

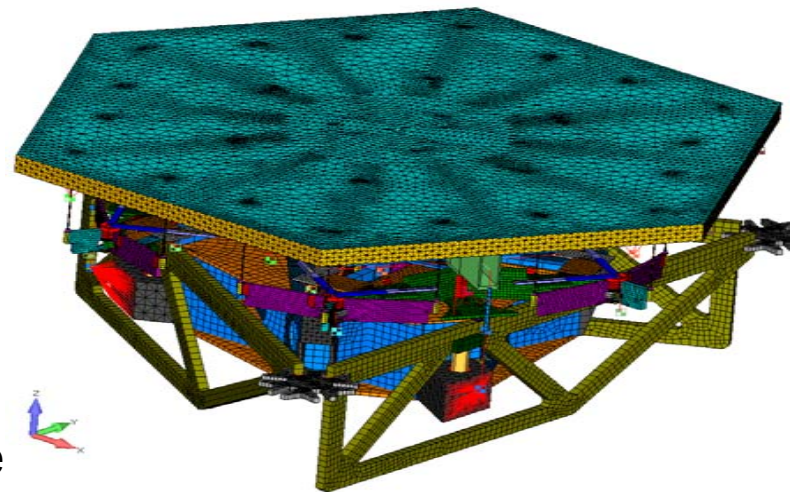
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# Description of TMT Segment Support Assembly (SSA) Finite Element Model

**September, 2009**

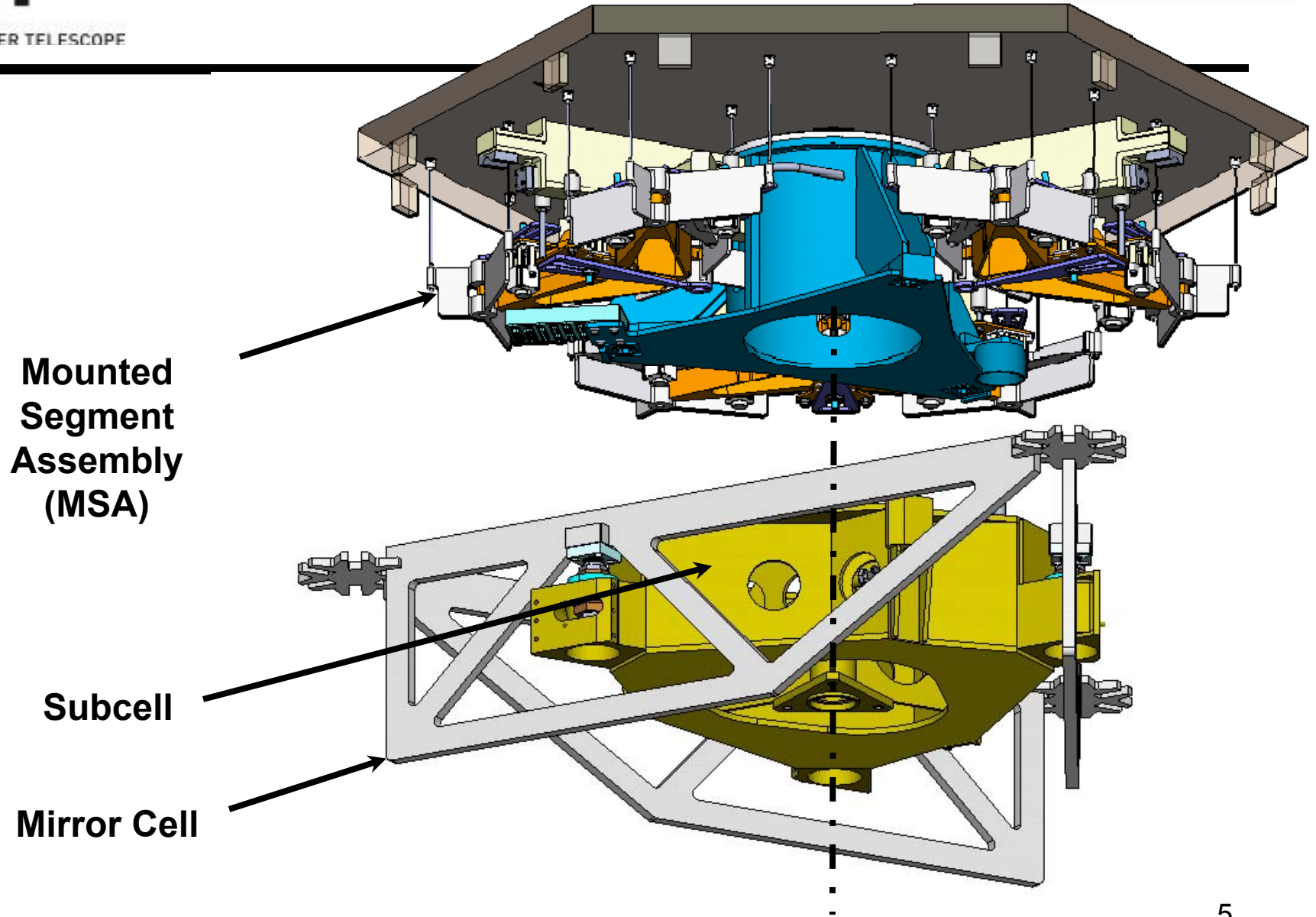
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- ◆ Finite Element Model
    - Model Description
  
  - ◆ Optical Performance Predictions
    - Gravity and thermal unit cases

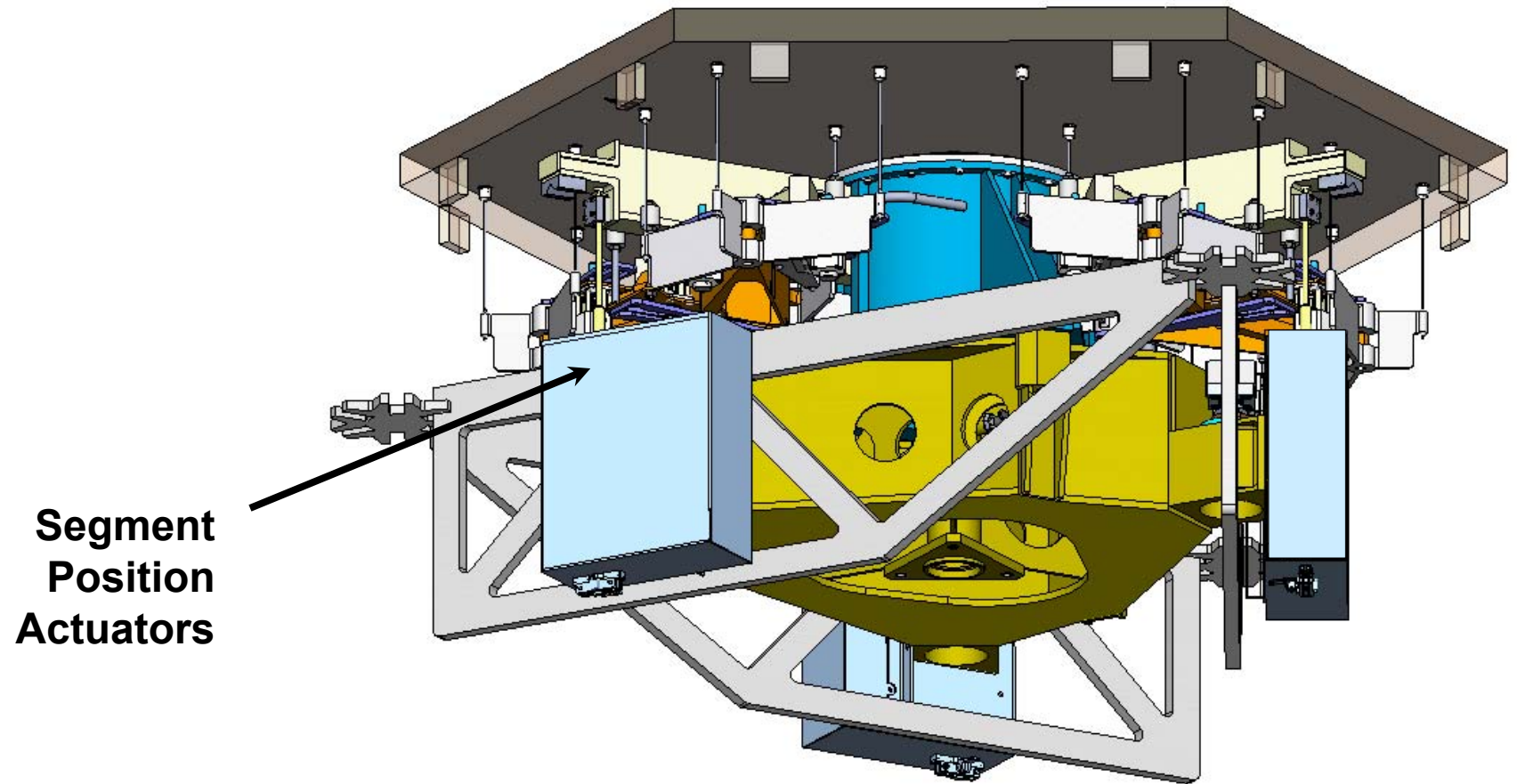
- ◆ FEMAP Program File used to generate NASTRAN FEM
- ◆ NASTRAN model available for evaluation and use by potential vendors of SSA gravity performance verification metrology.
- ◆ Model has been extensively exercised and validated
  - Prototype test data used for model correlation and improvement
  - Standard NASTRAN model fidelity checks performed - grounding, epsilon, etc.
- ◆ SigFit used for optical surface assessment and correction
  - Sigfit input and output files are available for gravity and thermal unit cases.



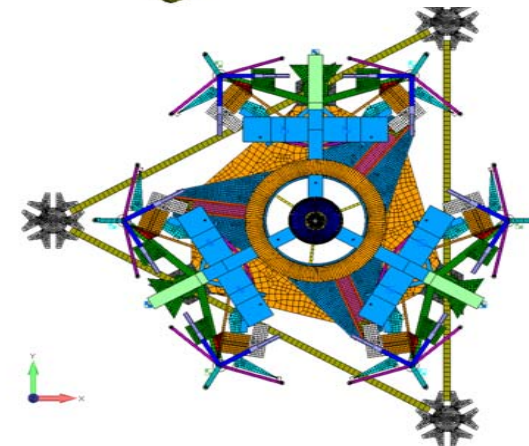
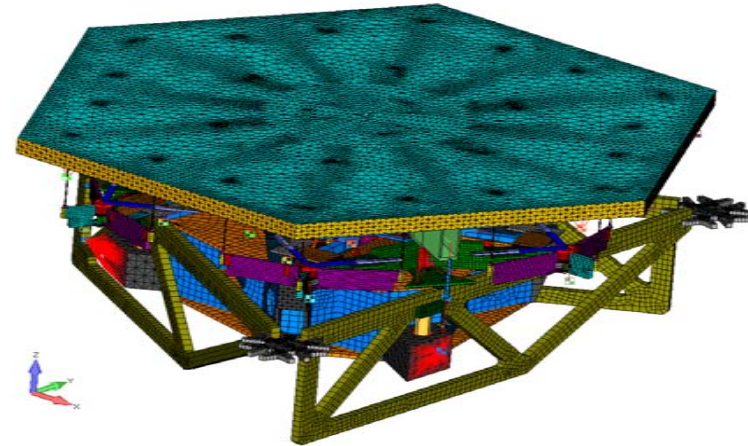
- ◆ Model includes all components associated with a single M1 segment:
  - Mounted Segment Assembly (MSA)
    - ◆ This is TMT-furnished hardware to be tested
    - ◆ Includes segment, whiffletree, warping harness, stationary tower
  - Subcell, Mirror Cell, and Segment Position Actuators
    - ◆ To first order, these components do not affect the optical surface of the segment.
    - ◆ This hardware may or may not be furnished by TMT, pending discussions with vendors
  
- ◆ Components shown on next slides

# M1 Nomenclature





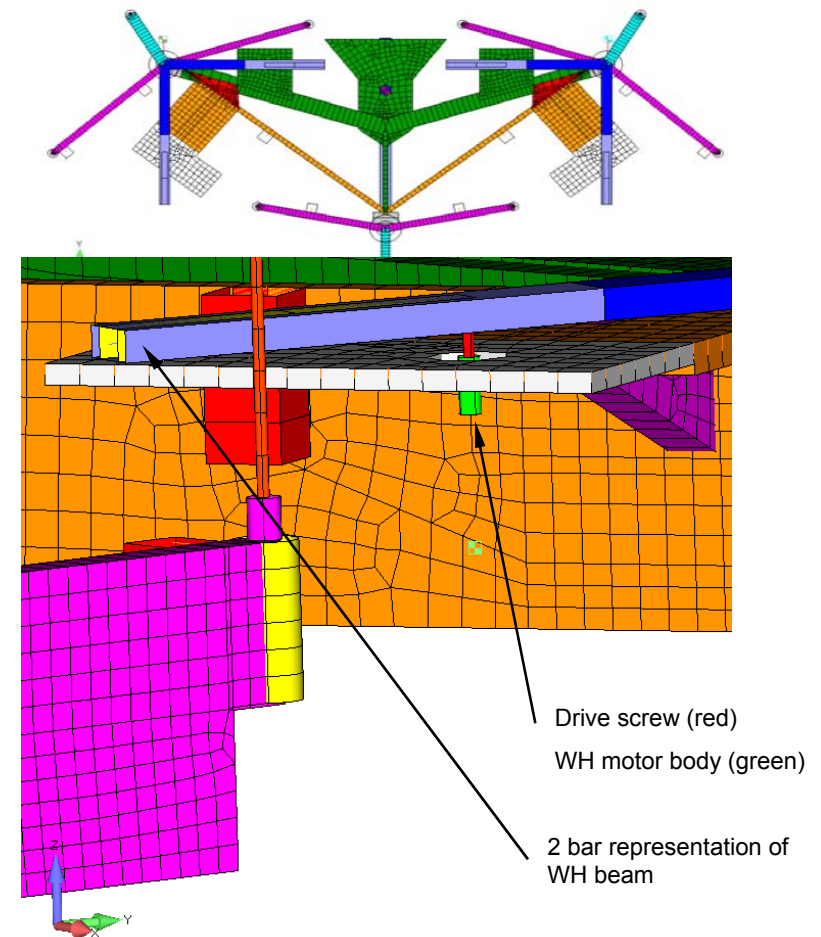
- ◆ Detailed FEM, suitable for high fidelity predictions and trade studies
  - All load paths and significant masses captured
  - Model extends to mirror cell truss nodes
    - ◆ Fixed all 6 DOF each node
  - Just over 1M DOF
  
- ◆ Detailed component modeling
  - Hexagonal Mirror/Pucks/Edge Sensors
  - Diaphragm (flat, Invar 36)
  - EA2216 bonds
  - Whiffletrees, Rod Flexure, Pivots
  - Warping Harness
  - Sheet and Lateral Guide Flexures



(Mirror/edge sensors/pucks removed for clarity)

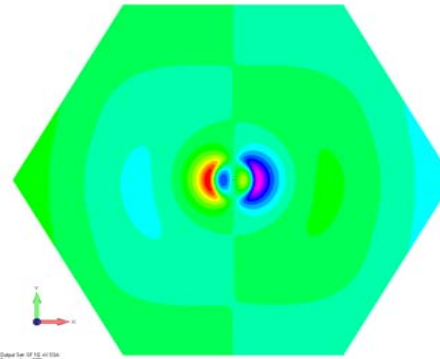
# Warping Harness Implementation

- ◆ Hardware implementation: stepper-driven lead screw exerts moments by acting on re-entrant leaf spring
- ◆ FEA implementation: Leaf spring - 2 cross section bar equivalent stiffness representation
  - Re-entrant tab modeled separately
- ◆ Drive Screw and Motor Body modeled as bar elements.
  - Drive screw flexured to relieve all DOFs but axial load and torsion.
- ◆ WH unit moment at pivot achieved by inducing axial force in drive screw via thermal load
  - 21 separate load cases

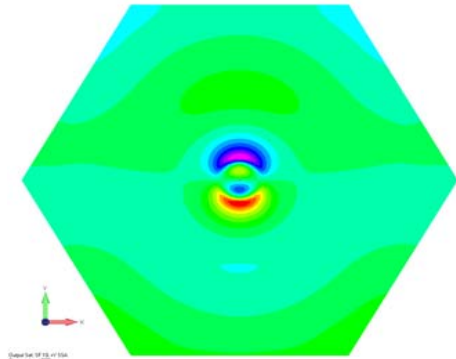


# Optical Performance: Unit Load Cases

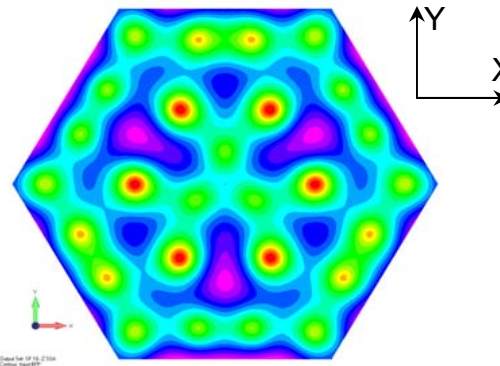
- ◆ Used for design trades:
  - 1g body loads, +X, +Y, -Z
  - +1°C ΔT
- ◆ Results for baseline design shown at right:
  - Contours of  $U_z$ , after removal of best-fit-plane
  - Each plot uses its own color scale
  - FEA model, Sigfit input and/or output available.



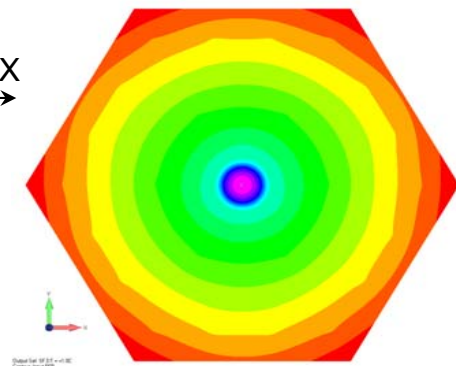
**Lateral (+1g<sub>x</sub>)**  
RMS = 11.9 nm, P-V = 219 nm  
Purple = -109 nm, Red = +110 nm



**Lateral (+1g<sub>y</sub>)**  
RMS = 11.9 nm, P-V = 218 nm  
Purple = -109 nm, Red = +109 nm



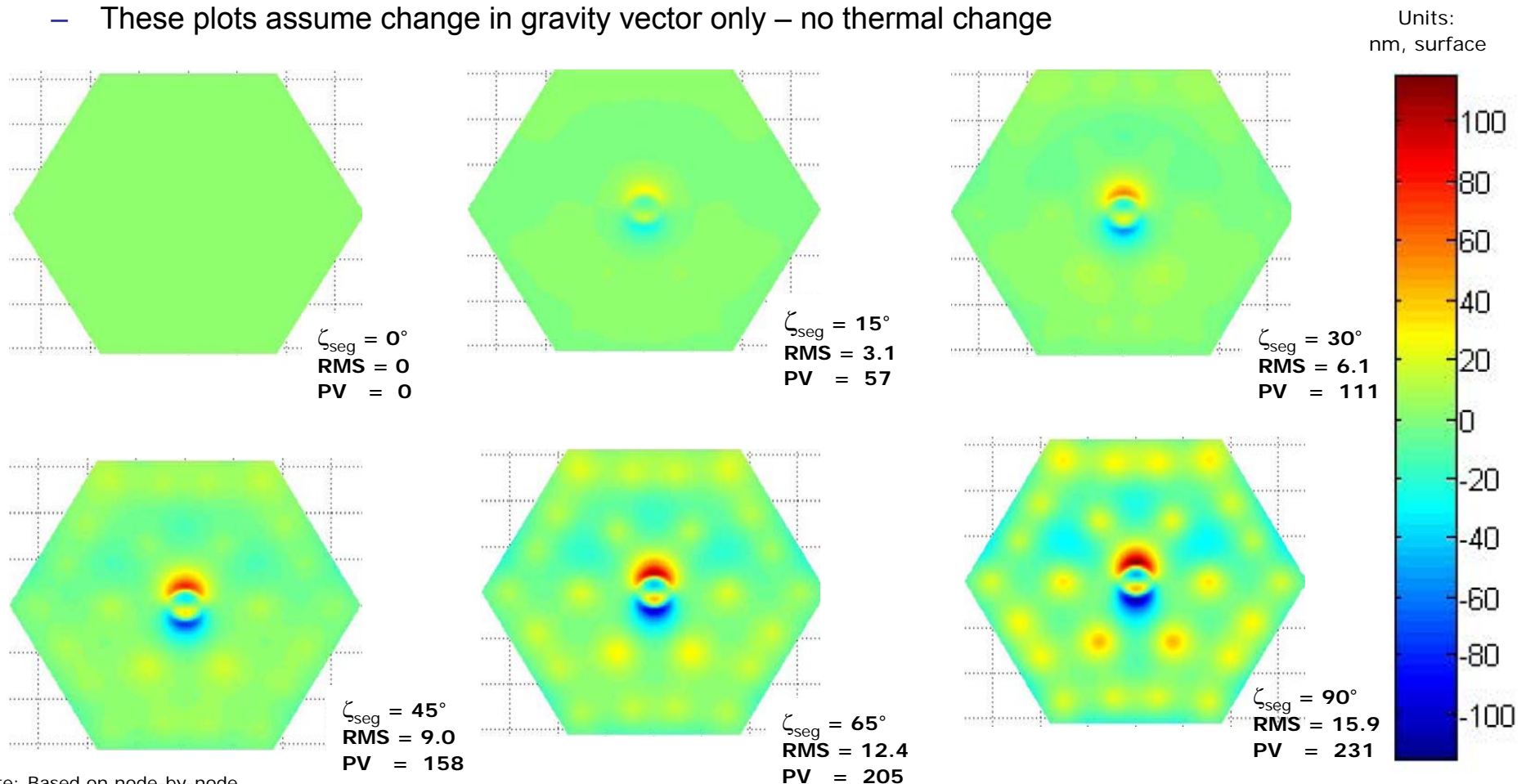
**Axial (-1g<sub>z</sub>)**  
RMS = 10.4 nm, P-V = 57.6 nm  
Purple = -24.4 nm, Red = +33.2 nm



**ΔT = +1°C**  
RMS = 2.34 nm, P-V = 15.0 nm  
Purple = -10.5 nm, Red = +4.5 nm

# Performance Prediction: Varying Gravity Field

- ◆ Predicted gravity-induced surface change, relative to zenith-pointing configuration
  - note that this is the predicted *change*, in addition there will be a comparatively large static surface error
  - These plots assume change in gravity vector only – no thermal change



Note: Based on node-by-node sum of scaled FEA results.

# Acknowledgements

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