HELENA – HERA LIDAR ENGINEERING MODEL ALTIMETER

Paulo Gordo – FCUL & Armilar (Omnidea group)

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Introduction

- Content:
- Development LIDAR Team
- HELENA timeline
- ABPA LIDAR (i.e. Previous lidar)
- HELENA requirements
- HELENA power budget

TEAM

- Current LIDAR team (for ENGINEERING MODEL OF A LASER ALTIMETER FOR THE AIM activity):
- EFACEC (prime) – Arlindo Marques

(Portugal and Romania)

  - Space electronics, mechanical design, full system integration

- FCUL & OMNIDEA – Paulo Gordo

(Portugal - Faculty of Sciences University of Lisbon)

  - Optic design, opto-mechanics and optical system MAIT

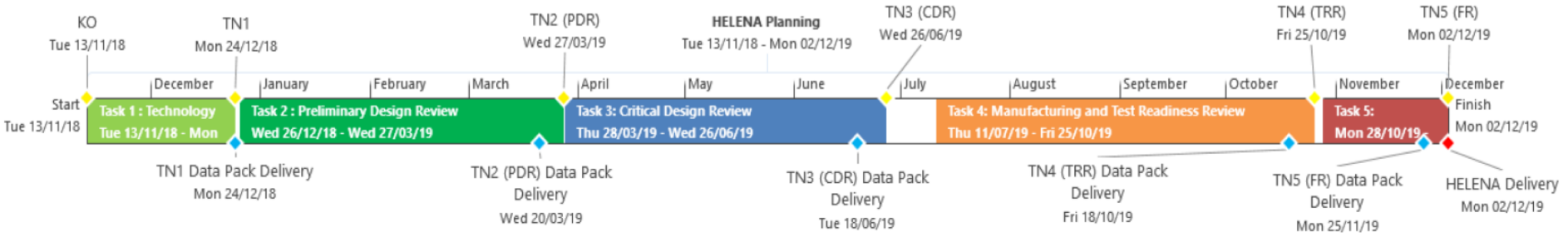
- INOE - Doina Nicolae

(Romania - National Institute of Research and Development for Optoelectronics)

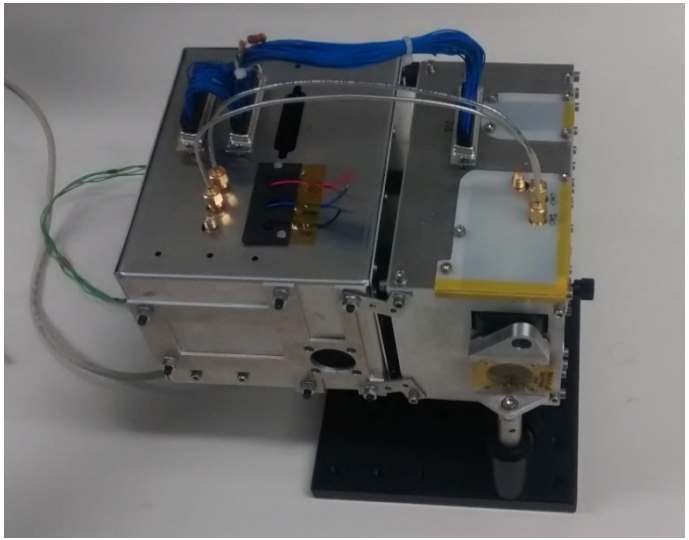
  - Optic design, LIDAR simulation

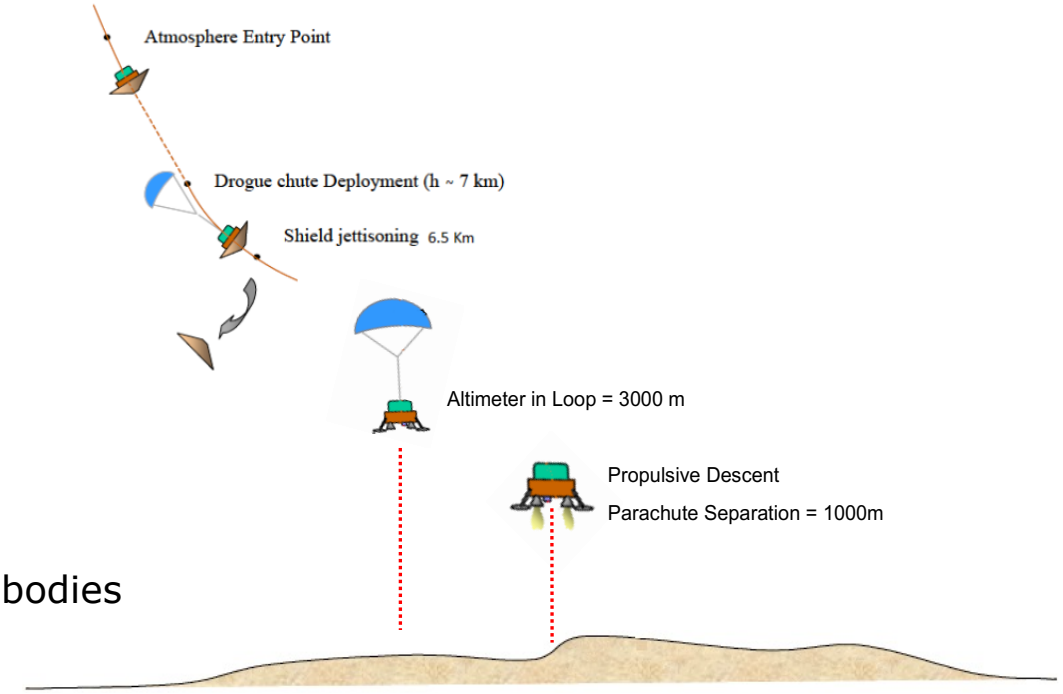
- ESA TO – Georgios Tzeremes

HELENA planning



ABPA LIDAR





- Developed for Landing in celestial bodies
- Compact, low power
- Lidar and / or Radar frontend
- 2 protocols (SpW and/or CAN Bus…)

ABPA LIDAR - Performance

Parameter	Requirement	Remarks	RADAR Altimeter Unit Results	LIDAR Altimeter Unit Results
Operational envelope for altitude [km]	3km down to 0.01km	Portion of the altitude in which the altimeter shall supply data to the GNC loop for action	Max:2,2km Min 10m	Max: 810m Min:18m Maximum distance limited by test campaign.
Maximum G-load [m/s2]	40g	To survive the Earth launch and the Mars entry and parachute deployment	On breadboard, 8g	On breadboard, 8g
Maximum Mass [kg]	1kg	Including electronic box and required antennas or telescope	1,7kg (with antennas)	0,585 kg (unit box only)
Maximum Dimensions of the electronic box on height, length and width [cm, cm, cm]	10cm x 10cm x 15cm	Emphasis is placed on miniaturisation	12,0cm x 15,0cm x 10,0cm	12,0cm x 15,0cm x 10,0cm
Maximum Power Consumption [W]	5W	For the entire assembly (8W worst case)	5,6W	8,6W
Maximum supply voltage	Nominal: 28V Peak: 36V	Compatible with the typical Descent Module architecture	Nominal: 28V Peak: 36V	Nominal: 28V Peak: 36V

Electronics box +LIDAR unit - 1,4kg with margin (1,19kg without)

HELENA requirements

Requirement	HELENA	Problem & Solution approach
Range	–20 Km 200m	- ABPA design range was 3Km to 0.01Km - Increase optical aperture - Increase APD Sensor Gain - Cooled APDs receivers with TIA - additional circuit with APD receiver working in Geiger mode
Operational Wavelength	1.5um	- LIDAR LASER source is a 1.5um microchip laser
FOV	< 3 degrees	- Design FOV is 0.5 degree
Measure rate	10Hz	
Operational temperature	-40 to 70	- ABPA was -40oC to 60oC - Design issue to be consider
Data Handling Interfaces	Compatible with both Space Wire and CAN-Bus.	- It is foreseen around 3 kbit/s
Accuracy	0.5 m (goal 0.1m)	0.1 m is challenging – 0.67ns TOF error 0.5 m is comfortable - 3.34 ns TOF error ABPA requirement was 1% (2 m at 200m) Radar accuracy was 1,68% Vvery limited testing in Laboratory: ABPA LIDAR accuracy at 75m is 4,6% (3 m) ABPA LIDAR accuracy at 810m is 8%

HELENA power budget

$$E_r = E_{tr}\tau_r \frac{A_r}{R_m^2}\frac{r_s}{\pi}{\tau_a}^2[\mathrm{J}]$$

Er - pulse energy (J),
Etr - transmitted pulse energy (J)
τr - receiver optics transmission
Ar - receiver telescope aperture area
rs - target surface reflectivity (assuming Lambertian)
τa - atmosphere transmission

System parameters		
Symbol	Value	Description
E_{laser}	100 µJ	Laser pulse energy (TBD)
Δt	2 ns	Pulse width (TBD)
E_{tr}	90 µJ	Transmitted laser pulse energy (after optics)
τ_t	$9{,}03^{-01}$	Emitted optics transmission
τ_r	$9{,}40^{-01}$	Receiver optics transmission
A_r	(diameter 50mm to 150 mm)	Receiver telescope entrance aperture area. Parameter to be explored
r_s	0,1	Asteroid surface diffusive reflectivity
τ_a	1	No atmosphere
P		Peak power of receiver signal
λ	1535 nm	Laser wavelength (TBD)
I_d	50 nA	APD dark Current
η	0,75	APD quantum efficiency at 1550 nm
K_{eff}	0,6	APD ionization coefficient ratio
R_{APD}	25	APD responsivity (considering an M=25)

HELENA power budget

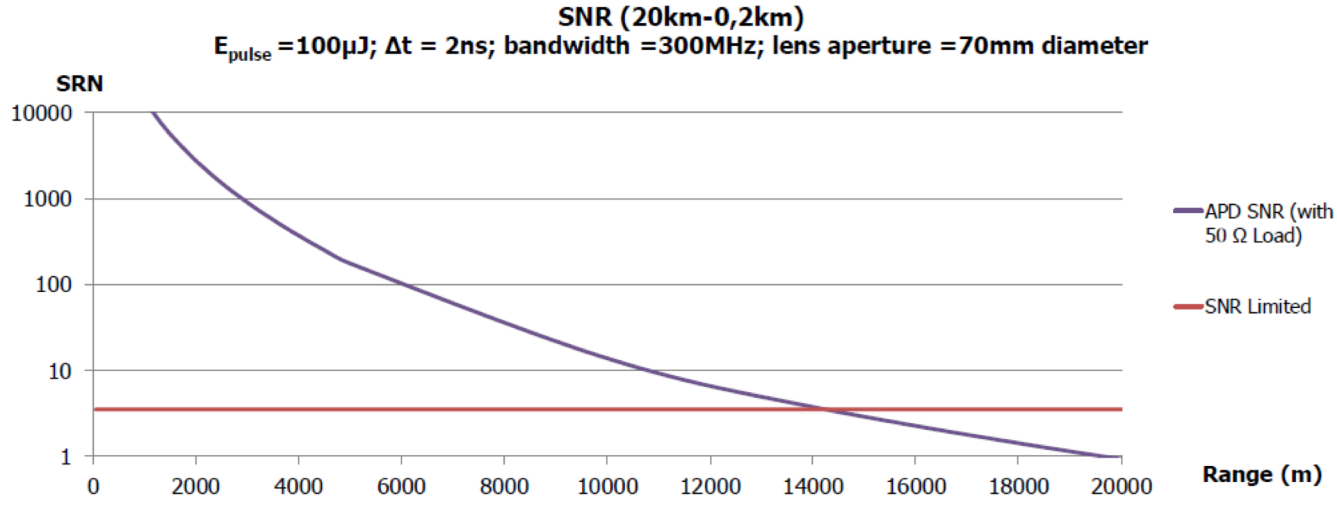


Figure 4 - LIDAR SNR as function of distance

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