ATLAST 9.2 m
Presentation to Tech Days

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**with a large team of collaborators from
JPL, SAO, MSFC, StScI**

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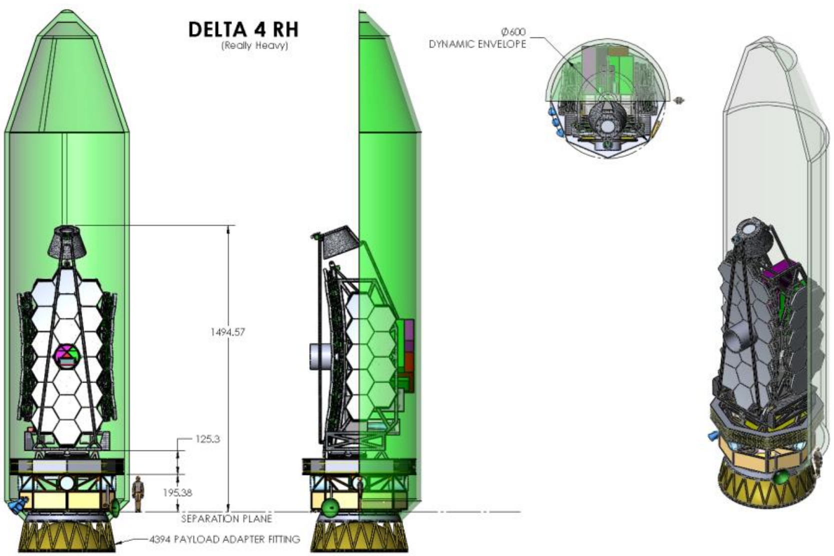
Background

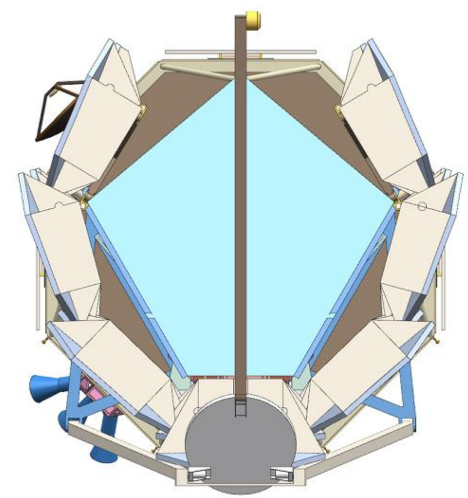
- In 2009, 3 Advanced Technology Large Aperture Space Telescope (ATLAST) architectures were developed (8, 9.2 and 16 meters) that all assumed a new class of launch vehicles with more mass and volume
  - This put us in the position of possibly not having a proven launch vehicle by 2020
- Last year, the ATLAST team developed a circular deployment geometry that fit a 36-segment 9.2 m telescope within a Delta IV Heavy
- The team has also assessed a 11.9 m aperture that required a different way to unfold the secondary mirror support structure
- This past year, the team has been focused on the ATLAST 9.2 m “reference” architecture that can make use of an existing Delta IV Heavy
  - Assessing in detail the mechanical/optical stability, followed by affirming that mass and volume closes
  - Integrated modeling being used to assess performance, status reported here
- Prior to modeling, team performed simple stability scaling calculations which show sufficient feasibility to proceed with detailed analysis
  - Presented at SPIE 2014

ATLAST 9.2 m
JWST-like Deployment

2009 (Early GSFC ATLAST Studies)
Assumed Larger EELV
JWST Geometry Wings



2013 Circular Geometry
Delta IVH
(Feinberg et al, SPIE, 2014)



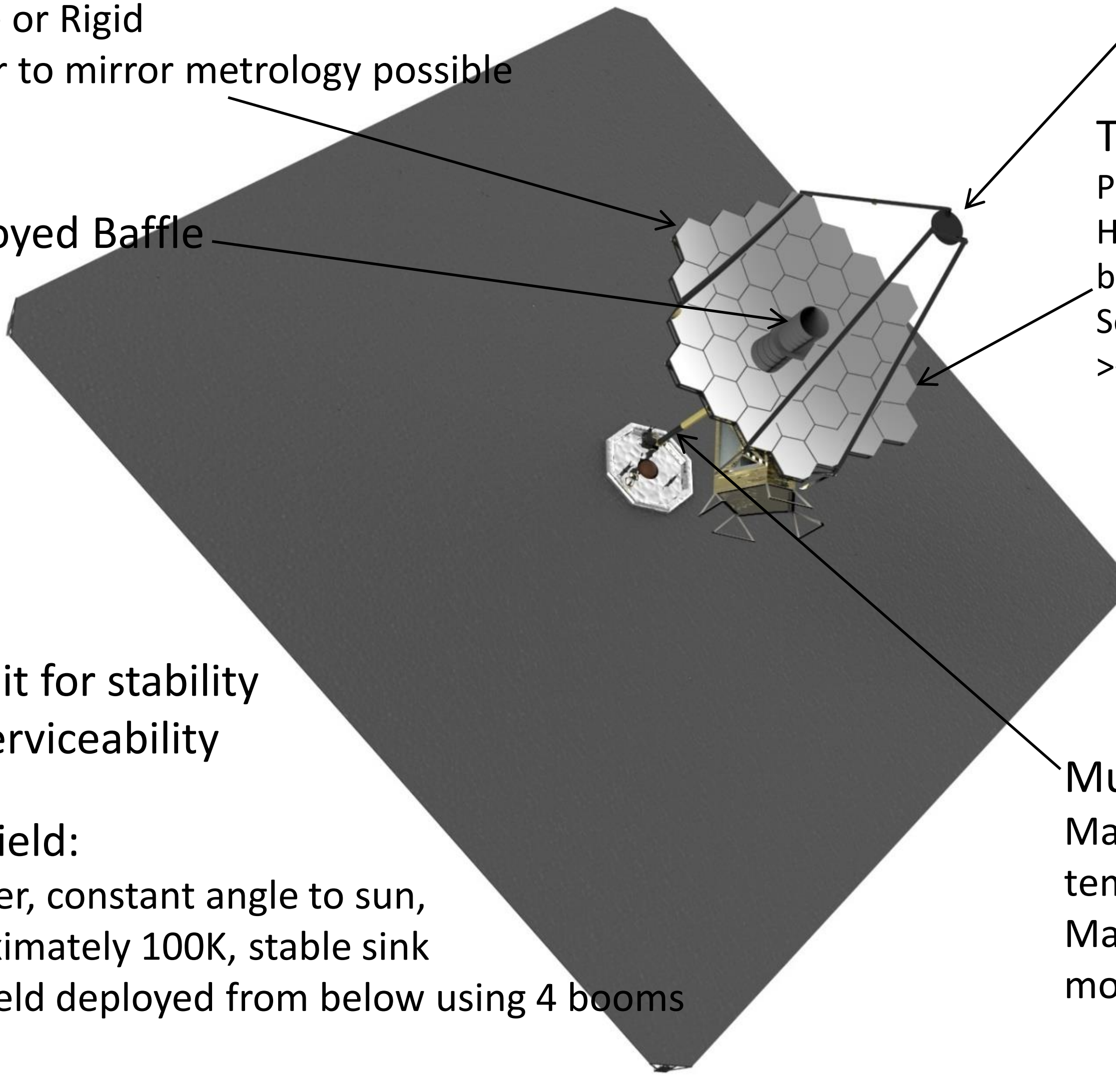
Notional 9.2 m Architecture Deployed Configuration

36 JWST Size Segments
Glass or SiC
Active or Rigid
Mirror to mirror metrology possible

Deployed Baffle

Actively controlled SM
Metrology to SI

Thermal Stability:
Primary Mirror only views deep space
Heater cavity around backplane controls boundary condition to mK
Segment level thermal control
>+/-45 degree FOR



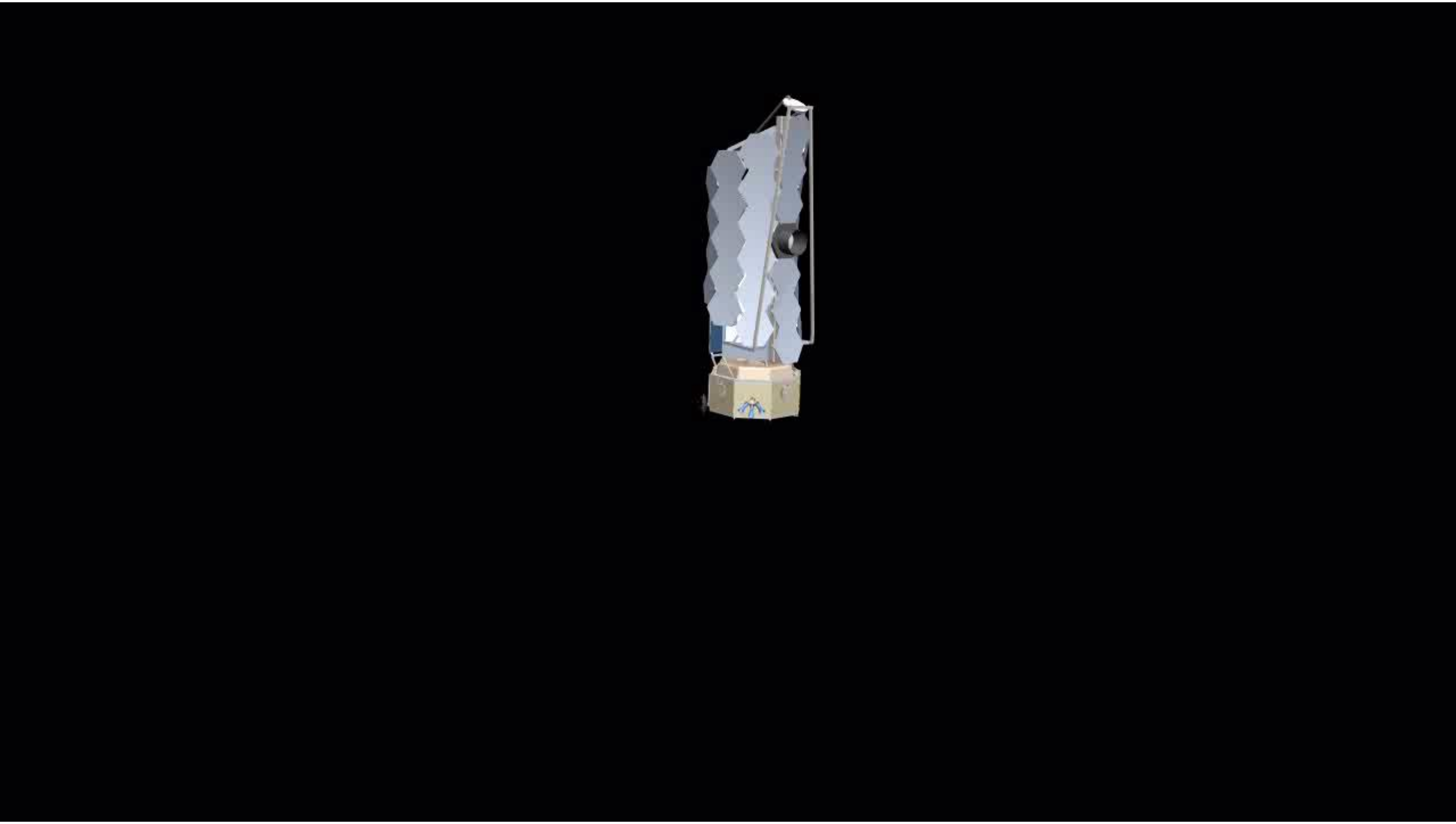
Dynamically Isolated from SC
Non-contact isolation between spacecraft and telescope
Signal and power fully isolated

L2 orbit for stability and serviceability

Multi-dof Gimbal
Maintains Sunshield at constant temperature
Maintains constant CG minimizing momentum unloading

Sunshield:
3-4 layer, constant angle to sun,
Approximately 100K, stable sink
Sunshield deployed from below using 4 booms

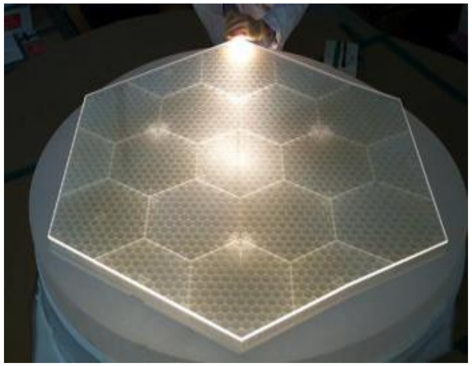
9.2m Deployment



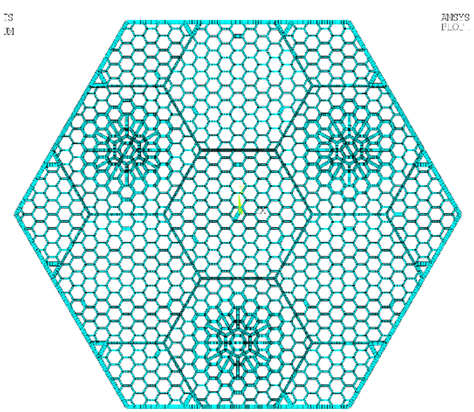
Telescope Design Parameters

Telescope Parameter	Consensus Requirement
Primary Mirror Aperture	≥ 8 meters
Primary Mirror Temperature	~20 C, pending detailed thermal design
UV Coverage	100 nm (90 nm goal) – 300 nm
Vis/NIR Coverage	300 nm – 2500 nm
Mid-IR Coverage	Under evaluation to ~ 8000 nm
Vis/NIR Image Quality	Diffraction-limited performance at 500 nm
Stray Light	Zodi-limited in 400 nm – 2000 nm wavelengths
Wavefront Error Stability for Exoplanet Imaging Using an Internal Coronagraph	1×10^{-10} system contrast < 10 pm rms residual system WFE for < 10 min bandpass between λ/D and $10\lambda/D$

Mirror Segment Stability Assessed



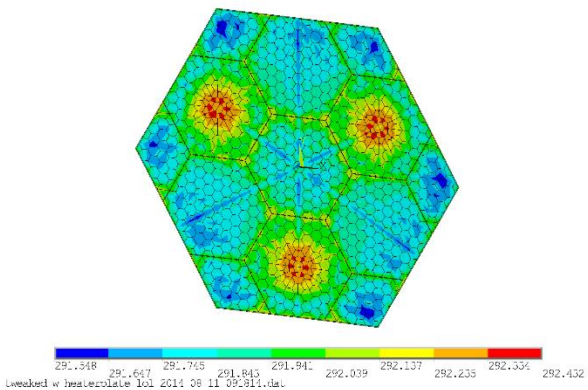
- **Realizable ULE mirrors based on existing mirrors and real radial CTE data, built by Exelis**
- **>1.15m flt to flt**
- **Substrate approximately half areal density of JWST segment**
- **Mounts not included**



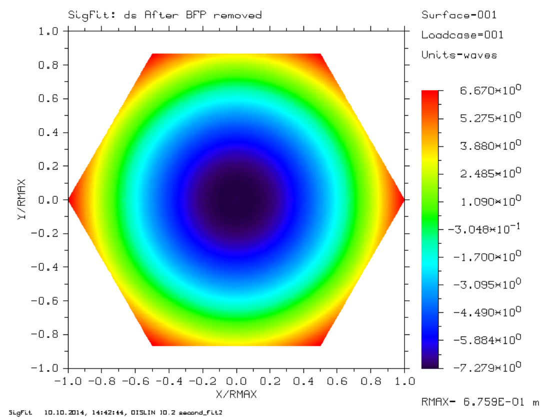
- **Mirror mapped temperatures**
- **1mK control from rear-side radiative heater plate**
  - **Considered conservative level of control**
  - **Commercial sensors <100uK available**
- **Steady state hot to cold**
  - **Improvements gained by taking advantage of transient under study**
- **Front surface changes over worse case slews for 100K sunshield confirmed to be small (approx. 50uW)**

NOTE: See other talks on Zerodur and SiC stability modeling

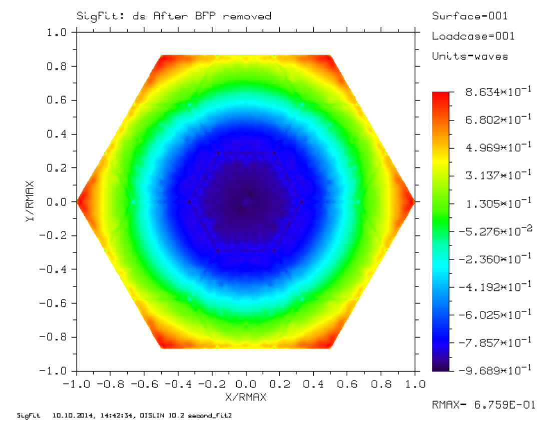
Mirror Segment Stability Results



Thermal Result



RMS: 3.80 pm
PV: 13.9 pm



RMS: 0.514 pm
PV: 1.82 pm

	.98mK control		1.27mK control	
CTE Distribution	RMS (pm)	PV (pm)	RMS (pm)	PV (pm)
Mirror 1	3.8	13.9	4.94	18.1
Mirror 2	0.514	1.82	0.67	2.38

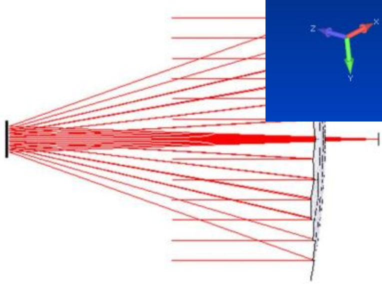
Goal of <5 picometers demonstrated without taking advantage of time variation
Dominated by power resulting from front to back gradient

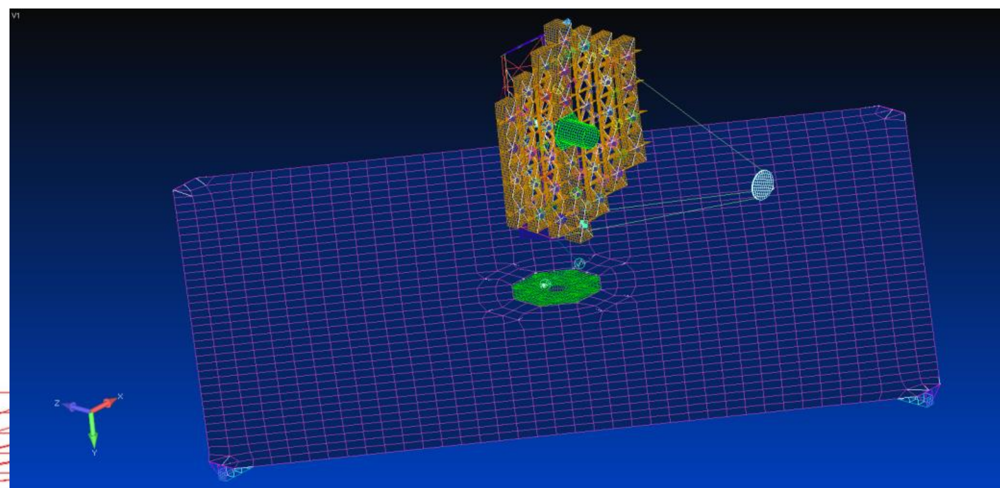
ATLAST Integrated Modeling: Dynamics

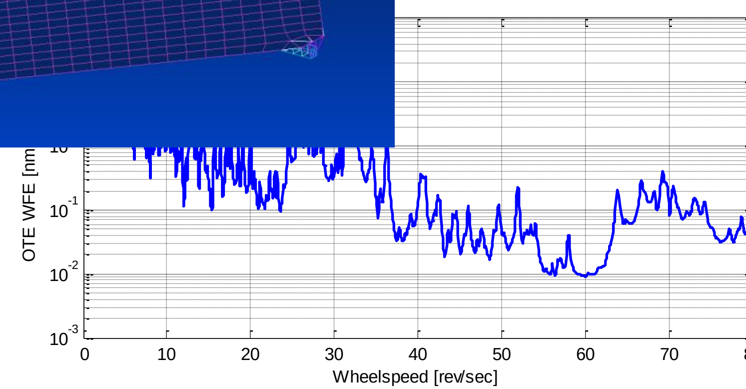
Scaling performed based on JWST and using the PSD of a non-contact isolation system
- Results suggested <5 picometers is feasible but needs detailed study

Integrated FEM/optical/dynamics model has been developed

First results of LOS and WFE are in review, so far looks consistent with scaling that was done
- Employing non-contact isolator deemed to be TRL 5/6, reaction wheel isolation





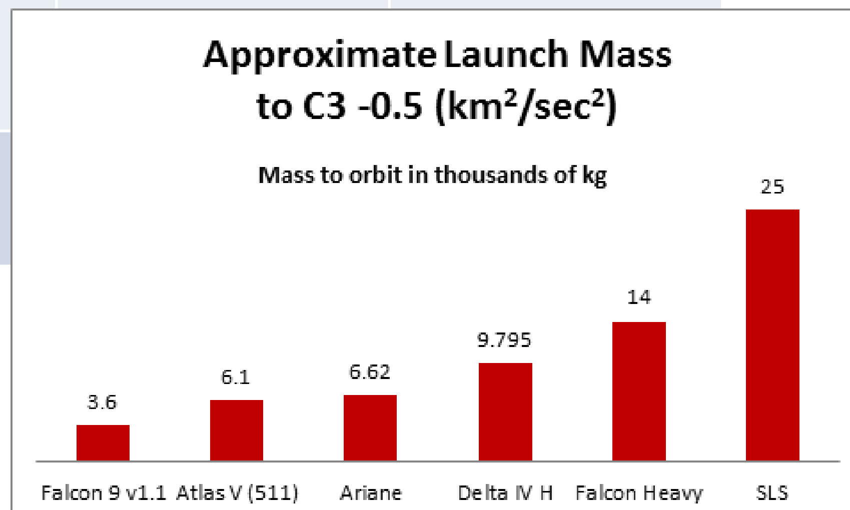


Mass vs. Launch Capability

	6.5 m	9.2 m	11 m	16 m
Mirror Mass (kg)*	1600	3200	4888	12444
Total Observatory Mass (kg)	6600	8200	9888	17444
50% Lower Areal Density Mirrors (kg)	800	1600	2444	6222
Observatory Mass w/Lower Areal Density Mirrors (kg)	5800	6600	7444	11222
Approx. # of segments	18	36		

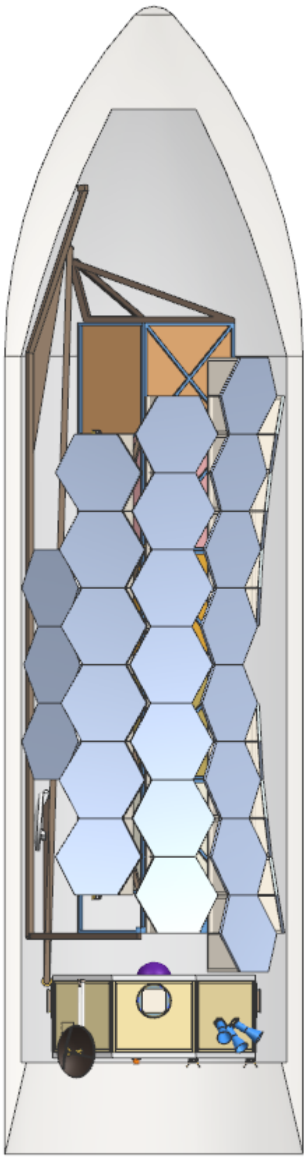
*backplane plus mirrors only

Scaled from JWST, more detailed effort planned



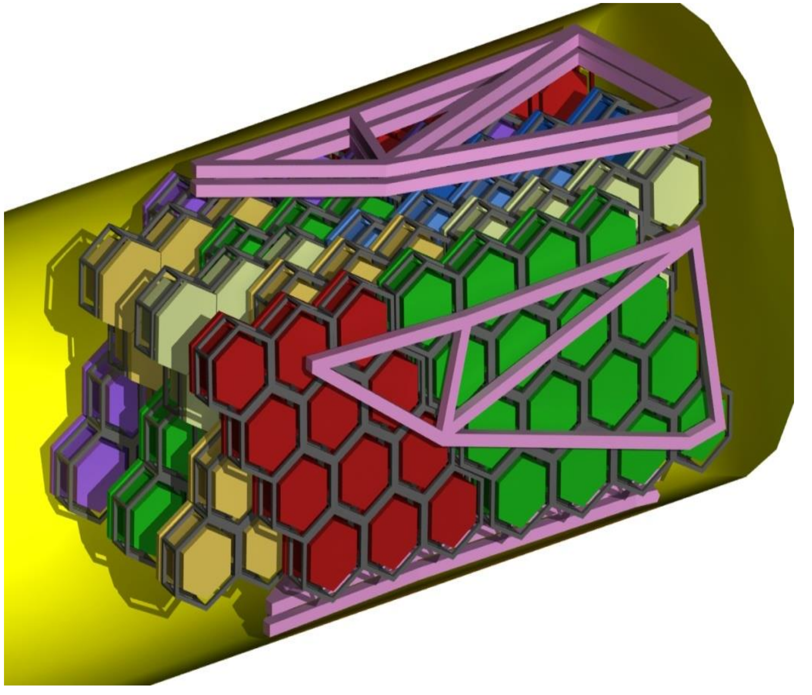
Bigger Telescopes Assessed

11.9 m Segmented



- An 11.9 meter using the circular geometry was just able to fit
- Required changing the SM deployment approach
- If SLS Block 2 available, JWST SM deployment feasible and even larger aperture feasible, can also consider larger segments

20 m Assembled



- Launch in pieces
- Leverage architecture from 9.2m studies

Driving Capabilities

Faint/Distant Objects → Sensitivity; Resolution → Aperture
(D^4) (λ/D)

Starlight Suppression (High Contrast) → WFE Stability → Mech., Therm. Stability

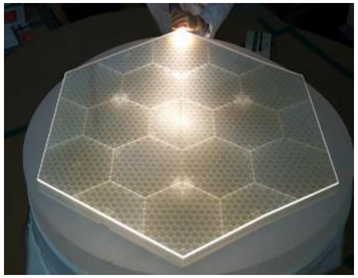
Driving Capability	Need	Comparison to Current or Planned Space Missions
Sensitivity Resolution	10+ m aperture	300x HST, 6x JWST 4x HST, 6x JWST
Starlight Suppression (Contrast)	10^{-10}	10 – 100x WFIRST-AFTA
Wavefront Error Stability (WFE) (Using Internal Coronagraph)	10 pm over 10 min (TBR)	1000x JWST
Coronagraphic Efficiency	Hundreds of potentially habitable stars surveyed in 5 years	Internal coronagraph surveys 10-100x more stars than occulters

Enabling Technology Investments

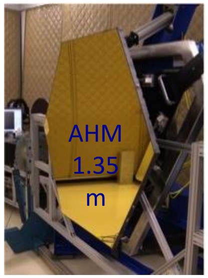
Technology already exists to build a large segmented UV-Visible-NIR general purpose observatory leveraging JWST and follow-on work

Key challenges to support high contrast imaging include:

- Starlight Suppression System (Most Critical)
  - Two leading candidates are ACAD/Hybrid and VNC type internal coronagraphs
  - Need broad enough bandpass, sufficient IWA, sufficient contrast to do surveys
  - Need to iterate what is possible with science studies
  - Associated components (deformable mirrors, etc.)
  - Potential to relax observatory requirements with a clever approach here
    - Avoiding rolling the observatory, coating uniformity requirements
  - Starshade under consideration for spectroscopy or for new survey strategies
- Stable, Lightweight Mirror Segments and Systems
  - Lightweight ULE mirror excellent candidate
  - SiC an option depending on stability performance
  - Mirror Coatings, considered enhancing
  - Key need is thermal stability demos
  - Laser metrology could play a role (picometer level)
- Vibration Isolation and Control
  - A non-contact isolation candidate is deemed TRL-5/6
  - Modelling underway to assess this
  - Combine with reaction wheel isolation, damping
- Detector Systems
  - Photon counting, considered enhancing



MMSD Lightweight ULE Segment Substrate



AHM SiC-based Segment Substrate

Summary

- ATLAST 9.2 m architecture feasibility assessment continues to progress
  - “Yardstick” architecture
- Scalable approach that can be made bigger, colder
  - Heavily leverages JWST design, experience
  - Alternative segment size and segmentation are possible
- ATLAST 9.2 m Stability Results are progressing
    - Segment stability looks promising
    - Expect dynamics modeling results in next few months, initial results look consistent with scaling, need to assure backplane volume is sufficient
    - Developing Segment to Segment active thermal control architecture
  - 9.2 m mass Looks promising even with Delta IVH
- Key technology priority is internal coronagraph demonstration
  - Contrast at Inner Working Angle over large bandpass
  - First generation approach should focus on survey efficiency