HELIOPOLIS

The Next Giant Leap

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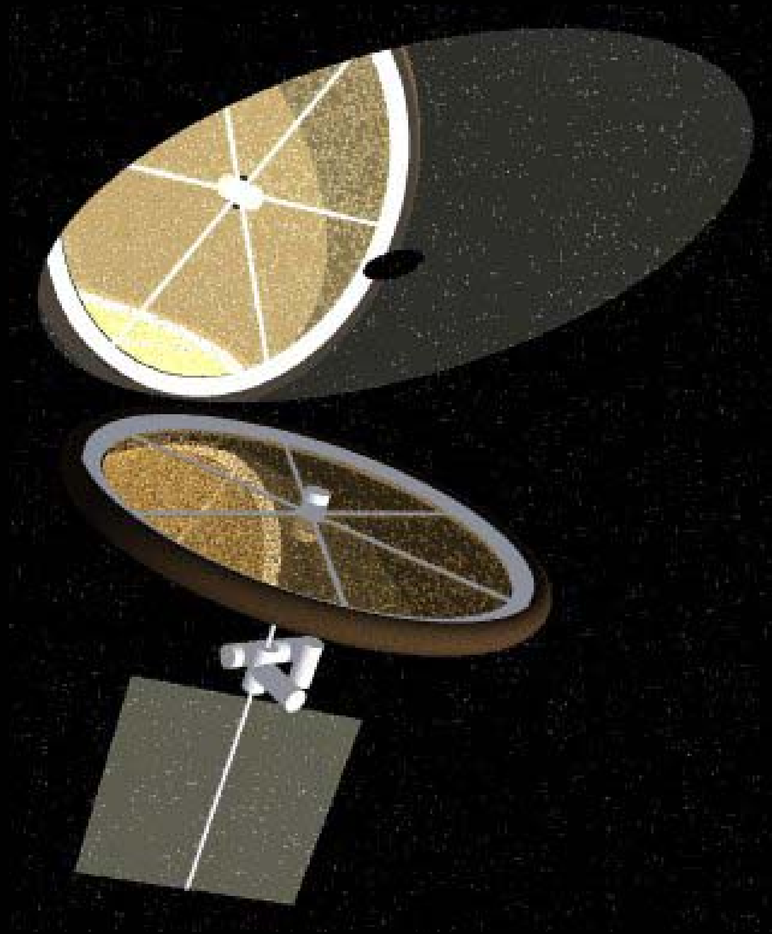
Heliopolis Mission

To build a profitable, self-sustaining foothold for humanity in space

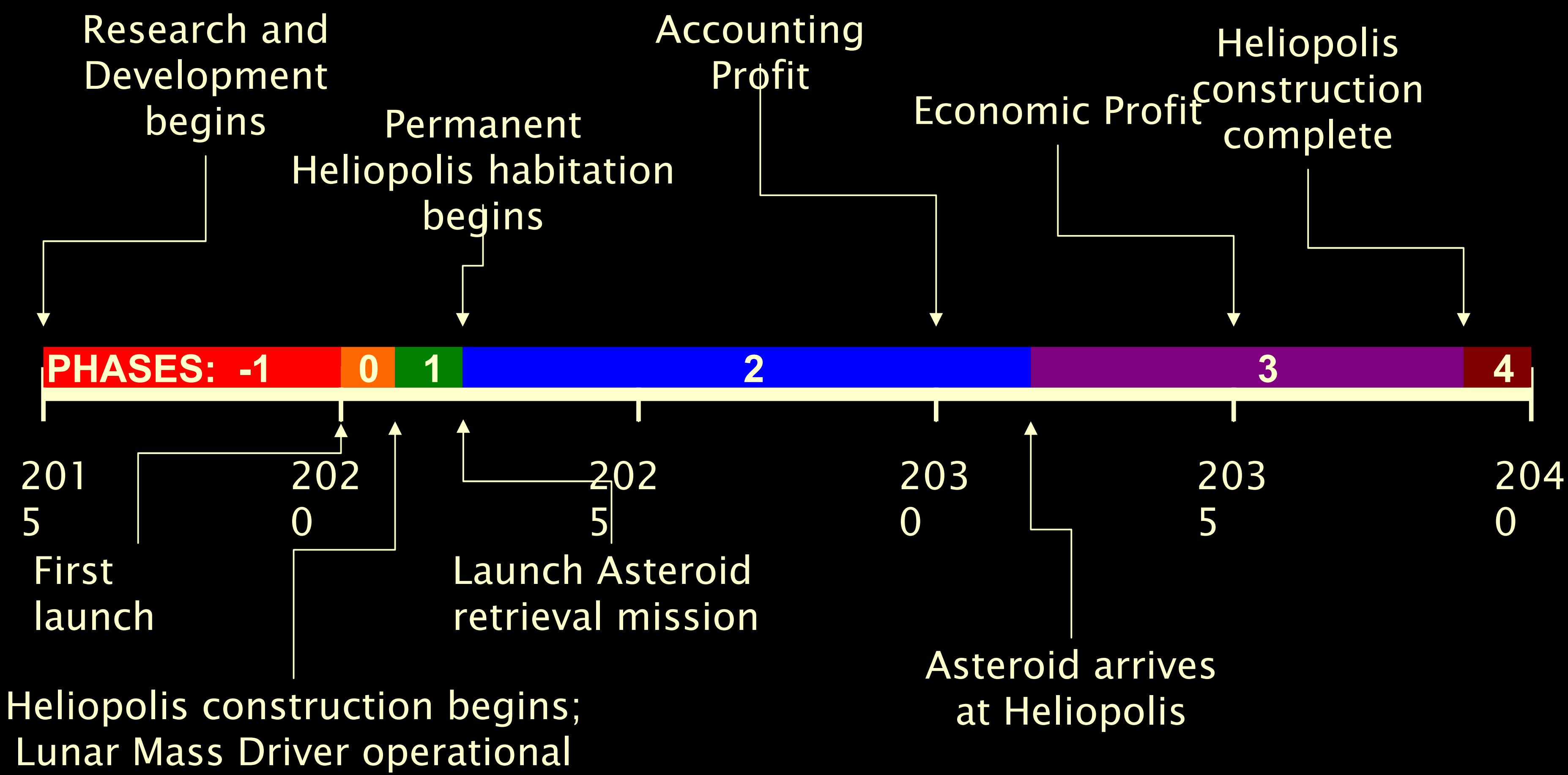
Heliopolis:
Space Business Park / Community

- Support several industries
  - Solar power satellites (SPS)*
  - Communications satellites
  - Zero-gravity manufacturing
  - Tourism
  - Asteroid mining
  - Capacity for growth (self-replication)
- Lunar L1 halo orbit
  - Continuous sunlight
  - Moon-viewing for tourists
- Necessary for future space infrastructure



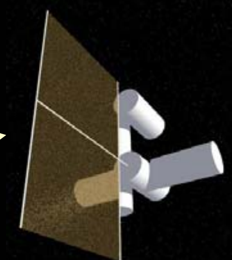
*Only revenue from SPS modeled

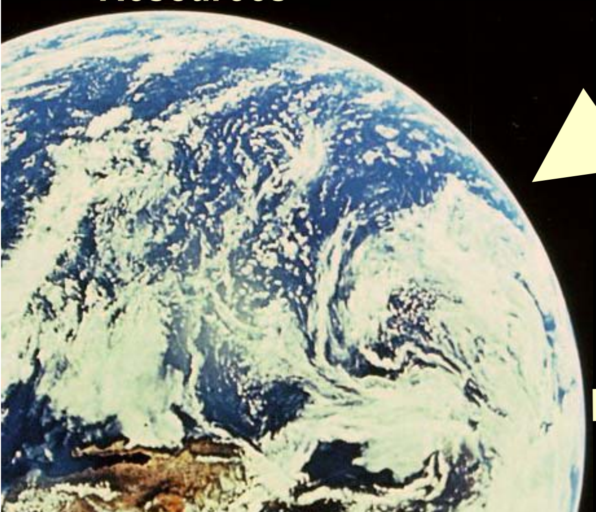
Heliopolis Development Timeline



Phase 0 (2020-2021)

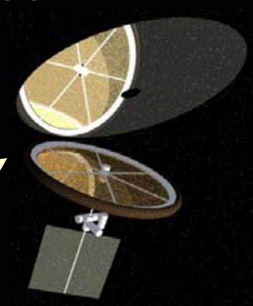
- **Shanty Town Construction**
  - ISS-like modules to L1
  - Mass driver to Moon
  - 3-month crew rotations
  - **Cost: 35 B$ (Y2K)**
  - **People: 0-100**





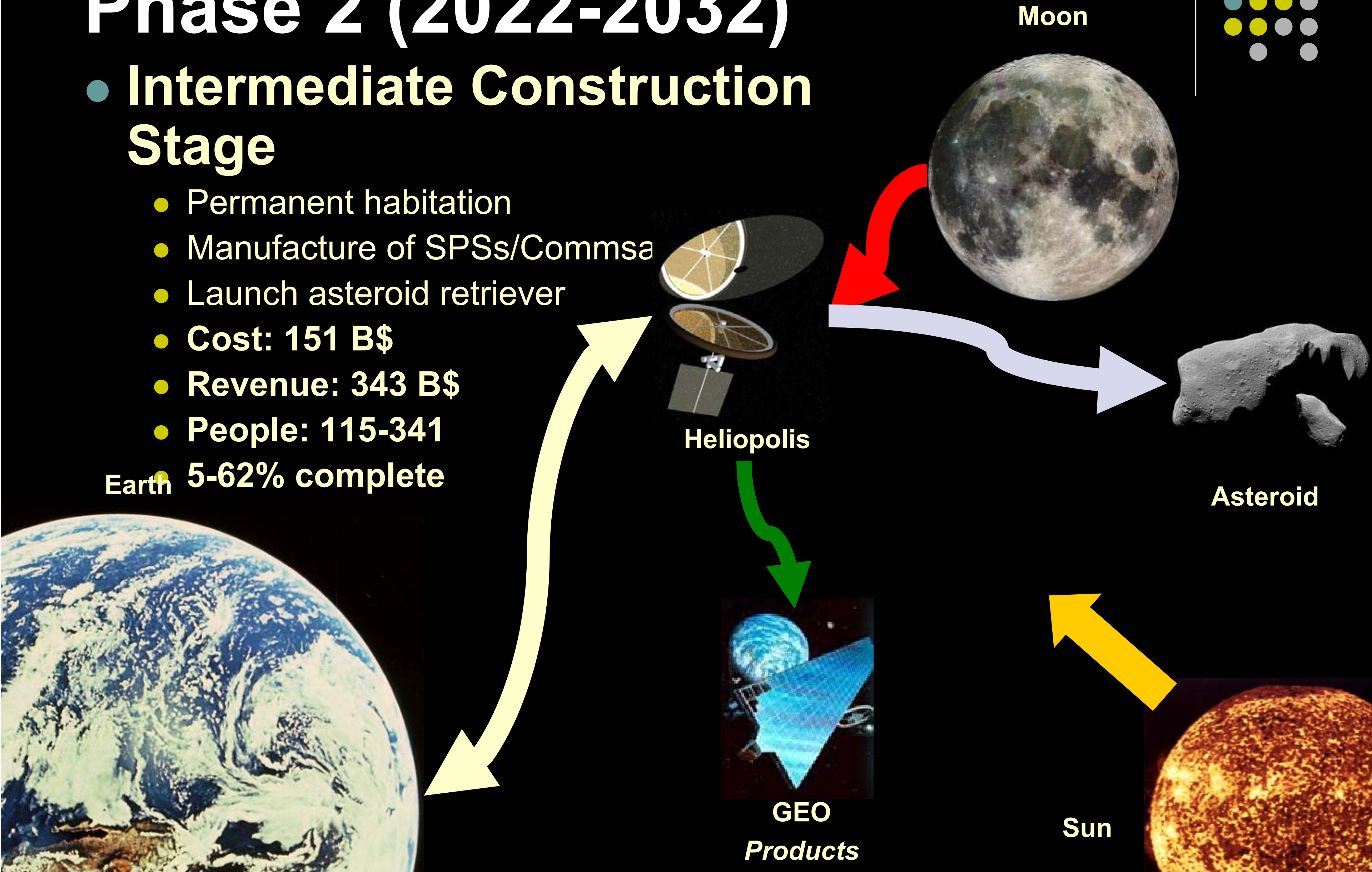
Phase 1 (2021-2022)

- **Begin Construction of Heliopolis**
  - Build first permanent habitation modules
  - Construction materials from Moon
  - 3-month crew rotations
  - **Cost: 27 B$**
  - **People: 100-115**
  - **0-5% complete**



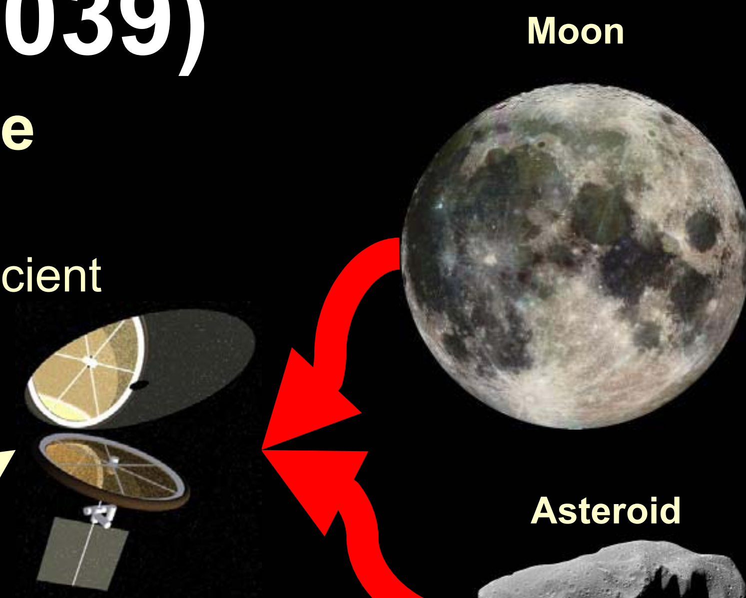
Phase 2 (2022-2032)

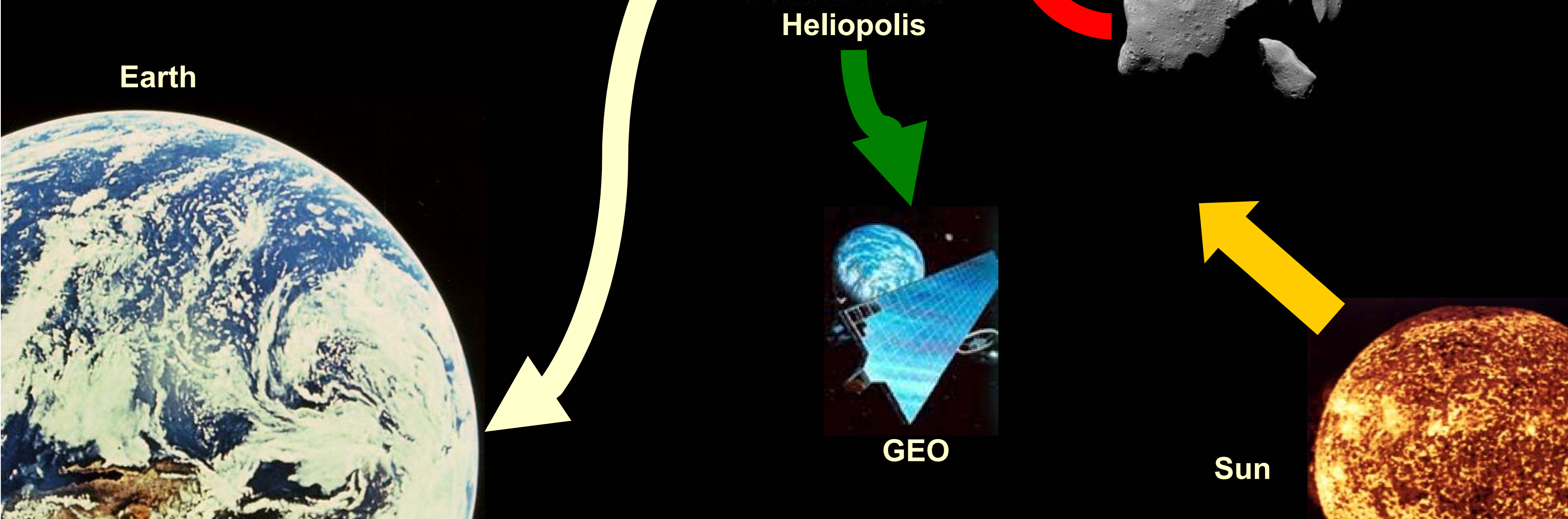
- **Intermediate Construction Stage**
  - Permanent habitation
  - Manufacture of SPSs/Commsa
  - Launch asteroid retriever
  - **Cost: 151 B$**
  - **Revenue: 343 B$**
  - **People: 115-341**
  - **5-62% complete**



Phase 3 (2032-2039)

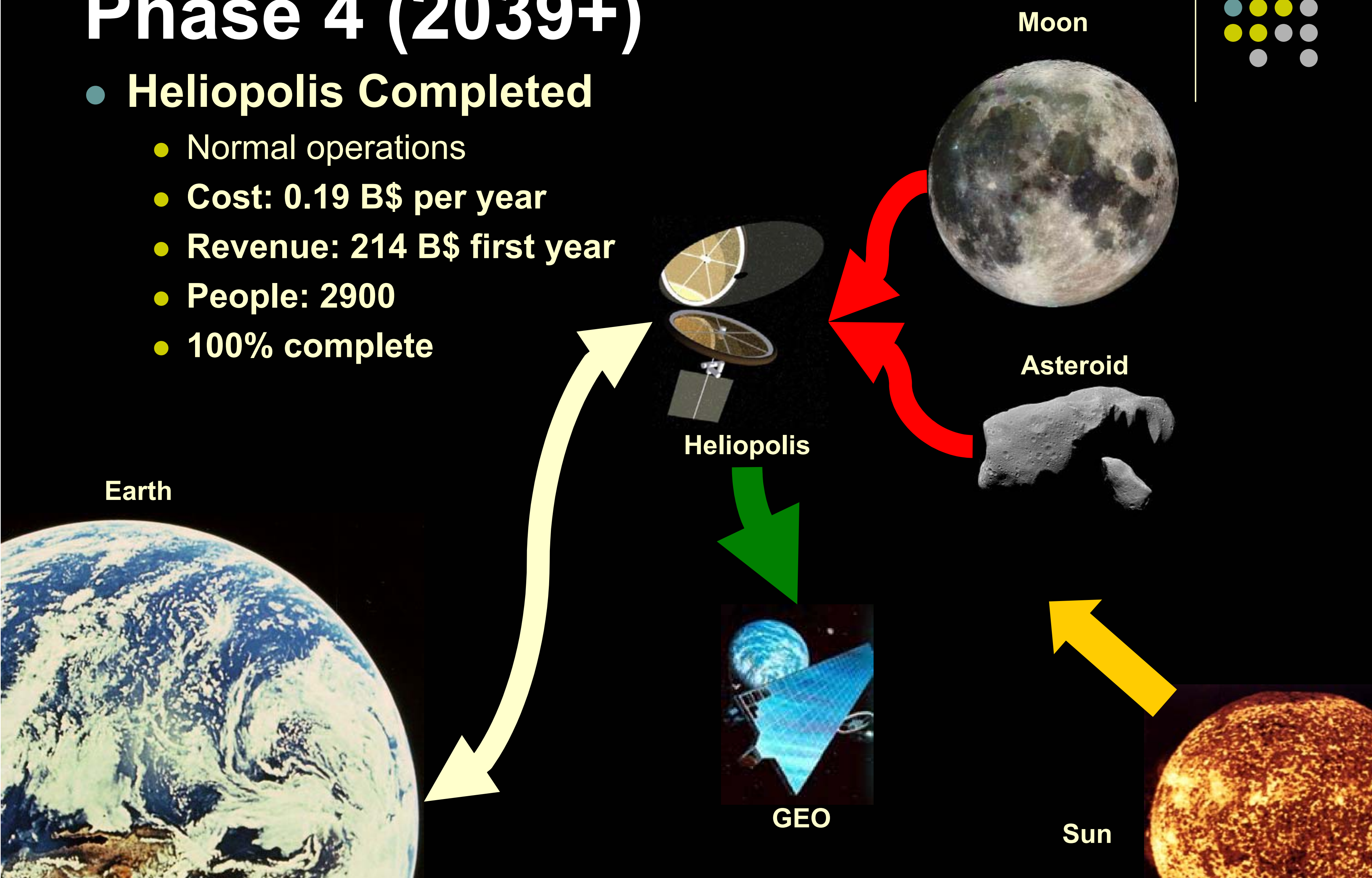
- **Final Construction Stage**
  - Asteroid returned
  - Heliopolis essentially self-sufficient
  - **Cost: 50 B$**
  - **Revenue: 850 B$**
  - **People: 1500-2900**
  - **62-100% complete**





Phase 4 (2039+)

- **Heliopolis Completed**
  - Normal operations
  - **Cost: 0.19 B$ per year**
  - **Revenue: 214 B$ first year**
  - **People: 2900**
  - **100% complete**



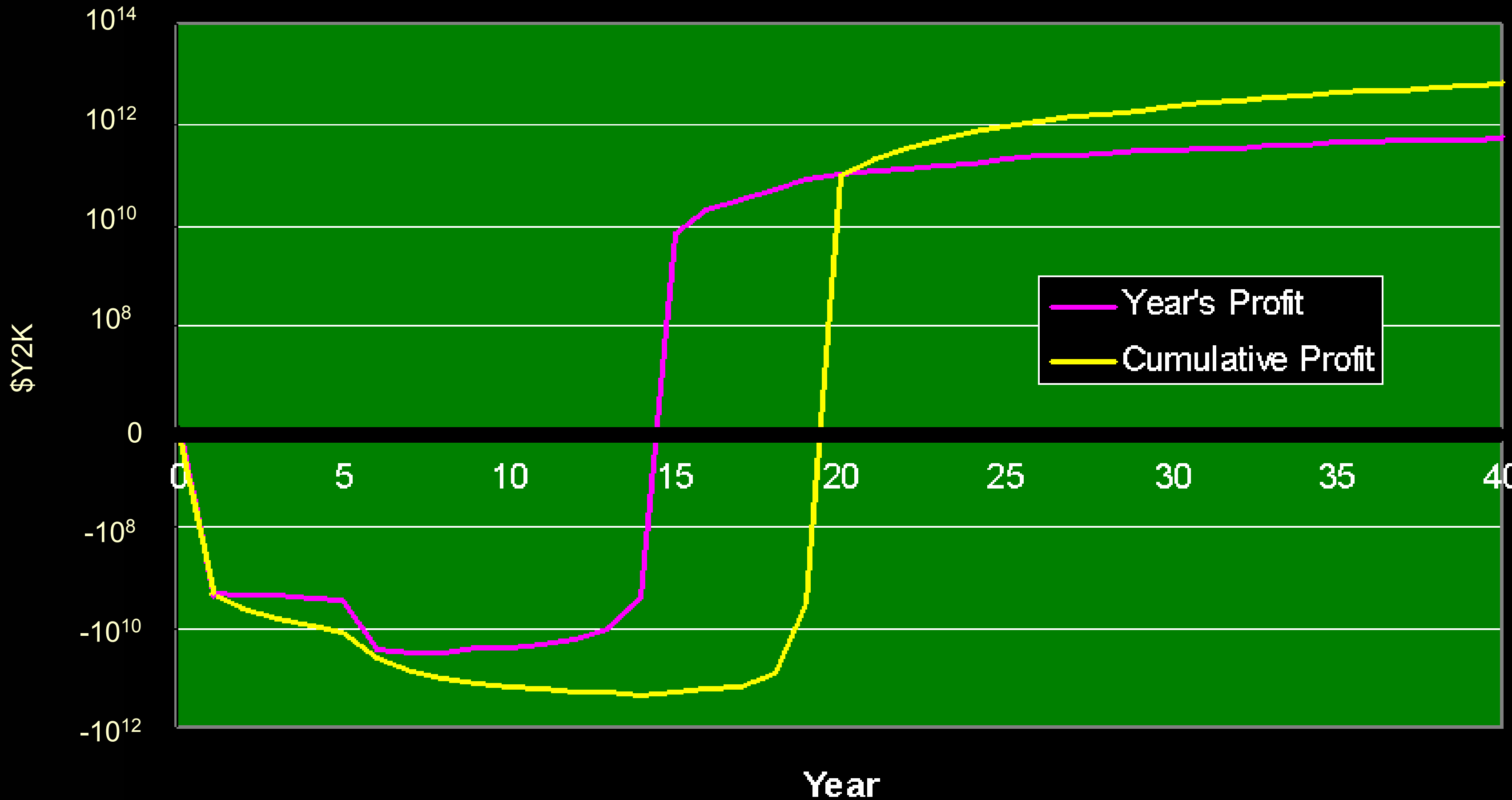
Infrastructure Requirements

- Module fabrication facility
- Heavy-lift launch vehicle (HLLV) services
- Lunar mass driver
- Inter-orbital shuttle
- Ground receiver arrays (rectennas)

Technology Requirements

- Enabling Technology
  - 250-tonne-to-LEO class HLLV
  - Improved automation
  - Nuclear reactor in space
  - Closed-loop recycling
- Enhancing Technology
  - SEP using O_2
  - Nuclear thermal propulsion
  - Improved PowerSail efficiency
  - Mass driver propulsion
  - Self-Replicating Machines

Cash Flow Analysis (log scale)

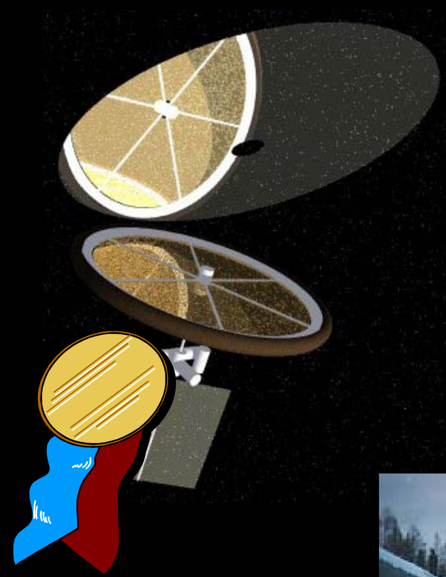


Chad

Alaska Pipeline Comparison

	Alaska Pipeline	Heliopolis
Cost before revenue	22.7 B$	105 B$
Time to revenue	2.21 years	15 years
Avg. cost per year before revenue	10.3 B$	7 B$
Avg. profit per year	3 B$	214 B$[1]
Energy supplied per year[2]	94.5 MBTUs delivered	233 MBTUs produced

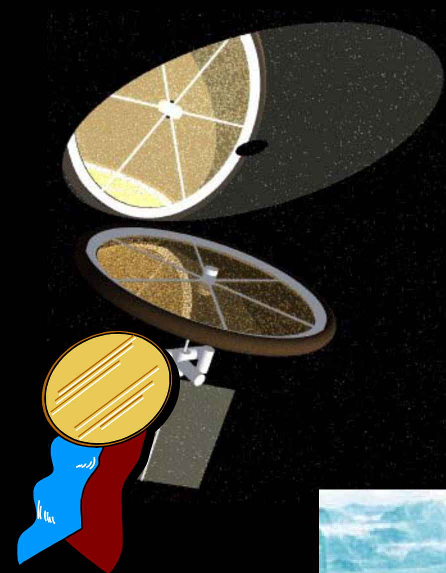
[1]Beginning of Phase 4
[2]World demand of 612 QBTUs in 2020

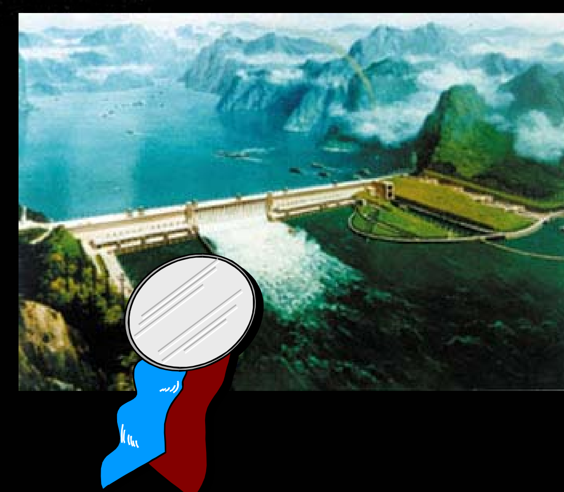


Three Gorges Dam Comparison

	Three Gorges Dam	Heliopolis
Cost before revenue	26.6 B$	105 B$
Time to revenue	20 years	15 years
Avg. cost per year before revenue	1.33 B$	7 B$
Avg. profit per year	62.8 B$[3]	214 B$[1]
Energy supplied per year[2]	0.54 MBTUs delivered	233 MBTUs produced

[1]Beginning of Phase 4
[2]World demand of 612 QBTUs in 2020
[3]Revenue; profit figures unavailable





Environmental Impact

Alaska Pipeline	Three Gorges Dam	Nuclear Power	Heliopolis
12 M gallons of oil spilled over last 25 years	Toxic levels of arsenic, mercury, lead, cyanide in water supply; 1.9 million people displaced	Chernobyl affected 7 million, contaminated 155,000 sq.km[1]	Construction of rectennas (but still allows use of land); microwaves not harmful[2]

[1] Belarussian Embassy website
[2] 1975 Stanford study

Conclusions (1 of 3)

- O'Neill was right: world market exists to begin supply of solar energy
  - World demand of 612 QBTUs[1] far exceeds world production capability of 496 QBTUs[2]
  - SPS production can begin to supply unmet demand
- Solar energy from SPS cleaner, safer than alternatives
  - No risk of toxic wastes/spills
  - No risk of explosions or meltdowns
  - No people displaced, no land made unusable

[1]US DoE
[2]International Energy Agency

Conclusions (2 of 3)

- LSMD study comparable to 1975 Stanford study
  - Differences reflect 25 years of technological advances
- However: LSMD study represents fundamentally new analysis
  - Integrated cost model demonstrates project's economic feasibility
- Technology exists or can be designed to begin project in the next 20 years

Conclusions (3 of 3)

- Economic profit returned in 20 years
  - Positive cash flow in 15 years
  - Initial investment of $105 billion
  - Self-sufficiency and internalizing costs critical to project success
- Power requirements dominated by industrial refinery needs
- Project cost driven by food production
  - Low mass, but biomass only available from Earth
  - Personnel costs surprisingly insignificant