Ares V an Enabling Capability for Future Space Science Missions

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Executive Summary

Current Launch Vehicle Mass & Volume limits drive Mission Architecture & Performance:

- Volume limits Aperture
  - Asymmetric Aperture - TPF
  - Deployable Segmented Telescope - LUVO
- Mass limits Areal Density
  - Extreme Lightweighting - ConX

And, drive Mission Implementation Cost & Risk

Ares V eliminates these constraints and enables an entirely new class of future mission architectures.

While Ares V is ~2018, <u>now</u> is time to start planning future missions such as 6-8 m monolithic observatory.

Ares V delivers 5X more Mass to Orbit

Sun

Earth

Moon

Hubble in LEO

Delta IV can Deliver

23,000 kg to Low Earth Orbit
13,000 kg to GTO or L2 Orbit w/ phasing
5 meter Shroud

Ares V can Deliver

130,000 kg to Low Earth Orbit
60,000 kg to GTO or L2 Orbit w/ phasing
8.4 meter Shroud
(slightly less with 12 meter Shroud)

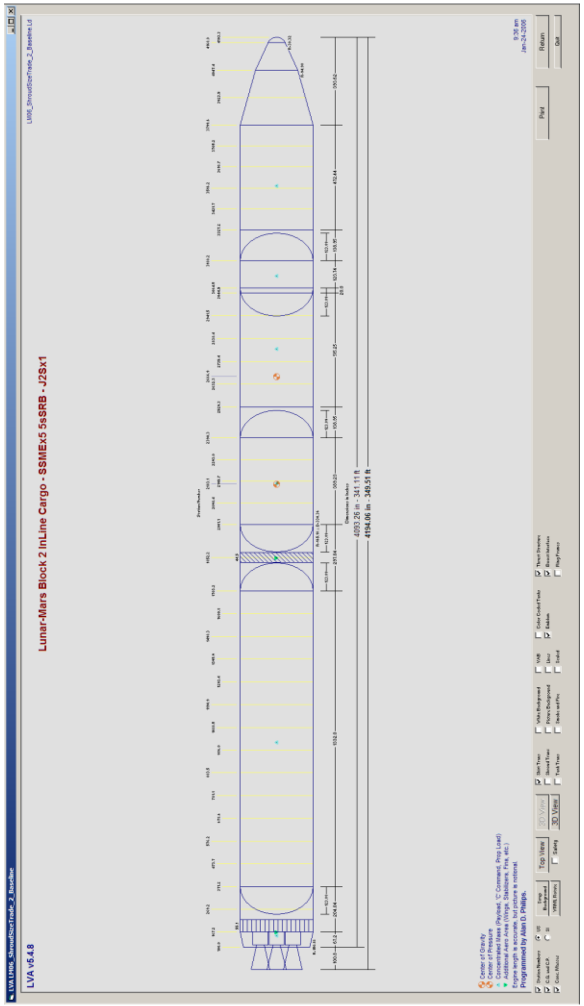
L2

1.5 M km from Earth

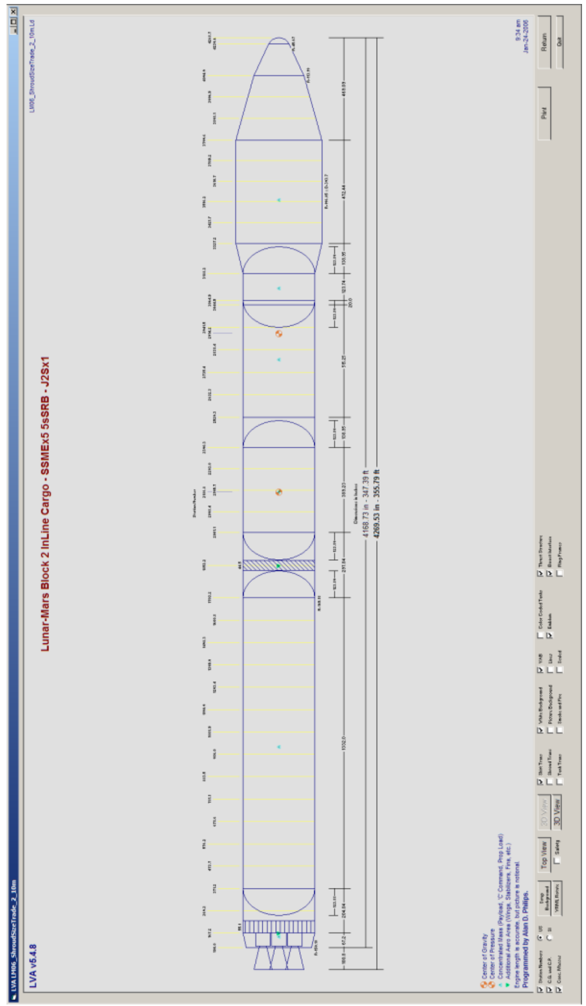
Ares V - Preliminary Shroud Concepts

(from MSFC Ares V Office)

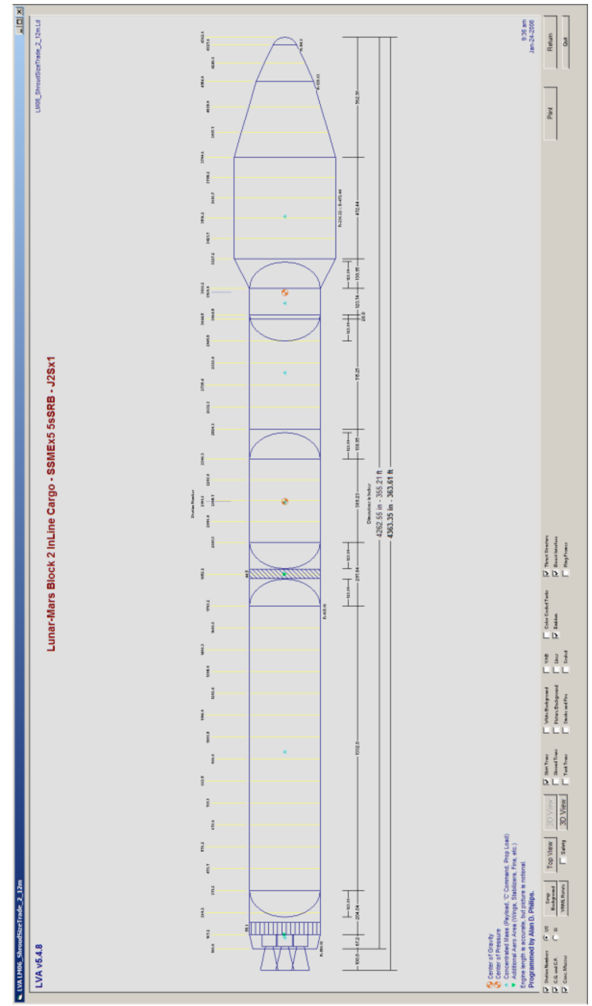
Baseline CaLV 8.4 m Shroud



CaLV w/ 10m Shroud

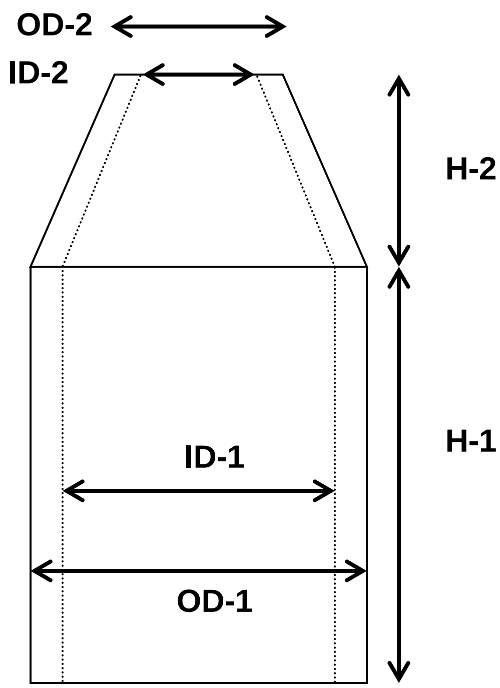


CaLV w/ 12m Shroud



Ares V Preliminary Shroud Dimensions
(from MSFC Ares V Office)

ID is the payload dynamic envelope, not the wall thickness.



	Shroud Outer Diameter			
	8.4-m	**10-m**	**12-m**	
Shroud Mass	5.9	8.4	12.5	**mT**
OD-1	8.4	10	12	**m**
ID-1	7.5	8.8	10.3	**m**
H-1	12	12	12	**m**
OD-2	4.8	5.8	6.9	**m**
ID-2	3.9	4.5	5.2	**m**
H-2	6.3	7.5	9	**m**
Total Height	18.3	19.5	21	**m**
Payload to SEL2	60.1	59.4	58.1	**mT**
	baseline			

NOTE: these shroud dimensions are preliminary, are subject to change, and have not been approved by the Ares project office.

Ares V Changes Paradigms

Ares V Mass & Volume enable entirely new Mission Architectures:

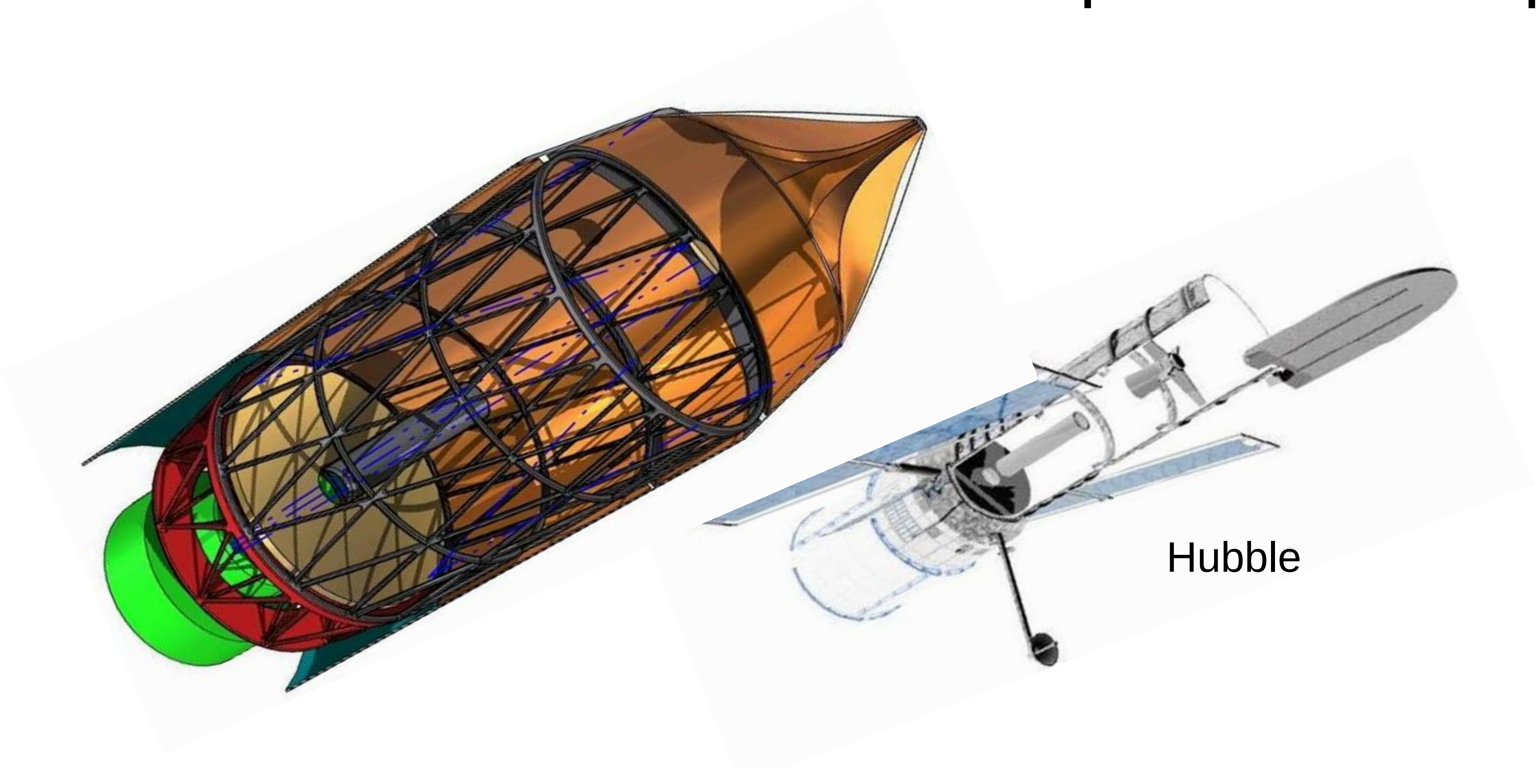
- 6 to 8 meter class Monolithic UV/Visible Observatory
- 5 meter cube (130,000 kg) Cosmic Ray Water Calorimeter
- 4 meter class X-Ray Observatory (XMM/Newton or Segmented)
- 15 to 18 meter class Far-IR/Sub-MM Observatory (JWST scale-up)
- 150 meter class Radio/Microwave/Terahertz Antenna
- Constellations of Formation Flying Spacecraft

All of these can be built with Existing Technology

Thus allowing NASA to concentrate its Technology Development Investments on Reducing Cost/Risk and Enhancing Science Return

To use a 2018 Launch, should start mission planning now

Case Study:
6 to 8 meter Class Monolithic Space Telescope



Enables Compelling High Priority Science:

UV/Visible Science

Terrestrial Planet Finding Science

Science Enabled by a 6 to 8 meter Telescope

Dark Energy/Dark Matter

Missing Baryons	UV Spectroscopy
Supernovae	Wide Field Optical/IR Imaging
Baryonic Oscillation	Optical Grism Spectroscopy
Weak Lensing	Wide Field Optical Imaging

Galaxy & Star Formation

Reionization	Optical Grism Spectroscopy
Star Formation	Wide Field UV/Optical Imaging
Cooling of White Dwarfs	Wide Field Optical Imaging

Extra-Solar Planets

Census of Planetary Systems	Wide Field UV/Optical/Near IR Imaging
Transiting Hot Jupiters	UV Spectroscopy

Design Concept

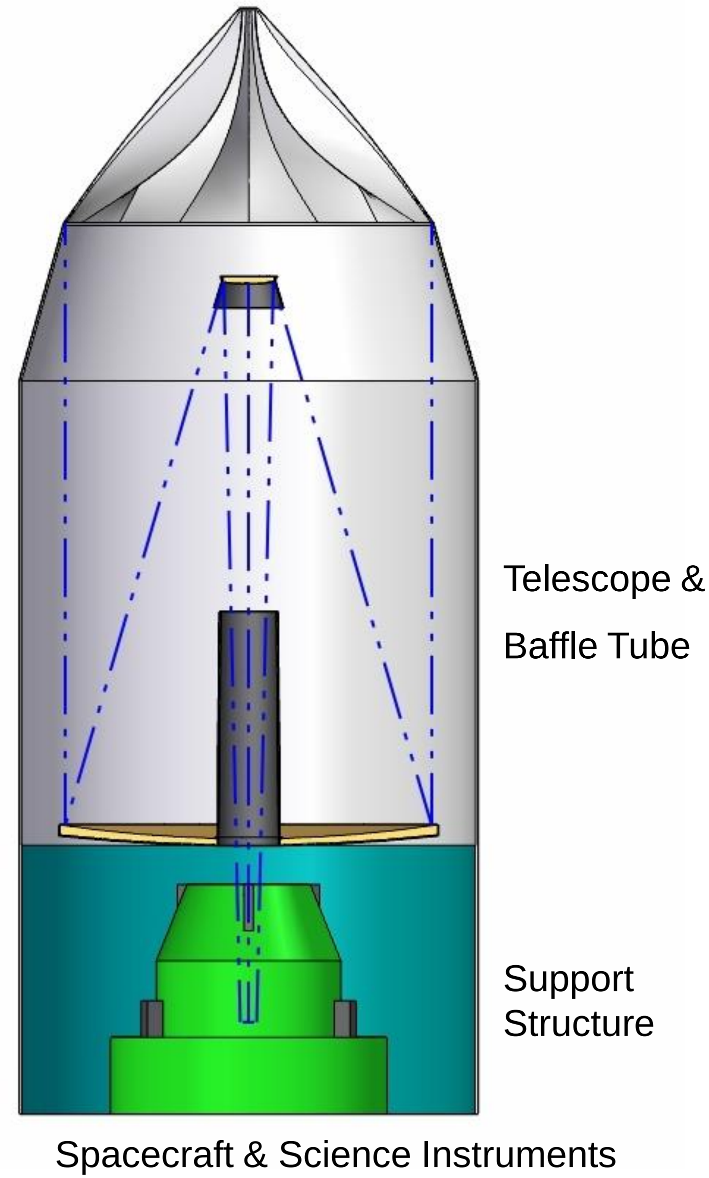
6 to 8 meter Monolithic Telescope & tube can fit inside Ares V envelop (8.4 to 12 meter shrouds).

Minimize Cost (& Risk) by using existing ground telescope mirror technology – optics & structure.

8-meter diameter is State of Art

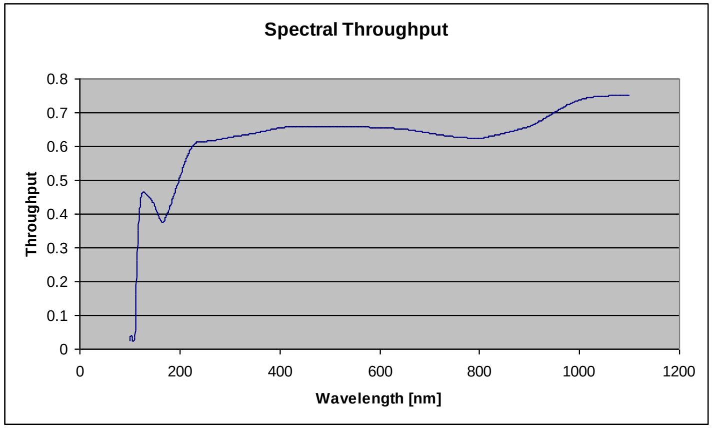
- 7 existing: VLT, Gemini, Subaru
- 23,000 kg (6 m would be ~13,000 kg)
- ~$20M (JWST PM cost ~$100M)
- 7.8 nm rms surface figure (~TPF spec)

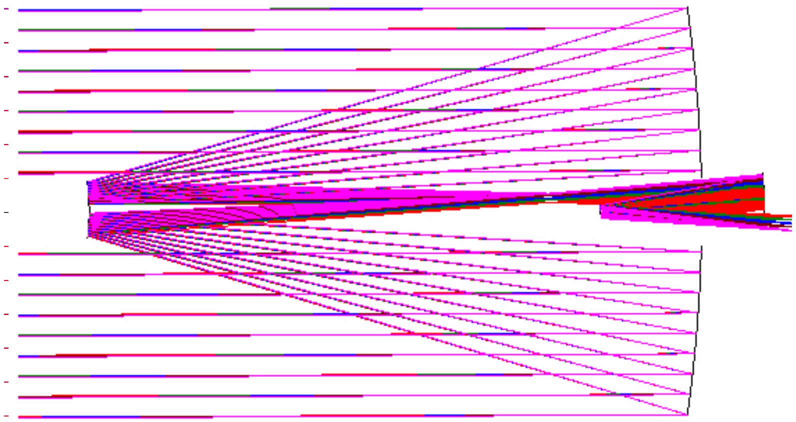
Expect similar savings for structure



6 meter Optical Design

Ritchey-Chretién optical configuration
- F/15
- Diffraction Limited Performance at <500 nm
- Diffraction Limited FOV of 1.22 arc minute
  - (10 arc minute FOV with Corrector Group)
- Coating: Aluminum with Mg F2 overcoat
  - Average transmission > 63% for wave lengths of 200 to 1,000 nm
- Primary to secondary mirror vertex: 9089.5 mm
- Primary mirror vertex to focal plane: 3,000 mm





All Reflective Design
- Three Mirror Anastigmatic
- With Fine Steering Mirror
- Multi-Spectral 10 arc min FOV
- Reduced Throughput

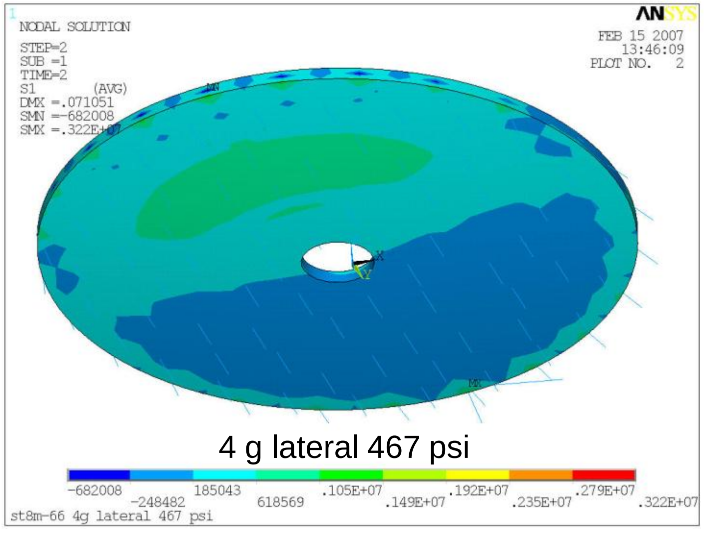
Structural Analysis

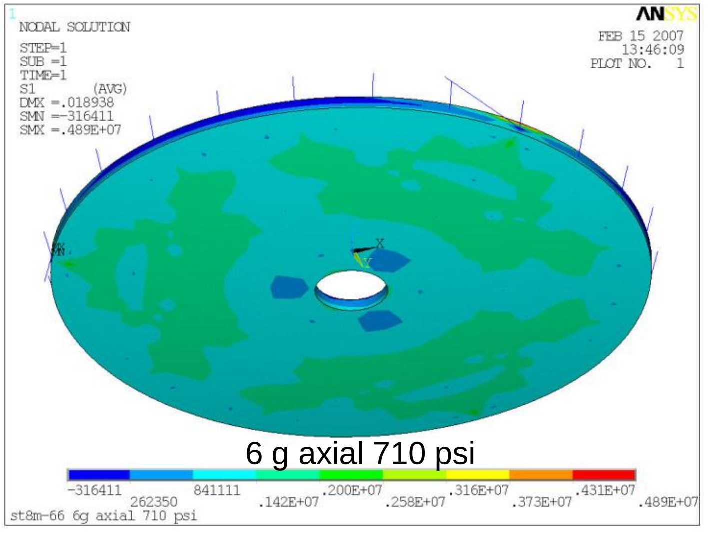
Launch loads: *maximum* values from POST3D

Axial:	4 g's
Lateral-y:	7×10^{-6} g's
Lateral-z:	6×10^{-4} g's

8.2 meter 175 mm thick meniscus primary mirror <u>can survive launch</u>.

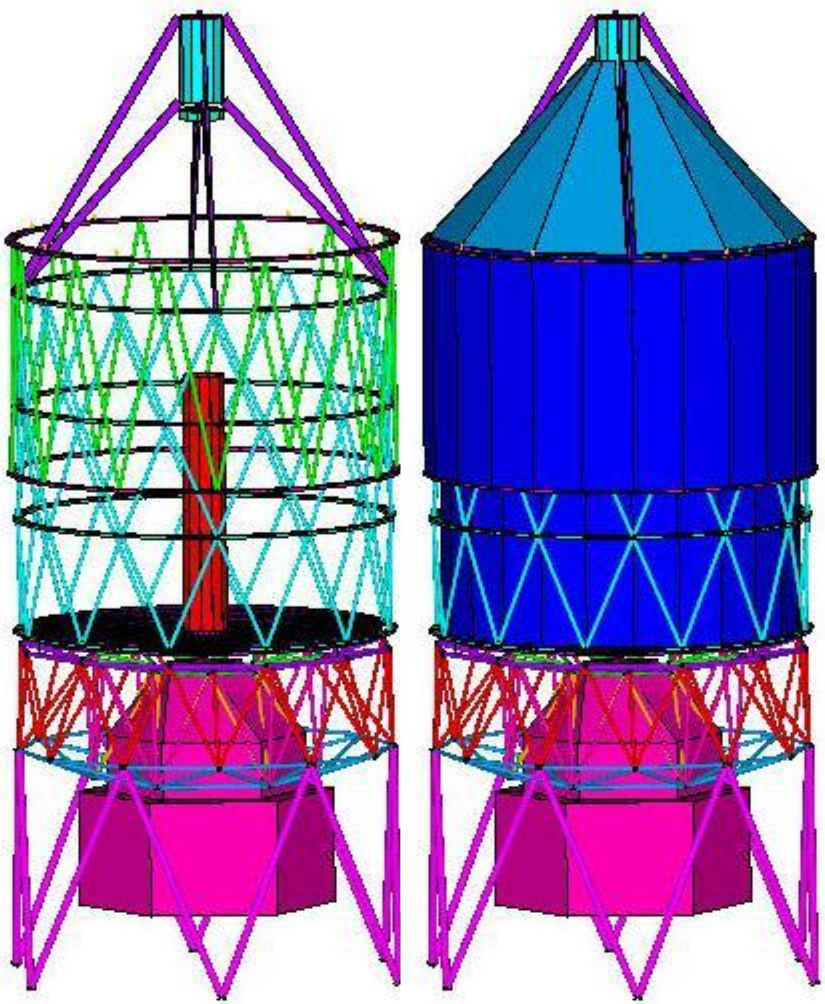
66 axial supports keep stress levels below 1000 psi



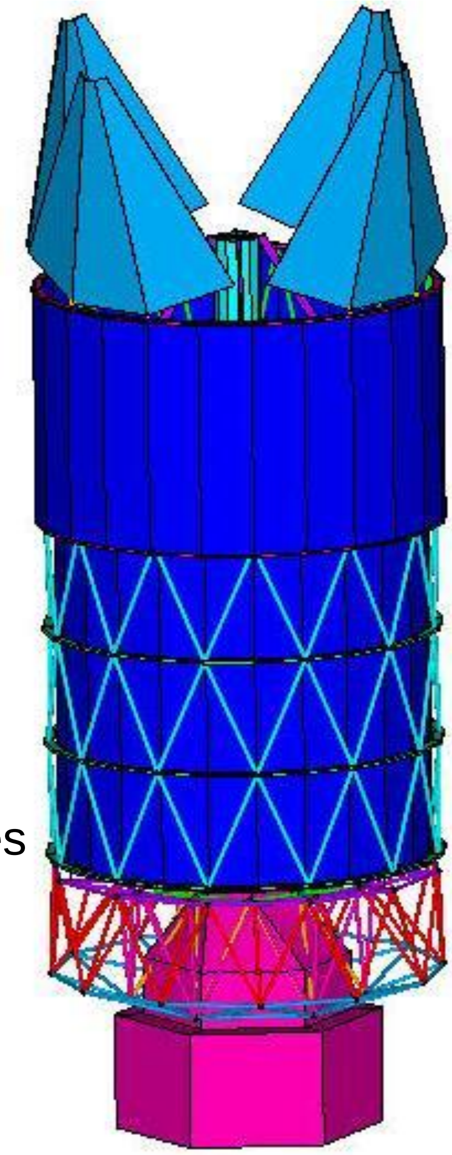


Structural Design

Launch Configuration



Operational



Tube is split and slides forward on-orbit.

Faster PM or taller shroud may allow for one piece tube.

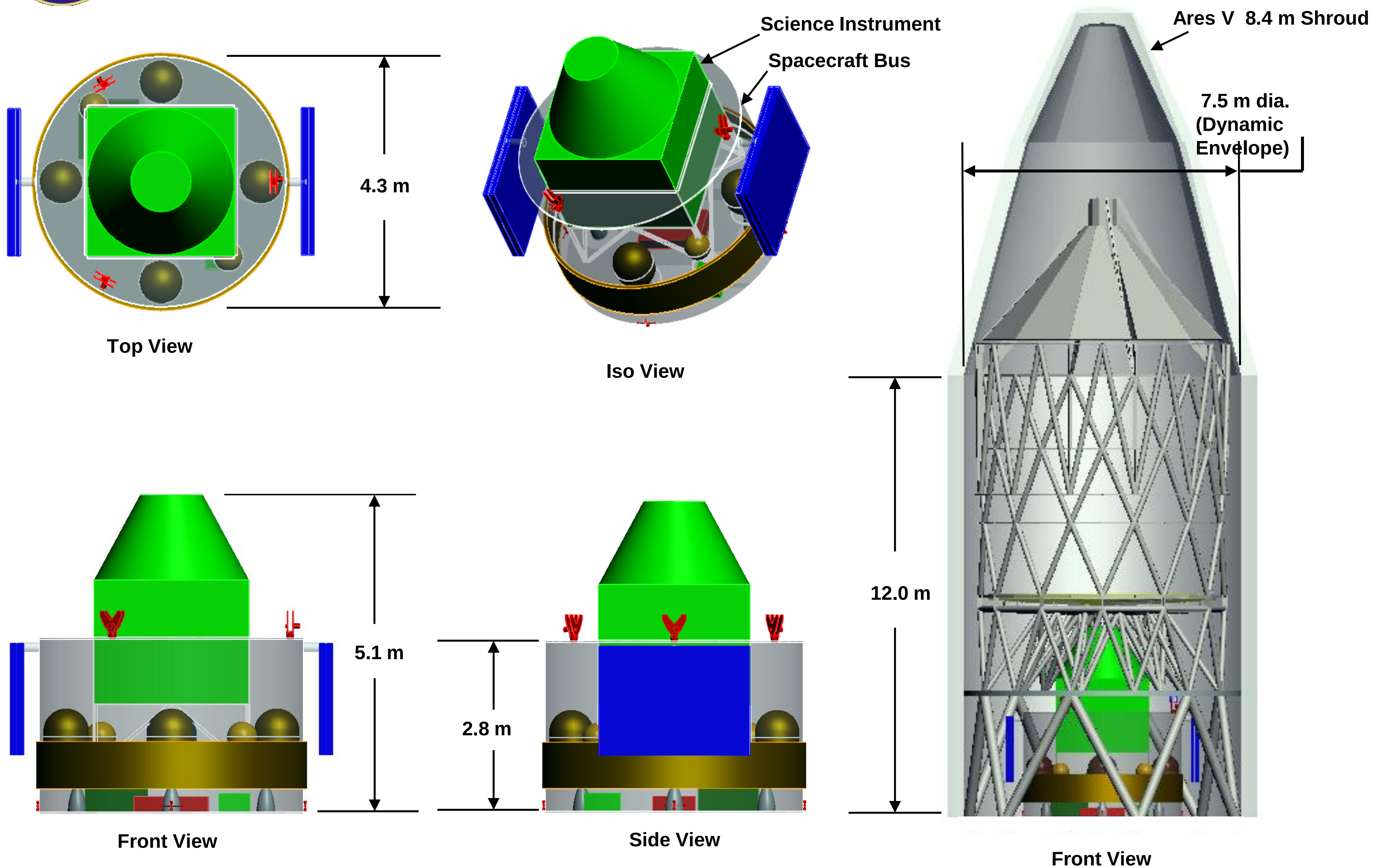
Doors can open/close

Forward Structure is hybrid of Hubble style and four-legged stinger

Truss Structure interfaces with 66 mirror support attachment locations

Launch Structure attaches Truss to Ares V

Spacecraft Design Detail and Shroud Integration



NOTE: All dimensions are in meters.

6 meter Preliminary Mass Budget

	Mass (Kg)	Heritage	Notes
Primary mirror assembly	**20000**		
Primary mirror	13,000	calculated	Zerodur 175 mm thk. meniscus
Primary mirror support structure	6,750	estimate	Structural Model
Primary mirror center baffel	250	estimate	Structural Model
Secondary mirror assembly	**985**		
Secondary mirror	185	calculated	Zerodur 50% light weight
Secondary mirror support & drive	350	estimate	Structual Model
Secondary mirror baffle	50	estimate	Structual Model
Secondary mirror spider	400	estimate	Structual Model
Telescope enclosure	**5,600**		
Metering structure with internal baffels	4,800	estimate	Marcel Bluth
Rear cover	300	estimate	WAG
Head ring	200	estimate	WAG
Front cover & actuator	300	estimate	WAG
Attitude Determination and Control System	300	JWST	estimate plus JWST scaled
Communications	76	EI63	
Command And Data Handling System	53	JWST	
Power	500	EI63	
Thermal Management System	1060	JWST	400% of JWST
Structures	2,000	estimate	WAG
Guidance and Navigation	50	estimate	50% WAG
Propulsion	250	JWST	
Computer Systems	50	estimate	WAG
Propellant	50	Ei63	
Docking station	1,000	estimate	WAG
OTE W / Bus mass	**31,974**		
Science Instrument	1500	JWST	ISIM, contains Fine Guidance Sensor
Attitude Determination and Control System	300	JWST	estimate plus JWST scaled
Communications	76	EI63	
Command And Data Handling System	53	JWST	
Power	480	EI63	
Thermal Management System	300	EI63	
Structures	2,000	estimate	WAG
Guidance and Navigation	50	estimate	50% WAG
Propulsion	250	EI63	
Computer Systems	50	estimate	WAG
Propellant	1530	EI63	
Docking station	1,000	estimate	WAG
Science Instrument W / Bus mass	**7,589**		

33% Mass Reserve

Total mass = OTE W / Bus + Science Instrument W / Bus = 39,563 kg

8 meter Preliminary Budget is 50,000 kg (16.5% Reserve)

Thermal Analysis

Spacecraft wrapped with 10 layer MLI blankets

16.0 m^2 thermal radiators

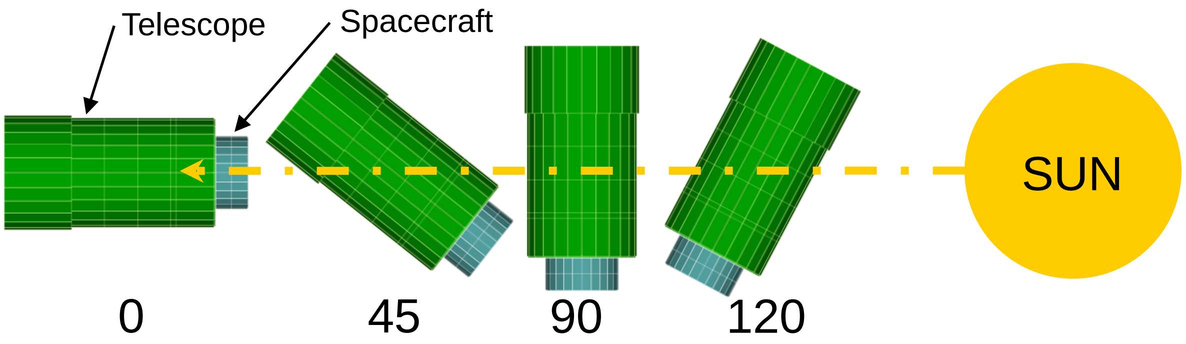
Load Cases

0 (base)

45

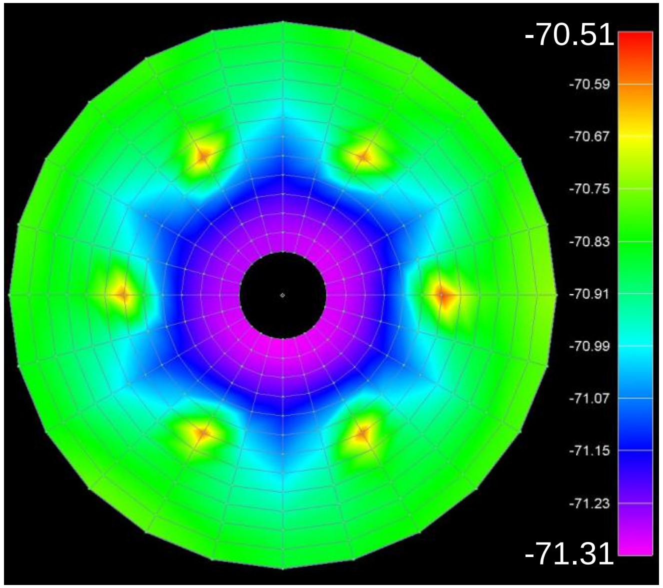
90 (broadside)

120



Thermal Analysis Results

Sun = 0



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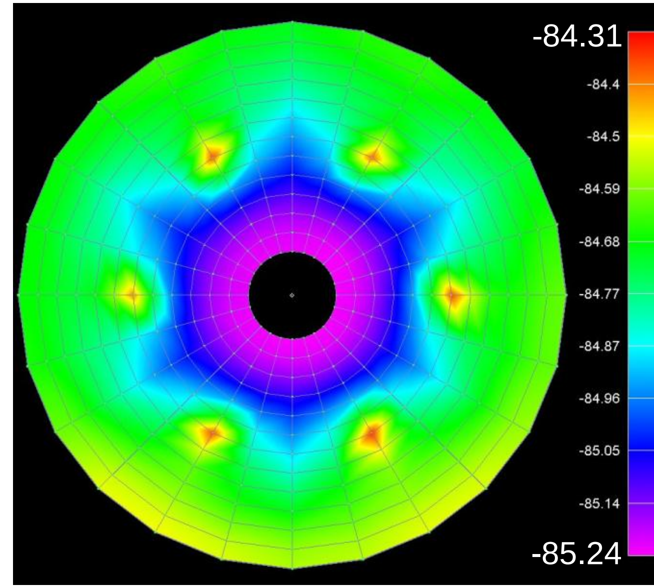
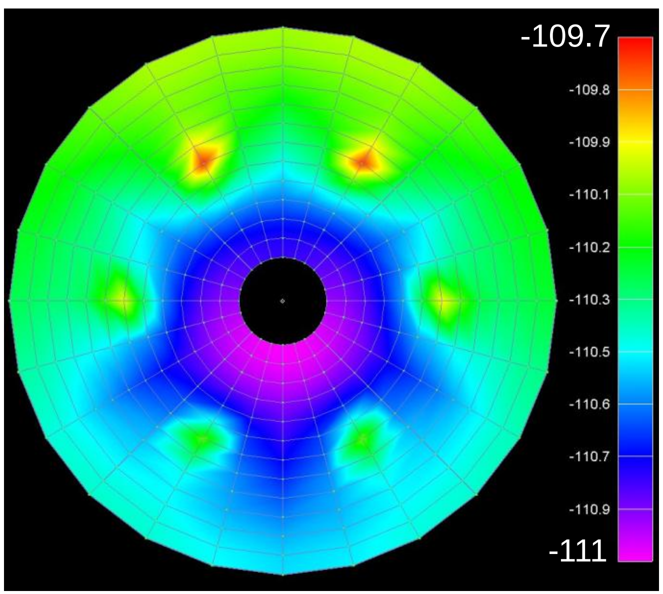
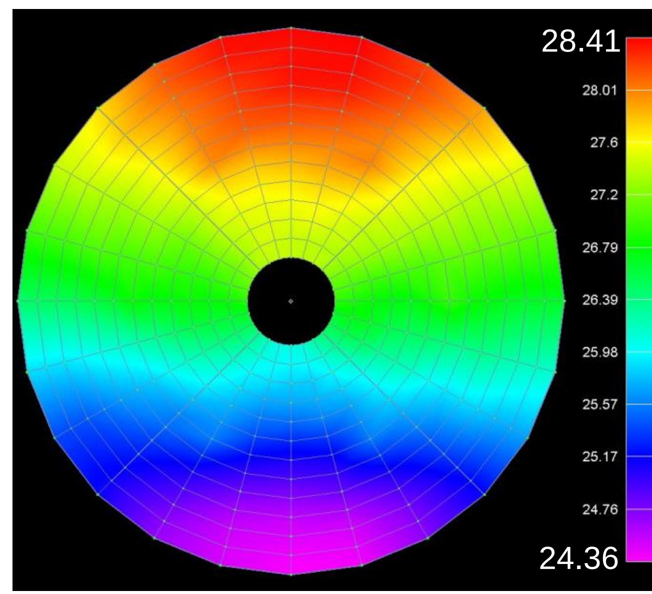


90



120



* Temperatures are in C. Note varied temperature scale for each load case.

Thermal Analysis

Active Thermal Management via 14 Heat Pipes yields a Primary Mirror with less than 1K Thermal Variation.

No Thermal Management yields a Cold PM

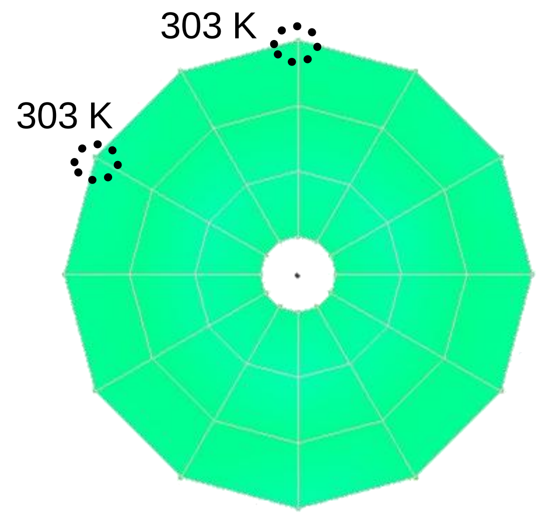
Sun Angle	Temp
0 deg	200K
90 deg	160K
120 deg	300K

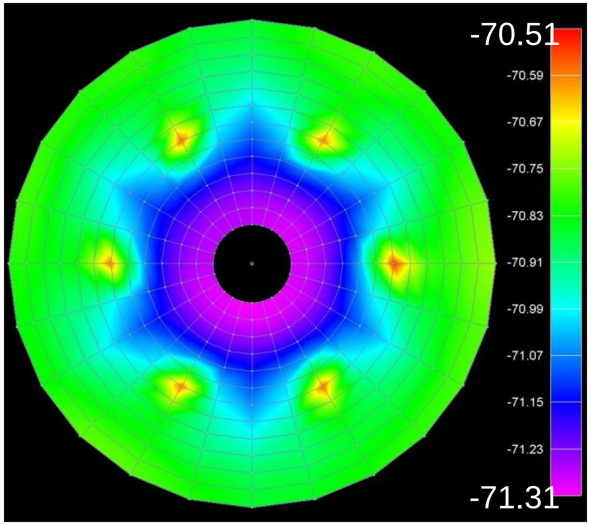
with 1K Thermal Variation

Thus, possible End of Life use as a NIR/Mid-IR Observatory.

Figure Change will be drive by CTE Change from 300K to 150K

- Zerodur CTE is approximately 0.2 ppm.
- ULE or SiO2 CTE is approx 0.6 ppm.





Mission Life

Initial Mission designed for a 5 yr mission life (10 yr goal) should produce compelling science results well worth the modest mission cost.

But, there is no reason why the mission should end after 5 or even 10 years.

Hubble has demonstrated the value of on-orbit servicing

The telescope itself could last 30 or even 50 years.

30 to 50 year Mission Life

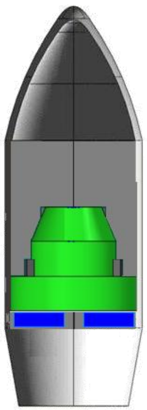
Copy Ground Observatory Model – L2 Virtual Mountain

Design the observatory to be serviceable

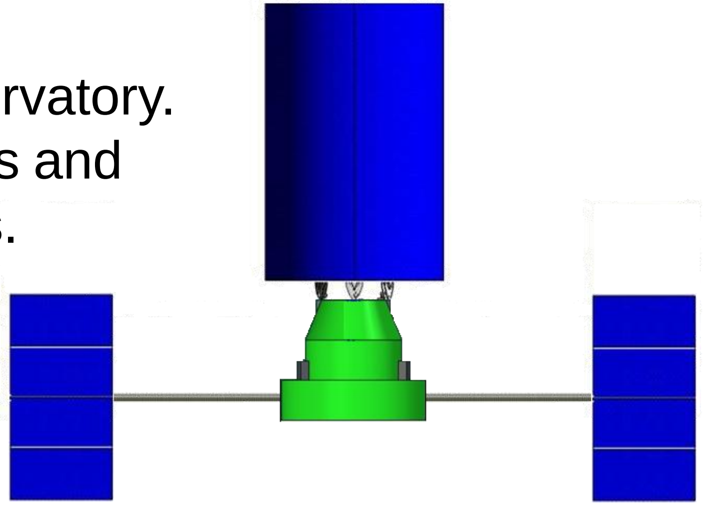
- Telescope has no inherent life limits
- Replace Science Instruments every 3-5 yrs (or even 10 yrs)

Replacement Spacecraft in ELV

Observatory has split bus with on-board attitude control and propulsion during servicing. (already in mass budget)



Autonomously Docks to Observatory. Replaces Science Instruments and ALL Serviceable Components.



Conclusion

Ares V Mass & Volume capabilities enable entirely new Mission Architectures:

- 6 to 8 meter class Monolithic UV/Visible Observatory
- 5 meter cube (130,000 kg) Cosmic Ray Water Calorimeter
- 4 meter class X-Ray Observatory (XMM/Newton or Segmented)
- 15 to 18 meter class Far-IR/Sub-MM Observatory (JWST scale-up)
- 150 meter class Radio/Microwave/Terahertz Antenna
- Constellations of Formation Flying Spacecraft

Conceptual Design Study indicates that a 6 meter class monolithic UV/Visible Observatory is achievable, compelling and could be ready for an early Ares V launch before 2018.

Primary technical challenge is autonomous rendezvous & docking for servicing