Ares V an Enabling Capability for Future Space Astrophysics Missions

H. Philip Stahl, Ph.D.

The potential capability offered by an Ares V launch vehicle completely changes the paradigm for future space astrophysics missions. This presentation examines some details of this capability and its impact on potential missions. A specific case study is presented: implementing a 6 to 8 meter class monolithic UV/Visible telescope at an L2 orbit. Additionally discussed is how to extend the mission life of such a telescope to 30 years or longer.

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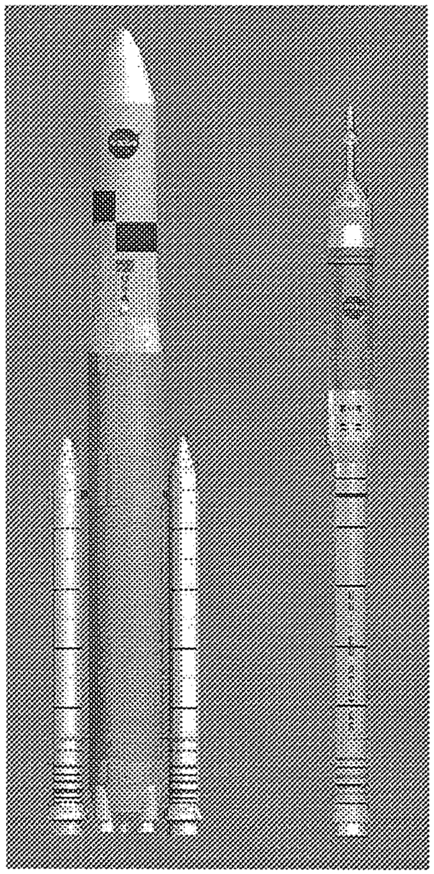
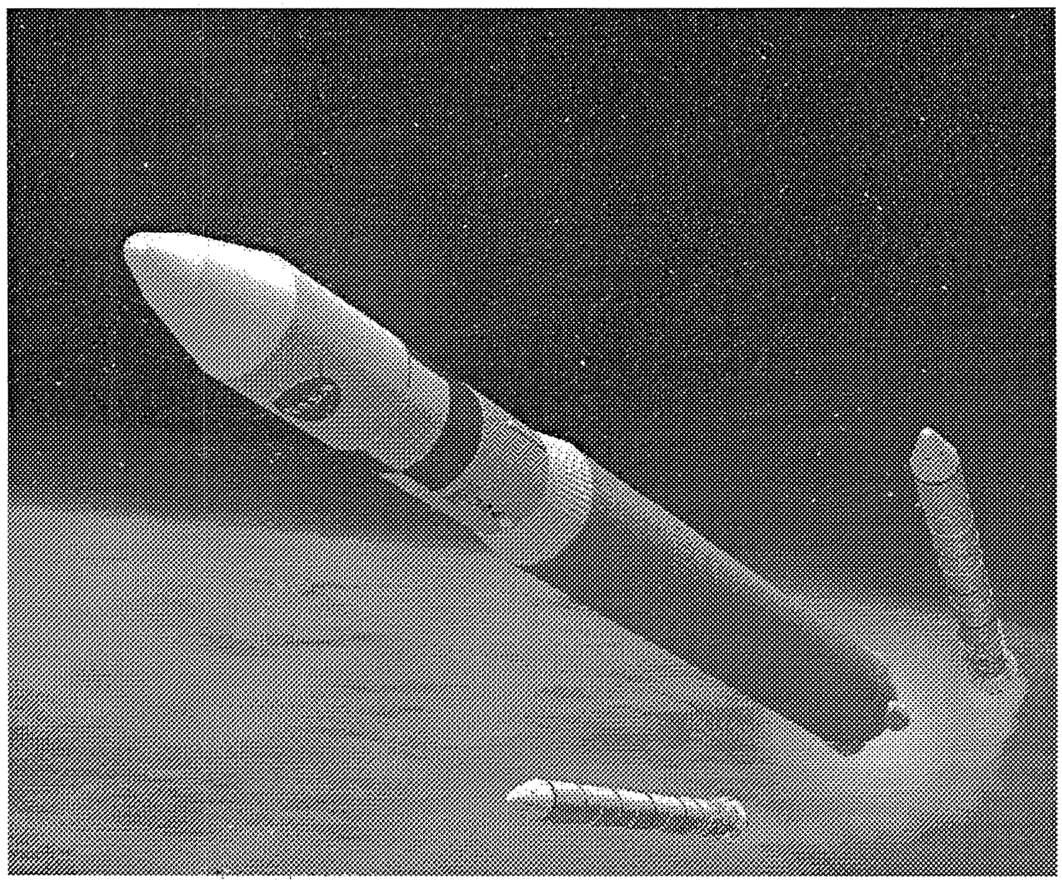




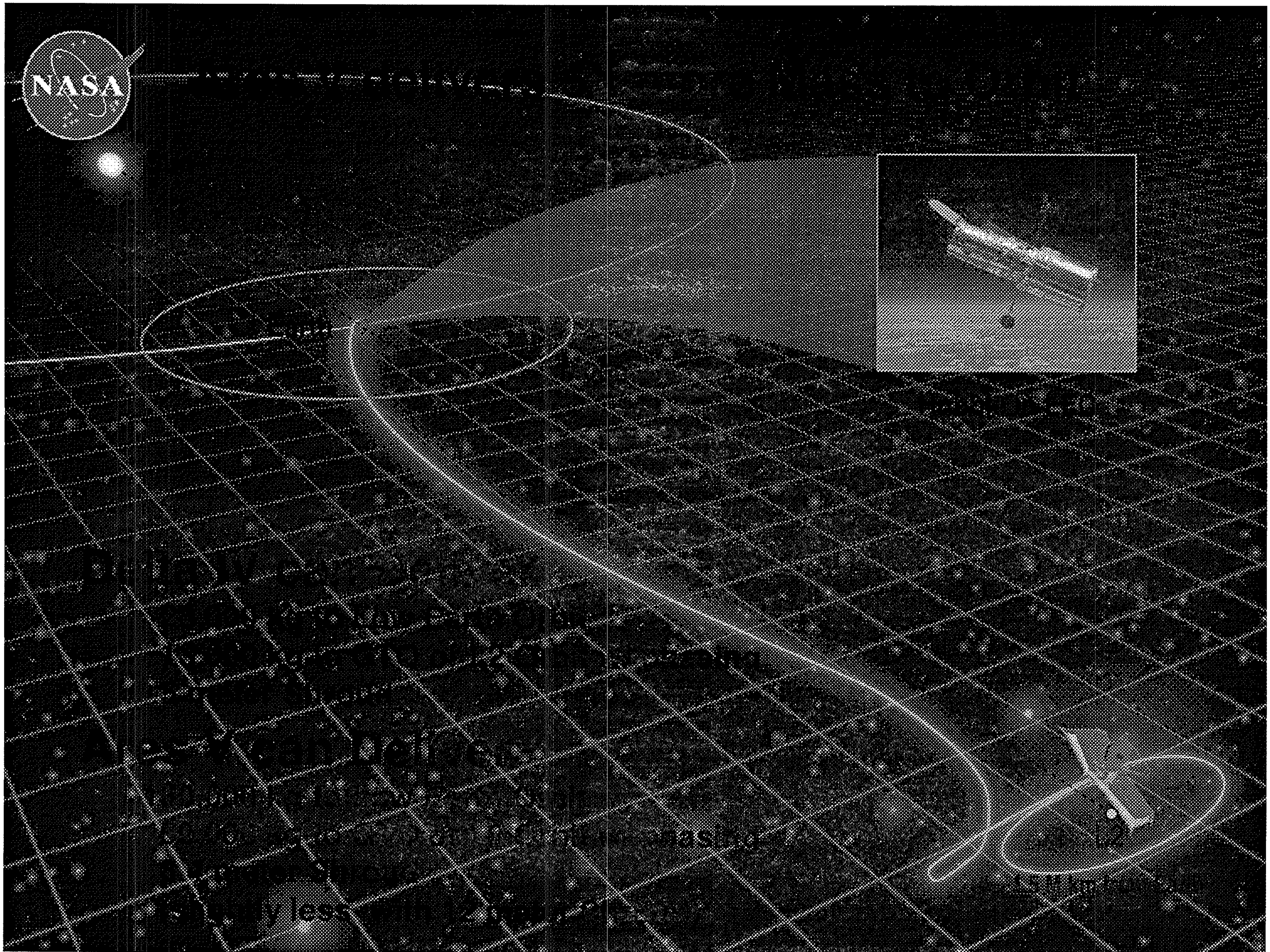
Executive Summary

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

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

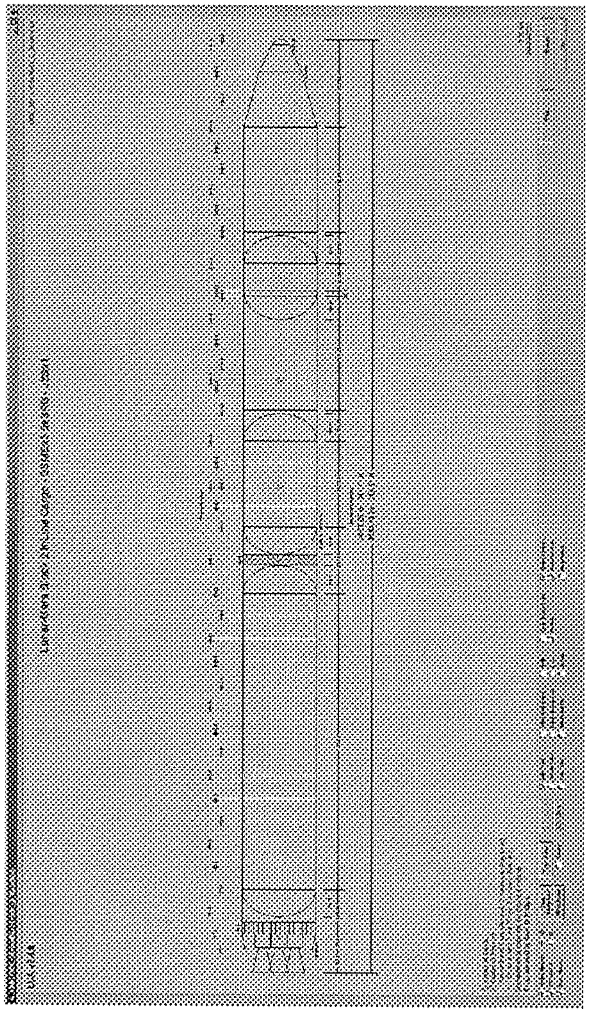
And, drive Mission Implementation Cost & Risk

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

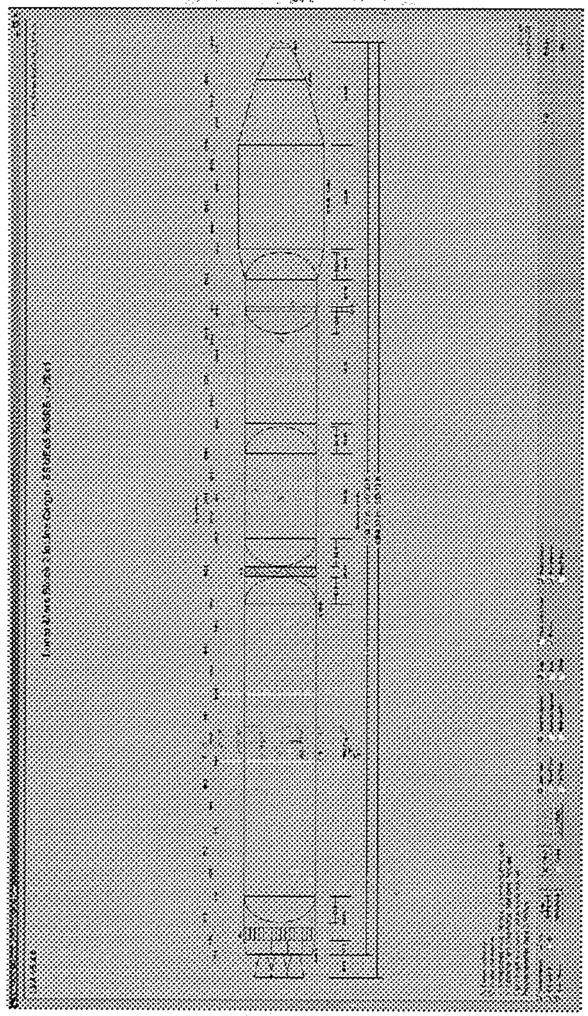


Ares V - Preliminary Shroud Concepts

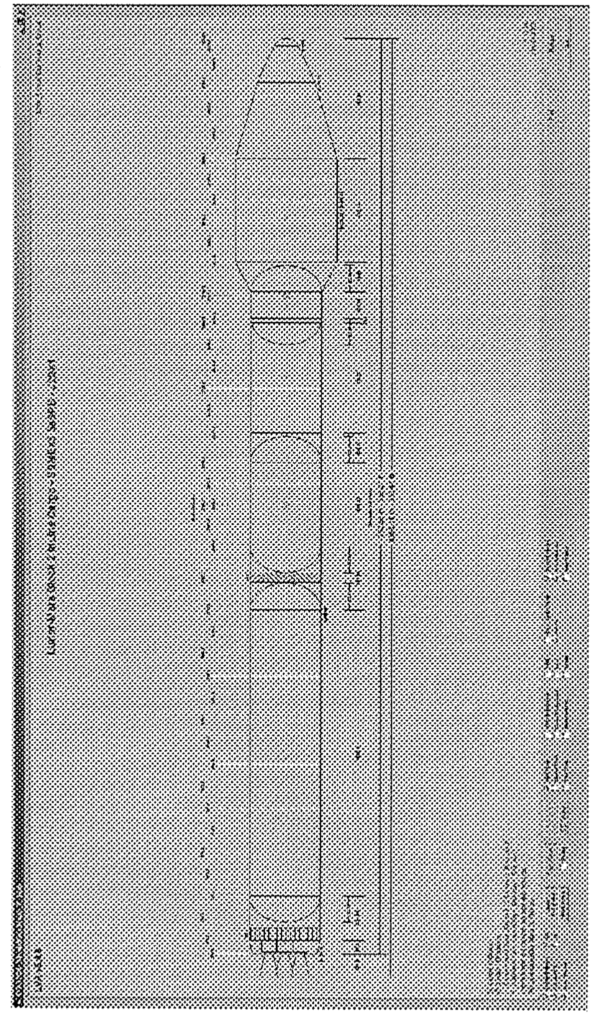
Baseline CaLV 8.4 m Shroud



CaLV w/ 10m Shroud

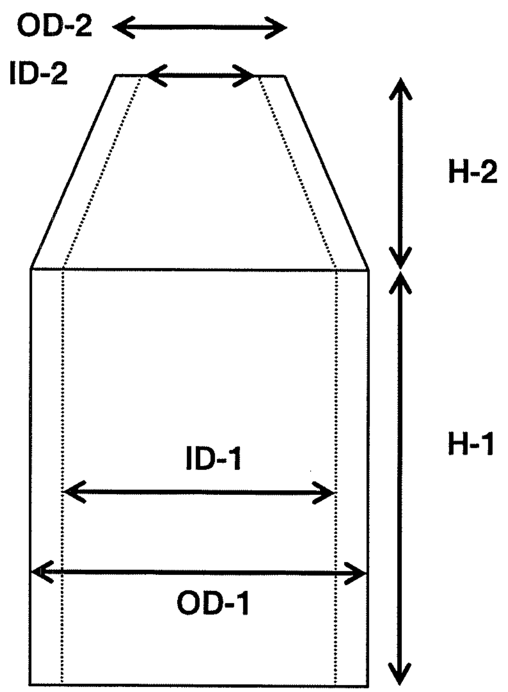


CaLV w/ 12m Shroud



Ares V Preliminary Shroud Dimensions

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	8.77	10.3	m
H-1	12	12	12	m
OD-2	4.8	5.75	6.9	m
ID-2	3.9	4.52	5.2	m
H-2	6.3	7.5	9	m
Total Height	18.3	19.5	21	m
Payload to SEL2	62	61	60	mT

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 enables entirely new Mission Architectures:

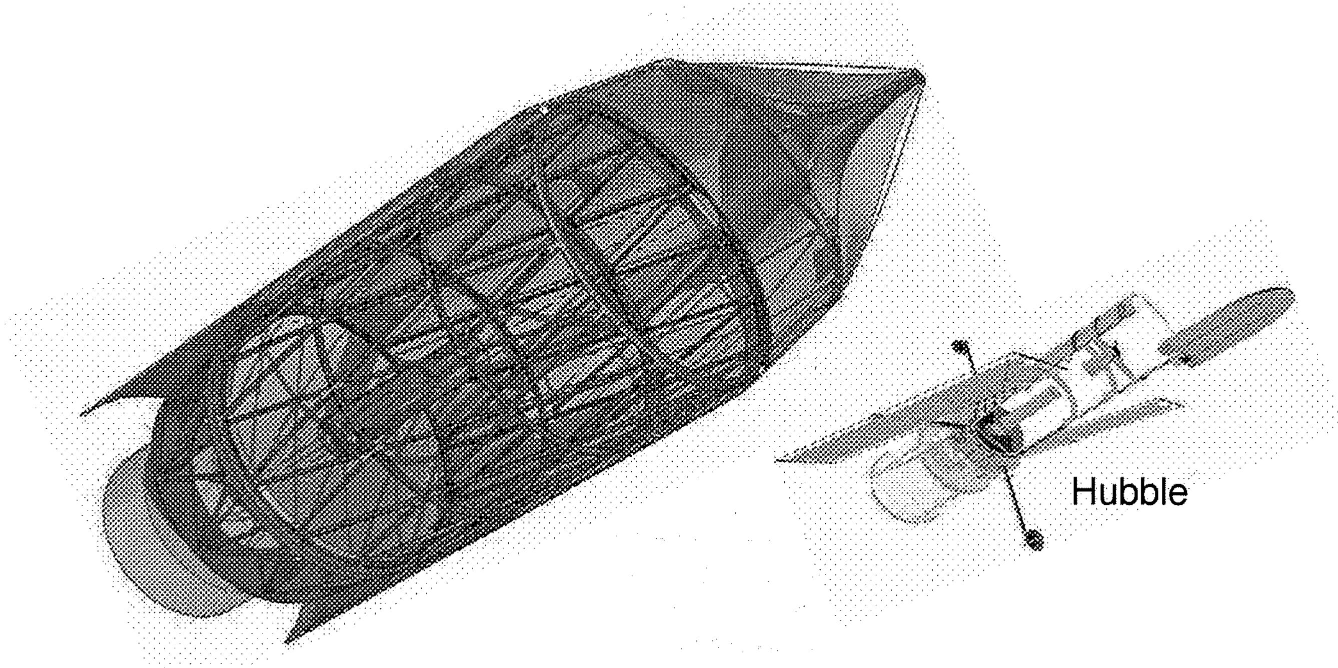
- 6 to 8 meter class Monolithic UV/Visible Observatory
- 5 meter cube (130,000 kg) Cosmic Ray Water Calorimeter
- 4 meter class X-Ray Observatory (XMM/Newton or Segmented)
- 15 to 18 meter class Far-IR/Sub-MM Observatory (JWST scale-up)
- 150 meter class Radio/Microwave/Terahertz Antenna
- Constellations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

All of these can be built with <u>Existing</u> Technology

Allows NASA to concentrate Technology Development Investments

on Reducing Cost/Risk and Enhancing Science Return

Case Study:
6 to 8 meter Class Monolithic Space Telescope



Enables Compelling High Priority Science:

UV/Visible Science
Terrestrial Planet Finding Science

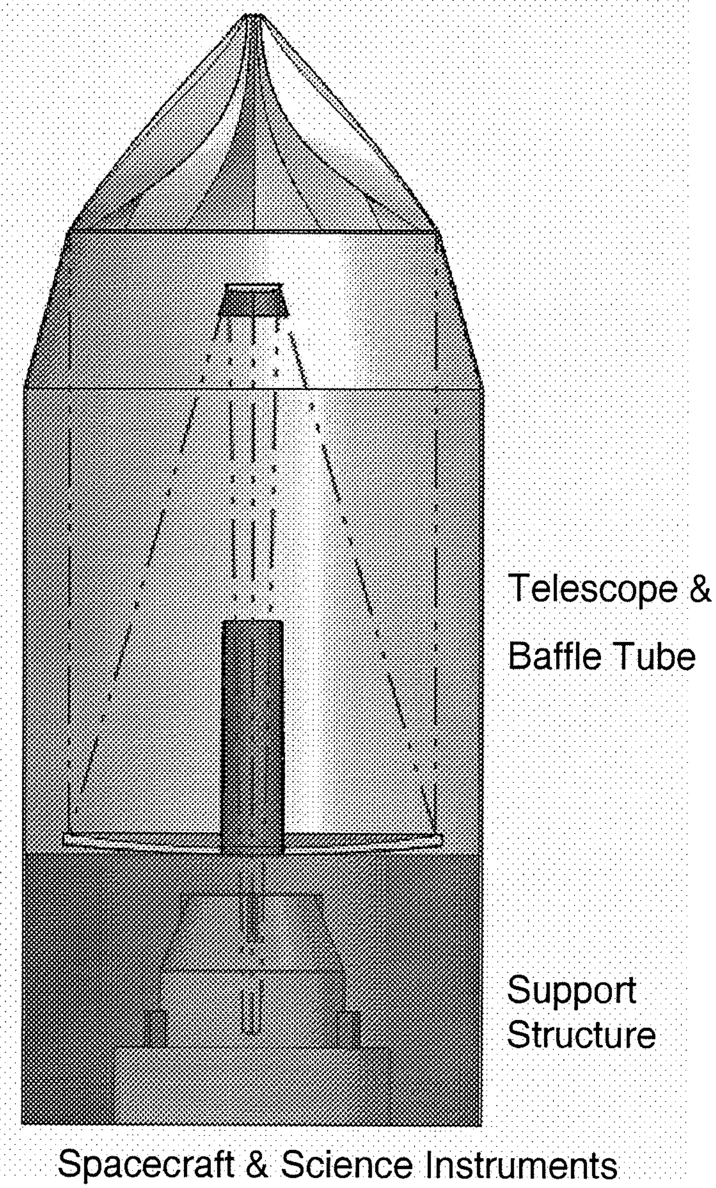
Design Concept

6 to 8 meter Monolithic Telescope with full baffle tube can fit inside the dynamic envelop of Ares V (8.4 to 12 meter shrouds).

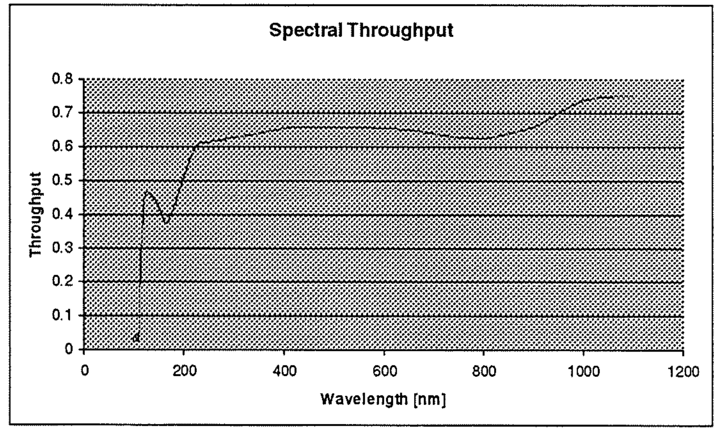
Minimize Cost (& Risk) by using existing ground telescope mirror technology.

8-meter diameter is State of Art

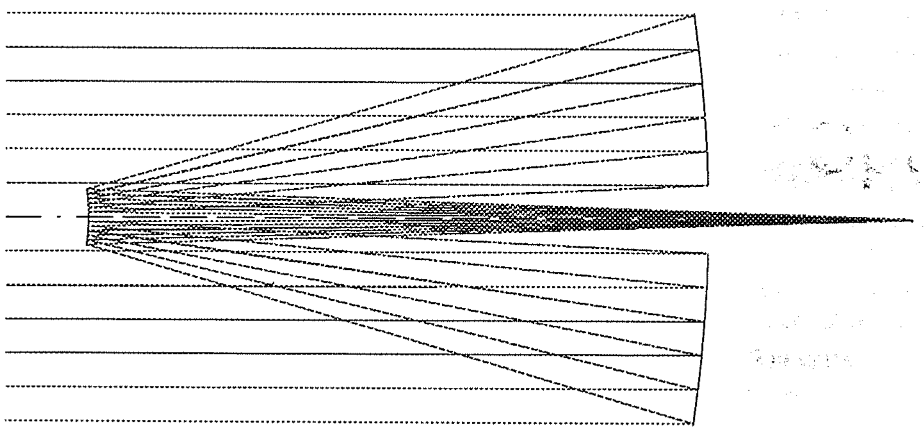
- 7 existing: VLT, Gemini, Subaru
- 23,000 kg (6 m would be ~13,000 kg)
- ~$20M (JWST PM cost ~$100M)
- 7.8 nm rms surface figure (~TPF spec)

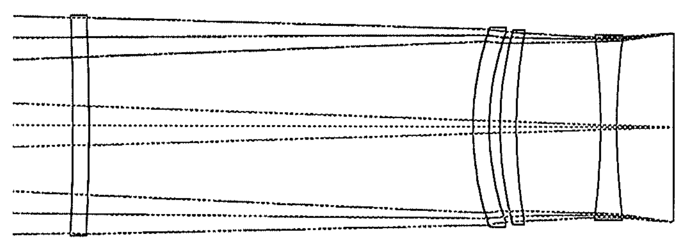


6 meter Optical Design



- 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





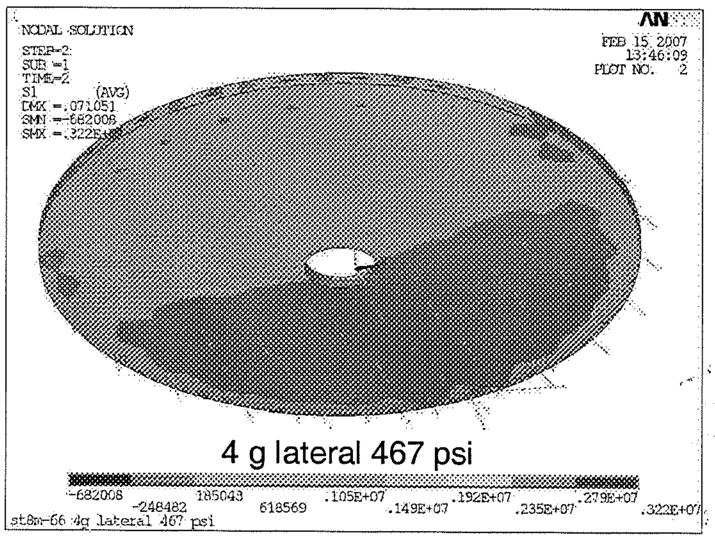
10 arc min Refractive Corrector Group

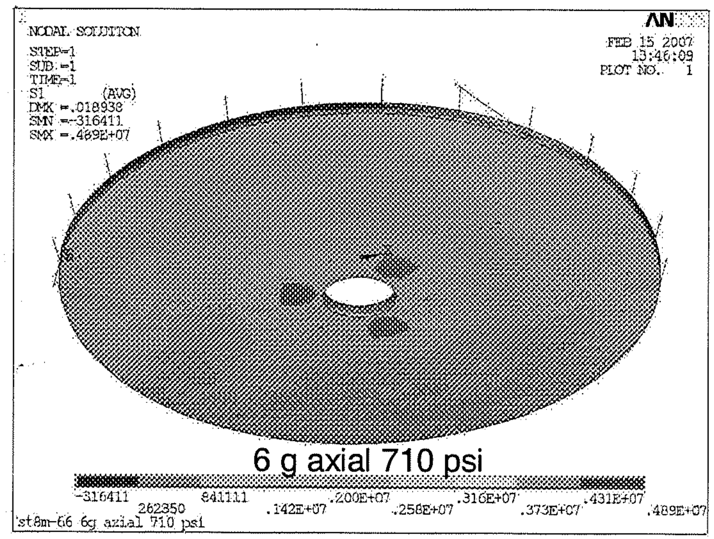
Need to design Reflective Corrector

Structural Analysis

6 to 8 meter class 175 mm thick meniscus primary mirror can survive launch.

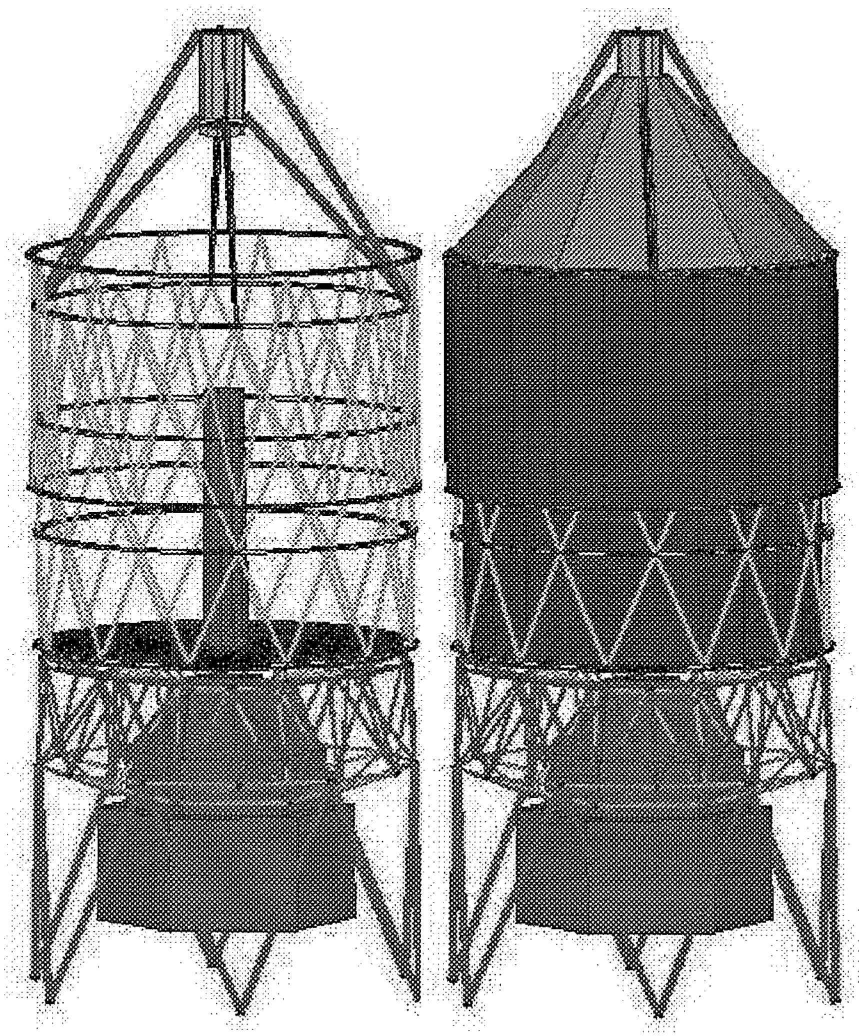
66 axial supports keep stress levels below 1000 psi for 4 g lateral and 6 g axial equivalent acceleration levels (8.2 m analysis)



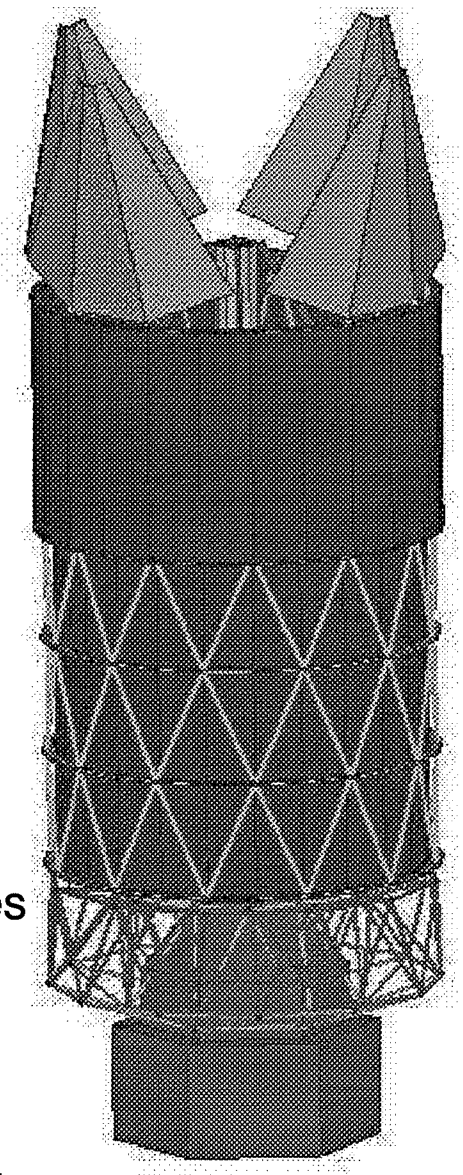


Structural Design

Launch Configuration



Operational



Baffle Tube is split and slides forward on-orbit.

- Faster PM may allow for 1 piece tube.

Doors can open/close

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

Truss Structure interfaces with 66 mirror support attachment locations

Launch Structure attaches Truss to Ares V

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)

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

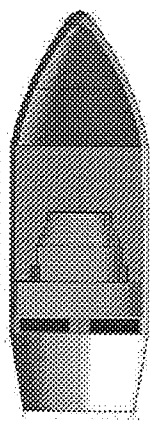
The telescope can easily last 30 or even 50 years.

30 to 50 year Mission Life

Design the observatory to be serviceable

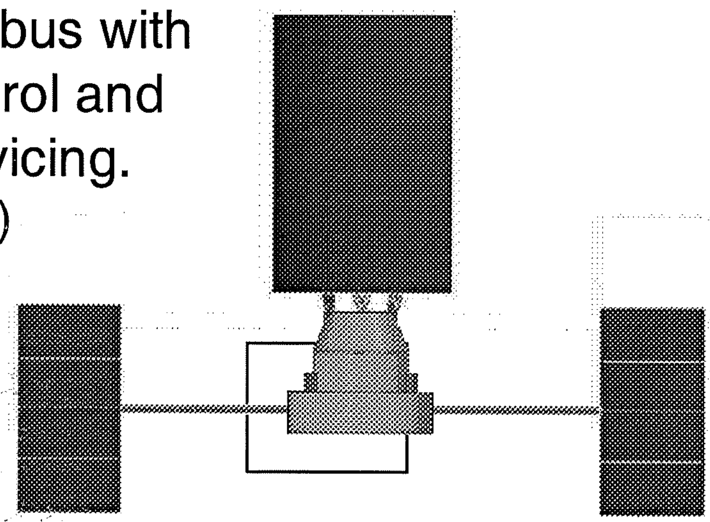
Replace Science Instruments every 3-5 yrs (or even 10 yrs)

Replacement Spacecraft in ELV



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

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



Copy Ground Observatory Model – L2 Virtual Mountain

Thermal Analysis

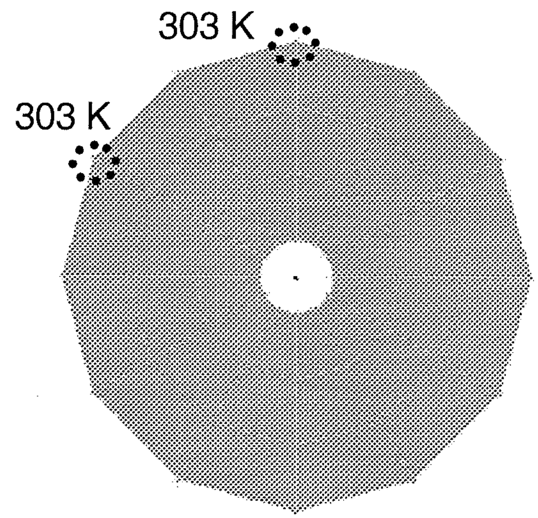
Active Thermal Management via Heat Pipes yields a Primary Mirror with less than 1K Thermal Variation.

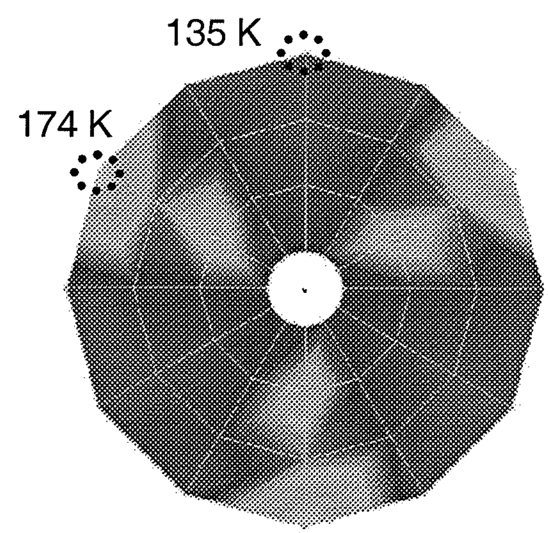
No Thermal Management yields a Cold PM (155K) with a 39K Thermal Variation.

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.





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
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Conceptual Design Study indicates that a 6 meter class monolithic UV/Visible Observatory is achievable and compelling.

Primary technical challenge is autonomous rendezvous & docking for servicing