Stratospheric Observatory For Infrared Astronomy (SOFIA) Telescope Assembly Controlled Response Utilizing NASTRAN and MATLAB/Simulink for Pointing Analysis

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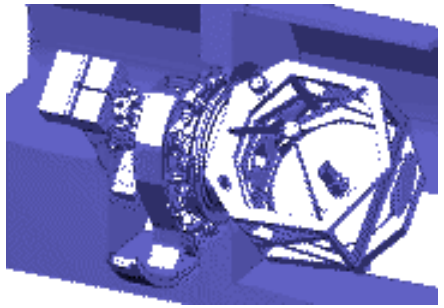
Stratospheric Observatory For Infrared Astronomy (SOFIA) Telescope

- The heart of any observatory is its telescope, and the heart of any large research telescope is its main light-collecting mirror. With an effective diameter of 2.5 meters (98.75 inches), the SOFIA telescope mirror will be the largest ever to leave the surface of the earth. It will collect and concentrate 162,000 times more light than can the human eye, and nine times more light than its predecessor, the .91 meter (36 inches) telescope carried aboard the Kuiper Airborne Observatory.



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Stratospheric Observatory For Infrared Astronomy (SOFIA) Telescope

- Designing a large telescope to operate from an aircraft presents many significant engineering challenges. It must be much lighter than an equivalent ground-based telescope, so the aircraft can stay aloft for as long as possible. At the same time, it must be extremely strong and rigid, so it won't bend under the constant buffeting of the 550-mile-per-hour aircraft slipstream blowing into the open cavity. Finally, its support and control system must accurately point the telescope and keep it precisely on target even as the aircraft is flying through sometimes-turbulent air.
- The world's largest airborne telescope.
- The modifications to the plane include a 10'X10' opening in the side of the aft portion of the fuselage.
- A structural finite element model of the telescope assembly was created to evaluate structural integrity, stability, control and structural loads of the telescope assembly and the induced loads to the aircraft.

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Key Telescope Characteristics

Weight of telescope including science instrument:	ca. 20,000 kg
Configuration:	Cassegrain-telescope with Nasmyth focus, permanent access to science instrument from cabin
Structural layout:	CFRP-structure in Dumbbell shape with trusswork metering tube
Rotation isolation system:	hydrostatic bearing with 2 ring segments, 1.2 m diameter, 10-30 bars pressure
Rotation drive system:	coarse drive for elevation and fine drive (brushless DC spherical segment motors) for elevation, cross-elevation and line-of-sight (L.O.S.)
Vibration isolation system:	12 springs/dampers around the hydrostatic bearing in longitudinal and tangential directions
Primary mirror (PM):	diameter 2.7 m, effective aperture 2.5 m, lightweighted ZERODUR structure on 18-point whiffle-tree support, PM ratio f/1.28, aluminum coated
Secondary mirror (SM):	from SiC material, 352 mm diameter, aluminum coated
SM functions:	focus, alignment, chopping (2-axis in arbitrary directions, offset, three point, stationary)
Tertiary mirror(TM):	2 flat exchangeable mirrors, dichroic (gold coated) and non-dichroic (aluminum coated)
System focal ratio:	f/19.6
Wavelength range:	0.3 to 1,600 microns
Unvignetted field of view:	8 arcmin
Ranges of motion:	elevation 15-70 degrees (20-60 degrees unvignetted), cross-elevation and L.O.S. ± 3.0 degrees
Image quality:	80% energy in 1.5 arcsec circle at 0.6 microns wavelength
Image stability:	0.2 arcsec rms for focal plane tracking

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SOFIA Telescope Assembly Controlled Response Utilizing NASTRAN and MATLAB/Simulink for Pointing Analysis

- SOFIA Telescope Assembly (TA) NASTRAN model is used to create modal state space model that is fed into MATLAB/Simulink controls model.
- MATLAB/Simulink model is used to apply external forces, implement control laws and perform overall controlled TA pointing calculations.
- MATLAB/Simulink calculated displacements are fed back into NASTRAN to generate full animations of the TA structures controlled response.

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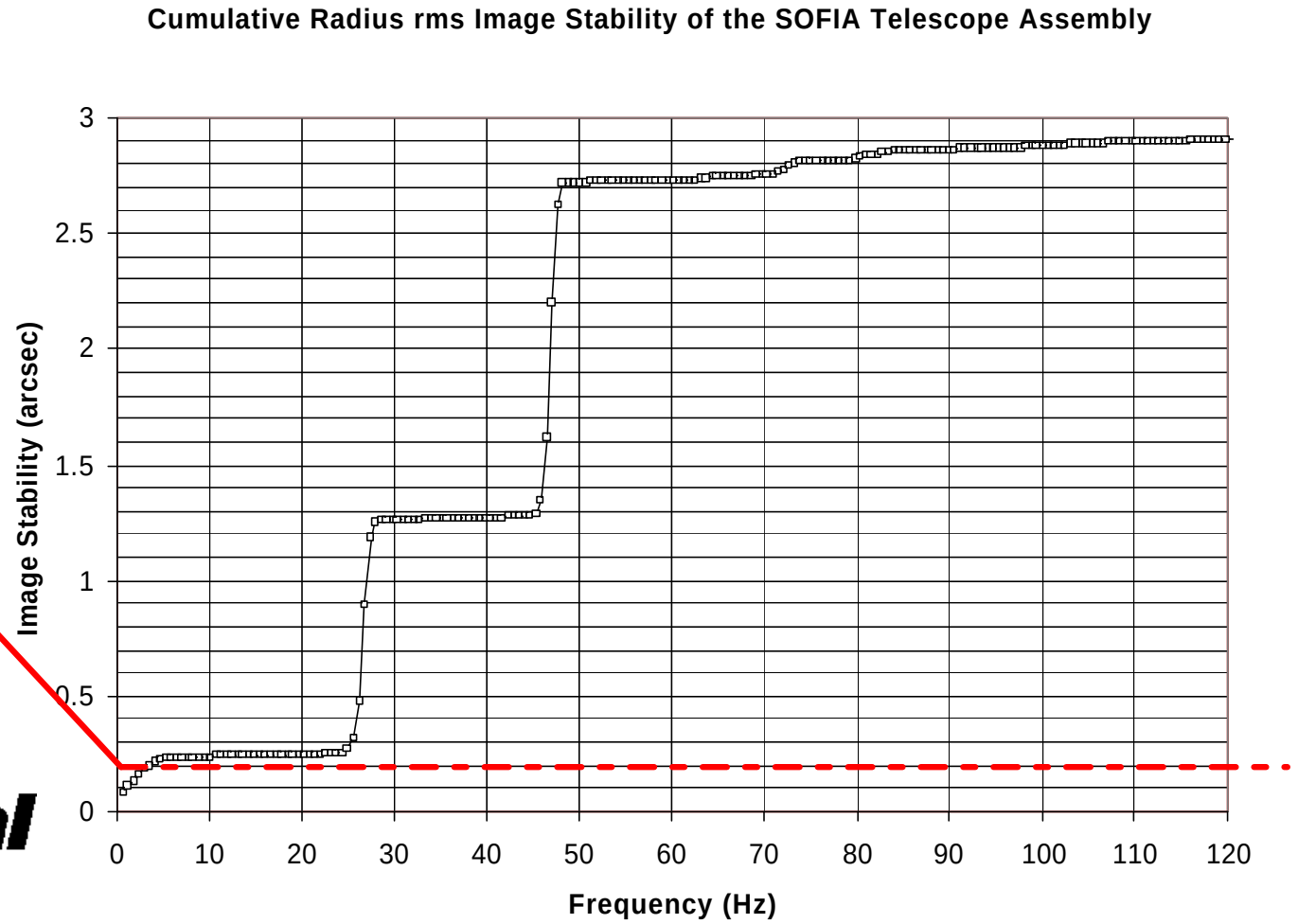
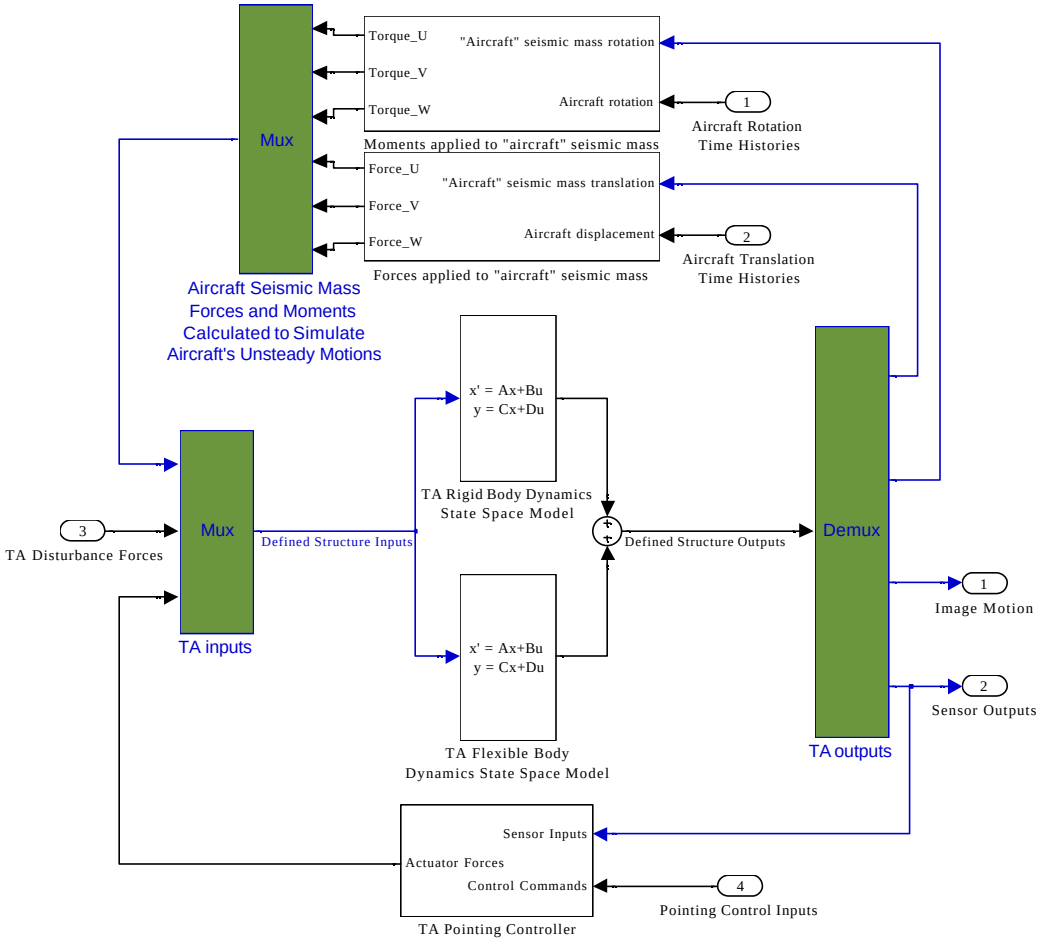
Cumulative Radius RMS Image Stability of the SOFIA Telescope Assembly- Open loop System

Closed Loop Requirement is 0.2 arcseconds



Aircraft Base Motion As Well As Aero-Acoustic Forces on the Telescope Are Applied to the Model in Matlab to Produce Total Image Motion Estimate



SOFIA Telescope Assembly- Primary Nasmyth Tube Bending Mode