FEM and Multiphysics Applications at NASA/GSFC

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“Provide accurate, timely, and reliable structural analysis support to NASA space flight missions and new technology development areas.”

- Structural Dynamics and Loads
- Structural/Optical/Thermal Performance Analysis
- Structural Mechanics/Stress Analysis
- 30 structural analysts in the branch
Available FEM Software

- MSC/Nastran
- Abaqus
- Ansys/Multiphysics
- COSMOS/M
- “Home-grown” programs

- Pre/Post-processors
  - Patran, FEMAP
MSC/Nastran

- Primary “workhorse” FEA package
  - Originally developed by NASA
  - Common “language” that we communicate with other NASA centers, major contractors, and international partners
  - Used primarily for linear statics and dynamics, coupled loads analysis, structural distortion, and structural performance problems.
Wilkinson Microwave Anisotropy Probe (WMAP)

WMAP’s mission is to study the Cosmic Microwave Background (CMB) radiation which determines the age of the universe.

WMAP was launched June 2001.
Primary FEA package for all Micro-electro-mechanical systems (MEMS) analysis.
- Electrostatic/structural, Magnetic/structural, and Fluid/structural/thermal interaction problems
  - MEMS micro-mirrors, MEMS micro-shutters, MEMS thrusters, MEMS tunable filters
- Also used for its robust non-linear analysis capabilities
Micro-mirror

- 100μm x 100μm micro-mirror actuated at 50°K using nonlinear 1100 series Al properties
MEMS Tunable Filter

3-D FEM

Static Non-Linear Force-Deflection FEA
Verification of FEA Results

- GSFC has extensive test and characterization capabilities.
  - Modal test facility, High Capacity Centrifuge, Static test facility, Vibration Facility, Acoustic Chamber, Thermal Vacuum Chambers for “macro” structures.
  - Extensive lab capabilities for “micro” structures. Including SEM, AFM, confocal microscopy, nano-indentation, magnetic facilities, optical and electrical performance labs.
GSFC Code 542 Best Practices

- Verification, Verification, Verification
  - Verify component models as early as possible
    - Strength/Stiffness
  - Verify primary structural strength/stiffness
    - Correlate all primary structural frequencies prior to...
  - Verification coupled loads cycle
    - Last update of the payload’s structural loads
    - Once the loads are updated, all structural strength margins of safety verified during strength testing are reevaluated to ensure structural integrity during launch.
Metrics

- We get one chance to get it right.
- Public customers want a return on their investment.
- Science customers may only get one shot for a mission over their career.
- Others may be trying to get the same information

Primary metric Mission Success!