Disaggregation as a Tool For Astrophysics

ASTRA Workshop

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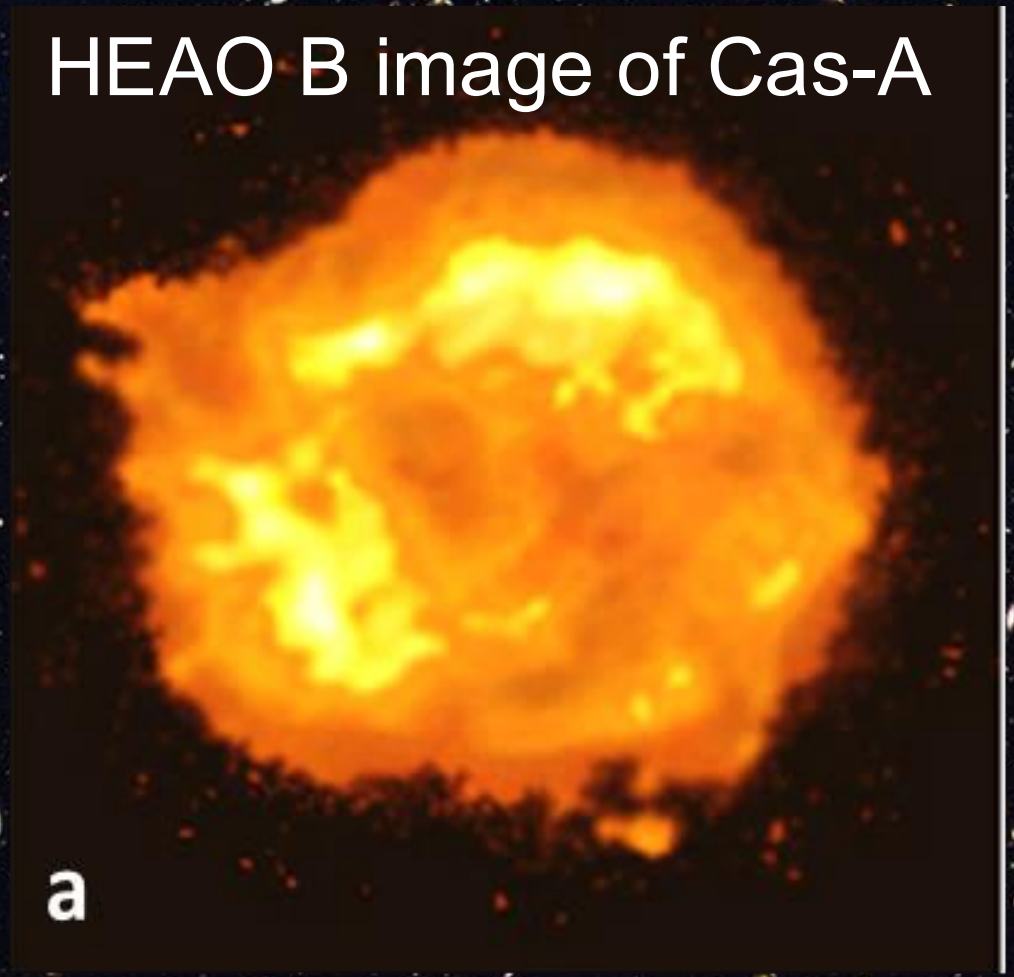
HEAO B image of Cas-A



Chandra image of Cas-A

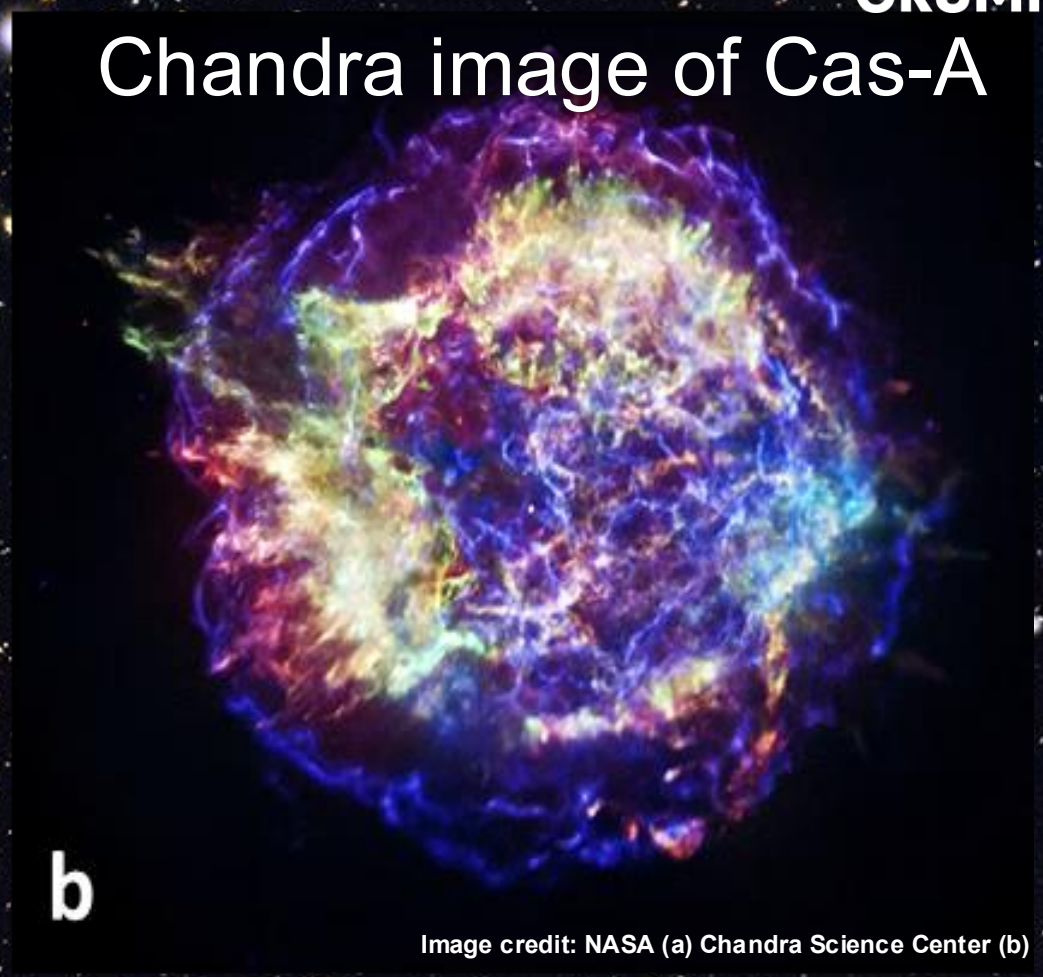


Image credit: NASA (a) Chandra Science Center (b)

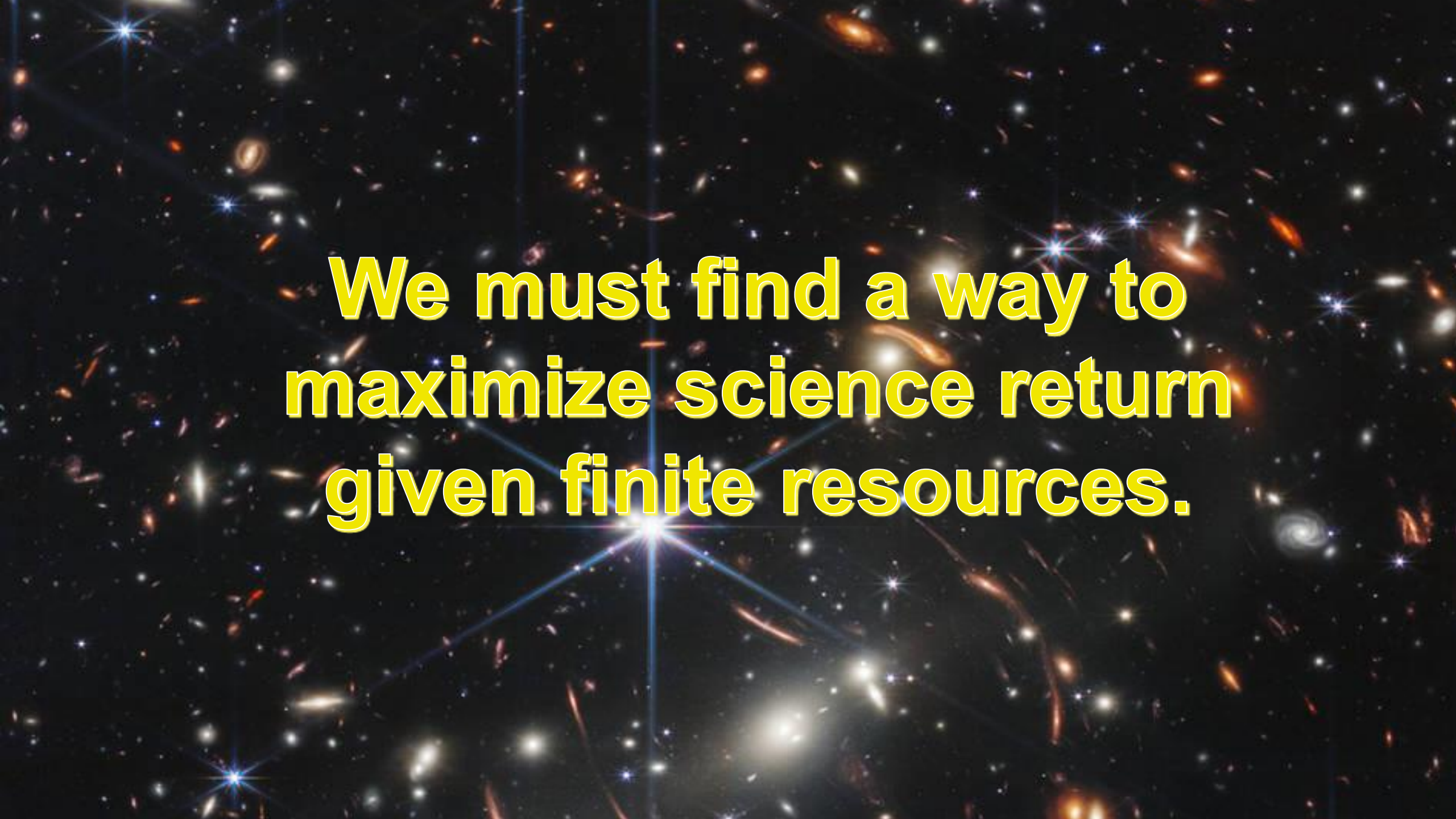
In astronomy, observation trumps physics.

Riccardo Giacconi

Northrop Clearance Case 21-0650

Astrophysics is
technologically limited.

Astrophysics is resource limited.


We must find a way to
maximize science return
given finite resources.

The year is 2026.

The Space Ages: 2026 Cusp of Revolution

Paleo-space,
Old Space age,
Space 1.0

Meso-space,
Middle Space Age,
Space 2.0

Early

Late

Neo-space,
New Space Age,
Space 3.0

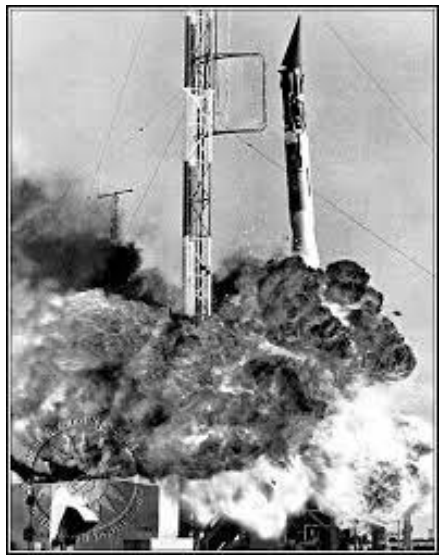
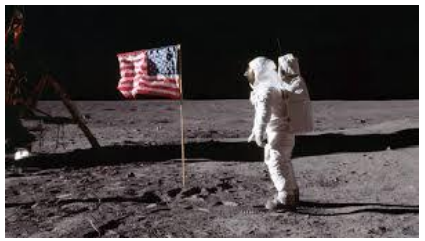


Image NASA

Apollo 1



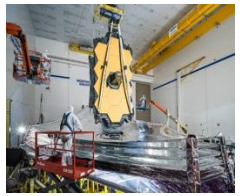
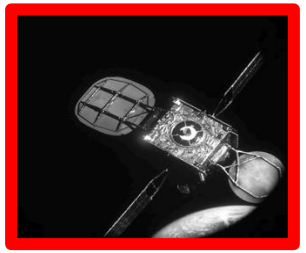


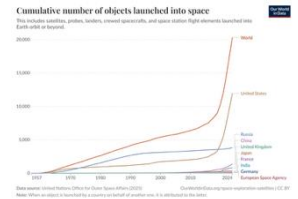
Image NASA

MEV 1



Lemuel Francis Abbott - John Wilkinson, The Ironmaster

- New Mission architectures
- Servicing
- More spacefaring nations and organizations
  - Launchers and systems
  - Proliferated competence
- Proliferation of space hardware
- Robotics
- Communications
- Computing



“Just make it work.”

“Failure is not an option.”

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What Makes Design in Space 2.0 Hard?

Mission is self contained. Low tolerance for risk. Finite resources.

- Self-containment of the flight segment-Tyranny of the Fairing
  - Everything gets launched at once
    - Scheduled paced by slowest item
    - Verification
    - Mass and volumetric limits
    - Complex system development
- Cultural pressure of “Failure is not an option”
  - Tight margins- desire for ample margin
  - Need for complete analysis of all requirements in all environments
  - Technologies and materials with known behavior
- Limited options for communications: Drives instruments to be more complex
- Exquisite performance pushes modeling tools and capabilities
- Challenge of Development aka Lesson of Newness*
  - Simultaneous development and design
  - Antagonism in design (discovered late)

* Jonathan W. Arenberg, et al, , "Designing a new, large, complex observatory: learning the strategic lesson of newness from our experience on the James Webb Space Telescope," J. Astron. Telesc. Instrum. Syst. 10(1) 011209 (14 March 2024) https://doi.org/10.1117/1.JATIS.10.1.011209

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Characterizing the Space 3.0 Milieu

- Many more spacefarers than in earlier decades– growing commercial market
  - Different (commercial) risk posture
- Commercial launch, communications and operations
  - Reduced costs
  - Large fairings
  - Non-governmental communications networks
- Servicing and logistics
  - NG's MEV are commercial
- Robotics
- Advanced manufacturing
- **New mission architectures**
- New (designer) materials
- Computing advances
- Artificial intelligence and machine learning

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Revolutionary Times Requires Revolutionary Thinking (aka Openness to New Ideas to Leverage the Revolution)

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- A disciplined and proper mission architecture development looks at all the options and evaluates them against one another to determine the optimum architecture to deliver the science demanded consistent with the opportunity's endemic constraints
  - A good systems designer/architect should consider all possible options
  - Just because an idea or technology is new, does not make it automatically better, it just makes it new

- Need to think of missions in a greater numbers of ways before deciding on the right mission architecture
  - Traditional approaches (meso-space approach)
  - Modern approach

- Have to be realistic about the nattering nabobs of negativism aka cultural resistance- "that is not the way we do things…."
  - Make good and convincing argument about why the selected design is advantageous
    - Quantitative and causal.

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Flagship Missions Are Large Complex Endeavors

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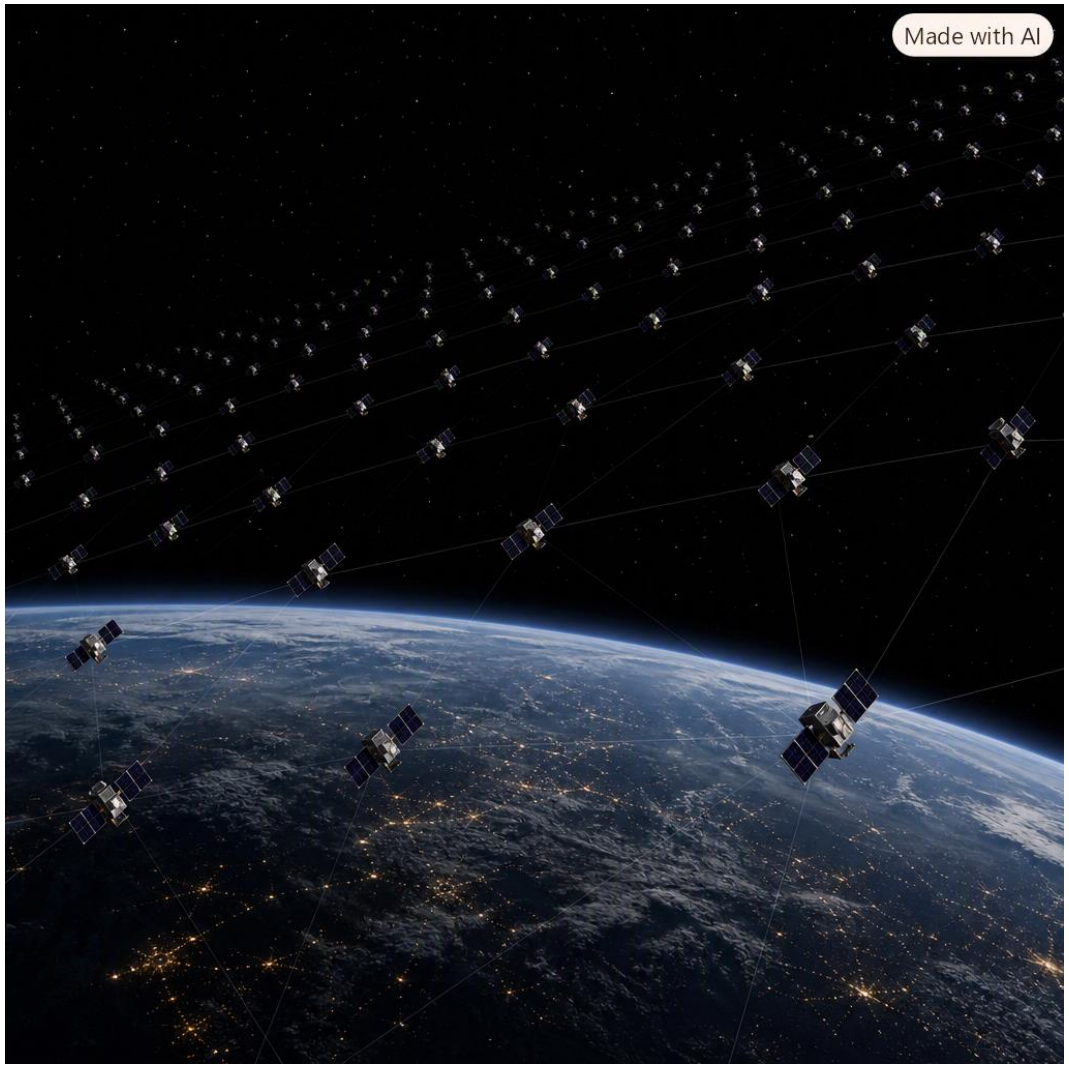
Flagship Missions Are Large Complex Endeavors

There is no silver bullet.

Defining Terms

- Disaggregation: Taking something apart

- Proliferated
  - Constellation: A mission with more than one flight segment
  - Fleet: A group of missions with some common overarching commonality (in hardware)



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Why Take Things Apart?

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To Make Things Better

Issue in aggregated systems	Possible Outcome
➢ Performance	➢ Look at multiple targets ➢ Instruments don't share time
➢ Cost	➢ Reduce LOE ➢ Savings from re-use
➢ Schedule	➢ Parallel manufacturing paths ➢ Don't have wait for the last item
➢ Risk (Development)	➢ Full pathfinder ➢ Avoid antagonism in design ➢ Fewer interfaces

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This is idea is not new: Constellation-X (circa 2004)

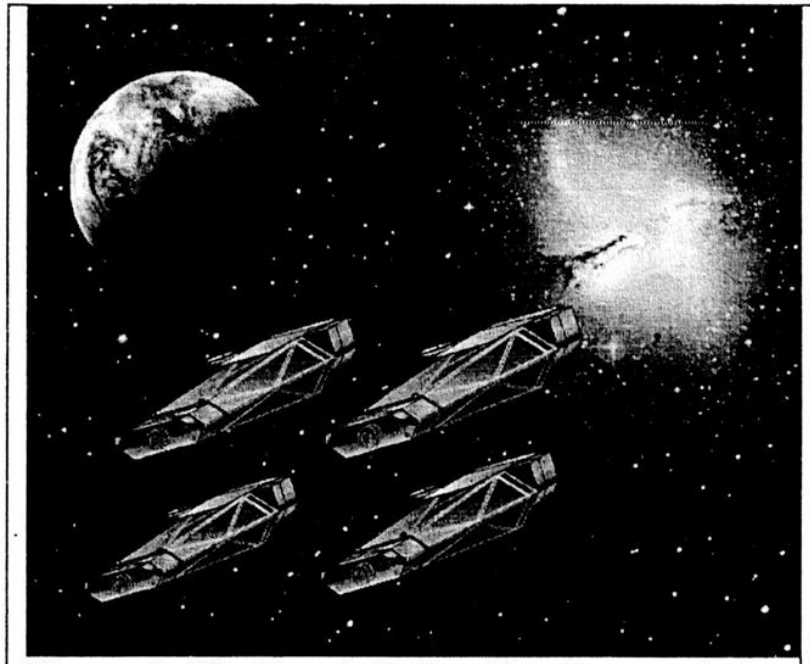

Figure 1. The **Constellation-X** reference design achieves high throughput and reduces mission risk by dividing the collecting area across four separate spacecraft launched two at a time. An orbit at L2 will facilitate high observing efficiency, provide an environment optimal for cryogenic cooling, and simplify the spacecraft design. Use of identical off-the-shelf spacecraft buses and a parallel production line will minimize cost.

Each satellite will contain two telescope systems: one with high energy resolution (E/DE ~ 300–3000) for imaging X-ray spectroscopy (0.2–10 keV), and one with low energy resolution (E/DE ~ 10) for imaging hard X-rays (to 60 keV). The spectroscopy telescopes will have 15 arcsec resolution (half power diameter) in a 2.5 arcmin field imaged by 900-pixel quantum micro-calorimeters (with 2 eV energy resolution). They will also include a set of reflection gratings (resolution 0.05 Angstrom in first order). The hard X-ray telescopes will be the first focusing optics above 10 keV and have 1 arcmin resolution (half power diameter) in an 8 arcmin field.

All of the Constellation-X technologies are an evolution of existing, flight-proven instruments and telescopes. Substantial progress has been made in key areas of technology, including lightweight X-ray mirrors, improved energy resolution and construction of larger arrays of X-ray microcalorimeters, multilayer depositions for hard X-ray telescopes, and Cadmium-Zinc-Telluride detectors for hard X-rays.

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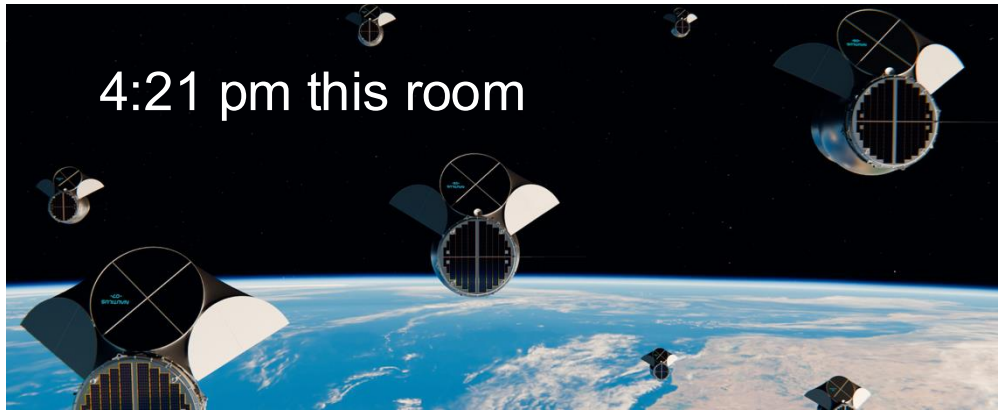
This idea is not unique:



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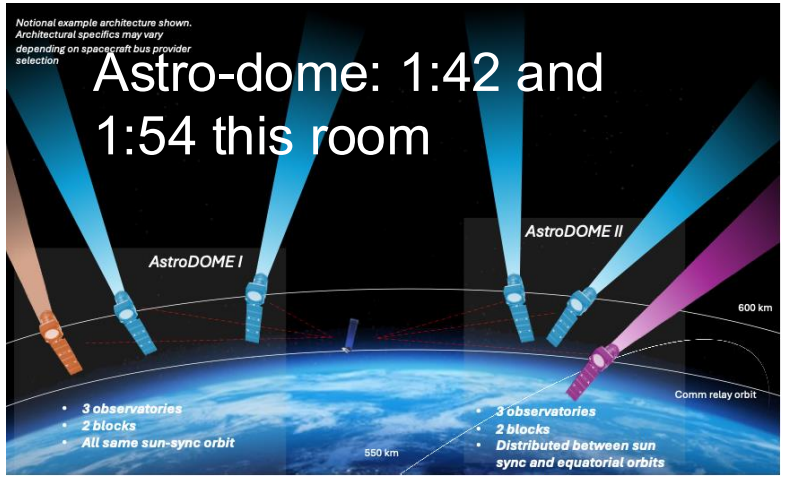

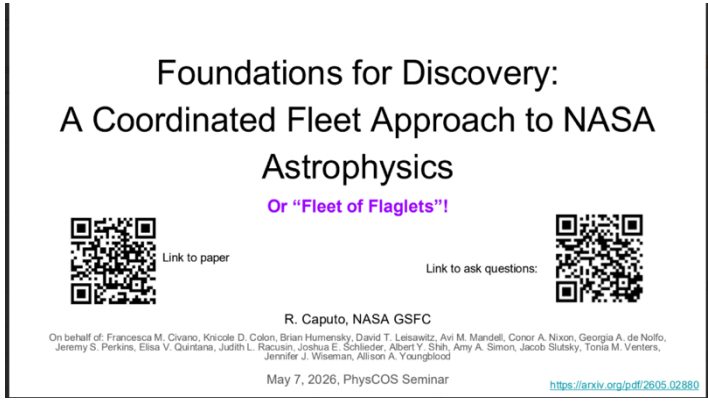

- Within NASA, Earth and Helio are moving to disaggregated architectures
- Most other USG space missions are disaggregated or proliferated
- Many commercial missions are proliferated

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We are in the Neo-space age,
think like it!

Let’s use all the tools
at our disposal.

Capere revolutionem

Credit: Marc Sansebastian, gift of the artist