# Super-Heavy Launchers and Future Great Observatories

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# A Decade of Falcon 9

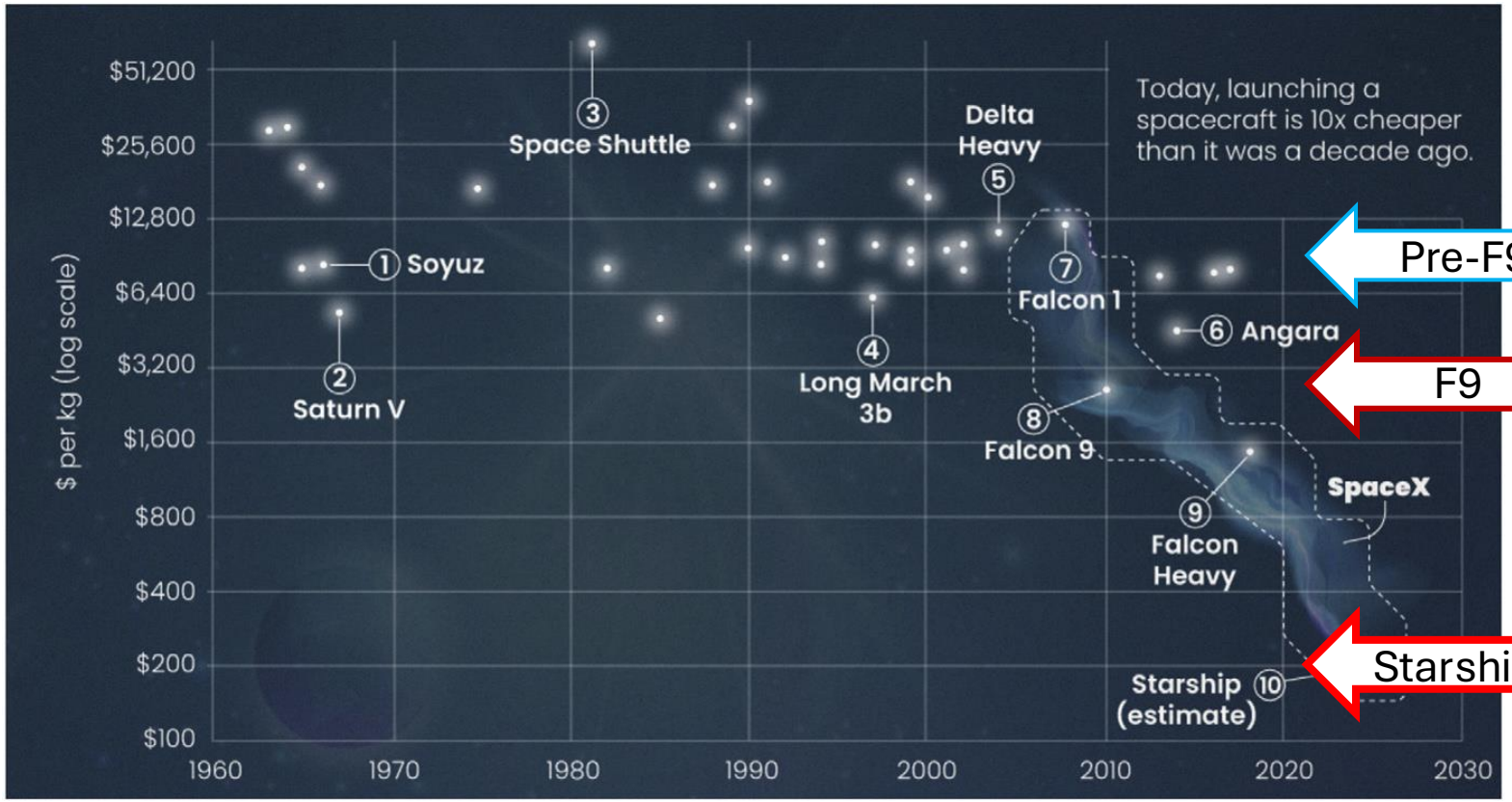
A closeup of the Falcon 9 first stage, safely down on the SpaceX landing barge, *Of Course I Still Love You*

**SpaceX launches cargo ship to orbit, sticks ocean landing**

By William Harwood

Updated on April 8, 2016 / 8:50 PM EDT / CBS New

# Falcon 9 to Starship




Pre-F9 ~$10,000/kg

F9 ~$2,000/kg

Starship ~$200/kg ?



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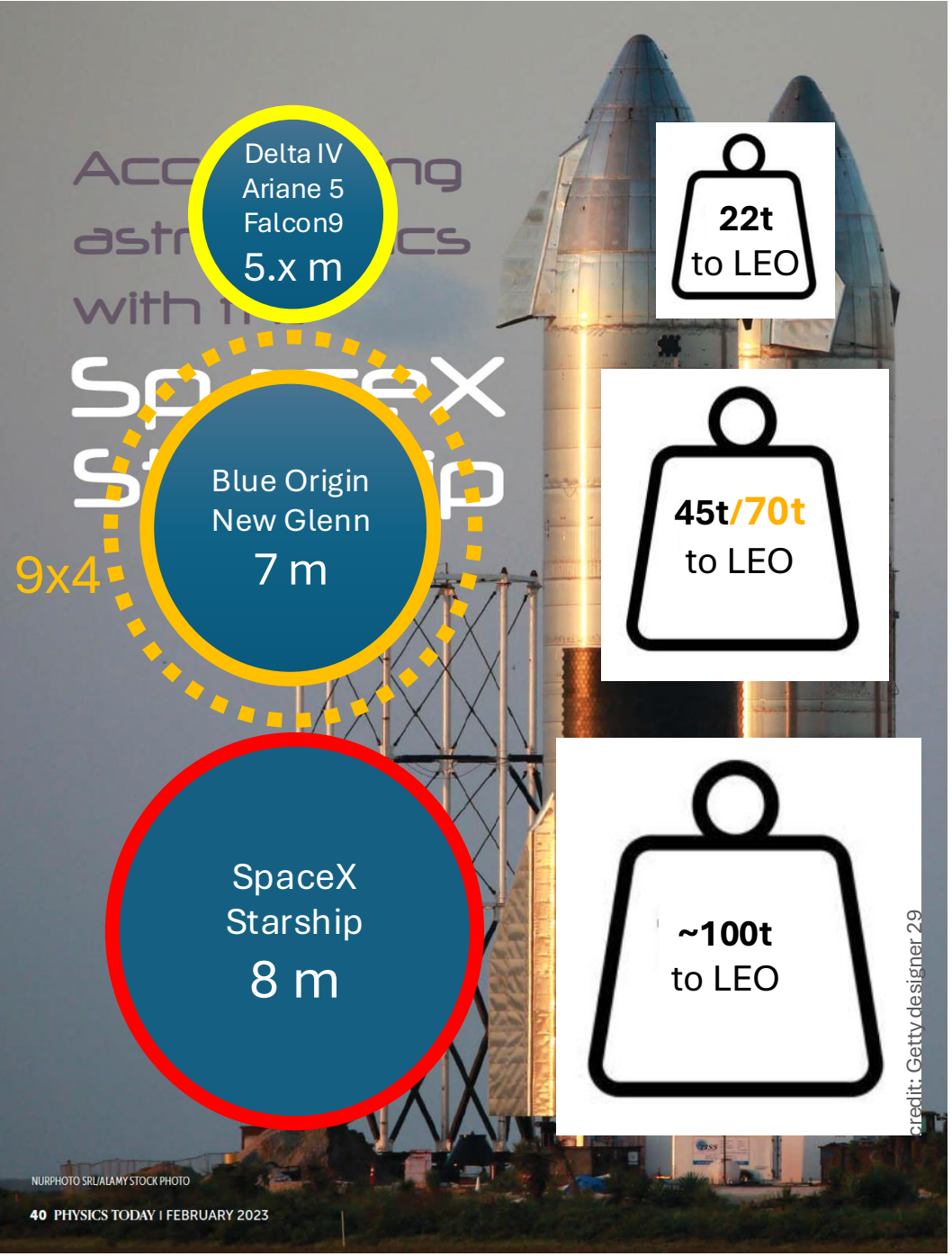



credit: Getty designer 29

# Super-Heavy Launch:
## New Capabilities
## New design spaces

- Same or lower cost/launch – 2 providers
- **Wide Fairings**: mechanical simplicity
- **Large Masses**: robust margins, less exotic materials

→Faster design/build/test

→ Cheaper

→a host of new commercial products

→ *Astronomers can leverage these*

# Super-Heavy cost savings across the board

## Optics

- Larger, simpler
  - UVOIR
- Higher mass
  - X-ray
  - Gamma-ray?

## Detectors

- >> mass, power
  - Cryo cooling

## Ground

- OCC 5X smaller
- Telemetry formats

+ AI (e.g., SAOimageDS9*)

*V8.8beta downloadable at ds9.si.edu

## Spacecraft

- OTS
- e.g. K2 “Giga”
- 15 t, 6x6 m, 110 kW
- ~$50M*,

+ Laser comm

* private communication

# Cambrian Explosion of Mission Concepts

Ewan Douglas et al., 2023,
arXiv:2309.04934

# 1. Lower Cost 6.5m opt/NIR

*[Submitted on 10 Sep 2023 (v1), last revised 19 Oct 2023 (this version, v2)]*

**Approaches to lowering the cost of large space telescopes**

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

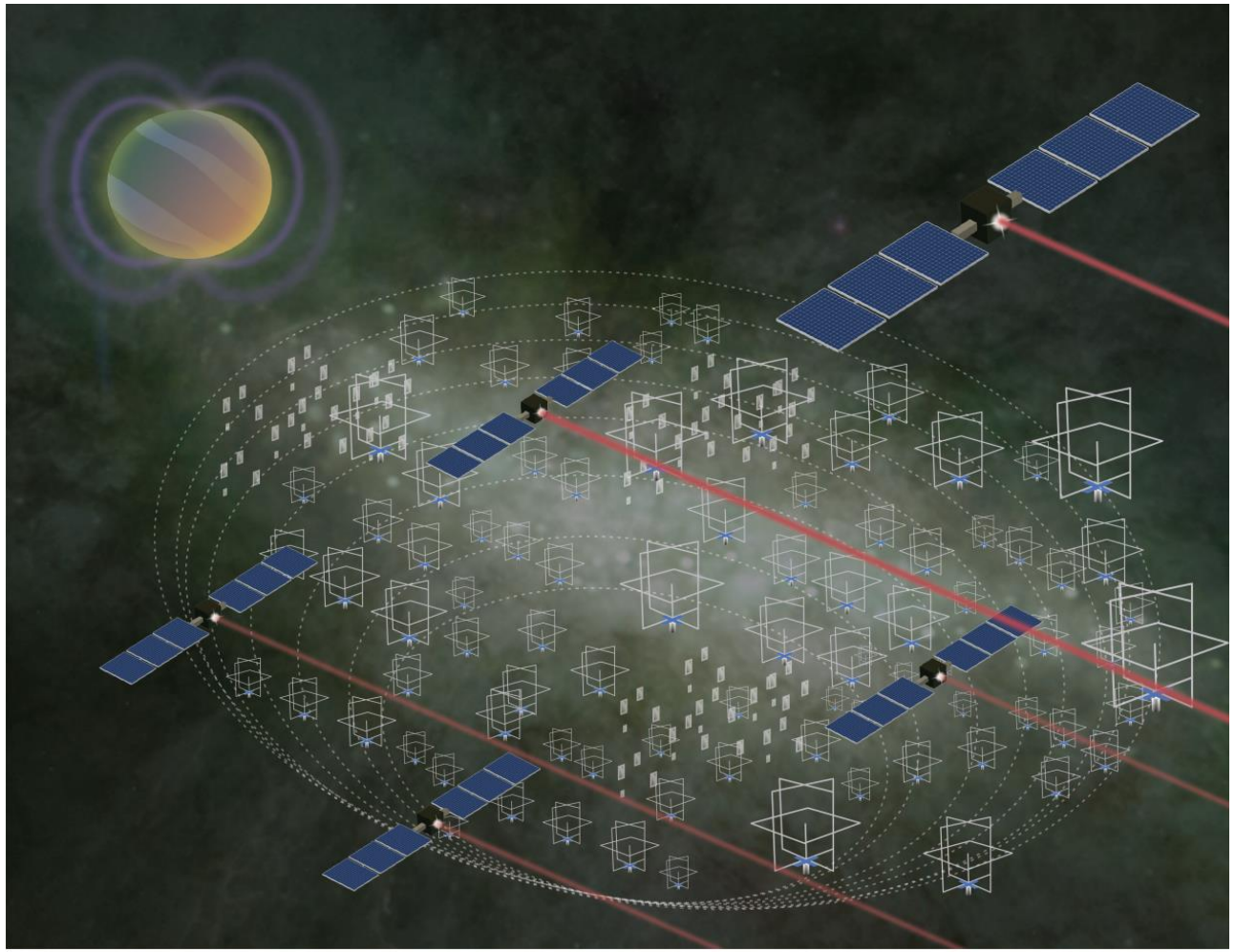
- 6.5m optical telescope
- "No fold" design
- high mass/area mirror

+ Additional tech advances:
  - CMOS @ 0ºC
  - TESS orbits
  - Rad tolerant compute
  - JSON interface control

- All point to *lower cost, faster launch*

Mary Knapp et al., 2024 NIAC I report.
arXiv:2404.08432v1

# 2. GO-LoW: low frequency radio



- Mass production:
  - 100,000 3U nodes
  - 100-1000 ESPA Compute centers
- Allows relaxed failure rate
  - cheaper
- at Earth-Sun L4/L5 =1AU from here
  - Laser comm
- Scaleable: 6-11 Starship launches

L4, L5 = Lagrange points ahead and behind Earth

Peter Cheimets+ 2026 – Day 2 X-ray & UV Breakout
[abstract #114]

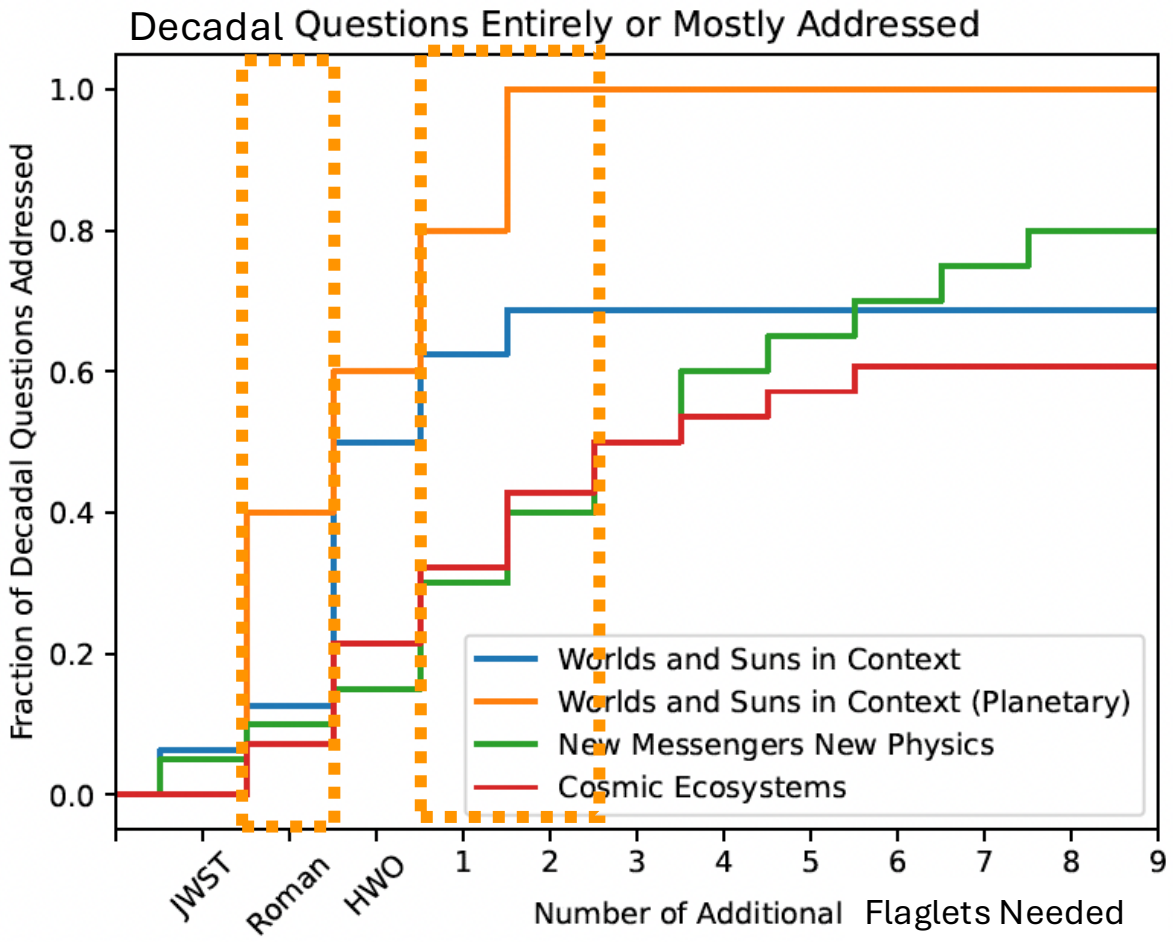
# 3. Lynx redux: X-ray

Lynx grazing incidence mirror design

- 20X Chandra area, (sub-)arcsec PSF
- Lynx 2020: 2t mirror - 37,492 0.5mm shells
- **Lynx 2030 8t mirror (> JWST total mass!)**
- *So what?*
- Why thicker?
  - Stiffness goes as (thickness)$^3$
  - 2 mm shells will be 64X stiffer
    →figuring, mounting, alignment far easier
  - cut number of shell segments by factor 4
    → quicker manufacturing, lower cost

+ new figuring tech: deterministic
→schedule, cost confidence
→smaller reserves

Regina Caputo et al., 2026,
arXiv:2605.02880v2




# Flaglets

- Alternate paradigm:
  - a coordinated fleet
- Compare “science reach” per $
- 4 $2B “flaglet” program may do more than one $10B flagship
- Without such “Tensioning”

  a single flagship always wins

Martin Elvis,
2016, arXiv:1608.01004

# Implications for NASA

- Astronomers always want “More Light”
  → contain mission creep
- Decadal SOW : rank programs, not missions
- More mass no longer means higher cost
- OTS spacecraft – no mods allowed
  - payloads may have to absorb S/C functions
- Build to cost: overruns mean cancellation
- Multiple missions allows cancellation

SOW = statement of work
OTS = off the shelf

# Super-Heavy Launchers and Future Great Observatories

We have a rare opportunity
to do
More Science at Lower Cost

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