

AstroDOME – a new paradigm for Astrophysics missions

Part I: Rationale & Strategy

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Outline

Part I (this talk):

- Define what the AstroDOME study is
- Clarify the rationale for AstroDOME
- Describe the process for the study
 - Strategy
 - Principles
 - Science Case

Part II (M. Marcus' talk):

- Implementation and results
- Lessons learned
- The AstroDOME program – a vision for the future of Astrophysics

Summary of Part I

- AstroDOME proves that disaggregation, standardization, and commercial alignment can provide compelling, Decadal-quality science (e.g., multimessenger) with a more rapid, flexible, adaptable paradigm
- Not all problems in Astrophysics can be addressed with AstroDOME. Many will continue to require bespoke missions
 - Attitude control & precision stability the main drivers

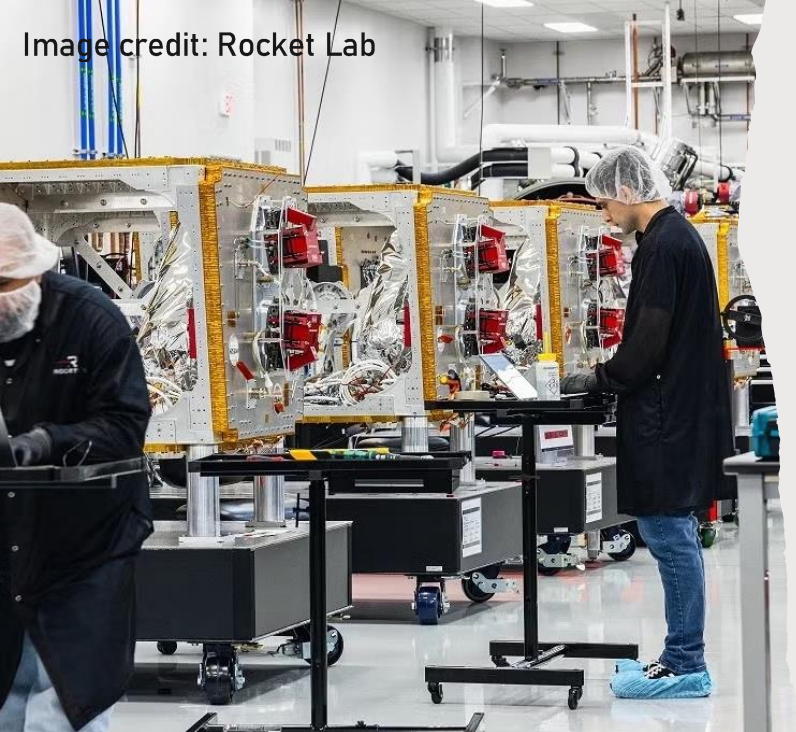


The DOME concept

Disaggregated Observatory for
Mission Efficiency

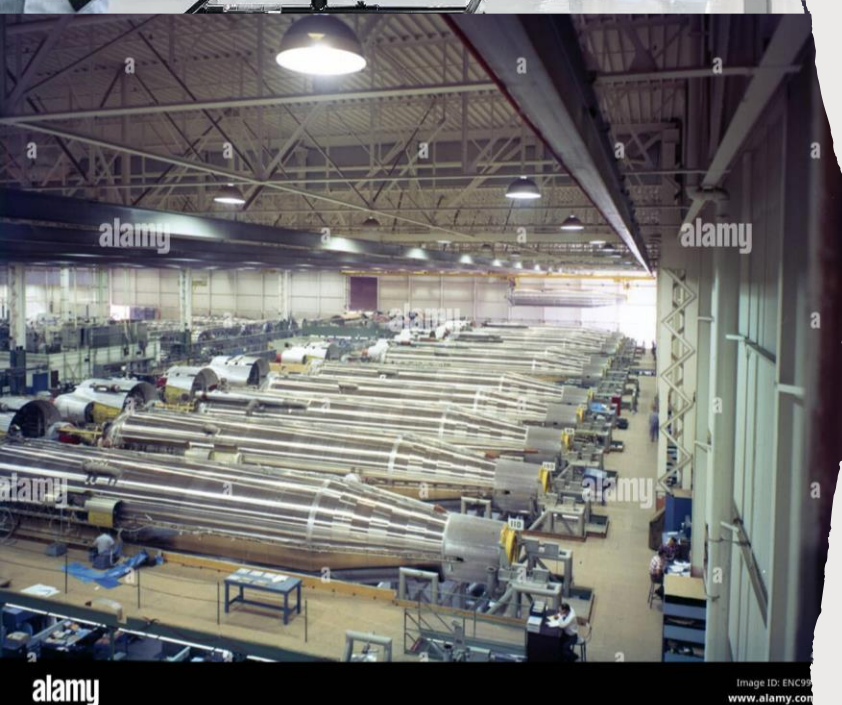
(J. Breed, 2024-2025)

- A set of s/c in space with separate launches and a payload each
- Pioneered by DoD (DARPA, Space Force)
- DOME: genesis at Goddard in the context of Earth Science – what if telescopes point up?

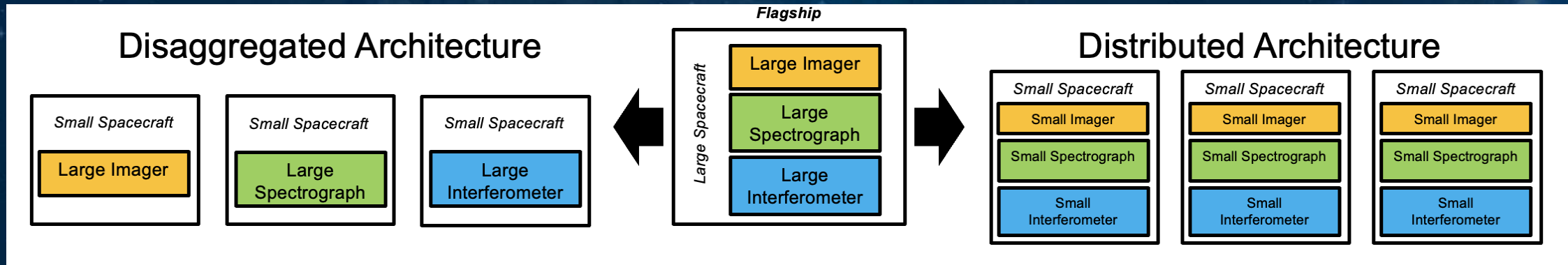


Context

- The “New Space” enabled by commercial proliferation in LEO
 - Precipitous drop in launch costs, bus assembly-lines, economies of scale
 - Rise of commercial off-the-shelf (COTS) SmallSat buses and megaconstellations (e.g., Starlink, SDA, Project Kuiper)
 - Transition from high-reliability, monolithic 10-to-15-year missions to rapid, disaggregated, replenishment models (Class D/commercial)
- The Problem AstroDOME Addresses
 - Traditional NASA astrophysics missions are custom-built and slow
 - *The Question*: Can NASA leverage mass-produced commercial SmallSat infrastructure to achieve compelling astrophysics?



Disaggregated vs. Distributed



Mission functions separated into independent spacecraft or platforms

Multiple spacecraft working together toward a common, tightly integrated mission objective

Advantages of Disaggregation

- Instead of mounting multiple instruments on one large, costly bus, disaggregate them across multiple smaller, dedicated buses
 - Decoupled risk: failure/delay affects only that specific s/c
 - Incremental Upgrades: Allows continuous, agile fleet replenishment and iterative tech upgrades every 2–5 years
 - Budget adaptation: can distribute cost over multiple budget cycles and still achieve science each cycle
 - Reduce pressure on program overall portfolio
 - Economies of scale for Recurrent Engineering

Disadvantages of Disaggregation

- Multiple launches
- More complex operations
 - Different strains of data calibrations
 - Coordination of s/c in orbit
 - S/c to s/c communication
- Cost: independent Aerospace-led study

AstroDOME process: 1. Core principles

1. *No design changes to spacecraft* – bus treated as “black box”
2. *Single-String Reliability & Replenishment*: Accept lower unit-level reliability (Class D) and rely on constellation replenishment
3. *Fixed Early Interfaces*: Establish firm ICDs (mechanical, electrical, data) by Phase A
4. *Minimized Oversight*: Accept reduced insight into COTS vendor internal processes.
5. *Mass Production without Modification*: Standardize identical payload units

AstroDOME process: 2. Case Study



Used a simplified SmallSat astrophysics mission targeting transient follow-up at three wavelengths (UV, Opt, IR)



Evaluated two architectures against the DOME principles:

Monolithic: Single bus carrying a complex 3-waveband payload (UV, Visible, NIR).

Disaggregated: Three separate observatories, each dedicated to a single waveband (UV, Visible, or NIR).



Utilized GSFC's Integrated Design Center (IDC) to pilot the "DOME Lab" concept.

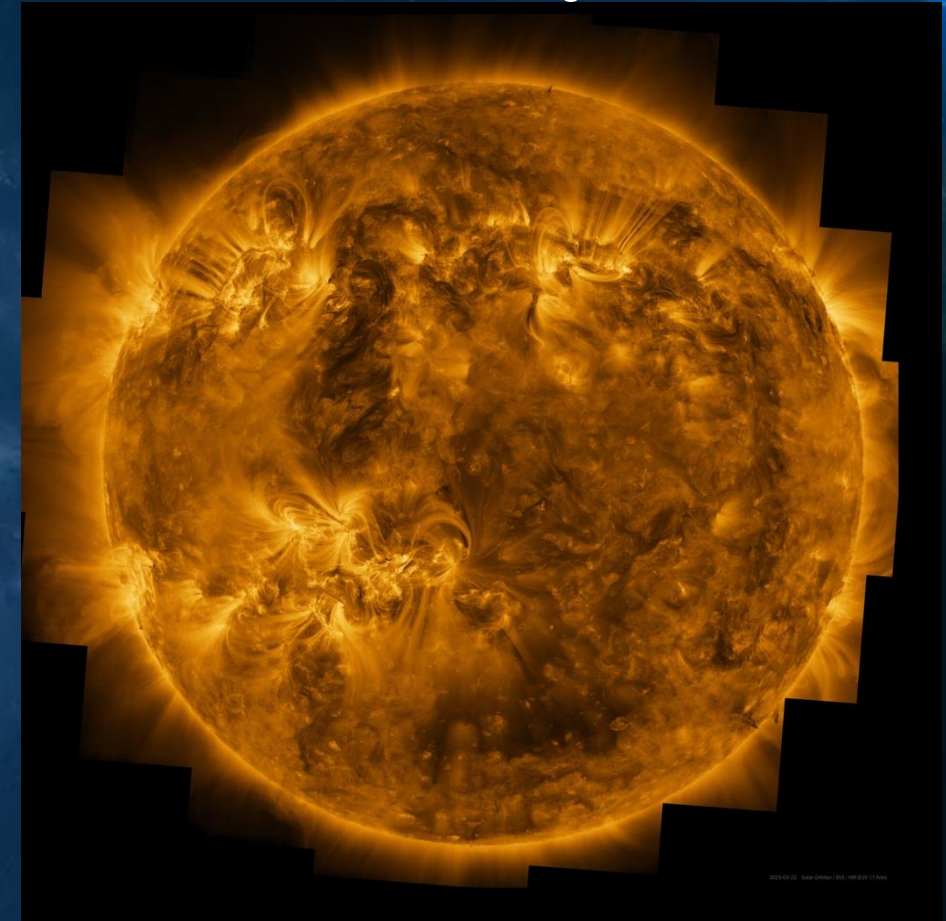


Merged instrument (IDL) and mission (MDL) disciplines across 20+ engineering domain experts.

Multi-disciplinary applications

- As part of the study we investigated applications to other space domains with minimal/no change of payload requirements:
 - Heliophysics
 - The Sun in UV
 - Space Weather and upper atmosphere-solar wind coupling
 - Planetary Defense
 - Follow-up of NEOs in IR
- Economies of scale can be leveraged (?)

Image credit: ESA



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