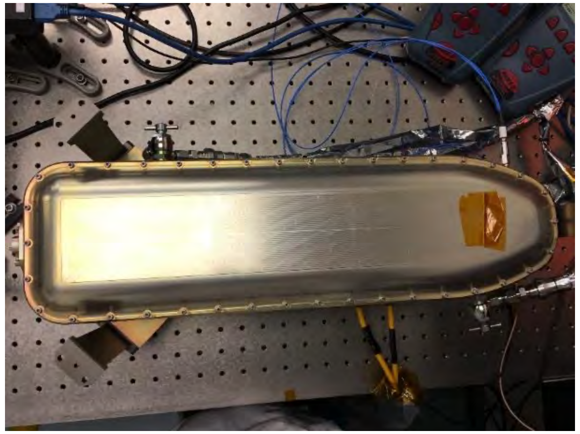
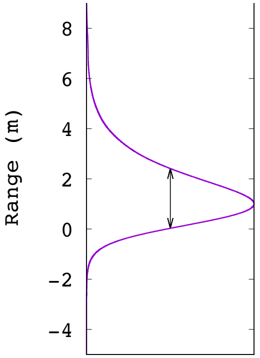
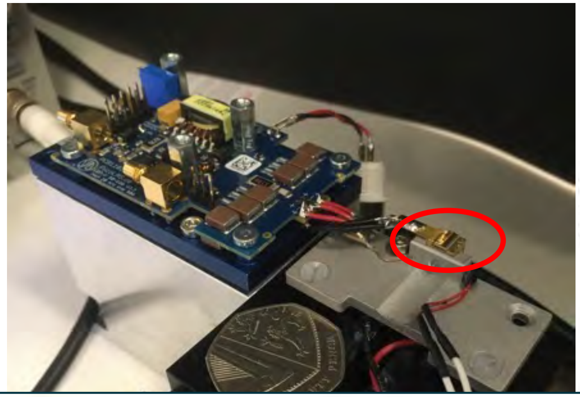
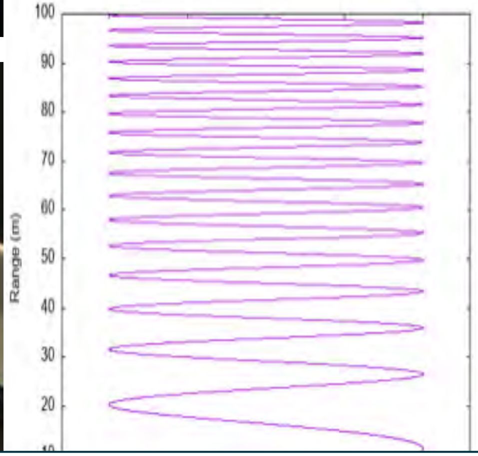
GLAMIS: Laser source



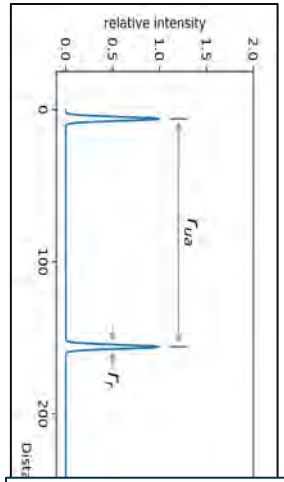


Solid-state laser pulse. 100’s kW

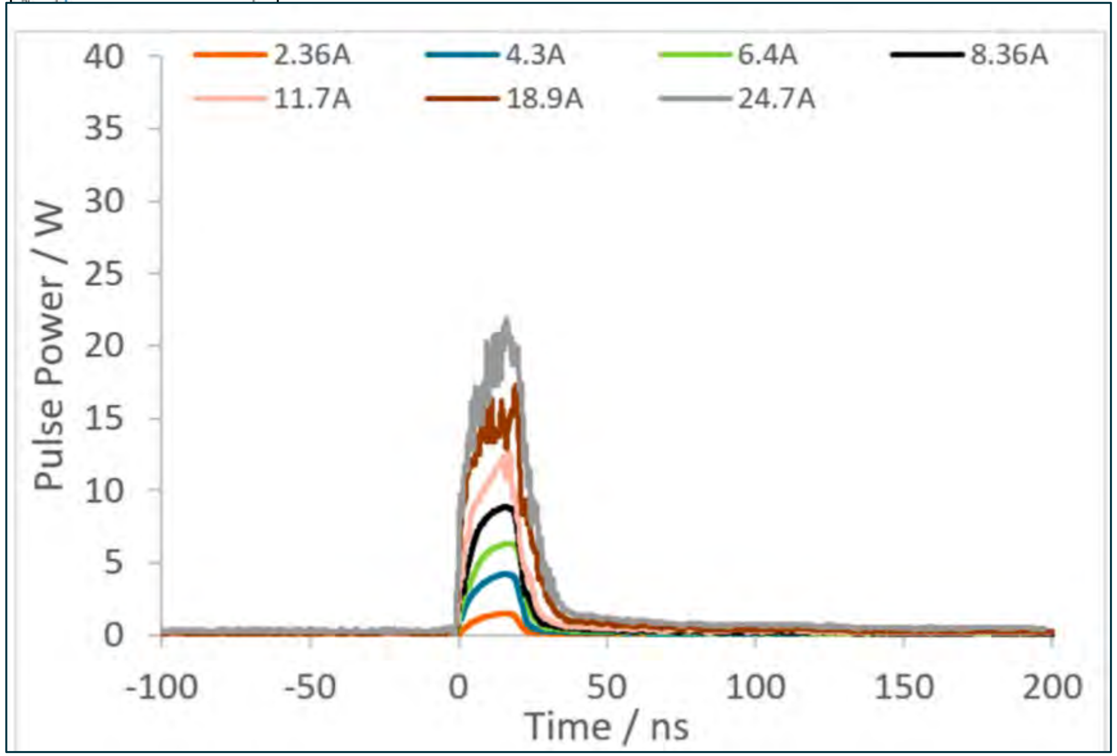


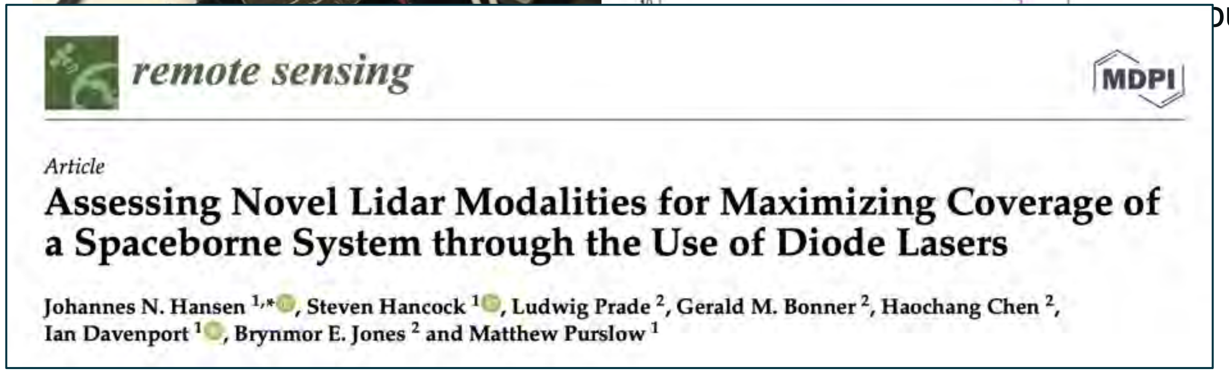


Diode laser, pulse compressed lidar (few Watts)



Diode laser pulse-train




remote sensing

MDPI

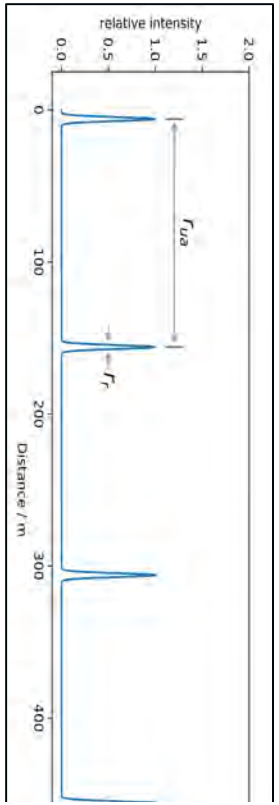
Article

Assessing Novel Lidar Modalities for Maximizing Coverage of a Spaceborne System through the Use of Diode Lasers

Johannes N. Hansen [1,*], Steven Hancock [1], Ludwig Prade [2], Gerald M. Bonner [2], Haochang Chen [2], Ian Davenport [1], Brynmor E. Jones [2] and Matthew Purslow [1]

GLAMIS: Constellation

Characteristic	Value
Altitude	500 km
Beam footprint	30 m
Peak power (per laser)	>= 8W
Pulse length	<= 33 ns
Average power (per laser)	0.26 W
Laser	diode laser, ~ 850 nm
Laser efficiency	>= 10%
Detector efficiency	58%
Payload power	120 W
Telescope diameter	58 cm
Number of lasers	30
Swath width	900 m (4.5 km if 20% sampling)



Spatial coverage	Number of satellites	
	5 year repeat	Annual repeat
100%	1	6
20%	1	2

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Acta Astronautica
ELSEVIER
journal homepage: www.elsevier.com/locate/actaastro
Research Paper

Spacecraft and optics design considerations for a spaceborne lidar mission with spatially continuous global coverage

Christopher John Lowe [a], Ciara Norah McGrath [b], Steven Hancock [c], Ian Davenport [c,g], Stephen Todd [d], Johannes Hansen [c,f], Iain Woodhouse [c], Callum Norrie [e], Malcolm Macdonald [a,*]

GLAMIS: CEOI-15

Space
Flow Ltd.

Instrument requirements and data processing

- Validate noise model and update instrument performance definition if needed
- Algorithm development – make spatial algorithms robust and determine energy saving possible

Transmitter laser module development

- Increase the combined laser and driver efficiency to at least 10%, with a focus on the driver efficiency
- Package the laser and attach fibre
- Raise TRL from 3 to 4.

Instrument optical model

- Produce the instrument design needed
- Confirm the size and weight needs.

Route to launch and operation

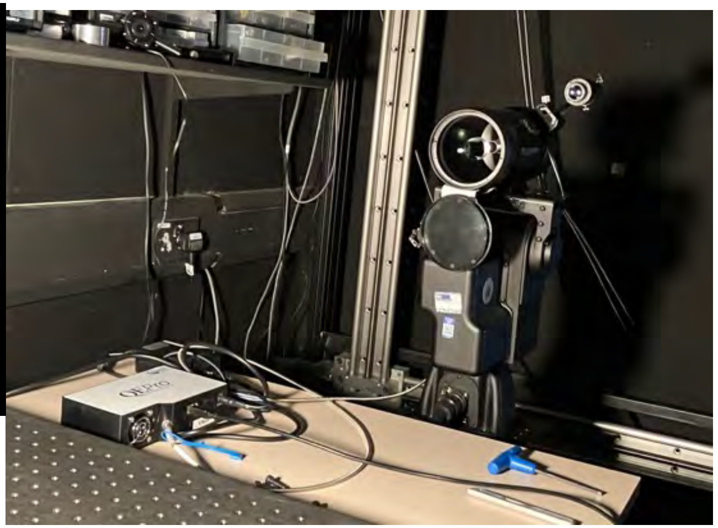
- System cost and model
- Scientific and commercial impact

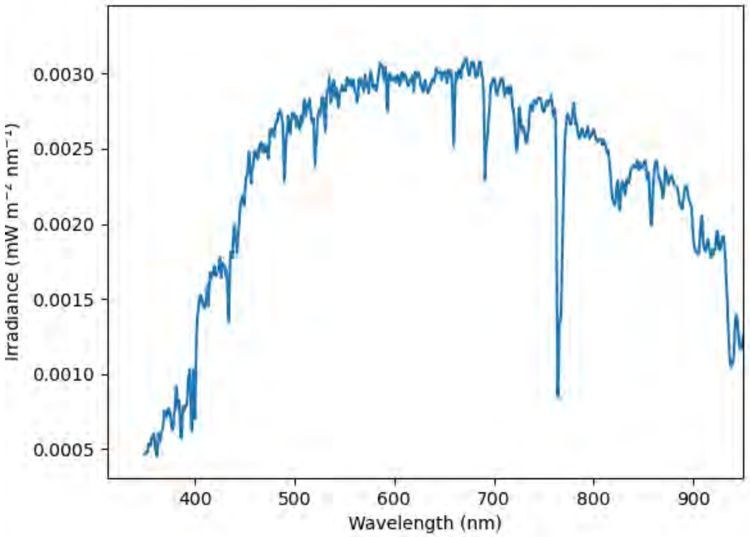
Noise model validation

Validate lunar irradiance

- Full moon measured
- For a 5 nm bandpass filter centred on 850 nm
    - **Surface lunar power of 0.013 mW m^{-2}**
    - **Modelled result = 0.0126 mW m^{-2} (at ground level)**

- With thanks to Ross Donaldson and Cameron Simmons of Herriot-Watt
- For GLAMIS's 500 km altitude, 58 cm diameter telescope, 58% efficient detector, 50% surface reflectance, 80% atmospheric transmission and 4.25 ms integration time
    - **52 lunar noise photons per pixel**



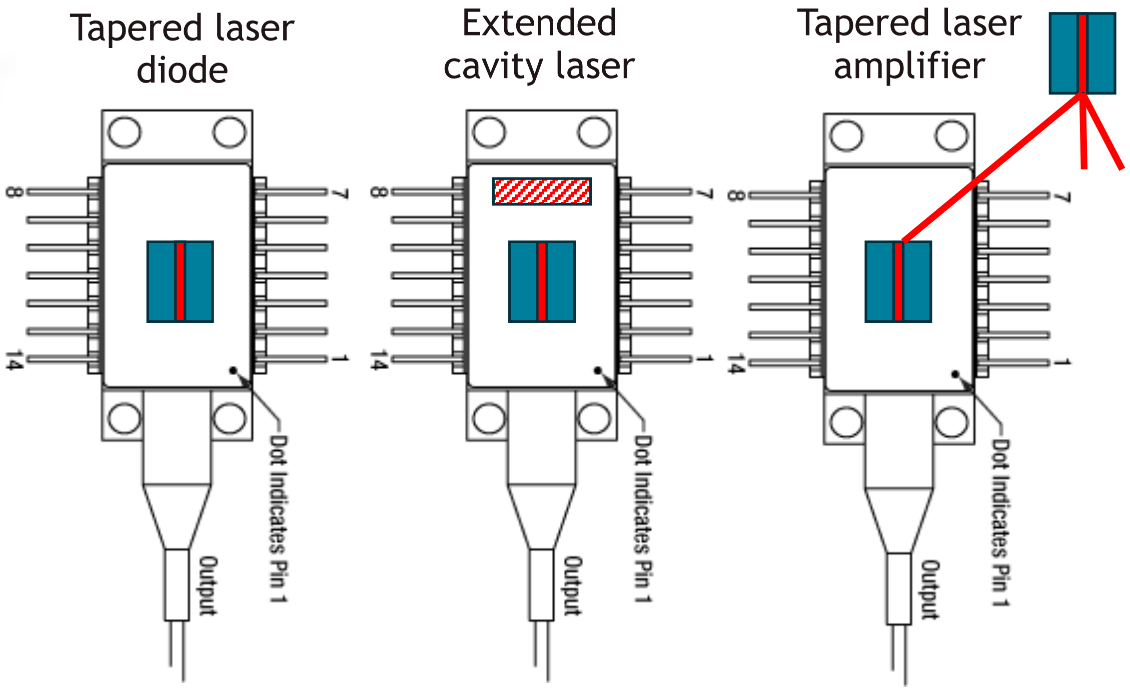


Updated instrument requirements

What can be adjusted in the instrument?

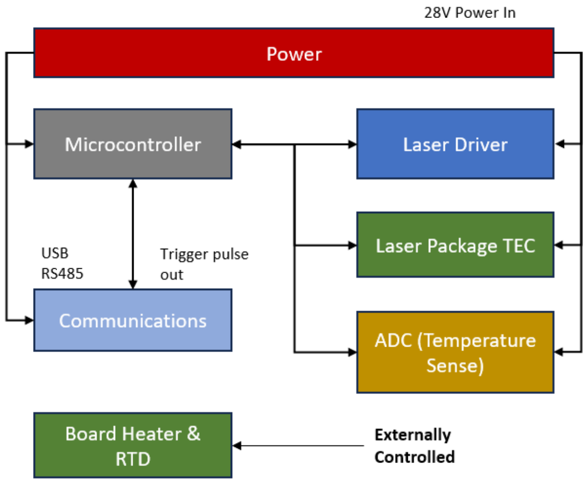
- Increase laser peak power – Currently max 20 W output
- Reduce detector fov footprint - Currently 60 m diameter for 30 m laser footprint
- Reduce bandpass filter - Currently 5 nm.
- Reduce the integration time (PRR) - Currently 4.25 ms from 500 km
- Reduce signal strength requirements - Currently 115 signal photons with SNR=20

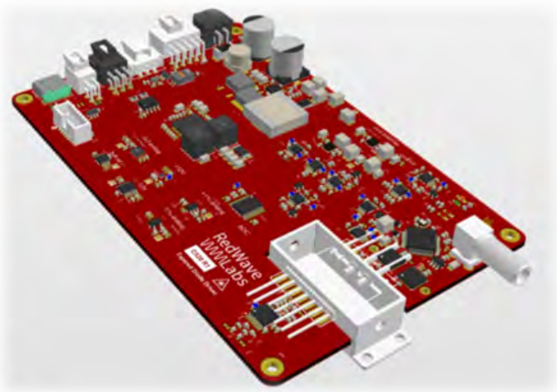
Variable	SCIATRAN	Degnan	Laser energy	Integration	Bandpass	FOV
Signal	149.1	149.1	*			
Total noise	104.1	82.7				
Lunar noise	78.5	57.1		*	*	*
Laser noise	22.2	22.2	*	*		
Dark count	3.4	3.4		*		
SNR	1.44	1.80				



CEOI-15: Laser driver

C520 Driver Overview



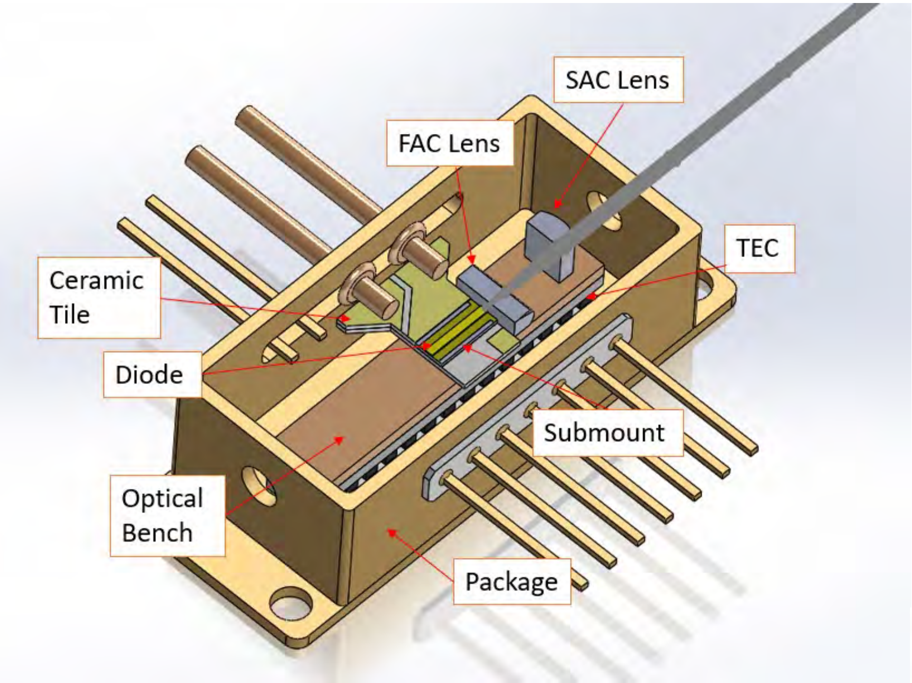


- 28V satellite power input.
- Laser driver tested and controllable as discussed.
- Laser driver current and voltage monitor to calculate efficiency.
- TEC control available for tapered diode package with current and voltage monitor.
- Power connection available for board (with RTD) for cold start condition.
- 50 Ohm SMA pulse out (matching trigger pulse width) for time-of-flight and laser calibration.
- USB and RS485 communications for SCPI commands.

Laser packaging

WP3320 - MECHANICAL DESIGN
MECHANICAL DESIGN REV 1

- Diode Packaging design
  - The design began with a thermal analysis
    - For this design we use a TEC
    - An efficient thermal path is essential
    - Solders used for all attaches bar lenses
  - Electrical path is designed for low inductance
    - Ribbon bonds
    - Anode/cathode at the same side
    - Avoiding loop profiles as much as possible
  - We leave real estate for a self-seeding path if needed



Fraunhofer CAP

ALTER TECHNOLOGY UK

Parallel projects

Fraunhofer CAP

Space Flow Ltd.

Build a UAV demonstrator of the pulse-train lidar

- Validate pulse train modality lidar in the field
- Designed to match satellite SNR

Parameter	Value	Notes
Footprint D	12.6 cm	
Telescope D	3-5 cm	Possibly 3 cm
Optical efficiency	70 %	
--------	--------	---
Wavelength	808 nm	
Max power	250 mW	Currently 100 mW
Energy per pulse	100 mW	
Pulse duration	1.5 ns	Running at 5 ns
PRR	4 MHz	Running at 1 MHz
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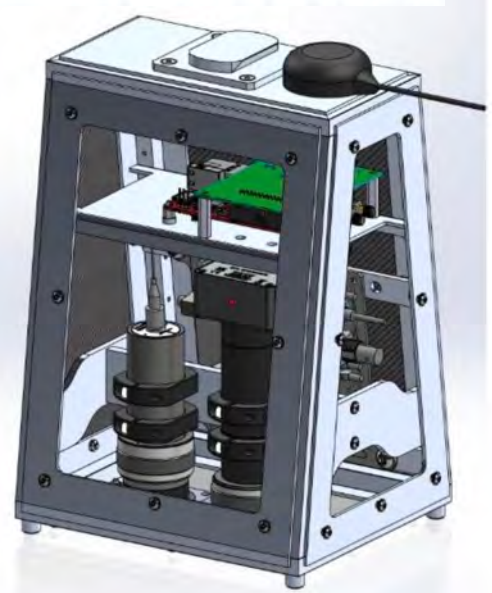
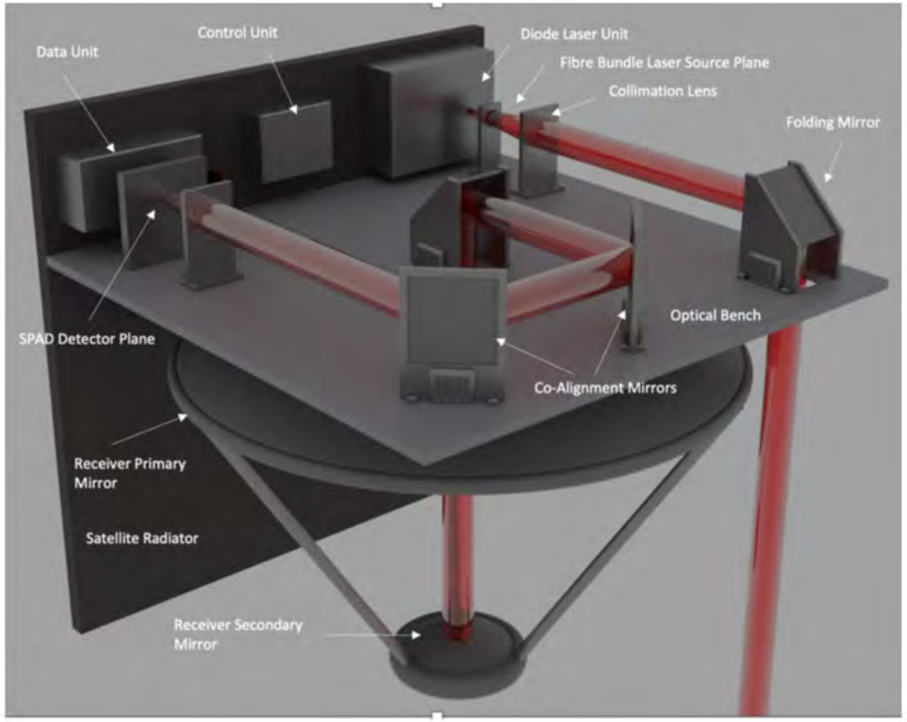
Dark count	300 cps	
Bandpass filter	5 nm	Ongoing
Q	20%	For SPAD option
Q	13%	For MPPS option

Platform	Type	Rate
UAV	Signal	1.11 photons/shot
	Dark count	0.0003 photons/shot
	Background day	766 photons/shot
	Background night	0.0019 photons/shot
Satellite	Signal	0.012 photons/shot
	Dark count	0.0008 photons/shot
	Background day	542 photons/shot
	Background night	0.0014 photons/shot



Preliminary instrument design and formalise user requirements

- Systems engineering approach to whole instrument
- Community engagement to finalise carbon change data requirements



Getting GLAMIS into space

- There are no globally continuous lidar datasets
- There is no long-term (decadal) lidar dataset

To get to launch, it is required to:

- Diode + driver efficiency raised to at least 10%
- Instrument performance requirements finalised (noise)
- Meet instrument performance requirement
- Instrument design
- 20% or 100% sampling decided (or configurable?)
- TRL raised to 6
- Satellite platform selected (maximising payload power and telescope area)
- Funding to launch identified (1 demonstrator then constellation)

It would be desirable to have

- More efficient detector
- Deployable optics

Above-Ground Biomass Density