San Diego Composites LLC
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Low Cost, Precision Carbon-carbon Mirrors And Telescope Structures For Exo-atmospheric Interceptor Seekers

Prepared for: Technology Days in the Government

"Mirror Development and Related Technologies"

Sept 16-18, 2003

Prepared by: San Diego Composites LLC, 1940 Garnet Ave., Ste. 207, San Diego, CA 02109, 858 270-1280, gwonacott@sdcomposites.com

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Phase I – Requirements Driven Materials Selection (Beryllium Baseline)

OPTICAL PERFORMANCE IS FIRST PRIORITY

Candidate Materials	Requirements				
	Isotropic/Thru Thickness CTE Magnitude	Structural Dynamics and Weight	Humidity	Radiation Hardening	Cost and Lead Time
Beryllium	Yes/moderate	X (3)*	X	X	
Resin Matrix Composites	No/large	X (1)			
Silicon Carbide	Yes/small	X (5)	X		
Graphite Reinforced Magnesium	No/moderate	X (3)	X		
Disonctinuous Silicon Carbide Aluminum	Yes/moderate	X (6)			
Carbon-Carbon	**No/small**	**X (2)**	**X**	**X**	**X**

(#) – Relative ranking; weight is most sensitive to facesheet and core density and minimum gage for frequency critical design and structural construction approach (i.e., sandwich versus open-back)

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Carbon-carbon is a Proven Performer

- Proposed approach: carbon-carbon substrate and metering structure; SiO_x Coating using vacuum deposition process, and polishing
- Very small thermal expansion coefficients; athermalization achievable; moisture insensitive
- High specific properties; compatible with structurally efficient sandwich construction
  - carbon foam and or honeycomb core
- Meets cost and lead time criteria
- Low atomic number and low CTE make it attractive for nuclear threat environment; well characterized; compatible with thick glass coating and conventional polishing approaches

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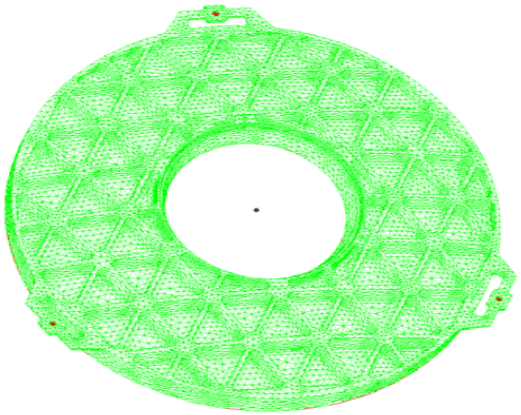
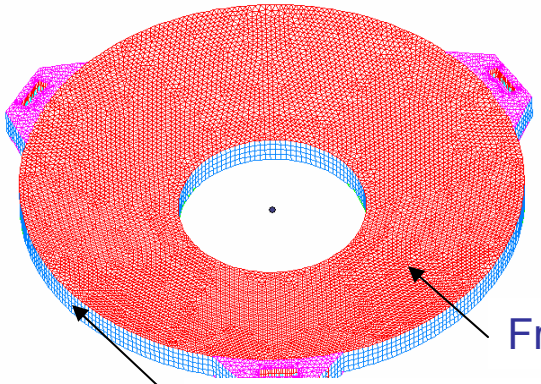
Be and C-C Primary Mirror Configurations

Beryllium | **Carbon-carbon**

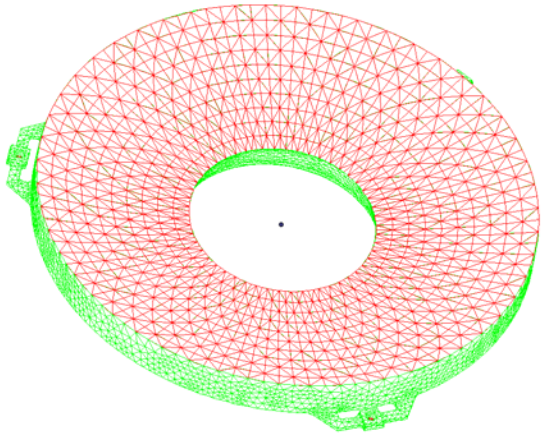
1.457 Lb ← **Weight** → **0.707 Lb (including flexures)**
0.659 Lb (without flexures)

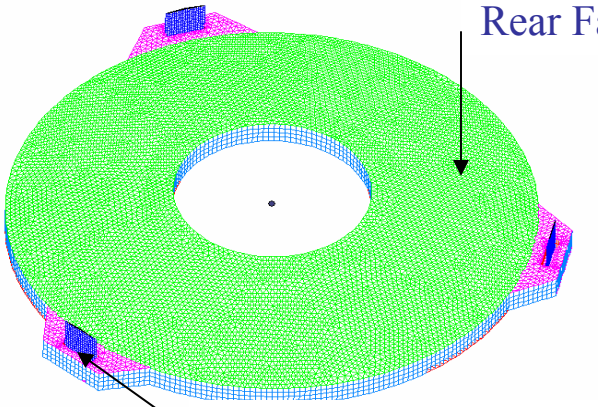
Iso-grid
Back Side





Front Side





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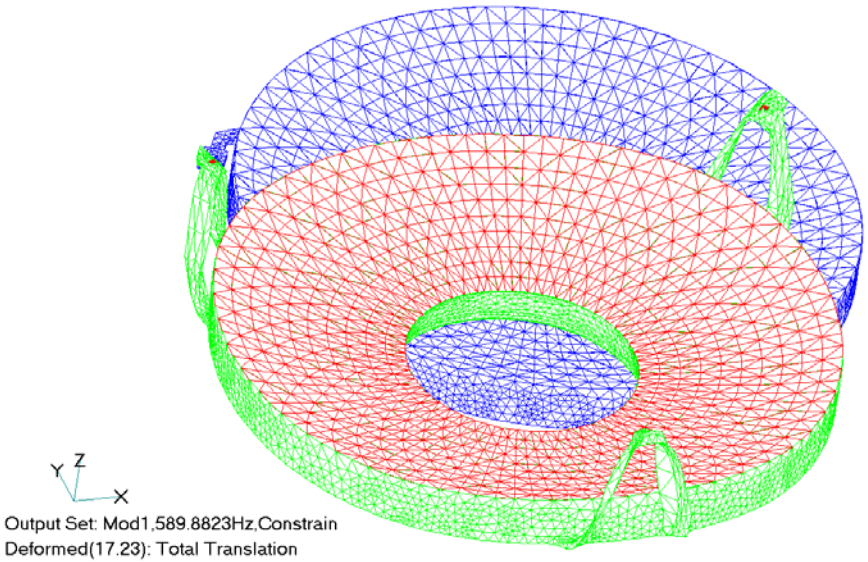
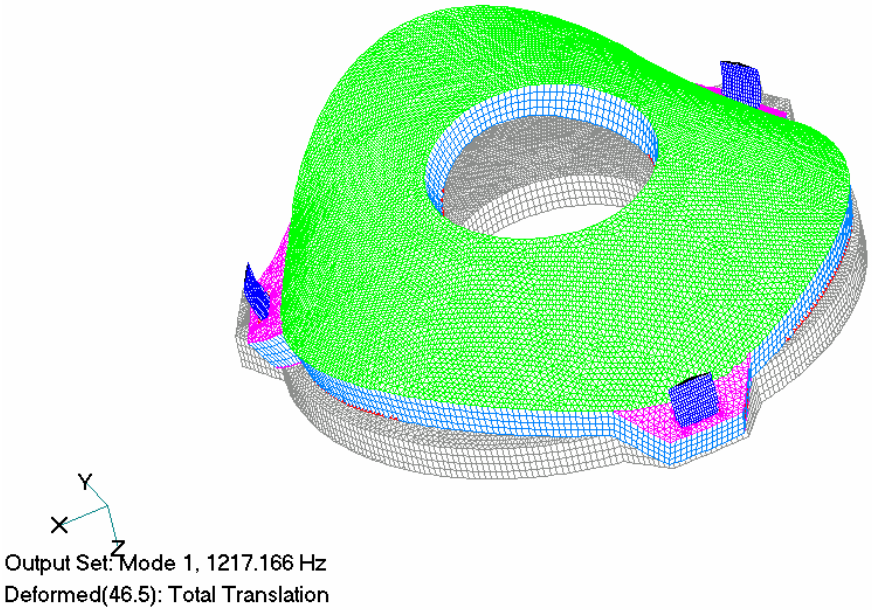
Modal Analysis Results

- Fixed at 3 Points - First Mode Shape





Beryllium
First mode at 590 Hz

Composite
First mode at 1217 Hz

Flexure orientation and lighter weight composite sandwich construction (i.e., 1.46 lbs for Be versus 0.71 lbs for composite [49%]) yield higher frequency

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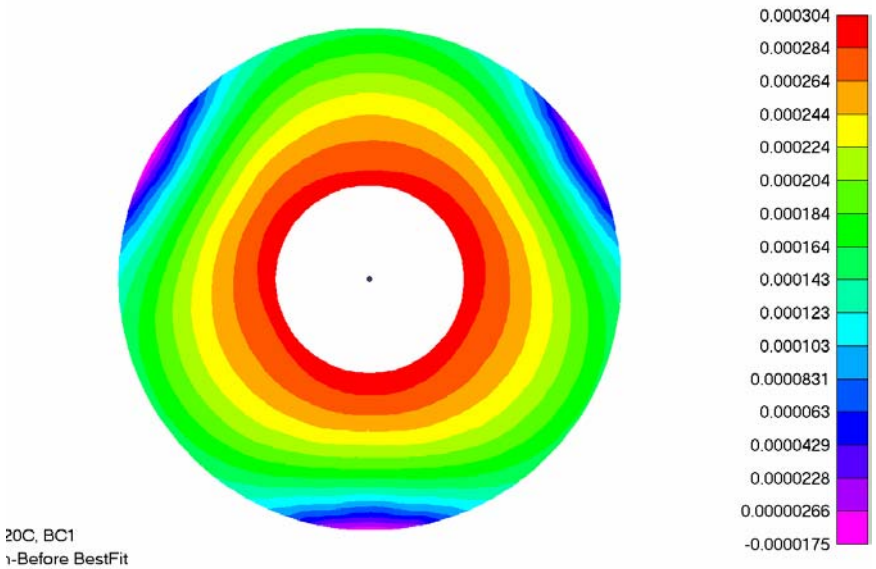
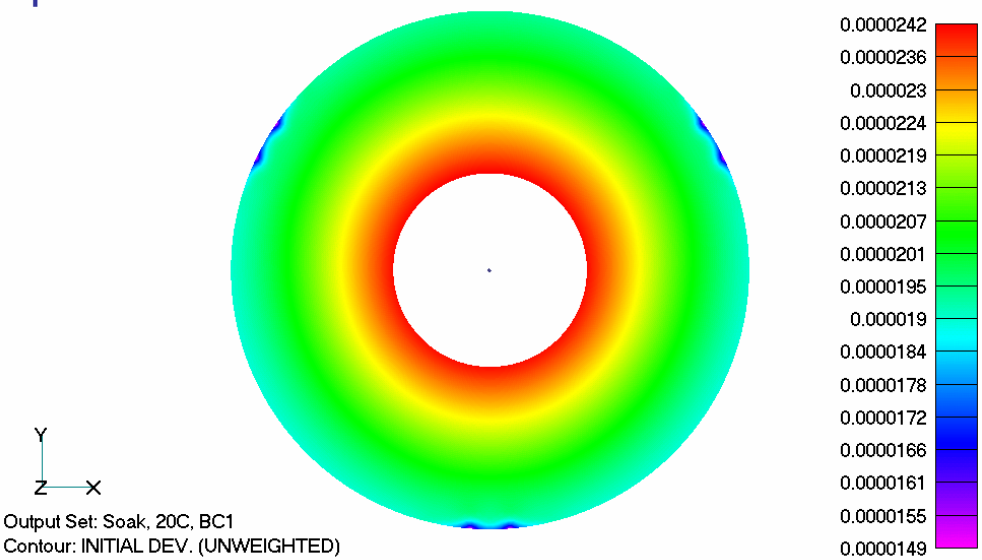
One-half Optical Path Differences - Surface Deformation Contours (Inches), Before Best Fit

All six Degrees of Freedom
Fixed at Flexures; 20 ^{0}C temperature excursion





Beryllium
5.735 µm RMS

Carbon-carbon
0.534 µm RMS

Carbon-carbon is a Low Coefficient of Thermal Expansion Material

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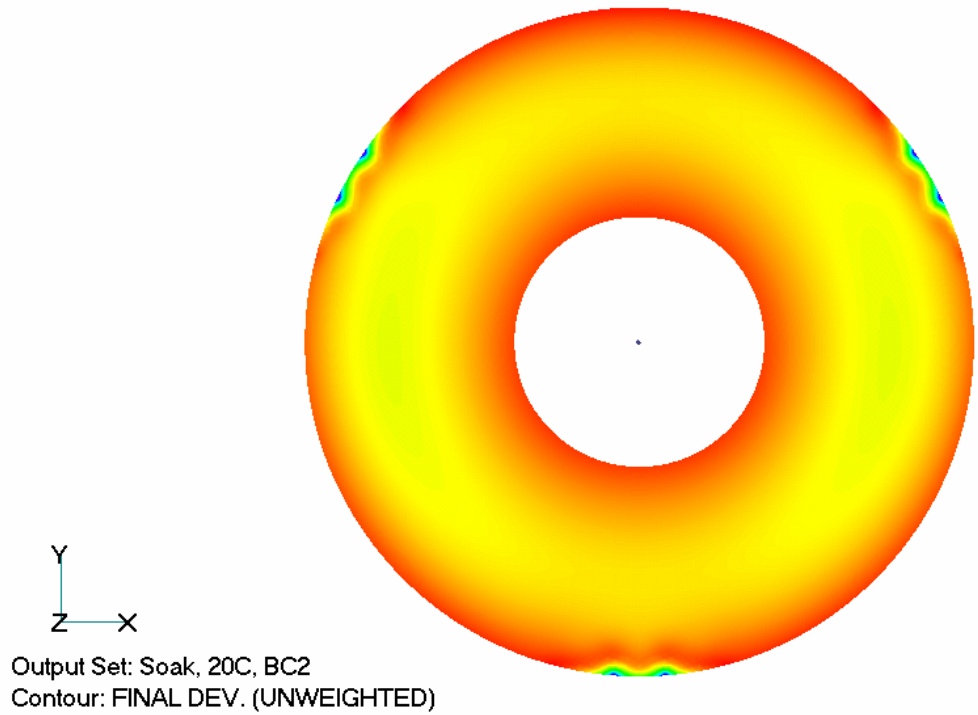
One-half Optical Path Differences - Surface Deformation Contours (Inches)

After Best Fit (Rigid Body + Focal Length)



- 20 ^{0}C temperature excursion
- Radial degree of freedom free at flexures

Carbon-carbon is almost order magnitude better than the Raytheon supplied RMS requirement

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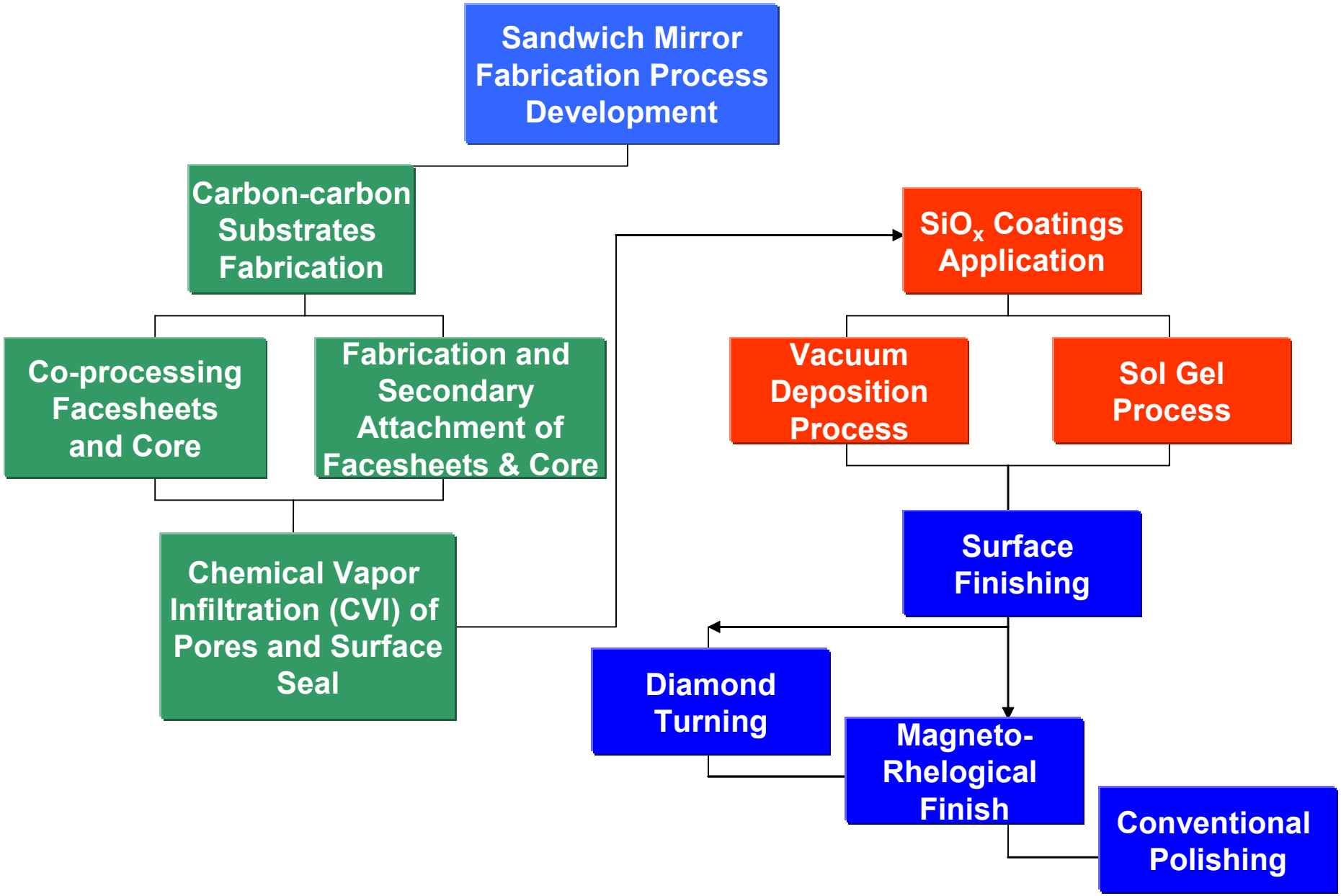
Phase II Planning



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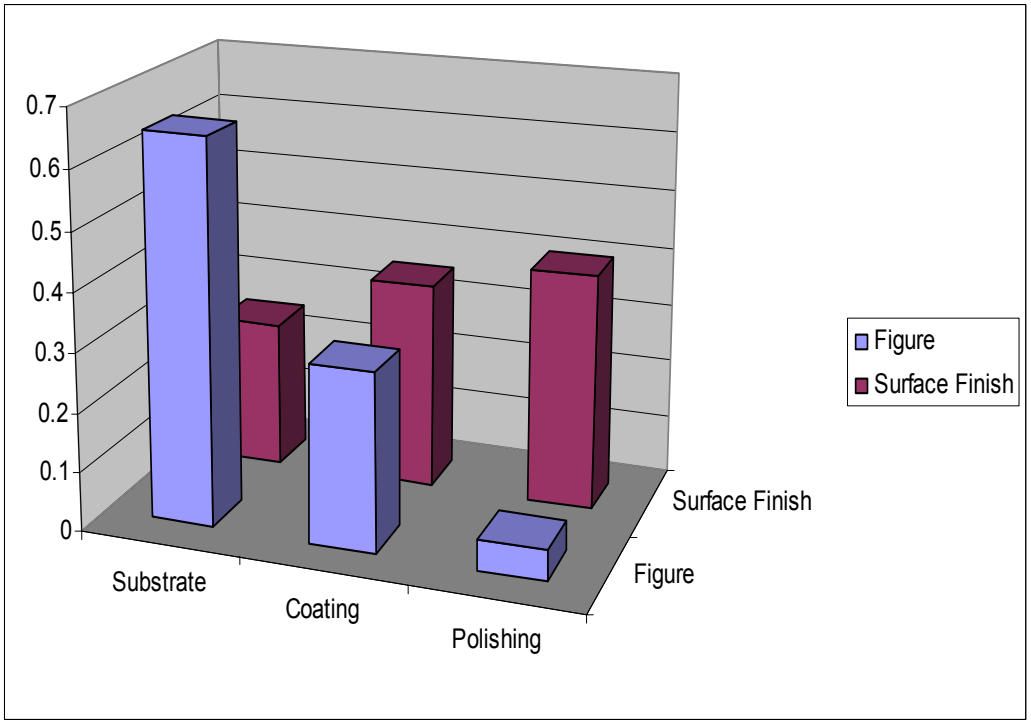
Phase II Challenge



Example of Vacuum Deposition Process of SiOx

The lowest cost process has the right balance of tolerances and associated costs for fabrication of the substrate, applying the coating and polishing

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Summary

- Material selected for mirrors and supporting structure based on requirements
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- Preliminary design developed for primary mirror that meets requirements
- Opto-structural analyses demonstrate feasibility of carbon-carbon mirror
- Technical approach developed for achieving system athermalization
- Technical approach identified to achieve figure and surface finish (i.e., SiO_x coating + MRF)