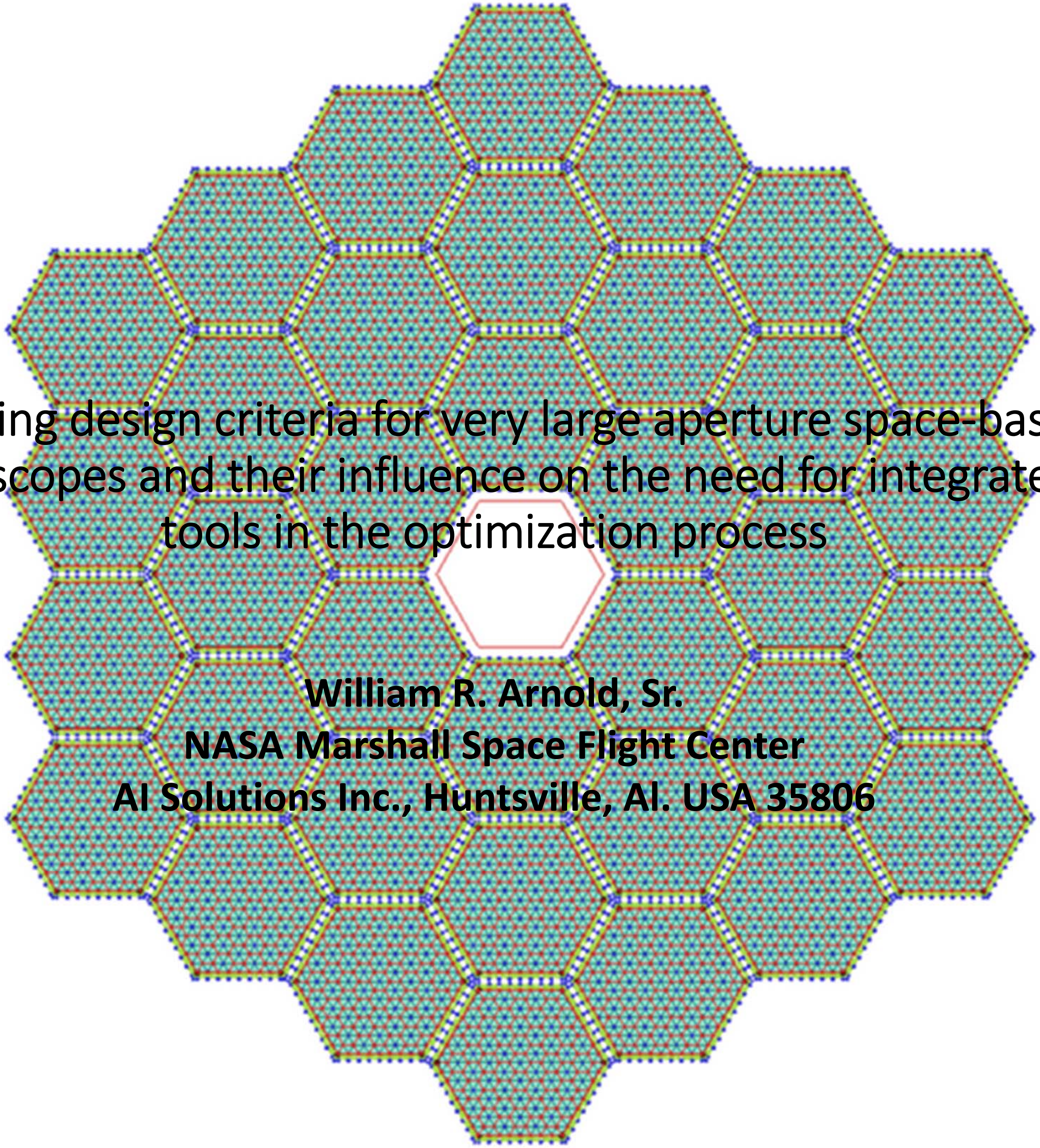

Evolving design criteria for very large aperture space-based telescopes and their influence on the need for integrated tools in the optimization process

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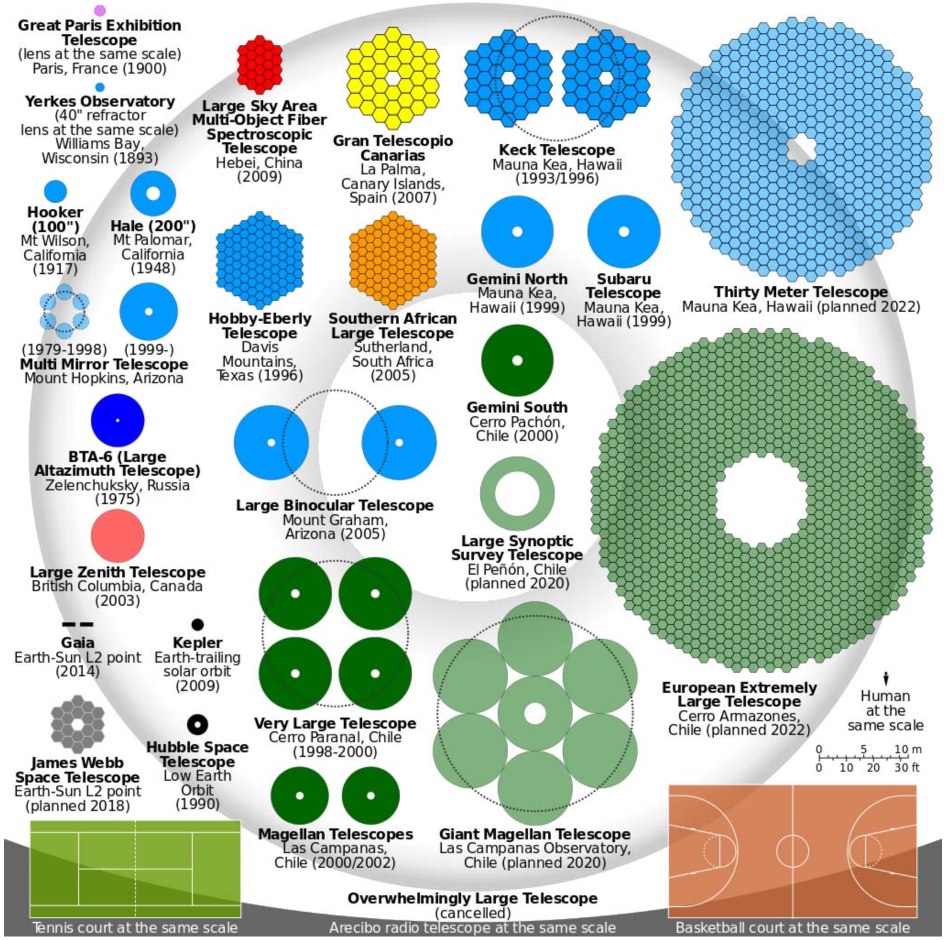
INTRODUCTION

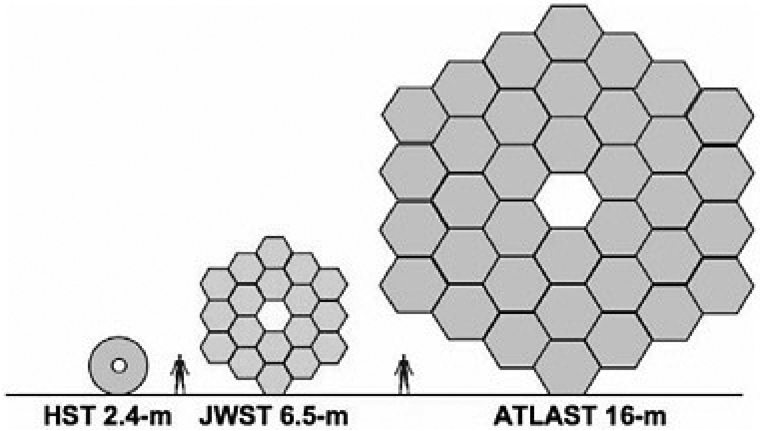
- **System design as an optimization problem**
  - **Often, the desires are out reaching the realities**
- **What are the key merit functions**
  - **Optical Performance**
  - **Mechanical Performance**
  - **Thermal Performance**
  - **Complexity & Reliability**
- **What are the constraints**
  - **Mass – available & planned launch vehicles**
  - **Volume – shroud interior volume**
  - **Cost & Schedule**
  - **Risk – technical, schedule, cost and mission success**
- **How Advanced Mirror Technology Development program fits in to all this**
  - **Building better tools**
  - **Increasing TRL levels**

EXPECTATIONS GROW

APERTURE OF ALL TELESCOPES

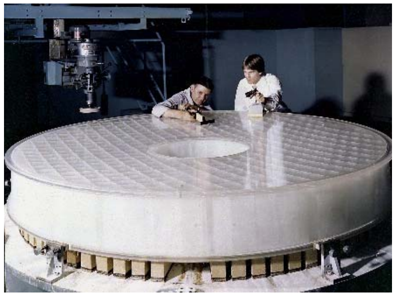


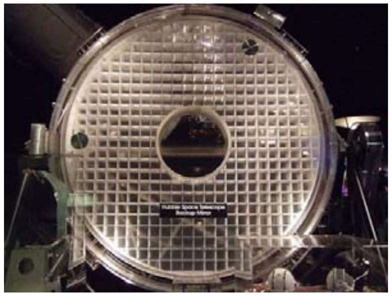
APERTURE OF SPACE-BASED TELESCOPES



As the technical capabilities grow, so grows the desire for larger and larger telescopes, both terrestrial and space-based

HOW HUBBLE WAS DESIGNED





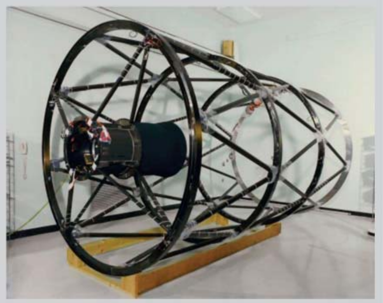
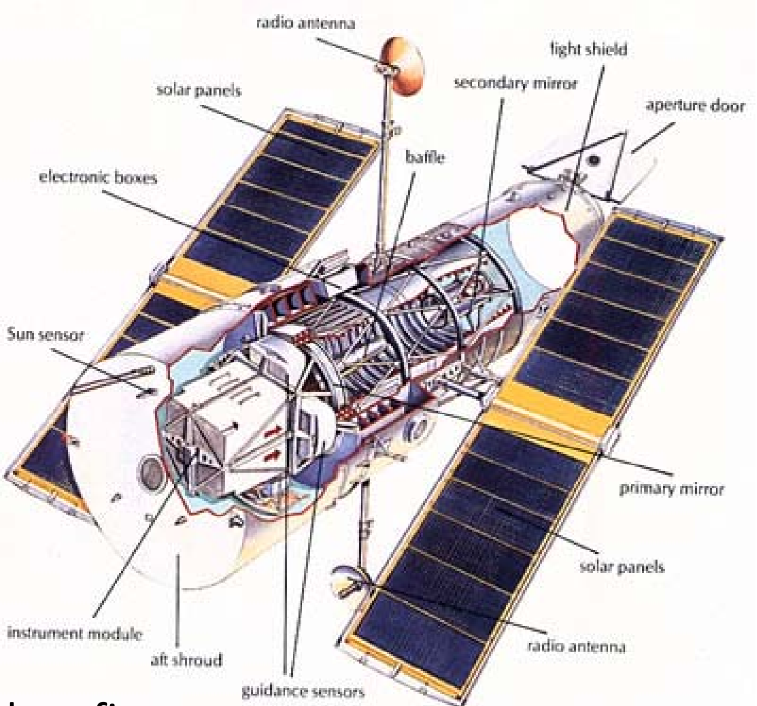
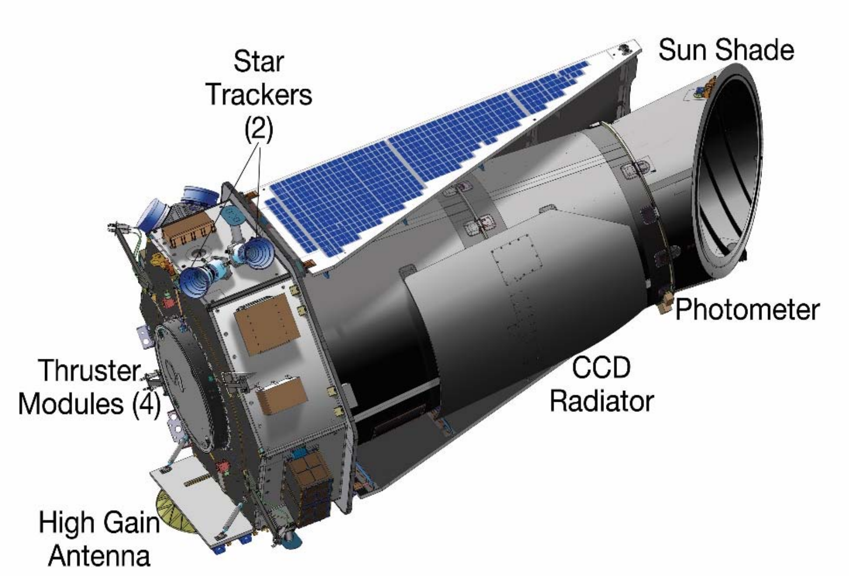


Figure 1: *Hubble*'s graphite-epoxy truss, which supports the primary and secondary mirrors. *Foreground*: the secondary-mirror housing, supported by the "spider." Not shown are the main ring and the primary mirror it supports, which are mounted at the far end of the truss. (Credit: Perkin-Elmer)



Hubble represented the state-of-the art when first designed, but much of its cost was actually long term storage. Each component was designed almost independent of other parts of the satellite and the primary mirror was only a small portion of the total mass.

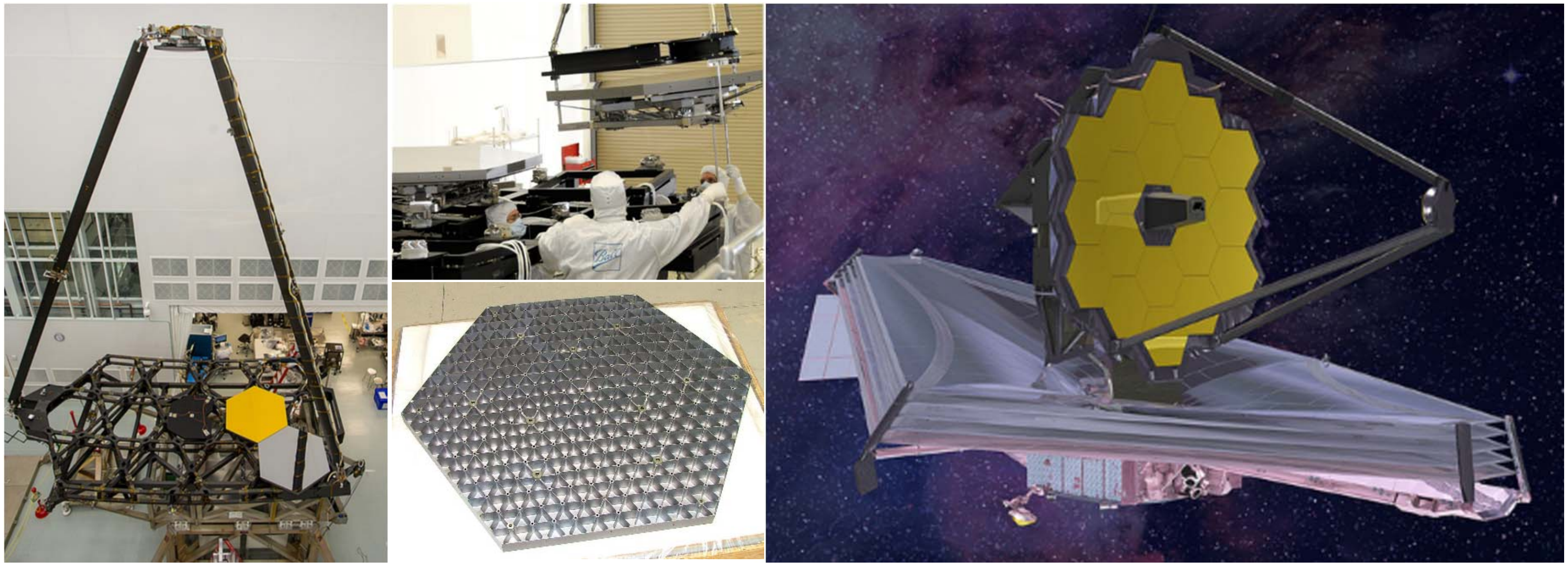
HOW KEPLER WAS DESIGNED



Kepler was cost sensitive and no backup mirror was available for the primary mirror, so it and it's support system were designed to have two rotation positions for attachment (in the event of damage during testing).

All the manufacturing and handling equipment were design simultaneously with the mirror and special reinforcements added just for tooling.

HOW JAMES WEB WAS DESIGNED



This was the first segmented space telescope, and much of the design was done by different organizations for different assemblies. One of the driving constraints was the shroud volume of the intended launch vehicle.

HOW DOES AMTD FIT IN?

- The goals of AMTD are to establish the technology basis for these anticipated projects.
- Tools to evaluate the optical, mechanical and thermal performance efficiently.
- Material databases and proven manufacturing techniques to feed the analysis tools
- Databases to establish risks and cost estimates on a neutral basis.

WHAT MAKES UP THE MASS

- Primary Mirror and Suspension
- Metering Structure
    - **Secondary Mirror and suspension**
    - **PMA backplane/truss**
    - **Stray-light and Thermal Baffles**
- Science Instruments
- Satellite
    - **Power**
    - **Communications**
    - **Station keeping and pointing**

EVERYONE FIGHTING FOR A LARGER SHARE

OPTICAL PERFORMANCE

- Here the science dominates the requirements
- Monolithic versus segmented (diffraction)
- Thermal and mechanical stability over time
- On axis versus off axis

- Bigger is almost always better, but not always!

MECHANICAL PERFORMANCE

- Has to survive launch environments.
- Has to deploy and function on orbit.
- Has to survive qualification and ground testing.
- Has to survive manufacture.
- Has to survive in stowed configuration

LOADING INCLUDES ACCELERATION, SINUSODAL, RANDOM AND THERMAL

THERMAL PERFORMANCE

- Response to gradients
- Response to transients
- Temporal stability

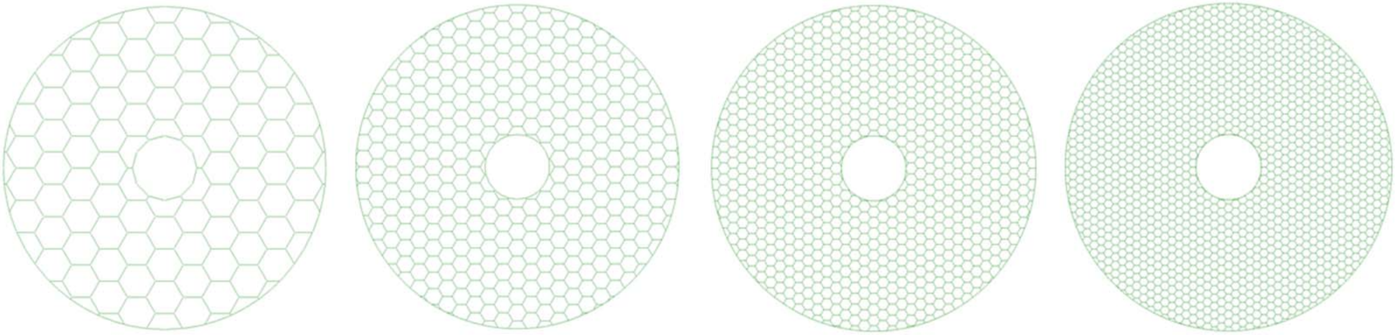
RISKS AND RELIABILITY

- Science expectations
- Mission life expectations
- Deployment risk (more complex, more risks)
- Manufacturing risks
- Test and alignment risks
- Cost and schedule risks

SCIENCE BUDGETS ARE LIMITED, THE PROJECT(S) WITH THE LOWEST COST AND RISKS WITH GOOD SCIENCE WILL HAVE THE BEST CHANCE OF FUNDING.

ILLUSTRATION

- Example of imposing a criteria, such as lowest bending mode of the mirror, which is not difficult for small mirrors to achieve, but impossible for larger mirrors.
- Assumptions, ULE as material, waterjet light-weighted core, frit bonded, limited to current or reasonable future enhancement capabilities of these techniques.



CRITERIA	2 meter		4 meter		6 meter		8 meter	
	kg	hz	kg	hz	kg	hz	kg	hz
100 hertz	88	100	911	106	14908	106	(2)	(2)
200 hertz	130	231	5727	204	(1)	(1)	(2)	(2)

(1) Doubling facesheet thickness (24010 kg) still only increased f=109 hz.

(2) Upper limits of feasible design (32,312 kg) only produced f=66 hz. at 8 meter OD

SUMMARY

ACKNOWLEDGEMENTS

REFERENCES