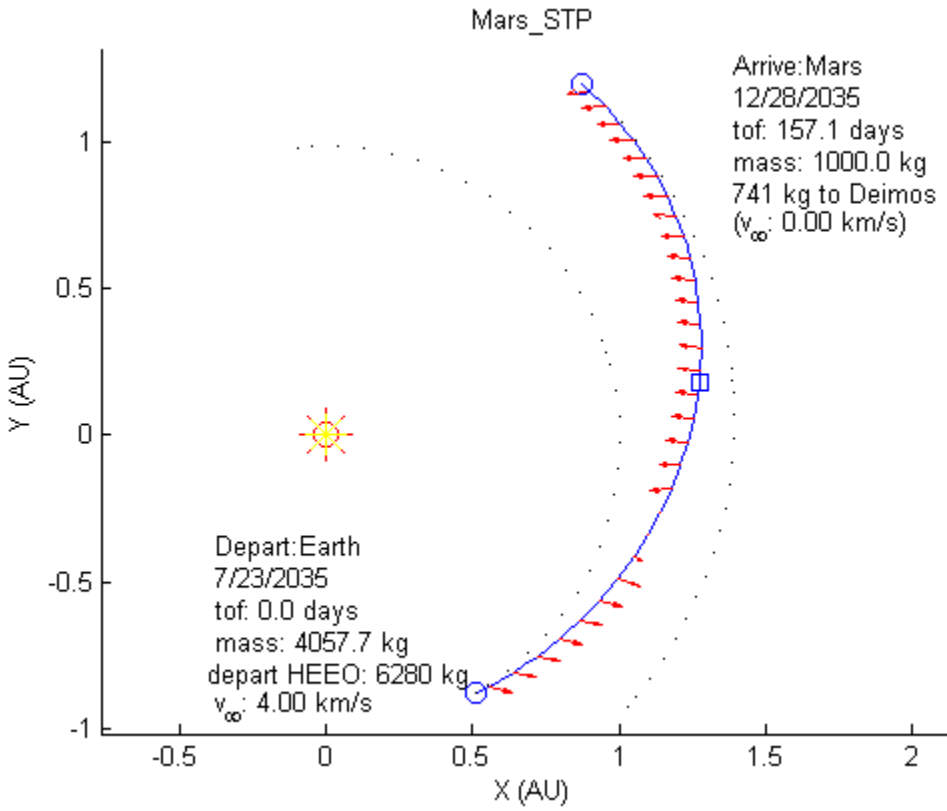
Mars orbit: 0.7 tons payload

nsit time: 162 days

DRM 5.0 missions are 180-200 days

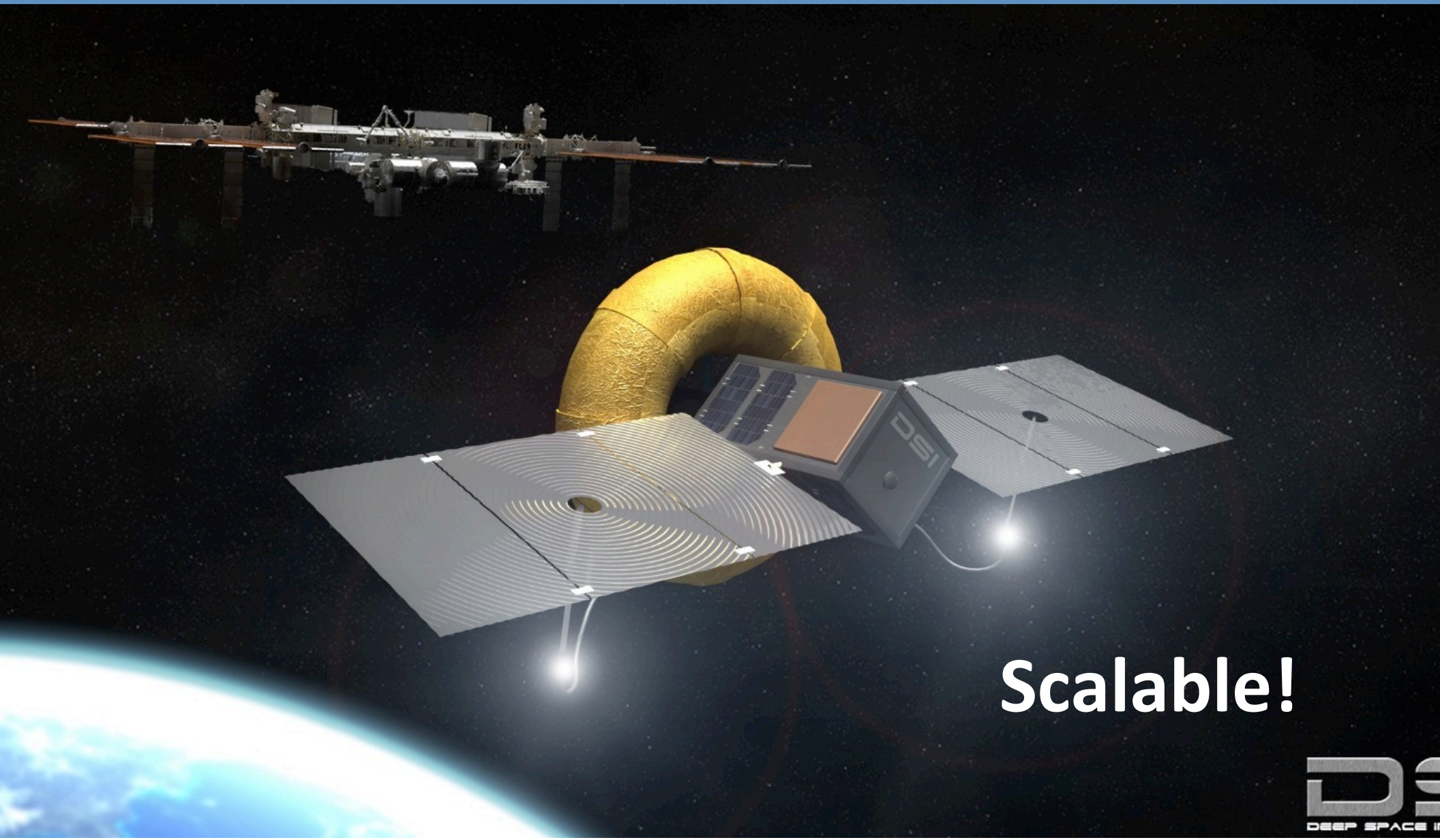
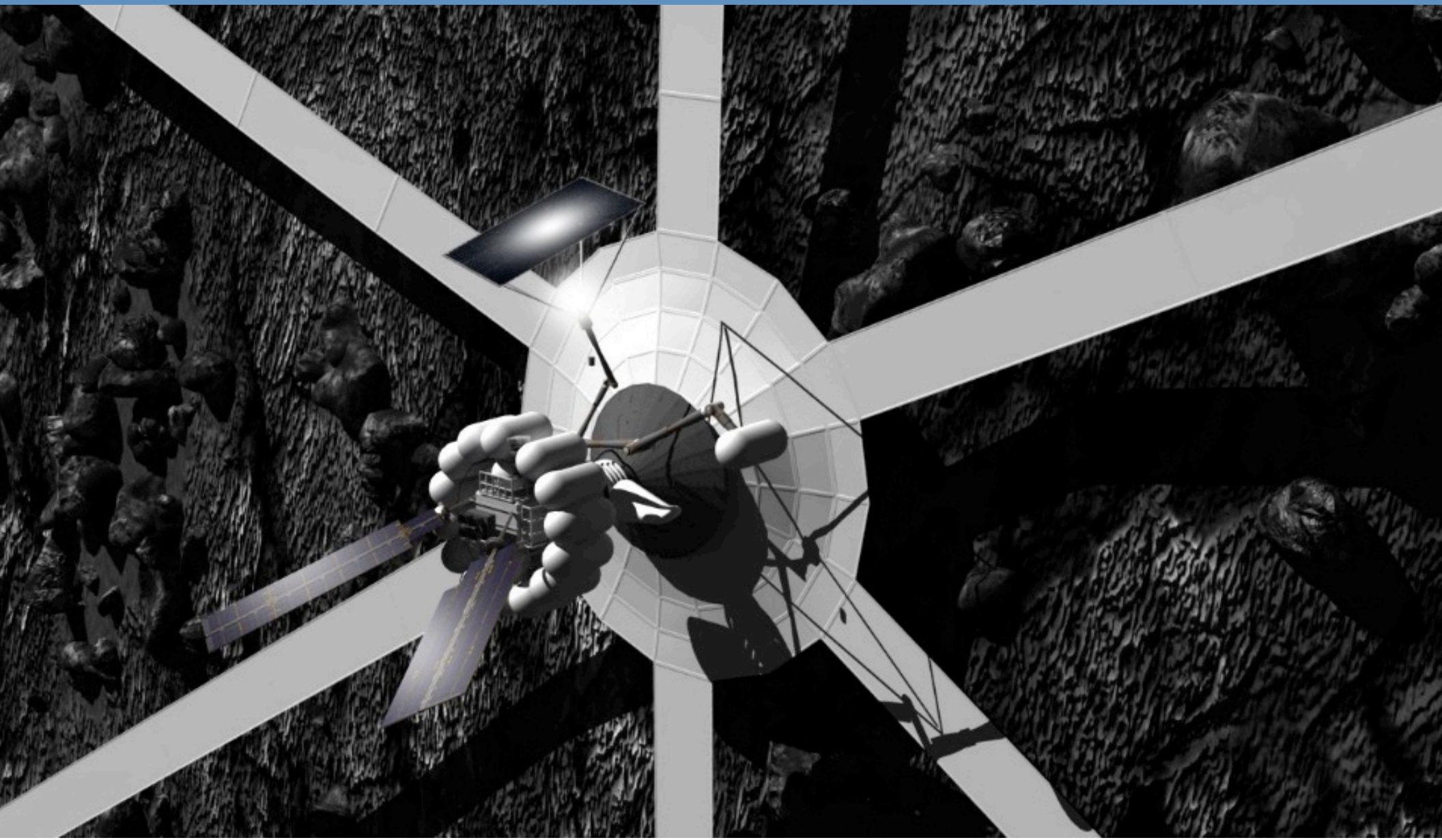
Cargo: 4.7 tons start mass and longer

day-transit also delivers 0.7 tons



DEEP SPACE INDUSTRIES

rt with STP Nanosat



opulsion mass also used for extraction heati