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ICE, CLOUD, and Land Elevation Satellite (ICESat-2) Project

ATLAS Laser Performance Specification

ICESat-2-ATSYS-SPEC-0099

Revision (-)

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Goddard Space Flight Center
Greenbelt. Marvland

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CM FOREWORD

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In this document, a requirement is identified by “shall,” a good practice by “should,” permission by “may” or “can,” expectation by “will,” and descriptive material by “is.”

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CHANGE HISTORY LOG

Revision Level	DESCRIPTION OF CHANGE	Approved by	Date Approved
(-)	Baseline per ICESat-2 Score-0011	G. Jackson	11/24/2009

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LIST OF TBDs/TBRs

Item No.	Location	Summary	Ind./Org.	Due Date
1	3.0	Laser temperature measurement point		
2	5.0	Electrical interface definition		
3	5.0	Thermal interface definition		
4	5.0	Mechanical interface definition		
5	5.0	Optical interface definition		

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1.0 General Information

1.1 Objective

This document captures the specification for a laser for the ATLAS instrument on ICESat-2. The laser will be a pulsed infrared laser with a removable frequency doubling module.

1.2 Purpose

While written in terms of a flight laser, the specifications in this version of the document are intended to guide the design and selection of breadboard lasers. It is intended that the breadboard laser development will lead to a flight design.

Subsequent versions of this specification will be appropriate for engineering model and flight lasers. They will take into account information learned during the breadboard laser effort, as well as refinement of the overall instrument design.

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2.0 Documentation

2.1 Applicable Documents

ICESat-2-ATSYS-SPEC-0114, “ATLAS Preliminary Component Environmental Specification”

ICESat-2-SMA-REQ-0037, “Radiation Environmental Requirements Document (ERD)”

2.2 Reference Documents

None

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3.0 Performance Requirements

IR Pulse Energy

The IR pulse energy shall be adjustable in 256 steps between 100 and 2000 microJoules per pulse (allowing infrequent on-orbit adjustment)

The pulse-to-pulse variation of IR pulse energy shall be less than 5% RMS over 1 second.

Doubling Efficiency

The efficiency of the doubler (ratio of green pulse energy to IR pulse energy) shall be greater than 50%.

Pulse Width

The mean IR pulse width shall be less than 1.5 ns FWHM.

Repetition Rate

The nominal repetition rate shall be 10 kHz.

The architecture shall support any value of repetition rate between 8 kHz and 20 kHz.

The standard deviation of the pulse-to-pulse interval, measured over any 1-second interval, shall be less than 3 microseconds.

IR Center Wavelength

The IR center wavelength shall be between 1020 and 1080 nanometers.

Wavelength Stability and linewidth

The laser spectrum shall fit fully within a 60 picometer (IR) fixed band in the wavelength window 1020 – 1080 nm over the life of the mission.

Polarization

The output shall be linearly polarized, with extinction ratio greater than 100:1, oriented within 1 degree of a reference.

Spatial Mode

The output spatial mode shall be Gaussian with M^2 less than 1.6 in the far field.

Beam Diameter

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The diameter of the beam exiting the laser shall be at least 2.2 millimeters at $1/e^2$, and less than 3 mm. (This is to ensure the energy is spread out enough to preclude damage to optical surfaces, and to define the clear aperture needed for the subsequent optics up to the input of the final beam expander.)

Beam Divergence

The divergence of the beam exiting the laser shall be less than 20 milliradians. (This is to limit the size of the combining optics and the entrance aperture of the final beam expander. The final beam expander, which is not part of the laser, will provide a much narrower divergence exiting the spacecraft.)

Shot-to-shot Pointing Stability

The standard deviation of pointing direction of the beam exiting the laser, measured over any 1-second time interval, shall be less than 10% of the beam divergence. Pointing direction shall be measured with respect to a fiducial surface on the outside of the laser.

Long-term Pointing Stability

The envelope of pointing direction of the beam exiting the laser, measured over the operating temperature range, shall be less than 20% of the beam divergence. Pointing direction shall be measured with respect to a fiducial surface on the outside of the laser.

Lifetime

The laser shall operate for a total of 5.5 years with pulse energy greater than 75% of its beginning-of-life value at the highest pulse energy setting and meeting all other specs except efficiency. (This allows for 5 years science operation, plus integration and test time before launch and commissioning after launch.)

Operating Temperature

The laser shall meet all requirements while operating in some 2 degree C temperature interval between 10 and 40 degrees C. (This defines the range of temperature set points that the thermal system needs to accommodate.) Laser temperature shall be measured at TBD point(s) in the interface to the instrument bench.

Operating Survival Temperature

The laser shall meet all requirements after being subjected to temperatures between 10˚ C and 40˚ C, while laser is operating.

Non-Operating Survival Temperature

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The laser shall meet all requirements after being subjected to temperatures between 0˚ C and 50˚ C, while laser is not operating.

Enclosure

The laser optics, including the cavity and doubling module, may be inside a hermetic enclosure with a suitable atmosphere inside. The enclosure will be in vacuum.

Environment

The laser shall conform to ICESat-2-ATSYS-SPEC-0114, "ATLAS Preliminary Component Environmental Specification".

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Table 3-1 Requirements Summary Table

Requirements:		
Parameter	**Specification**	**Notes**
Pulse Energy	2 mJ	Adjustable from 100-2000 µJ
Pulse Width	< 1.5 ns	
Repetition Rate	10 kHz (± 0.2 MHz)	Capable of operation between 8-20 kHz
Center Wavelength (IR)	1020 – 1080 nm	must be capable of being frequency-doubled
Wavelength Stability/Linewidth	< 60 pm	Must be transmitted by a fixed 60 pm filter
Polarization Extinction Ratio (PER)	> 100:1	
Polarization orientation	± 1 °	compared to linear reference
Spatial Mode	$M^2 < 1.6$	Gaussian
Pointing Stability (shot-to-shot)	< 10% of divergence	
Pointing Stability (long-term)	< 20% of divergence	
Lifetime	> 5 years	Continuous operation
Operating Temperature	± 1 °C of design wavelength	
Operating Survival Temperature	10 – 40 °C	
Non-Operating Survival Temperature	0 – 50 °C	
Shock/Vibe		See ICESat-2-ATSYS-SPEC-0114
radiation		See ICESat-2-SMA-REQ-0037
Vacuum		See ICESat-2-ATSYS-SPEC-0114
Design Goals:		
Mass	< 10 kg	
Volume	< 40 x 25 x 15 cm^3	
Efficiency (Wallplug)	> 15%	

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4.0 Design Goals

Mass

The total mass of the laser, including optics, electronics, and enclosure, should be less than 10 kilograms.

Volume

The footprint of the laser, including optics, electronics, and enclosure, on the instrument bench should be less than 40 x 25 centimeters. The height should be less than 15 centimeters.

Electrical-to-Optical Efficiency (Wallplug)

At the beginning of life, the electrical-to-optical efficiency should be greater than 15% at the highest pulse energy setting; greater than 10% at all pulse energy settings. At end of life, greater than 12% at the highest pulse energy setting. Efficiency shall be measured using average IR optical power and primary electrical input power.

5.0 Interfaces

Electrical

The electrical interface between the laser and the instrument shall be TBD.

Thermal

The thermal interface between the laser and the instrument shall be TBD.

Mechanical

The mechanical interface between the laser and the instrument shall be TBD.

Optical

The optical interface between the laser and the instrument shall be TBD.

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APPENDIX A List of Abbreviations and Acronyms

Abbreviation/ Acronym	DEFINITION
FWHM	Full width at half maximum
IR	Infrared

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