LASER ALTIMETER FOR PLANETARY EXPLORATION

Ivan Prochazka, Karel Hamal
Czech Technical University in Prague.Brehova str. 7, 115 19 Prague 1, Czech Republic
prochazk@mbox.cesnet.cz phone +420 723 920 786, fax +420 224 922 822

Abstract

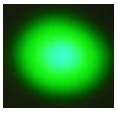
We are reporting on the research and development of a Laser Altimeter for Planetary Exploration (LAPE). It has been selected by ESA as a key-technology for future planetary missions. The device has to provide altimetry in the range of 400 to 1400 km and 1m range resolution under rough environmental conditions - Sun illumination, high background radiation under extremely limited weight and power consumption allowances. The proposed LAPE is designed to be a modular test equipment to test critical components and technologies such as the microlaser source, the photon counting detector and its electronics. In particular the signal to noise ratio under various background light conditions in the near infrared and the detector sensitivity under various cooling concepts need to be characterised. Photon counting strategies for high repetition rate data acquisition, signal processing techniques and data reduction will be investigated. This project builds on our experience acquired within the Russian altimeter missions Mars '92 and in Lidar for the NASA Mars Polar Lander '98.

Goals:

- To develop a modular test equipment:
  Technology Demonstrator to test critical components and technologies of the photon counting
  Laser Altimeter for Planetary Exploration LAPE.

- CRITICAL COMPONENTS
- microlaser multi kHz
- detector SPAD / ADP
- optical filter

- CRITICAL PROCEDURES
- energy budget link & S/ N ratio
- data acquisition and processing
- signal mining techniques

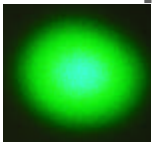


LAPE Parameters

- Altitude 400 – 1000 (1400) km
- Resolution 1 meter
- Background day and night operation
  on planetary orbit
- Concept photon counting
  multi kHz repetition rate
- Mass / Power 5 kg / 10 W
- Optics separate T / R
  receiver reflector, 150 mm
  transmitter refractor 30 mm

LAPE Technology Demonstrator
Philosophy

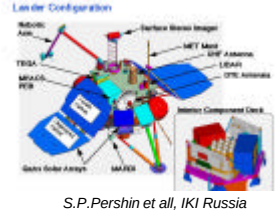
- Based on experience acquired in space projects MARS and Mars Polar Lander
- Use of off-shelf components whenever possible
- Optical <u>apertures scaled down</u> to enable indoor and ground based tests of energy budget link *(Difficult to test 1000 km / vacuum baseline)*
- Receiver <u>FOV and filter bandwidth scaled up</u> to enable indoor and ground based tests of the S/N ratio and signal processing techniques



Photon Counting Laser Altimeter & Lidar

Project MARS 92, Russia

NASA Mars Polar Lander 98

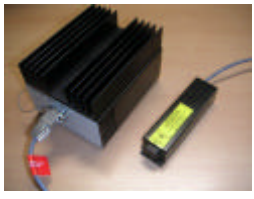


S.P.Pershin et all, IKI Russia

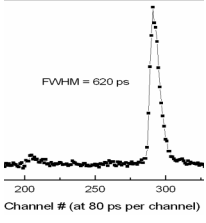
• Laser		diode 100nJ / 2kHz
Optics		30 x 50 mm
• Receiver		Si SPAD 40 um
Optics		20 mm diameter
• altimetry		0 - 5 km
• visibility		0 - 50 km
• clouds		heights, density
• mass	400+400+100	900 g
• power	average	< 30 mW
	peak	< 4 W (LD heat)

LAPE Technology Demonstrator LASER

TRANSMITTER

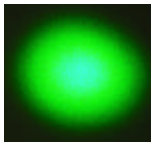


- diode pumped microlaser
- frequency doubled NdYAG
- 10 mW @ 532nm , 10 kHz
  = > 1 uJ / shot



FWHM = 620 psec

TEM_{00} mode
divergence 4 mrad



LAPE Technology Demonstrator

Detector, Timing and Control

- DETECTOR PACKAGE
- # 1 SPAD on Silicon K14
- 25 um diameter, uncooled
  space qualified
- cw / gated, active quenching
- # 2 APD @ 1064 nm, cooled
  made by Silicon Sensors

- TIMING & CONTROL
- program. gate arrays 100MHz
- interval & epoch timing
- range gating
- µP controller

LAPE Technology Demonstrator

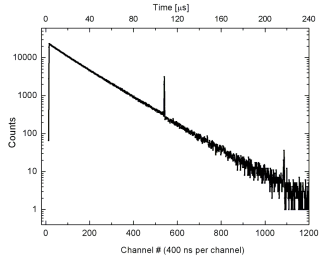
Energy Budget Link and S / N Scaling

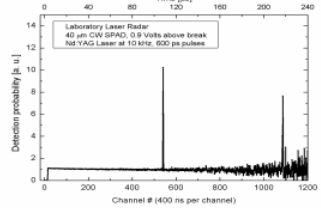
- PHASE A indoor / static
- energy budget reduced $2.3 * 10^{10}$
- = > range reduced $1.5 * 10^{5}$
  1 -10 m indoor corresponds to 150-1500 km in orbit
- background increased $1 * 10^{1}$
  Earth daylight corresponds to Mercury daylight

- PHASE B outdoor / air-born / dynamic
- energy budget reduced $2.3 * 10^{6}$
- = > range reduced $1.5 * 10^{3}$
  100-1000 m ground corresponds to 150-1500 km in space
- background increased $1 * 10^{1}$
  Earth daylight corresponds to Mercury daylight

LAPE Technology Demonstrator

Energy Budget Link and S / N Test Results





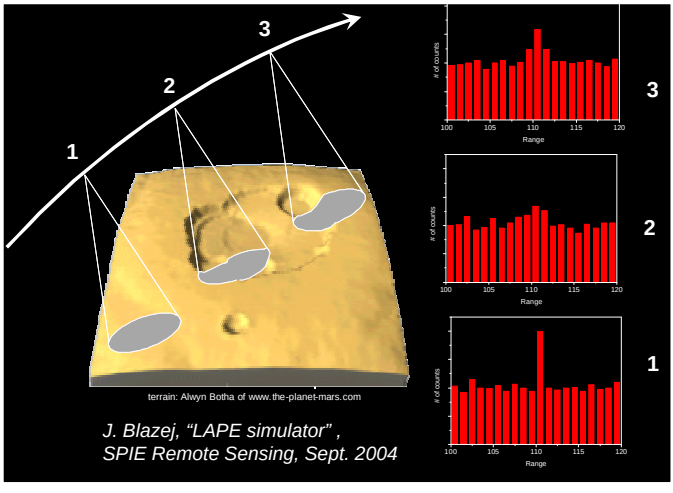
- INDOOR RANGING, Phase A
- 1.5 m distance < = > 225 km
- 10 kHz @ 532 nm laser
- high noon background
- raw data histogram, log scale
- echo data rate 100 / s
- window 240 us ~ 36 km

- the same data set converted to detection probabilities

- demonstrates the feasibility of 30 km wide range gates in daylight on a low altitudes

LAPE Technology Demonstrator

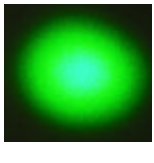
Planet Topography Contribution to S/N Ration Degradation



LAPE Technology Demonstrator

Conclusion

- The Technology Demonstrator of the photon counting Laser Altimeter for Planetary Exploration LAPE is under development
- PHASE A indoor / static tests
- the Demonstrator version A - operational 10kHz / 1uJ @ 532 nm / SPAD
- - energy budget link
- - S/N ratio for daylight
- the planet topography contribution simulator under construction



- PHASE B outdoor / air-born / moving objects tests
- 2 kHz/ 10 uJ @ 1064 / APD
- project funding dependent