National Aeronautics and Space Administration

JPL-Caltech-Cornell Concept Study for a 25-meter Submillimeter Telescope

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Project Objective: **Building the most sensitive ground-based submillimeter telescope will require an active surface to maintain 10 µm wavefront error including manufacturing, alignment, gravity, and thermal effects. JPL's task has been to understand the active surface, define key aspects of its performance, develop a complete design for this system, and specify the required components. JPL work has focused on three key aspects:**

(1)Developing a complete software model of the active surface system;

(2) evaluation of laser metrology for real-world measurement of distances in the system;

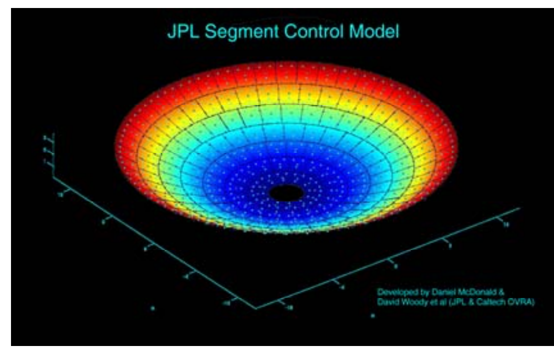
(3) investigations of capabilities to manufacture carbon fiber reinforced surface panels from which to build the telescope.

FY07 Results: Active Surface System (D.M.)

- **Defined to control 210 keystone-shaped segments of f/ 0.4 primary reflector each kinematically supported by 3 actuators**
- **Can include edge sensors (measuring piston displacements), dihedral (adjacent panel) angle sensors, metrology (distance to fixed point) sensors, and Shack Hartman (segment tip-tilt angle) sensors**
- ***SEG* program calculates the error multiplier of the system, which is the factor by which sensor noise and panel errors is multiplied to get the final surface error. *SEG* does this by exercising each degree of freedom (DOF) of the surface and inverting matrix of resulting outputs to obtain the normal modes of the surface. Each normal mode has error multiplier, reflecting how well this mode is sensed by the suite of sensors.**
- ***SEG* includes the curvature of the reflector (a first among such modeling programs, can rapidly change sensor locations, types, and performance, as well as allowing for different panel geometries**

CONCLUSIONS

With a combination of edge sensors and Shack Harman sensors we can obtain an overall error multiplier of 2, which should be acceptable. This includes the effect of thermal distortions of the panels.



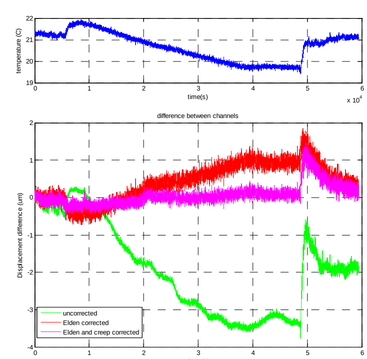
FY07 Results: Laser Metrology (A.K.)

- **We have constructed a test bench to evaluate atmospheric effects on laser metrology system developed previously at JPL. This can measure on baselines up to 4m and compares distance measured in air to that measured through an evacuated tube. Measurement system can be vertically or horizontally oriented.**

CONCLUSIONS

Distance stability better than 1 micron over 2 m path can be achieved with proper corrections for mean air properties (n, T)

Averaging over period of seconds indicates that turbulence is not likely to be a significant limitation.



Laser Metrology Stability Measurements

Top panel: temp. vs. time. Bottom panel: Green - raw data. Red - the correction for variations of the air's refractive index applied to raw data (Elden eqn). Purple - the creep correction applied.

FY07 Results: Surface Panels (E.C.)

- **We have investigated manufacturability of surface panels made of carbon fiber reinforced plastic (CFRP). Previous development work had been carried out by JPL for Precision Segmented Reflector (PSR) and FIRST telescope projects providing a starting point for this study.**

CONCLUSIONS

We can expect specifications to be met, but cost is a major challenge as is reproducibility of panel behavior. This will require further study and work with industry.

Benefits to NASA and JPL: This project is called the Cornell Caltech Atacama Telescope (CCAT) based on the initial partners and the proposed location. CCAT will offer the best performance in terms of collecting area and atmospheric transmission, of any single aperture telescope in the world. As such, it will enable astronomers to carry out many exciting studies, including tracing the evolution of galaxies throughout cosmic time, studying star formation in galaxies of very different characteristics, searching for young stars forming in dense molecular clouds in the Milky Way, and probing the outer regions of our solar system for cold, small bodies.

- Developing the technology required for CCAT fits in with other JPL areas of activity (precision optics; active structures)
- CCAT will keep JPL astronomers at the cutting edge of science, which is essential for successfully proposing future space missions
- CCAT will be the premier test bed for instruments being planned for future space observatories, including SPICA and CALISTO.
- CCAT offers JPL astronomers terrific opportunities for collaborations with other institutions.

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