without the resulting measurement errors from the test set up exceeding the requirement for the flight instrument.

To cover the RF stability design challenge, the portions of the scatterometer that are not calibrated by the loop-back, (e.g., attenuators, switches, diplexers, couplers, and coaxial cables) are tightly thermally controlled, and have been characterized over temperature to contribute less than 0.05 dB of calibration error over worst-case thermal variation. To address the verification challenge, including the components that are not calibrated by the loop-back, a stable fiber optic delay line (FODL) was used to delay the transmitted pulse, and to route it into the receiver. In this way, the internal loop-back signal amplitude variations can be compared to the full transmit/receive external path, while the flight hardware is in the worst-case thermal environment.

The practical delay for implementing the FODL is 100 µs. The scatterometer pulse width is 1 ms so a test mode was incorporated early in the design phase to scale the 1 ms pulse at 100-Hz pulse repetition interval (PRI), by a factor of 18, to be a 55 µs pulse with 556 µs PRI. This scaling maintains the duty cycle, thus maintaining a representative thermal state for the RF components.

The FODL consists of an RF-modulated fiber-optic transmitter, 20 km SMF-28 standard single-mode fiber, and a photodetector. Thermoelectric cooling and insulating packaging are used to achieve high thermal stability of the FODL components. The chassis was insulated with 1-in. (≈2.5-cm) thermal isolation foam. Nylon rods support the Micarta plate, onto which are mounted four 5-km fiber spool boxes. A copper plate heat sink was mounted on top of the fiber boxes (with thermal grease layer) and screwed onto the thermoelectric cooler plate. Another thermal isolation layer in the middle separates the fiber-optics chamber from the RF electronics components, which are also mounted on a copper plate that is screwed onto another thermoelectric cooler.

The scatterometer subsystem's overall stability was successfully verified to be calibratable to within 0.1 dB error in thermal vacuum (TVAC) testing with the fiber-optic delay line, while the scatterometer temperature was ramped from 10 to 30 °C, which is a much larger temperature range than the worst-case expected seasonal variations.

This work was done by Dalia A. McWatters, Craig M. Cheetham, Shouhua Huang, Mark A. Fischman, Anhua J. Chu, and Adam P. Freedman of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47559

Test Port for Fiber-Optic-Coupled Laser Altimeter

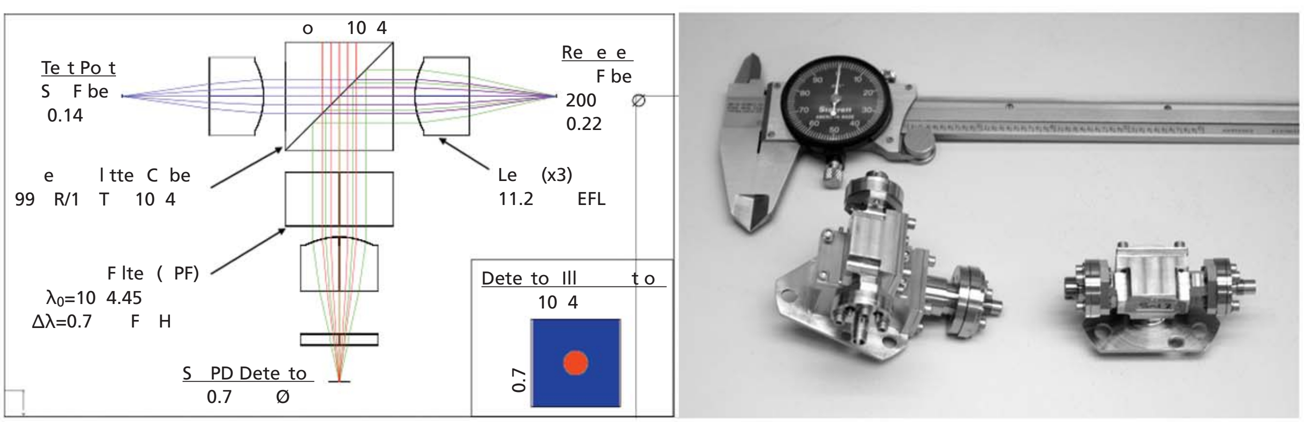
Test port simplifies verification of focal setting and boresight alignment.

Goddard Space Flight Center, Greenbelt, Maryland

A test port designed as part of a fiber-optic-coupled laser altimeter receiver optical system allows for the back-illumination of the optical system for alignment verification, as well as illumination of the detector(s) for testing the receiver electronics and signal-processing algorithms. Measuring the optical alignment of a laser altimeter instrument is difficult after the instrument is fully assembled. The addition of a test port in the receiver aft-optics allows for the back-illumination of the receiver system such that its focal setting and boresight alignment can be easily verified. For a multiple-detector receiver system, the addition of the aft-optics test port offers the added advantage of being able to simultaneously test all the detectors with different signals that simulate the expected operational conditions.

On a laser altimeter instrument (see figure), the aft-optics couple the light from the receiver telescope to the receiver detector(s). Incorporating a beam splitter in the aft-optics design allows for the addition of a test port to back-illuminate the receiver telescope and/or detectors. The aft-optics layout resembles a "T" with the detector on one leg, the receiver telescope input port on the second leg, and the test port on the third leg. The use of a custom beam splitter with 99-percent reflection, 1-percent transmission, and a mirrored roof can send the test port light to the receiver telescope leg as well as the detector leg, without unduly sacrificing the signal from the receiver telescope to the detector.

The ability to test the receiver system alignment, as well as multiple detectors



( ) (b)

Lunar Orbiter Laser Altimeter (LOLA) Aft-Optics: (a) Optical Layout, (b) Assemblies.

with different signals without the need to disassemble the instrument or connect and reconnect components, is a great advantage to the aft-optics test port. Another benefit is that the receiver telescope aperture is fully back-illuminated by the test port so the receiver telescope focal setting vs. pressure and or temperature can be accurately measured (as compared to schemes where the aperture is only partially illuminated). Fiber-optic coupling the test port also allows for the modularity of testing the receiver detectors with a variety of background and signal laser sources without the need of using complex optical set-ups to optimize the efficiency of each source.

This work was done by Luis Ramos-Izquierdo, V. Stanley Scott, Haris Riris, and John Cavanaugh of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GCS-15890-1

Phase Retrieval System for Assessing Diamond Turning and Optical Surface Defects

Goddard Space Flight Center, Greenbelt, Maryland

An optical design is presented for a measurement system used to assess the impact of surface errors originating from diamond turning artifacts. Diamond turning artifacts are common by-products of optical surface shaping using the diamond turning process (a diamond-tipped cutting tool used in a lathe configuration).

Assessing and evaluating the errors imparted by diamond turning (including other surface errors attributed to optical manufacturing techniques) can be problematic and generally requires the use of an optical interferometer. Commercial interferometers can be expensive when compared to the simple optical setup developed here, which is used in combination with an image-based sensing technique (phase retrieval). Phase retrieval is a general term used in optics to describe the estimation of optical imperfections or “aberrations.”

This turnkey system uses only image-based data and has minimal hardware requirements. The system is straightforward to set up, easy to align, and can provide nanometer accuracy on the measurement of optical surface defects.

This work was done by Bruce Dean, Alex Maldonado, and Matthew Bolcar of the Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15976-1

Laser Oscillator Incorporating a Wedged Polarization Rotator and a Porro Prism as Cavity Mirror

Goddard Space Flight Center, Greenbelt, Maryland

A laser cavity was designed and implemented by using a wedged polarization rotator and a Porro prism in order to reduce the parts count, and to improve the laser reliability. In this invention, a z-cut quartz polarization rotator is used to compensate the wavelength retardance introduced by the Porro prism. The polarization rotator rotates the polarization of the linear polarized beam with a designed angle that is independent of the orientation of the rotator. This unique property was used to combine the retardance compensation and a Risley prism to a single optical component: a wedged polarization rotator. This greatly simplifies the laser alignment procedure and reduces the number of the laser optical components.

This work was done by Steven Li of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15833-1