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Development of the Mars Observer Laser Altimeter (MOLA)

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The Mars Observer (MO) spacecraft payload scientific mission is to gather data on Martian global topography, gravity, weather, magnetic field and its interaction with the solar flux, surface chemistry and mineralogy over one Mars year (≈2 Earth years). In mid-1988 the need for a replacement altimeter as part of the payload complement arose. The MOLA was proposed by GSFC as an in-house effort and shortly afterward was "conditionally" accepted. Constrains on funding (fixed price cap), schedule, power and mass were imposed with periodic reviews during the instrument development to authorize continuation. MOLA was designed, tested, and delivered in less than 36 months (August '88 to July '91) and integrated with the spacecraft. During spacecraft payload testing the laser failed due to contamination in the laser cavity. In only 6 months the laser was removed, rebuilt from spare parts, retested and the instrument reassembled, realigned, requalified, and again delivered for spacecraft integration.

The spacecraft will arrive at Mars in October 1993, begin orbit insertion and reach its final 250 mile orbital altitude about 3 months later. MOLA will measure the laser pulse round-trip flight time from the spacecraft to the Martian surface, providing relative surface topography data to 1.5 meters for examining features of particular interest. Over the 2 year period a 0.2 X 0.2 degree global topographic grid of Mars will be generated with a vertical accuracy of 30 meters (mainly a function of orbit position accuracy knowledge) providing data on geophysics, geology and atmospheric circulation. By examining the return pulse through the four filter channels, surface slope will be inferred. Comparing transmitted energy with return energy will give surface reflectivity at 1.064 microns (the laser wavelength). These data will contribute to analyses of global surface mineralogy.

The transmitter is a lithium niobate Q-switched, Nd:YAG laser, pumped by a 44 bar aluminium gallium arsenide (AlGaAs) laser diode array. Pulsewidth is 7.5 nsec at 10 Hz. and 1.064 microns wavelength. At launch the measured output energy is greater than 40 millijoules. At the expected rate of degradation the output will be 30 millijoules at end of mission, still providing sufficient link margin to meet measurement requirements. Power consumption of the laser transmitter is 14 watts, only about half of total instrument consumption. The laser was developed by McDonnell Douglas Electronic Systems Inc. of St. Louis, MO.

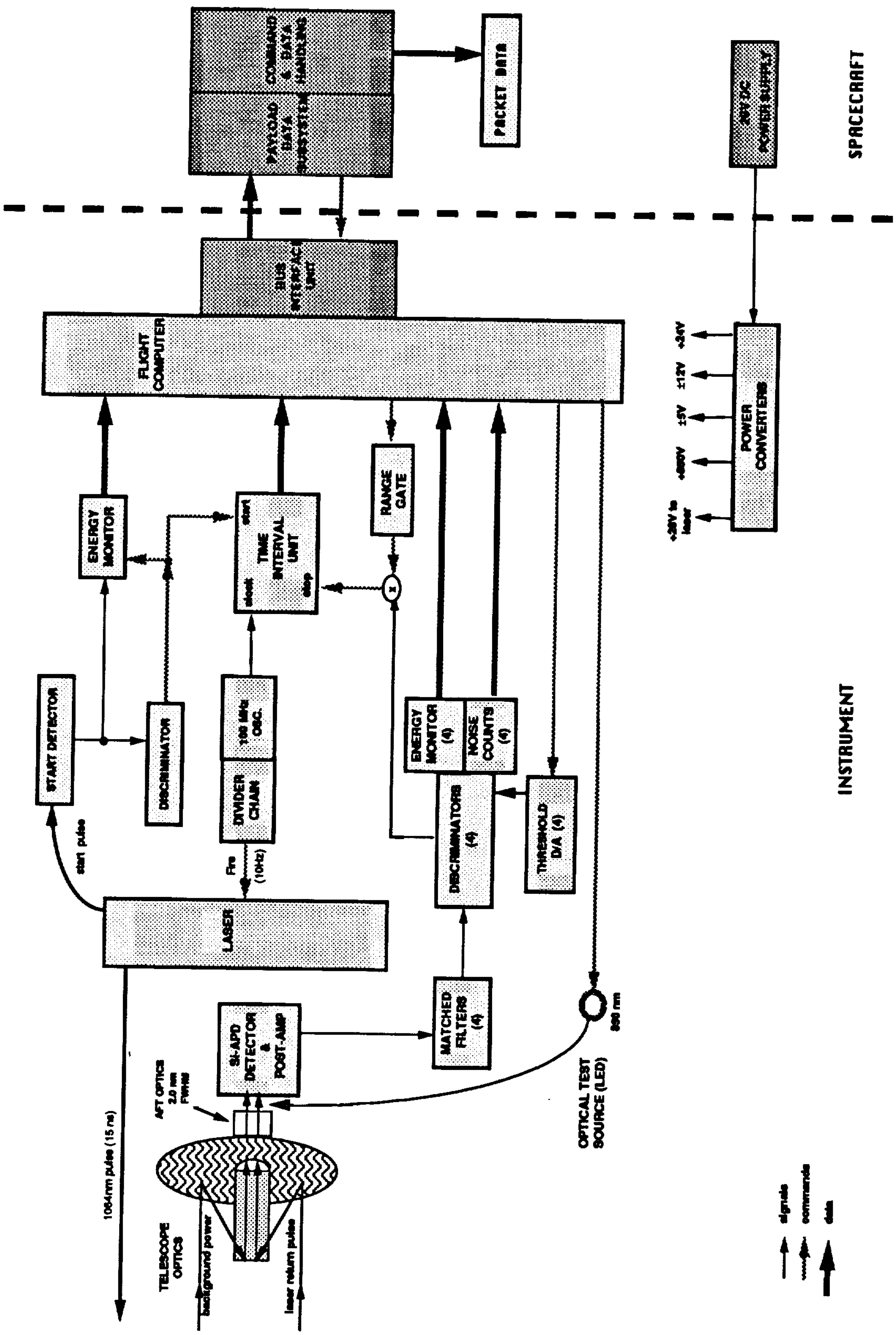
A 100 MHz clock is the standard by which the time interval unit measures the laser pulse round-trip flight time. The flight computer is set-up to begin ranging as soon as the instrument is powered on. Laser firing provides the range timing start pulse. The center of the laser beam is sampled optically and focused onto a fiber optic cable which carries the pulse to the PIN diode start detector. This starts the time interval unit (TIU). The clock provides timing for the laser firing as well as the TIU. Laser output energy is inferred from the start detector output.

The laser signal return from the Mars surface is received by a 50 cm. diameter beryllium telescope and focused on a silicon avalanche photo diode (40% quantum efficiency at 1.064 microns). In addition to focusing optics, the aft optics contain a bandpass filter to minimize solar background and a solar rejection filter for reducing solar input if the sun is viewed. The signal is amplified and passes through 4 low pass filters. Filter widths were selected to optimize detection probabilities for Mars footprint-scale surface slopes of 1.7, 5, 15 and 39 degrees. The flight computer continuously updates receiver channel thresholds, maximizing detection probabilities and establishing a fixed rate of false alarms.

Physically the instrument is about 2' tall and its baseplate is triangular, about 2' on a side. It weighs 28 kg. and draws 30 watts including heater power. The telescope sun shield is attached to the laser/telescope interface plate, acting as a radiator to cool the laser. Thermostatically controlled heaters are mounted to the laser for additional thermal control.

The MOLA instrument underwent full environmental testing at the Goddard Space Flight Center (thermal balance, thermal vacuum, vibration, acoustic, and EMI/EMC) as well as thermal vacuum, EMI/EMC, and acoustic testing while integrated with the spacecraft. The Mars Observer Spacecraft is scheduled for launch in Sept./Oct. 1992.

For a comprehensive description of the MOLA experiment refer to the paper by M.T. Zuber et. al., The Mars Observer Laser Altimeter Investigation, *Journal of Geophysical Research*, vol. 97, No. E5, Pages 7781-7797, May 25, 1992.



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