space science: government vs commercial paradigm

https://www.sciencedirect.com/science/article/pii/S0265964625000372

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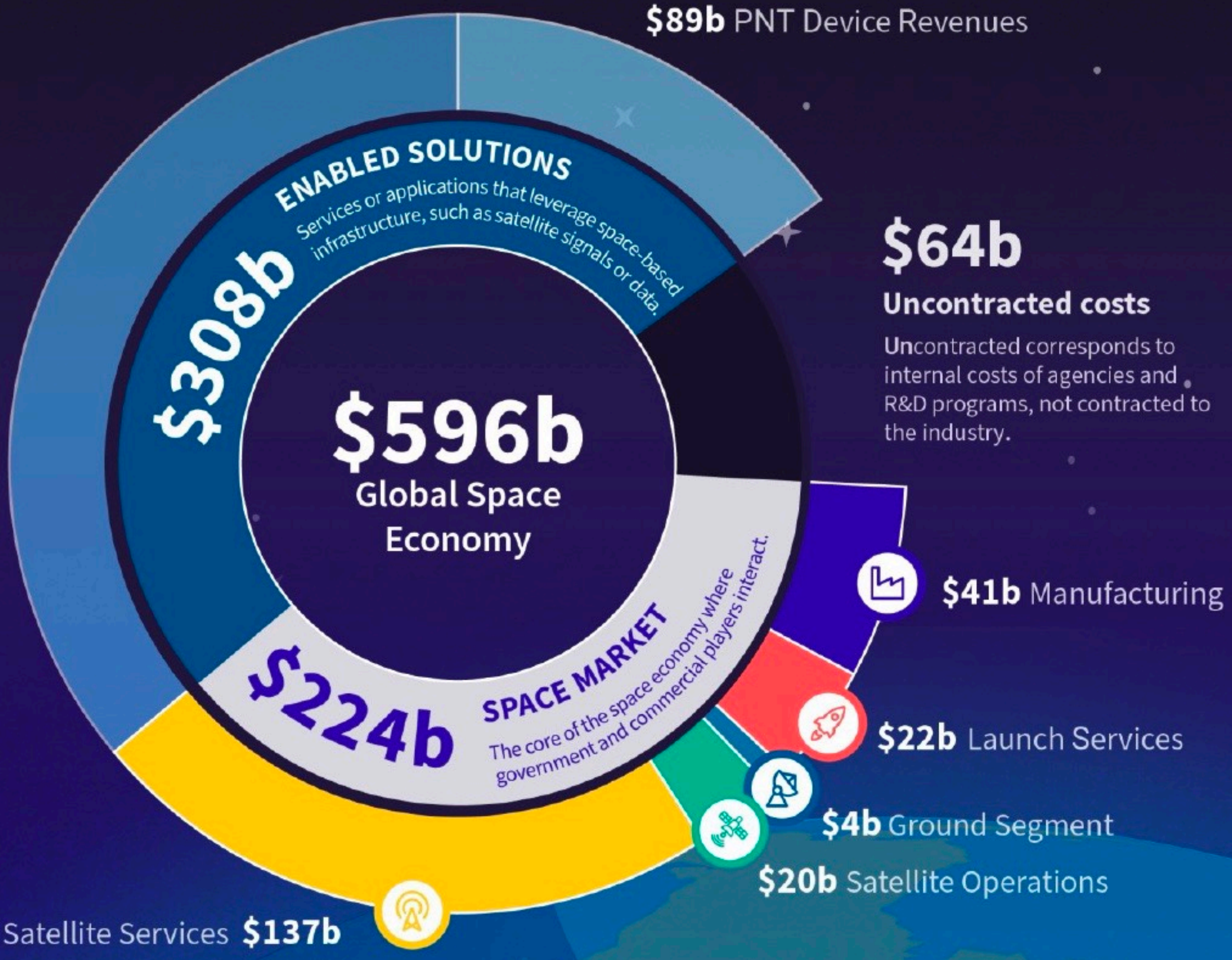
2024 Space Economy Valuation

in USD



Space Market by Application

Space Market by Region

Regional segmentation is excluding ground segment market value

NOVASPACE

Source: Novaspace, Space Economy Report, 2024

strategic vs commercial paradigm

geopolitical influence, no risk, no incentive to bring down cost	make money, low cost, risk openess
military advantage	quality of life, wellness, proportional to innovation
need new invention	allow new invention
Technological development is pushed	Technological development is pulled
single missions but distributed procurement, artisanal production	constellation, vertical integration, scale production
timing is not a driver	time is money, fast deliver is mandatory

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public funding pros & cons

basic science missions are possible	single missions, sometime high risk
funding more stable than in private sector	intrinsically limited funding: ESA-NASA budgets
spin-off possible	limited incentives for spin-off, reduced efficiency in innovation, difficulty in hiring best personnel, hierarchical organization of research teams, complexity of administrative procedures
possibility to exploit synergies with strategic programs, military	

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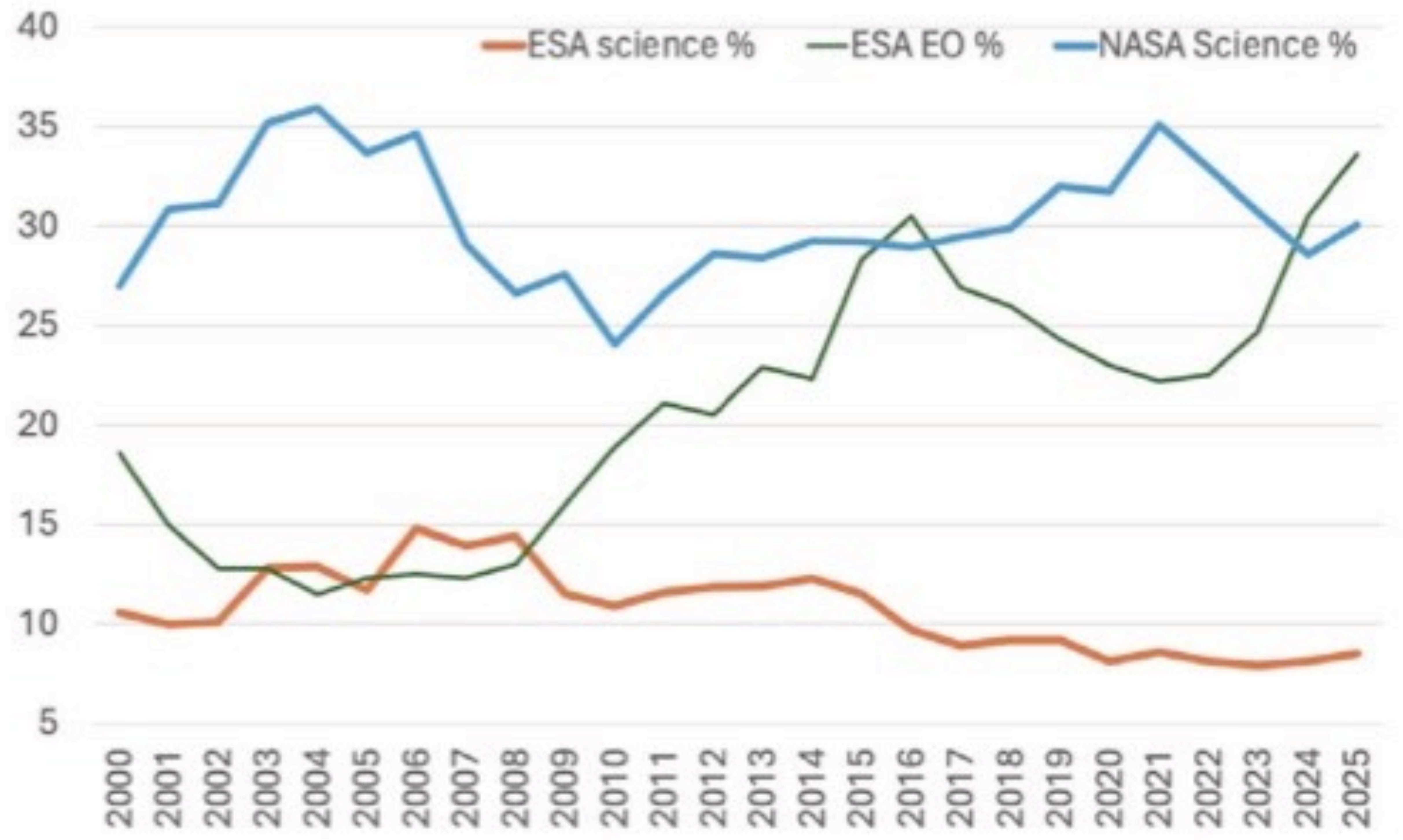

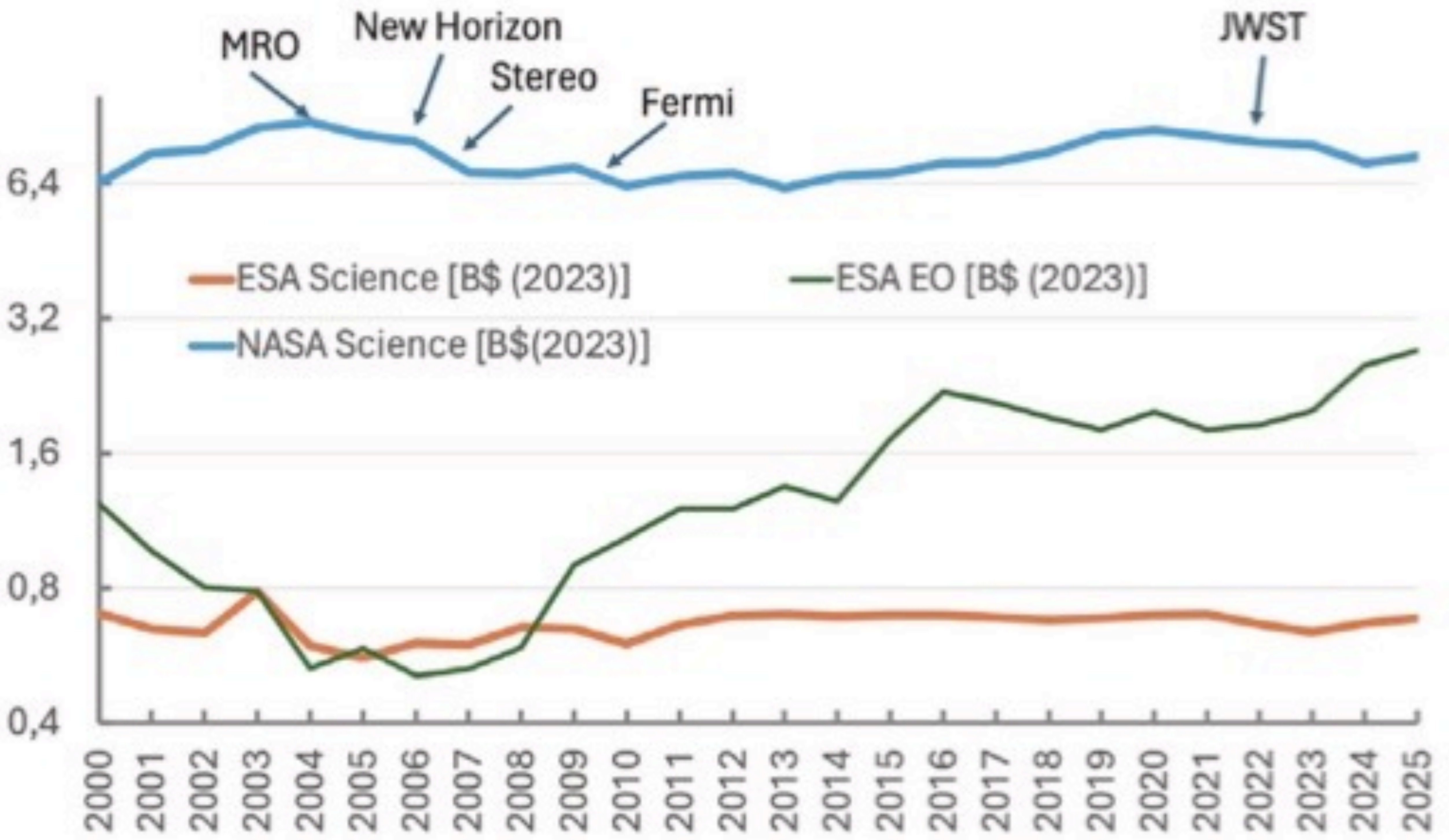

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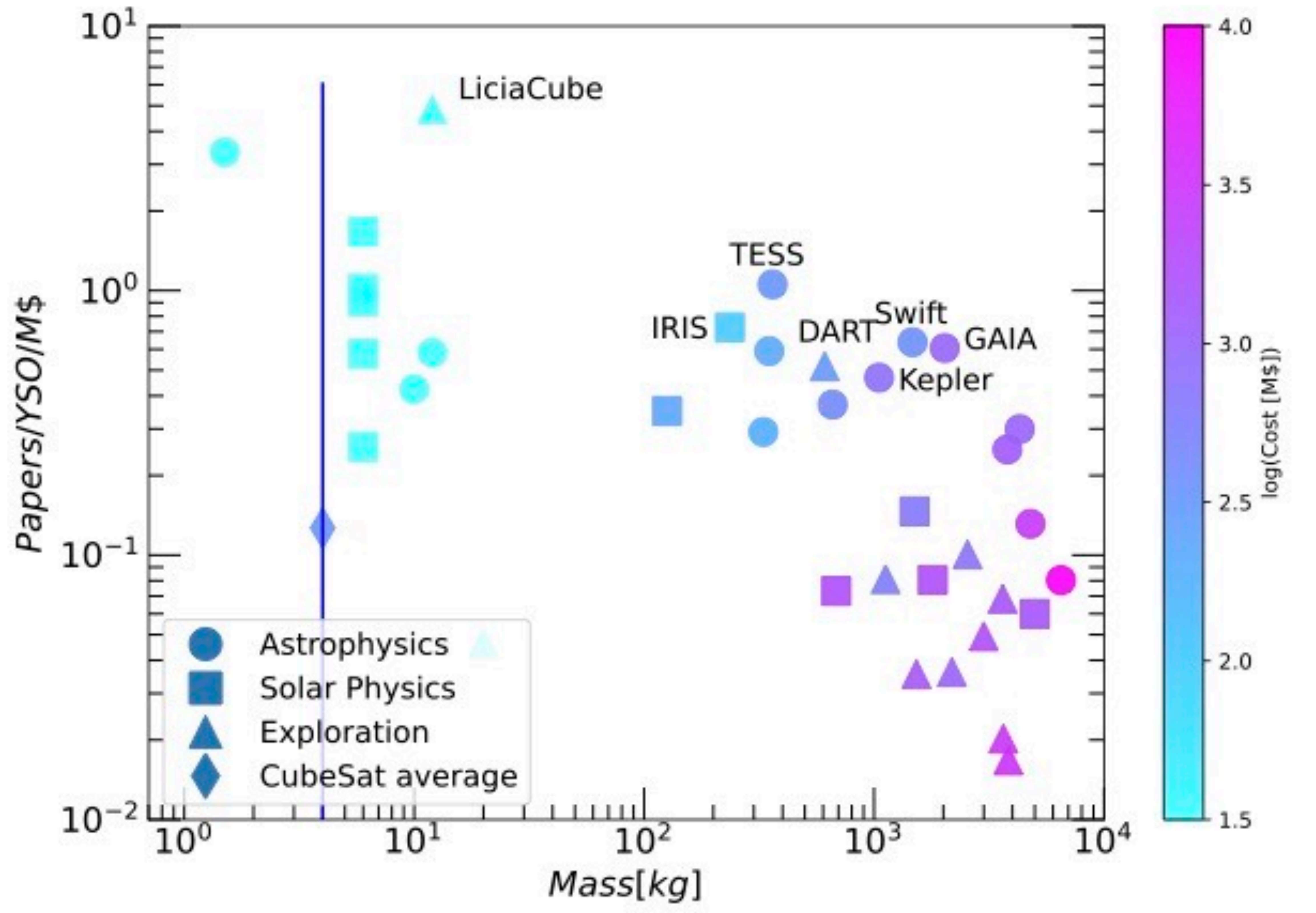
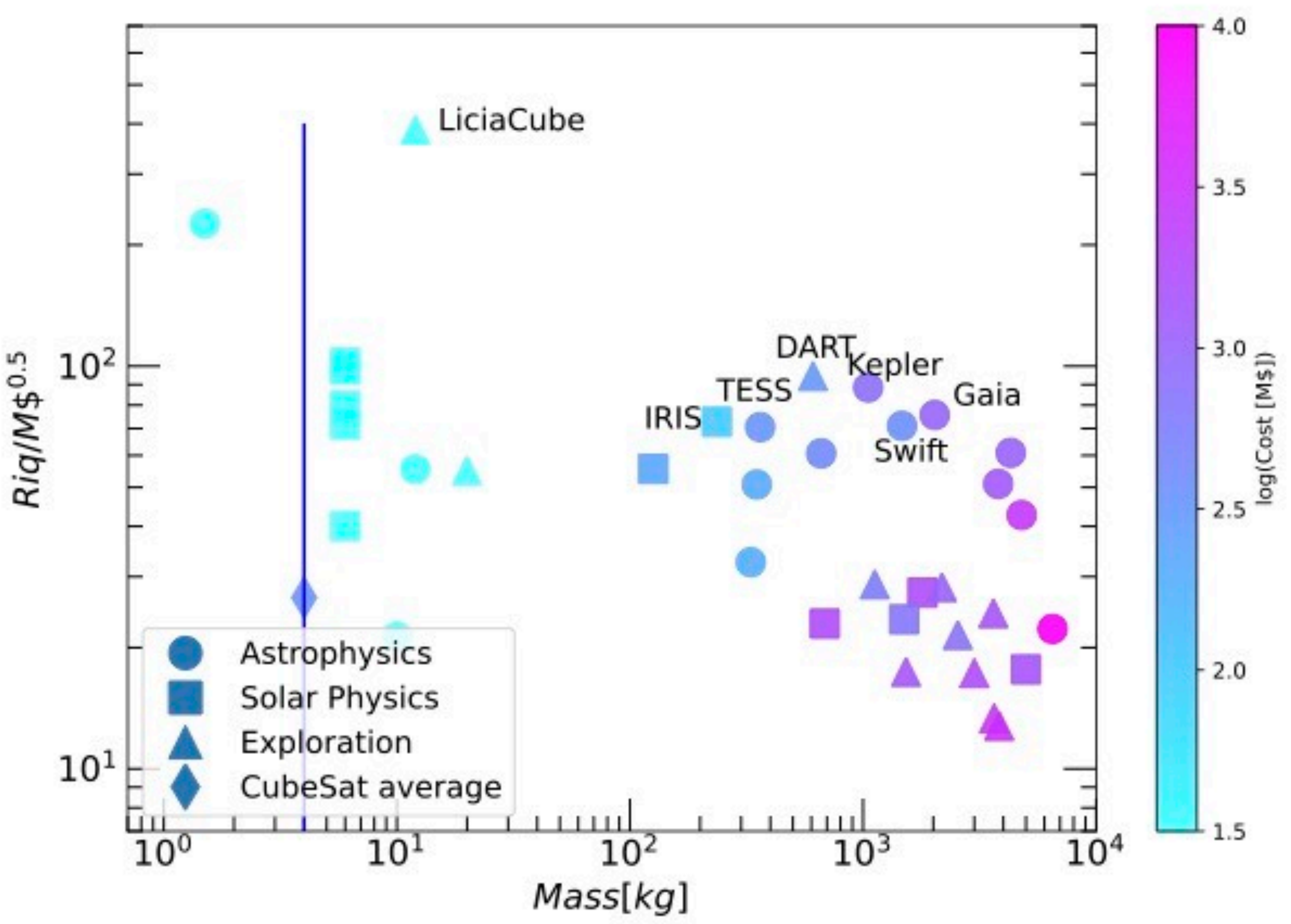
metrics for science mission success

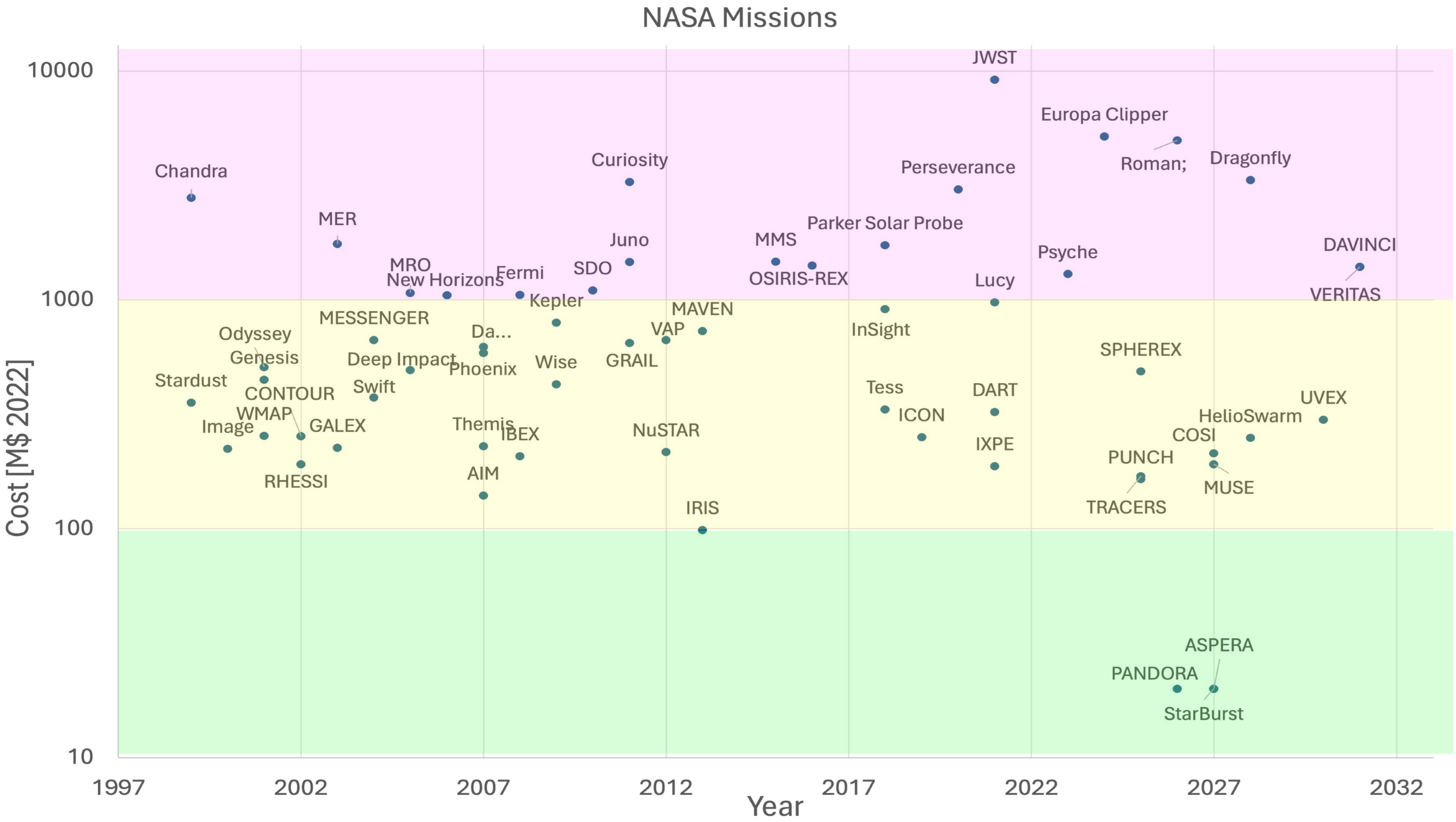




$$tori = \sum_n 1/ar$$

$$riq = \sqrt{tori/yso}$$

a is the number of authors of each citing paper and r is the number of references of the citing paper



NASA Missions
Cost [M$ 2022]
Year
10000
1000
100
10
1997
2002
2007
2012
2017
2022
2027
2032
JWST
Europa Clipper
Roman;
Dragonfly
Chandra
Curiosity
Perseverance
MER
Parker Solar Probe
Juno
MMS
DAVINCI
Psyche
MRO
New Horizons
Fermi
SDO
OSIRIS-REX
Lucy
VERITAS
Kepler
MAVEN
InSight
MESSENGER
Odyssey
Da...
VAP
SPHEREX
Genesis
Deep Impact
Phoenix
Wise
GRAIL
Stardust
CONTOUR
Swift
Tess
DART
UVEX
WMAP
ICON
HelioSwarm
Image
GALEX
Themis
IBEX
NuSTAR
COSI
IXPE
PUNCH
RHESSI
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TRACERS
IRIS
ASPERA
PANDORA
StarBurst

ESA missions
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1997
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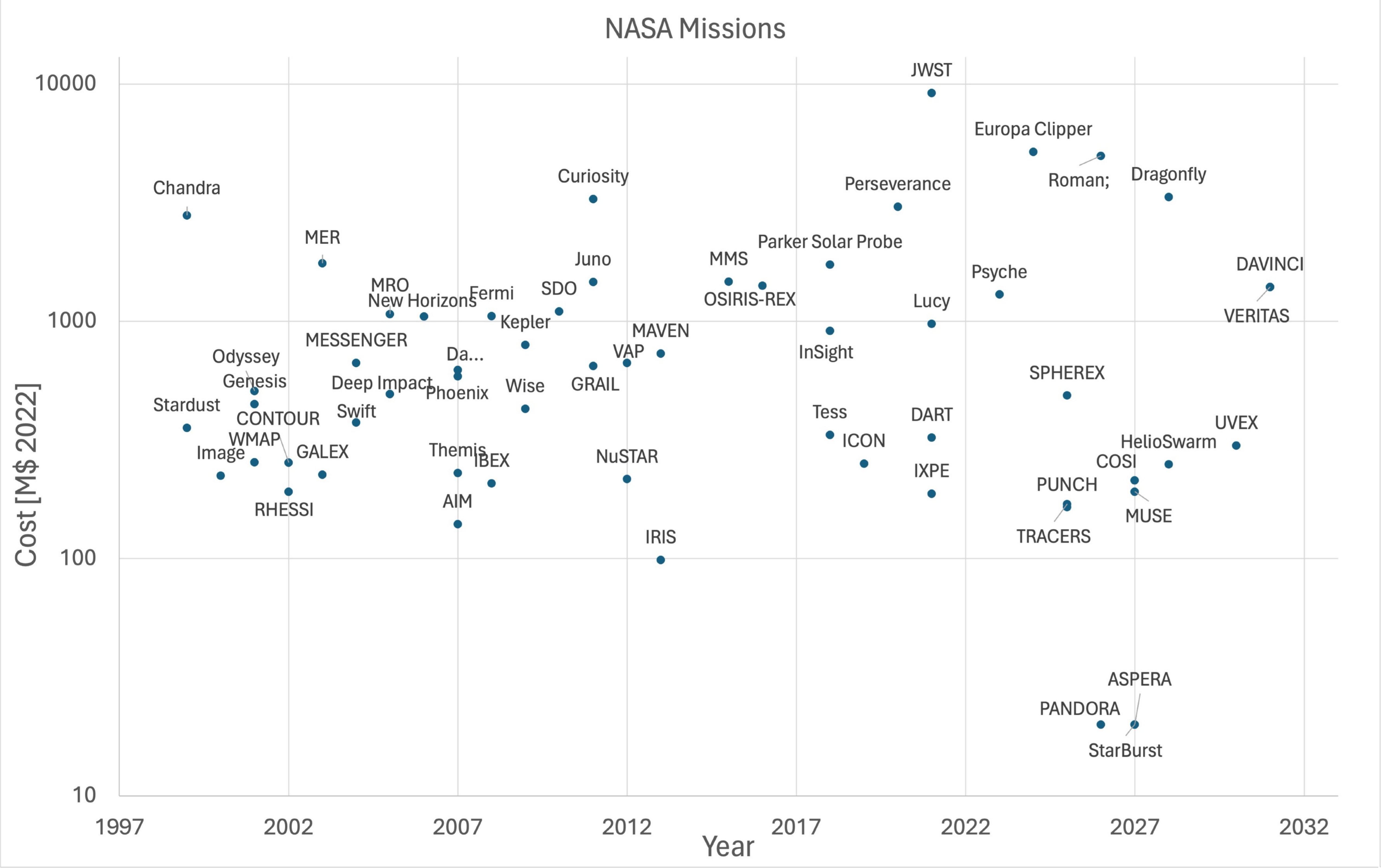
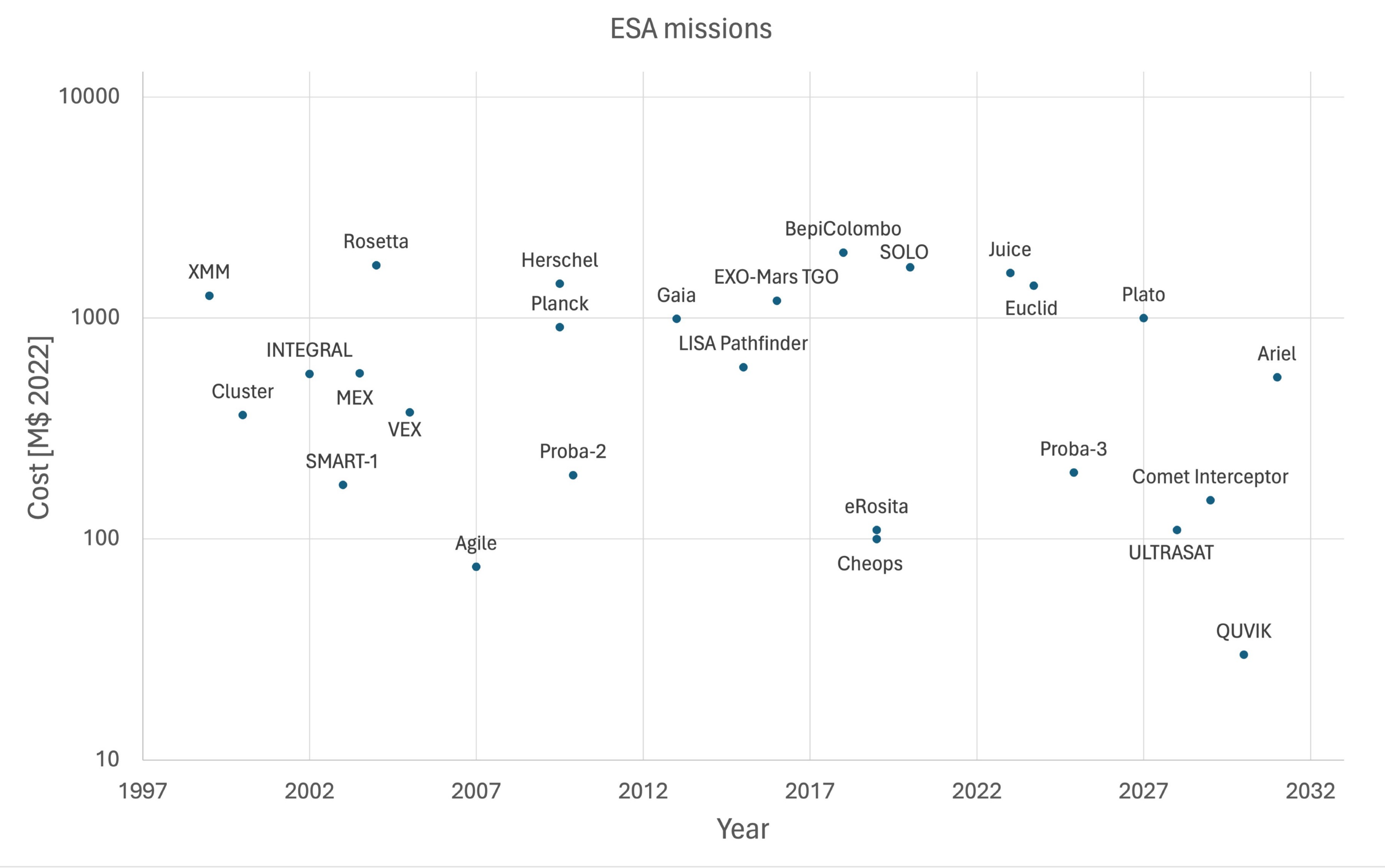
XMM
Rosetta
Herschel
Planck
Gaia
EXO-Mars TGO
BepiColombo
SOLO
Juice
Euclid
Plato
INTEGRAL
Cluster
MEX
VEX
SMART-1
Proba-2
LISA Pathfinder
Ariel
Proba-3
Comet Interceptor
eRosita
Cheops
ULTRASAT
Agile
QUVIK

NASA vs EU science missions 2000-2030





NASA:

20 missions >1B$

40 missions 0.1-1B$

3 missions <50M$

EU:

10 missions >1B$

10 missions 0.1-1B$

1 missions <50M$

toward new ambitious but affordable science missions

also in EUROPE

applying the CubeSat, Explorer, Pioneers approaches to larger spacecraft

two main steps:

- a broader funding base
- innovation

broadening the funding base

- private investors:
  - advertising their activities;
  - profit opportunities in activities such as planetary protection, or exploration of Moon, Mars and Asteroids for resource prospecting, or using science mission to test advanced technologies;
  - buy knowledge
- philanthropic foundations
- public-private partnerships as in e.g. NASA Commercial Orbital Transportation Services (COTS) and Commercial Lunar Payload Services (CLIPS)
- inter-governmental organizations like the European Commission

innovation

- make the requirements smart, where you end is not where you start. iterative approach to achieve the main science goal, during which the science requirements are continually challenged and questioned, with rapid iteration at each step of the development process
- before looking for complex technical solutions we must be sure they are really necessary to reach our main scientific objectives
- exploit as much as possible vertical integration and scale production, commercial buses:
  - starshield
  - https://www.k2space.com/
  - https://www.apexspace.com/

Approaches to lowering the cost of large space telescopes

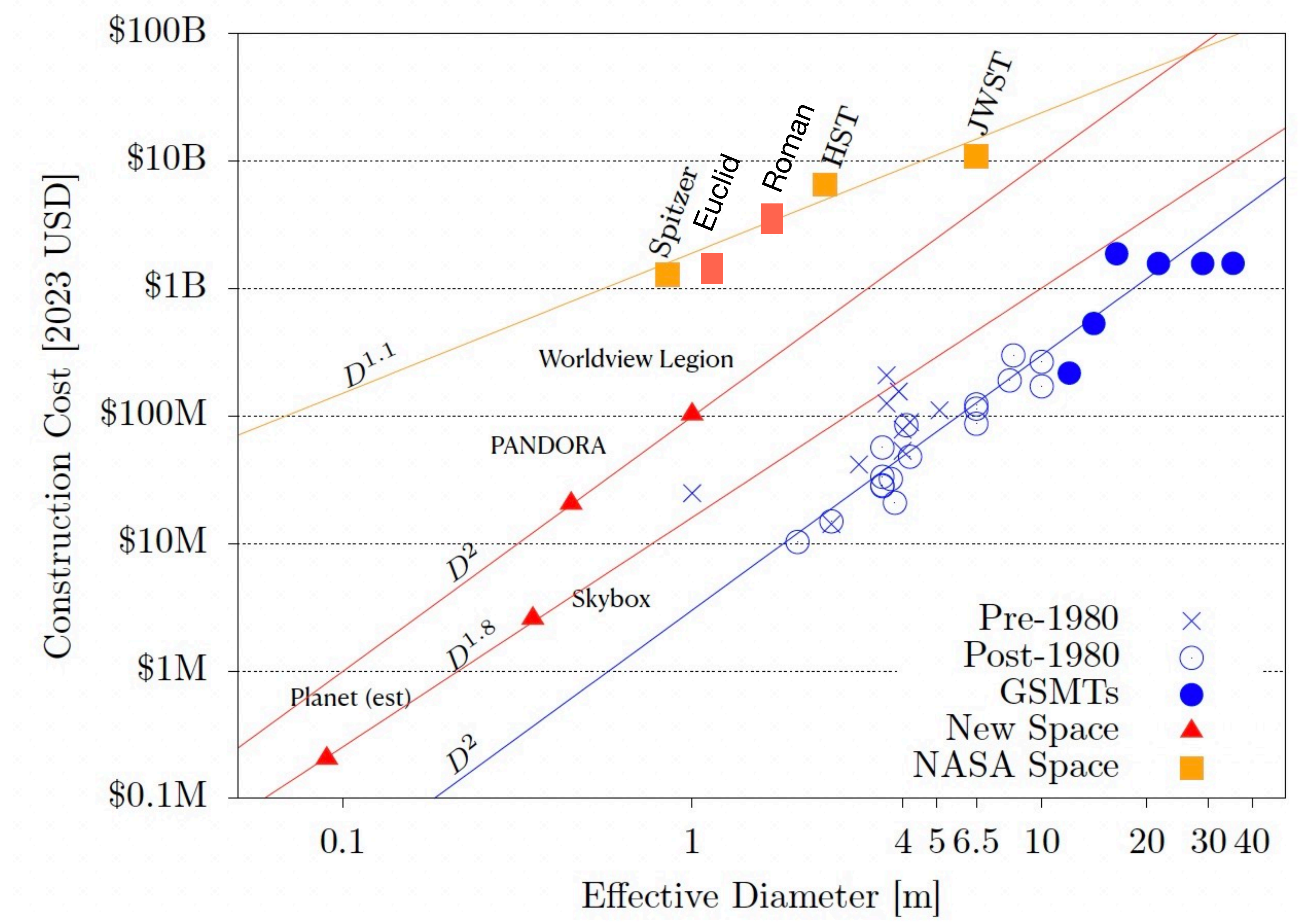
Ewan S Douglas[a], Greg Aldering[b], Greg W. Allan[c], Ramya Anche[a], Roger Angel[a], Cameron C. Ard[a], Supriya Chakrabarti[d], Laird M. Close[a], Kevin Derby[a], Jerry Edelstein[e], John Ford[a], Jessica Gersh-Range[f], Sebastiaan Y. Haffert[a], Patrick J. Ingraham[a], Hyukmo Kang[a], Douglas M. Kelly[a], Daewook Kim[a], Michael Lesser[a], Jarron M. Leisenring[a], Yu-Chia Lin[a], Jared R. Males[a], Buddy Martin[a], Bianca Alondra Payan[a], Sai Krishanth P.M.[a], David Rubin[g], Sanford Selznick[h], Kyle Van Gorkom[a], Buell T. Jannuzi[a], and Saul Perlmutter[b,e,i]

science goals:

- spectrophotometry of type1a SN
- high contrast imaging of sub-neptune planets around nearby stars

engeeniring constraints

- use fairing of Starship, 6.5m
- ~~6.5m~~ 3m light-weighted borosilicate honeycomb mirror
- adapt smallsat concepts to enable larger satellites



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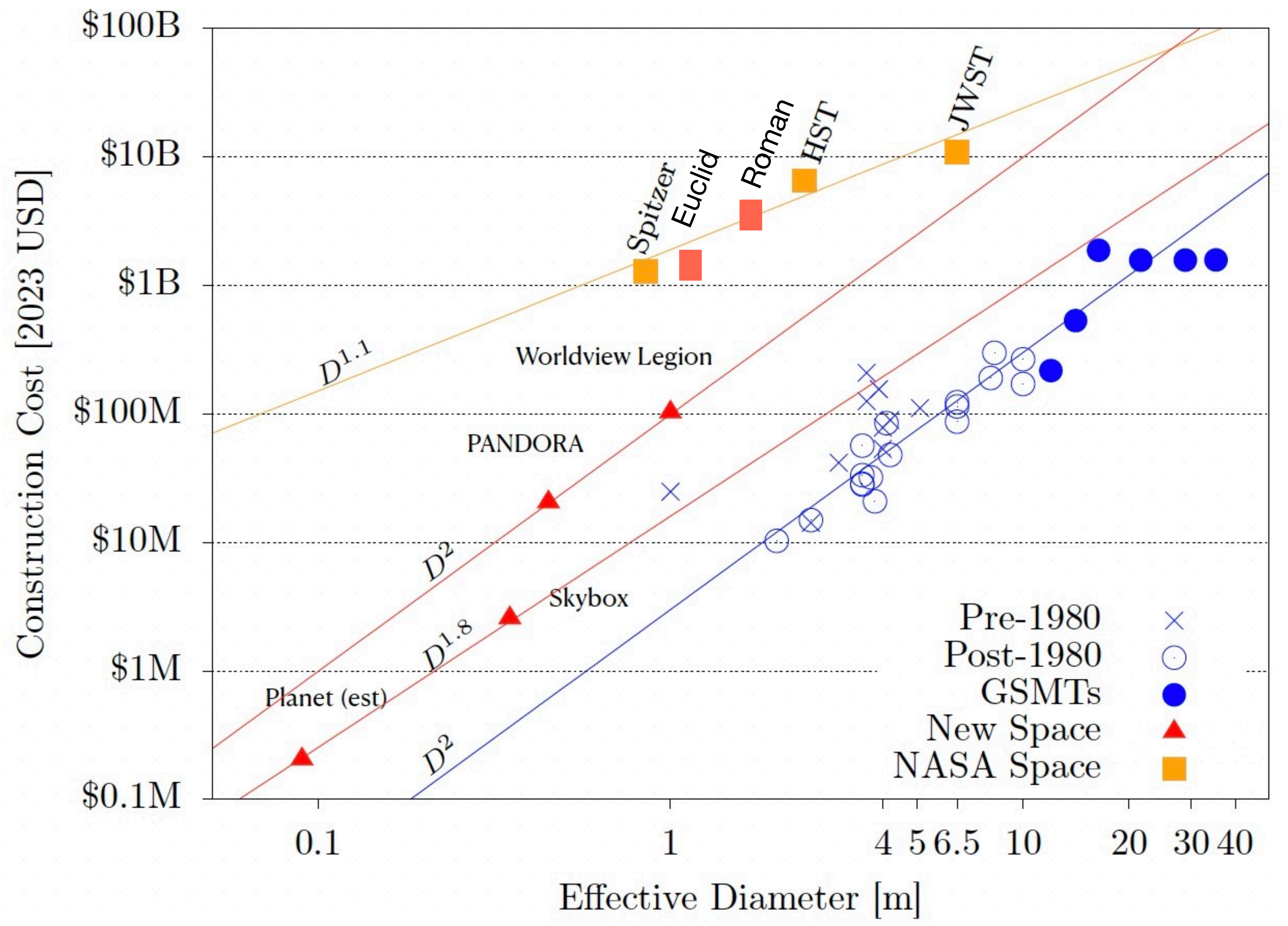

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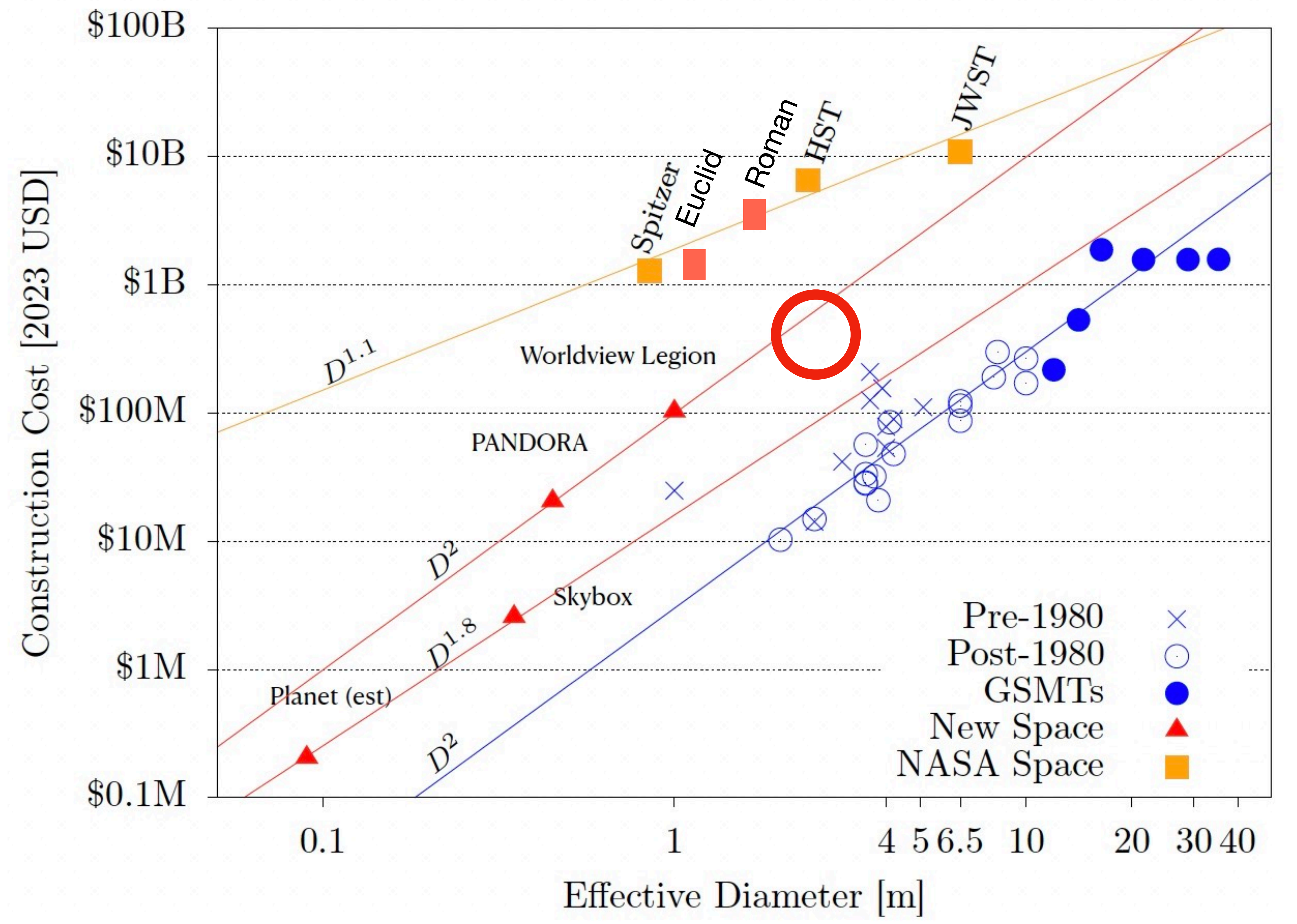
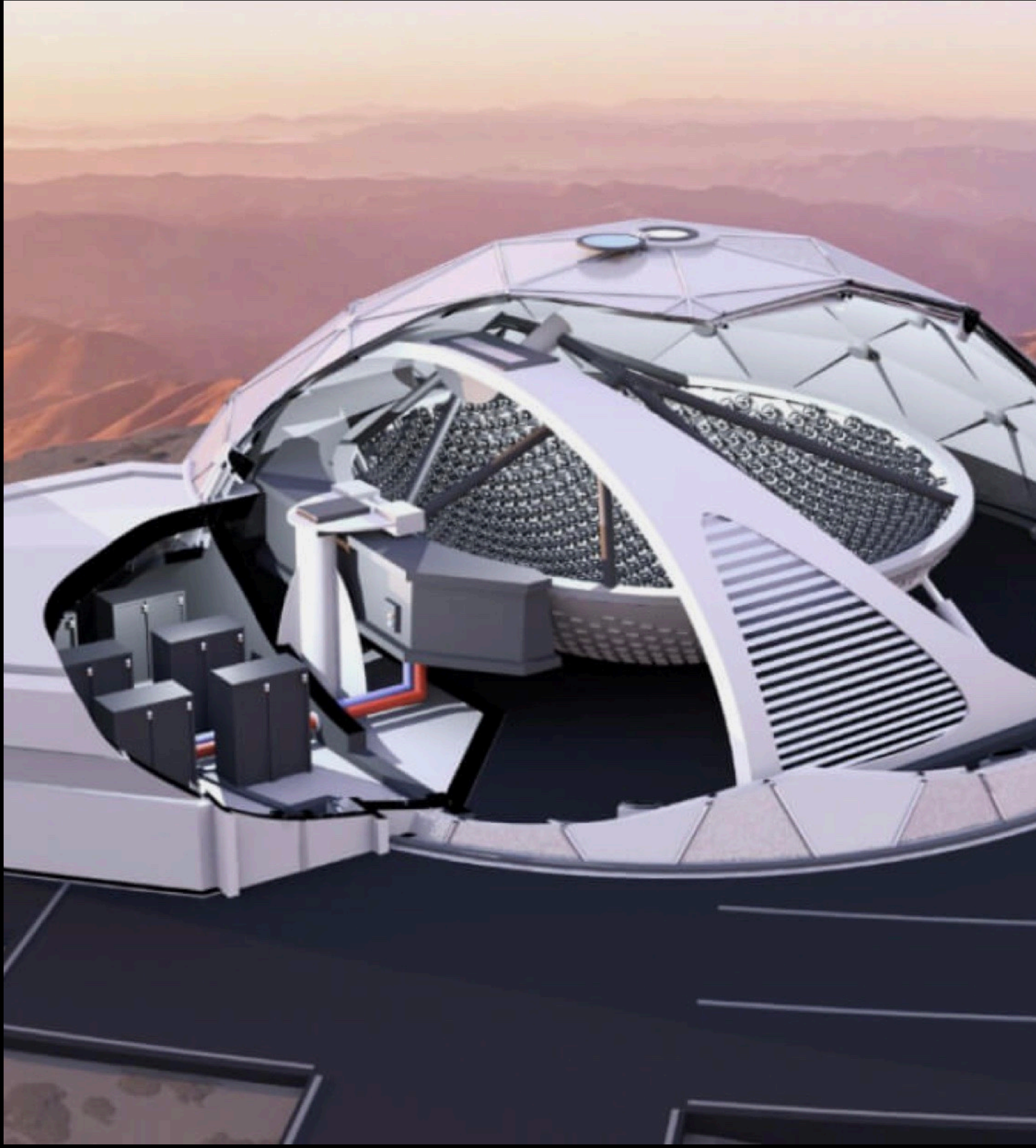


Argus array
Schmidt science

- time domain astronomy
- 1200 telescopes - equivalent to 8m
- 8000 deg2
- point source sensitivity:
- 1s g=16.8
- 1m g=20.0
- 1hr g=22.3
- 1night g=23.2
- planned 2028

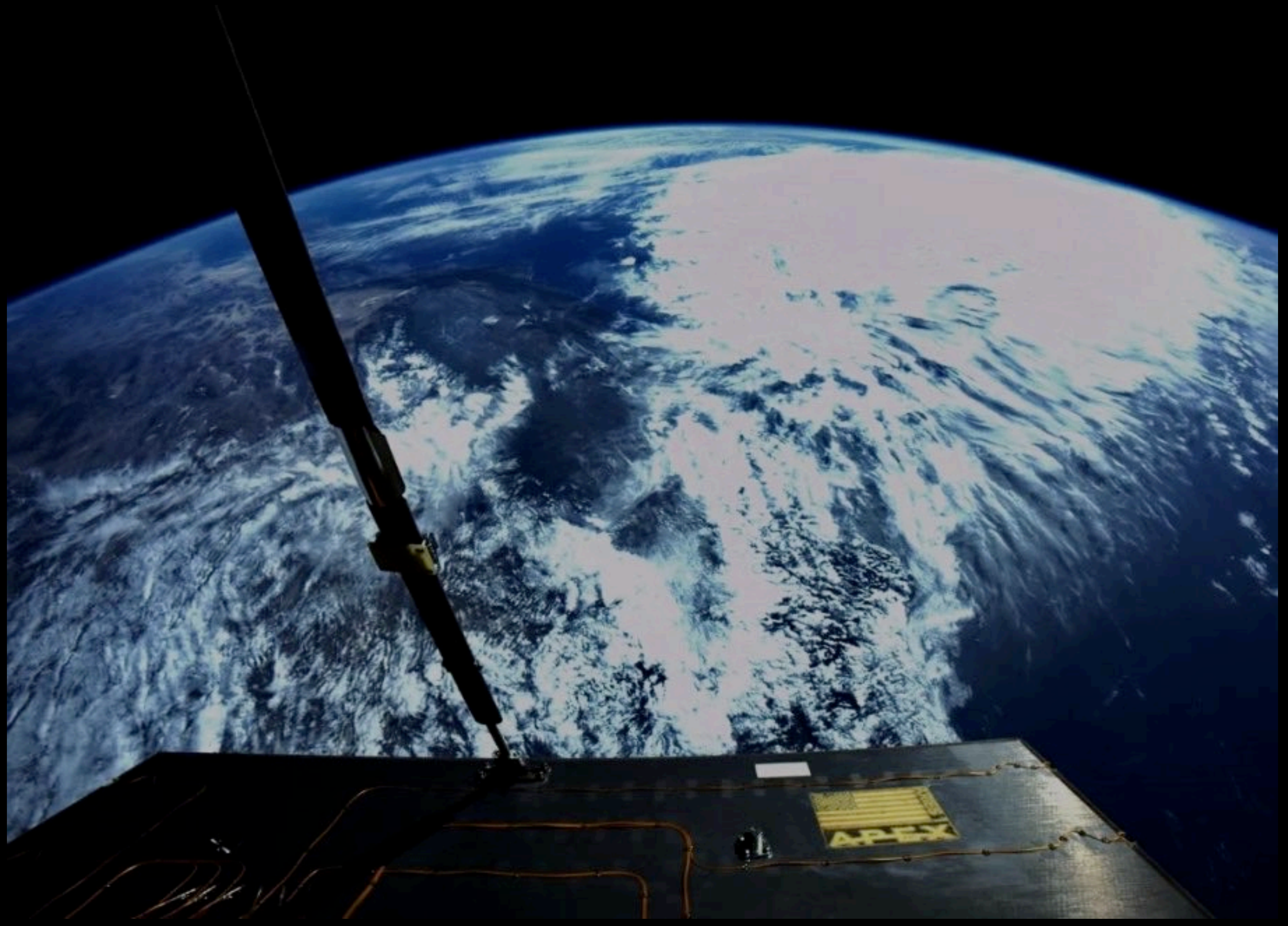


adapt smallsat (cubesat, explorer missions) to enable large basic science missions

- bus ~10MEur

https://www.apexspace.com/order-now

- P/L up to 150kg ~10MEur
- system engineering & system AIT ~10MEur
- launch ~10MEur
- precursos, GS, operations and margings ~10MEur
- Total 50MEur



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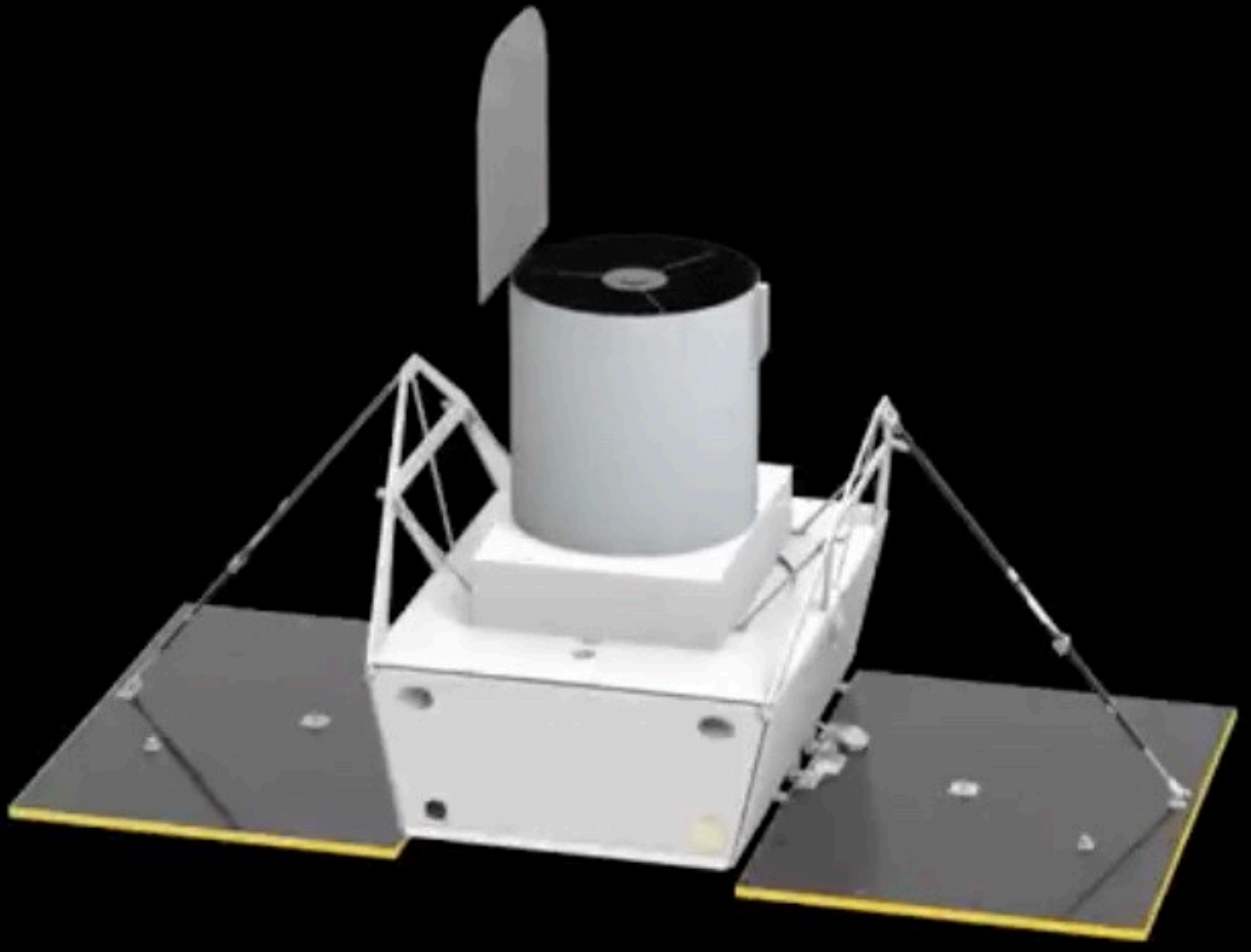

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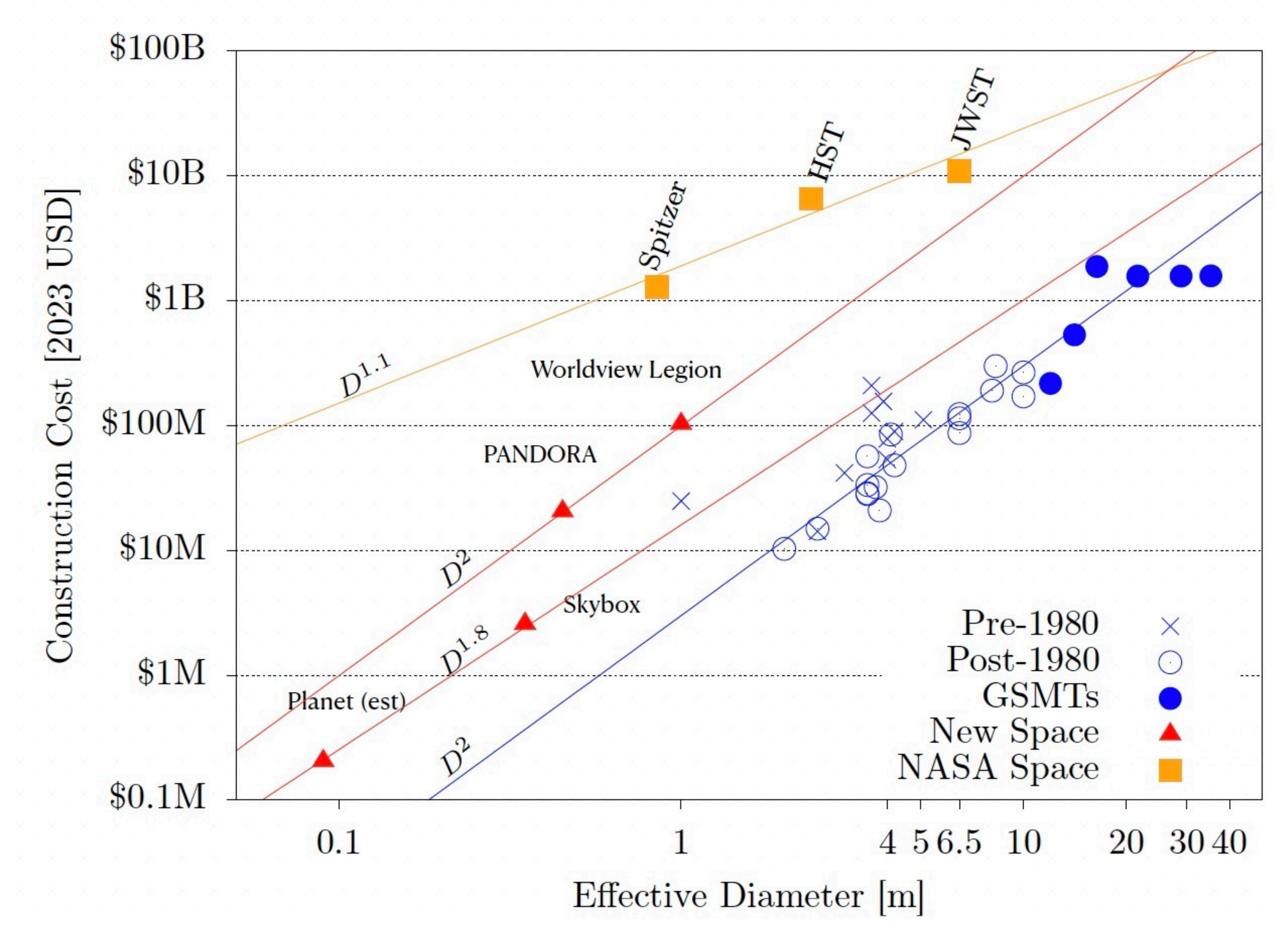

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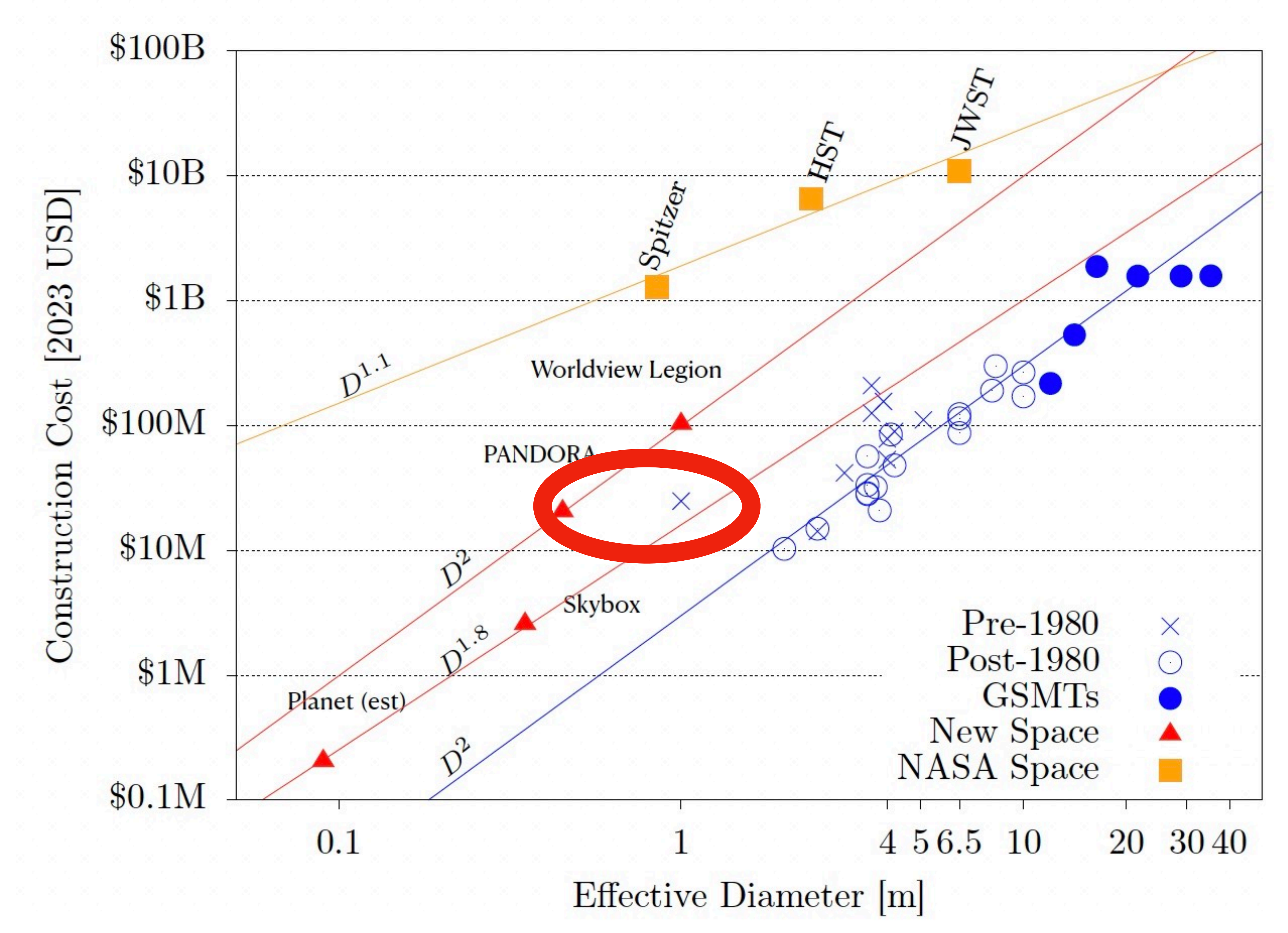

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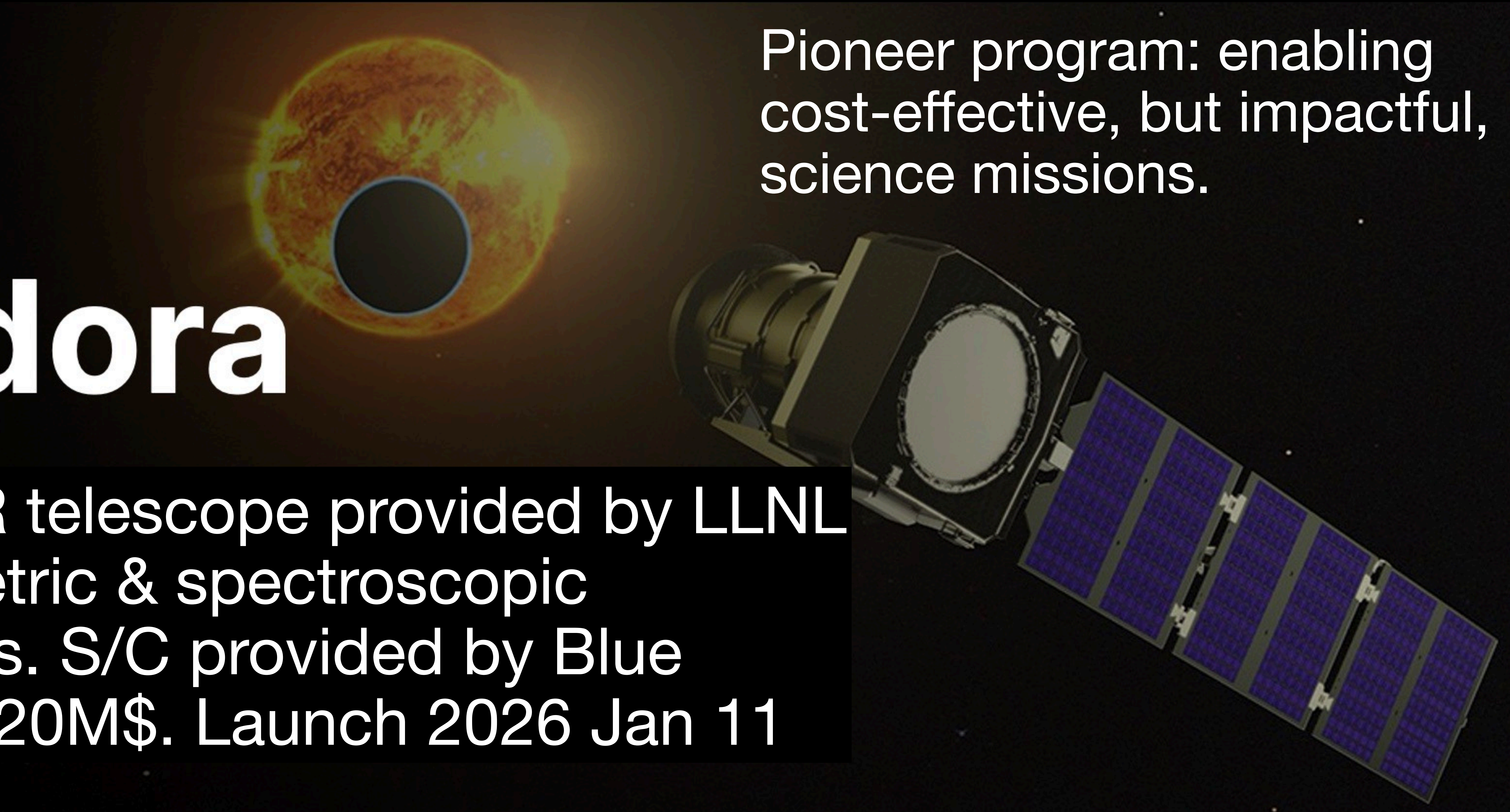


Pioneer program: enabling cost-effective, but impactful, science missions.

0.45m ONIR telescope provided by LLNL for photometric & spectroscopic observations. S/C provided by Blue Canyon - ~20M$. Launch 2026 Jan 11

adapt smallsat (cubesat, explorer missions) to enable large basic science missions

ESCAPADE

Escape and Plasma Acceleration and Dynamics Explorers

2 S/C to be operated in Mars orbit, manufactured by Rocket Lab: <80M$. Launch 2025, Nov 13

NASA Pioneers program

- PANDORA
- ASPERA
- StarBurst

NASA Pioneers program

ASPERA: WHIM mapping using OVI line

UV spectrograph from UArizona

spectral resolution <0.07nm

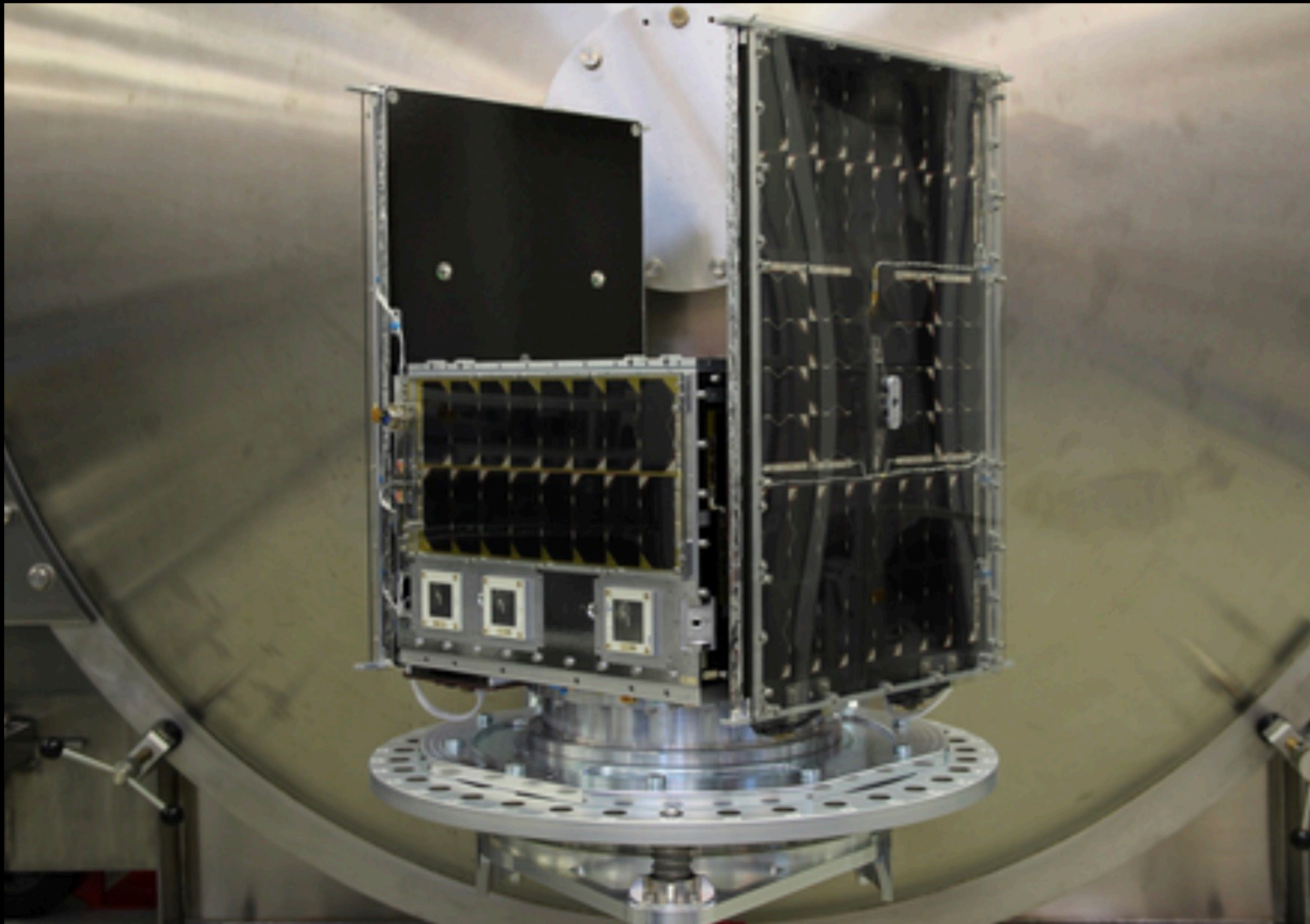
spatial resolution<1arcmin

FoV 60arcmin x 0.5 arcmin

S/C UTIAS SFL (Canada) DEFIANT, 60kg

20M$ total cost

launch Q1 2026 on Rocket Lab Electron



NASA Pioneers program

StarBurst: GRB and EM counterparts of GE events

Gamma-ray spectrograph provided by NRL

collecting area GBM x 5; 12 12 CsI(Tl) read out by SiPM;

30-1000 keV

S/C UTIAS SFL (Canada) DAUNTLESS, 300kg

20M$ total cost

launch 2025 on SpaceX F9

PRESENTAZIONE DELLE CARROZZE INDUSTRIALI PER LA PARTECIPAZIONE AL BANDO INAF PER LA "PICCOLA MISSIONE SCIENTIFICA NAZIONALE"

« Tutti gli Eventi

Presentazione delle carrozze industriali per la partecipazione al bando INAF per la "Piccola Missione Scientifica Nazionale"

13 Febbraio

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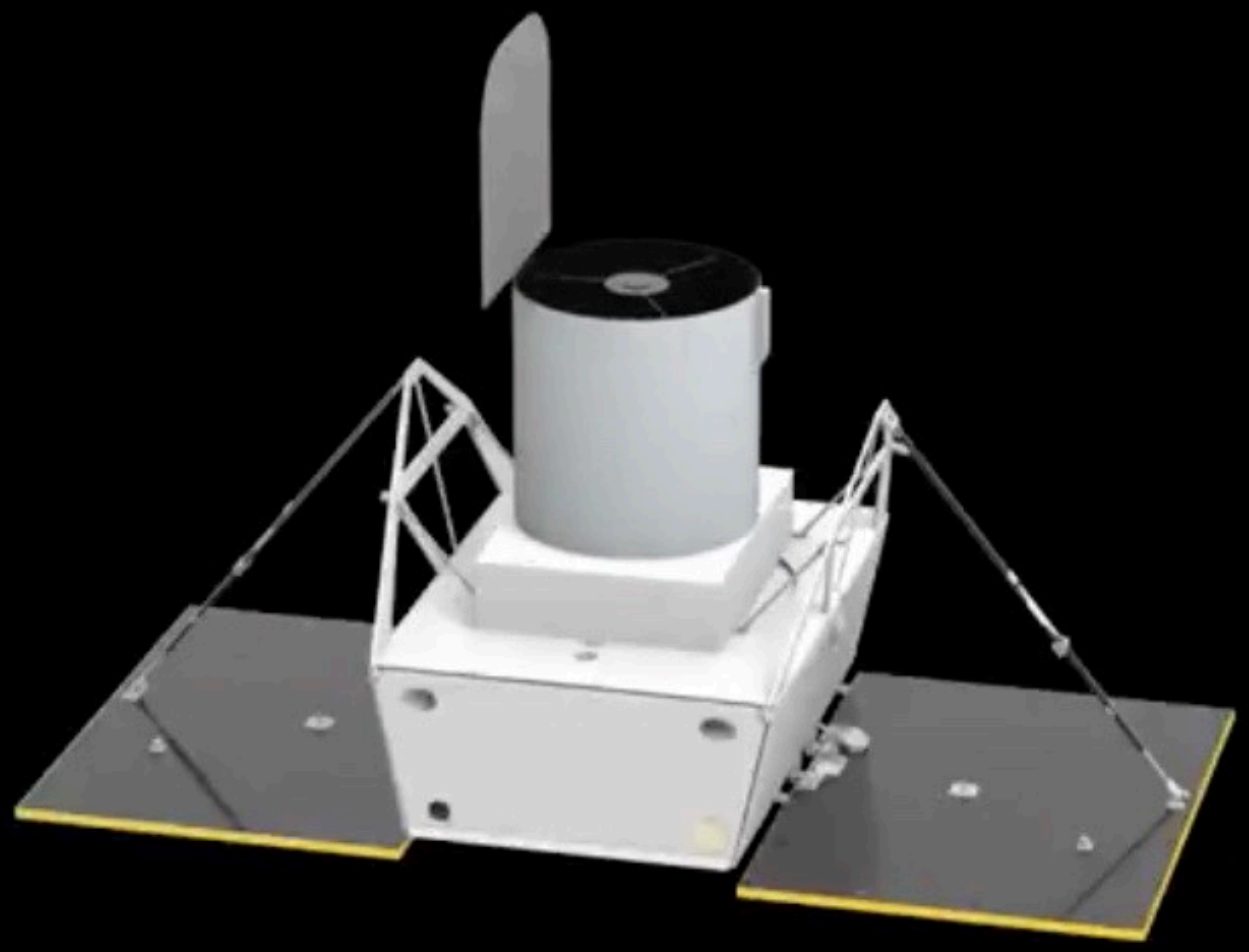
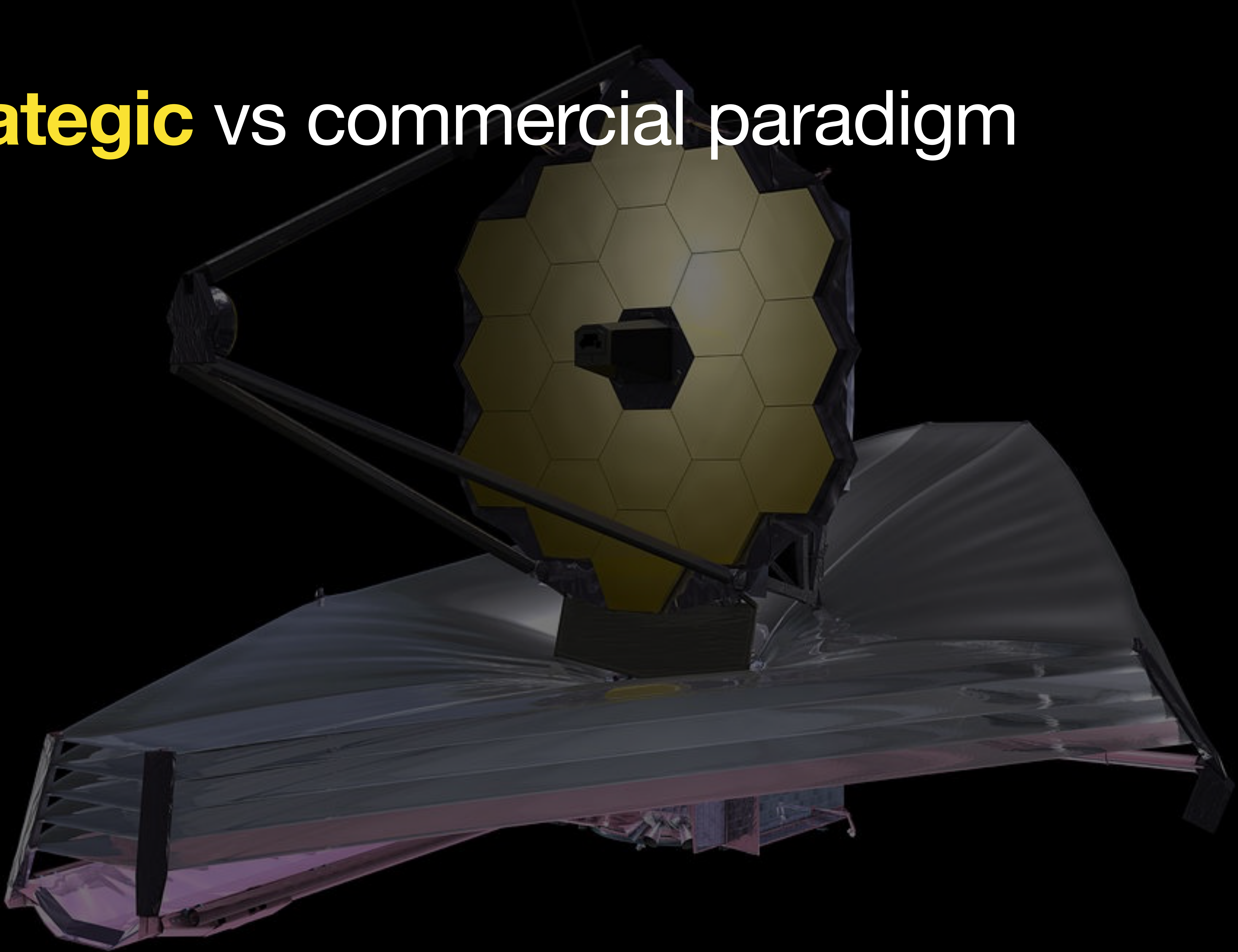


thanks!

strategic vs commercial paradigm



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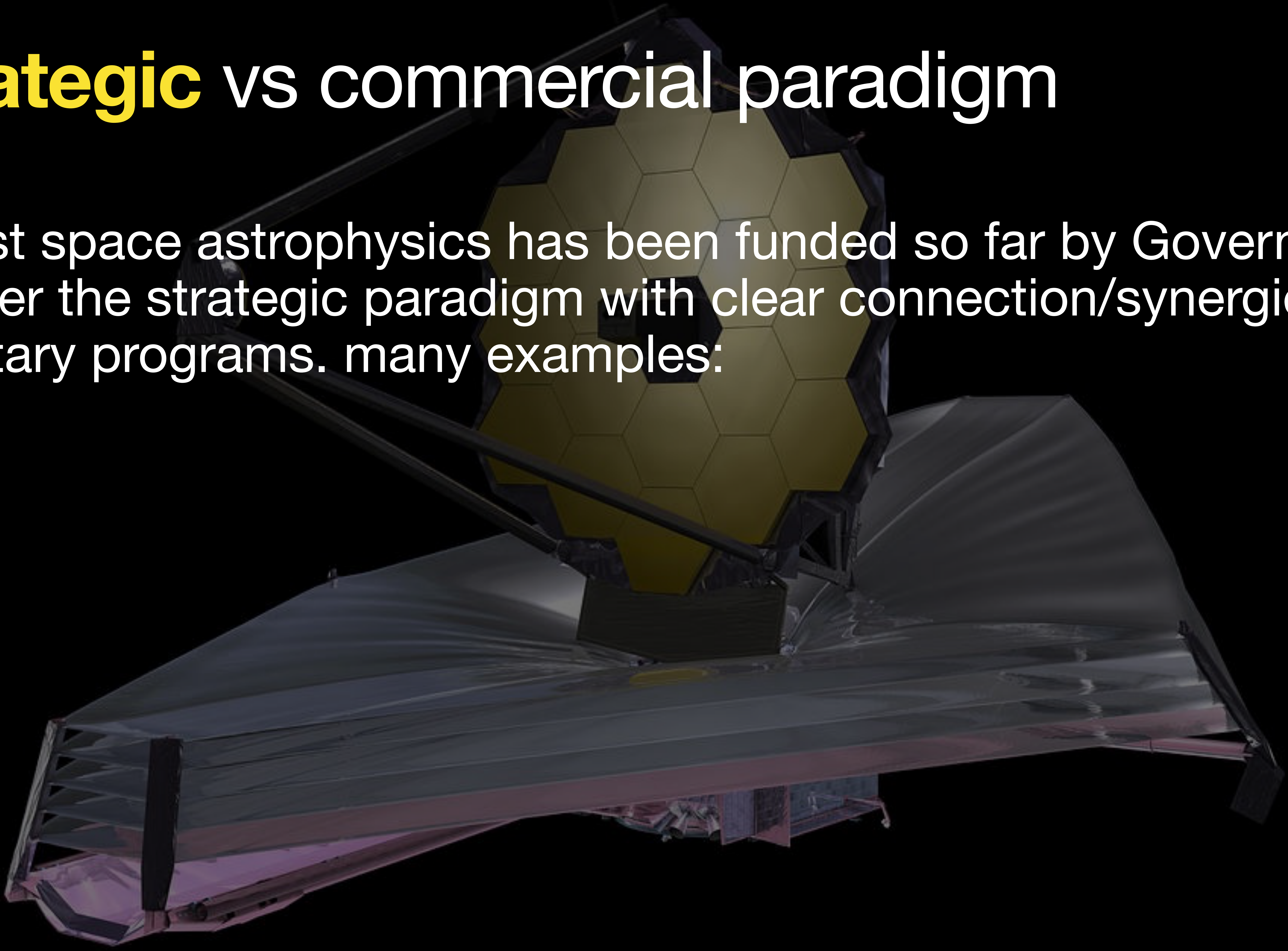

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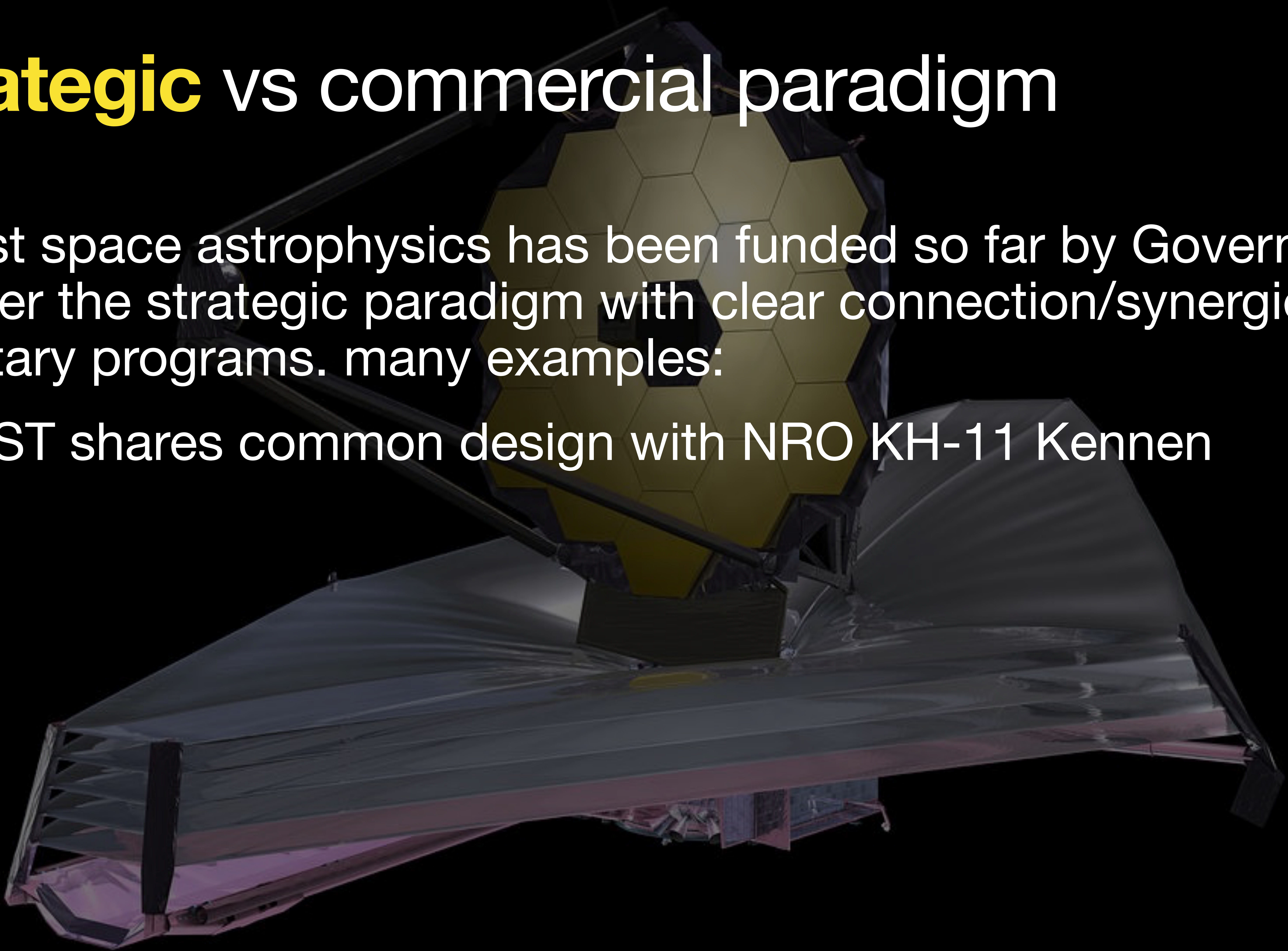

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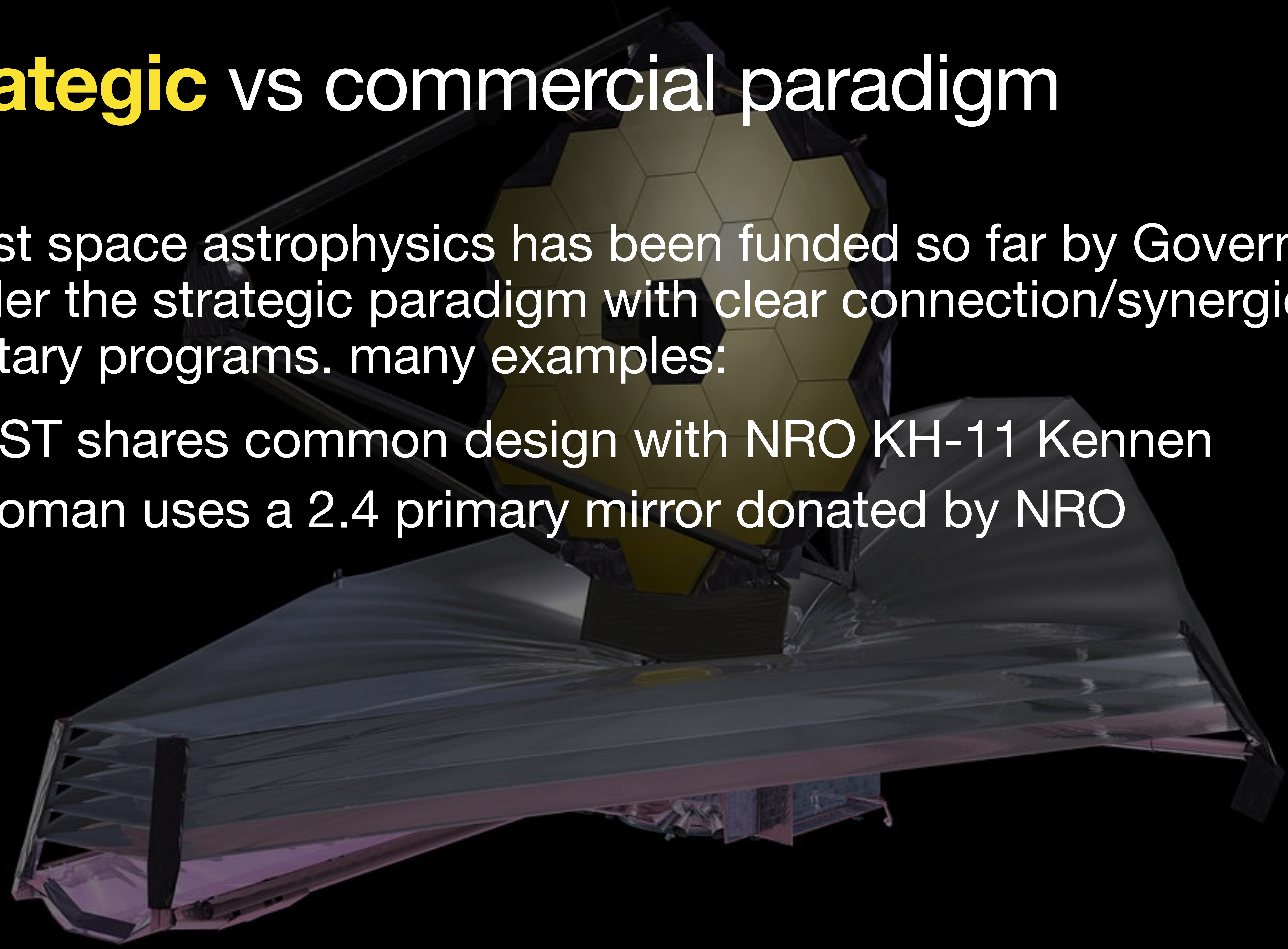

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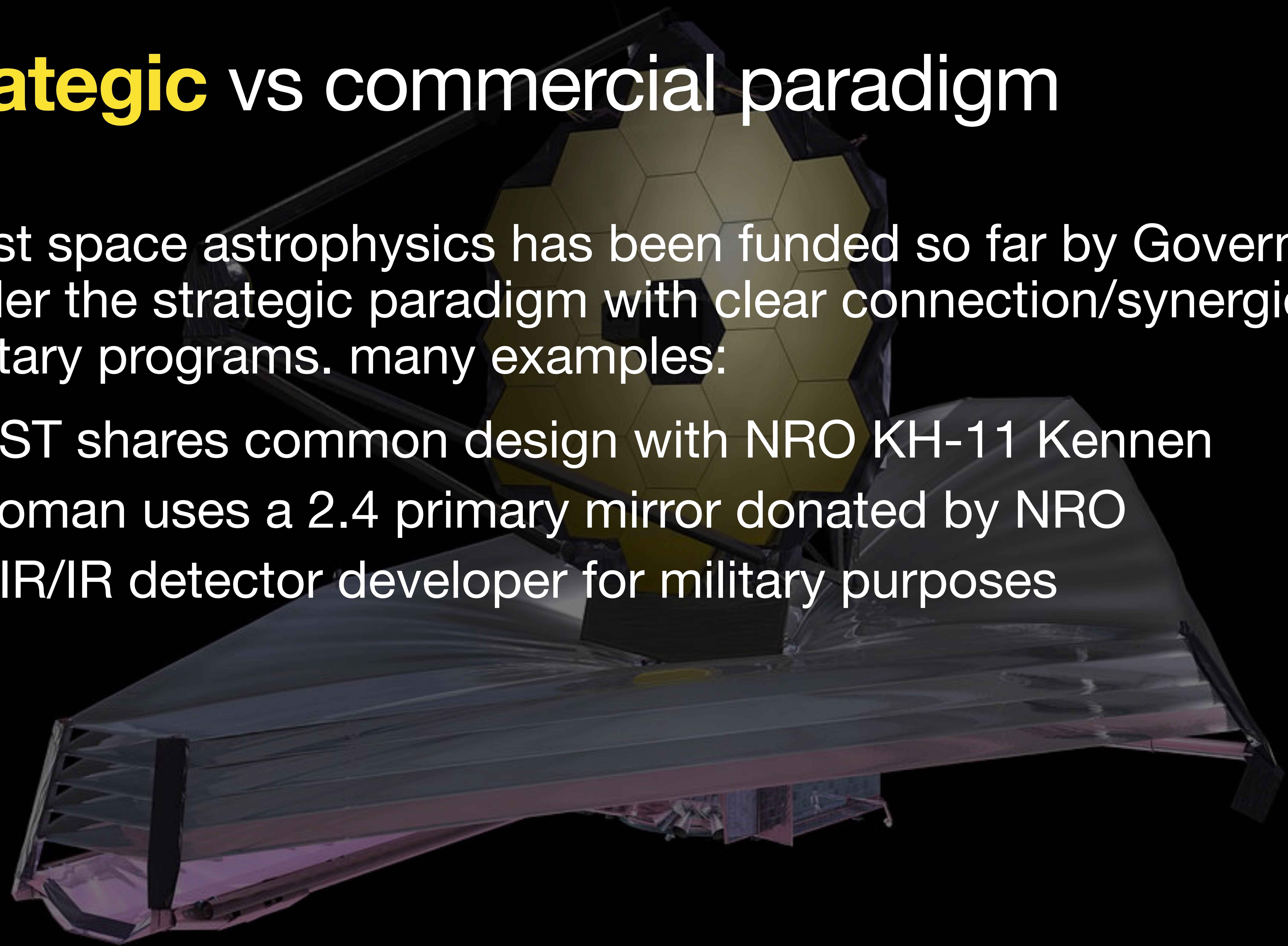

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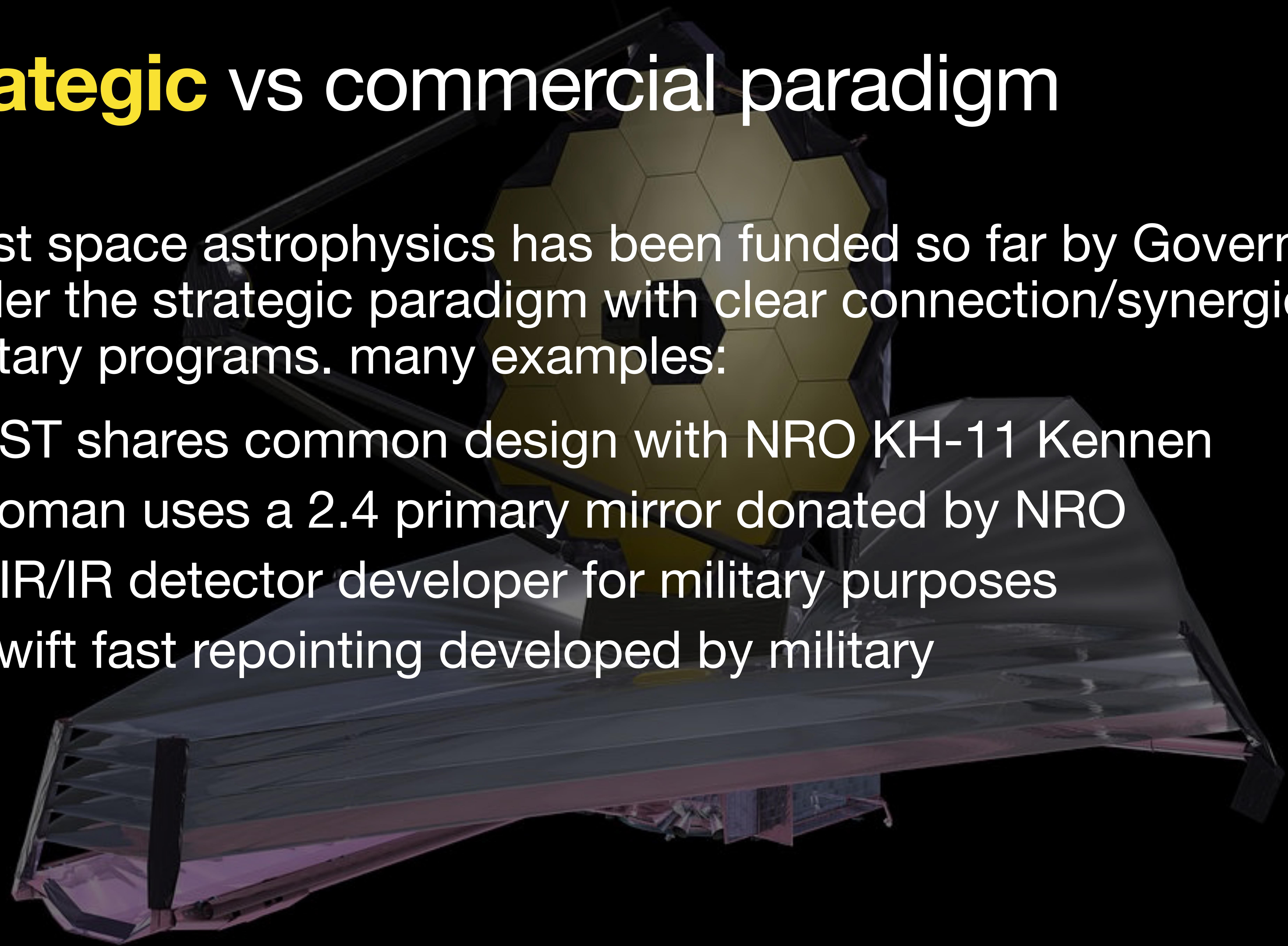

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  - JWST segmented berillum primary mirror developed jointly by NASA & DoD: Advanced Mirror System Demonstrator (AMSD) program

Feature	JWST Implementation	Military Synergies	Examples/Impacts
Lightweight Beryllium Mirrors	Gold-plated segments for 25.4 m^2 collecting area; stable at cryogenic temps.	Enables compact, high-performance optics in drones, satellites, and aircraft; X-ray transparency aids secure comms.	Used in EO/IR sensors for UAVs (e.g., Predator drones); DoD satellites for missile warning. Enhances stealth via lighter designs.
Cryogenic Stability	Maintains shape at 30–50 K; low thermal distortion for precise alignment.	Critical for high-altitude or space-based IR sensors detecting heat signatures in extreme environments.	Missile seekers (e.g., AIM-9X Sidewinder); space-based infrared systems (SBIRS) for ballistic missile defense. Improves reliability in hypersonic scenarios.
Segmented/ Deployable Design	18 segments with actuators for on-orbit phasing; survives launch vibrations.	Supports scalable, foldable optics for small satellites or deployable arrays in contested orbits.	Adaptive optics in military telescopes (e.g., ground-based laser systems); future deployable surveillance sats..
Precision Actuation & Alignment	132 actuators total; aligns to <25 nm rms surface error post-deployment.	Enables real-time wavefront correction in dynamic environments like airborne targeting.	Laser weapon systems (e.g., HELIOS); gimbal-stabilized EO/IR turrets on ships/aircraft. Boosts accuracy in electronic warfare.

Feature	JWST Implementation	Military Synergies	Examples/Impacts
		, high- cs in drones, craft; X-ray secure	Used in EO/IR sensors for UAVs (e.g., Predator drones); DoD satellites for missile warning. Enhances stealth via lighter designs.
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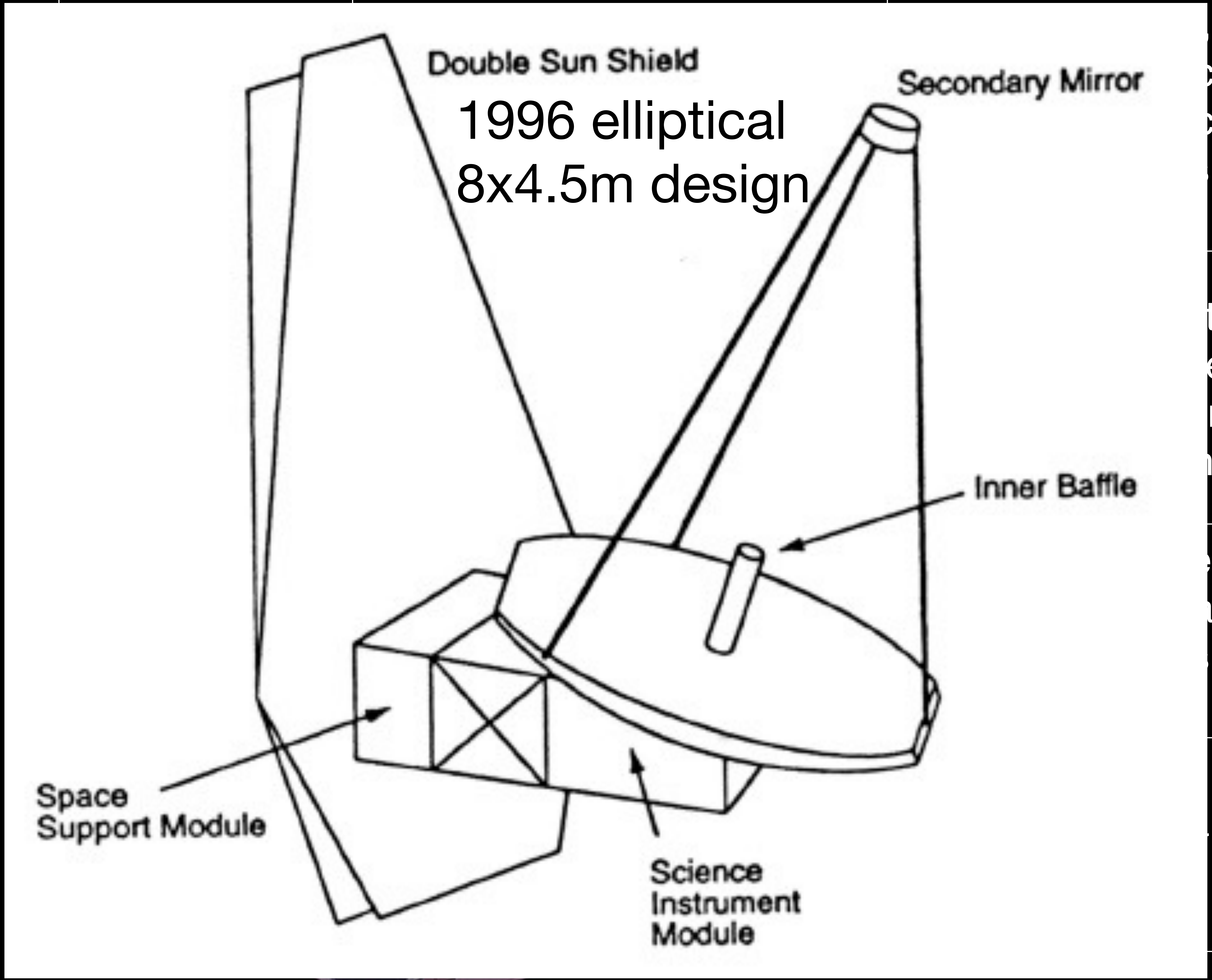
		, foldable tellites or in contested	Adaptive optics in military telescopes (e.g., ground-based laser systems); future deployable surveillance sats..
		wavefront mic airborne	Laser weapon systems (e.g., HELIOS); gimbal-stabilized EO/IR turrets on ships/aircraft. Boosts accuracy in electronic warfare.



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