



ARNOLD LIGHTWEIGHT MIRROR MODELER

VERSION 2.0

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HERITAGE




- **SECOND GENERATION OF EGGCRATE MODELER DEVELOPED AT L3-COMM BRASHEAR, PITTSBURGH, PA. USED TO DESIGN PRIMARY MIRROR, SUPPORT SYSTEM AND MIRROR HANDLING EQUIPMENT FOR THE KEPLER PLANET FINDER.**
- **COMPLETE REWRITE FOR USE ON WINDOWS 7 AND ABOVE OPERATING SYSTEMS.**
- **EXPANDED TO MULTI-SEGMENT MIRROR AS WELL AS SINGLE MIRROR SYSTEMS.**





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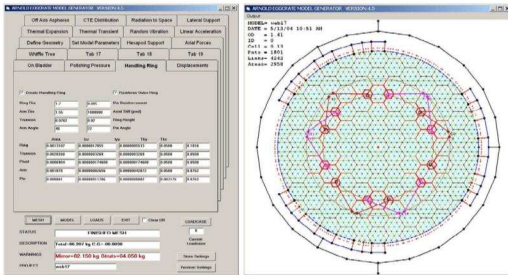


INTEGRATED PRODUCT DESIGN




Integrated Design of Handling Equipment




Design tool allows evaluation and design of handling fixtures during the preliminary design of the mirror blank. As mirrors become lighter, the difficulties of handling the glass during manufacturing requires careful attention to these operations. Special reinforced features were added to the blank specifically to aid the manufacturing process and reduce risk.








NASA Tech Days 2004

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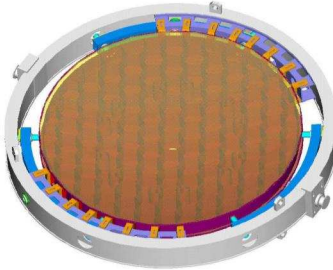


CONVERT ANALYSIS TO DESIGN




Primary Mirror in Flipping Ring

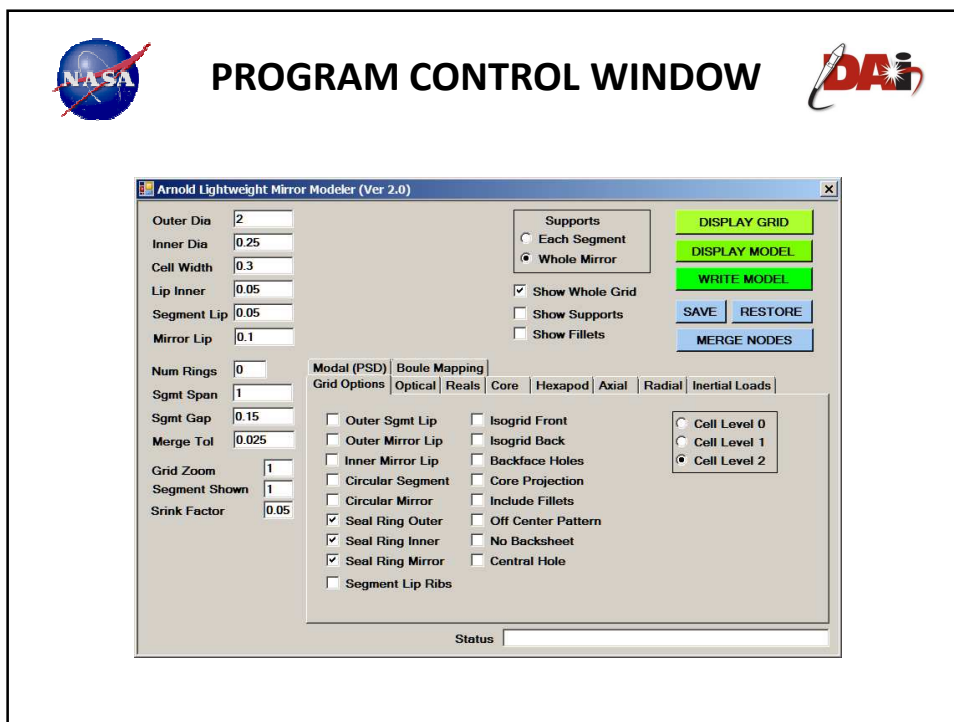


The handling ring interfaces with special reinforced slots in the mirror core. With the addition of storage shields, the unit can act as a temporary container. Does not touch optical surfaces or fragile edges.



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BOTH 2D AND 3D DISPLAYS



The screenshot displays two windows side-by-side. The left window, titled 'Grid', shows a 2D hexagonal grid of cyan triangles with red outlines. A control panel to its right includes buttons for 'U', 'L', 'C', 'R', 'D', 'IN', 'OUT', 'Shrink', '+', '-', and 'Sgmt Num'. The right window, titled 'Model 3D Display', shows a 3D perspective view of the same hexagonal structure, rendered with grey and blue faces.

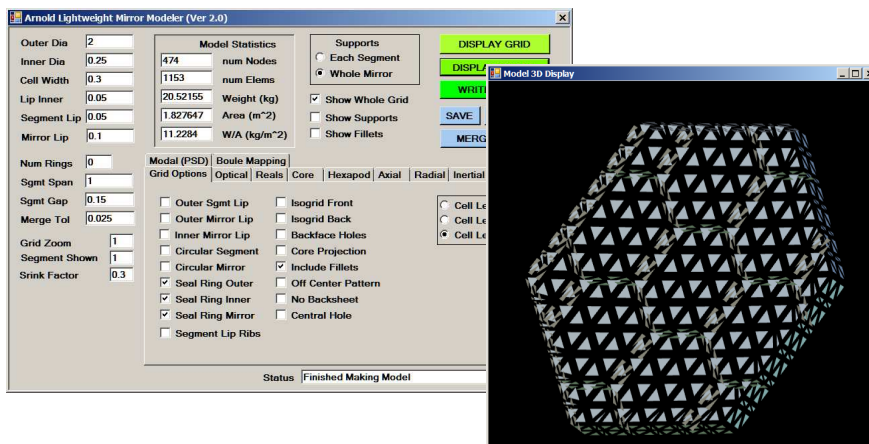


GUI ALLOWS PAN AND ZOOM

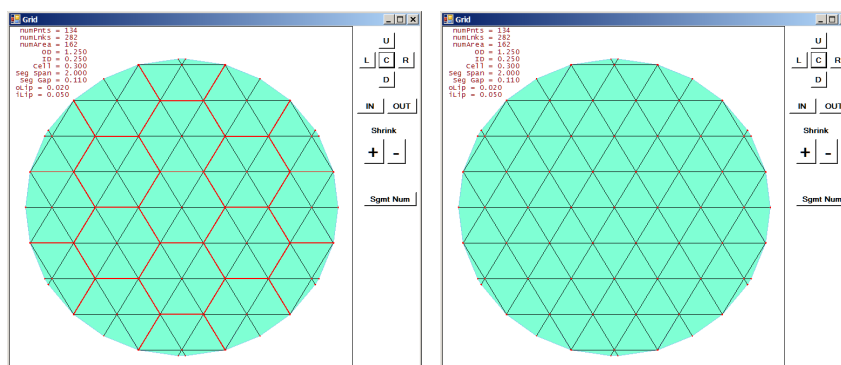


This screenshot is identical to the one above, but the 2D grid in the 'Grid' window is zoomed in, showing individual triangles and their edges more clearly. The 3D model in the 'Model 3D Display' window remains the same.

NASA ELEMENT SHRINK HELPS UNDERSTAND MESH

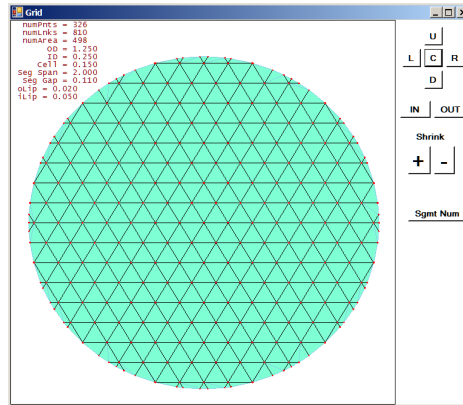


NASA ALSO ISOGRID AND SIMPLIFIED MESHES

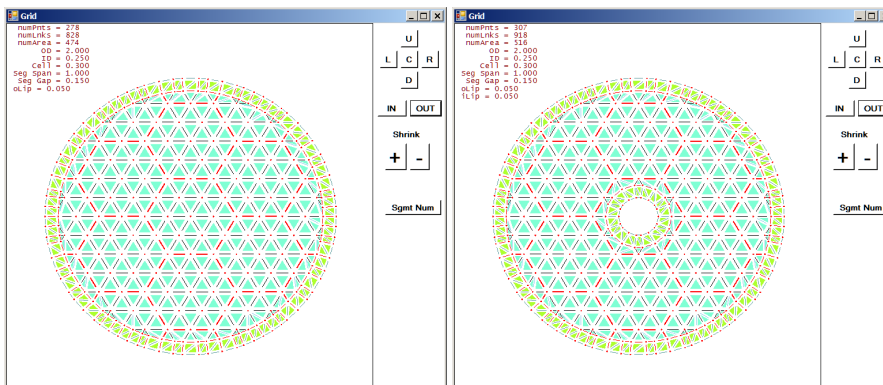




QUICKLY REMESH

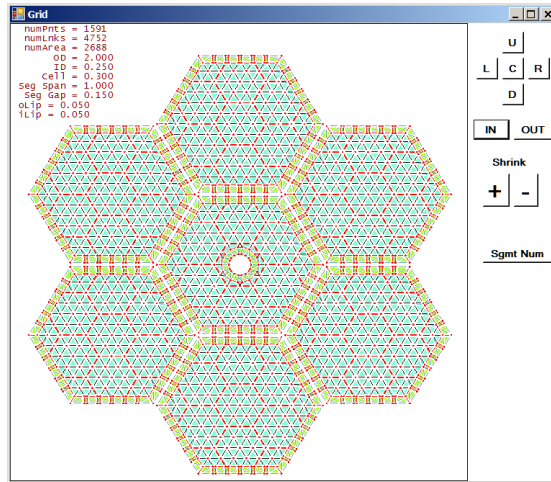


ADD CENTRAL HOLE EASILY

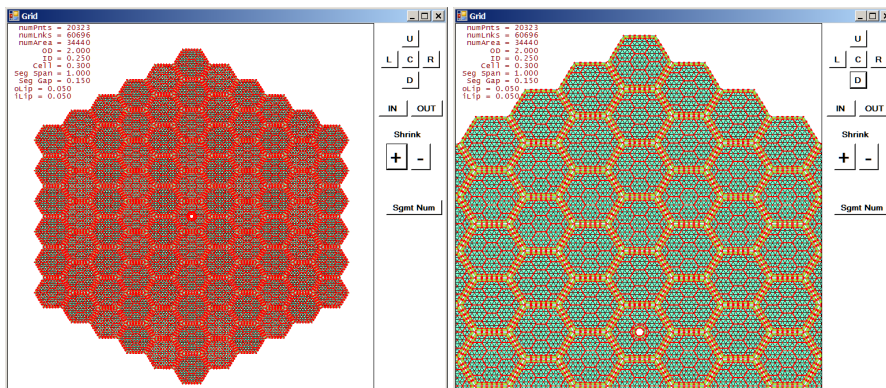




MODEL SEGMENTED MIRRORS

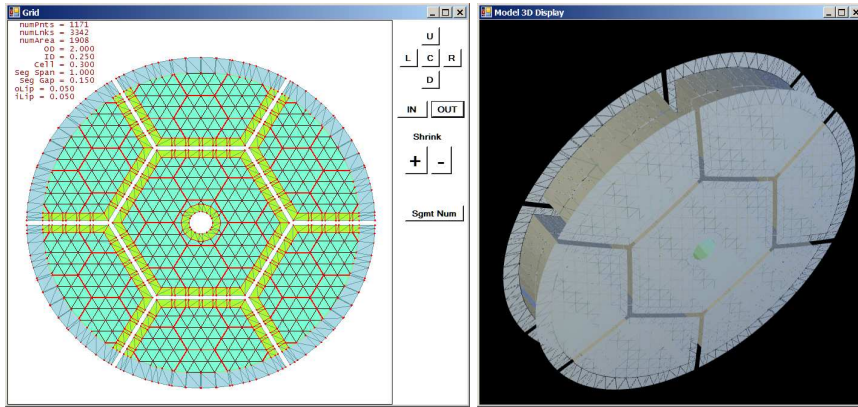


ALMOST UNLIMITED SIZE

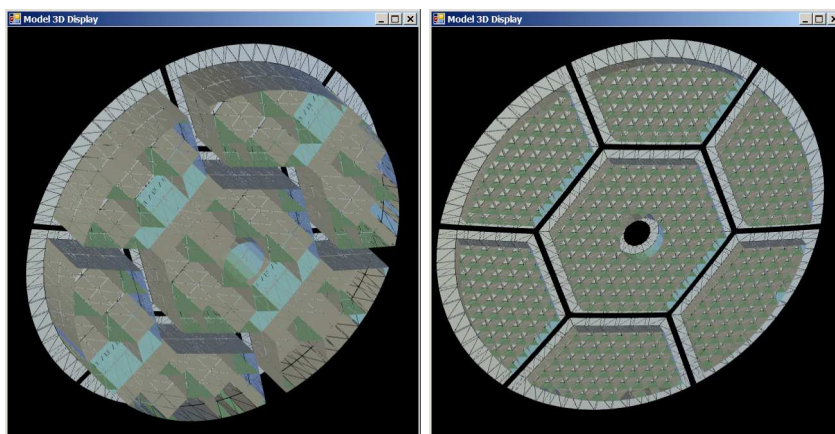




MODEL CIRCULAR SEGMENTED MIRRORS

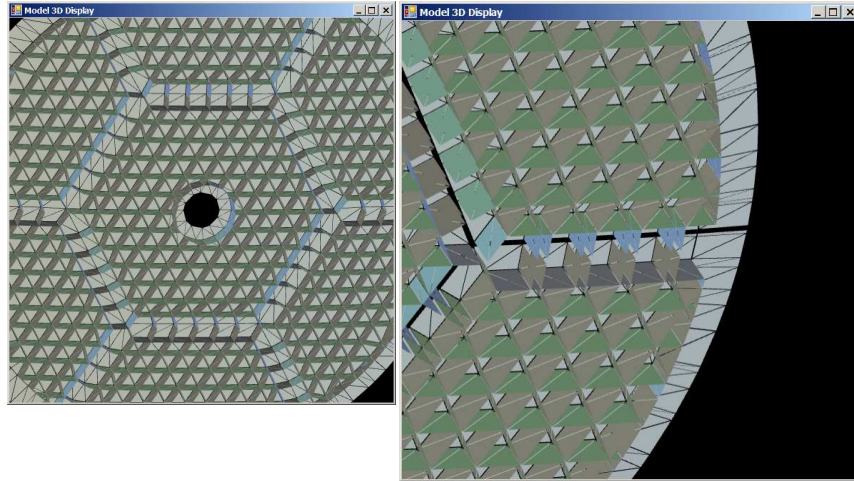


SUPPORTS ISOGRID FACESHEETS

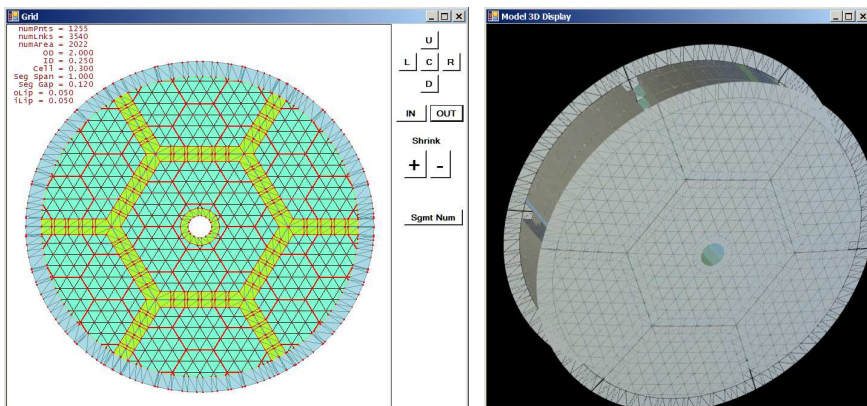




EDGES CAN HAVE RIBS

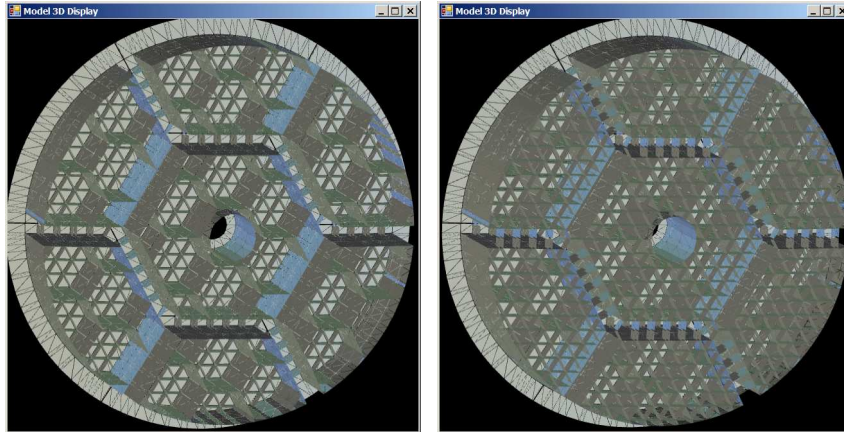


MODEL CAN BE MERGED IN ONE MIRROR

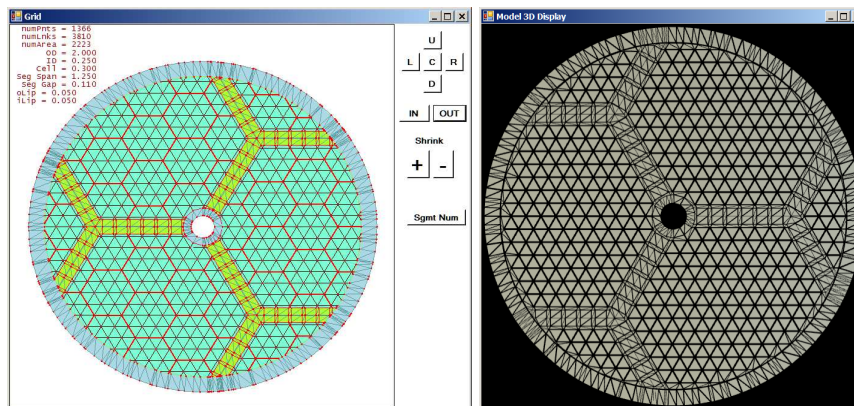


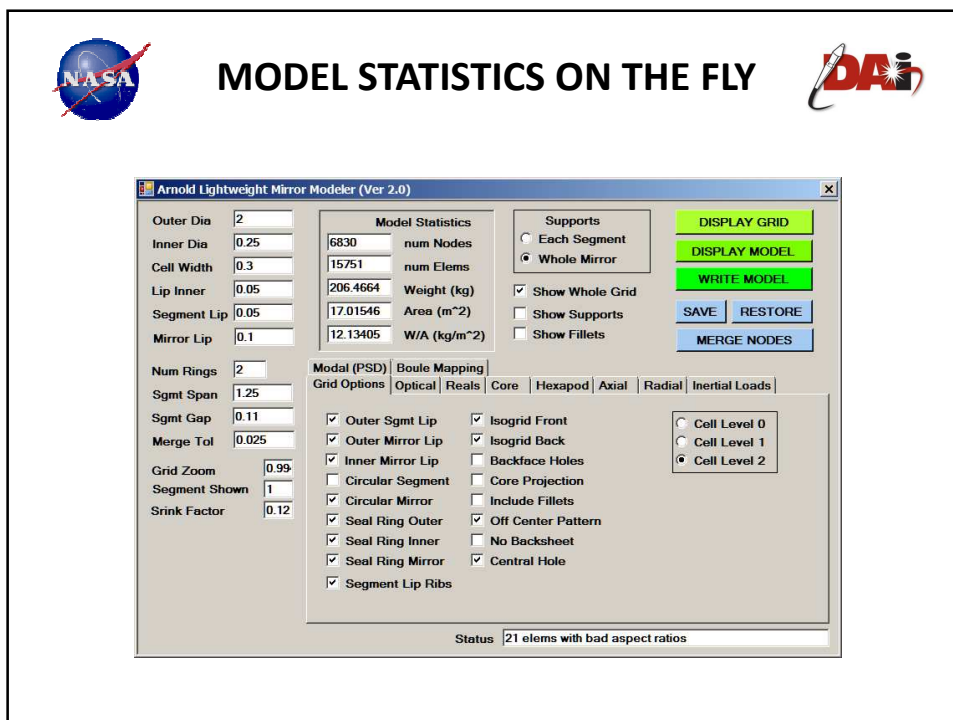


FRONT AND BACK ISOGRIDS SUPPORTED



OFFSET SUPER-CELLS SUPPORTED







ANY OPTIC SUBSCRIPTION SUPPORTED



Arnold Lightweight Mirror Modeler (Ver 2.0)

Outer Dia	2	Model Statistics		Supports		DISPLAY GRID
Inner Dia	0.25	6830	num Nodes	<input type="radio"/> Each Segment		DISPLAY MODEL
Cell Width	0.3	15751	num Elems	<input checked="" type="radio"/> Whole Mirror		WRITE MODEL
Lip Inner	0.05	206.4664	Weight (kg)	<input checked="" type="checkbox"/> Show Whole Grid		SAVE RESTORE
Segment Lip	0.05	17.01546	Area (m ²)	<input type="checkbox"/> Show Supports		MERGE NODES
Mirror Lip	0.1	12.13405	W/A (kg/m ²)	<input type="checkbox"/> Show Fillets		
Num Rings	2	Modal (PSD)		Boule Mapping		
Sgmt Span	1.25	Grid Options		Optical	Reals	Core
Sgmt Gap	0.11	Radius		7.5	Coefficient(1)	0
Merge Tol	0.025	Conic		-1	Coefficient(2)	0
Grid Zoom	0.99	Aspheric Order		0	Coefficient(3)	0
Segment Shown	1				Coefficient(4)	0
Shrink Factor	0.12				Coefficient(5)	0

Status: 21 elems with bad aspect ratios



CONTROL OVER MOST VARIABLES



Arnold Lightweight Mirror Modeler (Ver 2.0)

Outer Dia	2	Model Statistics		Supports		DISPLAY GRID
Inner Dia	0.25	6830	num Nodes	<input type="radio"/> Each Segment		DISPLAY MODEL
Cell Width	0.3	15751	num Elems	<input checked="" type="radio"/> Whole Mirror		WRITE MODEL
Lip Inner	0.05	206.4664	Weight (kg)	<input checked="" type="checkbox"/> Show Whole Grid		SAVE RESTORE
Segment Lip	0.05	17.01546	Area (m ²)	<input type="checkbox"/> Show Supports		MERGE NODES
Mirror Lip	0.1	12.13405	W/A (kg/m ²)	<input type="checkbox"/> Show Fillets		
Num Rings	2	Modal (PSD)		Boule Mapping		
Sgmt Span	1.25	Grid Options		Optical	Reals	Core
Sgmt Gap	0.11	r, 1	0.005	Front Facesheet	<input checked="" type="checkbox"/> Show	Mirror Material <input checked="" type="radio"/> ULE <input type="radio"/> Zerodur <input type="radio"/> E6 <input type="radio"/> Fused Silica <input type="radio"/> BK7 <input type="radio"/> Silicon Carbide
Merge Tol	0.025	r, 2	0.005	Back Facesheet	<input type="checkbox"/> Show	
Grid Zoom	0.99	r, 3	0.005	Front IsoGrid Web	<input checked="" type="checkbox"/> Show	
Segment Shown	1	r, 4	0.005	Outer Seal Ring	<input checked="" type="checkbox"/> Show	
Shrink Factor	0.12	r, 5	0.005	Inner Seal Ring	<input checked="" type="checkbox"/> Show	
		r, 6	0.005	Core Web	<input checked="" type="checkbox"/> Show	
		r, 7	0.005	Back IsoGrid Web	<input type="checkbox"/> Show	
		r, 8	0.015	Front Outer Seg Lip	<input checked="" type="checkbox"/> Show	
		r, 9	0.015	Back Outer Seg Lip	<input type="checkbox"/> Show	

Status: 21 elems with bad aspect ratios



CONTROL OVER CORE DESIGN



Arnold Lightweight Mirror Modeler (Ver 2.0)

Outer Dia	2	Model Statistics	6830	num Nodes	Supports	<input type="radio"/> Each Segment	DISPLAY GRID	
Inner Dia	0.25		15751	num Elems		<input checked="" type="radio"/> Whole Mirror		DISPLAY MODEL
Cell Width	0.3	206.4664	Weight (kg)	<input checked="" type="checkbox"/> Show Whole Grid	WRITE MODEL			
Lip Inner	0.05	17.01546	Area (m ²)	<input type="checkbox"/> Show Supports	SAVE	RESTORE		
Segment Lip	0.05	12.13405	W/A (kg/m ²)	<input type="checkbox"/> Show Fillets	MERGE NODES			
Mirror Lip	0.1							
Num Rings	2	Modal (PSD) Boule Mapping						
Sgmt Span	1.25	Grid Options Optical Reals Core Hexapod Axial Radial Inertial Loads						
Sgmt Gap	0.11	Front Depth	0.0254					
Merge Tol	0.025	Core Depth	0.0762					
Grid Zoom	0.99	Back Depth	0.0254					
Segment Shown	1	Total Depth	0.127					
Sink Factor	0.12	Core Layers	2					
		CoreWeb Fillet Radius	0.005					
		IsoGrid Fillet Radius	0.005					
Status 21 elems with bad aspect ratios								





WHOLE MIRROR OR SEGMENT SUPPORTS



Arnold Lightweight Mirror Modeler (Ver 2.0)

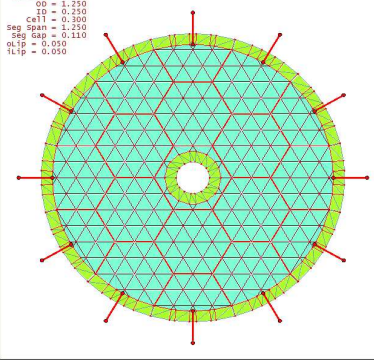
Outer Dia	2	Model Statistics	6830	num Nodes	Supports	<input type="radio"/> Each Segment	DISPLAY GRID	
Inner Dia	0.25		15751	num Elems		<input checked="" type="radio"/> Whole Mirror		DISPLAY MODEL
Cell Width	0.3	206.4664	Weight (kg)	<input checked="" type="checkbox"/> Show Whole Grid	WRITE MODEL			
Lip Inner	0.05	17.01546	Area (m ²)	<input type="checkbox"/> Show Supports	SAVE	RESTORE		
Segment Lip	0.05	12.13405	W/A (kg/m ²)	<input type="checkbox"/> Show Fillets	MERGE NODES			
Mirror Lip	0.1							
Num Rings	2	Modal (PSD) Boule Mapping						
Sgmt Span	1.25	Grid Options Optical Reals Core Hexapod Axial Radial Inertial Loads						
Sgmt Gap	0.11					<input type="checkbox"/> Do Radial Support		
Merge Tol	0.025	Num Points	12					
Grid Zoom	0.99	Support Length	0.15 (m)					
Segment Shown	1	Spring Rate	2000 (N/m)					
Sink Factor	0.12	Start Angle	0 (deg)					
		Fitting Mass	1 (kg)					
		Acceptable Near	1E-05 (m)					
Status 21 elems with bad aspect ratios								


USER CAN ADJUST AND OPTIMIZE


Grid

```

numPnts = 411
numRings = 3308
numArea = 744
OD = 1.250
ID = 0.250
Cell W = 0.300
Seg Span = 1.250
Seg Gap = 0.110
oLip = 0.050
lLip = 0.050
                    
```



U

L C R

D

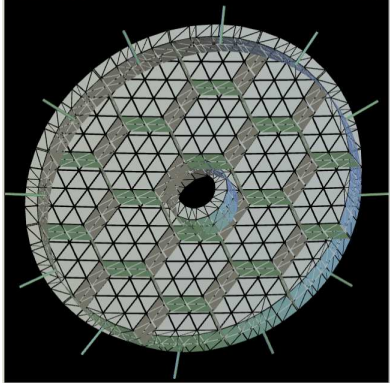
IN OUT



Shrink

+ -

Sgmt Num

Model 3D Display




AXIAL AS WELL AS RADIAL STYLES


Arnold Lightweight Mirror Modeler (Ver 2.0)

Outer Dia

Inner Dia

Cell Width

Lip Inner

Segment Lip

Mirror Lip

Num Rings

Sgmt Span

Sgmt Gap

Merge Tol

Grid Zoom

Segment Shown

Srink Factor

Supports

Each Segment

Whole Mirror

Show Whole Grid

Show Supports

Show Fillets

Do Axial Support

Fitting Mass (kg)

Support Ground (m)

Acceptable Near (m)

Modal (PSD) | Boule Mapping

Grid Options | Optical | Reals | Core | Hexapod | Axial | Radial | Inertial Loads

Pnts	Diameter (m)	Start Ang (deg)	Spring Rate (N/m)
12	0.85	15	2000
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

DISPLAY GRID

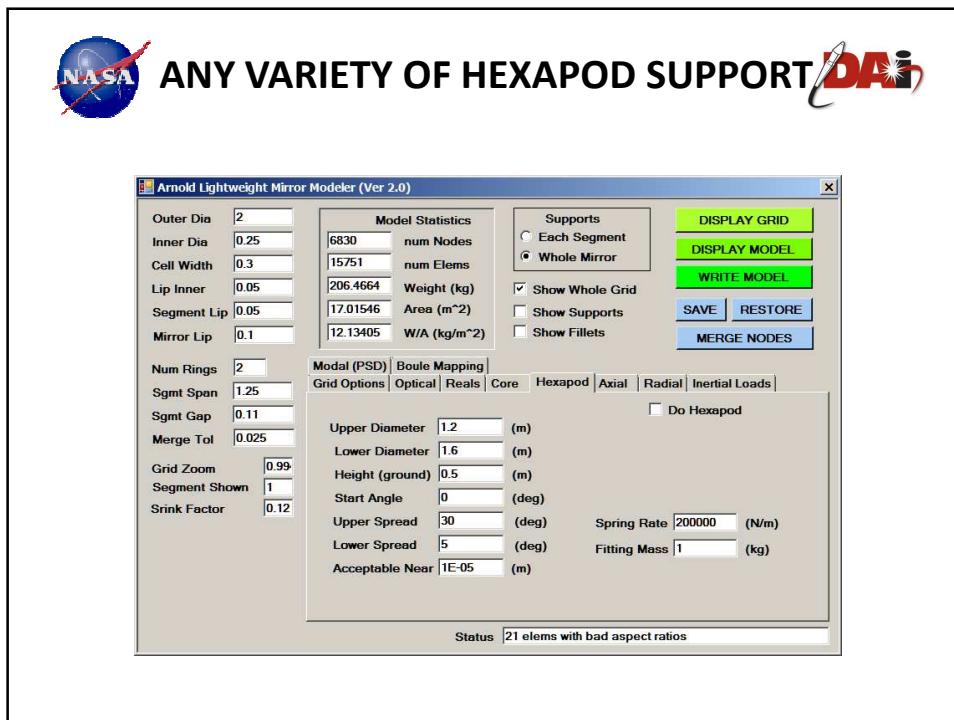
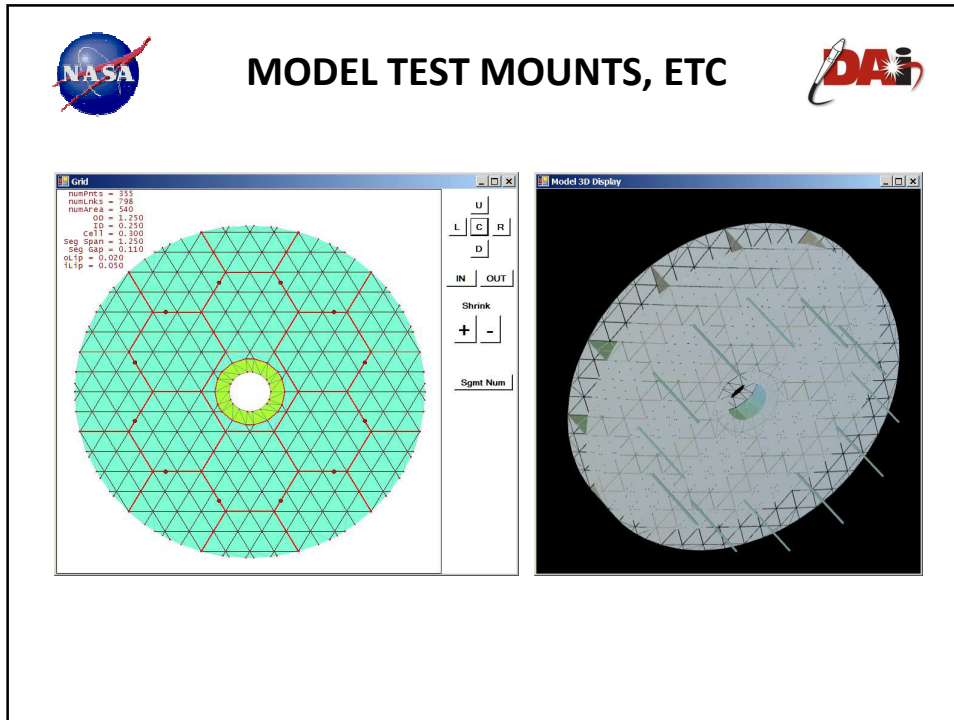
DISPLAY MODEL

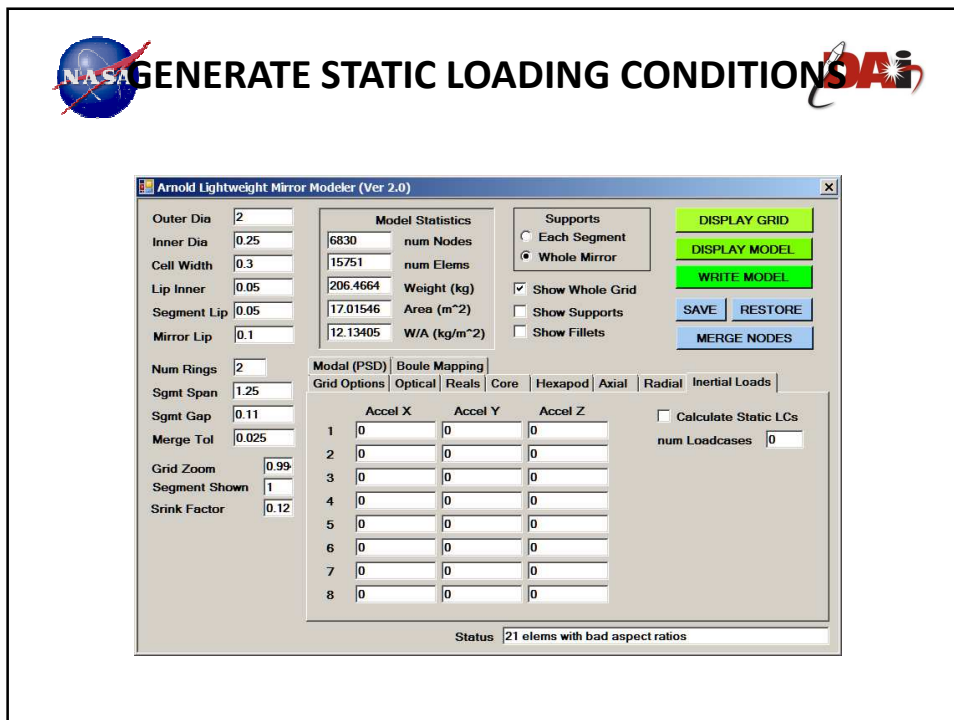
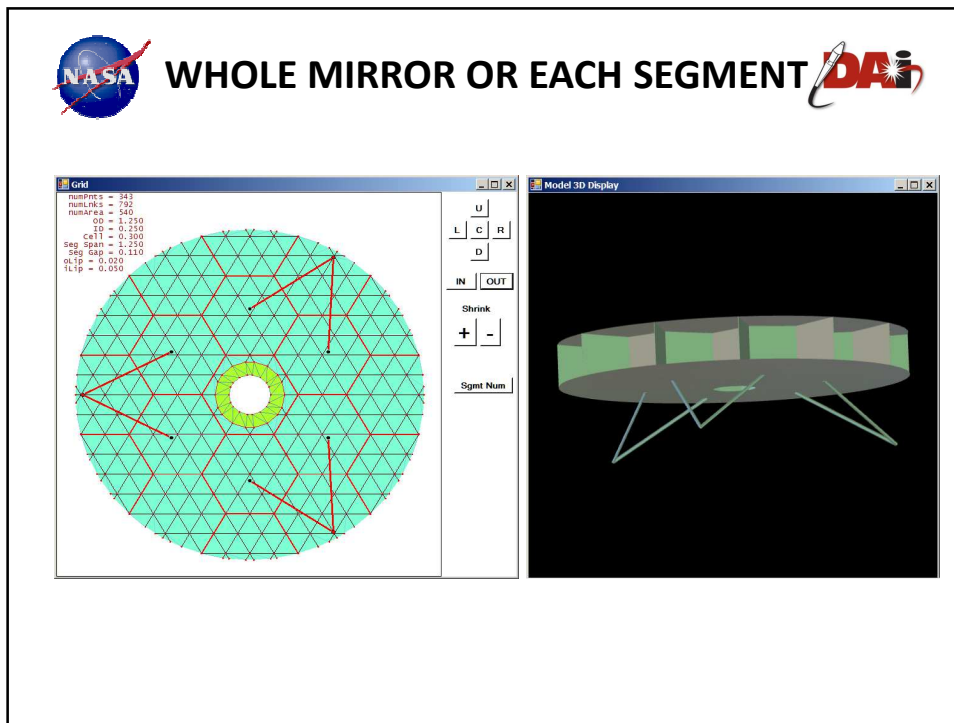
WRITE MODEL

SAVE RESTORE

MERGE NODES

Status: Finished Building Grid







GENERATE DYNAMIC LOADING SETS

Arnold Lightweight Mirror Modeler (Ver 2.0)

Outer Dia: 2
 Inner Dia: 0.25
 Cell Width: 0.3
 Lip Inner: 0.05
 Segment Lip: 0.05
 Mirror Lip: 0.1

Num Rings: 2
 Sgmt Span: 1.25
 Sgmt Gap: 0.11
 Merge Tol: 0.025

Grid Zoom: 0.99
 Segment Shown: 1
 Srink Factor: 0.12

Model Statistics
 6830 num Nodes
 15751 num Elems
 206.4664 Weight (kg)
 17.01546 Area (m²)
 12.13405 W/A (kg/m²)

Supports
 Each Segment
 Whole Mirror
 Show Whole Grid
 Show Supports
 Show Fillets

Grid Options | Optical | Reals | Core | Hexapod | Axial | Radial | Inertial Loads |
 Modal (PSD) | Boule Mapping

Calculate Modes
 num Modes: 10

Calculate X PSD
 Calculate Y PSD
 Calculate Z PSD

	f1	f2	f3	f4	f5	f6	f7
f	0	0	0	0	0	0	0
g2	0	0	0	0	0	0	0
f	0	0	0	0	0	0	0
g2	0	0	0	0	0	0	0
f	0	0	0	0	0	0	0
g2	0	0	0	0	0	0	0

Buttons: DISPLAY GRID, DISPLAY MODEL, WRITE MODEL, SAVE, RESTORE, MERGE NODES

Status: 21 elems with bad aspect ratios



(IN WORK) ULE CTE MAPPING

Arnold Lightweight Mirror Modeler (Ver 2.0)

Outer Dia: 2
 Inner Dia: 0.25
 Cell Width: 0.3
 Lip Inner: 0.05
 Segment Lip: 0.05
 Mirror Lip: 0.1

Num Rings: 2
 Sgmt Span: 1.25
 Sgmt Gap: 0.11
 Merge Tol: 0.025

Grid Zoom: 0.99
 Segment Shown: 1
 Srink Factor: 0.12

Model Statistics
 6830 num Nodes
 15751 num Elems
 206.4664 Weight (kg)
 17.01546 Area (m²)
 12.13405 W/A (kg/m²)

Supports
 Each Segment
 Whole Mirror
 Show Whole Grid
 Show Supports
 Show Fillets

Grid Options | Optical | Reals | Core | Hexapod | Axial | Radial | Inertial Loads |
 Modal (PSD) | Boule Mapping

Buttons: Input Boule Data, Write Boule Data, Load Boule Data, List Boule Data, Input Boule Assign Data, Write Boule AssignData, Load Boule AssignData, Map Boules to Model

Status: 21 elems with bad aspect ratios



FUTURE ENHANCEMENTS



- FINISH CTE MAPPING
- LOCALIZED MESH REFINEMENT AT ATTACHMENT POINTS
- REAL CONSTANT BASED COLOR 3D DISPLAY OF MODEL
- AUTOMATIC BAD ASPECT RATIO ELEMENT FLAGGING/PLOTTING
- HEXAPOD GEOMETRY OPTIMIZATION
- EXPAND ANSYS GENERATED DATA SUMMARIES
- ABACUS OUTPUT FORMAT (LOW PRIORITY FOR NOW)
- NASTRAN OUTPUT FORMAT (NEEDS SPONSOR)

- USER MANUAL
- TUTORIAL(S) ON HOW TO USE MODELER
- SHORT COURSE IN ADVANCED MIRROR DESIGN METHODS

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