JWST Optics Lessons Learned for Probe Missions

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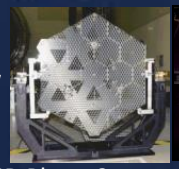
JWST Mirror Technology Flow

1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

Advanced Mirror System Demonstrator (AMSD)

Collaboration among 3 government agencies, competition
15Kg/m2, 1.2M diameter segments

Medium **Authority** Glass (ULE)



Low Authority **Beryllium**

AMSD Phase 1: 8 Mirror Designs

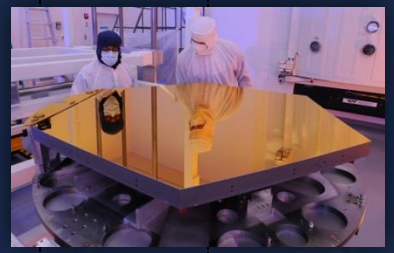
AMSD Phase 2: 3 mirrors developed

AMSD Phase 3/Six Sigma Study
Be manuf. and process improvements

Technology Readiness Level-6 Demonstrated:
All key requirements and environments demonstrated

OTE Complete

Launch



Subscale Beryllium Mirror Demonstrator (SBMD) – TRL4:
.5 meter diameter

OTE Optics Review (OOR): Beryllium Selected

Engineering Design Unit.

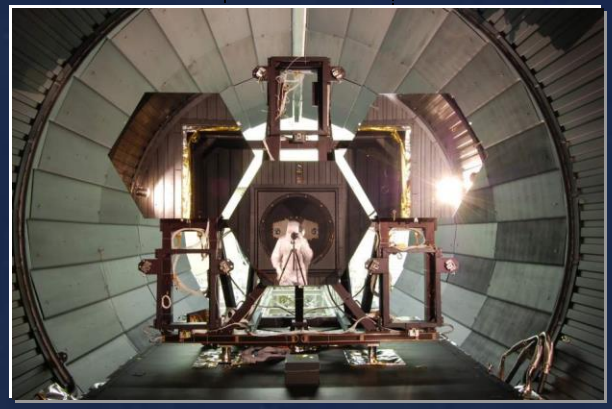
PM Manufacturing of 18 segments

Primary Mirror Segment Assemblies Complete

Machining Facility Complete

Cryo Testing

Polishing Facility Complete



NGST Mirror System Demonstrator (NMSD): Other architectures that were not successful

Relevant Optics Lessons Along the Way

- TRL6 testing (or TRL5) is to be done in a relevant environment and you won't know this early. Margin in the design can avoid this risk
  - After AMSD and team began flight design, loads went up after first couple loads analysis
  - Required redesigning structure (ribs, mounts)
  - Necessitated EDU be taken to acoustics for TRL6
- Mounts and bonding were extremely challenging, should be part of TRL-6
  - Launch and Ascent temperatures need to be bracketed – this was a major issue right up to launch for JWST
  - Entire lifecycle thermal stresses need to be understood
  - Flexures are complicated, balance thermal and launch
- Staffing a large manufacturing effort was not easy, expect attrition and challenges
- Need a good estimate of facilitization up front: Facilitization is the first early cost, occurs while ramping up phasing, if you underestimate it then it can use up significant reserves

Relevant Optics Lessons Along the Way (2)

- Metrology is hard and time consuming, needs to be included in TRL6 (probably TRL5)
- Scaling from .5m to 1.2m to 1.3m didn't uncover a lot of surprises, the bigger surprise had to do with more refined understanding of loads and environments using CLA
- Assembling the telescope needs to be thought through early as it can impact the design
  - Can you get mirrors off once mounted, can you reach shims, etc
- Practice, practice, practice. Pathfinders, AMSD, EDU were all immensely helpful.
- Testing the telescope was as hard as building the telescope. Needs to start early and be considered during the design.
- System margins are incredibly important: mass, volume, power etc
  - In the end, the choice of beryllium wound up being critical to dealing with mass constraints early in the program
  - This doesn't just apply to optics, it applies to thermal margins, etc
- Competition was extremely helpful in getting corporate attention and support

Documented lessons learned from JWST

JWST lessons learned are being published:

- Spotlight eBook, JWST Lessons Learned, in progress, expect in January
- Selections, JWST Lessons Learned + JATIS Systems Engineering Lessons Learned (JATIS, Menzel et al) + JATIS Stabilty Lessons Learned (JATIS, Feinberg et al)

- See JATIS JWST lessons learned special edition

- Lessons learned from testing the JWST Optical Components, Stahl, SPIE Proceedings, 2011

- Chart summary of JWST lessons learned talks are online (video and charts):
  - HWO Face to Face, Fall 2023 (Feinberg + Rigby talks)
  - Day 2 - HWO Working Groups - Google Drive