THE LUNAR ORBITER LASER ALTIMETER (LOLA) LASER TRANSMITTER

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ABSTRACT

We present the final configuration of the space flight laser transmitter as delivered to the Lunar Orbiter Laser Altimeter (LOLA) instrument. The instrument was launched in 2009 and has been in operation for close to two years and accumulated over 1.3 billion laser shots in space.

Index Terms**—** Space laser, alitmetry, topographic mapping

1. INTRODUCTION

The Lunar Orbiter Laser Altimeter instrument on board the Lunar Reconnaissance Orbiter (LRO) mission has been in operation since it was launched in 18 June 2009. Thus far the laser transmitter system, which consists of two individual lasers, has accumulated over 1.3 Billion shots and provided an unprecedented view of the lunar surface.[1] In this paper we present the final configuration of the space flight laser transmitter as delivered to the LOLA instrument along with some in-space operation performance data.

2. THE LOLA LASER TRANSMITTER

The LOLA instrument was turned on 4 July, 2009 and has been in essentially constant operation since then. The Exploration Phase of the mission, which lasted for 1-year after first turn-on has been completed and we are now in the Science Phase of the mission.[2] The LOLA laser transmitter follows the continued success of GLAS[3] and MLA[4] in using a diode pumped, Cr:Nd:YAG slab with passive q-switch and a cross-Porro resonator configuration. The laser transmitter consisted of a beryllium (Be) flight laser bench housing two oscillators (Laser 1 & Laser 2) that are polarization combined to provide a single output, an 18X transmit beam expander, a diffractive optical element (DOE) [4] to split a single beam into five, a receive telescope and the laser electronics. The LOLA instrument is the first multi-beam, non-scanning laser altimeter system in space. The single laser beam is split into five beams (arranged in a 4-pointed star with a central beam configuration) for measurement of the slopes both along and cross track. The on-orbit operation mode has each laser fire for a specific time period (usually four weeks) and then switch to the other laser for the next period during the course of the mission.

The LOLA laser oscillator (shown in Figure 1) is a cross-Porro resonator with an effective output reflectivity of ~18% to produce a specified output energy of 2.7±0.3 mJ per pulse (prior to transmit beam expander and DOE) at a rate of 28 Hz, with a minimum pulse width of 6±2 ns.

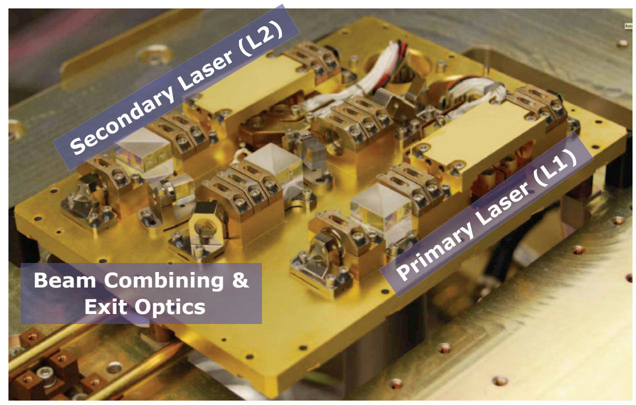

Figure 1. The LOLA flight laser transmitter.

The receive telescope is a refractor design in a beryllium structure with a sapphire objective. The received light is imaged onto fiber optic bundle placed at the focal plane of the telescope and coupled to the aft optics. The return light is detected by silicon APDs that have heritage from previous missions. The range measurement unit is similar in design to the MLA which uses high resolution time-of-flight ASICs. A DOE fabricated in etched fused silica with anti-reflective (AR) coating at 1064 nm is used to split a single laser beam five ways into the required five ground spots. The far field divergence of each of the five spots is 100 µrad. At 50 km orbit, this will produce five-5 m diameter spots with center-to-center separation of 25 m on the lunar surface.

As delivered, the threshold current and switch-out time of the passively q-switched oscillators are 61 Amp, 156 µs and

65 Amp, 168 µs respectively for Laser 1 (L1) and Laser 2 (L2). The lasers are designed to operate in constant energy mode so changes in switch-out time and threshold currents do not affect the energy output during the mission. As of this writing, the lasers have been operating nominally with the same threshold currents and switch-out times have increased by 2 µs and 10 µs respectively for L1 and L2.

3. IN SPACE PERFORMANCE

During the mission, the LOLA laser experienced a wide temperature extremes of -20°C to +40°C, and is designed to operate within specifications between 5°C to 28°C per lunar orbit. Survival heaters attached to the laser housing are used to ensure the low extreme will not go below -20°C. The instrument achieves a steady-state temperature during orbits with high solar beta angles (close to 90 degrees), but for the majority of the mission the laser bench minimum temperature will oscillate over the 113-minute orbit with the amplitude of this oscillation ranging from 0°C at beta 90 to 10°C at beta 0.

The LOLA laser transmitter successfully produced approximately 800 million combined shots during the Exploration Phase of the LRO mission. This provided an ample quantity of lunar elevation measurements that allowed the LOLA instrument to meet all high-level data requirements in delivering the most detailed three-dimensional map of the lunar surface to date.

Since it was first turned-on, the LOLA laser transmitter has a combined shots fired of over 1.3 Billion, with ~700 Million shots for L1 and ~600 Million shots for L2. Both lasers continue to operate nominally with energies the same as delivered and the orbit-averaged switch-out times for L1 and L2 are currently 158 µs and 178 µs, respectively.

4. CONCLUSIONS

The LOLA instrument is designed to map the lunar surface and provide unprecedented data products in anticipation of future manned flight missions. The laser transmitter has been operating on orbit at the Moon continuously since July 2009. The LOLA laser transmitter design has heritage dated back to the MOLA laser transmitter launched more than 10 years ago and incorporates lessons learned from previous laser altimeter missions at NASA Goddard Space Flight Center.

5. ACKNOWLEDGEMENT

The authors acknowledge the support of the LOLA science team, especially David E. Smith (PI), Maria Zuber (PI), the LOLA instrument team and Glenn Jackson (instrument manager).

6. REFERENCES

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