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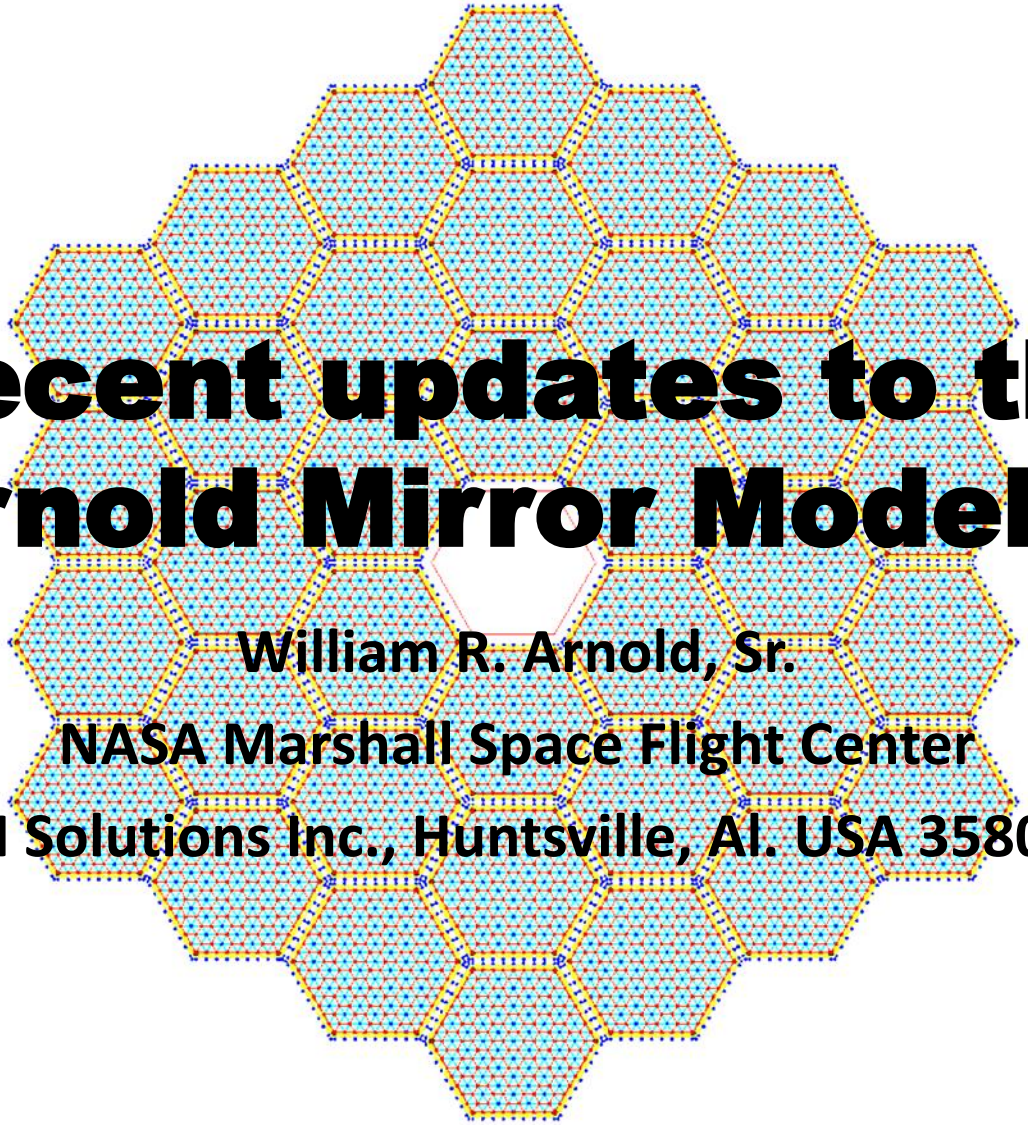

Recent updates to the Arnold Mirror Modeler

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NASA Marshall Space Flight Center

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WHAT IS THE MODELER?

- For a number of years the Advanced Mirror Technology Development (AMTD) project has been developing design tools and validating manufacturing methods to support the coming generations of large spaced based telescopes. [1,2,3,4,5]
- The challenges of larger size mirrors and limited payload and shroud capacities (for both existing , under development or planned) have created the need for optimization of all aspects of the optics and instruments.
- The Arnold Mirror Modeler is one of those tools intended to make the optimization problem more efficient by radically reducing the time required to generate complex Finite Element models of very large egg-crate style lightweight mirrors and their suspension systems (both monolith and segmented).

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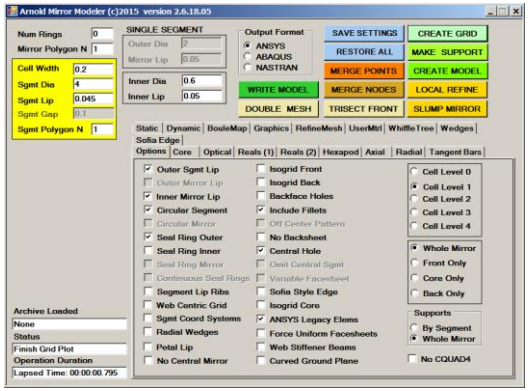
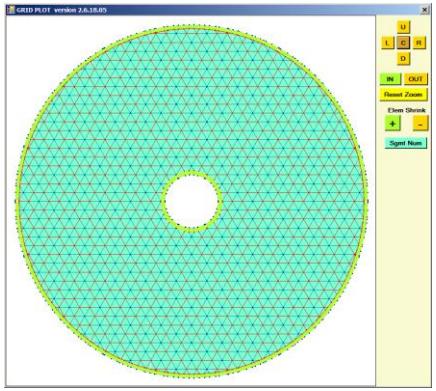
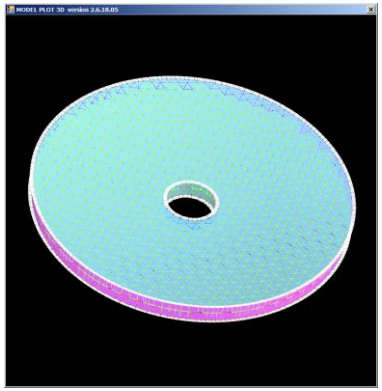
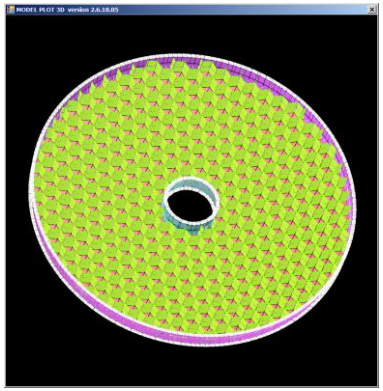
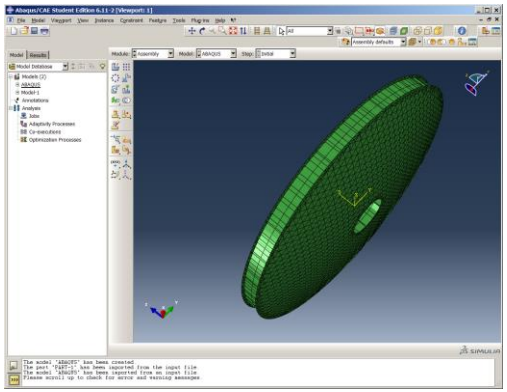
WHAT DOES MODELER DO?











The modeler creates input decks for ANSYS, ABAQUS and NASTRAN. The Modeler creates a complete analysis stream, including model, loads [static and dynamic], plots and a summary file of input variable and results suitable for optimization or trade studies. The values of all settings in the program can be archived and recalled to continue or redo any configuration.

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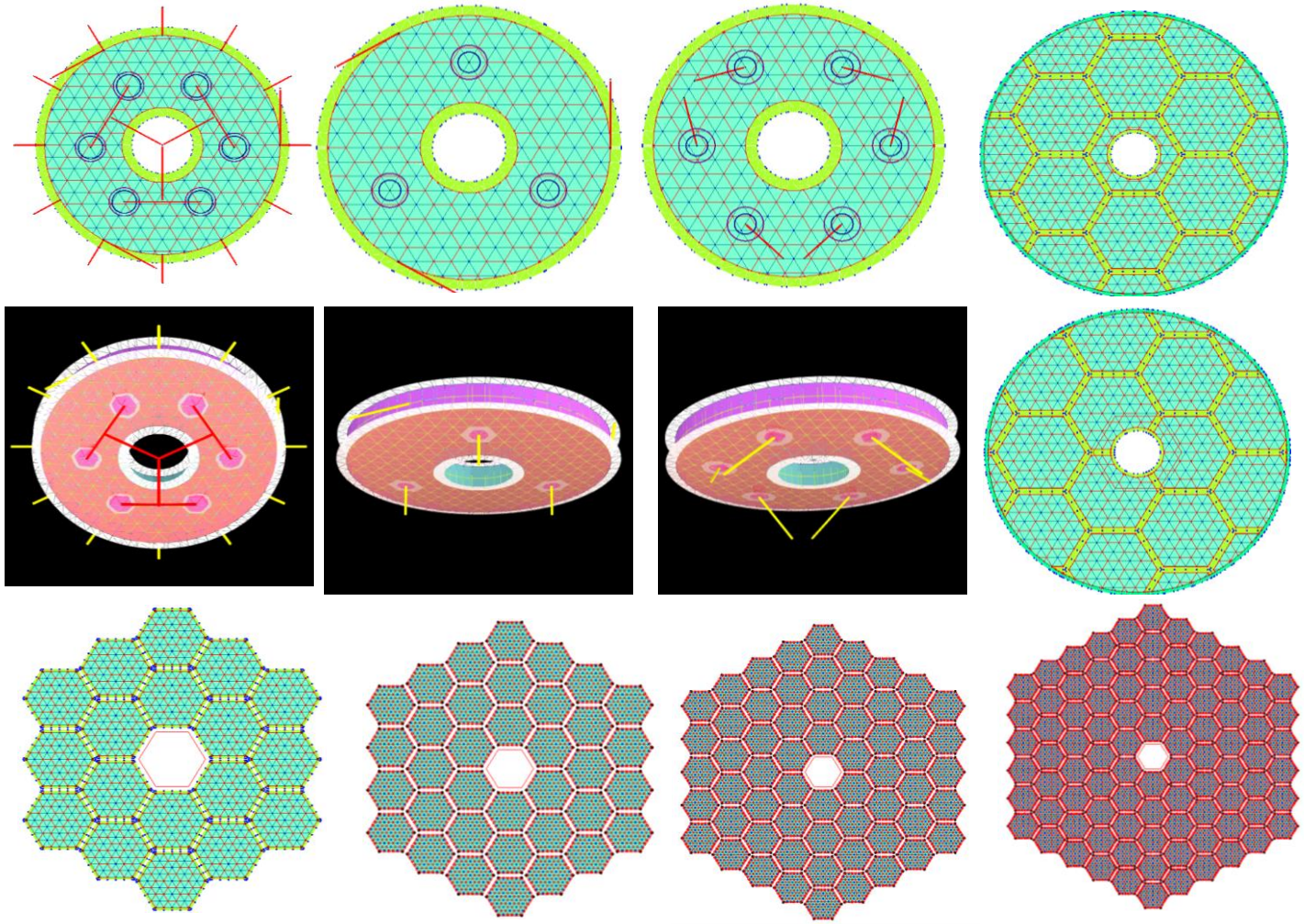
TYPES OF MODELS GENERATED



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SO WHATS NEW SINCE THE LAST TIME?

SEE THE REFERENCES FOR DETAILS OF EVERYTHING PRIOR VERSIONS OF THE MODELER CAN DO

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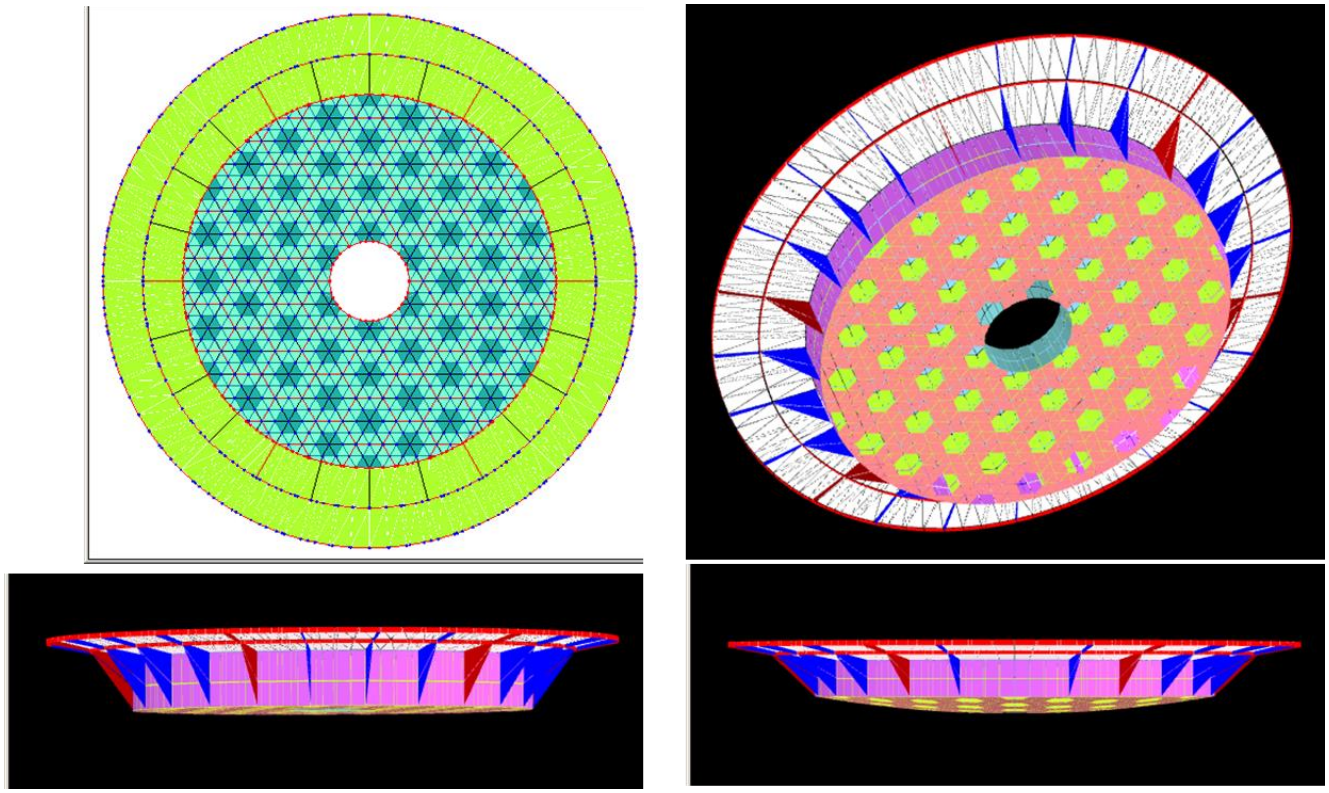
MODELING SOFIA STYLE MIRROS



Since light-weighting Zerodur mirrors require milling, undercut pocket milling of the cells is the most risky operation. The largest outer lib which can be open back milled is desirable.

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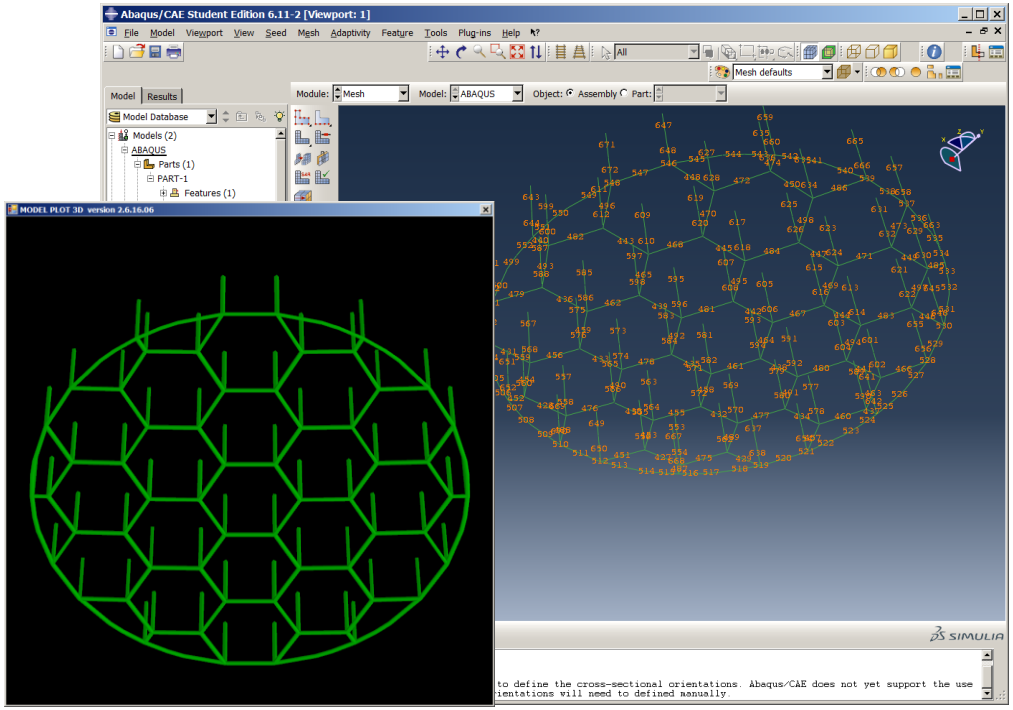
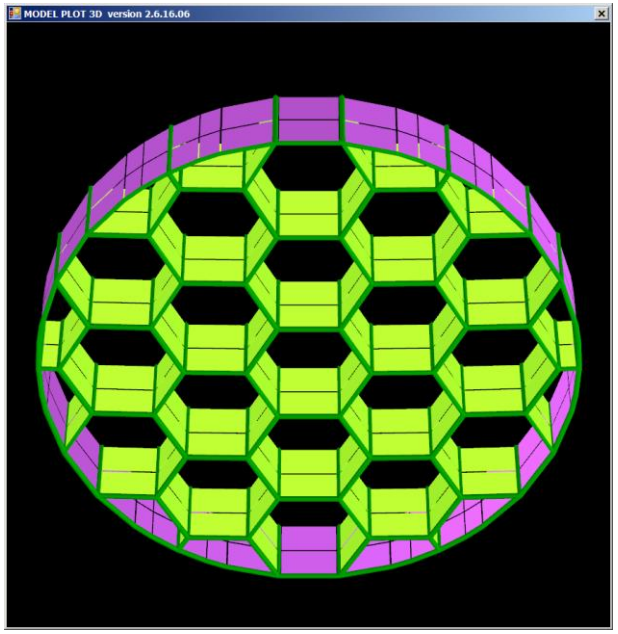
BACK EDGE STIFFENER BEAMS





A stiffness improvement over straight open back pocketing of Zerodur is to initially make wide webs, then undercut mill a portion of the web thickness. This is less aggressive than SOFIA's pocketing, but can be beneficial. This detail is also suitable to silicon carbide and even beryllium designs.

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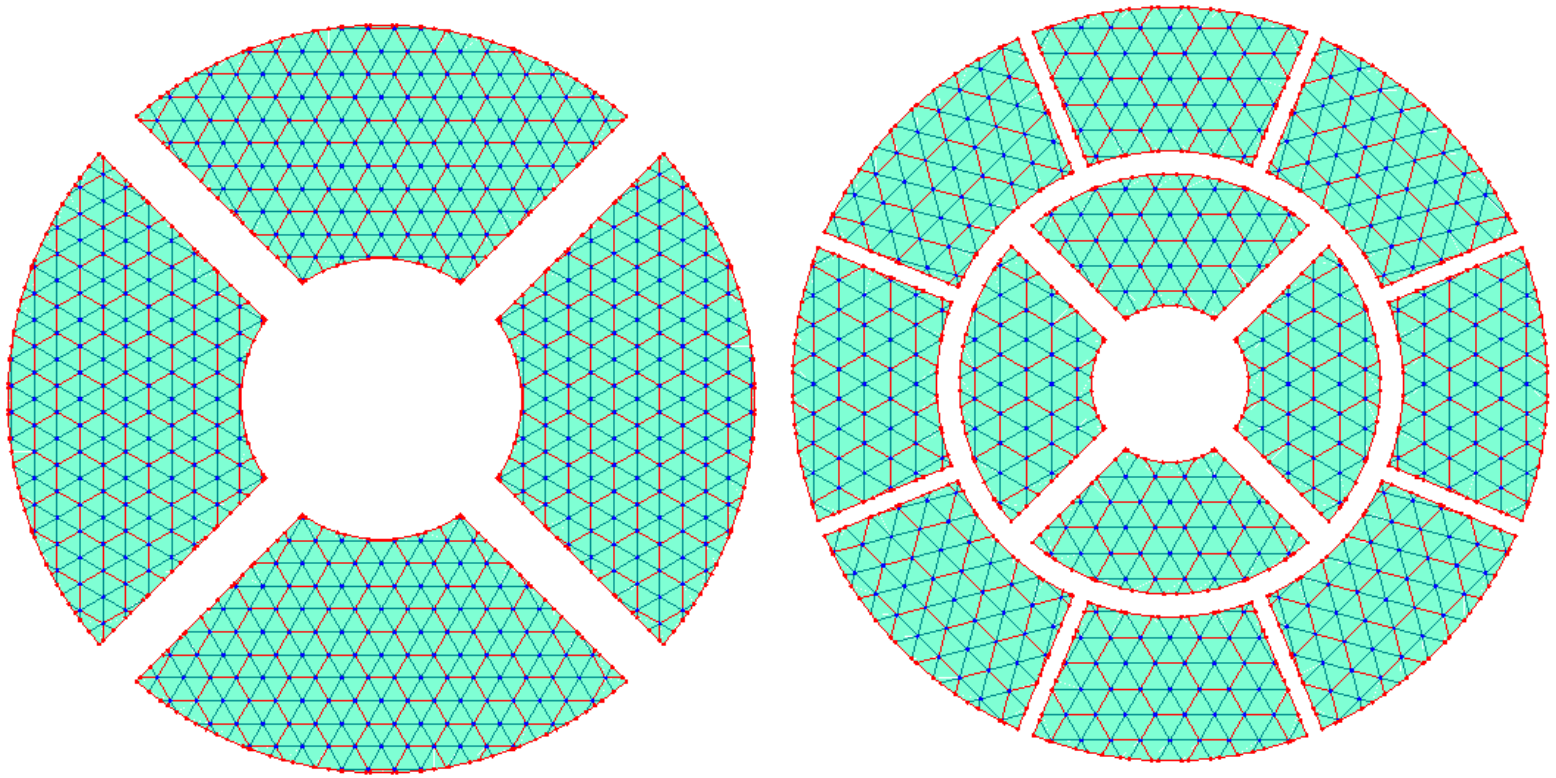
WEDGE SEGMENTS



These can be merged into monolithic mirrors to simulate for example the diffusion bonding of silicon carbide mirrors or low temperature fusion bonding of ULE segments. Another possibility is shown on next slide.

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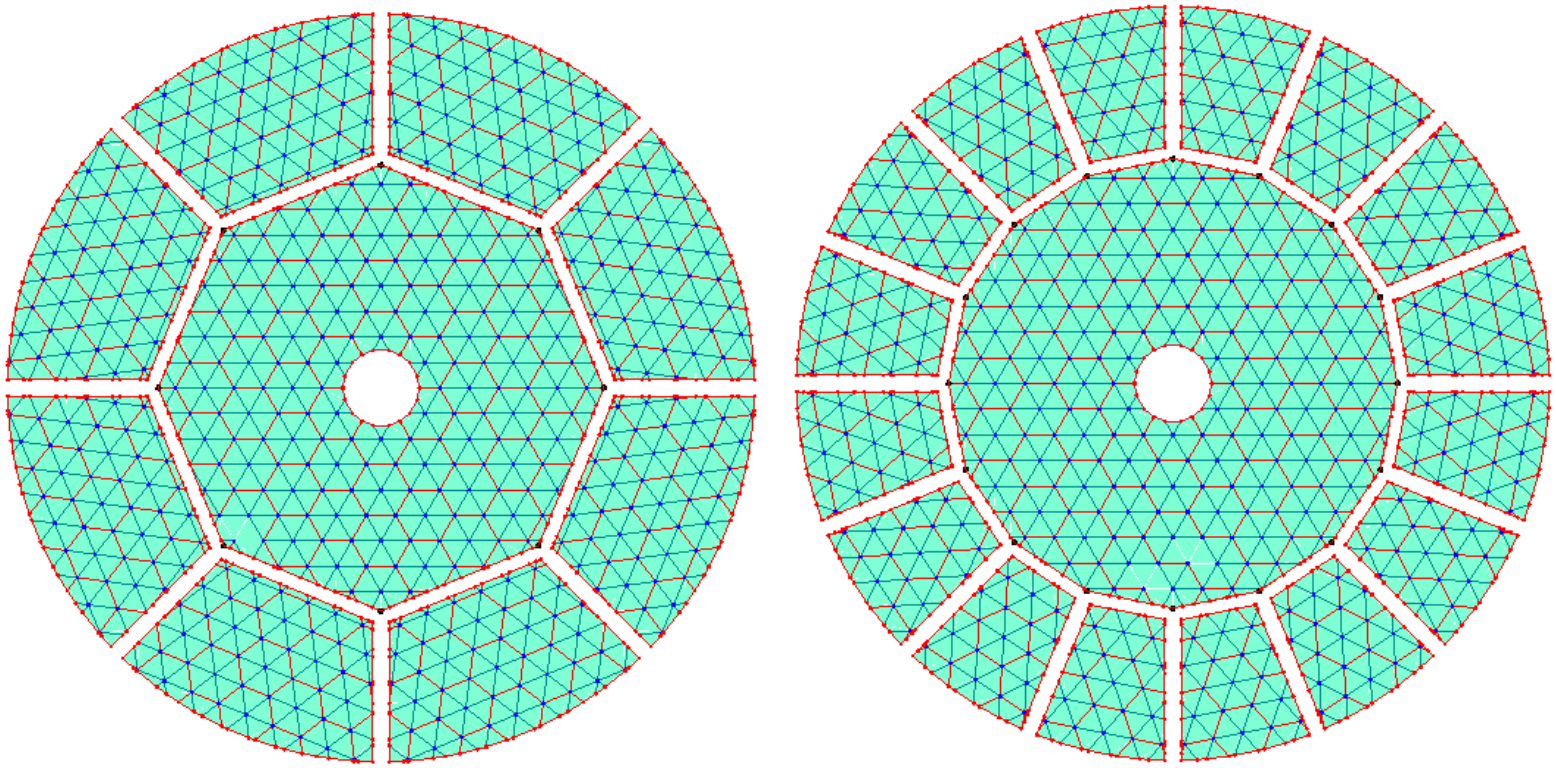
COMBINING PETALS WITH MONOLITH



One option for limited shroud diameter is to have as large a central monolith as possible, with deployable petals. This provides a better diffraction pattern than uniform segment patterns, as well as more mission flexibility.

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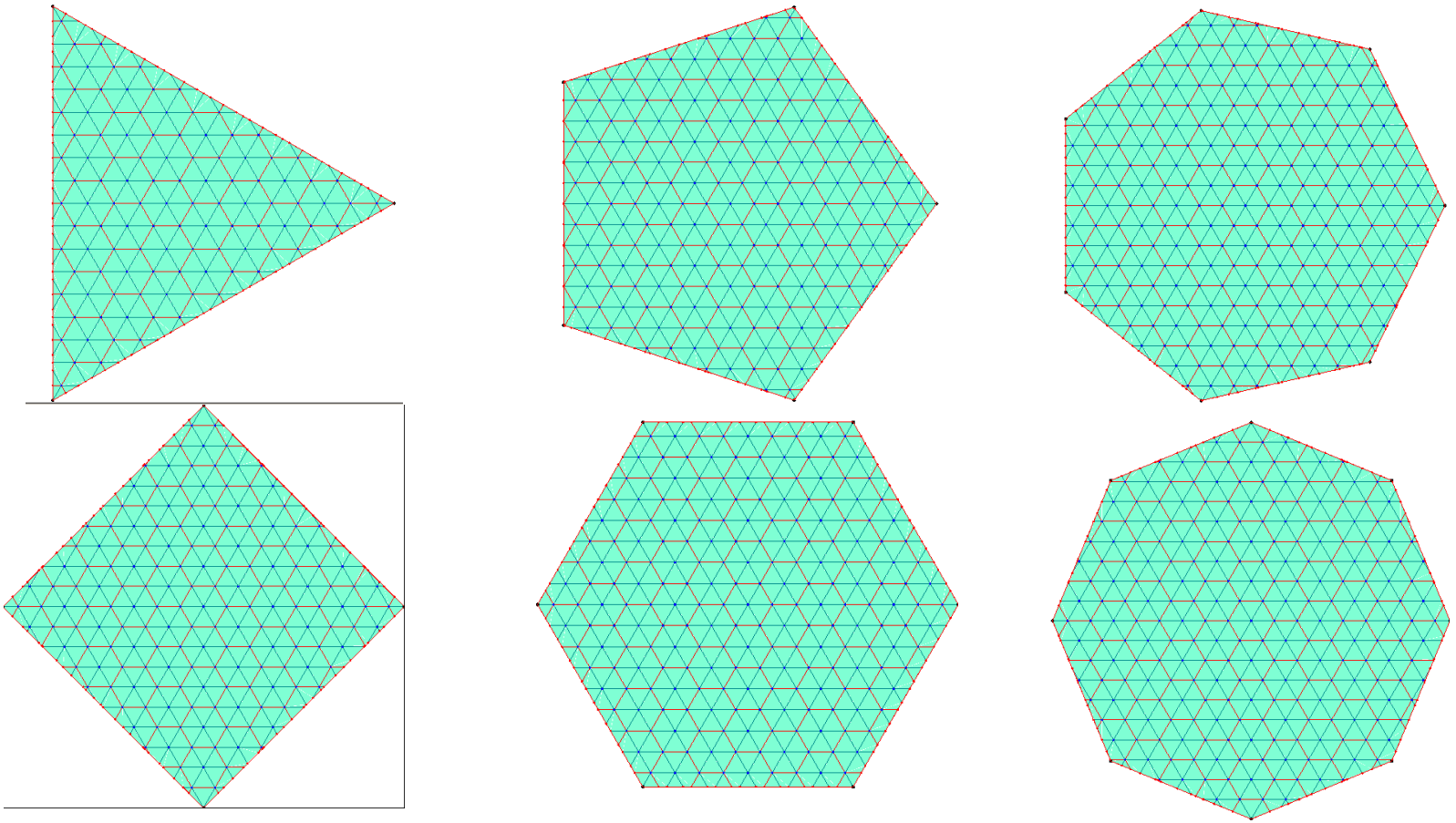
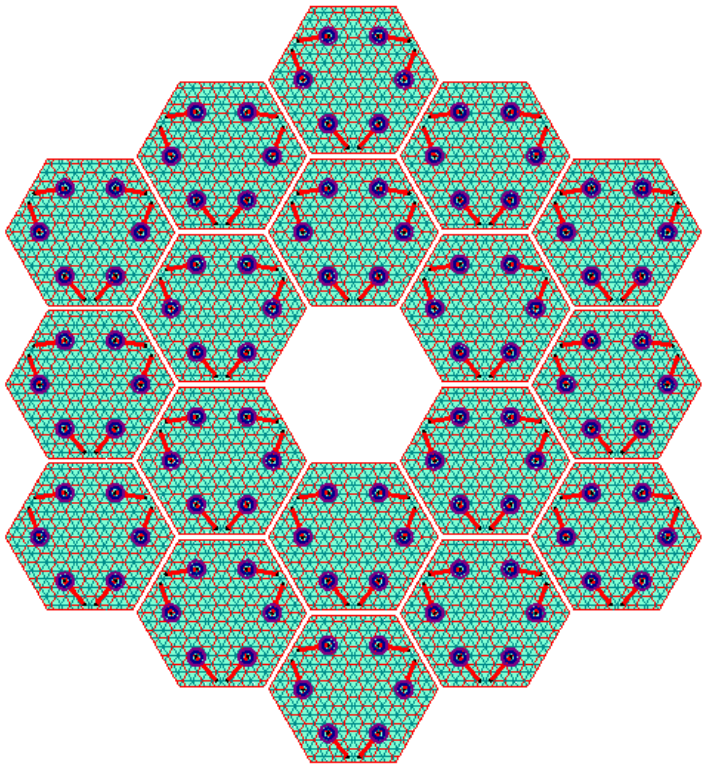
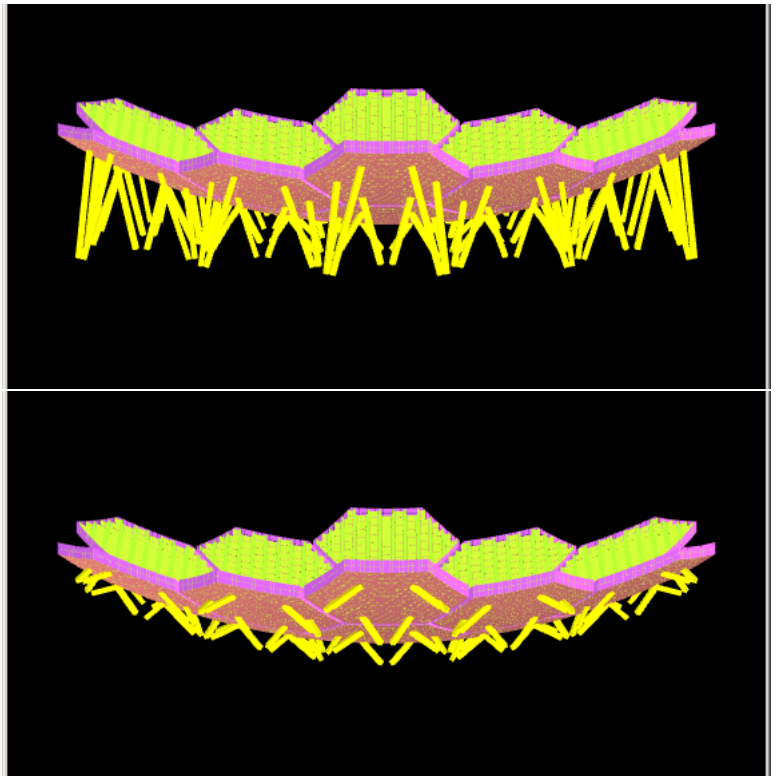
N-POLYGON PERIMETERS



POLYGONS UP TO ORDER 16 ARE NOW SUPPORTED AS WELL AS CIRCULAR
As a consequence of the petal or wedge capabilities.

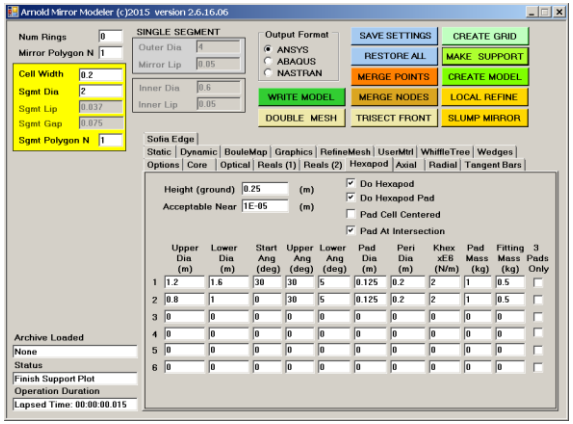
CURVED BACK PLANE DEFINITION





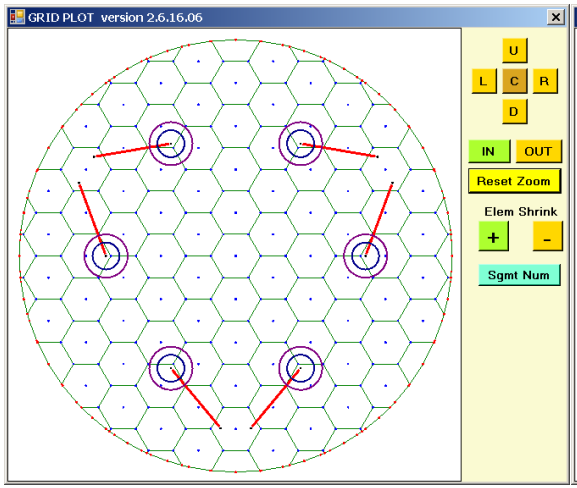
As the segmented mirror sizes continue to grow, it becomes desirable to define the attachment plane for the segment support systems as a curve. This provides a more uniform strut stiffness for dynamic behavior of system.

AUTOMATIC PAD REPOSITIONING

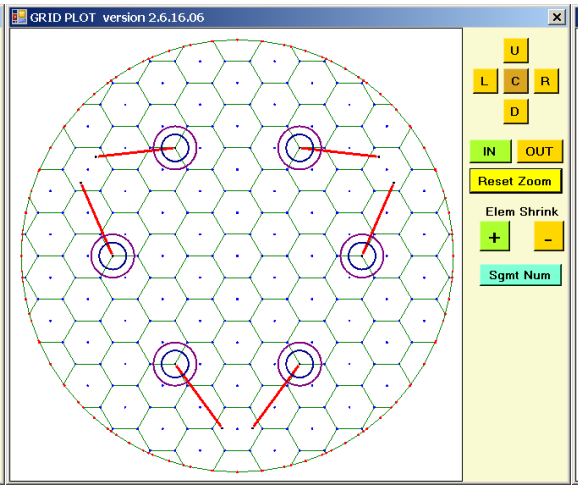


In addition to multiple simultaneous hexapod systems to support the wedge segments, it is now possible to force the pad locations to align exactly with either the center of a cell or the intersection of cell webs.

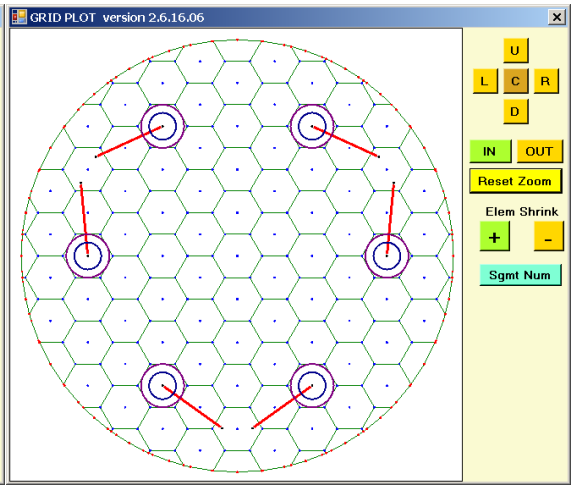
All it takes is checking the appropriate box!



INITIAL POSITION



CENTERED ON INTERSECTION



CENTERED ON CELL CENTER

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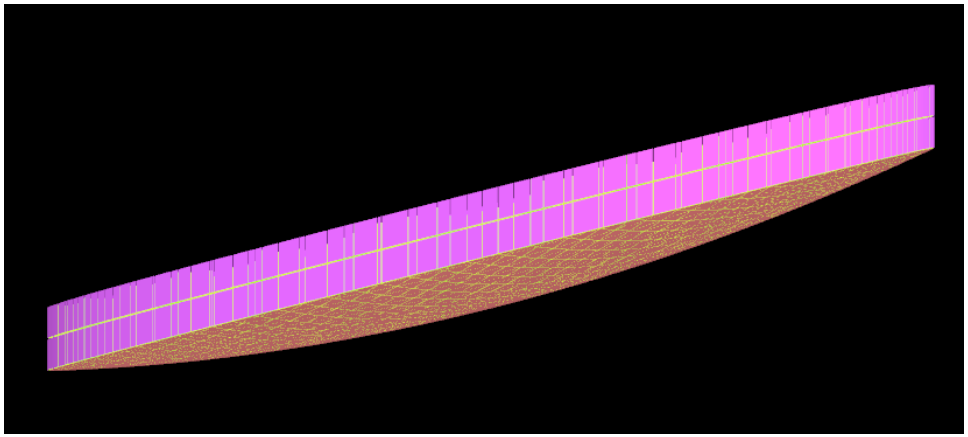
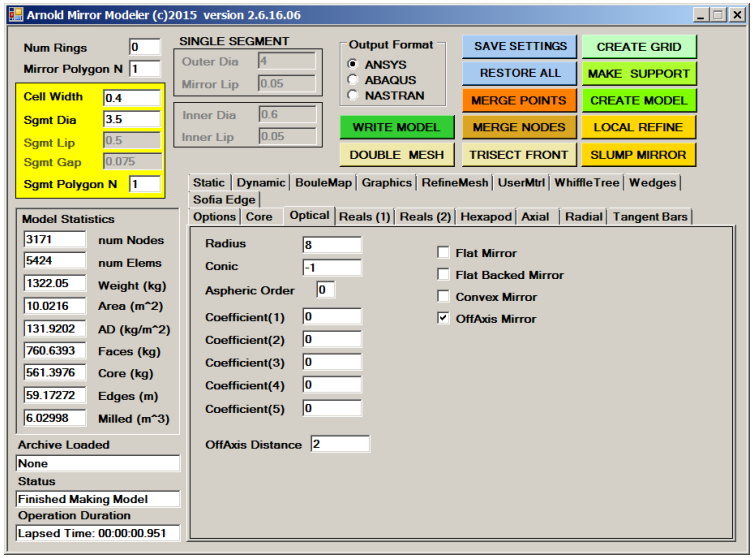
OFF-AXIS MIRRORS





With the emergence of interest in space-based UV optics, the diffraction advantages of off-axis systems, particularly monolithic primary based has spurred the development of the ability to create off-axis models.

WHERE ARE WE GOING FROM HERE?

- INITIAL PUBLICATION/RELEASE OF THE SOFTWARE IS PLANNED FOR SEPTEMBER 2015.
- CURRENTLY THE DISTRIBUTION OF THE PROGRAM IS EXPORT ADMINISTRATION REGULATIONS RESTRICTED TO US CITIZENS AND US ENTITIES.
- INTEGRATION OF THE OUTPUT FILE FORMATS WITH THE OPTICAL PERFORMANCE ANALYSIS SYSTEMS UNDER DEVELOPMENT FOR AMTD.
- IMPROVED BOND PAD MODELING TO INCLUDE GLUE LAYER AND ACTUAL PAD GEOMETRY (1ST ORDER DETAIL ONLY)

ACKNOWLEDGEMENTS

- This work has been supported by the AMTD project and Dr. H. Phil Stahl and the staff of ES31, ES22 and VP10 at Marshall Space Fight Center, Huntsville, Alabama.
- A number of NASA interns have made major contributions to the development of the program, through their tireless efforts to break the code during testing and creative interruptions of the user's manual under development.
    - Jacob Vehonsky
    - Ryan M. Bevins
    - Matthew Fitzgerald
    - Rubin Jaca Rosa
    - Erik Humfleet

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REFERENCES

1. **Arnold, W. R., "AMTD DESIGN PROCESS", NASA/SPIE Mirror Technology Days 2014, Albuquerque, NM (2014)**
2. **Arnold, W. R., "Arnold Mirror Modeler Demonstration Video (30 min)", NASA/SPIE Mirror Technology Days 2014, Albuquerque, NM (2014)**
3. **Arnold, W. R., Etal., "Next-generation lightweight mirror modeling software", SPIE Opto-mechanical Engineering 2013, San Diego, CA SPIE 8836-15 (2013)**
4. **Arnold, W. R., Etal., "Integration of mirror design with suspension system using NASA's new mirror modeling software", SPIE Opto-mechanical Engineering 2013, San Diego, CA SPIE 8836-17 (2013)**
5. **Arnold, W. R., Etal. "Next-generation lightweight mirror modeling software", NASA Mirror Tech Days 2013, Redondo Beach, CA (2013)**