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CCD Camera Lens Interface for Real-Time Theodolite Alignment

The lens simulates the human eye and creates an improved way to align a system.

Goddard Space Flight Center, Greenbelt, Maryland

Theodolites are a common instrument in the testing, alignment, and building of various systems ranging from a single optical component to an entire instrument. They provide a precise way to measure horizontal and vertical angles. They can be used to align multiple objects in a desired way at specific angles. They can also be used to reference a specific location or orientation of an object that has moved. Some systems may require a small margin of error in position of components. A theodolite can assist with accurately measuring and/or minimizing that error.

Previously, when aligning a system with a theodolite, it required the user to use their unaided eye with the theodolite eyepiece. When viewing the alignment through the eyepiece, the user could induce human error by how well they could see the alignment indicators. Other attempts have used a bare CCD (charge coupled device) array attached to the theodolite, but this technique limited the ability to achieve proper focus of the theodolite because it did not properly simulate the human eye, and therefore introduced error.

This technology minimizes time required to align a system with a Leica WildT3000 Theodolite or multiple theodolites. The secondary objective was to allow a single individual to align a single coupled system to multiple theodolites, simultaneously, in real time. This technology mounts a CCD camera with a lens at the theodolite eyepiece. This simulates the human eye and creates an improved way to align a system with the theodolite by increasing accuracy and adding the ability to record alignment quantitatively.

The technology is an adapter for a CCD camera with lens to attach to a Leica Wild T3000 Theodolite eyepiece that enables viewing on a connected monitor, and thus can be utilized with multiple theodolites simultaneously. This technology removes a substantial part of human error by relying on the CCD camera and monitors. It also allows image recording of the alignment, and therefore provides a quantitative means to measure such error.

This method allows a fast and accurate method of alignment and minimizes the need for multiple individuals to perform alignment of multiple theodolites. It also eliminates the need to look through the eyepiece of the theodolite, thus eliminating the chance of eye injury when dealing with high-intensity light sources. This method allows the ability to place the theodolite in constrained locations that someone using the traditional human eye technique could not do.

This work was done by Shane Wake and V. Stanley Scott, III of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16175-1

Peregrine 100-km Sounding Rocket Project

The objective is to design, build, test, and fly a stable, efficient liquefying fuel hybrid rocket.

Ames Research Center, Moffett Field, California

The Peregrine Sounding Rocket Program is a joint basic research program of NASA Ames Research Center, NASA Wallops, Stanford University, and the Space Propulsion Group, Inc. (SPG). The goal is to determine the applicability of this technology to a small launch system. The approach is to design, build, and fly a stable, efficient liquefying fuel hybrid rocket vehicle to an altitude of 100 km. The program was kicked off in October of 2006 and has seen considerable progress in the subsequent 18 months.

Within this period significant progress was made, including:

- Successfully completed Conceptual Design Review (CoDR) and Preliminary Design Review (PDR) for flight vehicle capable of 100-km altitude;
- Designed and fabricated flight-weight combustion chamber, main oxidizer valve, throttle system, and thrust structure;
- Successfully completed CoDR, preliminary design review (PDR), Critical Design Review (CDR), and Integrated Test Readiness Review (ITRR) for ground test facility at NASA Ames Research Center;
- Completed subsystem testing for flight weight main oxidizer valve, throttle system, helium pressurization system, ignition system, and thrust structure;
- Completed facility integrated test series including five cold-flow tests, two with live igniters, and three hot-fire tests;
- Successfully fired motor ten times, including one full duration burn during 1st phase of ground testing.

While this was a significant progress by any measure, the project suffered a schedule setback due to the July 2007 explosion at the Scaled Composites test site involving nitrous oxide. A thorough review of the system design and nitrous oxide operational procedures was undertaken and several changes have been implemented to increase human safety.

This research group began studying liquifying hybrid rocket fuel technology more than a decade ago. The overall goal of the research was to gain a better understanding of the fundamental physics of the liquid layer entrainment process responsible for the large increase in regression rate observed in these fuels, and to demonstrate the effect of increased regression rate on hybrid rocket motor performance. At the time of this reporting, more than 400 motor tests were conducted with a variety of oxidizers (N_2O, GOx, LOx) at ever increasing scales with thrust levels from 5 to over 15,000 pounds (22 N to over 66 kN) in order to move this technology from the laboratory to practical applications.

The Peregrine program is the natural next step in this development. A number of small sounding rockets with diameters of 3, 4, and 6 in. (7.6, 10.2, and 15.2 cm) have been flown, but Peregrine at a diameter of 15 in. (38.1 cm) and 14,000-lb (62.3-kN) thrust is by far the largest system ever attempted and will be one of the largest hybrids ever flown. Successful Peregrine flights will set the stage for a wide range of applications of this technology. The metrics of the program are:

- Demonstrate satisfactory motor performance in ground test.
- Demonstrate motor throttling in ground test.
- Fabricate the sounding rocket system, transport it to the NASA Wallops facility, and launch a payload to 100 km using paraffin and N_2O as the propellants.
- Demonstrate operational efficiency at the Wallops launch site.

This work was done by Gregory Zilliac of Ames Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-5761. Refer to ARC-16240-1.

SOFIA Closed- and Open-Door Aerodynamic Analyses

A series of important evaluations are completed.

Dryden Flight Research Center, Edwards, California

Work to evaluate the aerodynamic characteristics and the cavity acoustic environment of the SOFIA (Stratospheric Observatory for Infrared Astronomy) airplane has been completed. The airplane has been evaluated in its closed-door configuration, as well as several open-door configurations (see figure). Work performed included: acoustic analysis tool development, cavity acoustic evaluation, stability and control parameter estimation, air data calibration, and external flow evaluation.

Cavity acoustics were evaluated using measured pressure data. Of primary interest were sound pressure levels and frequency response curves. Analysis tools were primarily written for MATLAB. Several tools were developed to allow rapid analysis of acoustic data, giving engineers the ability to calculate and examine results from acoustic sensors in and around the telescope cavity. A batch analysis capability was created so that analysts could process data from an entire flight with one command.

Significant effort was put into completing the evaluation of the aerodynamic characteristics of the modified 747SP airplane in closed-door and open-door configurations. Parameter identification maneuvers were designed and then performed during closed and open door flight tests. Parameter estimation data analysis techniques were used in conjunction with existing aerodynamic models to create aerodynamic models for various airplane configurations. Any differences between configurations were examined.

Air data calibration maneuvers were also flown and calibrations were developed for the various air data systems, including the airplane pitot static system and a Flush Air Data Sensing (FADS) system. Results were compared for different door configurations, to determine if door position affected air data measurements.

Qualitative airflow data were obtained during the closed- and open-door flights using tufts on the aft portion of the fuselage. Video was taken from a chase plane. This video was analyzed for various flight conditions, and general flow descriptions of the aft fuselage of the 747SP were developed for the different closed and open door configurations.

This work was done by Stephen Cumming, Mike Frederick, and Mark Smith of Dryden Flight Research Center. For further information, contact Yvonne D. Gibbs at yvonne.d.gibbs@nasa.gov. DRC-010-016

Photo of **747SP SOFIA Airplane** undergoing tests in an open-door configuration.