NEAR Laser Rangefinder

The NEAR Laser Rangefinder (NLR) is an altimeter that uses a solid-state pulsed laser to measure distance between the spacecraft and the surface of the asteroid 433 Eros. It is one of the five facility instruments onboard the NEAR spacecraft and will make highly accurate measurements of the asteroid's shape and detailed surface structure. The Laser Rangefinder is a bistatic system, meaning that it consists of separate transmitter and receiver systems. The transmitter uses a diode-pumped neodymium–yttrium–aluminum–garnet (Nd-YAG) laser built by the McDonnell-Douglas Corporation. The receiver, built by the Johns Hopkins Applied Physics Laboratory, uses a compact reflecting telescope with baffle/door assembly, an enhanced hybrid silicon avalanche photodiode detector, a rad-hardened microprocessor controller with Mil-Std 1553 bus standard interface, and a custom gallium arsenide time-of-flight chip.

Specifications

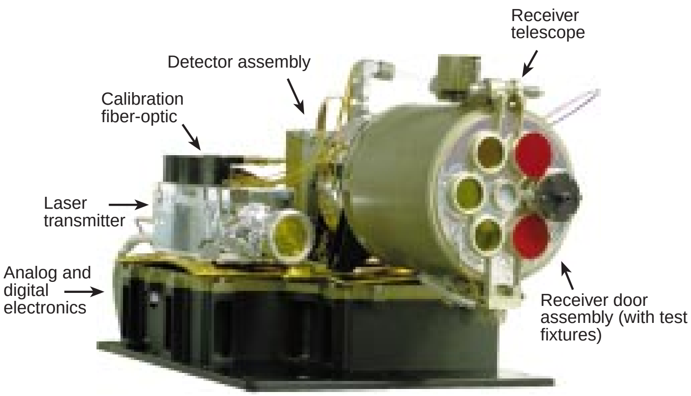
General

Mass: 5 kg

Power: 20.7 W peak, 16.5 W average

Volume: overall TX/RX assembly 37.5 cm (deep) × 21.6 cm (high) × 22.9 cm (wide) inclusive of overhangs; 10.9 × 15.2 × 3.8 cm laser power supply; 7.6 × 2.5 × 14 cm medium voltage power supply

Data rates: commandable, 51 bps or 6.4 bps



Technical

Laser wavelength: 1.064 μm

Range accuracy requirement: 6 m

Range requirement: 50 km

Inflight range calibration capability

Pulse repetition rate: commandable among 1/8, 1, 2, and 8 Hz

Pulse energy: 15 mJ

Pulse divergence: 235 μrad

Pulse duration: 12 ns

Range gates: two, commandable

Detector threshold: commandable, eight values

Receiver aperture: 7.6 cm (effective)

Range quantization level: 31 cm

Predicted range at asteroid acquisition: 150 km

Laser Altimetry

The NLR directly measures the range between the spacecraft and the asteroid. The transmitter generates a brief laser pulse, and the instrument measures the time required for the light to reach the asteroid and return. When the asteroid is 50 km away, light requires 333 millionths of a second to make the round trip. The time-of-flight measurements will be used to make accurate determinations of the asteroid's shape and will help to determine its rotational dynamics. These shape and kinematics measurements, when combined with analyses of the very precisely tracked spacecraft orbit around the asteroid, will yield information on its internal density structure. These data may address the fundamental question of whether the asteroid is a homogeneous body or an aggregate of distinctly different bodies.

In several ways, laser altimetry complements the visible and near-infrared imaging that will also be performed on NEAR. Unlike the imager, the NLR does not rely on solar illumination and can make measurements over the entire asteroid surface, including the dark side. The NLR and the NEAR multispectral imager are boresighted, and the imager can detect the laser spot when NLR is operated in its 8-Hz mode over the dark side of the asteroid. Laser altimetry further complements imaging because the direct range measurements enable unambiguous determinations of topography that will improve the interpretation of images. Laser altimetry will shed new light on geological processes on the surfaces of small bodies by allowing study of surface features such as craters, as well as grooves and vents if present.

NLR Description

The Near Laser Rangefinder is an incoherent, direct-detection laser altimeter. It is designed for high probability of detection in single-pulse operation to beyond a 50-km range for low albedo, diffusely reflecting surfaces. The instrument uses leading-edge detection with commandable thresholds and range gates. Waveform analysis is not performed.

The NLR is the first spaceborne laser altimeter to have continuous inflight range calibration capability. This is implemented with an optical fiber delay spool of known length (100 m), through which a small fraction of every emitted laser pulse is sent. The time at which the light from the calibration spool is detected after each transmitted pulse serves to calibrate the timing function, end-to-end.

Science Objectives

- Laser altimetry will yield rapid, accurate asteroid shape determinations
- Laser altimetry will measure detailed surface morphology to study geological processes

NLR Management

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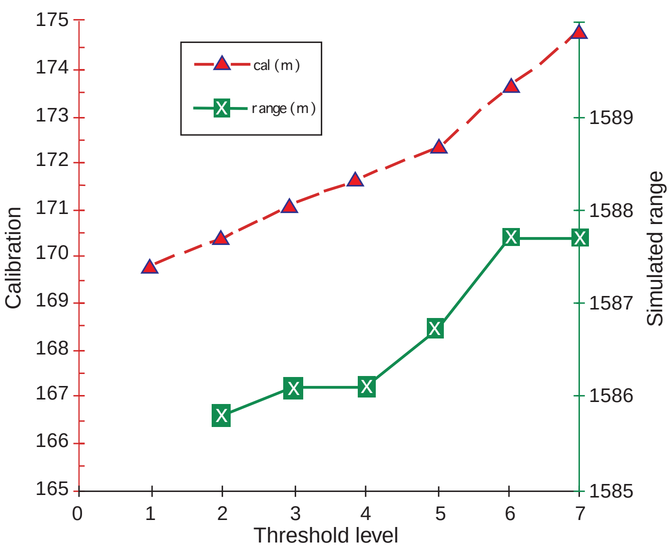

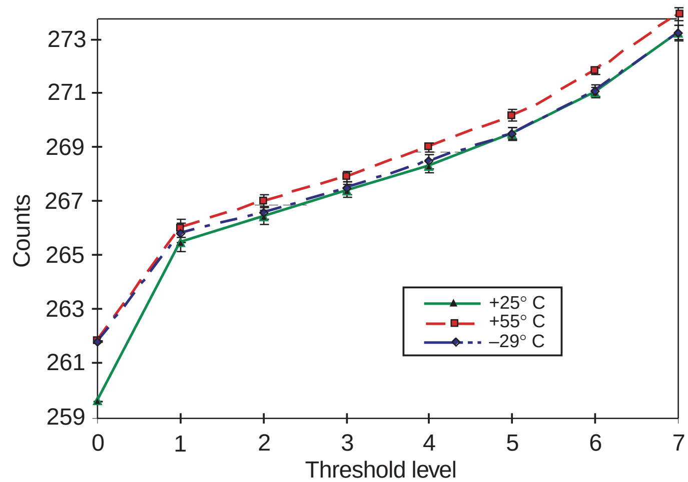

Calibration data from NLR. (Left panel) Dashed curve with superimposed triangles, left-hand scale, shows change in measured length of fixed calibration fiber as a function of detector threshold setting, a phenomenon known as range walk. Solid curve with superimposed squares, right-hand scale, shows measured range from simulated asteroid data and range walk. Total range walk is only ~4 counts in calibration fiber data and ~2 m in simulated asteroid data. (Right panel) Measured ranges from simulated asteroid data, in arbitrary units, showing range walk and variation with temperature. NLR has excellent temperature stability.

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