Structural Model Summary

Terrestrial Planet Finder Mission

TPF

A NASA Origins Mission

Components and Assumptions

- 6 x 3.5 m Primary Mirror

  ULE Glass (E= 68 Gpa, rho= 2200 kg/m^3, CTE= .03 ppm/K)
- 10 m Long Secondary Support Tower
- 1 Hz Passive Isolation between Payload & Spacecraft

  Input for Reaction Wheel Jitter Assumes 2nd Level of Isolation at RW Assembly Mount (.1N, .01Nm)
- 0.5% Uniform Passive Damping Assumed (Conservative)

  Will Look at Increased Damping for Critical Modes
- 6 V-groove Layer Sunshield (2 mil Kapton)

  3 psi membrane tension preload (geom stiff modeled with equiv shear props)
- Solar Array (4 Panels)
- Solar Sail (2 mil Kapton, 17 x 3.3 m, sized by Doug Lisman for 48 Hr between RW offloads)

  6 psi membrane tension preload (geom stiff modeled with equiv shear props)
- Predominant Material = Quasi-Iso M55J GrEp (E= 110 GPa, rho= 1633 kg/m^3, CTE= -.18 ppm/K)

Model Statistics

- System Dynamic Model: 1397 Nodes (~8,380 dofs), & 1888 Elements
- Primary Mirror Mid-Fidelity Model (for thermal def): 2100 Nodes (~12,600 dofs), & 4600 Elements

  2 Layers of Plate Elements for Front/Back Facesheets & Orthotropic Solids for Core
- Total Deployed Mass = 3,260 kg (cg= 0.86 m forward of RW Location)

  650 kg Primary Mirror, 250 kg Secondary Support Tower, 15 kg Secondary, 550 kg AMS

Structural Modeling Results Summary

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Vibration Mode Analysis Results

- Highest rigid body mode is 1.7e-5 Hz (indicates good rigid body behavior- i.e. no grounding)
- Lowest system elastic mode is at 0.126 Hz (due to solar sail)
- Lowest sunshield mode is at 0.25 Hz
- Lowest solar array mode is at 1.1 Hz
- Lowest secondary tower mode is at 21 Hz

Simplified RW Jitter Analysis Results:
Two Types of SC/Telescope Isolation considered: 1Hz Passive & Active*

Rigid Body Optic Response (Model v2b)

	WFE1	WFE2		
Description	Passive Damp	Acive Damp	Req	WFE2/Req
M1-M2 Despace (nm)	1.4	0.02	2	0.010
M1-M2 Decenter (nm)	5.2	0.07	8	0.009
M2 Rotation (nrad)	0.34	0.004	5	0.001

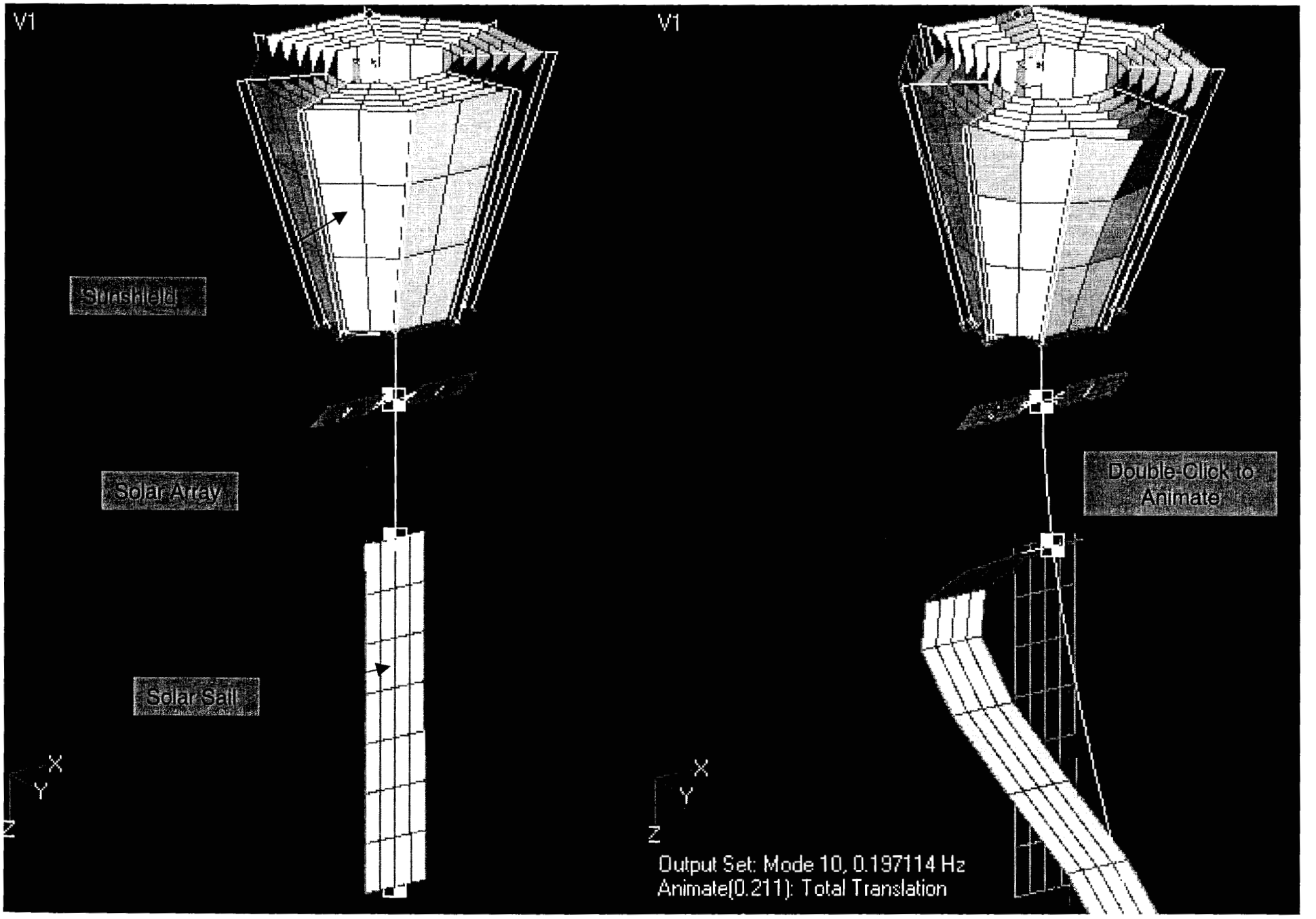
Primary Mirror Distortion Response (picometers, Model v2b)

		WFE1	WFE2		
Zernike	Descr	Passive Damp	Active Damp	Req	WFE2/Req
4	Power	117	1.5	5	0.3
5	1st Ast 45	113	1.4	10	0.1
6	1st Ast X	178	2.2	5	0.4
7	1st Coma Y	17	0.2	10	0.0
8	1st Coma X	16	0.2	1	0.2
9	1st Tref Y	36	0.5	5	0.1
10	1st Tref X	35	0.5	3	0.2
11	1st Sper	15	0.2	1	0.2
12	2nd Ast X	22	0.3	1	0.3
13	2nd Ast 45	11	0.1	1	0.1
14	1st Tetr X	18	0.2	1	0.2
15	1st Tetr Y	11	0.1	3	0.0

Thermal Distortion: Steady-State start & finish of 180d Roll from Sun at –Y to +Y (pm, Beta= 90d) (Mid-Fi Model)

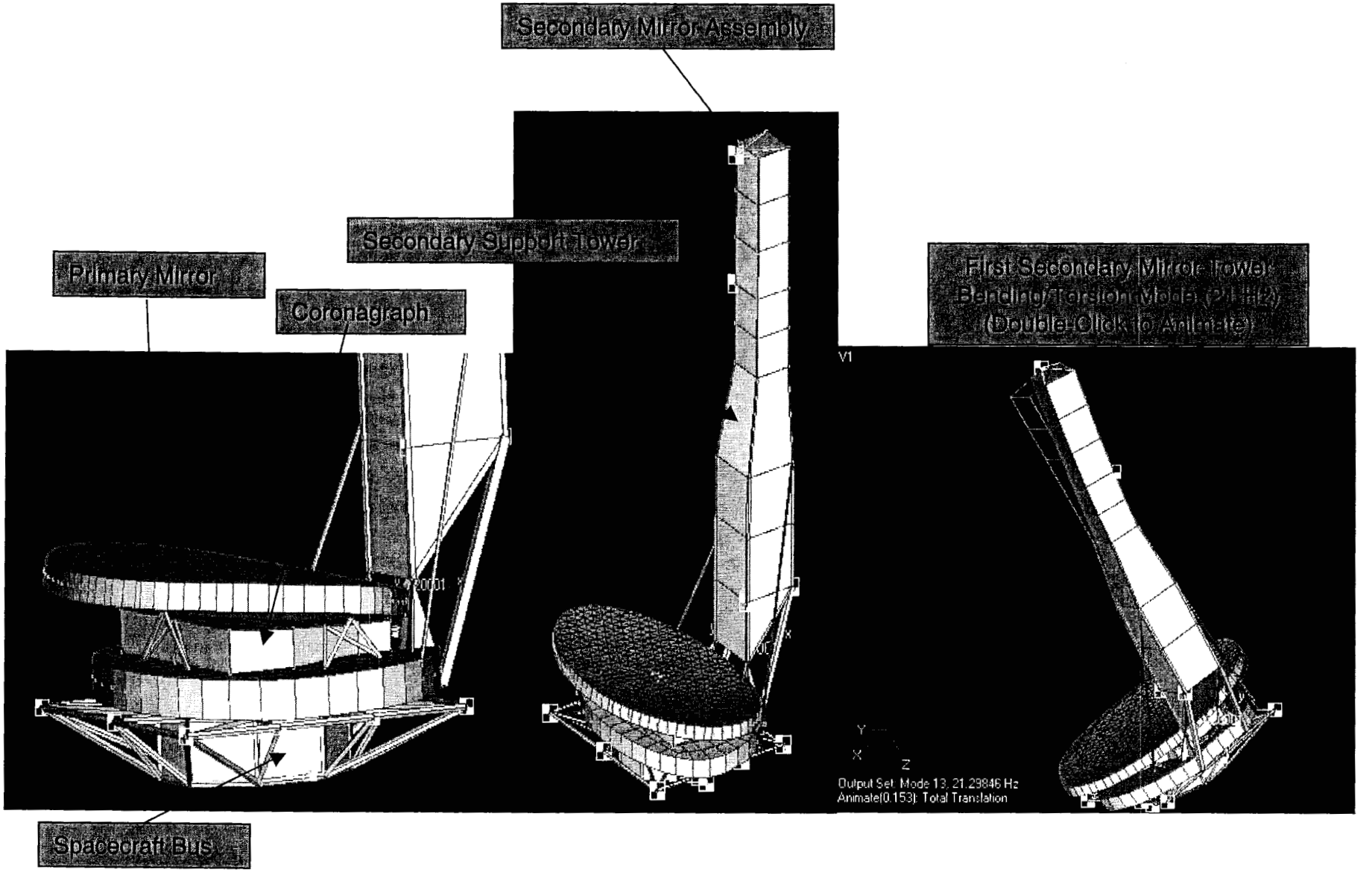
Zernike	Descr	WFE	Req	WFE/Req
4	Power	22.80	5	4.6
5	1st Ast 45	0.35	10	0.0
6	1st Ast X	13.00	5	2.6
7	1st Coma Y	2.54	10	0.3
8	1st Coma X	0.52	1	0.5
9	1st Tref Y	6.20	5	1.2
10	1st Tref X	0.28	3	0.1
11	1st Sper	0.17	1	0.2
12	2nd Ast X	0.55	1	0.6
13	2nd Ast 45	0.04	1	0.0
14	1st Tetr X	0.41	1	0.4
15	1st Tetr Y	0.17	3	0.1

* Note: Active Isolation results are estimated using scale factors based on LMCO test results for reduced systems

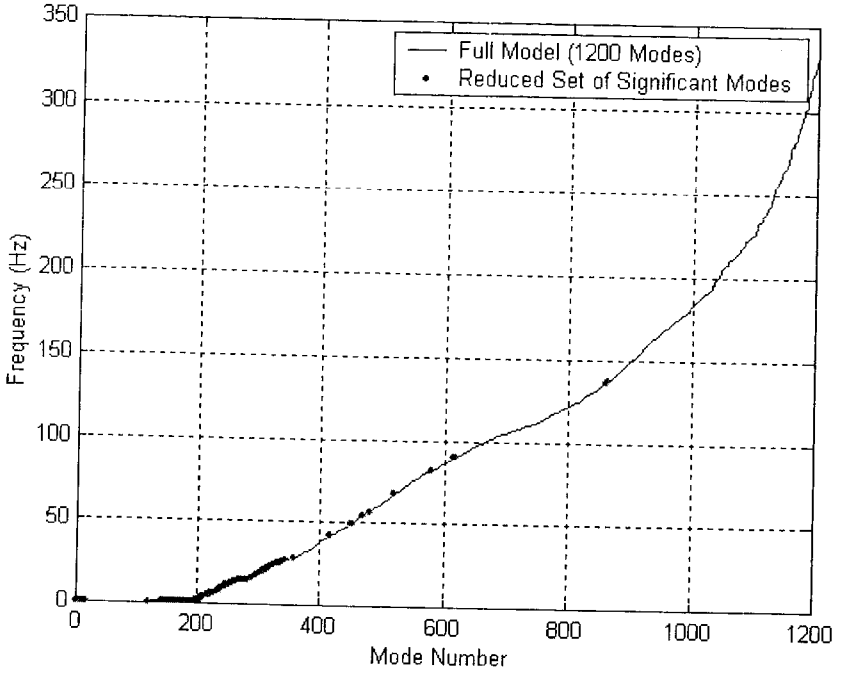


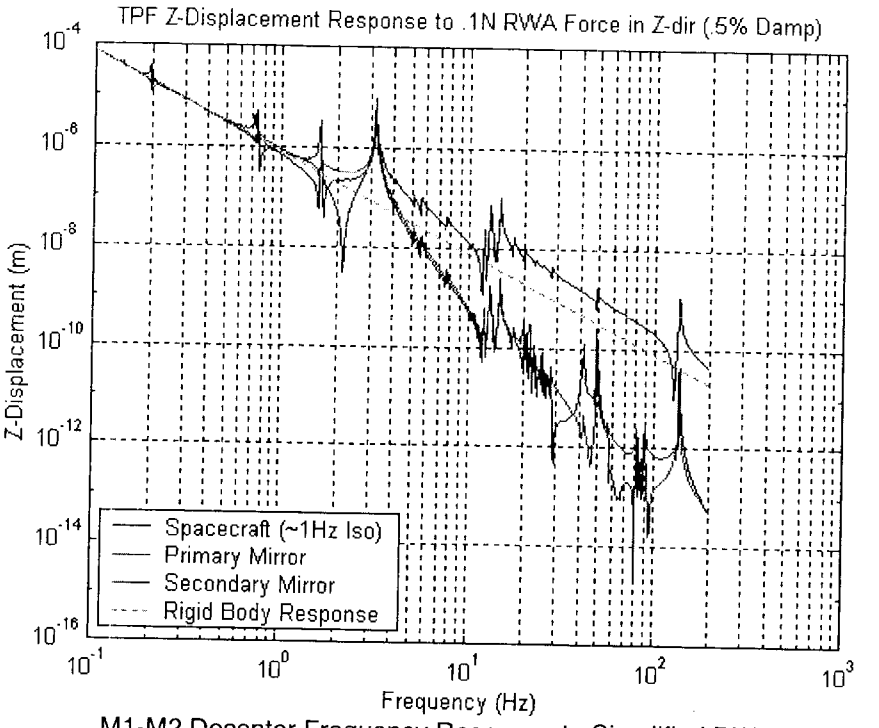
Structural Finite Element Model Plot

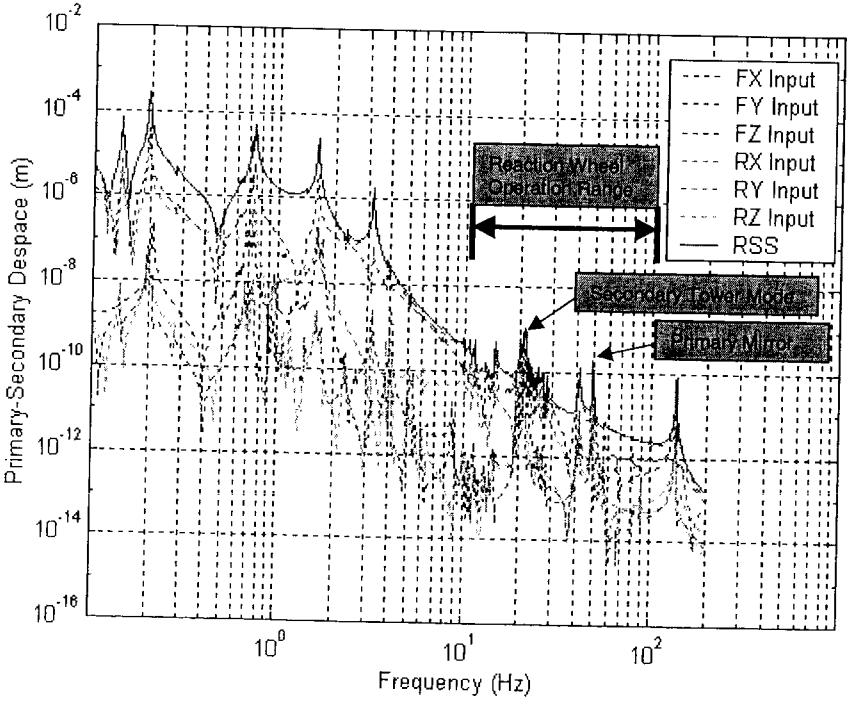
Magnified Displacements for Vib Mode 10 (.2 Hz)

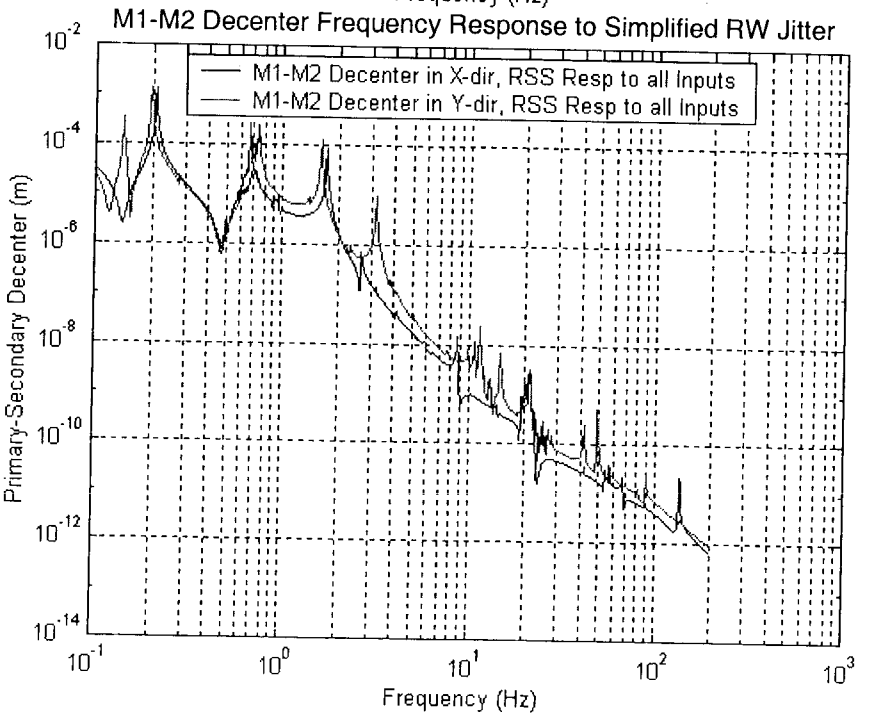


Model Plots of Primary & Secondary Sub-Assemblies

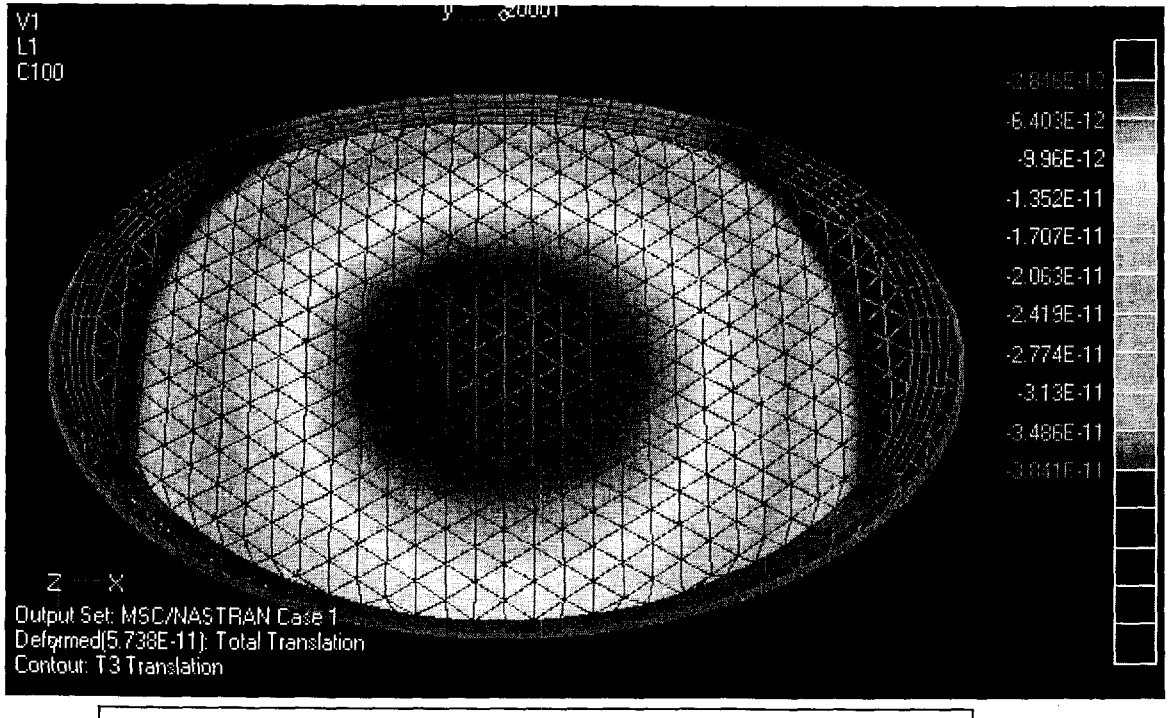

Full Model (1200 Modes)
Reduced Set of Significant Modes
Frequency (Hz)
Mode Number


TPF Z-Displacement Response to .1N RWA Force in Z-dir (.5% Damp)
Spacecraft (~1Hz Iso)
Primary Mirror
Secondary Mirror
Rigid Body Response
Z-Displacement (m)
Frequency (Hz)


FX Input
FY Input
FZ Input
RX Input
RY Input
RZ Input
RSS
Reaction Wheel Operation Range
Secondary Tower Mode
Primary Mirror
Primary-Secondary Despace (m)
Frequency (Hz)


M1-M2 Decenter Frequency Response to Simplified RW Jitter
M1-M2 Decenter in X-dir, RSS Resp to all Inputs
M1-M2 Decenter in Y-dir, RSS Resp to all Inputs
Primary-Secondary Decenter (m)
Frequency (Hz)

Structural Response to 180 deg Roll Using Steady-State Temperatures



FEM Displacements Highly Magnified and Z-disp Contours for Steady-State Delta Temps (Beta= 90 deg, ~Surface RMS WFE = 25.6 pm)

Breakdown of FEM Displacements into Zernike Components (see Notes below)

Zernike	Descr	WFE	Req	WFE/Req
4	Power	22.80	5	4.6
5	1st Ast 45	0.35	10	0.0
6	1st Ast X	13.00	5	2.6
7	1st Coma Y	2.54	10	0.3
8	1st Coma X	0.52	1	0.5
9	1st Tref Y	6.20	5	1.2
10	1st Tref X	0.28	3	0.1
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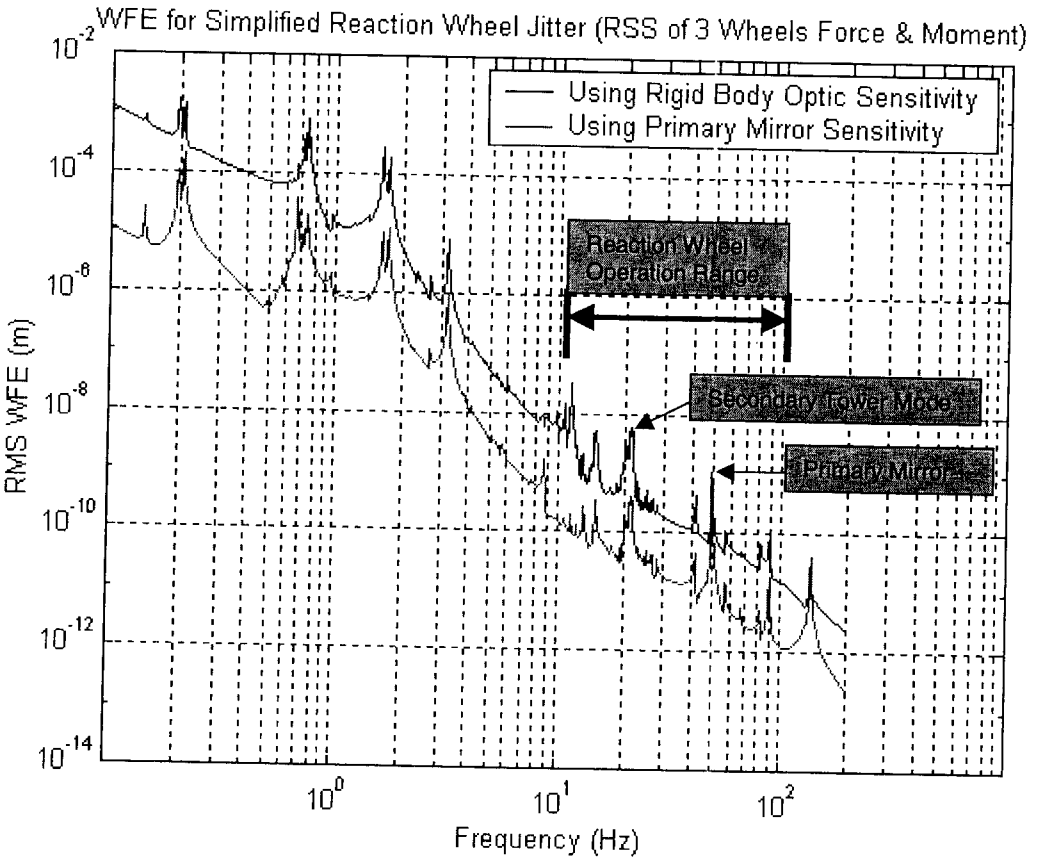
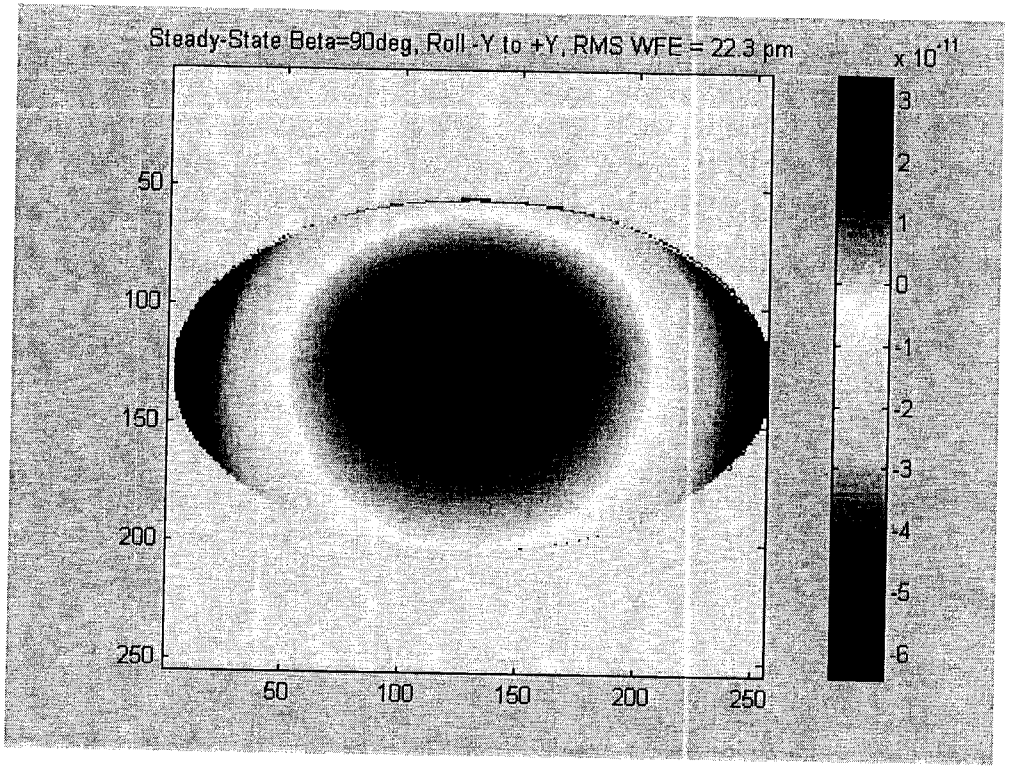
13	2nd Ast 45	0.04	1	0.0
14	1st Tetr X	0.41	1	0.4
15	1st Tetr Y	0.17	3	0.1

Notes: Tabulated Zernike WFEs are RMS values computed using elliptical Zernike functions, and PM displacements times 2 (rather than from the propagated sensitivity results)

For Optics Section

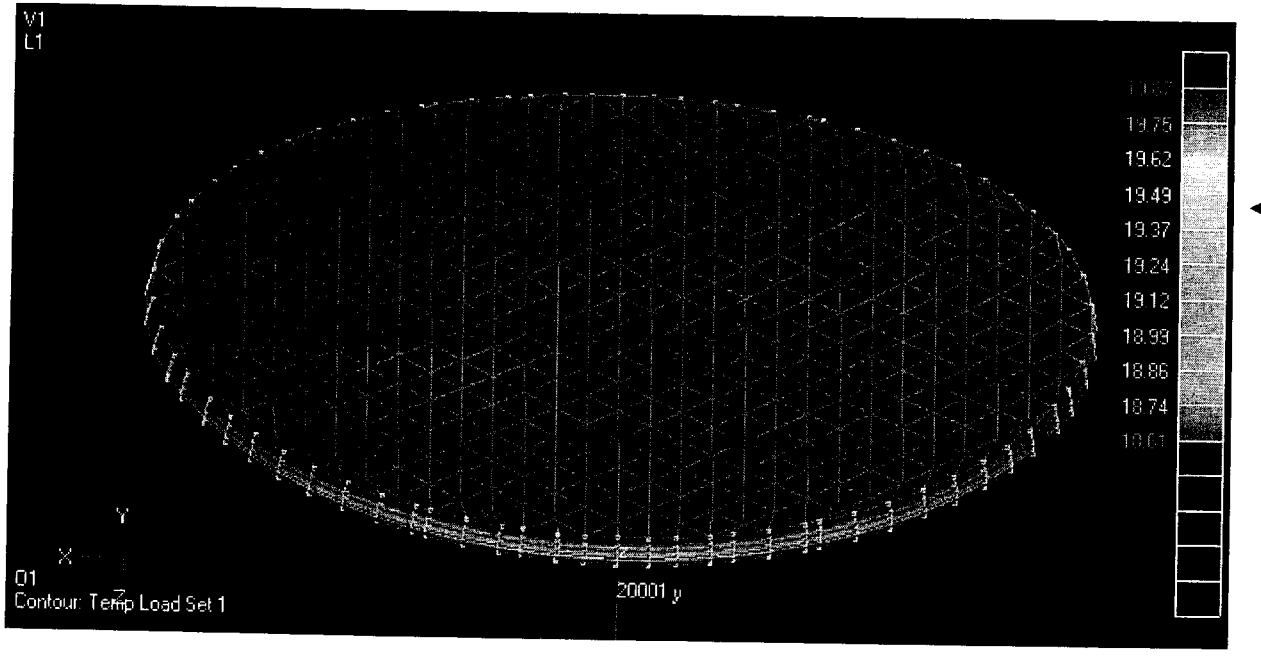


For Optics Section

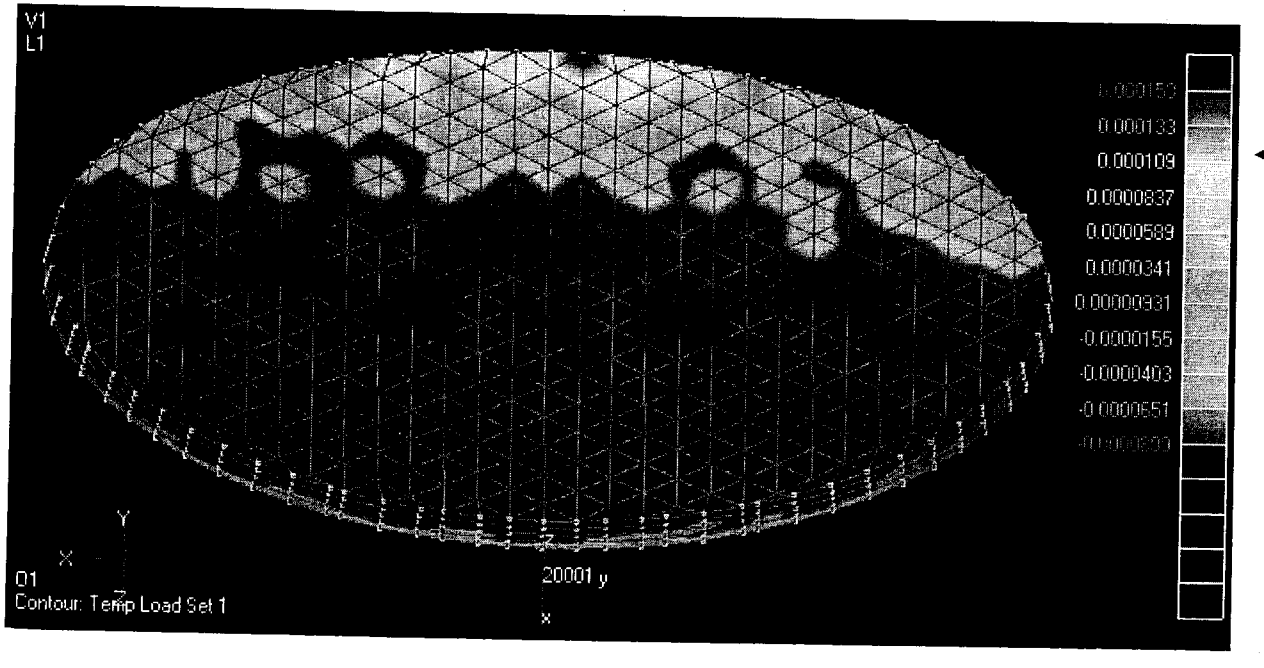


OPD Map from PM Sensitivity Matrix
for Response to 180 deg Roll (Beta=90)
Using Steady-State Temperatures

For Thermal Section



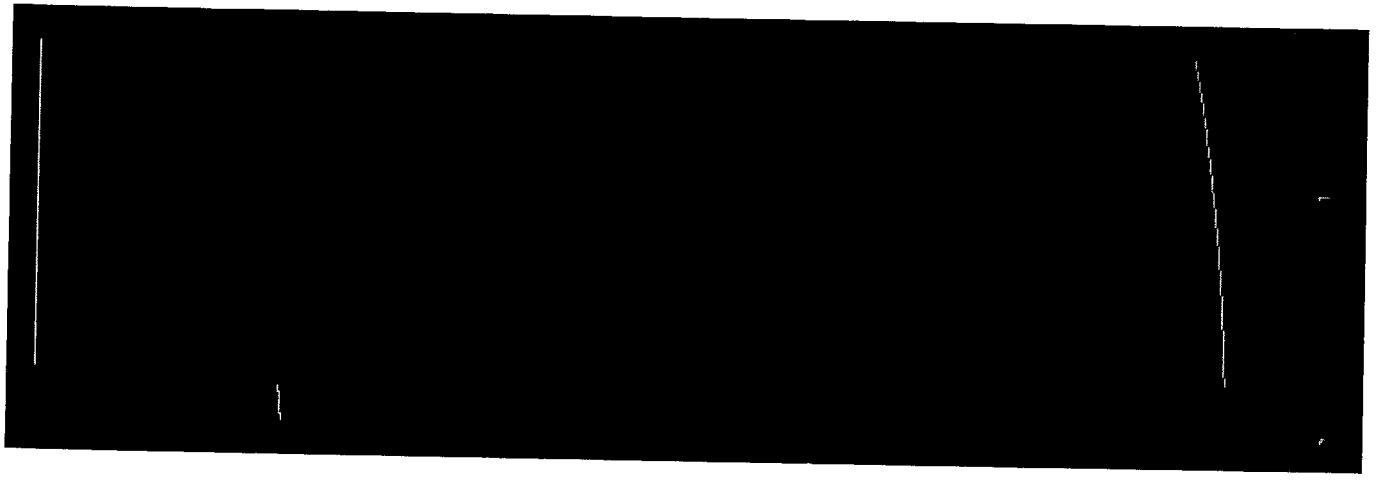
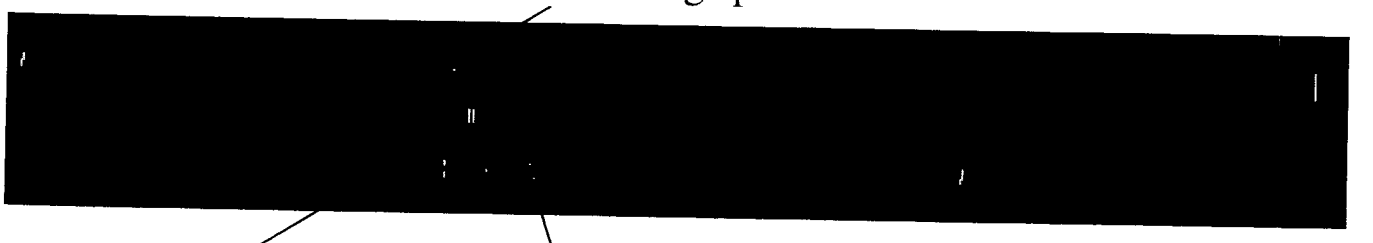
Pre-Roll Steady-State Temps for Beta= 90 deg and Sun at -Y Position



Steady-State Delta Temps for 180 deg Roll from -Y to +Y Orientation (~+- 0.2 mK Change)

Notes: Thermal model used includes mid-fidelity primary mirror (smeared core props) and 6 v-groove layer sunshield. secondary mirror & support struc not included.

6m x 3.5m Telescope



Optical Bench