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Planetary Altimeter for HERA Development

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The NASA DART and the ESA HERA missions aim to provide an experiment in asteroid defection, though a kinetic collision. DART spacecraft will be sent to collide at high speed, approximately at 6.6 km/s, with the smaller asteroid, usually called Didymoon of the binary asteroid system Didymos. HERA spacecraft will be sent to study the effects of the impact, so that our knowledge of the energy transmission due to the collision is improved. HERA spacecraft will evaluate Didymoon orbit change, structure of the asteroid, crater size [1].

HERA spacecraft carries several payload instruments to provide these studies, namely: Cameras, Radar, Satellite-to-Satellite Doppler tracking, LIDAR, Seismometer and Gravimeter.

In this work we report the LIDAR, also known as PALT for HERA, conception, design, and manufacturing process that is currently ongoing, as well its scientific aims and contribution to spacecraft navigation.

PALT is a ToF altimeter that provides time tagged distances measurements. The instrument can be used to support near asteroid navigation and provides scientific information (e.g. asteroid 3D topography and fall velocity) and also reports the power of the received pulse being possible to calculate the target reflectivity.

PALT first version EM is based on a Laser Landing Altimeter Engineering Model developed by EFACEC and Faculdade de Ciências, Universidade de Lisboa (FCUL), in the frame of an ESA NEO-MAPP project. THE PALT comprises a compact low power consumption microchip laser that emits 1.5 μm light pulses and a low noise sensor. This laser technology enables rangefinder compact designs. The synergies between these two technologies enable the development of a compact instrument for range measurements of from 500 m to 14 km with a low power consumption and envelope of 12 cm×15 cm×10 cm. The PALT electronics was designed to endure a TID of 100 krads.

PALT has four main blocks, power supply, processing unit, electronics frontend, ToF optical front end. Optical front end is composed by emitter and receiver.

Power supply uses a traditional flyback solution, optimised for the altimeter secondary powers consumption and outputs filtering.

Processing unit is based on a FPGA since it simplifies the process of keeping precise timings, required to operate the ToF unit. FPGA is also responsible to perform all the housekeeping acquisitions, to monitor the health of the altimeter and for the interface with the spacecraft, via Universal Serial Link.

ToF is the key block of the LIDAR altimeter with respect to its accuracy and precision. This unit is responsible to time tag all the laser emitter pulses as well as all the APD receptions, with a precise timed tag that will be then managed by the processing unit FPGA to compute the distance.

Frontend Electronics is responsible for the Laser power supply and triggering, also for the Laser pulses digitalization (emitted and received).

The preferred LASER source for PALT is currently being developed at FCUL. The laser used as source is a diode pumped, passively Q-switched Yb-Er Microchip Laser targeting a 100 µJ Gaussian pulse with a FWHM of 2 ns. The backscattered radiation is a gaussian pulse shape.

The main optical specifications of the optical front end follow the receiver, emitter, and filter parameters. The receiver optical aperture diameter and obscuration are 100 mm and 30 mm, respectively. The FOV receiver has 1.5 mrad value, a transmittance of 0.91; a sensor with a 230 kV/W responsivity. Relatively to the emitter properties, it has a FOV of 1 mrad and optics transmittance of 0.94. The energy budget was calculated using (1), which allowed an estimation of the magnitude of the returned power [2]:

$E_r \approx E_{TR}\, r_s/\pi\, A_r/D^2\, \tau_R\, OV$ (1)

where E_{TR} is the emitter transmittance, r_s is the asteroid reflectance, A_r is the telescope area, D is the distance, τ_R is the receiver transmittance and OV is the overlap.

Considering the emitted laser pulse has FWHM of 2 ns and Gaussian shape, the receiver power can be calculated.

The returned peak power Figure 1 along with saturation limits of the sensor and minimum detectable power considering solar background, sensor NEP and M=20.

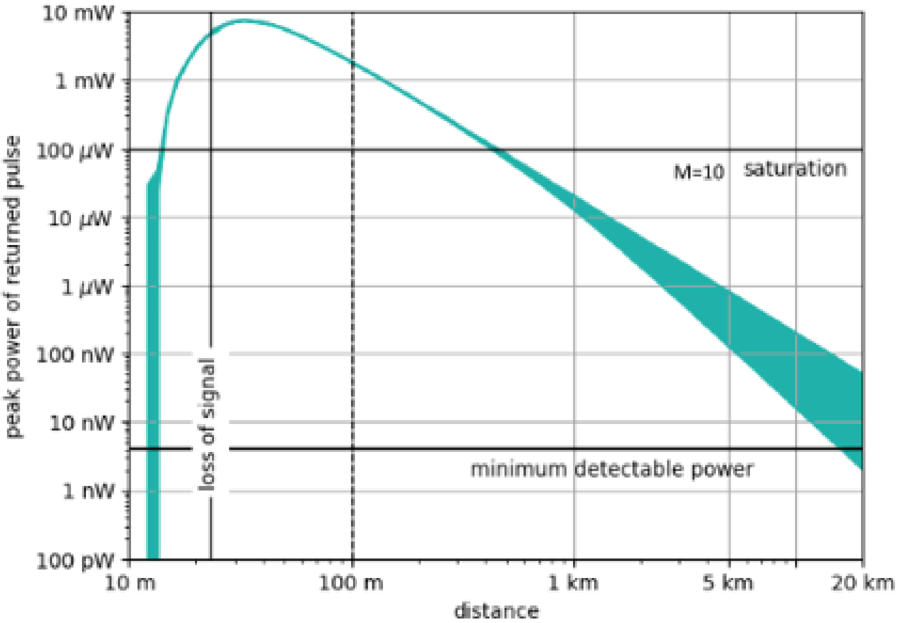

Figure 1. Detected peak power (higher and lower bound represents a 0º and 20º surface inclination).

The most critical component of the optics front end is the receiver telescope. The receiver telescope has a Cassegrain design. The primary mirror is made of zerodur and has 100 mm diameter. The secondary mirror is assembled on a carbon fiber tripod structure, the telescope ray tracing (zemax design), the footprint (on sensor) for different operating distances (Figure 2).

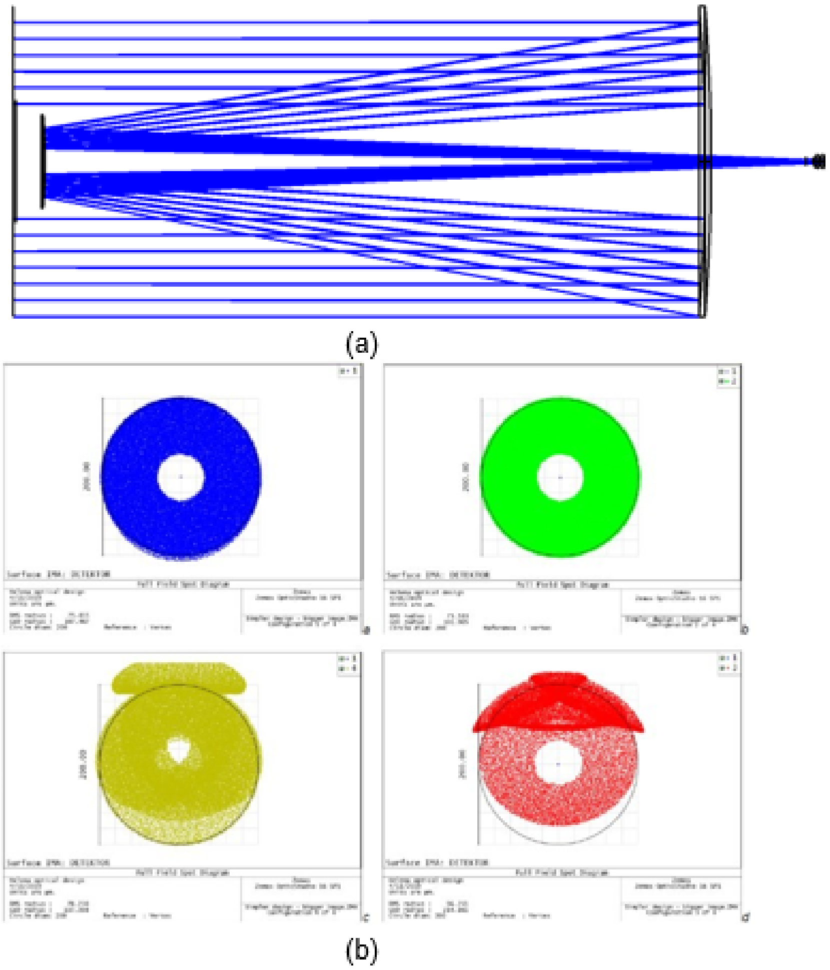

Figure 2. (a) Telescope ray trace; (b) spot diagram for several raging distances.

The LIDAR has to withstand the launcher load and maintain integrity and performance of the optical receiver telescope (Figure 3) (a) system; (b) present a light telescope structure that withstand launch vibrations.

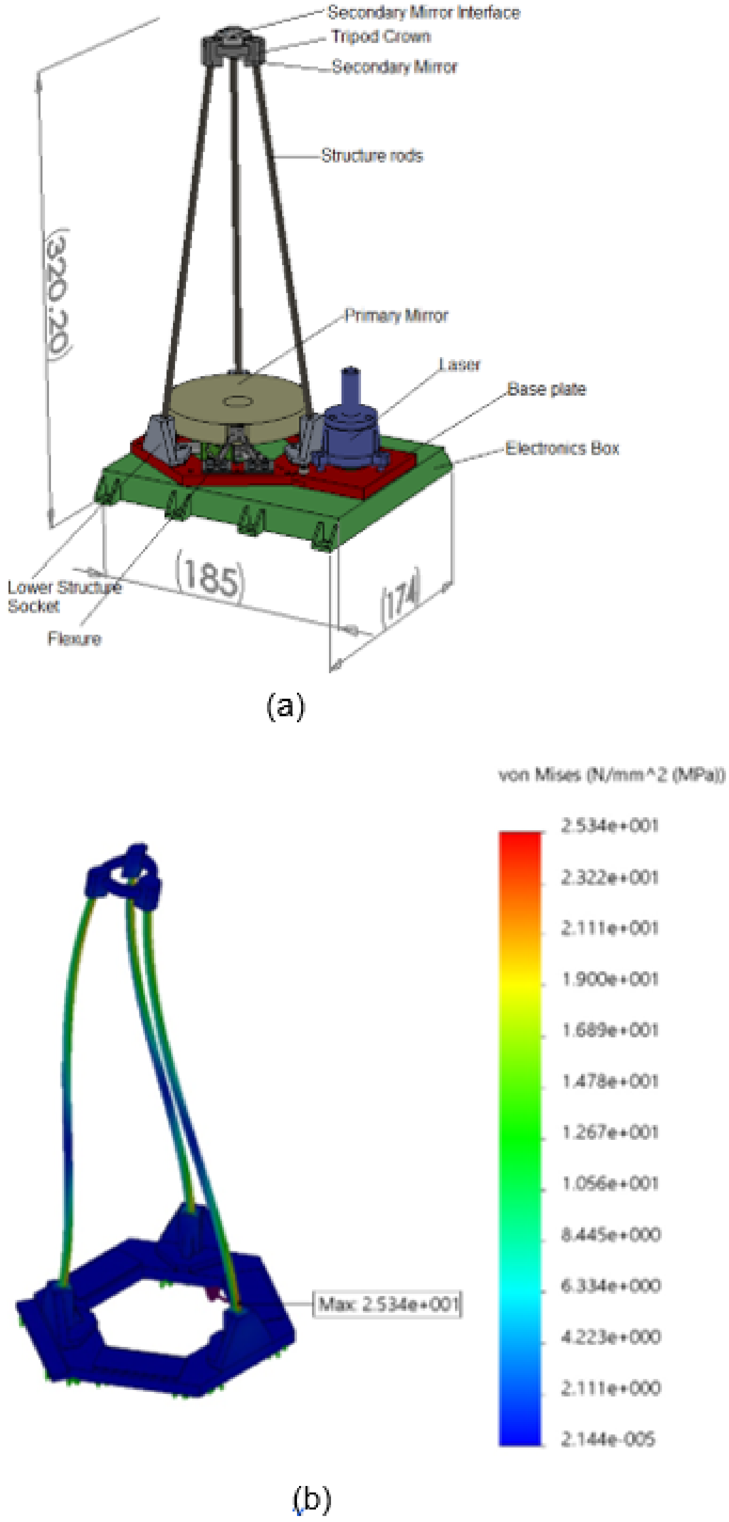

Figure 3. (a) Lidar system 3D CAD design; (b) Vibration simulation of telescope structure.

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