

AstroDOME

Building Blocks for Democratized,
Disaggregated Astrophysics

*Part II: Implementation, Lessons Learned, and a Vision
for the Future*

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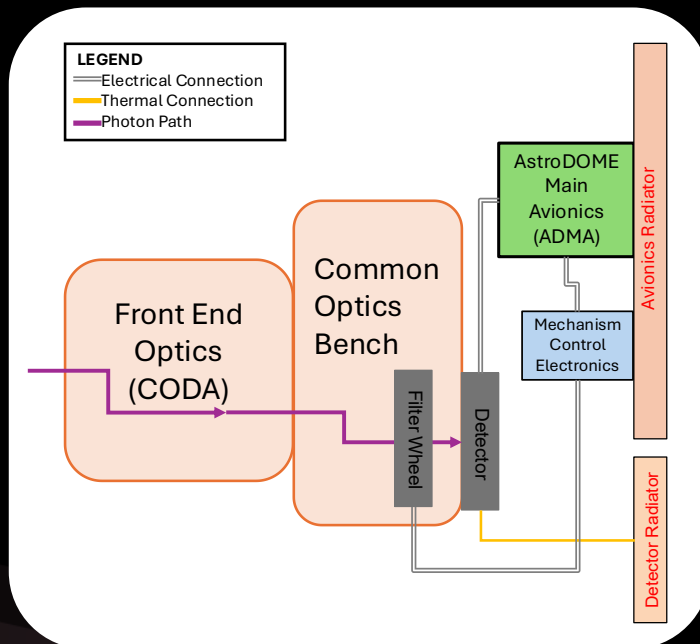
*Ad ASTRA Workshop
September 2, 2026*

Engineering/Programmatic Context

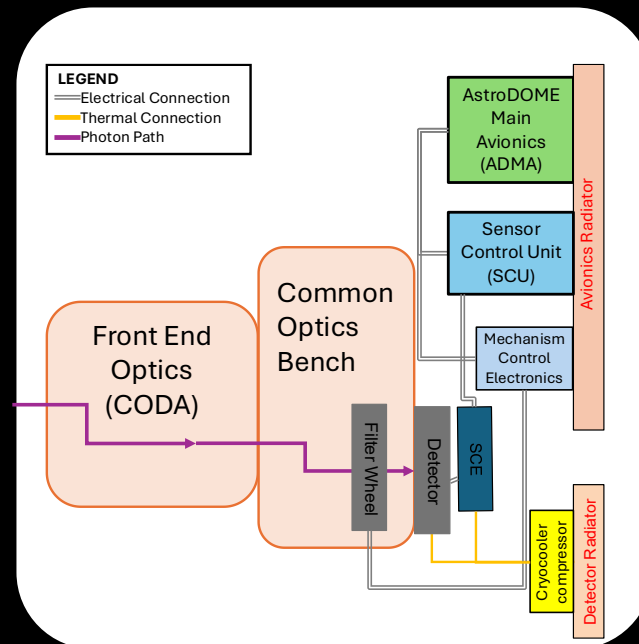
- Develop a disaggregated system that
 - Can perform an example Time Domain and Multi-Messenger (TDAMM) mission
 - Is extensible to a wide variety of SMEX-class missions
- Investigate potential benefits to astrophysics from disaggregated missions
 - Schedule savings
 - Democratization of SMEX-level astrophysics
- Implementation:
 - Discretize electromagnetic spectrum into standardized measurement “blocks”
 - Each measurement type addressed by a fixed payload architecture block
 - Follow DOME design principles to design each block
- Develop a roadmap to extend AstroDOME to wider array of missions

AstroDOME I Results

- Mission performed by three observatories, two blocks
 - Ultraviolet (UV)/Visible (x2): 180-750nm
 - Near Infrared (NIR) (x1): 800-1500nm
- Common optics bench between blocks

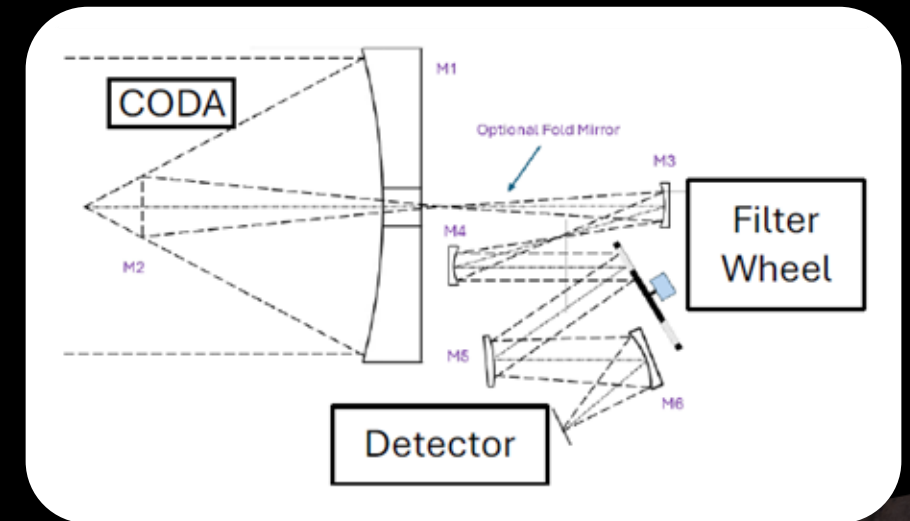


Vis/UV Block



NIR Block

- Optics
 - **Cassegrain telescope** design based on the Pandora payload (CODA)
 - Use a **single, fully reflective, inherently achromatic backend optics design**



Disaggregated Optics Design

Technical Lessons Learned – AstroDOME

Flexible Requirements Enable Success:

Science team's adaptability on radiometry, latency, and data volume was crucial for convergence

Optical Design:

A common optical design works for all both NIR and Vis/UV blocks

Commercial Spacecraft Limitations:

For imaging astrophysics applications, their pointing requirements may not be met by published commercial spacecraft capabilities

Commercial Partner Relationship Management:

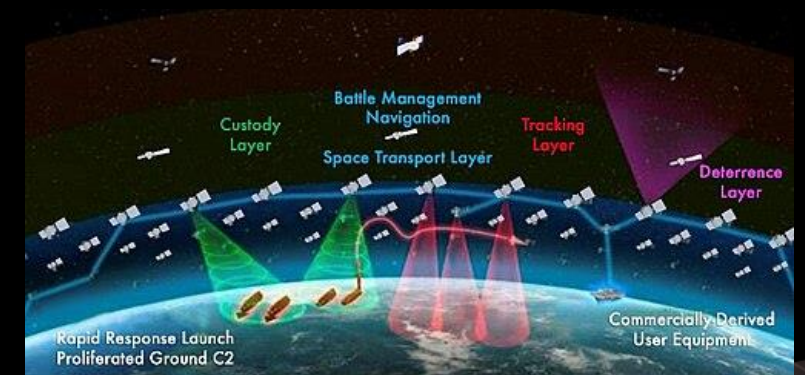
Many **newer spacecraft vendors prefer limited, interface-focused interactions** rather than technical oversight, requiring adaptation of traditional approaches

Applicability to Planetary Defense and Space Weather:

Small modifications to current blocks allow for significant expansion to applications beyond astrophysics

The Vision

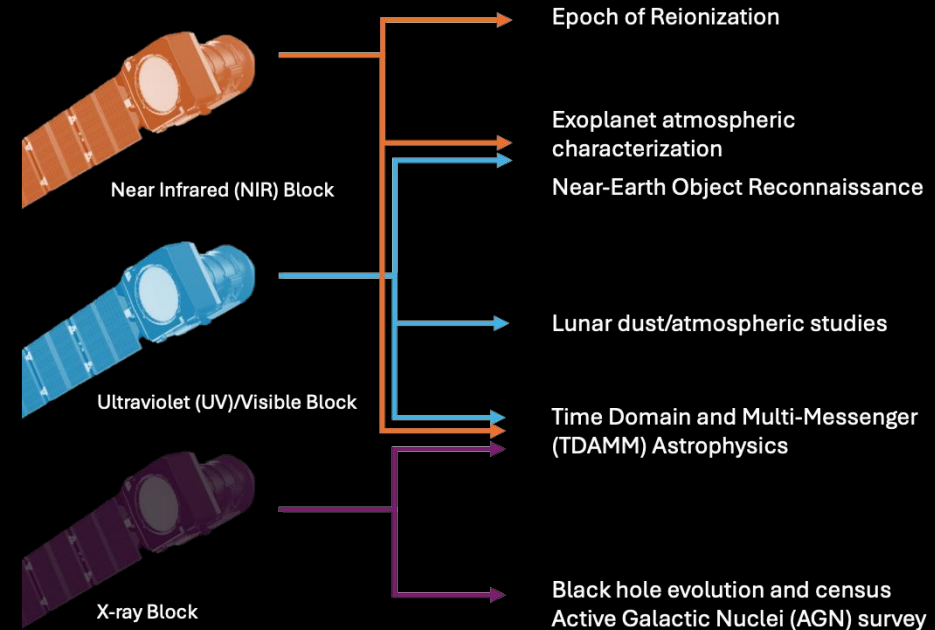
- AstroDOME provides a path to **democratize astrophysics missions**
- Can we use it to achieve authority to proceed **(ATP) to launch in 2-3 years (2x or better)?**
- Over the last ~10 years:
 - Precipitous drop in cost of access to space
 - Proliferation of:
 - low-cost commercial spacecraft busses
 - disaggregated constellations
 - **How do we (the space science community) capitalize on these shifts?**



Credit: SDA

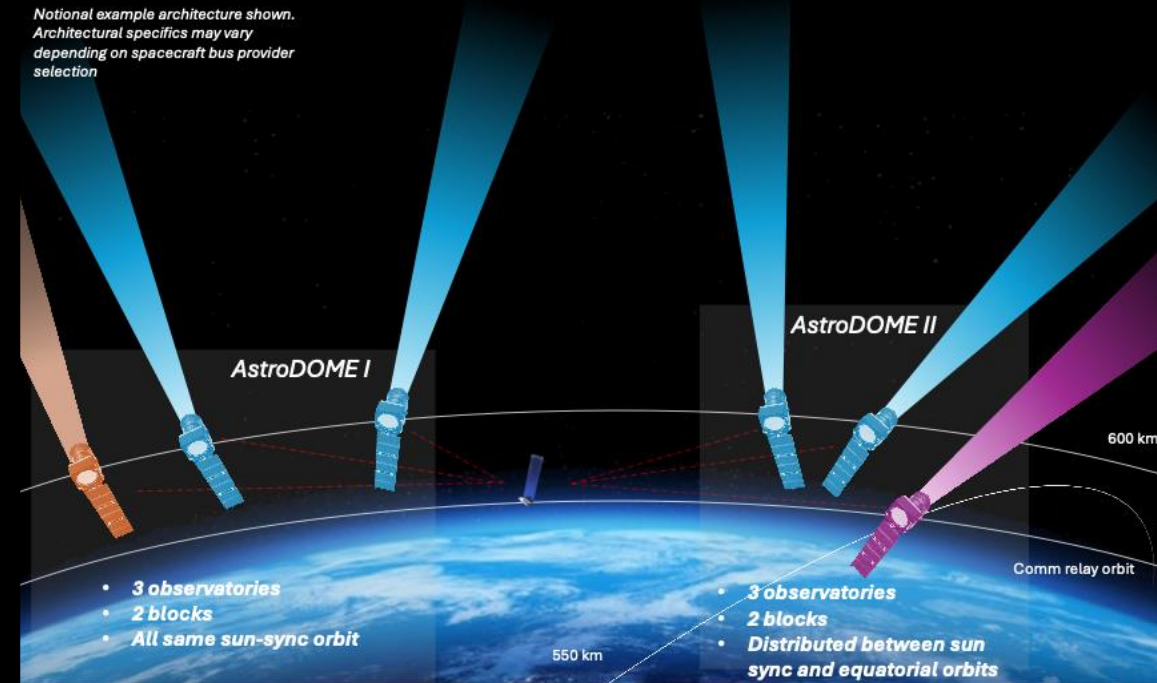
Disaggregation/Proliferation

- **SCALABLE:** PIs assemble a mission by combining existing blocks
- **RAPID:**
 - Once a block design is established, new units can be on orbit in under 2 years
- **LOW UNIT COST:**
 - Individual blocks are produced at scale
 - Spreads payload nonrecurring engineering (NRE) across many identical architecture units
 - Utilize existing low-cost commercial spacecraft pipelines from other sectors
- **INCREMENTAL IMPROVEMENT:**
 - Continuous production allows rapid iteration
 - Decouples instrument development campaigns for multi-instrument missions



A Resilient, Democratized Future

- The investment:
 - New blocks are developed and demonstrated, and existing ones incrementally improved, as funding allows
- The supply side:
 - Observatories produced in assembly line fashion
 - A catalogue of proven blocks is made available to proposing PIs
- The demand side:
 - A survey of GSFC space scientists revealed many interested users in astrophysics and beyond
 - Conducting SMEX-level missions under this paradigm maximizes the number of investigations that can be performed with limited resources
- Initial availability in 3 years from ATP



Questions?

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AstroDOME I
IEEE Aerospace Paper:



Backup

DOME Design Principles

1. No design changes to the spacecraft

- *No changes to the design or operating environment of the spacecraft*
- *Treat the spacecraft bus, to the greatest extent possible, as a black box*

2. Minimize redundancy, but plan for healthy replenishment

- *Single string, except where making an existing design single string increases NRE*
- *Assume a single vehicle lifetime of 2-5 years*

3. The well-defined spacecraft bus to payload interface shall be established by the start of Phase A

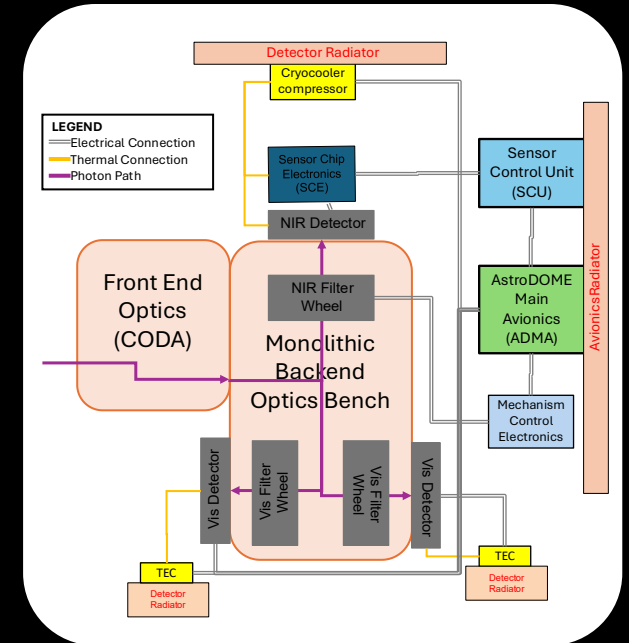
- *Detailed mechanical, electrical, and data ICDs should be established at the outset of concept development*
- *These should include data rates/volumes supported, and pointing performance and restrictions*

DOME Design Principles

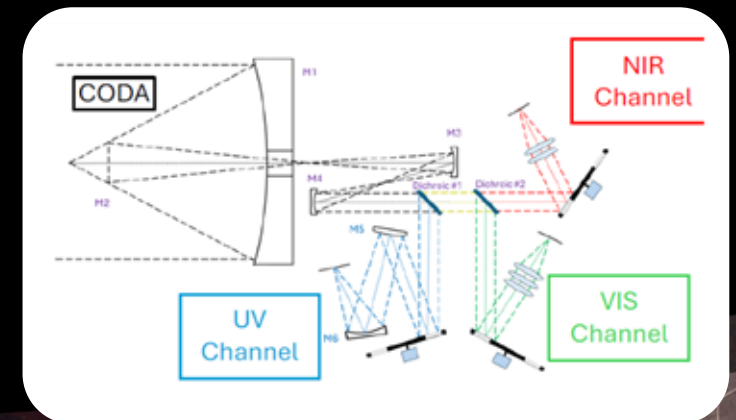
- 4. Minimize requests for customer oversight and insight into the spacecraft design and spacecraft partner's design practices**
- 5. Mass produce payloads without modification from one unit to the next**
 - To the greatest extent possible, the payloads developed for each spacecraft in the constellation shall be identical to each other*
 - Incremental improvements may be made following agile design principles, but only after the first set of flight unit has been produced*

AstroDOME I Results

- Monolithic Mission performed by single “superblock”
 - UV/Visible/NIR (x1): 180-1500nm
- Unique complex optics bench to accommodate three cameras and cryocooler hardware
- Optics
 - **Cassegrain telescope** design based on the Pandora payload (CODA)
 - Use a **single, fully reflective**, inherently achromatic backend optics design



Monolithic Instrument Architecture

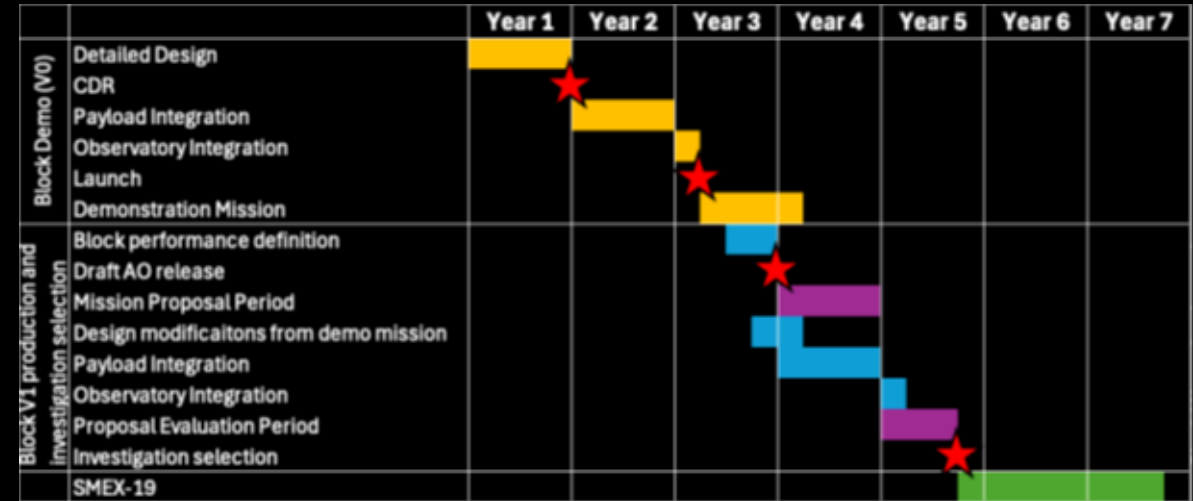


Monolithic Optics Design

Phase In Timeline

- Initial availability in 3 years from ATP
- Blocks developed in parallel or series depending on available resources
 - Disaggregated, parallel development leads to overall program resiliency
- Capabilities document based on demo mission performance
- Science focused, single step AO process
- ATP to launch in under 2 years for operational missions after block demo
 - Conservatively assumes integration activities follow same schedule as demo mission

Notional timeline



- Detailed design: 1 year
- Payload I&T: 1 year
- Observatory I&T and launch: 3 mos
- Demonstration mission: 1 year

Conclusions

- AstroDOME is part of the path to an agile, democratized future for astrophysics
- Many unique investigations can be constructed out of standardized blocks
 - NRE spent once, spread across many (10+) units
 - Decoupled critical paths – each block's path to availability independent of the others
- Cross-discipline demand for AstroDOME capabilities
- Architecture scalable to available resources and community demand
 - Individual, SMEX-class missions possible at a reduced cost
 - Larger scale distributed missions possible with increasing performance as constellation grows