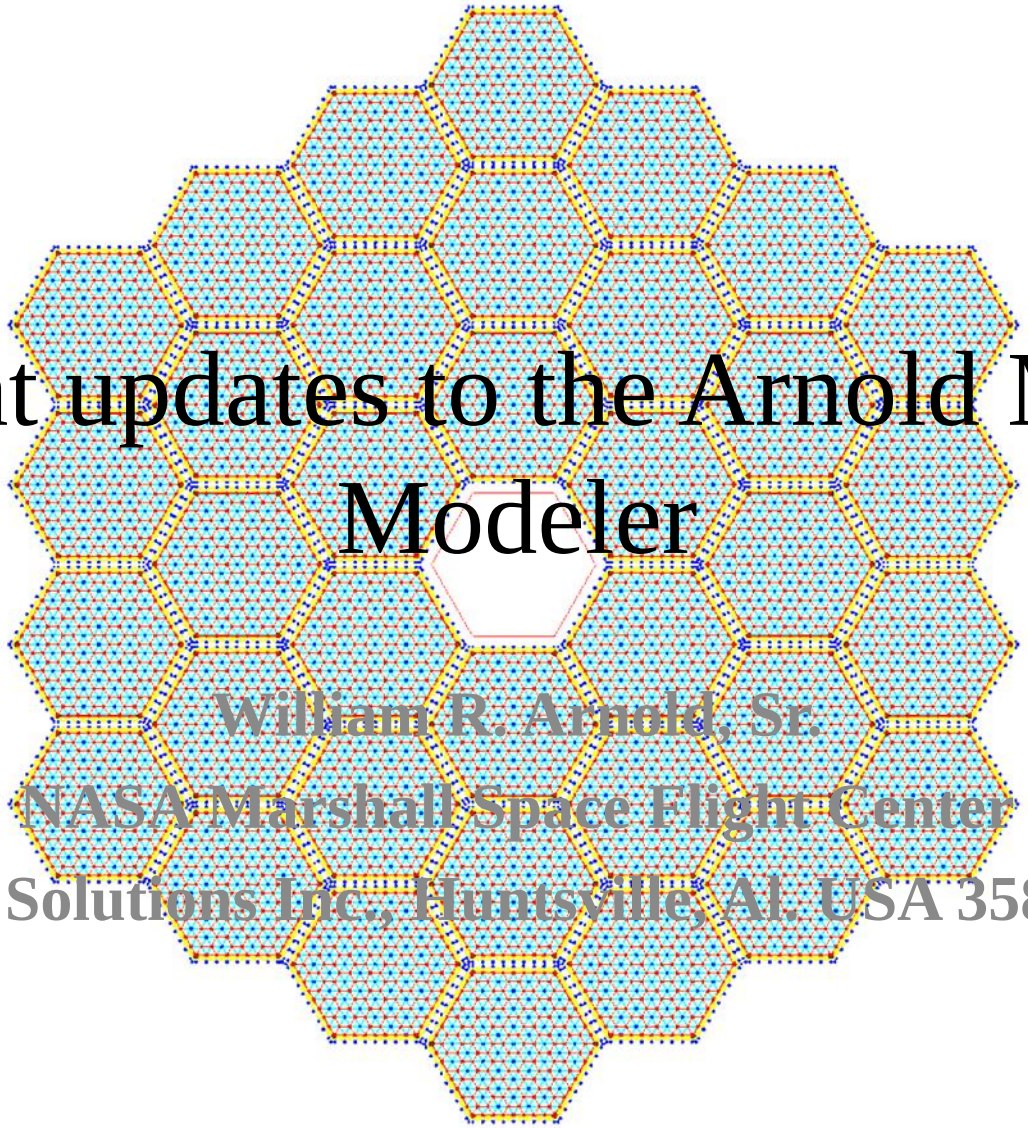
Advanced Mirror Technology Development (AMTD) Project: Arnold Mirror Modeler Status and Use on 4-meter Design Trades

H. Philip Stahl, MSFC

AMTD is a funded NASA Strategic Astrophysics Technology (SAT) project

SPIE Conference on Advances in Optical and Mechanical Technologies for Telescopes and Instrumentation, 2016



Recent updates to the Arnold Mirror Modeler

William R. Arnold, Sr.
NASA Marshall Space Flight Center
AI Solutions Inc., Huntsville, Al. USA 35806

NASA Mirror Technology Days 2016

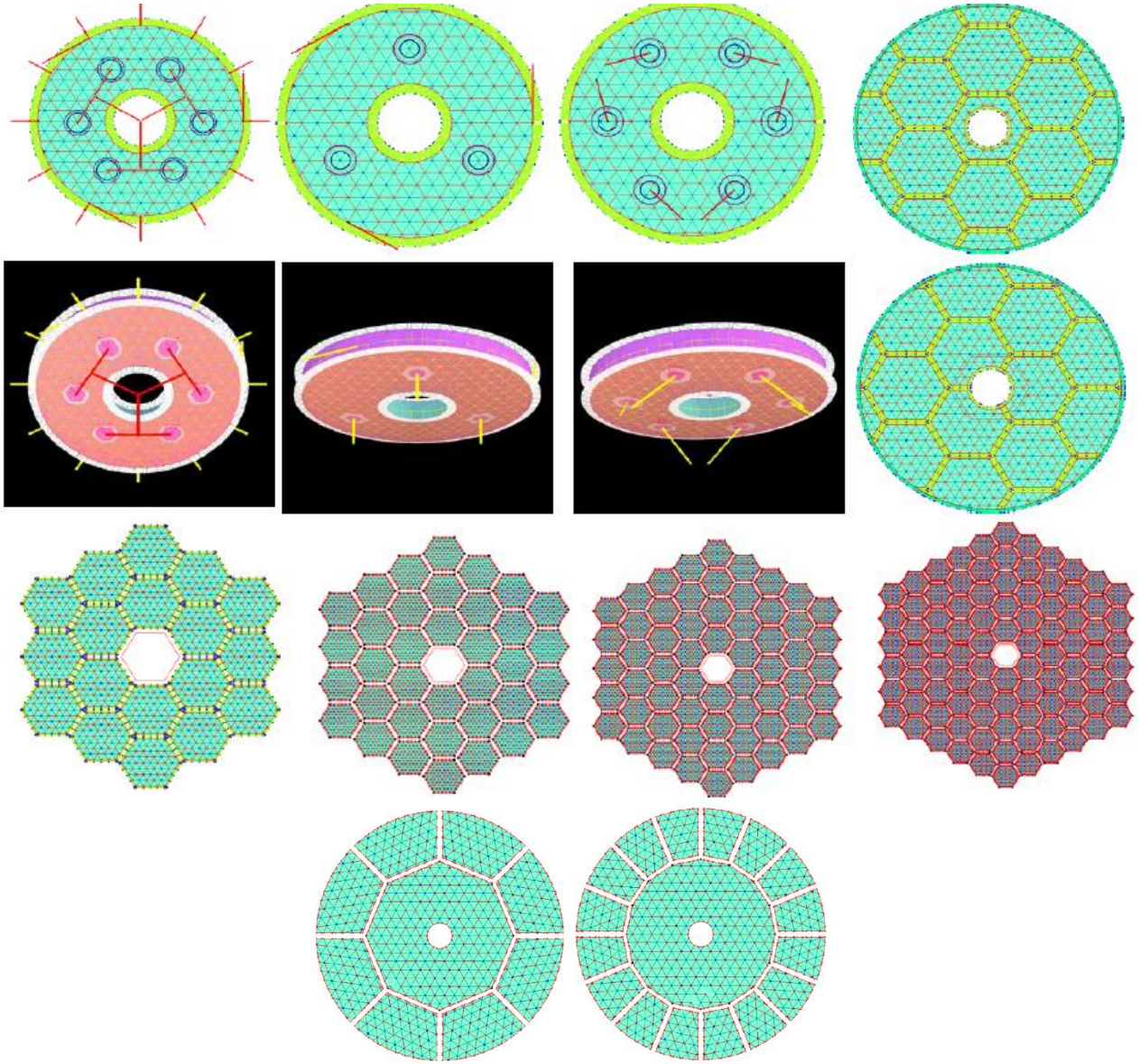
Arnold Mirror Modeler (AMM)

The AMM creates input decks for ANSYS, ABAQUS and NASTRAN. It 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 are archived and recalled to continue or redo any configuration.

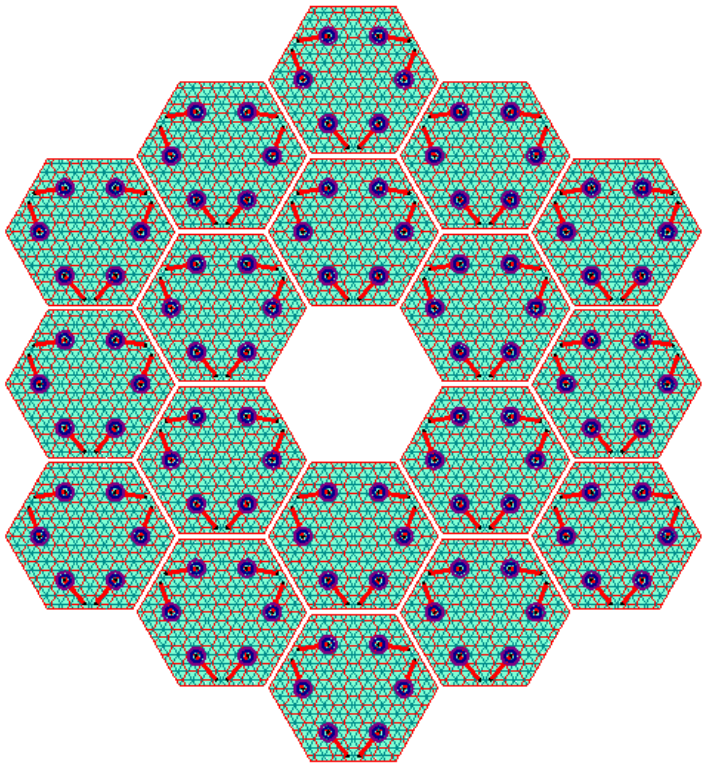
Capabilities include:

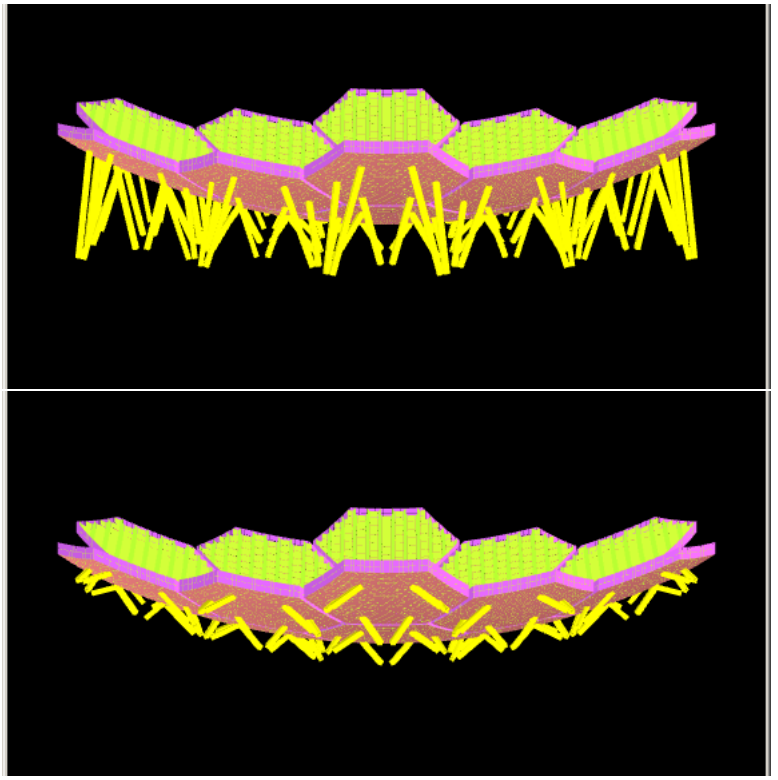
- Monolithic and Segmented
- Hexapod and Hindle Support Mounts up to 18-point
- Launch Support System

Monolithic and Segmented Apertures



Curved & Flat Back Hexapod Support Systems



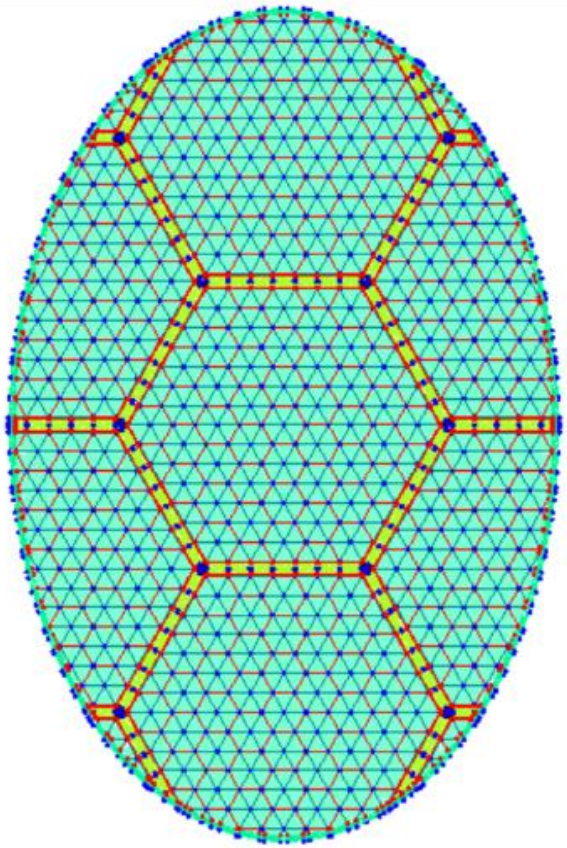


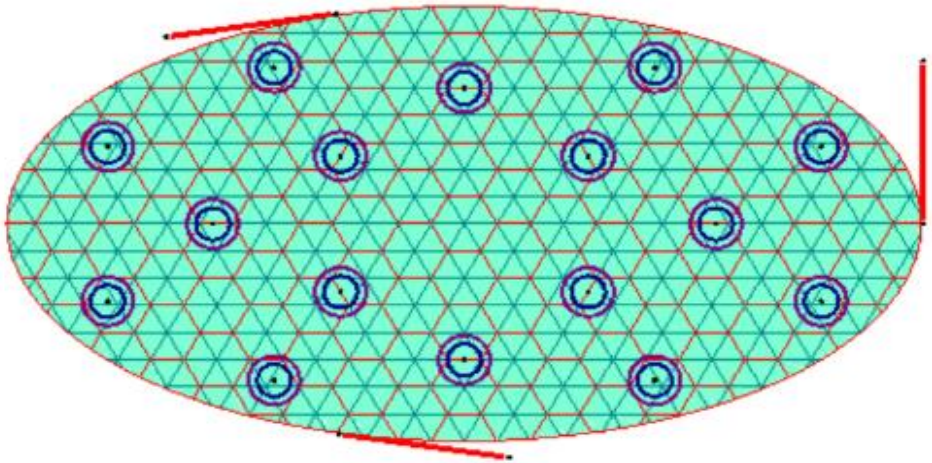
As the segmented mirror sizes continue to grow, it becomes desirable to define the attachment plane for the segment support systems as a curve. This provides a more uniform strut stiffness for dynamic behavior of system.

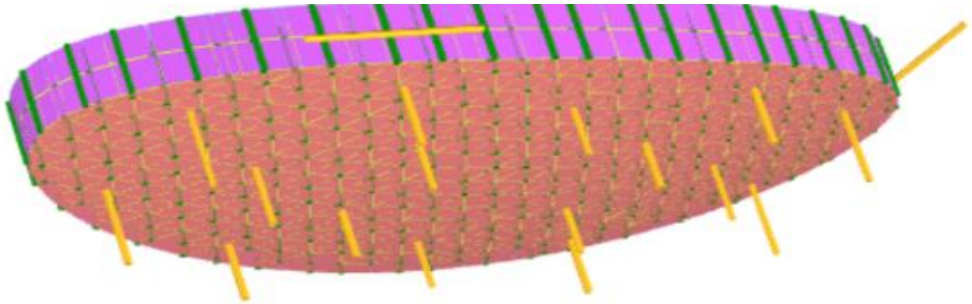
Changes Since Tech Days 2015

- Running check cases (needed to ‘release’) to insure consist results for ANSYS, ABAQUS and NASTRAN uncovered multiple small ‘bugs’ whose ‘fixes’ were time consuming.
- Added Features
  - Elliptical Mirrors and Suspension System
  - Either Metric or English Unit Models
  - Zernike Support (Outputs Optical Surface Nodes & Displacements).
- Using for HabEx primary mirror trade studies
- Making Progress on Release
  - It has taken a very long time to navigate the NASA process for releasing code. There are multiple rules that must be satisfied.
    - ADA Compliant – to make usable by visually impaired individuals, added large help boxes.
    - ITAR – code must be encrypted; only available to US Gov Contractors.
  - Working on a ‘release’ User Manual
    - Quick Start and Full Manual
    - How To Tutorials (multi-segment, suspensions, hexapods, etc.)

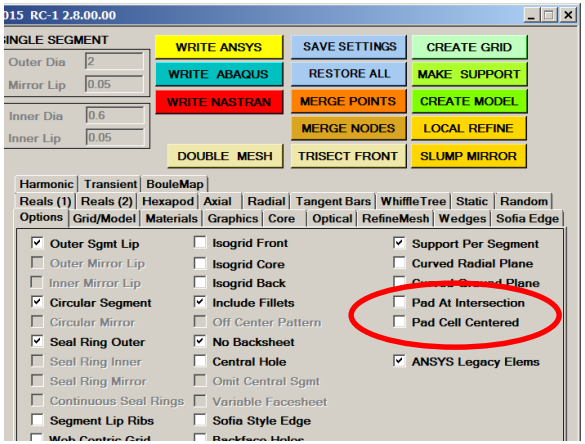
EXAMPLES OF ELLIPTICAL MIRRORS





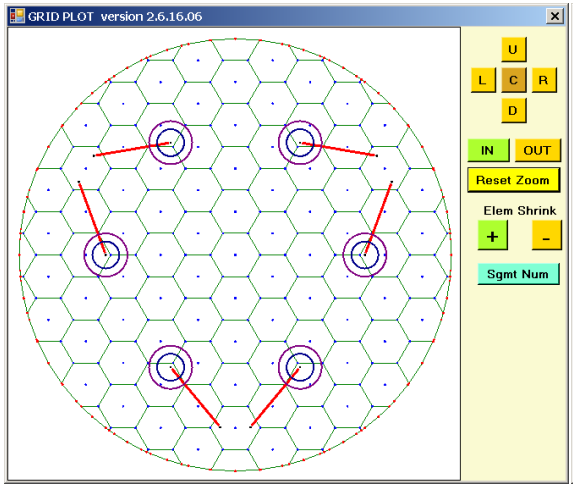


AUTOMATIC PAD REPOSITIONING

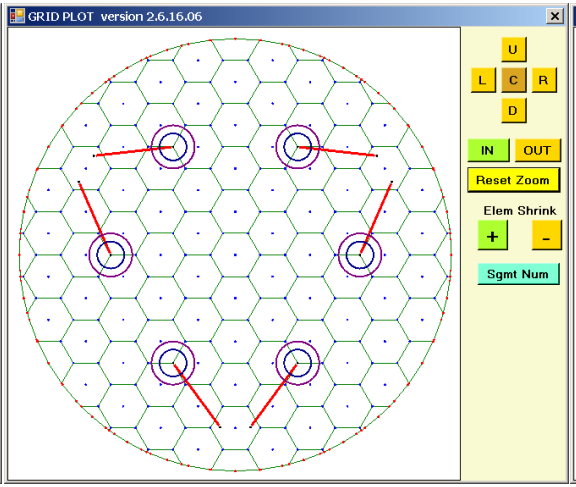


In addition to multiple simultaneous hexapod systems to support the wedge segments, it is now possible to force the pad locations to align exactly with either the center of a cell or the intersection of cell webs.

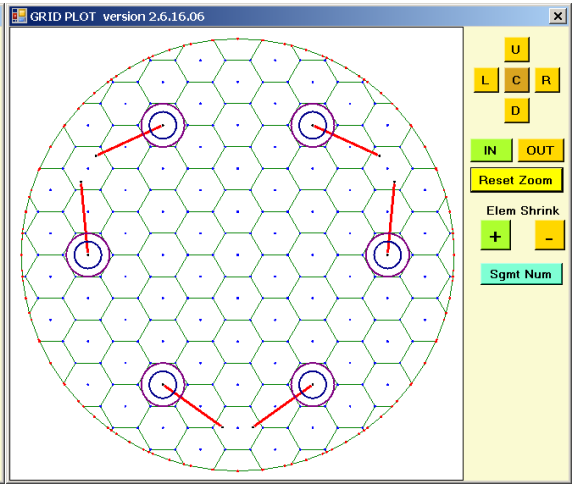
All it takes is checking the appropriate box!



INITIAL POSITION



CENTERED ON INTERSECTION



CENTERED ON CELL CENTER

ACKNOWLEDGEMENTS

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

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)

HabEx Trade Studies

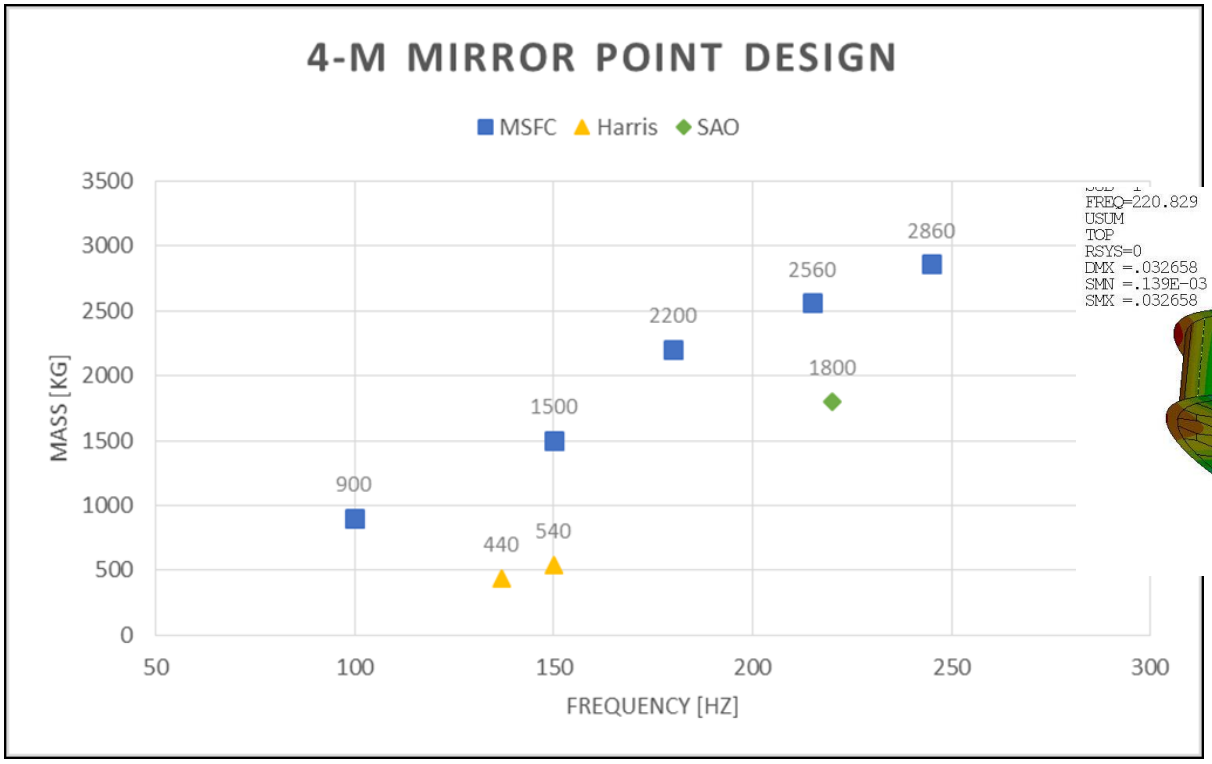
Jacqueline Roche
NASA Marshall Space Flight Center
Huntsville, Al. USA 35806

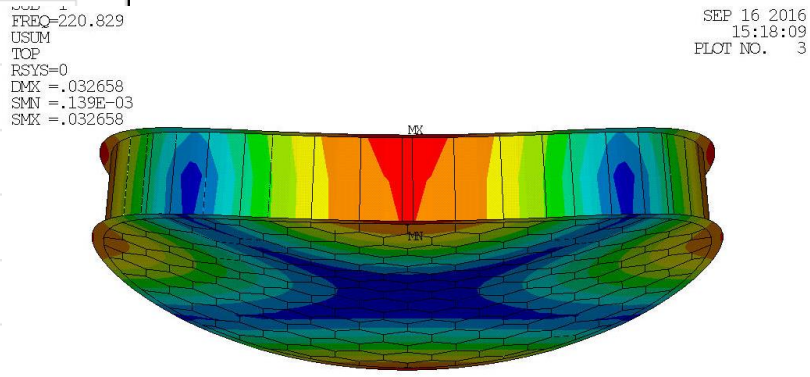
NASA Mirror Technology Days 2016

HabEx 4-m Mirror Trade Studies

AMTD has produced multiple 4-m Point Designs

- Harris Corporation explored lower limit of mass.
- MSFC explored range of higher mass, more robust designs.

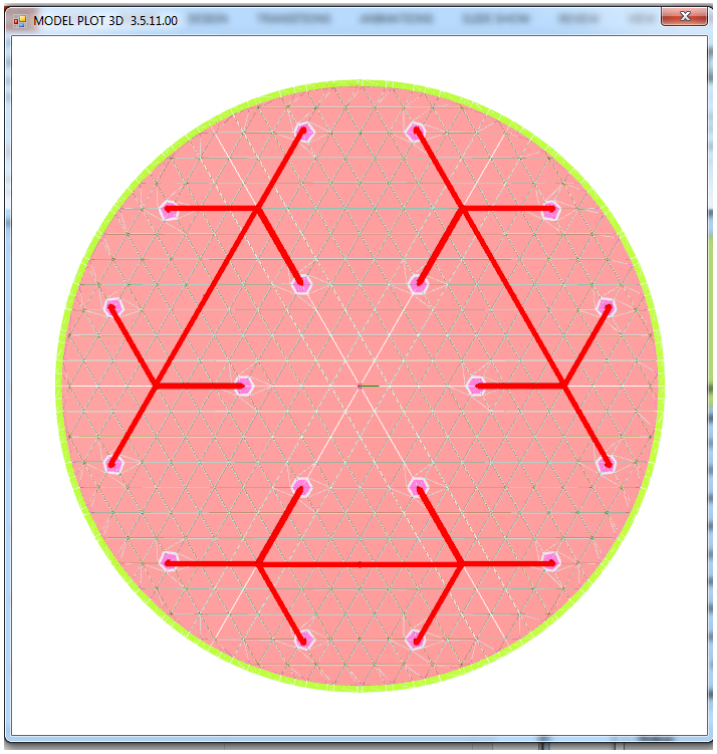


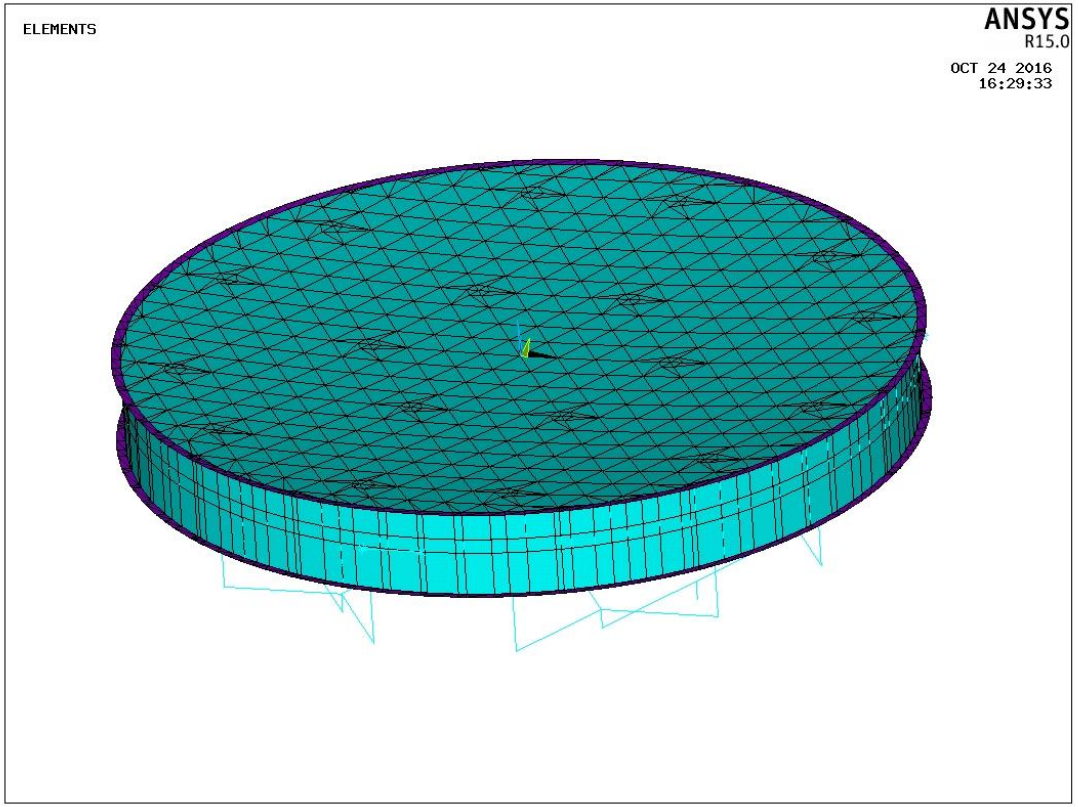


HabEx 4-m Mirror Trade Studies

depth (m)	0.4	0.45	0.6	0.75
mass (kg)	980	2200	2475	2860
cell size (m)	0.167	0.167	0.167	0.167
front fs (m)	0.013	0.0277	0.028	0.0277
back fs (m)	0.013	0.0231	0.023	0.0231
1st mode (Hz)	110	180	215	245
3-point Vertical Gravity Sag [um]	11.77	9.73	7.28	5.41
6-point Vertical Gravity Sag [um]	4.30	3.49	2.63	1.97
9-point Vertical Gravity Sag [um]	2.83	2.47	1.39	1.39
18-point Vertical Gravity Sag [um]	1.40	1.12	1.00	0.80

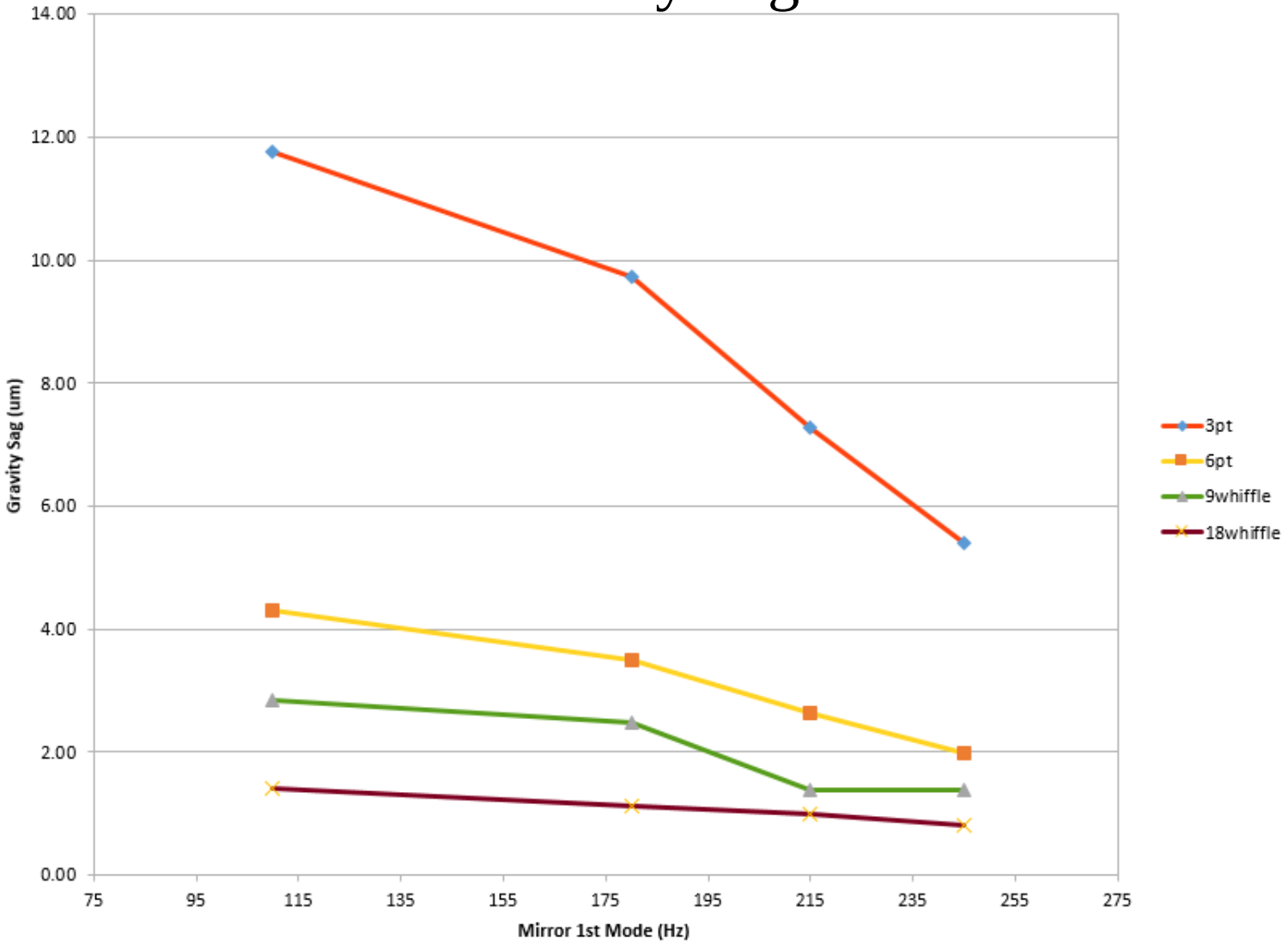
HabEx 4-m Mirror Trade Studies





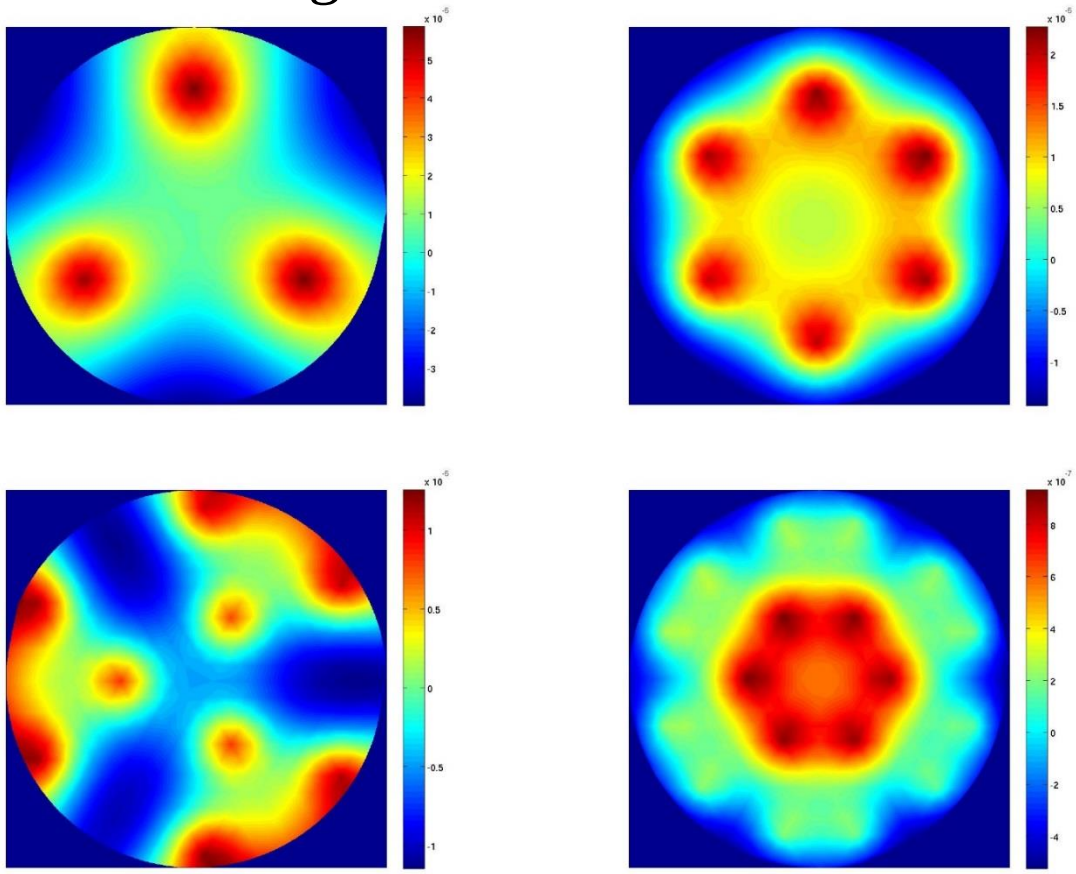
HabEx 4-m Mirror Trade Studies

Gravity Sag



HabEx 4-m Mirror Trade Studies

Gravity Sag – Piston & Tilt
Design 2: 180Hz 1st mode



Gravity Sag of 9-point and 18-point mounts can be reduced by adjusting the cell sizes to optimize mount pad locations.

Conclusions

Continuing improvement of Arnold Mirror Modeler for rapid design of mirror substrates and support systems to enable point design trade studies.

Using AMM for HabEx Trade Studies

Expecting first ‘Release’