AMSD Modeling and Analysis

Overview by Ramona Cummings (NASA MSFC)

MSFC Team:

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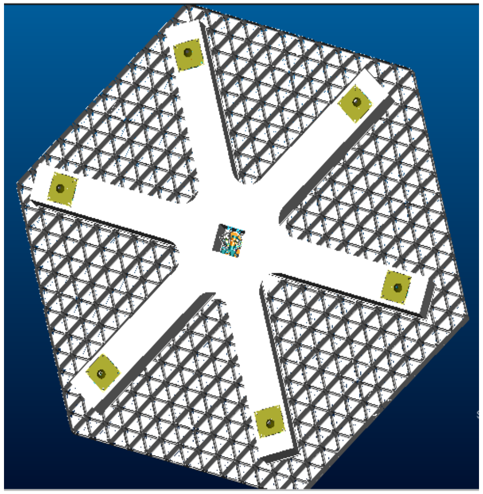
Steve Sutherlin (Raytheon), Todd Cline (SvT), Bruce Peters (Schafer)

Consultant: Lester Cohen (SAO)

AMSD Modeling and Analysis

“ 3 ” AMSD Concept Designs:



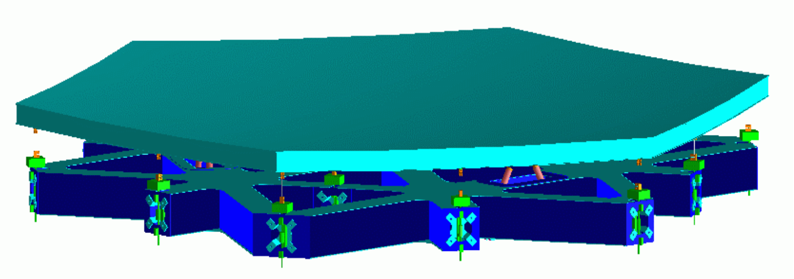
Concept 1

Beryllium Mirror;
1st Composite Concept(M55J/954-3)
7 actuators (3 tip/tilt/piston actuators
+3 simulators on arms, 1 ROC actuator at center)

Concept 1 R

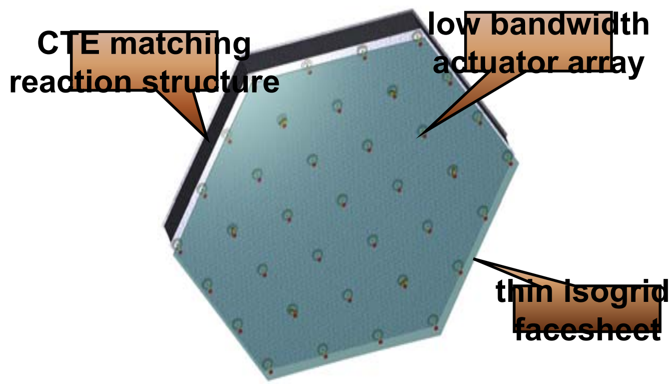
Beryllium Mirror;
1st Composite Concept(M55J/954-3)
3 bipod actuators (tip/tilt/piston) on strongback,
1 ROC actuator at center tied to bi-pods not RS

+ Concept 1 R alternatives



Concept 2 (AC U 2C 19)

ULE Mirror;
2nd Composite Concept (M55J/954-3);
16 soft force actuators, 3 bi-pods for displacement



Concept 3

Glass (Fused Silica) Mirror;
3rd Composite Concept (M55J/954-6);
37 actuators (31 axial force and
6 bi-pod displacements)

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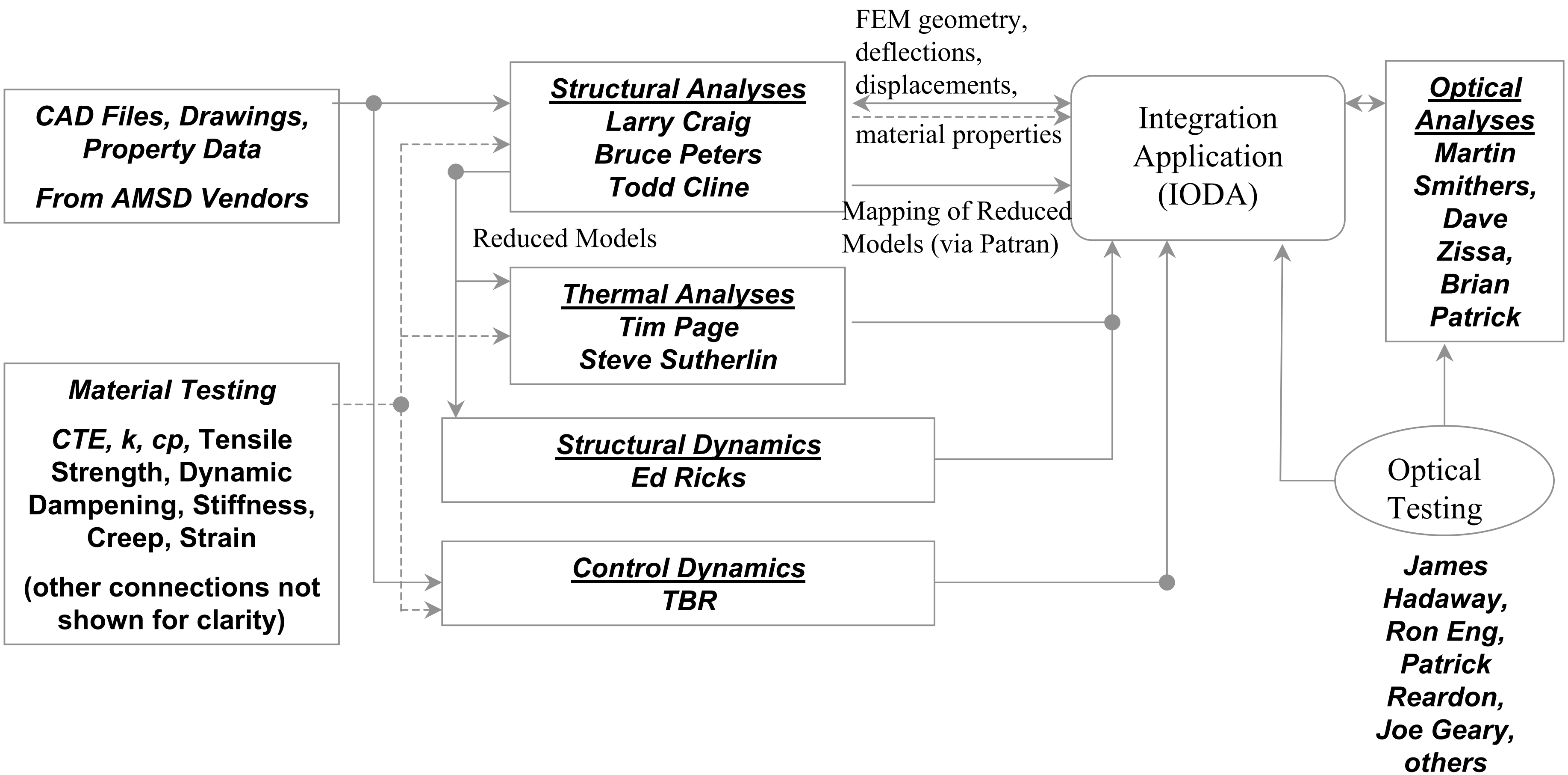
Concept	Simulated Items: Mirror	Reaction Structure	Strong Back	Actuators	Flexures	Vendor Test Fixture	Material Properties at 35 K
1 R (Ball Redesign)	Per Design Dwgs (before acid etch decision)	n/a	Preliminary, sketch info only	Per B/L Design Dwgs so needs insert changes	need updated design	vendor has not released	Extrapolated properties
2 (Kodak)	Per Design Dwgs	Per Design Dwgs	n/a	Per verbal information	Buckling Analysis but no info on varied physical size	vendor has not released	Some extrapolated properties; rest missing
3 (Goodrich)	Per As-Built and Fab'd dwgs and info	Per As-Built and Fab'd dwgs and info	n/a	Per Design Dwgs	Per Design Dwgs	Preliminary Version (Feb 02)	Extrapolated properties

Red	No suitable information has been received from vendor
Yellow	Only preliminary information has been received from vendor; If design drawings, as-built/as-finished data not yet released from vendor
Green	All known as-built and as-finished data received from vendor

AMSD Modeling and Analysis



AMSD Modeling and Analysis

- MSFC, Vendor, and Consultant Teams use a variety of analyzers on AMSD, including
  - *Optical Modeling*
    - CodeV, ZeMax, IDL
  - *Structural Modeling*
    - Nastran, Algor, Ansys, Patran
  - *Thermal Modeling*
    - SINDA, TRASys, Thermal Desktop, TSS, TAK, NEVADA, Nastran
  - *Dynamics Modeling*
    - Patran

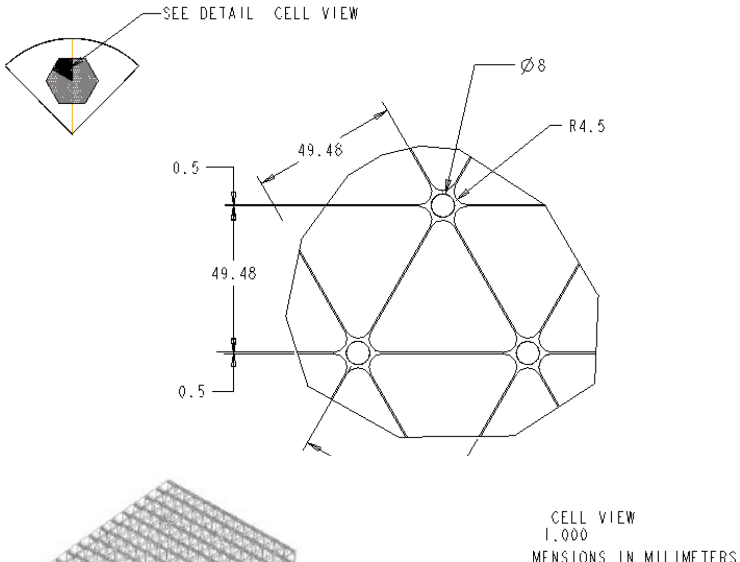
AMSD Modeling and Analysis

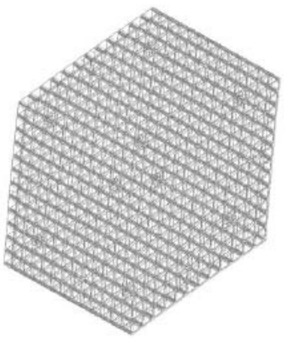
- **With the variety of tools used, <u>results</u> rather than models must be compared**
- **Therefore, specific model verifications and validations with test correlations are required**
  - ***These are as proposed in AMSD Modeling Comparison Plan***
    - **draft of May 3, 2002 in review with SAO/Lester Cohen**
    - **final due June 7, 2002**
  - ***Three reviews (schedule TBR) to present and evaluate analytical predictions***
    - **Late June on all entity and assembly Verifications**
    - **Late July or early August on all currently identified Validations**
    - **Late August or Mid-September for added Validations and additional test correlations**

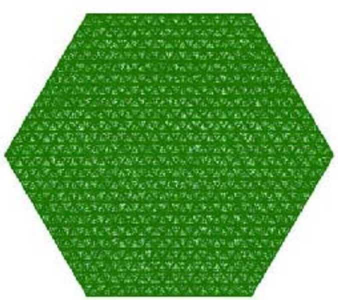
AMSD Modeling and Analysis

- **Model Verifications include**
  - *Conservation of Mass throughout Analyses*
  - *Structural Analyses*
    - Rigid Body Error Check
    - Free Body Error Check
    - Uniform Thermal Soak with Same CTE
  - *Thermal Analyses*
    - Energy Balance, Temperature Convergence, Unity Form Factor Sums
    - Simple Gradient
    - Uniform Flux
  - *Optical*
    - RMS, PV, and PSF verifications of idealized model
    - Optical Checkout of idealized model with well defined aberrations
  - *Dynamics*
    - Modal run for first five out of plane displacements, mirror unconstrained

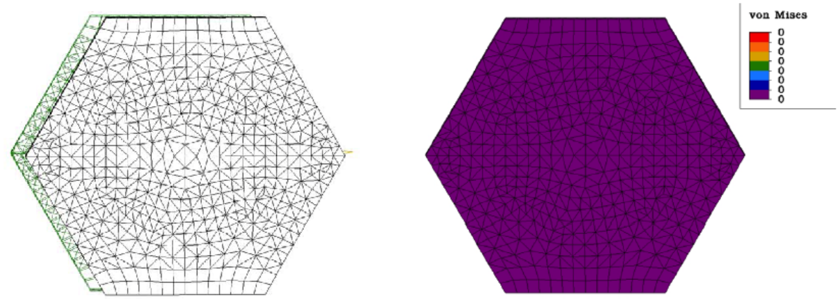
AMSD Modeling and Analysis







Ball AMSD Mirror Model
Fixed Displacement

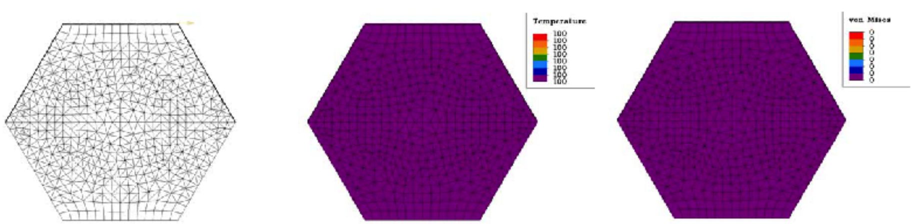


X Fixed Displacement 30mm

No Stress Evident

- **Comparable results for X,Y, and Z**
- **No gaps or irregular connections**

Ball AMSD Mirror Model
Uniform Thermal Soak

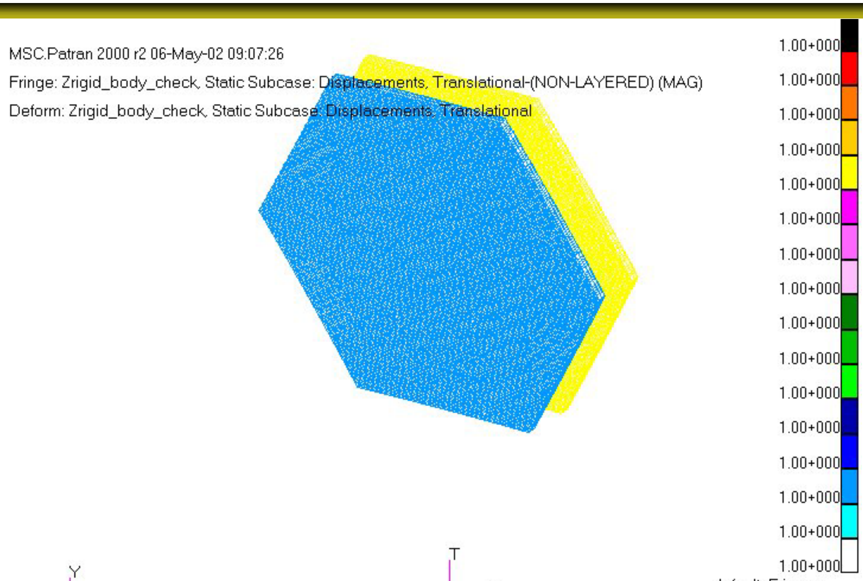


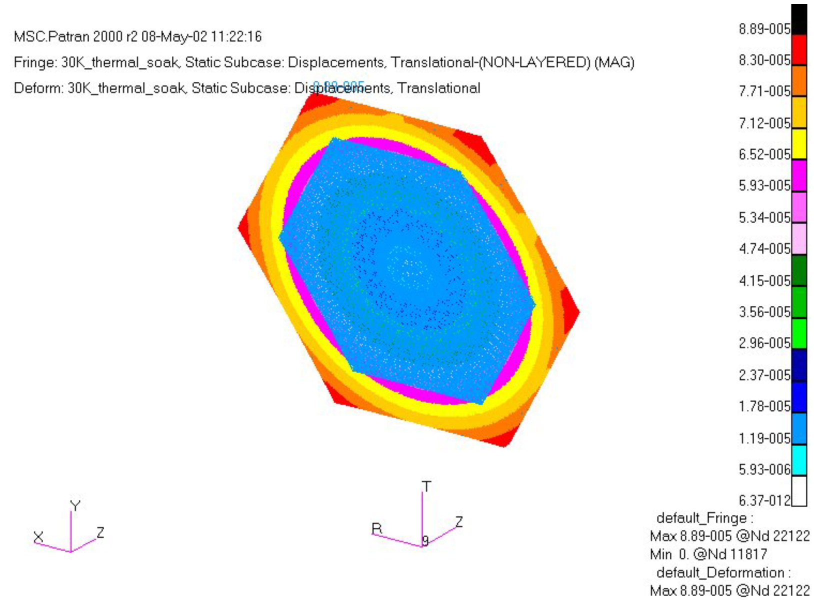
Temperature Lowered From 273 K (20°C) to 100 K

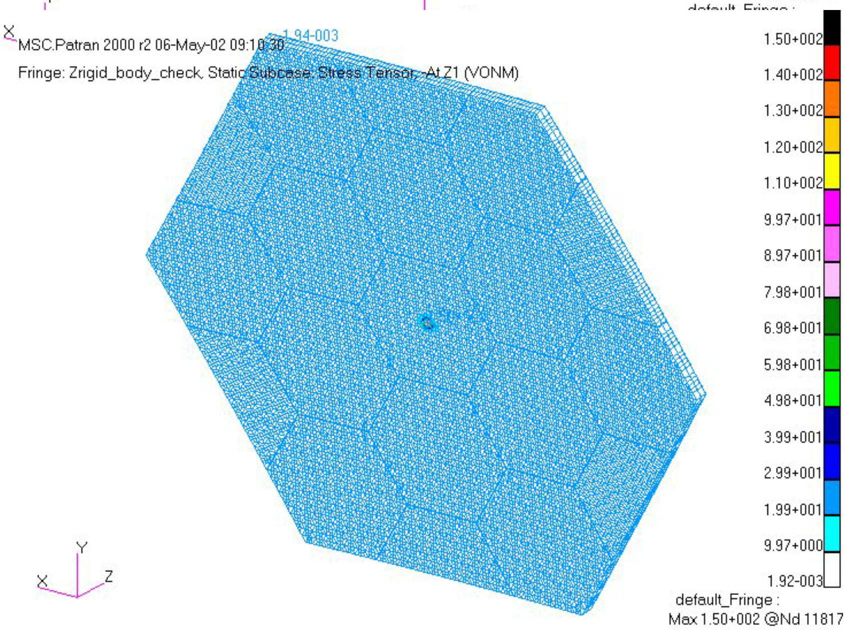
No Stress Evident

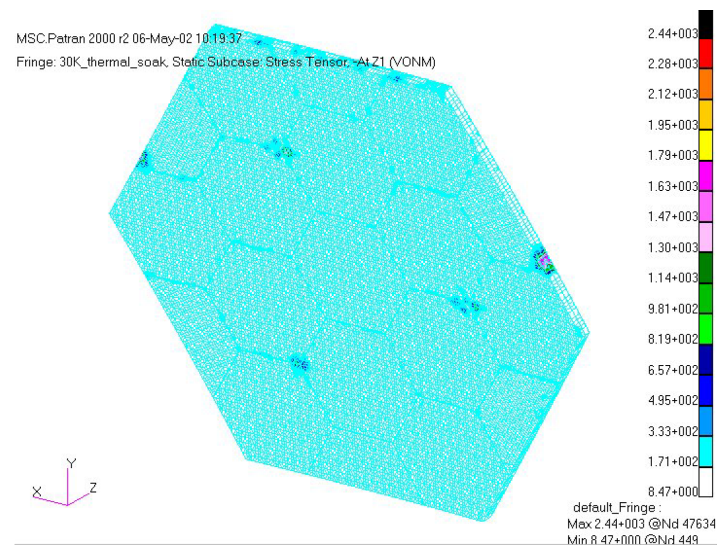
- **Confirmed uniform mirror material properties**

AMSD Modeling and Analysis

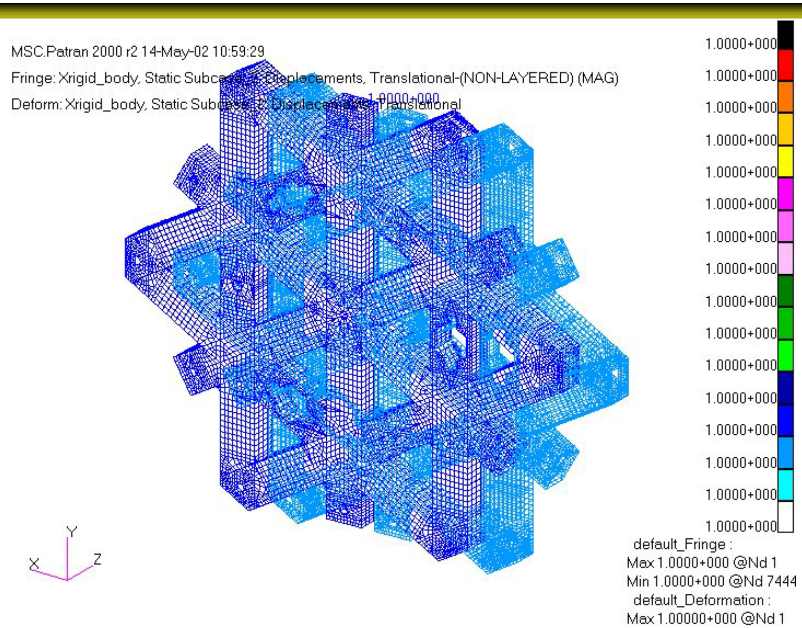


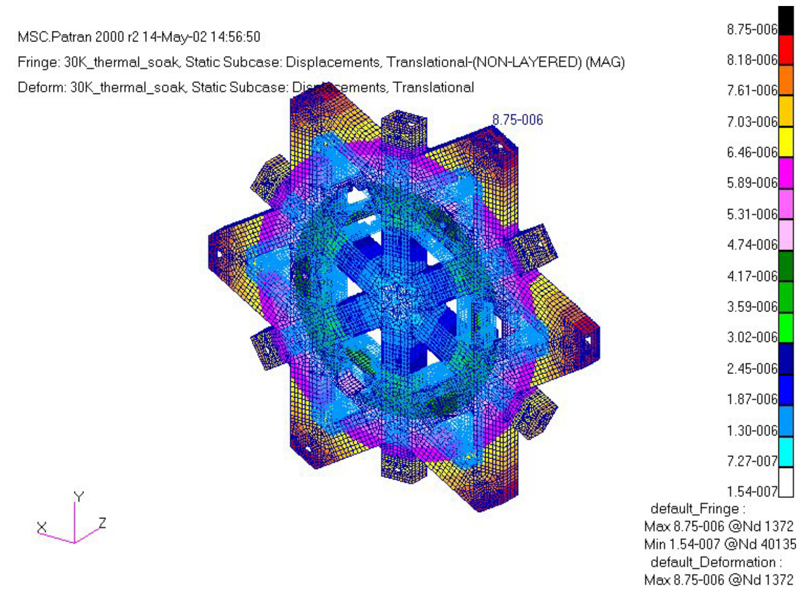


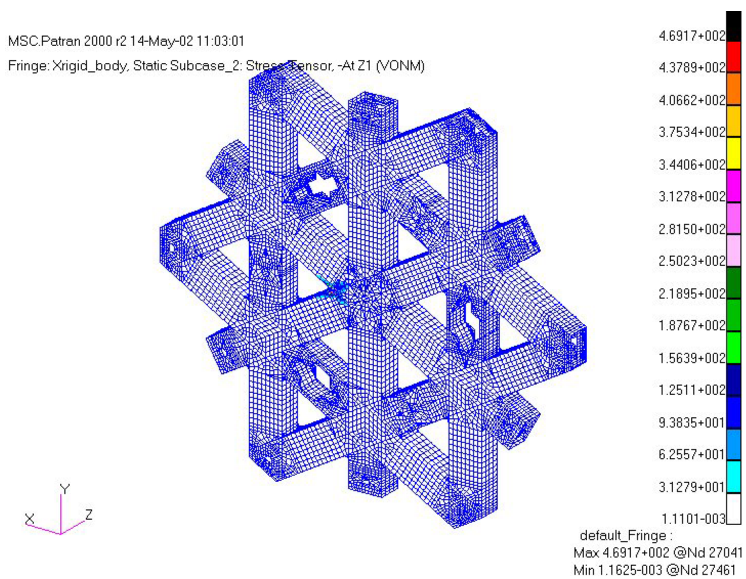


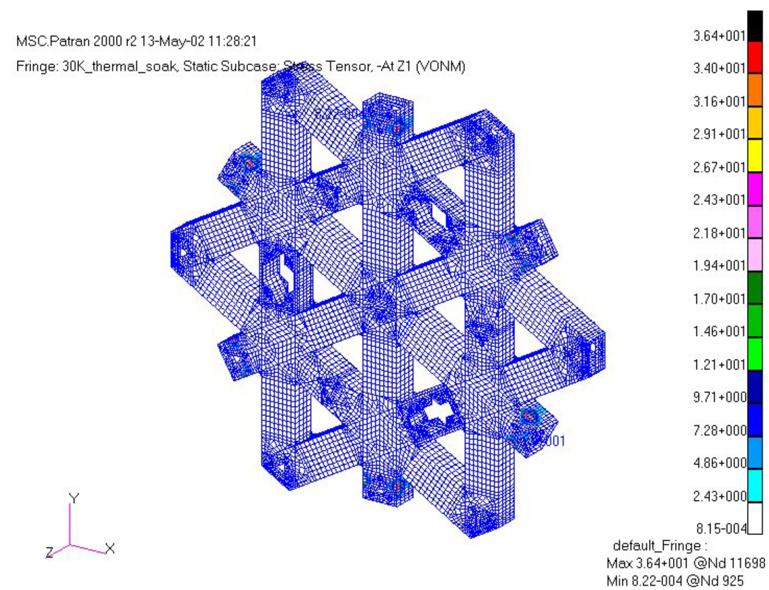


AMSD Modeling and Analysis



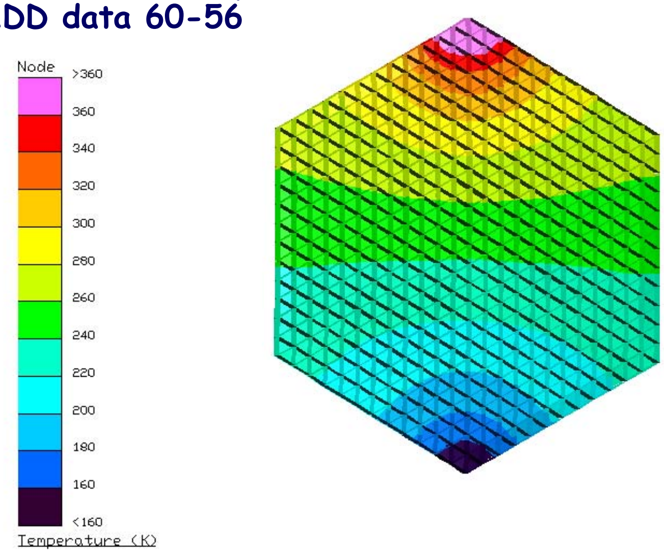


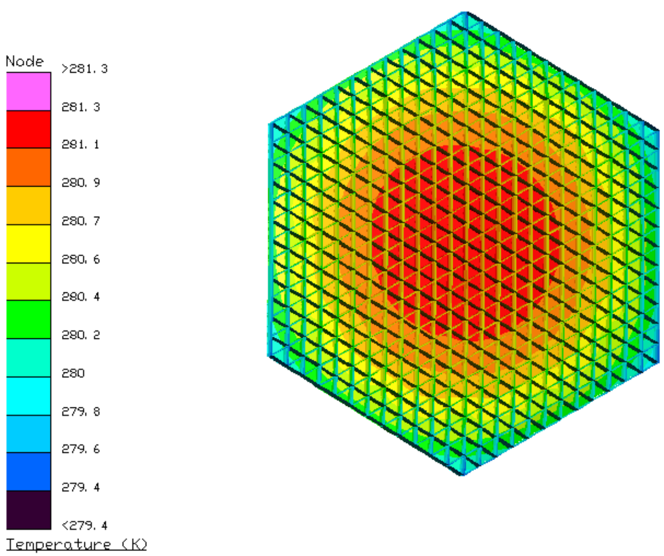




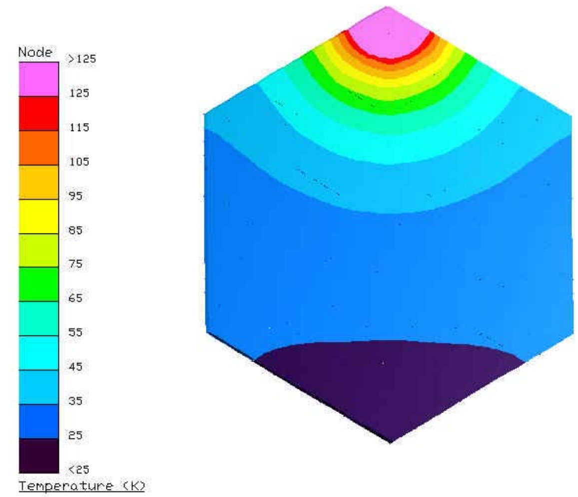
AMSD Modeling and Analysis

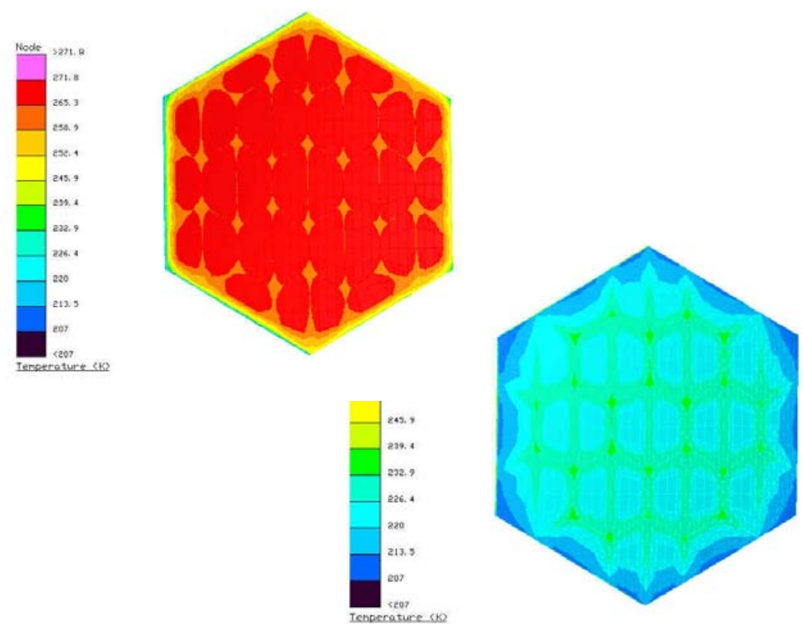
–Ball Model Thermal Verifications
– uses WADD data 60-56





–Kodak Model Thermal Verifications





AMSD Modeling and Analysis

Validation Use of Models include:

- **Static 1g Load on Mirror aligned to Optical Axis**
  - *Run on the AMSD mirror only, by simply supported edge and by three point support*
    - Determine deflection results caused by the self-weight gravity induced sag
    - Should yield symmetrical results for any AMSD mirror
  - *Compare FE results to contractor interferograms*
- **Static 1g Load on Mirror normal to Optical Axis**
  - *Run analysis of the AMSD mirror only, support by three point mount*
    - Look at reasonableness of deflection results caused by the self-weight gravity induced sag
    - Astigmatism and considerable deformation at the mounting points is expected
    - Symmetry of the mirror should preclude need to rotate mirror
  - *Compare data collected during mirror fab and polishing to FE results*
  - *Compare FE results to data collected in the XRCF ambient tests*

AMSD Modeling and Analysis

(Validation Use of Models, continued)

- Static 1g Load on Mirror Assembly mounted normal to Optical Axis
  - *Run analysis of the AMSD mirror assembly (reaction structure, actuators) in the designed support fixture*
    - Determine deflection results caused by the self-weight gravity induced sag
    - Some astigmatism and deformation at the mounting points is expected
    - Symmetry of the mirror should preclude need to rotate mirror
  - *Compare FE results to data collected in the XRCF ambient tests and to required contractor FE results*
- Backed out static gravity sag on Mirror Assembly mounted normal to OA
  - *Run analysis of the AMSD mirror assembly in the designed support fixture with actuator reactions fully backing out effects of gravity on the mirror*
    - Compare FE results to test data collected at the XRCF when the actuators are activated for mirror figure correction
    - FE models should yield a residual RMS surface error comparable to the measured residual surface RMS error

AMSD Modeling and Analysis

NGST

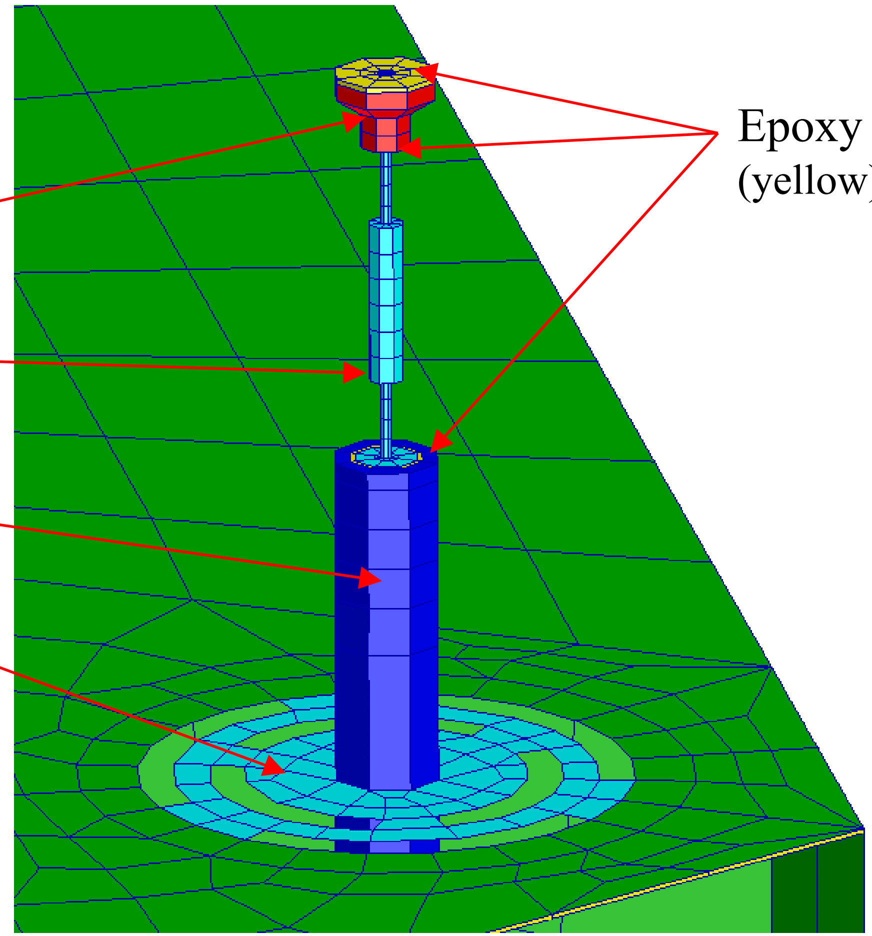
(Validation Use of Models, continued)

- Actuator Influence Functions
  - *Run analysis on the displacement of each actuator attachment point*
  - *Determine set of actuator influence functions*
- Mirror Light-weighting effect on surface figure map, Strehl Ratio, and EE
- Line of Sight Stability at 80 K, 55 K, and 35 K
  - *Run analysis of AMSD mirror assembly in the designed support fixture before and after actuator correction for listed stabilized temperatures*
    - Compare FE results to test data collected at the XRCF
- Line of Sight Stability at induced thermal gradients
  - *Run analysis of AMSD mirror assembly in the designed support fixture before and after actuator correction at TBR induced thermal gradients*
    - Compare FE results to test data collected at the XRCF
- Dynamic Analysis of disturbances on AMSD mirror assembly
  - *Modal runs for assembly at XRCF ambient then cryo test with chamber and table forcing functions*

AMSD Modeling and Analysis

Goodrich Axial Actuators

Total of 10 Axial Actuators



Epoxy Joints
(yellow)

Fused Silica

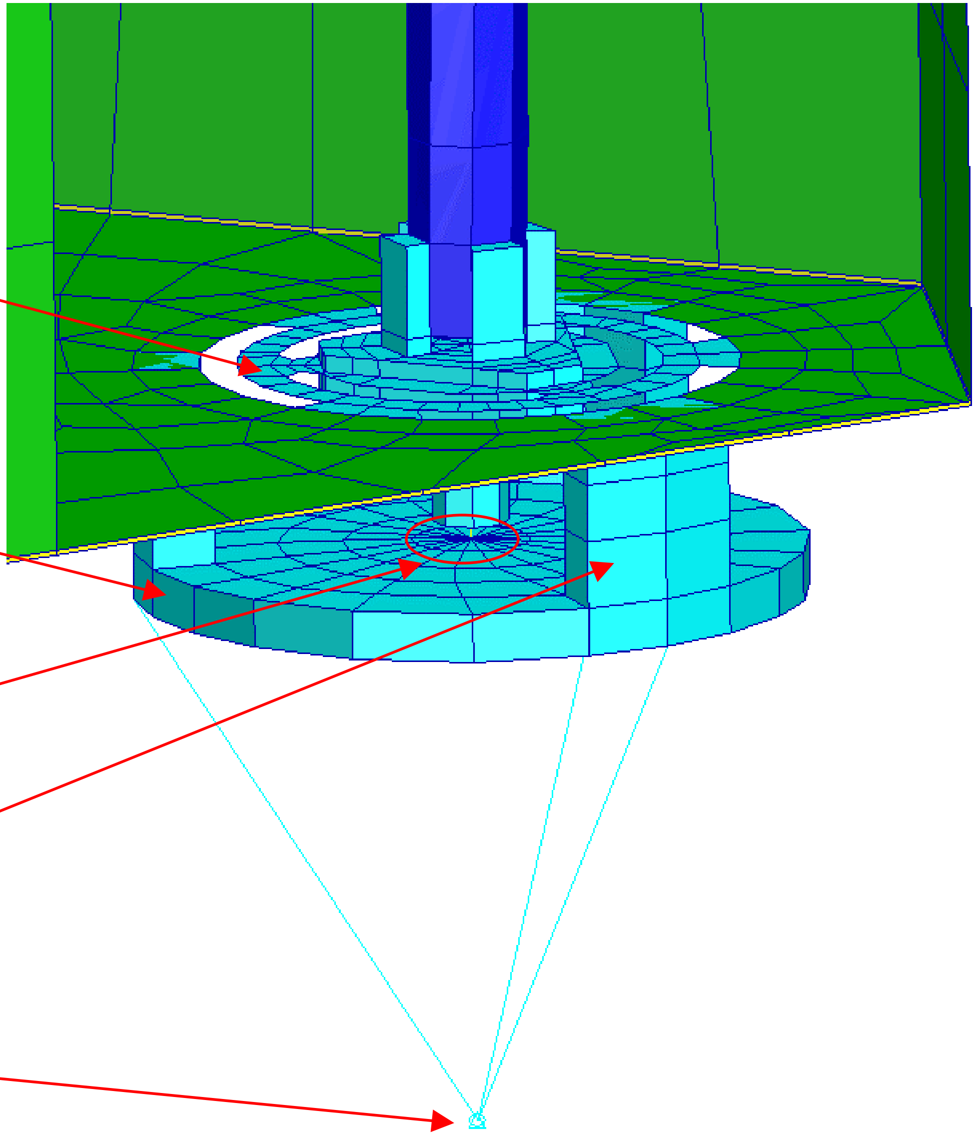
Titanium - (0.635mm and
2mm diameter)

M55J composite tube

Titanium - 0.25mm thick bonded
to face sheet (Epoxy not modeled)

AMSD Modeling and Analysis

Goodrich Axial Actuators



Ti - 0.25mm thick bonded
to face sheet (Epoxy not modeled)

Ti disk 2.5mm thick
with zero density (So Actuator
CG will not be affected)

Bar element with 7000lbf/in stiffness
(Temperature gradient applied
will simulate actuator motion)

Ti Actuator Spacers

Point Element at Actuator
CG (157grams)

Pathfinder Bipod Actuators

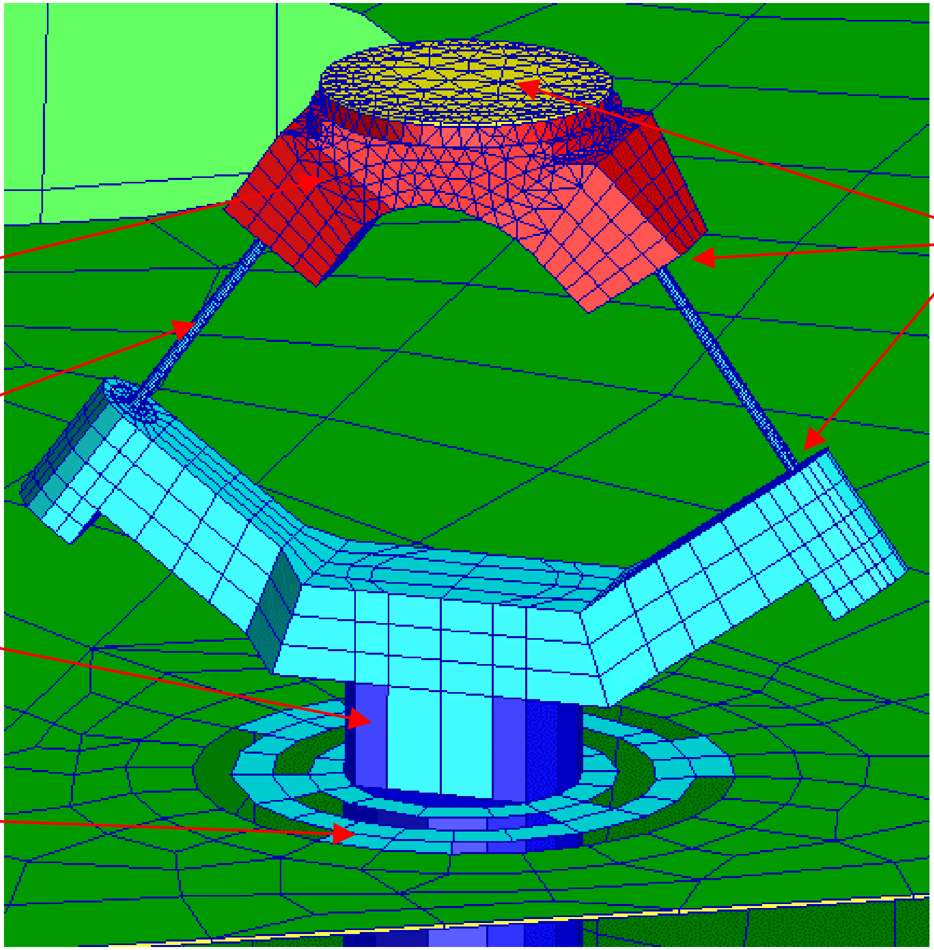
3 Bipod Actuators

Fused Silica

Titanium - (0.634mm diameter)

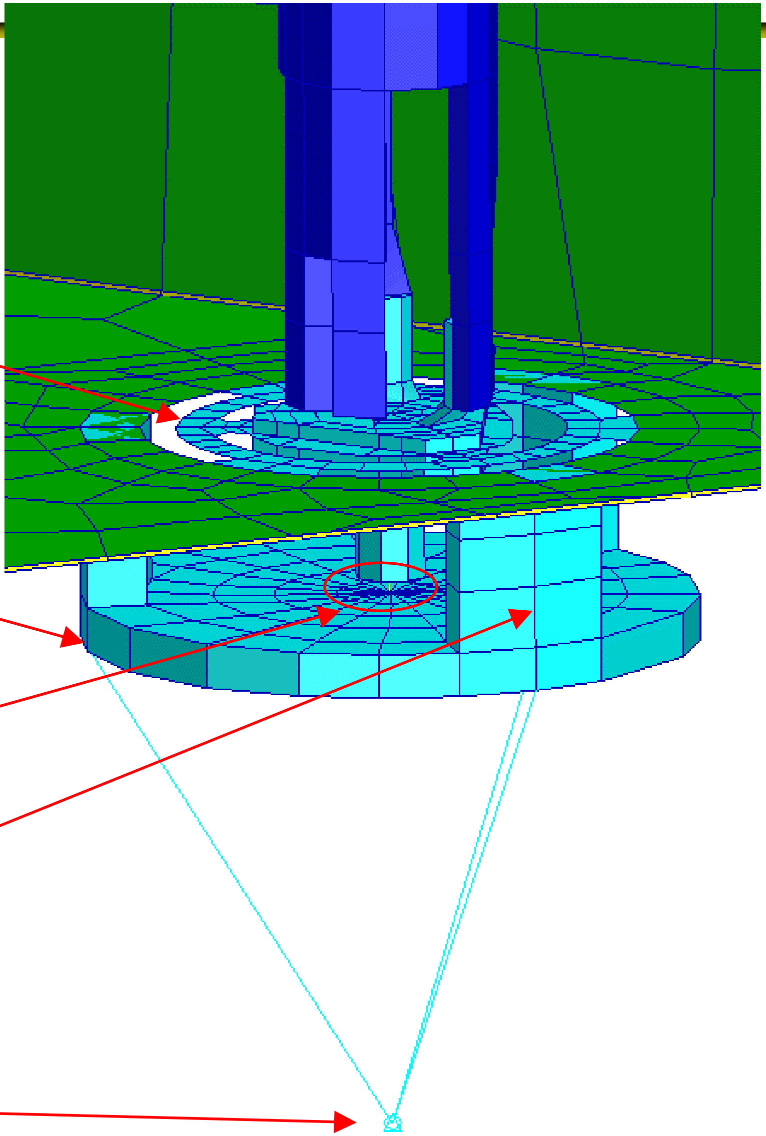
M55J composite tube

Titanium - 0.25mm thick bonded to face sheet (Epoxy not modeled)



Epoxy Joints (yellow)

Pathfinder Bipod Actuators



Ti - 0.25mm thick bonded
to face sheet (Epoxy not modeled)

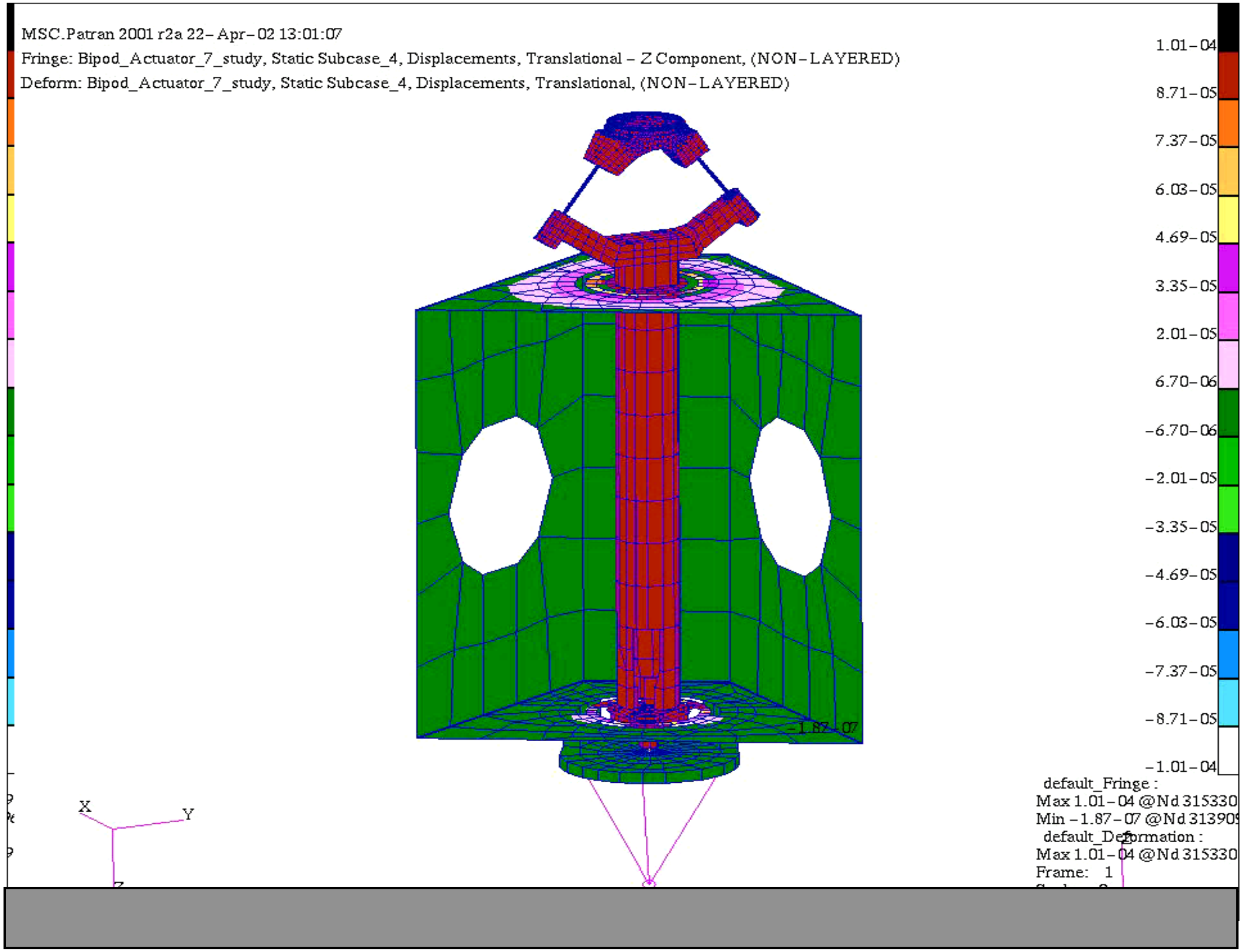
Ti disk 2.5mm thick
with zero density (So Actuator
CG will not be affected)

Bar element with 7000lbf/in stiffness
(Temperature gradient applied
will simulate actuator motion)

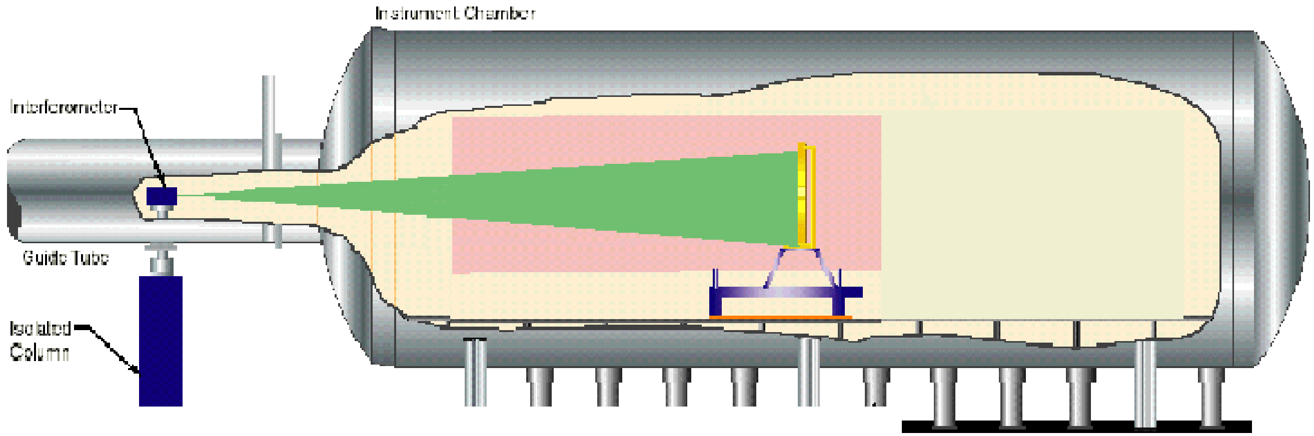
Ti Actuator Spacers

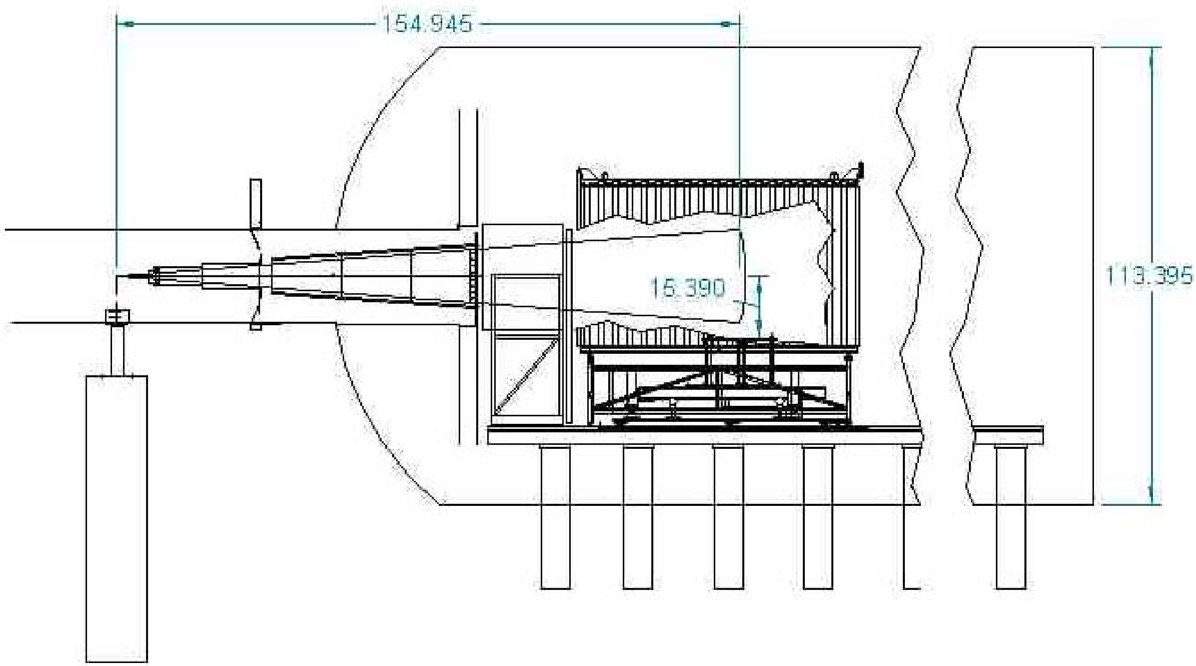
Point Element at Actuator
CG (157grams)

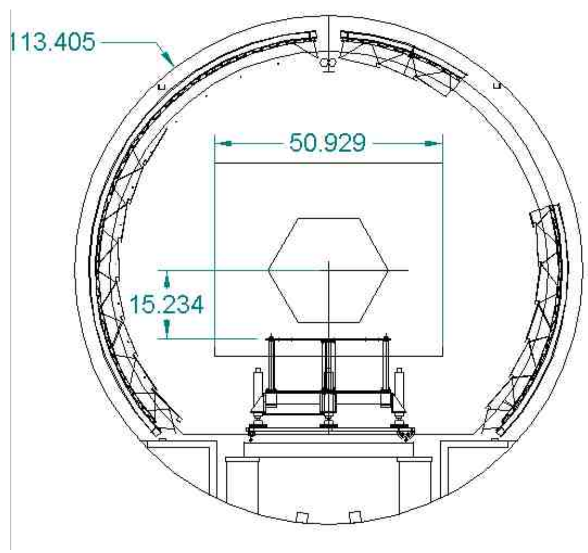
Goodrich Bi-Pod Actuators



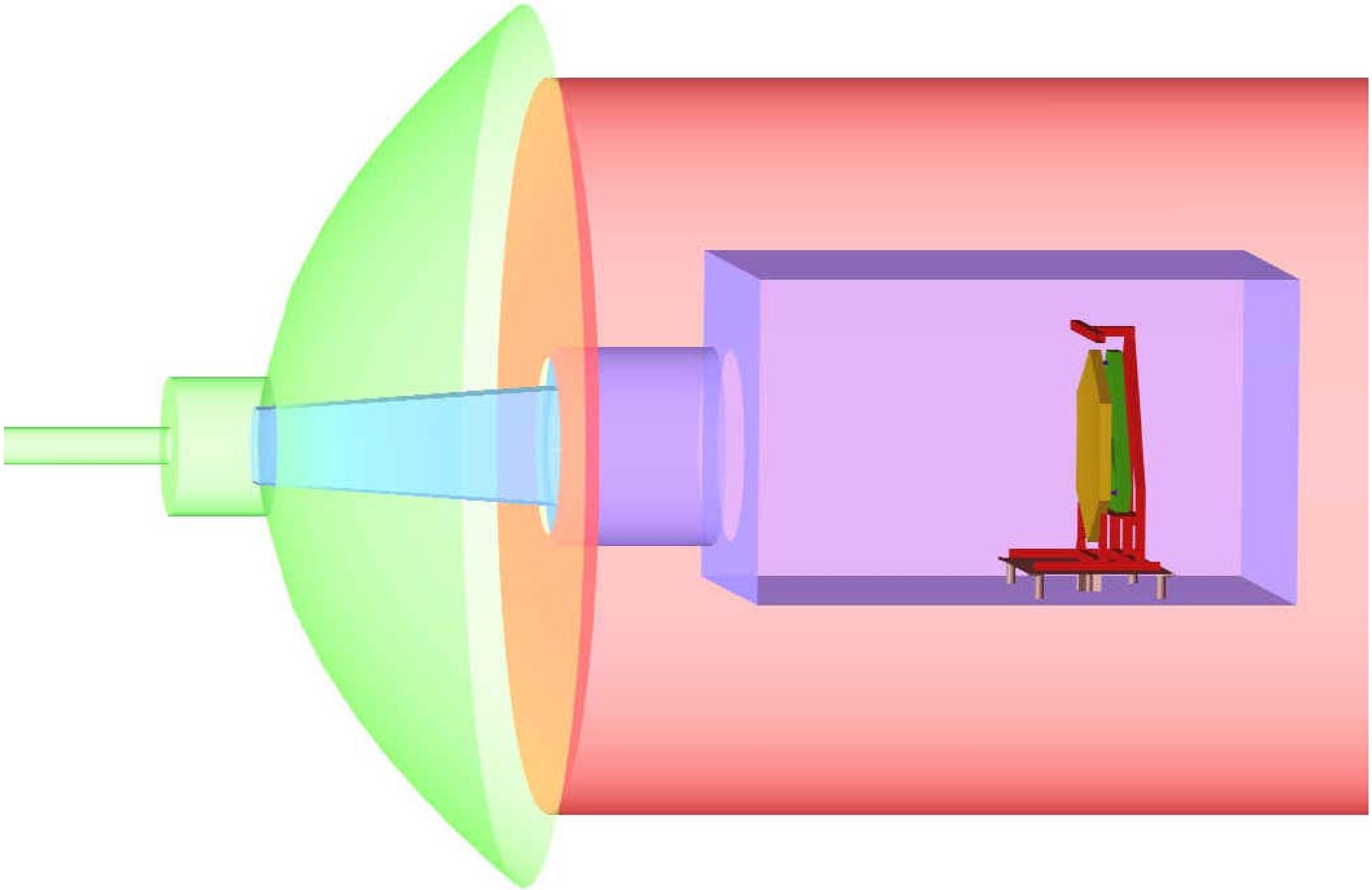
AMSD Modeling and Analysis







AMSD Modeling and Analysis

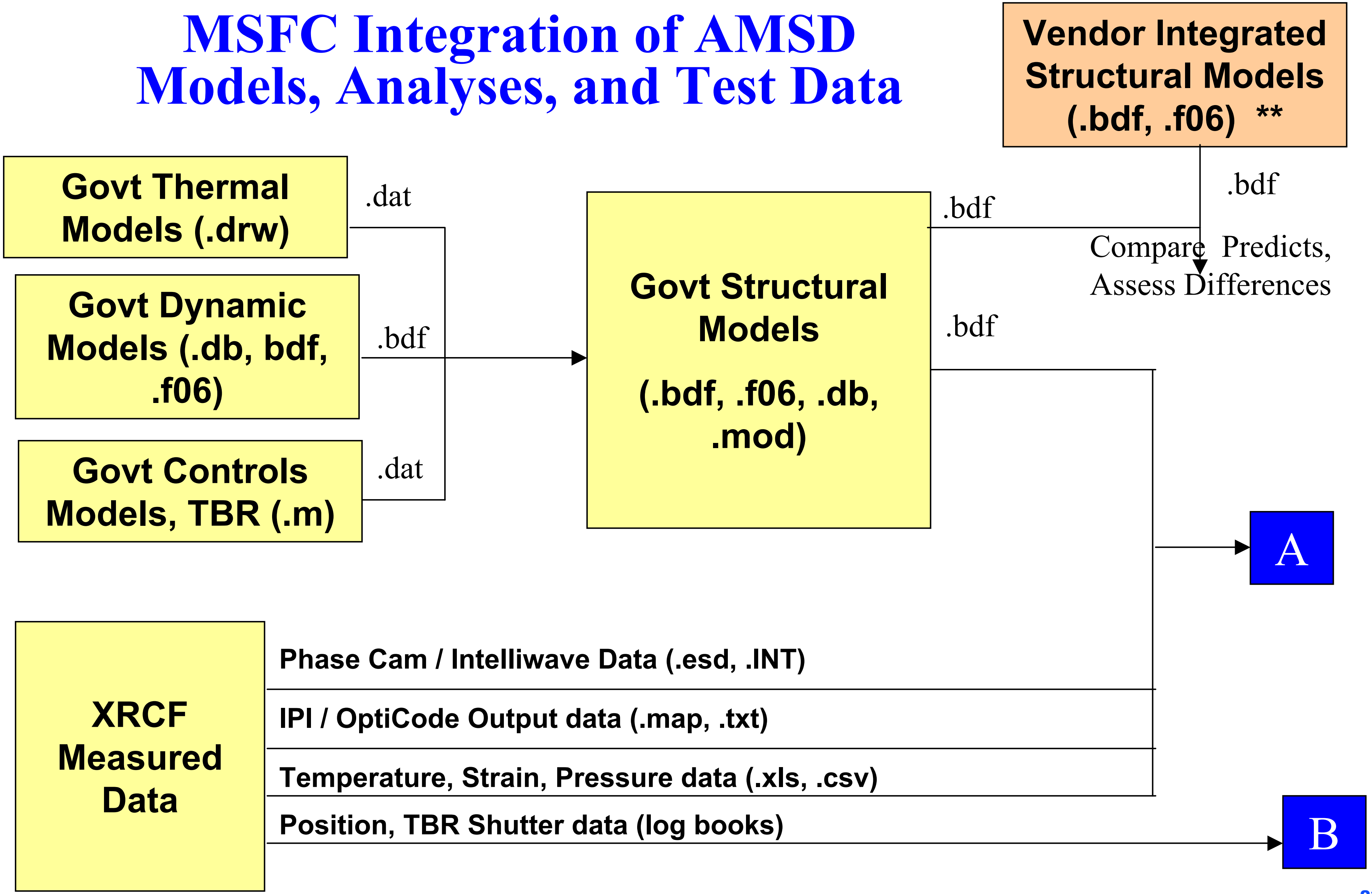


AMSD Modeling and Analysis

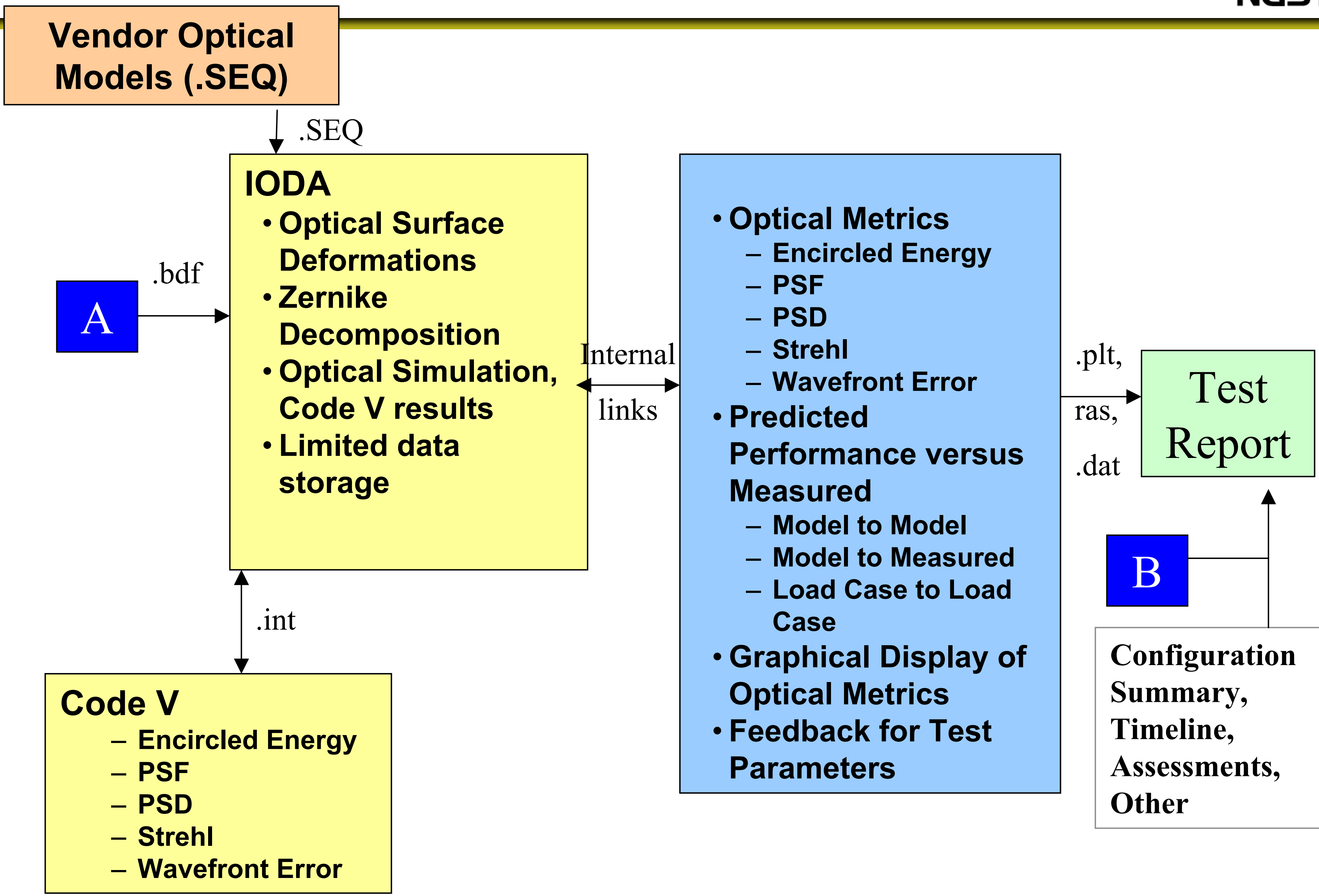
- **Integration tool in use by the MSFC Team is IODA (Integrated Optical Design and Analysis)**
  - *Translations*
    - ANSYS to Nastran
    - Algor to Nastran
    - ZeMax to CodeV
    - Others
  - *Transfer of geometry, displacement, and deformation information to CodeV*
    - Accommodates high fidelity Structural Model (100,000's of elements) to same or reduced size Optical Model
  - *Macro calls to CodeV*
  - *Graphical display of predicted and measured results*

NGST

MSFC Integration of AMSD Models, Analyses, and Test Data



AMSD Modeling and Analysis



AMSD Modeling and Analysis

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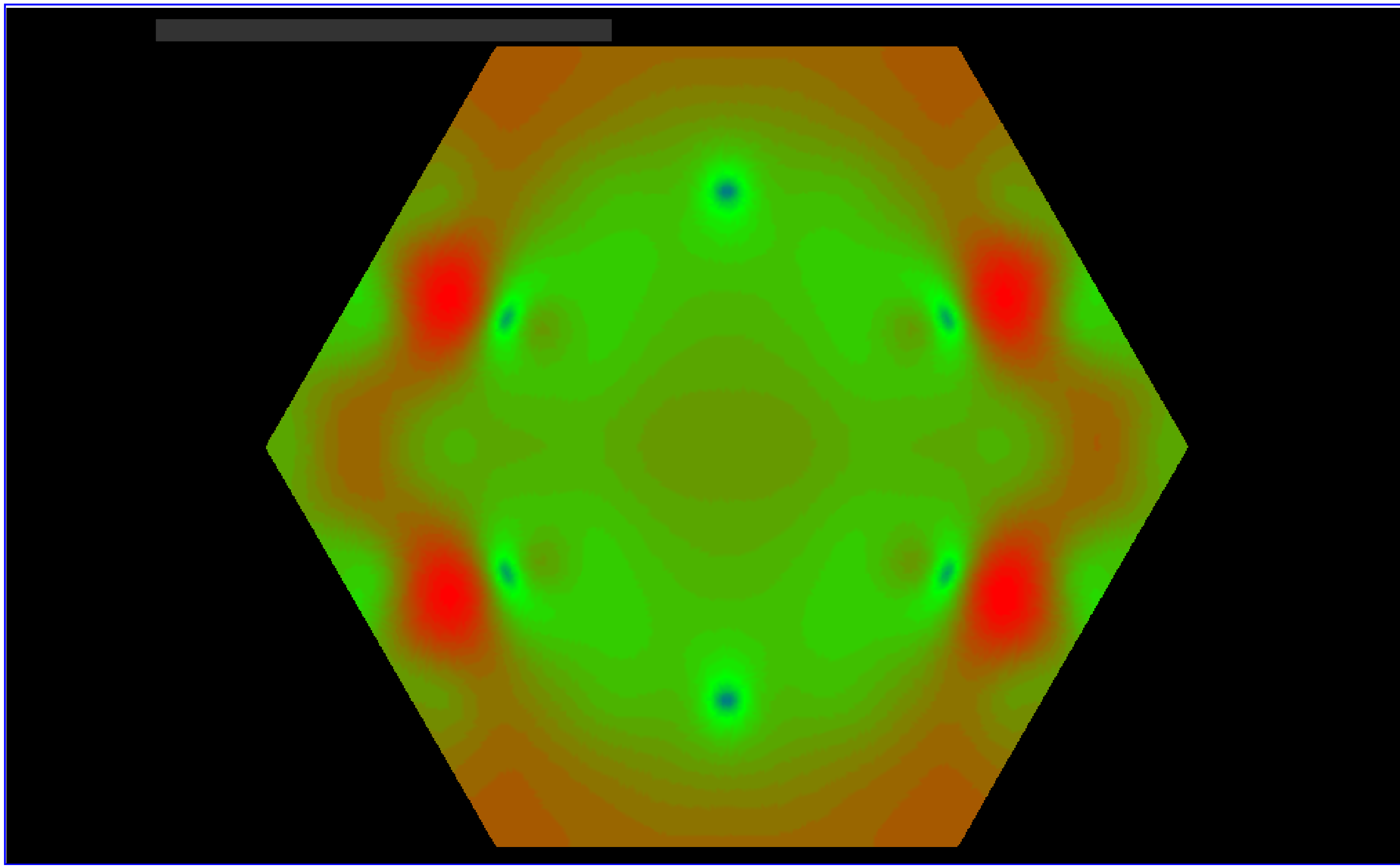
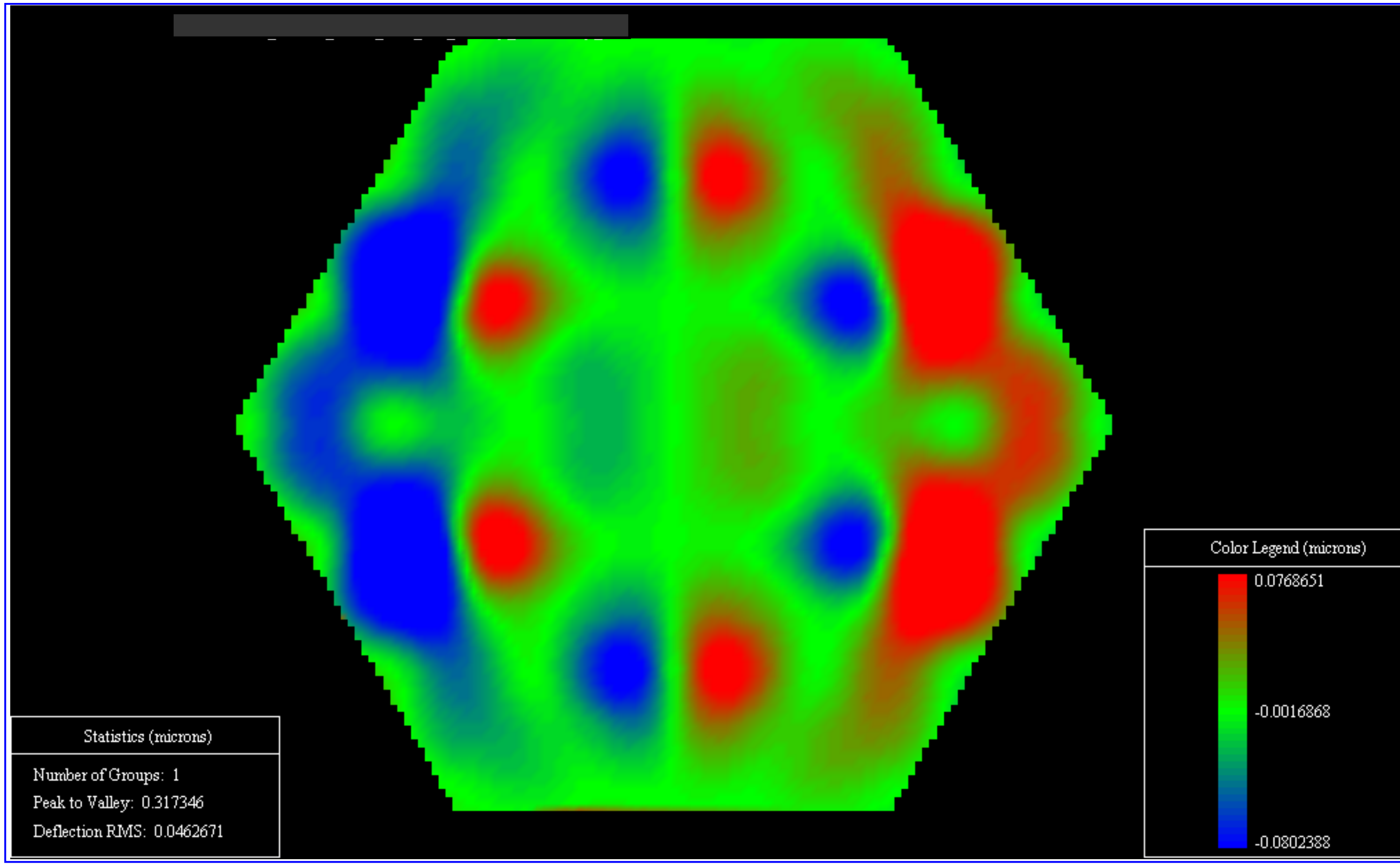
NASTRAN generated Surface Deflections extracted and generated in IODA



AMSD Modeling and Analysis

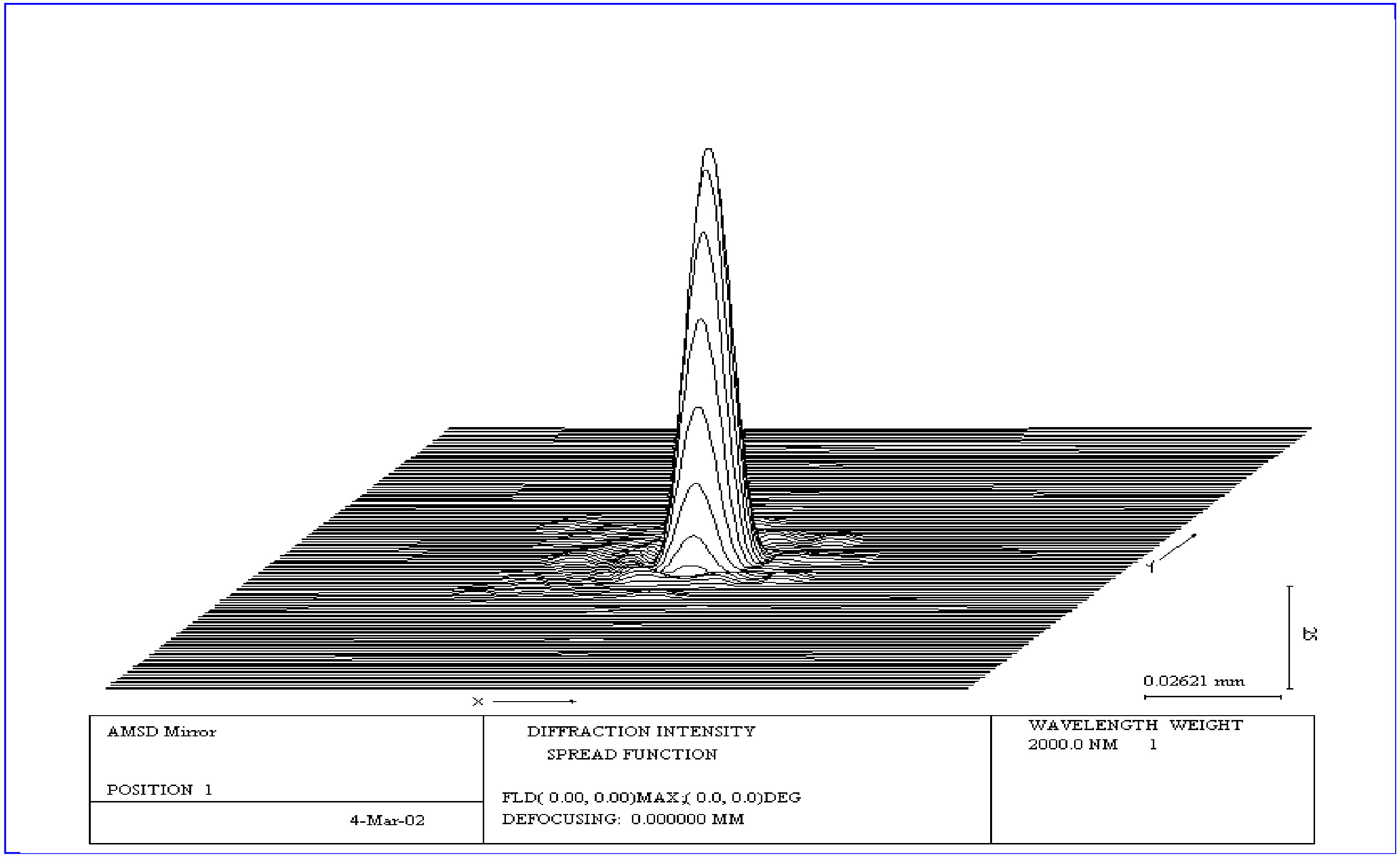
NGST

Code V generated Surface Metrics, extracted and displayed in IODA (PV and RMS)



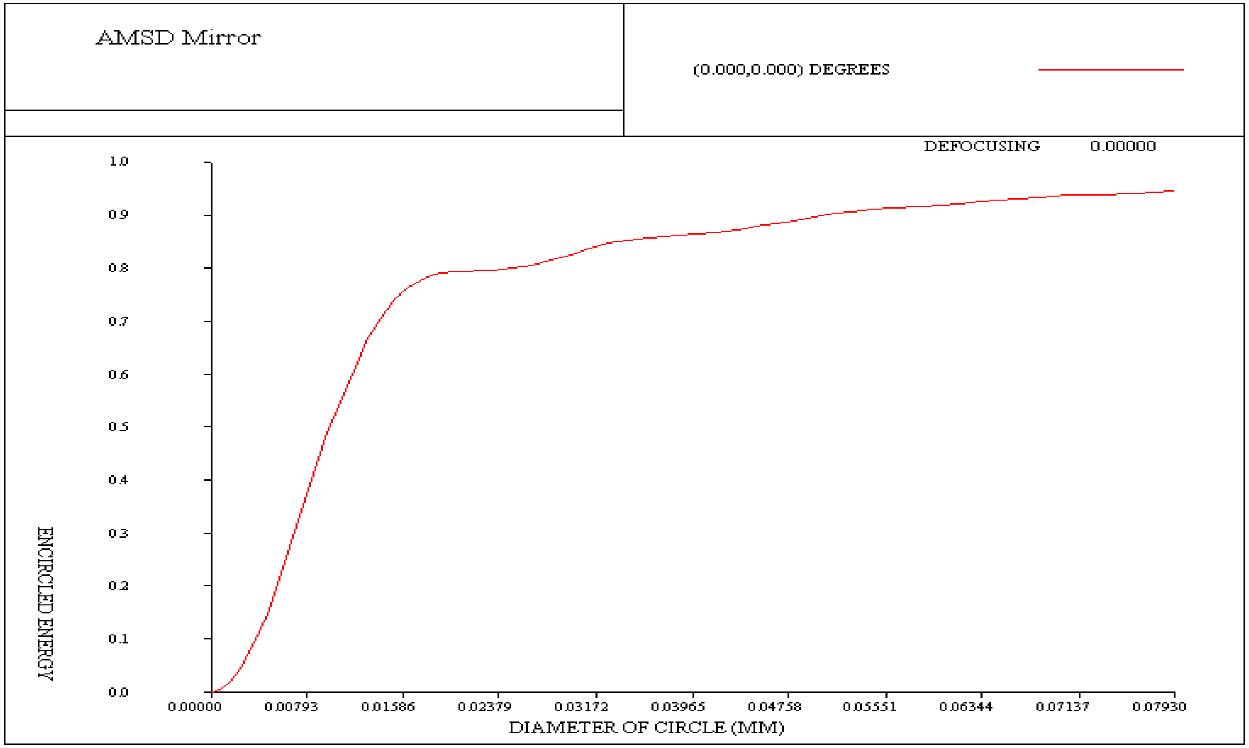
AMSD Modeling and Analysis

Code V generated Strehl Ratio, extracted and plotted using IODA macros (mimics Code V plot format)



AMSD Modeling and Analysis

Code V generated Encircled Energy, extracted and plotted using IODA macros (mimics Code V plot format)



AMSD Modeling and Analysis

Next speaker:

Larry Craig

SBMD Cryo Quilting