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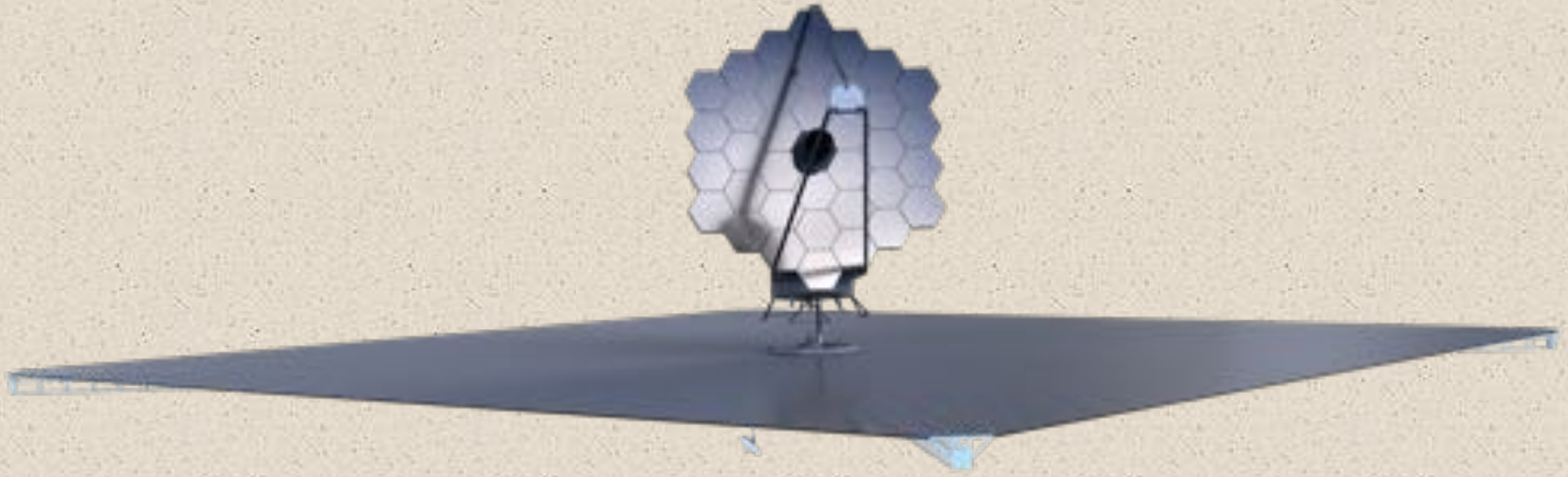
Continuing the Legacy of the Hubble Space Telescope

The Advanced Technology Large-Aperture Space Telescope (ATLAST)



Mark Clampin
and
The ATLAST Study Team

June 25, 2015

CONCEPT OVERVIEW

- A four-institution design study of a 10-meter class UVOIR observatory
  - Scalable to larger (up to ~14 m) apertures depending upon availability of launch vehicle
  - Non-cryogenic, thus easier to integrate and test (I&T): $T_{telescope} \approx 273 - 293$
  - Serviceable and upgradable, also allows ready access during I&T
  - Broad wavelength coverage: 90 nm – 1.8+ μm; longer wavelength operation under assessment
- Adopted 9.2-meter segmented aperture derived from JWST experience as reference design . . .
  - Allows increasingly detailed engineering design – thermal/mechanical stability, estimated system scientific performance, deployment technique, etc. – to affirm that science goals are achieved
  - Allows identification of technology priorities common to wide range of segmented aperture diameters
  - Largest aperture within existing launch vehicle fairing that deploys similarly to JWST
- Synergy: Enables cutting-edge general astrophysics *and* search for exoEarths as recommended by:
  - *Enduring Quests, Daring Visions* (NASA Thirty-Year Roadmap, 2014)
  - *From Cosmic Birth to Living Earths* (AURA "Beyond JWST" report, 2015)

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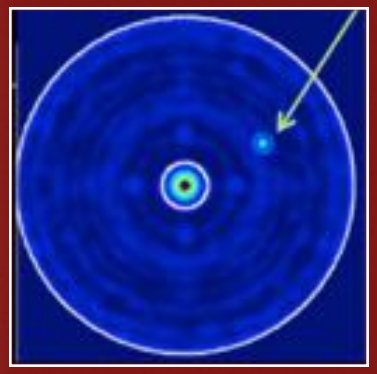
The Advanced Technology Large-Aperture Telescope (ATLAST)

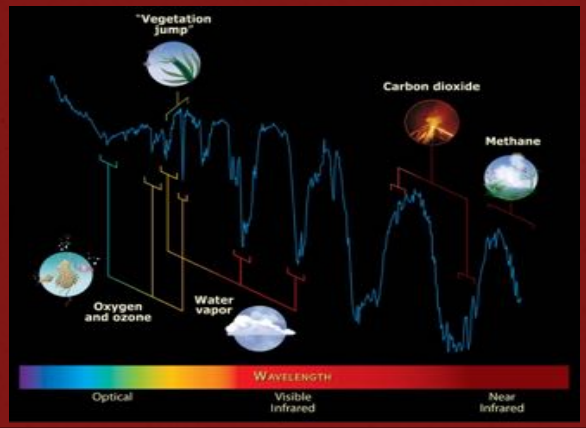
The Next Great Leap In Astrophysics

The ATLAST Reference Design

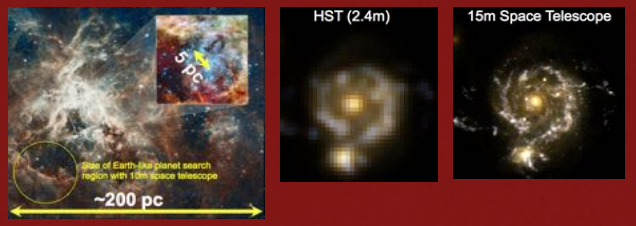
This ATLAST reference design is a 9.2-m observatory under assessment as a candidate for selection by the 2020 Decadal Survey. It is designed to be a powerful general-purpose non-cryogenic observatory operating from 0.1 μm to 1.8+ μm and able to search for biomarkers in the spectra of candidate exoEarths in the Solar neighborhood.

Identification of Habitable Zone Planets and detection of Biosignatures

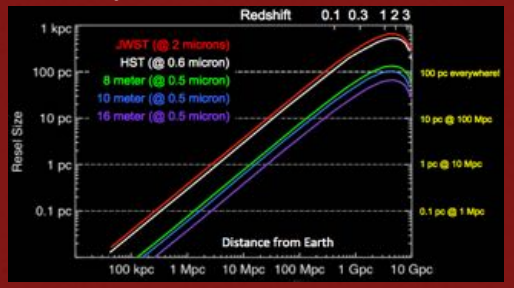




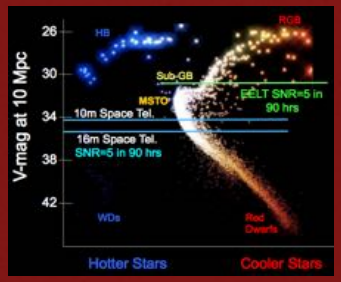
Breakthrough in UVOIR Resolution and Sensitivity throughout the Universe



Resolve 100 pc Star-Forming Regions Everywhere in the Universe

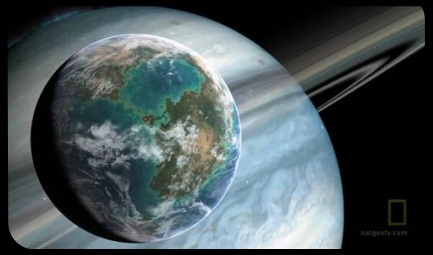


Tracing the History of Star Formation in all Types of Galaxies up to 10 Mpc



ATLAST Science: Are We Alone?

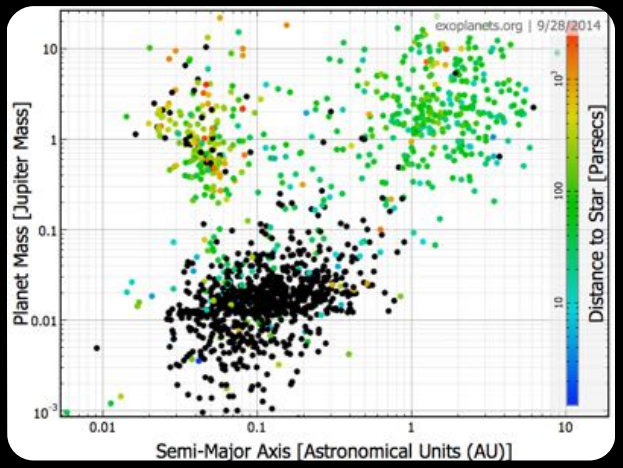
Are We Alone ?



"The most important experiment in modern biology is the search for extra-terrestrial life."

- E. O. Wilson
Evolutionary Biologist

1746 Confirmed Exoplanets

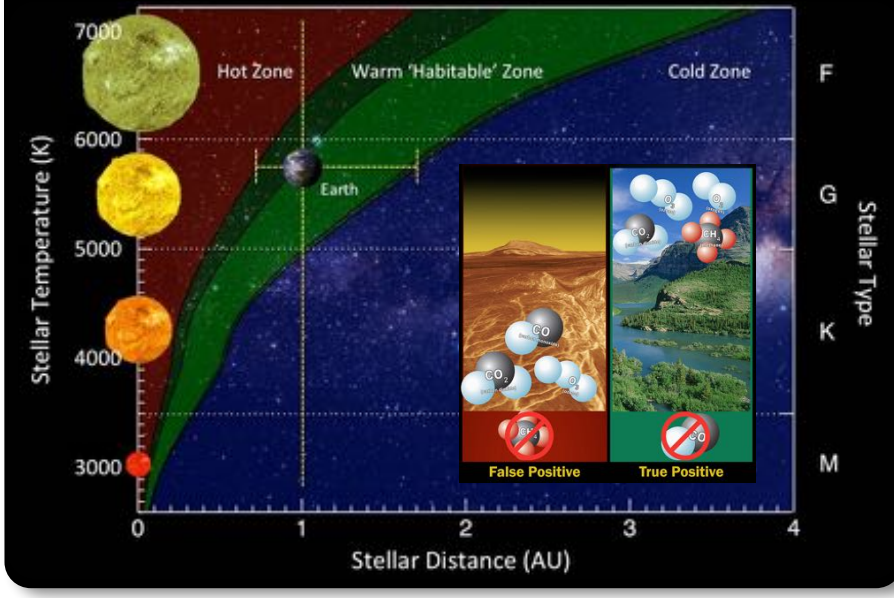


Discovered via:
- Radial velocity
- Transits
- Imaging > 10 AU

Biased to short periods

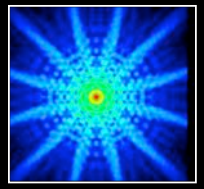
To find Earth 2.0:
- Survey nearest F, G, K stars
- Spectroscopy of habitable zone candidates for key spectral lines (biomarkers)

Habitable Zone vs Stellar Temperature

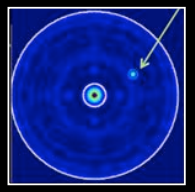


Key Requirements for an HZ Survey

Suppression of starlight

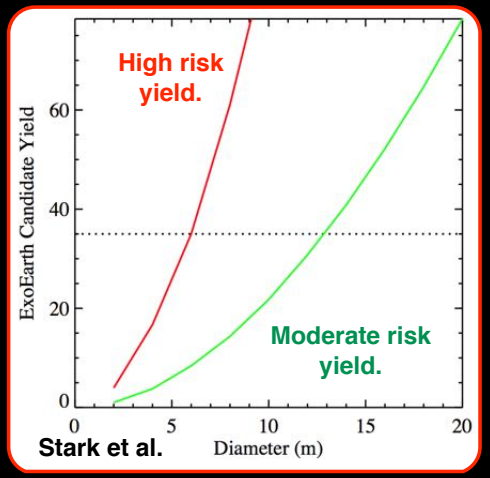


No suppression



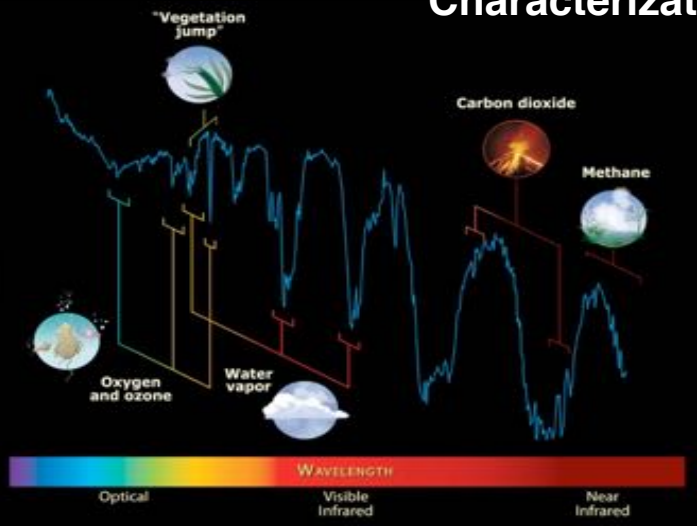
10^{-10} suppression

Minimum aperture ≥ 12 meter
➠ SNR & inner working angle

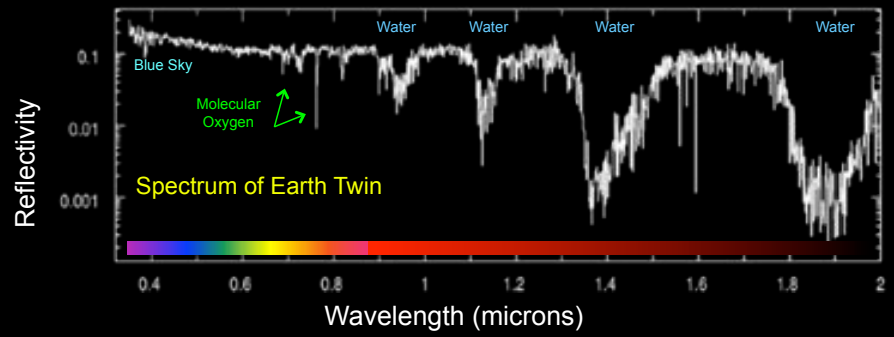


ATLAST Science: Are We Alone?

Characterization of Habitable Zone Planets

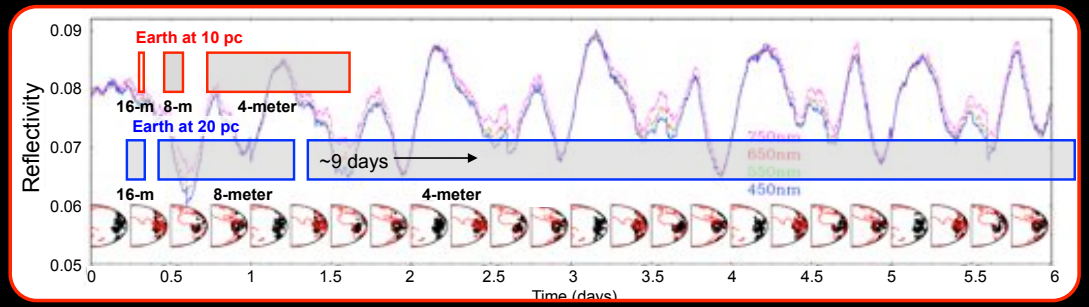


Detection of Biosignatures in Habitable Zone Planets

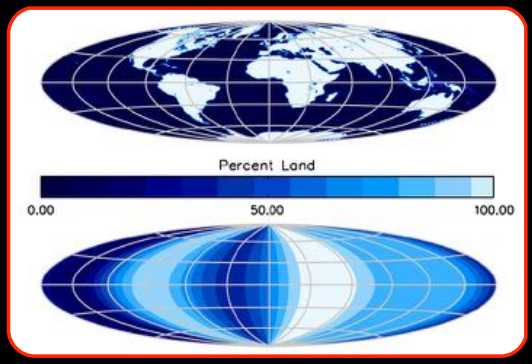


Oxygen and water in the atmosphere of an Earth-like planet can be detected in its spectrum.

Monitoring for Diurnal Photometric Variations



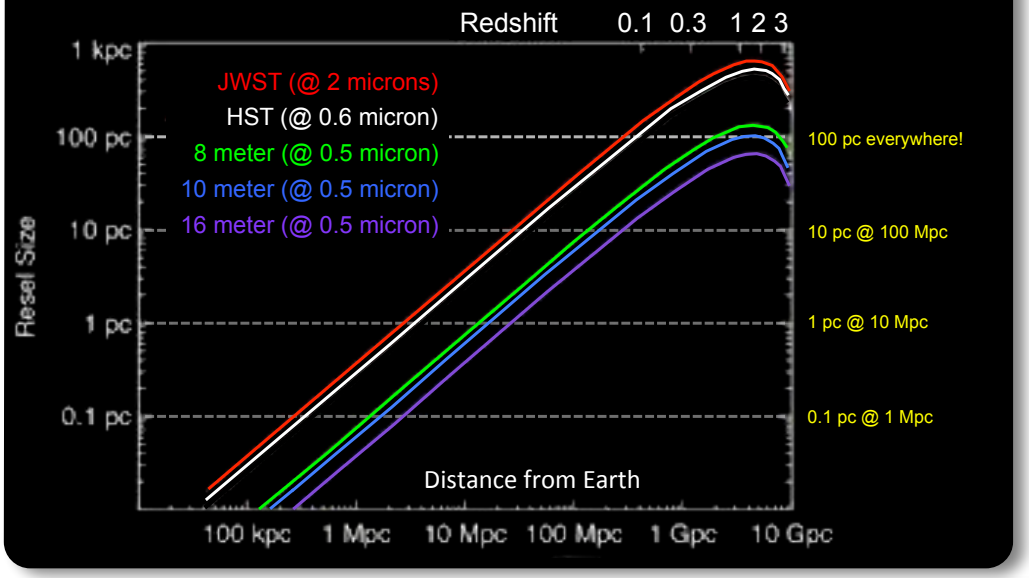
Require S/N ~ 20 (5% photometry) to detect ~20% temporal variations in reflectivity.



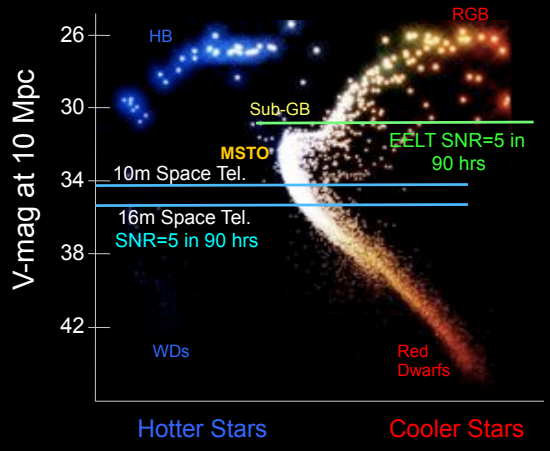
Reconstruction of Earth's land-sea ratio from disk-averaged time-resolved imaging with the EPOXI mission.

ATLAST Science: Are We Alone?

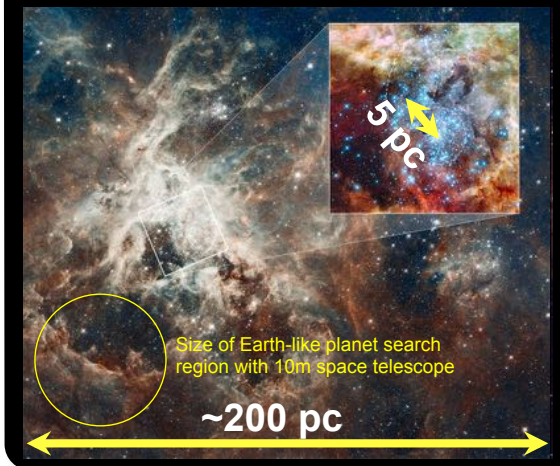
Breakthrough in UVOIR Resolution and Sensitivity

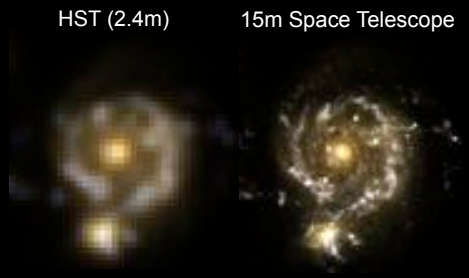


Detection of the Main Sequence Turn-Off in galaxies up to 10 Mpc traces the Star Formation History in all types of galaxies.



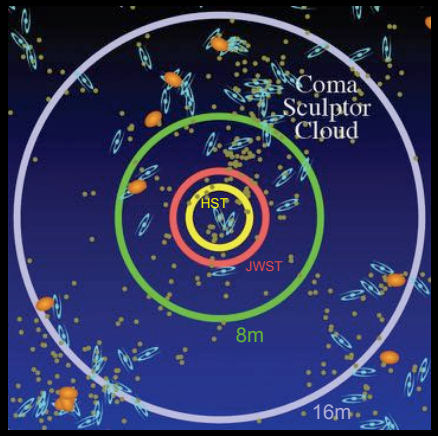
Resolve 100pc star-forming regions everywhere in the universe





z = 2 Galaxy: Look-back time = 76% age of universe

Measure circumgalactic gas in the same galaxies where we measure the star formation histories from resolved stars!



Telescope Design Parameters

Parameter		Requirement	Stretch Goal
Primary Mirror Aperture		≥ 8 meters	12 meters
Telescope Temperature		273 K – 293 K	-
Wavelength Coverage	UV	100 nm – 300 nm	90 nm – 300 nm
	Vis	300 nm – 950 nm	-
	NIR	950 nm – 1.8 μm	950 nm – 2.5 μm
	MIR	-	Capability Under Evaluation
Image Quality	UV	< 0.20 arcsec at 150 nm	-
	Vis/NIR/MIR	Diffraction-limited at 500 nm	-
Stray Light		Zodi-limited between 400 nm – 1.8 μm	-
Wavefront Error Stability (for Exoplanet Science)		< 10 pm RMS uncorrected WFE per control step	-
Pointing		≤ 1 milli-arcsec	-

Ongoing Engineering Formulation

- Highest-priority engineering formulation activities
  - Dynamic stability analysis
    - *Jitter modeling for preliminary estimate of jitter-induced wave front error*
    - *Primitive Finite Element Model (FEM) of observatory being validated*
  - Thermal stability snalysis
    - *Validate milli-kelvin-level control of mirror segment assembly*
    - *Validate control of thermally induced wave front error control*
  - Starlight suppression via coronagraph or starshade
    - *Multiple concepts for coronagraphy, although in early stage*
    - *Successful concept may reduce demanding requirements on system's dynamic stability*
- Mass estimation proceeding within limitations of available resources
- Work begun on bounding observatory instrument interfaces
  - Too early to downselect to final instrument suite
  - Bound mass, power, optical geometries, data rates, data volume, thermal, etc.
- SLS + ATLAST/LUVOIR engineering working group ongoing
  - Engineer-to-engineer development of conceptual interfaces and requirements

ATLAST 10+ m Class Architecture

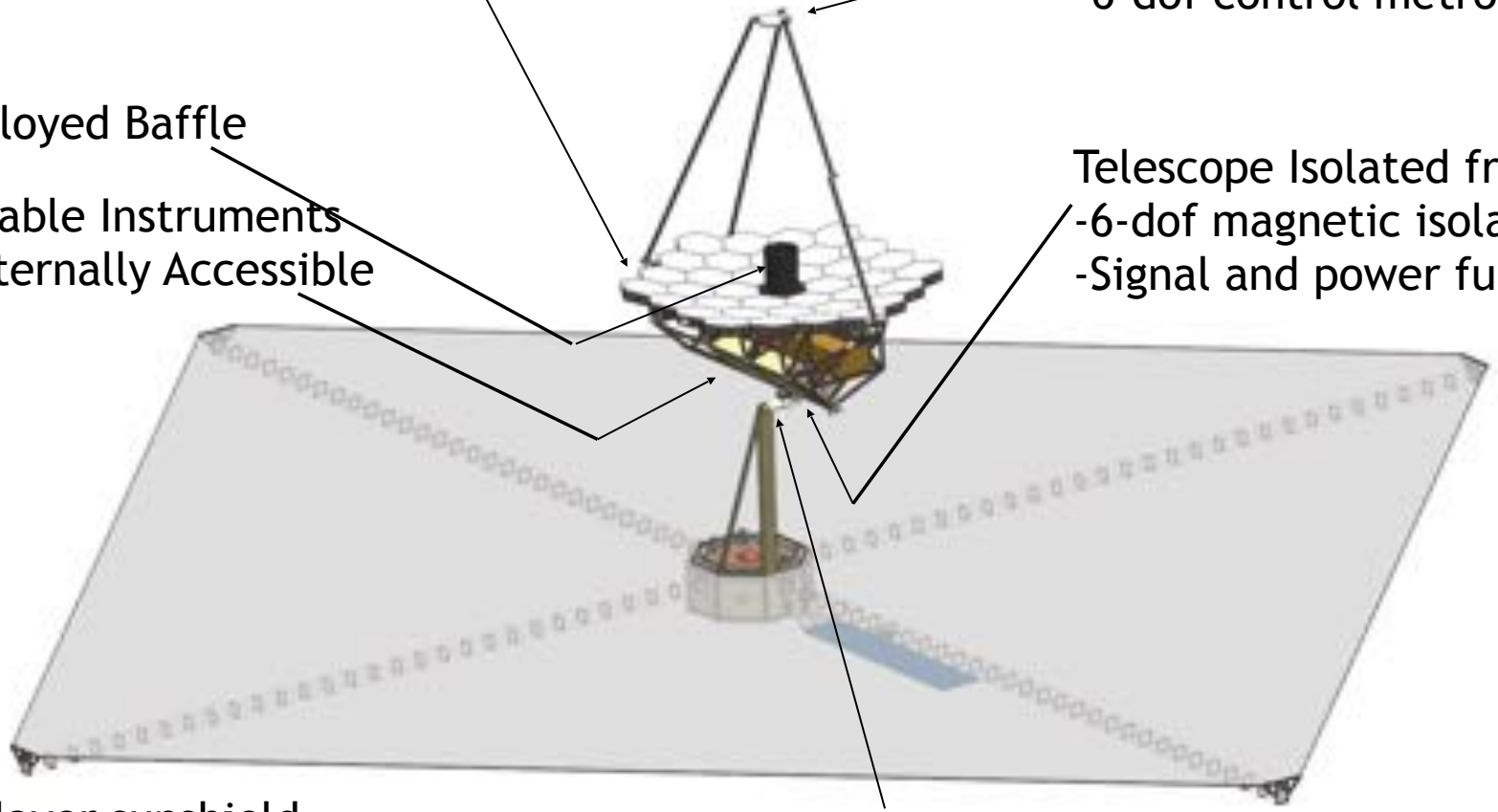
36 JWST-Size Segments
(Glass or SiC, Heater Plates)

Actively controlled SM
6-dof control metrology to S

Deployed Baffle

Serviceable Instruments
are Externally Accessible

Telescope Isolated from SC
-6-dof magnetic isolation
-Signal and power fully isolat



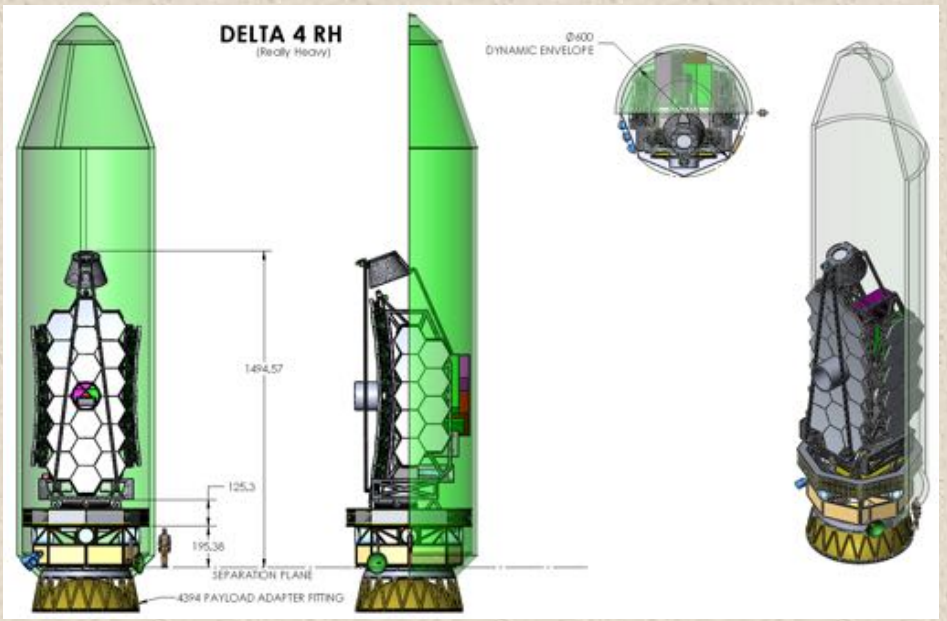
Three-layer sunshield,
Constant angle to sun, warm, stable sink
Sunshield deployed from below using four booms

Pointing gimbal maintains
constant sun angle;
Single pointing axis enhances stiffness

ATLAST 9.2 m
JWST-like Deployment

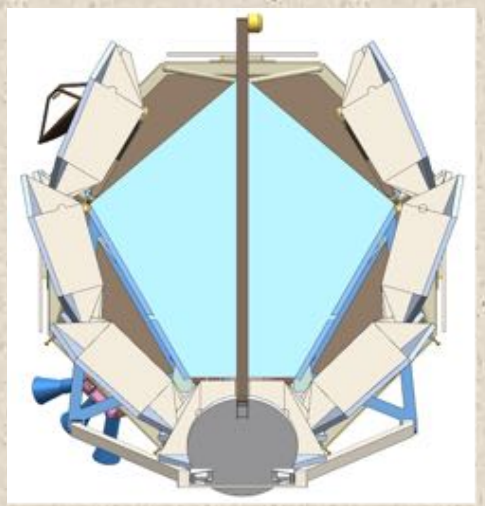
Early ATLAST Studies (2009)

Assumed Larger EELV was Under Development
and used JWST-Geometry Wings



Current Circular Geometry

Delta IVH



Design reference mission builds upon experience with JWST to manage overall cost and schedule.

Summary

- Conducted a design study of a 10-meter class UVOIR observatory
- Demonstrated aperture requirement to achieve statistical answer to question "Are we alone?"
- Synergy between general astrophysics *and* search for exoEarths
- Multiple studies making similar recommendations: See also…..
  - *Enduring Quests, Daring Visions* (NASA Thirty-Year Roadmap, 2014)
  - *From Cosmic Birth to Living Earths* (AURA "Beyond JWST" report, 2015)