

ATLAS Project Controlled Document
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**Ice, Cloud, and Land Elevation Satellite
(ICESat-2) Project**

**Flight Laser Systems
Statement of Work**

ICESat-2-LAS-CTR-0451

Revision B

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**Goddard Space Flight Center
Greenbelt, Maryland**

National Aeronautics and
Space Administration

CM FOREWORD

This document is an Ice, Cloud, and Land Elevation (ICESat-2) Project signature-controlled document. Changes to this document require prior approval of the applicable Product Design Lead (PDL) or designee. Proposed changes shall be submitted in the ICESat-2 Management Information System (MIS) via a Signature Controlled Request (SCoRe), along with supportive material justifying the proposed change.

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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INTRODUCTION

GENERAL INFORMATION

The Ice, Cloud, Elevation, Satellite (ICESat-2) Mission is the second NASA Mission with the objective to measure global ice topography and canopy height. To do so, the Mission requires multiple micropulse space flight laser systems.

This document defines the work to be performed by the Contractor in the design, development, fabrication, test and delivery of the ICESAT-2 space flight laser systems. These systems consist of the optical, electrical, mechanical, material, wire harnessing, thermal control flight software, flight firmware, and support hardware to meet the laser performance and functional requirements (ICESAT-2-ATSYS-SPEC-0099). The space flight laser systems from here on in this document are referred to as the laser.

This is the statement of work (SOW) for the design, build, and test of four (4) Lasers and one (1) I&T-specific Laser (ITL). The first of the four Lasers will be tested in a flight-like environment, on the ground, for the mission duration per ICESAT-2-ATSYS-SPEC-0099 by NASA Goddard Space Flight Center (GSFC) Laser and Electro-Optic Branch (Code 554).

The work breakdown structure is found in Appendix G of this document and follows the statement of work organization.

SCOPE

The contractor **shall** provide the facilities, personnel, services, tools, equipment, and materials necessary to design, analyze, manufacture, test, verify life, estimate reliability and deliver the hardware and data in accordance with the requirements of this SOW and the documents referenced herein.

This SOW defines the contractor tasks, deliverables, responsibilities, and schedule, either within this document or by reference.

APPLICABLE DOCUMENTS

All applicable documentation identified in this document **shall** apply. In the event of a conflict between the SOW and the specification, the SOW **shall** take precedence. See Appendix C for list of applicable documents.

Released Version

1.0 MANAGEMENT

1.1 PROGRAM MANAGEMENT

The contractor shall designate a single individual who has full responsibility and authority to manage and administer all phases of the work specified by the contract and ensure that all requirements are met and deliverables are accomplished within schedule constraints.

The contractor shall designate a single individual who shall serve as a point of contact (POC) with the NASA/GSFC Contracting Officer's Technical Representative (COTR) for all technical aspects for the Lasers.

The contractor shall establish and apply a program control system for managing all resources, controlling schedules, managing all engineering, manufacturing and procurement activities, configuration management, Quality Assurance, documentation control, and document distribution. In addition, the program control system shall utilize an earned value management system (EVMS).

1.2 REPORTING

1.2.1 Weekly Meeting

The Contractor shall prepare and present to the GSFC a written status report via weekly telephone conference. This shall include, but shall not be limited to a review of the previous week's: accomplishments and progress against the original schedule; procurements; key personnel changes; completed designs, drawings, and documents; material and process changes; test and inspection results; performance assurance issues; requirements verification changes; hardware shipments; action or open items; problems; facility readiness and planning; and the next week's planned activities. New risks shall be identified and presented to GSFC at the Weekly Meeting.

1.2.2 Monthly Status Meeting and Report

The contractor shall conduct a Monthly Management Meeting with the GSFC COTR and contracting officers (CO). The agenda for the

monthly management meeting will be defined at the Weekly Meeting at least one week prior.

The Contractor shall prepare and submit to the GSFC a written Monthly Status Report to e-mail addresses supplied at contract award in a Portable Document Format (PDF) file. The report shall include the same information reported in the Weekly Meeting but for the previous month rather than the previous week. In addition the report shall include the next month's planned activities, and an updated schedule. The schedule shall identify and show traceability to all risk mitigation efforts.

The Contractor **shall** submit, as part of the monthly report, monthly financial management reports using NASA Form 533M/Q in accordance with the NPR 9501.2D, "NASA Contractor Financial Management Reporting". and a Contract Performance Report (CPR) Formats 1,3 and 5. Contractor formats may be substituted for CPR formats whenever they contain all the required data elements at the specified reporting levels in a form suitable for use by NASA management. CPR formats shall be completed according to the instructions outlined in DI-MGMT-81466. Images of the CPR forms and instructions for completion are located at:

http://www.acq.osd.mil/pm/currentpolicy/cpr_cfsr/CPR%20Final%203-30-05.pdf

The contractor **shall** provide, as part of the monthly report, a copy of the monthly schedule update.

The Contractor **shall** provide, as part of the monthly report, a list of all open anomaly, nonconformance and failure reports and a separate list of the anomaly and failure reports closed during the month. For each reported anomaly, nonconformance and failure, there **shall** be a report that documents the investigation and engineering analysis to determine the root cause and corrective actions to disposition the nonconformance, anomaly, or failure.

The Contractor **shall** provide, as part of the monthly report, a list of all open and closed Laser risks during the past month. New risks **shall** be identified and explained in detail.

1.3 ADVANCE NOTIFICATIONS

The contractor **shall** notify the NASA/GSFC COTR at least fourteen (14) calendar days in advance of all mandatory hardware inspections, mandatory inspection points (MIPs), test activities, technical interchange meetings (TIM's), and deliveries at either the contractor's or a sub-contractor's facility to allow timely participation by the NASA/GSFC Quality Assurance representative or delegate.

1.4 ASSESSMENTS, REVIEWS AND MEETINGS

The contractor **shall** support onsite instrument-level major milestone reviews at NASA Goddard Space Flight Center. These reviews include but are not limited to:

- Instrument Preliminary Design Review (iPDR)
- Instrument Critical Design Review (iCDR)
- Instrument Pre-Environmental Review (iPER)
- Instrument Pre-Ship Review (iPSR)

1.4.1 Kick-off Meeting (KoM)

The contractor **shall** organize and present a KoM establishing the personnel interfaces and organization structure between the vendor's team and the GSFC Laser Team.

1.4.2 Preliminary Design Assessment (PDA)

The contractor **shall** organize and present a Preliminary Design Assessment to a GSFC Review Team at the contractor's facility. The contractor **shall** provide to the COTR a Preliminary Design Assessment Presentation Package and all other required deliverable data prior to the review as specified in Appendix D. The PDA **shall** address all program management, design, drawings, analysis, manufacturing, test, and quality assurance activities outlined in this SOW and the Ice, Cloud, Elevation Satellite Project Laser Systems Specification ICESAT-2-ATSYS-SPEC-0099 in sufficient detail to ensure that the proposed design conforms to all requirements and is ready for detailed final design to begin. At this review the contractor **shall** present test data on the achievement of Technology Readiness Level-6 (TRL-6) per ICESat-2-LAS-TN-0173.

1.4.2.1 PDA Presentation Package

At a minimum, the presentation package should cover the following areas in the contractor's preferred order:

- Agenda
- Program Management
- Quality Assurance
- Electrical, Mechanical, Thermal, Optical and Environmental specifications
- Parts, including stress analysis and radiation hardness assessment
- Drawing Package
- Manufacturing flow with inspection points
- Facilities
- Optical modeling including alignment and through-put current best estimates and budget
- Flight Laser Test Plan
- Materials and Processes
- Laser Contamination Control Plan
- Laser Diode Qualification Status
- Preliminary Flight Laser Performance Modeling Results
 - The Laser Center Wavelength (LCW) **shall** be known and reported to a confidence tolerance of +/- 45 pm and reported as the parameter LCW1. The wavelength band of +/- 45 pm will fall entirely within the laser specification for laser center wavelength.
 - NASA will obtain knowledge of the laser center wavelength 'window' that culminates in the 30 pm 'window' for the last three (3) lasers delivered. Wavelength reporting will assist instrument level systems development.
- Preliminary Flight Laser Reliability Modeling Results
- Preliminary Laser command and telemetry database
- Mass Analysis
- Mechanical/Structural analyses
- Flight Heritage
- Requirements Verification Matrix

- TRL-6 achievement test data

Review minutes **shall** be prepared and, as a minimum, **shall** include attendance, action items, action item accomplishment responsibility and agreements. All items **shall** be in sufficient detail to be self-explanatory.

GSFC will not close the PDA until all open action items have been closed or otherwise dispositioned. Action items will be tracked in the ICESat-2 online Management Information System (MIS) system.

1.4.2.2 Schedule at PDA

The contractor **shall** supply the latest schedule at PDA that **shall** include milestone charts depicting critical paths and indicating critical dates in the program. The Contractor **shall** define the start, implementation, and completion dates for the detailed activities associated with the design, analysis, manufacturing, and testing of all components, subassemblies, and Lasers. The contractor **shall** identify the vendor lead times for procured parts and materials. This review will constitute the Integrated Baseline Review (IBR) for the Laser development with the objectives of

- o The PDA schedule and financial resource plan review at the PDA shall verify
- o The technical scope of work is fully included and consistent with the requirements
- o Key schedule milestones are identified
- o Supporting schedule reflect a logical flow to accomplish the work scope
- o Resources are adequate and available for the tasks
- o Task are planned and can be measured objectively
- o Underlying Performance Measurement Baseline (PMB) rationales are reasonable

The IBR, at the PDA, shall verify that the contractor is using a reliable performance measurement baseline, which includes the contract scope through SN#4 delivery, is consistent with contract schedule requirements and has adequate resources assigned.

1.4.2.3 PDA/TRL-6 Report

The contractor **shall** provide a Preliminary Design Assessment Report following the review in accordance with the ICESAT-2 Laser Systems Deliverable Items List and Schedule, APPENDIX D. The report **shall** include the meeting notice, agenda, review meeting minutes, and responses to all recommendations and action items.

1.4.3 Critical Design Assessment (CDA)

The contractor **shall** organize and conduct a Critical Design Assessment (CDA) at the contractor's facility. This presentation **shall** demonstrate overall conformance of the requirements specified in the Ice, Cloud, Elevation Satellite Project Laser Systems Specification, ICESAT-2-ATSYS-SPEC-0099, and this SOW. This presentation **shall** cover programmatic, technical, test and verification, and quality assurance topics, and address any changes made to the Verification Matrix since PDA. This review **shall** provide an opportunity to review the qualification and Laser test plans and procedures and all analyses required to approve the fabrication, assembly and testing of the flight hardware.

1.4.3.1 CDA Presentation Package

The contractor **shall** provide a CDA Presentation Package. This **shall** address qualification and Laser performance in environment and manufacturing readiness in sufficient detail to ensure that the proposed build conforms to all requirements and is ready to begin.

At a minimum, the presentation package should cover the following areas in the contractor's preferred order:

- Agenda
- Program Management
- Requested Waivers
- Supporting Analysis
- Quality Assurance
- Parts, including stress analysis and radiation hardness assessment
- Facilities

- Optical modeling including alignment and through-put current best estimates and budget
- Flight Laser Test Procedure
- Readiness for Testing
- Materials and Processes
- Final Flight Laser Performance Modeling Results
 - The laser center wavelength shall be known and reported to a confidence tolerance of +/- 15pm and reported as LCW2. The wavelength band of +/- 15 pm shall fall entirely within the laser center wavelength band reported at the PDA.
 - NASA will obtain knowledge of the laser center wavelength 'window' that culminates in the 30 pm 'window' for the last three (3) lasers delivered. Wavelength reporting will assist instrument level systems development.

- Laser command and telemetry database
- Mechanical/Structural analyses
- Electrical Worst-Case analyses
- Failure Modes Effects Analysis
- Flight Heritage
- Updated Verification Matrix, including verification method description statements

GSFC will not close the CDA until all open action items have been closed and dispositioned appropriately.

1.4.3.2 Schedule at CDA

The contractor **shall** supply the latest schedule at CDA that **shall** include milestone charts depicting critical paths and indicating critical dates in the program. The Contractor **shall** define the start, implementation, and completion dates for the detailed activities associated with the manufacturing and testing of all components, subassemblies, and Lasers.

1.4.3.3 CDA Report

The Contractor **shall** provide a Critical Design Assessment Report following the review in accordance with the ICESAT-2 Laser Systems Deliverable Items List and Schedule, APPENDIX

D. The report shall include the meeting notice, agenda, review meeting minutes, and responses to all recommendations and action items.

1.4.4 Pre-Environmental Review (PER)

The contractor shall organize and conduct a Pre-Environmental Review (PER) at the contractor's facility before the environment test of each flight Laser. This presentation shall demonstrate overall conformance of the requirements specified in the Ice, Cloud, Elevation Satellite Project Laser Systems Specification ICESAT-2-ATSYS-SPEC-0099 and this SOW. This presentation shall cover programmatic, technical, test and verification, and quality assurance topics, and address any changes made to the Verification Matrix since CDA. This review shall also provide an opportunity to review test plans and procedures and all analyses required to approve flight Laser testing. This review will summarize results from component or subassembly qualification tests to date.

The contractor shall supply the documentation listed in the following subsections, associated with the PER in accordance with the ICESAT-2 Laser Systems Deliverable Items List and Schedule, APPENDIX D.

1.4.4.1 PER Presentation Package

The contractor shall provide a PER Presentation Package in accordance with the ICESAT-2 Laser Systems Deliverable Items List and Schedule, APPENDIX D. The package shall summarize the material which the contractor will cover in more detail in the documentation associated with the PER review. This required documentation is defined in this section. The presentation package shall contain an updated schedule.

At a minimum, the presentation package should cover the following areas in the contractor's preferred order:

- Agenda
- Program Management
- Environmental test plans
- Environmental test procedures
- Environmental test environments

- Results of latest Laser comprehensive performance test (CPT). This will be the environmental performance testing baseline.
- Test equipment and test article status
- Trend tool status (hardware and software)
- Test facility status.
- Safety data review and verifications for upcoming tests
 - Identification of safety hazards for hardware and personnel.
- The disposition and status of previous anomalies, deviations, and waivers.
- Identification of risks and mitigation approaches to allow for proceeding to environmental testing.
- Risk levels are appropriately identified and have been accepted by the GSFC COTR.

1.4.4.2 PER Report

The contractor **shall** prepare and deliver a Pre Environmental Review Report in accordance with the "ICESAT-2 Laser Systems Deliverable Items List and Schedule, APPENDIX D. The report **shall** include the meeting notice, agenda, review meeting minutes, and responses to all recommendations and action items.

1.4.5 Pre-Ship Review (PSR)

The contractor **shall** hold a Pre-Ship Review for each flight Laser at the contractor's facility. This presentation **shall** demonstrate completion of all activities required for Laser delivery, and note any activities that are incomplete. In particular, the contractor **shall** present the completed verification matrix that shows requirements verification and presents actual data (results of tests or analyses) supporting the verification. Any requirements that are not met **shall** be identified in the Deviations/Waivers etc. list and discussed with GSFC during the review.

Each Delivery Data Package **shall** be made available for review during pre-ship reviews for each of the different hardware deliverables. This package **shall** also be delivered with each Laser. The package should be comprised of, but not limited to, the following data:

- The deliverable Laser Systems, serial number, part number, and classification status (e.g., flight or ITL).
- Appropriate approval signatures (e.g., contractor's quality representative, product design lead, government Representative, etc.)
- As-run work orders from the final assembly and associated tests
- As-Built vs. As Designed Parts List, (EEE parts, includes serialization/revisions)
- As-Built Final Drawing Package (including rework instructions, if any)
- Problem/anomaly reporting (complete copies of report)
- Deviations/Waivers/shortages/open items/non-conformances and their dispositions, with supporting rationale
- Status of all action items from previous reviews
- Class I MRBs (complete copies of reports)
- List of As-Built Materials and Processes used
- Achieved surface cleanliness and outgassing rate data (when applicable)
- As-built Flight Laser wavelength and stability
 - The 30 pm band of laser center wavelengths of all Lasers **shall** be the laser center wavelength reported at CDA.
- As-built Flight Laser alignment and stability
- Log of total operating time and failure-free operation
- List and status of all identified Life-Limited Items
- Trended Critical Parameters Data from first full Laser assembly power-on.
- Verification matrix (including environmental), test data and reports
- Photograph Documentation (Pre and Post conformal coating, Pre-Closure and Closed)
- Certificate of Conformance, with contractor management signature and contractor quality assurance signature
- End Item Inspection Report
- Storage and Transportation Plans and Requirements
- Status of the Delivery Data Package

1.4.5.1 PSR Slide Packages

The contractor **shall** provide a PSR Slide Package per Laser delivery.

1.4.5.2 PSR Report

The contractor **shall** prepare a Pre-Ship Review Report per Laser shipment to Goddard. The report **shall** include the meeting notice, agenda, review meeting minutes, and responses to all recommendations and action items. The review minutes **shall** include attendance, action items, action item accomplishment responsibility and agreements. If any of the information presented in the earlier reviews has changed, the Contractor **shall** present this in the PSR report to GSFC in accordance with the ICESAT-2 Laser Systems Deliverable Items List and Schedule, APPENDIX D. The PSR report, with the other documentation required by this document **shall** present a level of detail to permit a review team to compare the flight Lasers' design, assembly, acceptance test, and performance against the requirements of this document and the ICESAT-2 Laser Systems Specification, ICESAT-2-ATSYS-SPEC-0099.

1.4.5.3 End Item Acceptance Data Package

The contractor **shall** prepare and deliver a delivery data package to the GSFC with each Laser in accordance with Appendix F, Laser SMA CDRL No. 51. This is a data package specific to the serial number laser being delivered. For each Laser, this **shall** contain the as built list, a list of parts and materials used in the Laser, a list of processes used to manufacture the Laser, a test log book which documents the total operating time and thermal (air or vacuum) cycles for each test, a list of open items and the reason the items are open, results of the verifications required by this specification including dates of completion and what test equipment was used, TQCM data, a summary of all repairs for that Laser, a series of digital color photographs of each side of the Laser, a copy of all Material Review Board (MRB) actions generated against the Laser, and a copy of all problem/failure reports generated against the Laser. The Contractor **shall** document the issue/revision numbers of the drawings and specifications to which particular hardware has been fabricated,

inspected, and tested as the as-built configuration. The Contractor **shall** provide evidence of compliance with the as-built documentation as a basis for acceptance of the hardware.

1.4.6 Technical Interchange Meetings (TIM)

The contractor **shall** plan for and facilitate quarterly informal, face-to-face technical interchange meetings to be held at the contractor facilities. These TIMs should support review and coordination of technical issues including, but not limited to, anomalies, risks, nonconformances, failure reports, reliability, parts, build status, test plans, test procedures, software changes, design modifications, and design analyses.

1.5 GENERAL LASER DEVELOPMENT DOCUMENTATION

The contractor **shall** ensure the generation and delivery of all documentation as called for in the contract and listed in APPENDIX D.

In addition to that documentation specifically called for in the contract, upon request by the NASA/GSFC COTR, the contractor **shall** make available a copy of any document or data generated during this contract performance for review by GSFC at either the contractor's facility or via the internet. This includes, but is not limited to, technical reports and memorandums, drawings, schematics, studies, analyses, parts and materials data, test data, alerts, etc.

1.6 NASA/GSFC FURNISHED DATA, EQUIPMENT, AND FACILITIES

NASA/GSFC will provide space flight multi-layer insulation with this procurement.

NASA/GSFC will integrate the multi-layer insulation.

2.0 DESIGN AND ANALYSIS

The contractor **shall** perform design and analyses of the Laser per the technical and environmental requirements specified in the Ice, Cloud, Elevation Satellite Project Laser Systems Specification (ICESAT-2-ATSYS-SPEC-0099) to ensure compliance of the hardware, software, firmware, fabrication, piece-part testing, component assembly and Laser assembly.

2.1 LASER PERFORMANCE ANALYSIS

The contractor **shall** conduct laser performance analysis. The analysis will be a key contributor to the laser design and testing plans.

2.1.1 Laser Performance Computer Model Support

2.1.1.1 The contractor **shall** provide laser performance computer modeling support to predict laser performance under untested conditions that NASA is interested in in both pre-launch and post-launch environments.

2.1.1.2 The contractor **shall** deliver documentation explaining (at a minimum but not limited to) the theoretical background of the computer model, the experimental validation of the computer model, any assumptions in the computer model, and all inputs and outputs to the computer modeling effort.

2.1.2 Laser performance analysis report

The contractor **shall** provide a Laser Performance Analysis Report for each Laser unit delivery. This report **shall** include at least:

1. Actual performance versus computer model performance predictions.
2. Predicted end-of-life performance based on the computer modeling.

2.2 LASER DESIGN

The contractor **shall** conduct laser design.

2.2.1 Laser User Manual

The contractor shall provide a Laser user's manual for each laser delivery. This manual shall include at least:

3. Safe-to-mate procedure
4. Turn-on procedure
5. Turn-off procedure
6. Purge procedure
7. Recharge procedure (as appropriate)
8. Command and Telemetry database
9. Ground test cooling requirements and procedure

2.2.2 Laser Interface Control Documentation (ICD)

2.2.2.1 The contractor shall develop and maintain the mechanical interface documentation including the drawings and written interface documents.

The GSFC will provide document(s) and/or drawing(s) that define, in detail, all electrical, and thermal interfaces between the Laser and the instrument. These documents will include the multi-layer insulation (MLI) template dimensions and MLI fastener locations as necessary.

2.2.3 Laser Drawing Package

The contractor shall supply a drawing package for the Lasers consisting of:

Electrical Drawings:

- assembly
- interface drawings
- board level schematics

Mechanical Drawings:

- assembly
- piece-part drawings
- interface drawings and documentation

2.2.4 Laser Design Computer Aided Drawing (CAD) Models

The contractor shall deliver the laser design CAD models.

2.3 STRUCTURAL ANALYSIS

The contractor shall conduct laser structural analysis.

2.3.1 Structural Analysis Model

Each formal finite element model submittal shall be submitted with documentation that describes the following:

- The version of the model.
- A list of element, node, property, and material identification (ID) numbers.
- A description of the nonstructural mass represented on each property card.
- A description of units.
- A description of the local reference coordinate system.
- The results of validity checks.
- Mass Properties (CG location, Inertias, and total model mass).
- Frequencies of the first ten modes while in a free-free boundary condition.

2.3.1.1 Finite Element Model Submittal

Formal finite element model submittals shall adhere to the following:

- Model submitted as a MacNeal Schwendler Corporation (MSC)/NASA Structural Analysis (NASTRAN) data deck.
- Model file name include the date (MMDDYYYY) that they were made at the beginning of their name.
- All model property and material cards have descriptive names.
- Model submission is "full" model with no symmetry assumptions made to reduce model size.
- Model includes no "Super Elements".
- Model submission includes an explicit Single Point Constraint set.
- Until actual hardware mass properties are verified and final, the finite element model

is adjusted to the maximum allocated mass for each subsystem and component.

- Model passes the following validity checks: unit enforced displacement and rotation, free-free dynamics with equilibrium check, and unit gravity loading.
- Finite element modes used for thermal analysis pass a unit increased temperature check.

2.3.2 Structural Analysis Report

The purpose of the structural analyses is to demonstrate compliance with the mechanical/structural design and test requirements. Structural analyses verify the structural integrity of the flight hardware by assessing the size and location of applied loads, load paths, and critical failure modes. The analysis shall address all the structural requirements in ICESat-2-ATSYS-SPEC-0099. A Structural Analysis shall be performed on the Laser structure to ensure the capability to withstand and survive launch, ascent, and on-orbit loads. Beryllium and composite materials shall not be qualified by analysis alone. The effects of any thermal inputs shall be reflected in the analyses as appropriate. This analysis shall include a Venting analyses for applicable flight components (such as thermal blankets and contamination enclosures) susceptible to pressure loadings to verify that positive strength margins exist at loads equal to twice those induced by the maximum pressure differential during launch. The results of these analyses shall be summarized in a contractor format Structural Analyses Report that will be provided to the NASA/GSFC COTR for review as specified in Appendix D.

2.4 ELECTRICAL ANALYSIS

The contractor shall conduct laser electrical analysis.

2.4.1 Electrical Analysis Report

The contractor shall document the laser electrical analysis in an Electrical Analysis Report.

2.4.1.1 Electric Power Analysis Section

The contractor **shall** include in the Electrical Analysis Report a prediction of the electric power consumption of the Laser under test conditions, at beginning of life, and at end of life. The prediction **shall** account for all environments defined in this specification including the effects of radiation, bus voltage fluctuation, and thermal cycling.

2.4.1.2 Worst Case Circuit Analysis Section

The contractor **shall** perform worst-case analyses for critical parameters that are subject to variations that could degrade performance or provides indication to put the laser flightworthiness in question. These analyses **shall** address the worst case conditions for the analysis performed on each component. Each analysis **shall** encompass the mission life and consider the critical parameters set at maximum and minimum limits and include the effect of environmental stresses on the operational parameters being evaluated.

2.4.1.3 Parts Stress Analysis Section

The contractor **shall** perform parts stress analyses on Electrical, Electronic, and Electromechanical (EEE) parts and devices as employed in the Laser circuit designs to certify conformance with the derating requirements of EEE parts. The analyses **shall** be documented, and justification **shall** be included for all applications that do not meet the derating criteria. The Contractor **shall** use NASA document EEE-INST-002, Instructions for EEE Parts Selection, Screening, Qualification, and Derating to establish criteria. Contractor derating guidelines may be considered in place of EEE-INST-002 guidelines but **shall** be submitted to the COTR for approval. The results of these analyses **shall** be summarized in this section of the Electrical Analysis Report.

2.4.1.4 EEE Part Radiation Hardness Analysis Section

The Contractor **shall** document the radiation hardness assessment for each EEE part with respect to total ionizing dose (TID).

Test plans and reports for parts that require radiation testing shall be submitted to the NASA/GSFC COTR for review.

The analysis shall address all the requirements contained in ICESAT-2-ATSYS-SPEC-0099.

The results of these analyses shall be summarized in this section of the Electrical Analysis Report.

2.5 MASS ANALYSIS REPORT

The contractor shall supply a mass estimate by component for the Lasers in accordance with the ICESAT-2 Laser Systems Deliverable Items List and Schedule, APPENDIX D. This report shall supply:

- the estimated center of mass location for the Laser
- the estimated moments and products of inertia for the Lasers
- a final measured mass for each Laser

2.6 THERMAL ANALYSIS

The contractor shall conduct laser thermal analysis.

2.6.1 Reduced Thermal Models Details

- 2.6.1.1 Contractor **shall** provide a reduced laser thermal model for integration into the instrument thermal model.
- 2.6.1.2 Reduced Laser thermal models **shall** have no more than 100 nodes.
- 2.6.1.3 Reduced Laser thermal models **shall** be in either Thermal Desktop or SINDA/TSS formats.
- 2.6.1.4 Reduced Laser thermal model deliveries shall be accompanied by a thermal model description document in the portable document format (PDF) and including all information listed in the ATLAS Thermal Model Delivery Report Template (ICESat-2-THM-RPT-0212).
- 2.6.1.5 The reduced laser thermal model **shall** be capable of running upon delivery, and must include an analysis case to verify that the as-delivered model replicates the results obtained by the model contractor.
- 2.6.1.6 Reduced Laser thermal models **shall** reflect the latest known power levels and mechanical configuration.
- 2.6.1.7 Reduced Laser thermal models **shall** correctly represent the temperature of any internal temperature sensors.
- 2.6.1.8 After Laser thermal testing, Laser thermal models **shall** be correlated to accurately represent the temperature of all internal temperature sensors to within 2C of the value measured in test.

2.6.2 Thermal Analysis Report

The contractor **shall** provide a report containing data that will enable GSFC to accurately model the thermal performance of the Laser Systems. This data **shall** enable a thermal analysis demonstrating that the component, assembly, device and/or the electronic part junction temperatures are within the Electrical, Electronic, and Electromechanical (EEE) parts derating guidelines for operation in a vacuum environment. Analysis **shall** prove that component will be within junction derating temperatures when the Laser thermal interface is at maximum qualification temperature and when component is operating at maximum power dissipation. By analysis or by similarity to other flight qualified parts, the contractor **shall** also prove that operation at minimum operational temperature is not an

issue. This data shall include Beginning-of-Life (BOL) and End-of-Life (EOL) efficiency as a function of temperature, operating voltage, and degradation.

2.7 RELIABILITY ANALYSIS

The contractor shall provide a numerical reliability assessment of the laser, using reliability data from historical telecommunication systems, on-orbit performance, life-testing, or data books. The reliability analysis shall be done assuming no failed strings, one failed strings, and two failed strings (if the vendor is building parallel strings to the Laser).

The reliability analysis shall include development of a laser reliability block diagram.

The contractor shall support and assist GSFC in-house laser reliability modeling effort.

Reliability analysis may lead to laser design modification.

2.7.1 Reliability Analysis Report

The results of this analysis shall be summarized in a Contractor format Reliability Analysis Report that will be provided to the GSFC COTR for review in accordance with APPENDIX D.

2.8 FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

The Contractor shall perform a Failure Modes and Effects Analysis (FMEA) in accordance with MIL-STD-1629A, Failure Modes and Effects Analysis. The FMEA shall identify failures at the functional/component interface level and address attendant consequences. Each failure mode shall be assigned a severity based on the most severe effect caused by that failure. The FMEA may lead to Laser design modification.

2.8.1 FMEA Report

The results of these analyses shall be summarized in a Contractor format FMEA Report that will be provided to the NASA/GSFC COTR for review.

2.9 SAFETY ANALYSIS

The contractor **shall** perform any safety related analyses necessary to support the safety requirements of Section 5.2. Safety analysis may lead to Laser design modification.

2.9.1 Safety Analysis Report

The results of these analyses **shall** be summarized in a Contractor format Safety Analysis Report that will be provided to the NASA/GSFC COTR for review in accordance with APPENDIX D.

3.0 PROCUREMENT AND MANUFACTURING

3.1 GENERAL REQUIREMENTS

The contractor shall either procure or manufacture all components required to assemble, integrate, and test the Lasers to support the delivery dates listed in APPENDIX D.

The contractor shall assemble the quantities of Laser hardware described below.

3.2 LASERS

The contractor shall provide the following hardware to meet the requirements of the Ice, Cloud, and Elevation Satellite Project Laser Systems Specification (ICESAT-2-ATSYS-SPEC-0099).

- 1) Four (4) Lasers per Ice, Cloud, Elevation Satellite Project Laser Systems Specification (ICESAT-2-ATSYS-SPEC-0099) including
 - a. User's manual for each
 - b. Shipping containers for each
- 2) Two (2) sets of Laser Support equipment including
 - a. Electrical support equipment necessary to operate laser installed in the instrument
 - b. Mechanical support equipment necessary to integrate and de-integrate the laser per the Interface Control Document.
 - c. Optical support equipment necessary to operate laser installed in the instrument
 - d. Thermal support equipment. This equipment will allow extended duration (greater than 8 hours) operation on a bench before integration into the instrument.
- 3) One Integration & Test Laser (ITL) complying with the laser contamination control plan, electrical, mechanical and optical ICD and requirements noted in Appendix B to the Ice, Cloud, Elevation Satellite Project Laser Systems Specification (ICESAT-2-ATSYS-SPEC-0099) including
 - a. User's manual
 - b. Electrical support equipment necessary to operate ITL installed in the instrument
 - c. Mechanical support equipment necessary to integrate and de-integrate the ITL per the Interface Control Document.
 - d. Optical support equipment necessary to operate ITL installed in the instrument
 - e. Thermal support equipment. This equipment will allow extended duration (greater than 8 hours) operation on a bench before integration into the instrument.
 - f. Shipping containers for the ITL

3.3 CONNECTOR SAVERS

The contractor **shall** supply flight quality connector savers for each flight connector on the Lasers, and ITL. Prior to delivery, the contractor **shall** use the savers for every connection made to flight connectors.

The contractor **shall** provide one spare set of connector savers.

3.4 SUPPORTING HARDWARE

3.4.1 Mating Connectors and Breakout Boxes

The contractor shall supply break out boxes with connectors that mate to the Lasers and ITL power, signal and test connectors. The harness between the mating connector and the break out box shall be $4 \pm .02$ meters long. The connector and the harness shall be flight quality.

There shall be one break out box with connector for each test connector and flight connector on a Laser.

3.4.2 Test Port Flight Connector Caps

The contractor shall supply a flight quality closeout cap for each of the test connectors.

The contractor shall provide a flight closeout cap installation procedure for each test port flight connector cap.

4.0 PERFORMANCE VERIFICATION

4.1 REQUIREMENTS VERIFICATION

The contractor **shall** verify all the Laser requirements.

4.1.1 Requirements Verification Plan

A Verification Plan **shall** be generated by the contractor to describe the details of how the analyses, inspections, and verification tests will be performed. Requirements will be verified with component and/or system level testing and/or analysis. Verification tests **shall** demonstrate the laser meets all of the specified performance requirements over the specified range of environments, measure performance parameters and reveal inadequacies in manufacturing and assembly such as workmanship or material problems.

The plan should state the purpose of each test or analysis, state acceptance criteria; describe in detail the test method, set up, instrumentation, data analysis methods (if applicable), and give the sequence of the tests. The plan shall include a verification matrix summarizing how all requirements are verified (analysis, inspection, test, per the definitions in the Spec.), and listing all tests that will be performed on the Lasers.

After Verification Plan approval, no changes **shall** be made without written GSFC COTR approval.

If any individual test plans are created in addition to the Verification Plans described below, such as for Thermal Vacuum testing, those plans **shall** also be provided in writing to the GSFC COTR.

The Life Test will be conducted by GSFC at GSFC.

The vendor **shall** verify the Laser life requirement via analysis.

NASA Goddard Space Flight Center will verify the Laser life requirement via testing laser serial #1 of the vendor's flight Lasers for one ICESat-2 mission life duration.

4.1.1.1 Verification Test Procedures

The contractor **shall** generate Verification Test Procedures in support of the Laser Requirements Verification Plan. The verification procedures **shall** be step-by-step instructions for performing tests in the contractor's test procedure format and process. The procedures should define the environmental conditions for the tests, required equipment and facilities, test constraints, use of diagnostic or performance test software, operating conditions, tolerance on all input stimuli, data to be recorded and pass/fail limits.

Verification Test Procedures **shall** be contractor controlled documents available for GSFC insight.

4.1.2 Qualification Testing

The contractor **shall** Qualification Test the first (serial #1) Laser unit. Successfully passing the Qualification Testing will qualify the Laser design for spaceflight.

4.1.2.1 Qualification Test Plan

The contractor **shall** supply a Qualification Test Plan for the verification tests required to Space Flight Qualify the Laser. Tests must demonstrate acceptable qualification performance over the specified range of performance requirements, measure performance parameters and reveal inadequacies in manufacturing and assembly process. The Qualification Test Plan **shall** state the purpose of each test, state acceptance criteria, describe in detail the test method and instrumentation, and give the sequence of the tests. The plan **shall** include a test matrix summarizing all tests that will be performed.

The Laser unit subjected to Qualification Testing **shall** receive sufficient testing to represent worst case levels, intensities, durations and thermal cycles equivalent to the number/amount the laser will cumulatively experience at the time of ICESat-2 Mission Launch. The ICESat-2 payload will launch with a total of 12 thermal cycles completed on the ground. The qualification testing will allow GSFC to enter directly into most-flight-like life testing of this laser unit.

After Qualification Plan approval, no changes **shall** be made without written GSFC COTR approval.

4.1.2.2 Qualification Test Procedures

The contractor **shall** develop Laser qualification test procedures that are step-by-step instructions for performing tests outlined in the Qualification Test Plan. The procedures **shall** define the environmental conditions for the tests, required equipment and facilities, test constraints, use of diagnostic or performance test software, operating conditions, tolerance on all input stimuli, data to be recorded and pass/fail limits. Test procedures **shall** also include Safe-to-Mate procedures to verify that Ground Support Equipment (GSE) can safely be mated to interfaces and that interfaces are safe to accept mating with the GSE.

Qualification Test Procedures **shall** be contractor controlled documents available for GSFC insight.

4.1.3 Acceptance Testing

The contractor **shall** perform an acceptance test for the subsequent Laser units at their facility. Successfully completing Acceptance Testing is a pre-requisite to conducting a Pre-Ship Review (PSR) per laser unit.

Contractor **shall** support onsite at GSFC post-shipment testing prior to integration to the instrument. The post-shipment testing will be a short form functional and performance test conducted by the contractor and GSFC personnel before the government accepts the laser and integrates it to the instrument.

4.1.3.1 Laser Acceptance Test Plan

The contractor **shall** write a Test Plan for the Acceptance Testing. Tests must demonstrate acceptable performance over the specified range of performance requirements, measure performance parameters and reveal inadequacies in manufacturing and assembly such as workmanship or material problems.

The plan shall state the purpose of each test, state acceptance criteria, describe in detail the test method and instrumentation, and give the sequence of the tests. The plan shall include a test matrix summarizing all tests that will be performed.

After Acceptance Test Plan approval, no changes shall be made without written GSFC COTR approval.

4.1.3.2 Laser Acceptance Test Procedures

The contractor shall write and deliver Test Procedures. The verification procedures shall be step-by-step instructions for performing tests outlined in the Test Plan. The procedures shall define the environmental conditions for the tests, required equipment and facilities, test constraints, use of diagnostic or performance test software, operating conditions, tolerance on all input stimuli, data to be recorded and pass/fail limits. Test procedures shall also include Safe-to-Mate procedures to verify that GSE can safely be mated to interfaces and that interfaces are safe to accept mating with the GSE.

Acceptance Test Procedures shall be contractor controlled documents available for GSFC insight.

4.2 VERIFICATION TEST REPORTS

The contractor shall generate Verification Test Reports. These reports shall document the results from each test that was performed, what test levels were achieved, what performance requirements were verified, what anomalies were seen, and how they were resolved.

The contractor shall deliver the following test reports in accordance with the ICESAT-2 Laser Systems Deliverable Items List and Schedule, APPENDIX D.

4.3.1 Qualification Report

The contractor shall supply a Laser qualification report detailing the results of tests to qualify the laser design.

This report may contain qualification data from subsystem tests and analysis.

The Laser Qualification Report shall include digitized copies of all the as-run work orders and test procedures.

4.3.2 Acceptance Test Report

The Contractor shall supply a Laser Acceptance Report detailing the Laser functional performance before, during, and after each environmental test exposure. There shall be an Acceptance Test Report per each laser delivery subsequent to the Qualification tests.

The Laser Acceptance Test Report shall include digitized copies of all the as-run work orders and test procedures.

5.0 QUALITY ASSURANCE

5.1 GENERAL REQUIREMENTS

5.1.1 Quality Assurance Plan/Manual

The contractor **shall** have a Quality Management System that is compliant with the requirements SAE AS9100 Quality Systems - Aerospace - Model for Quality Assurance in Design, Development, Production, Installation and Servicing or equivalent.

The contractor **shall** maintain the Laser Quality Assurance Plan. The Laser Quality Assurance Plan was created for the source selection activity by the contractor.

5.1.2 Surveillance of the Contractor

The work activities and operations of the contractor, subcontractors, and suppliers are subject to evaluation, review, survey, and inspection by a GSFC representative.

The contractor **shall** provide the GSFC representative with documents, records, equipment, and working areas within their facilities that are required by the representative to perform their surveillance activities.

5.1.2.1 Government Source Inspection

The Government may elect to perform inspections at a supplier's facilities. The following statement **shall** be included on all procurement documents:

All work on this order is subject to inspection and test by the Government in accordance with the inspection clauses in the contract.

The Government quality representative who has been delegated NASA quality assurance functions on this procurement **shall** be notified immediately upon contractor receipt of any supplier/subcontractor orders. The Government representative **shall** also be notified fourteen (14) calendar days in advance of the time that articles or materials are ready for inspection or test.

5.1.2.2 Contractor Source Inspection

The contractor **shall** ensure that its procurement documents impose the applicable requirements on subcontractors and other suppliers. The subcontractor and other suppliers **shall** in turn impose the requirements on their procurement sources.

The contractor **shall** perform source inspection at the subcontractor's or supplier's facilities in accordance with the procurement documentation or when one or more of the following conditions exist:

- In process, end item controls, or tests that are destructive in nature prevent the contractor from verifying quality after delivery to the contractor's facility.
- It is not feasible or economical for the contractor to determine the quality of procured articles solely by inspections or tests performed at the contractor's facility.
- Qualification tests are to be performed by the subcontractor or supplier.
- Products are shipped directly from the source to NASA, by-passing the contractor's inspection facilities.

5.1.2.3 Government Mandatory Inspection Points (MIPs)

The government or its representative will perform the following MIPs listed below. The government may request additional MIPs if a specific process prohibit inspection at a later time.

- Inspect 100% solder
- Inspect 100% crimps
- Inspect 100% conformal coating, staking, and potting
- Rework Inspection
- Pre-vibration test inspection
- Pre-thermal air test inspection
- Pre-thermal vacuum test inspection
- Pre-closure Inspection
- Pre-Ship Inspection/Data Review

5.1.3 Anomaly Reporting

Reporting of hardware anomalies to the GSFC COTR shall begin at contract award as GSFC anticipates the vendor should begin flight acquisition of hardware at contract award. The GSFC COTR shall be notified within 24 hours of each anomaly.

The contractor's processes for review, disposition and approval of anomaly reports shall be described in the Laser Quality Assurance Plan. In addition, this plan shall describe the members of the Material Review Board (MRB) and Failure Review Board (FRB). These processes shall ensure that positive corrective action has been taken to preclude recurrence and that appropriate audits and tests are performed to verify the implementation of the corrective action.

The contractor shall routinely inform the COTR of MRB and FRB meeting schedules and agendas with sufficient notice to permit the COTR to participate for insight purposes.

At the contractor's facility, NASA/Government representatives may participate in MRB/FRB activities as deemed appropriate to the GSFC COTR.

To assure process consistency and COTR insight, the contractor shall provide the COTR on-line access to their anomaly-reporting database.

The contractor shall provide, as part of the monthly report, a list of all open anomaly reports and a separate list of the anomaly reports closed during the month. For each reported anomaly or nonconformance, there shall be a report that documents the investigation and engineering analysis needed to determine the root cause and corrective actions to disposition the nonconformance, and identify any closed problem reports that do not have a root cause or corrective action. Reports shall be submitted to the GSFC COTR for review and approval of the disposition.

The contractor shall establish and maintain documented procedures to ensure product that does not conform to specific requirements is prevented from unintended use or installation. This control shall provide for identification, documentation, evaluation, segregation (when practical), disposition of

nonconforming product, and for notification to the functions concerned.

5.1.4 Configuration Management

The contractor's Configuration Management (CM) system (available for review on request) **shall** control the design, hardware, software, and firmware images by means of drawings, specifications, and other documents and **shall** ensure all applicable changes are reviewed in a systematic manner to determine the validity and impact on performance, cost and schedule before implementing configuration changes. The contractor's CM system **shall** have a change classification and impact assessment process that ensures Class I changes shall be forwarded to the Contracting Officer (CO) for approval prior to release/incorporation. Class I changes are defined as changes that affect form, fit, function, external interfaces, or requirements as stated within this document and the Laser Systems Specification. The CO will consult the COTR for concurrence to approve.

All other changes are considered to be Class II changes and **shall** be controlled and dispositioned by the contractor. All Class II changes **shall** be provided monthly to the GSFC COTR for insight purposes. GSFC reserves the right to review all Class II changes for technical content to ensure the proper classification has been assigned. Any flight item that is found to be non-compliant with the quality, workmanship and performance requirements of the contract **shall** be dispositioned via a waiver or MRB, unless the affected item is reworked to restore compliance or is replaced with a fully compliant item. The contractor **shall** submit Waivers to the GSFC CO for final approval. The CO will consult the COTR for concurrence to approve.

A contractor QA representative **shall** be a member of the Configuration Control Board. The QA activities **shall** be defined described in detail in the Laser Quality Assurance Plan.

5.1.5 Ground Support Equipment (GSE) Interfaces

Thermal, Optical, Mechanical and electrical ground support equipment (GSE) and associated software that directly interfaces with flight deliverable items **shall** be assembled and maintained to mitigate potential risk to flight hardware. Parts and

materials selection and reporting requirements are exempted as long as deliverable flight item contamination requirements are not compromised. However, all GSE direct interfaces to flight hardware shall be flight quality (i.e. connectors, baseplates, etc.).

5.2 SYSTEM SAFETY REQUIREMENTS

The contractor shall supply detailed descriptions of the design, test, operation and inspection requirements for all flight hardware and materials, ground support equipment (mechanical, electrical, thermal), and their interfaces necessary for a valid identification, assessment, control and mitigation of documented hazards. GSFC anticipates operation of this equipment at instrument, observatory and launch vehicle integration and test. This includes technical information concerning hazardous and safety critical equipment, systems, operations, handling and materials. For all identified hazards, the contractor shall also document hazard controls, verifications and tracking methods.

5.3 RELIABILITY REQUIREMENTS

The contractor shall manage reliability to show that the design reliability is consistent with laser life requirements. This will primarily consist of the contractor performing the reliability analyses concurrently with design activities, in order to optimize system configurations, and identify and promptly correct potential problems.

5.3.1 Stability Trending

The contractor shall also track measurable parameters that relate to performance stability and repeatability. Selected parameters shall be monitored for trends starting at piece-part acceptance testing and continuing through the laser system integration and test (I&T) phases. These parameters shall be compiled in the Trended Parameters List (TPL).

5.3.2 Limited-Life Items

The contractor shall identify and manage limited-life items. Limited-life items include all hardware that is subject to degradation because of limited shelf life or expected operating

times or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined.

The NASA/GSFC CO and COTR **shall** approve the use of an item whose expected life is less than twice the laser design life. For materials that have exceeded their allowable shelf life, a waiver can be submitted to the NASA/GSFC CO and COTR for use.

5.3.3 Control of Sub-Contractors And Suppliers

The contractor **shall** ensure that system elements obtained from sub-contractors and suppliers meet reliability and quality assurance requirements.

5.4 ANALYSIS, TRENDING, AND REPORTING OF TEST DATA

The contractor **shall** properly record, maintain and analyze test information during the normal test program to assess performance and flight worthiness and to aid in the identification and analysis of flight hardware failures and problems.

5.5 WORKMANSHIP STANDARDS AND PROCESSES

The contractor's workmanship program **shall** fully encompass the specific requirements of this SOW section. It is the contractor's responsibility to list all deviations from the baseline workmanship standards and to provide data supporting their position/rationale.

5.5.1 Workmanship Requirements for Diode Boards, Soldered Assemblies, Harnessing, and Fiber Optics

The following workmanship standards **shall** apply to printed circuit boards, soldered assemblies, harnessing, and fiber optics.

- Conformal Coating and Staking: NASA-STD-8739.1, WORKMANSHIP STANDARD FOR POLYMERIC APPLICATION ON ELECTRONIC ASSEMBLIES (Revision A with Change 1 of 7/23/09)
- Surface Mount Technology (SMT): NASA-STD-8739.2, Workmanship Standard for Surface Mount Technology
- Hand Soldering Assemblies: NASA-STD-8739.3, Soldered Electrical Connection

- Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring
- Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation
- Diode Board (PWB) Design: Space Flight PWB designs **shall** not include features that prevent the finished board(s) from complying with the Class 3 or 3/A Requirements of the appropriate manufacturing standard (e.g., specified plating thickness, internal annular ring dimensions, etc.).
 - IPC-2221, Generic Standard on Printed Board Design
 - IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards
 - IPC-2223, Sectional Design Standard for Flexible Printed Boards
 - IPC-2225 Sectional Design Standard for Organic Multichip Modules (MCM-L and MCM-L Assemblies)
- Diode Board (PWB) Manufacture:
 - IPC-A-600, Acceptability of Printed Boards (Class 3 requirements)
 - IPC-6011, Generic Performance Specification for Printed Boards (Class 3 requirements)
 - IPC-6012, Qualification and Performance Specification for Rigid Printed Boards (Class 3/A requirements)
 - IPC-6013, Qualification and Performance Specification for Flexible Printed Boards (Class 3 requirements)
 - IPC-6015 Qualification and Performance Specification for Organic Multichip Module (MCM-L) Mounting and Interconnecting Structures
 - IPC-6018 Microwave End Product Board Inspection and Test
 - Fire-Retardant Polyimide Board Laminate / Documentation Fire-Retardant Polyimide Laminates **shall** contain no discrete bromide particles - material must be fully homogeneous to avoid Conductive Anodic Filament (CAF) failures. Laminate manufacturer, material reference number, and /IPC designation **shall** be included in project materials list. In addition, coupon submittal sheets shall clearly note if brominated material was used in the PWB fabrication.
 - PWB coupons **shall** be submitted to GSFC COTR for inspection and approval. Boards should not be utilized until GSFC COTR approval is received.

5.5.2 New or Advanced Packaging Technologies

Workmanship requirements or standards, including design, qualification, and acceptance requirements, specified by the contractor for advanced packaging technologies, such as multi-chip modules (MCMs), stacked memories, chip on board, column-grid arrays (CGA) or ball grid arrays (BGA), shall be submitted to the NASA/GSFC CO and COTR for review and approval prior to use.

Each Non-Standard Process document shall address process control, fabrication, inspection, training, and acceptance and rejection criteria. Test data and evaluation records shall be submitted as part of the process support for approval, as applicable.

5.5.3 Electrostatic Discharge Control Requirements

The contractor shall document and implement an ESD Control Program suitable to protect the most ESD-sensitive instrument components at all levels of assembly and integration in accordance with the requirements of ANSI/ESD S20.20.

All personnel who manufacture, inspect, test or otherwise process electronic hardware or who require unescorted access into ESD protected areas shall be certified as having completed the contractor required training, appropriate to their involvement prior to handling any electronic hardware.

5.5.4 Training and Certification of Contractor Personnel

All personnel performing work on flight hardware requiring a prerequisite set of skills and competency shall be certified as having completed the contractor required training, appropriate to their involvement.

5.5.5 Hardware Handling, Cleaning and Packaging

The handling of flight hardware shall be performed by qualified personnel in accordance with contractor approved procedures that address cleaning, handling, packaging, tent enclosures, shipping containers, bagging, and purging. Compatible packaging shall be selected so that hardware is not contaminated or otherwise degraded during shipping or storage. All personnel working on flight hardware shall be certified as having completed the

contractor required training and competency certifications prior to handling any flight hardware. This includes, but is not limited to, workmanship, clean room and ESD awareness courses.

5.5.6 Workmanship: Use of Alternate Workmanship Standards

GSFC recognizes that the contractor may have an established workmanship program equivalent to the specific standards cited herein. In these instances, the contractor may use existing standards upon review and approval by the NASA/GSFC CO and COTR. It must be established that the contractor's workmanship program fully encompasses the specific requirements of this chapter. It is the contractor's responsibility to list all deviations from the baseline workmanship standards and to provide data supporting their position/rationale.

5.6 EEE PARTS REQUIREMENTS

5.6.1 EEE Parts in General

Laser EEE parts shall be selected and processed in accordance with the requirements of EEE-INST-002, Instructions for EEE parts selection, screening, qualification and derating. All application notes in EEE-INST-002 will apply.

The minimum acceptable EEE part grade available for flight laser use on ICESAT-2 is Class 2 with 100% Particle Impact Noise Detection (PIND) screening for cavity bodied devices and a sample Destructive Physical Analysis (DPA). This assumes that the radiation hardness requirements and system reliability goals are also being met. This would include parts costs, test costs, risk of test failures and reliability differences between both classes. The contractor shall maintain an EEE Parts Identification List and shall review proposed parts with the GSFC COTR. An As-Built Parts List (ABPL) shall be included as part of the end item data package for each laser delivery.

5.6.2 EEE Part Custom Devices

In addition to the applicable requirements of EEE-INST-002, custom microcircuits, hybrid microcircuits, MCM, ASIC and other non-standard application unique devices planned for flight lasers shall be subjected to a parts-level design review (with GSFC participation). The design review shall address, at a minimum, derating of elements, method used to certify acceptable

reliability, assembly and materials processes, methods for assuring adequate thermal matching of materials, and screening and qualification requirements.

5.6.3 **EEE Part Plastic Encapsulated Microcircuits**

The use of Plastic Encapsulated Microcircuits (PEMs) is discouraged in the laser. However, when use is necessary to achieve unique requirements that cannot be found in hermetic high reliability microcircuits, plastic encapsulated parts must meet the requirements of NASA GSFC EEE-INST-002. All PEM(s) require GSFC COTR review and concurrence. PEM usage shall be presented at the Preliminary Design Assessment and TIMs, as applicable.

5.6.4 **EEE Part Radiation Hardness**

All laser EEE parts shall be selected to meet their intended application in the ICESAT-2 radiation environment as defined in the Ice, Cloud, and Elevation Satellite Project Laser Systems Specification ICESAT-2-ATSYS-SPEC-0099. The contractor will document the radiation hardness assessment for each part in accordance with the requirements in Section 3, and include this assessment as part of the Preliminary Design Assessment Presentation Package. Test plans and reports for parts that require radiation testing shall be submitted to the GSFC COTR for review.

5.6.5 **EEE Parts Age Control**

Parts more than 5 years old require GSFC COTR approval for use. Contractors shall present justification with inspection and test requirements.

5.6.6 **EEE Part GIDEP Alerts and Problem Advisories**

Contractors shall keep sufficient selection and usage records for all flight parts and materials adequate to determine applicability of any issued Government Industry Data Exchange Program (GIDEP) alerts relevant to items used on ICESat-2. The contractor shall review and disposition all GIDEP Alerts for relevancy and impact. In addition, the contractor shall review and disposition any NASA Alerts and Advisories provided to the contractor by the COTR. Alert applicability, impact, and corrective actions shall be documented and status provided to

the COTR on a monthly basis.

5.6.7 **EEE Part Reuse and Materials**

EEE parts and materials that have been installed in an assembly and removed for any reason **shall** not be used again for flight.

5.7 **MATERIALS, PROCESSES REQUIREMENTS**

5.7.1 **Materials Selection Requirements**

To qualify material for flight use, the material must have a satisfactory flight heritage relevant to laser requirements or meet the following applicable selection criteria as defined herein for:

- Vacuum outgassing
- Stress corrosion cracking (SCC)
- Lubrication requirements
- Manufacturing process selection
- Fastener integrity
- Magnetic and Electrostatic Cleanliness
- Lubricants

The contractor **shall** create and maintain a Materials and Processes Identification List (M&P) using the forms in the Appendix, or an equivalent form. The contractor **shall** review proposed materials and processes with the GSFC COTR.

Materials containing silicones for flight use or processing use **shall** require a Material Usage Agreement approved by the GSFC COTR.

An As-Built Materials List (ABML) **shall** be included as part of the end item data package for each laser delivery in contractor format.

Pure Tin, Zinc, and Cadmium are not acceptable for flight use.

5.7.1.1 Vacuum Outgassing of Polymeric Materials

Only materials that have a total mass loss (TML) less than 0.25% and a collected volatile condensable mass (CVCM) less than 0.05% **shall** be approved for use in a vacuum

environment. Material vacuum outgassing **shall** be determined in accordance with ASTM E-595. If a material exceeds these maximum limits, the contractor **shall** be required to either replace with a compliant material or bring it into compliance via a vacuum bakeout, or to submit a Material Usage Agreement (MUA) for its usage.

GSFC maintains a database of materials vacuum stability tests on materials can be found on-line at <http://outgassing.nasa.gov/>. Marshall Space Flight Center also maintains a data base. Access can be gained at <http://maptis.nasa.gov/index.asp>. Historical data to demonstrate compliance to this requirement is acceptable, providing the following characteristics are the same for the historical usage of the material and the proposed usage:

- Primer (when tested as composite system)
- Mix ratio of components
- Cure conditions (time/temperature/humidity)
- Bakeout (temperature/pressure)

If these parameters are not the same or if there has been a significant change in the formulation of a material by its manufacturer, then a sample of the material that is processed in the same way as the flight material **shall** be tested per ASTM-E-595. GSFC has facilities for performing this testing and the contractor should contact the COTR for assistance. Additionally several commercial firms can also perform the testing.

5.7.1.2 Stress Corrosion Cracking of Inorganic Materials

Materials used in structural applications **shall** be highly resistant to stress corrosion cracking (SCC) as specified in MSFC-STD-3029. A Material Usage Agreement (MUA) and a SCC evaluation form **shall** be submitted, contractor format acceptable, for each material usage that does not comply with the MSFC-STD-3029 SCC requirements.

5.7.1.3 Process Selection Requirements

Materials and manufacturing process information **shall** be provided on the material list.

5.7.1.4 Fasteners

The contractor **shall** comply with the procurement and test requirements for flight hardware and critical ground support equipment fasteners contained in 541-PG-8072.1.2, Goddard Space Flight Center Fastener Integrity Requirements. Traceability **shall** be maintained for every fastener lot.

5.7.1.5 Lubricants

The contractor's material list **shall** include lubrication usage. Lubricants **shall** be selected for use with materials on the basis of flight heritage and valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination concerns.

All lubricated mechanisms **shall** be life tested unless it can be established and documented that a valid flight heritage exists to an identical mechanism used in an identical flight application or to an identical mechanism that has been separately qualified by suitable life testing.

5.7.2 Materials Procurement Requirements

Raw materials purchased by the contractor and its contractors **shall** be accompanied by a Certificate of Compliance and, where applicable, the results of nondestructive, chemical and physical tests. Certificate of Compliances **shall** be included in the Data Delivery Package with each laser delivery.

5.7.3 Dissimilar Metals

To avoid electrolytic corrosion, dissimilar metals should not be used in direct contact unless protection against corrosion has been provided in accordance with MIL-STD-889. Variances from this policy must be submitted to the GSFC COTR for approval.

5.8 CONTAMINATION CONTROL REQUIREMENTS

5.8.1 Laser Contamination Control Plan

The contractor shall prepare a Laser Contamination Control Plan (LCCP) that describes the procedures that will be followed to control contamination within the laser enclosure and outside the laser enclosure. The LCCP shall establish the implementation and describe the methods and procedures that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the laser integration and test. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging shall be described in detail at each phase of assembly, integration, test, and shipping. The LCCP shall define the use of protective covers and purges, vent locations and paths, and environmental constraints. The contractor shall submit their LCCP to the GSFC COTR for review and approval.

5.8.2 External Cleanliness

All hardware cleanliness shall be verified to meet the requirements of the specification ICESAT-2-ATSYS-SPEC-0099, prior to delivery to GSFC.

5.8.3 Material Outgassing

All materials shall be screened against the measured materials in NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data shall be considered valid for use for the laser if the material was processed in the same manner as the material in the Reference Publication 1124 (mix ratio, temperature, post cure bakeout, etc.) based on each component's operating conditions. Established material outgassing data shall be verified and shall be provided to the GSFC COTR for review and approval.

5.8.4 Thermal Vacuum Bakeouts

Thermal vacuum bake-out of laser systems shall be performed before delivery. The parameters of such bakeouts (e.g., temperature, duration, outgassing requirements, and pressure) are developed by the laser contractor.

A quartz crystal microbalance (QCM) or temperature controlled quartz crystal microbalance (TQCM) and cold finger **shall** be incorporated during all thermal vacuum bakeouts. These devices provide additional information to enable a determination of the duration and effectiveness of the thermal vacuum bakeout as well as compliance with the LCCP. If a QCM or TQCM is not available, the contractor **shall** notify the GSFC COTR for assistance.

Prior to Thermal vacuum bakeout, the Thermal Vacuum Bakeout Procedure and the following chamber configuration information, at a minimum, **shall** be made available to the GSFC COTR.

- Use of Shrouds
- Chamber Size
- General Test Setup
- Thermal layout
- Pressure Profile
- Temperature Profile
- TQCM Locations and how many
- Hardware placement plan (include drawings)
- TQCM Temperature
- Hardware Temperature
- Shroud Temperature
- Chamber dimensions
- Location of scavenger plates (if used)
- Location of cold finger (if used)
- Type of pump (i.e.: diffusion, cryopumped, etc.)

Thermal vacuum bakeout data will be provided to the GSFC COTR as the test progresses. Thermal vacuum bakeout results **shall** be verified and **shall** be provided to the GSFC COTR for review, 1 weeks after test is completed.

- Cold Finger Data
- Test Results Data
- TQCM Data (Take readings every 0.5 hours)
- Chamber Configuration Data

5.8.5 Wiping and Cleaning Materials

The contractor **shall** only use extracted wipes to clean the Lasers, housings and covers.

All wipes or other items used to clean the Lasers **shall** comply with vendor developed laser cavity cleaning processes.

All wipes or other items used to clean the Lasers **shall** be verified clean before contacting the lasers.

All materials used including solvents, cleansers, gloves, finger cots etc. **shall** be compatible with the Laser fabrication.

5.8.6 Room Cleanliness

The contractor **shall** manufacture and test hardware in an ISO Class 6 facility per ISO-14644.

5.8.7 Assembly Room Temperature

The contractor **shall** assemble the Lasers in a room between 15C and 30C.

5.8.8 Assembly Room Humidity

The contractor **shall** assemble the Lasers in a room having a humidity range meeting the Electrostatic Discharge Requirement and to prevent condensation on the flight hardware.

5.9 HANDLING, STORAGE, PACKAGING, PRESERVATION, AND DELIVERY

The contractor shall ship the lasers to GSFC.

Laser shipping containers shall be stored, preserved, marked, labeled, and packaged to prevent loss of marking, deterioration, contamination, excessive condensation and moisture, or damage during all phases of the handling. Stored and stocked items shall be controlled in accordance with documented procedures and be subject to quality surveillance.

The contractor shall provide an acceptable shipping container that protects the hardware appropriately.

While in a shipping container, the laser shall be wrapped in a non-ESD-generating vapor barrier with redundant maximum humidity indicators. Packaging materials and methods shall not degrade the molecular or particulate cleanliness of the item.

The shipping container shall also include shock and humidity indicators and shall be capable of prolonged shipping conditions. The contractor shall document what action GSFC is to take if the sensors are tripped when hardware arrives at the GSFC receiving area. A copy of this document shall be included with shipping documentation.

By executing the act of laser shipment, the supplier certifies that the laser complies with all contract requirements. Prior to shipping, quality assurance personnel shall ensure that:

- Fabrication, inspection, and test operations have been completed and accepted.
- All lasers are identified and marked in accordance with requirements.
- All shipping containers are identified and marked in accordance with requirements.
- The accompanying documentation (contractor's shipping and property accountable form) has been reviewed for completeness, identification, and quality approvals.
- Evidence exists that preservation and packaging are in compliance with requirements.
- Packaging and marking of products, as a minimum, comply with Interstate Commerce Commission rules and regulations

and are adequate to ensure safe arrival and ready identification at their destinations.

- The loading and transporting methods are in compliance with those designated in the shipping documents.
- Integrity seals are on shipping containers and externally observable shock or humidity monitors do not show excessive environmental exposure.
- In the event of unscheduled removal of a product from its container, the extent of re-inspection and retest **shall** be as authorized by GSFC COTR.
- Special handling instructions for receiving activities, including observation and recording requirements for shipping-environment monitors are provided where appropriate.
- Shipping documentation and containers **shall** contain appropriate measures (signs/warnings) to ensure that the item's packaging is only removed or opened inside of a cleanroom.
- Special handling instructions for receiving activities, including observation and recording requirements for shipping-environment monitors are provided where appropriate.

The contractor's quality assurance organization **shall** verify prior to shipment that the above requirements have been met and **shall** sign off appropriate shipping documents to provide evidence of this verification. The contractor **shall** ship Free On Board (F.O.B.) destination to NASA/GSFC, Space Laser Assembly Cleanroom, Building 33, Greenbelt, Maryland 20771. The contractor **shall** be responsible for any damage incurred during shipment.

APPENDIX A. ABBREVIATIONS AND ACRONYMS

Abbreviation/ Acronym	Definition
ABPL	As-Built Parts List
ANSI	American National Standards Institute
AR	Acceptance Review
BGA	Ball Grid Arrays
CCB	Configuration Control Board
CCP	Contamination Control Plan
CCR	Configuration Change Request
CDA	Critical Design Assessment
CIC	Coverglass-Interconnect-Cell
CM	Configuration Management
CIC	Coverglass, Interconnect, Cell
CO	Contracting Officer
COTR	Contracting Officer's Technical Representative
CVCM	Collected Volatile Condensable Mass
PDA	Preliminary Design Review
DDD	Displacement Damage Dose
DILS	Deliverable Items List and Schedule
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromechanical
ESD	Electrostatic-Discharge
FMEA	Failure Modes and Effects Analysis
FRB	Failure Review Board
GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
IBR	Integrated Baseline Review
LCW	Laser Center Wavelength
MCM	Multichip Modules
MIS	Management Information System
ICESat-2	Ice, Cloud, Elevation Satellite -2
MIP	Mandatory Inspection Point
MRB	Material Review Board
MUA	Materials Usage Agreement
PDL	Product Design Lead
PDA	Preliminary Design Assessment
PEMs	Plastic Encapsulated Microcircuits
PER	Pre-Environmental Review
PIND	Particle Impact Noise Detection

Abbreviation/ Acronym	Definition
pm	Pico meter
PMB	Performance measurement baseline
PSR	Pre-Ship Review
PWB	Printed Wiring Board
QA	Quality Assurance
QCM	Quartz Crystal Microbalance
QTY	Quantity
SCC	Stress Corrosion Cracking
SCM	Software Configuration Management
SCoRe	Signature Controlled Request (similar to a CCR)
S/C	Spacecraft
SEE	Single-Event Effects
SMT	Surface Mount Technology
SOW	Statement of Work
SQA	Software Quality Assurance
SQAP	Software Quality Assurance Program
SRR	Software Requirements Review
TBD	To Be Determined
TBR	To Be Resolved
TML	Total Mass Loss
TID	Total Ionizing Dose
TIM	Technical Interchange Meeting
TPL	Trended Parameters List
TQCM	Temperature Controlled Quartz Crystal Microbalance
TRR	Test Readiness Review
WVR	Waiver

APPENDIX B. ICESAT-2 MATERIAL SELECTION FORMS

MATERIAL USAGE AGREEMENT (MUA)			USAGE AGREEMENT NO. :			PAGE OF			
PROJECT :		:		ORIGINATOR:			ORGANIZATION:		
DETAIL DRAWING		NOMENCLATURE			USING ASSEMBLY			NOMENCLATURE	
MATERIAL & SPECIFICATION					MANUFACTURER & TRADE NAME				
USAGE	THICKNESS		WEIGHT		EXPOSED AREA		ENVIRONMENT		
							PRESSURE	TEMPERATURE	MEDIA
APPLICATION:									
RATIONALE:									
ORIGINATOR:					PROJECT MANAGER:			DATE:	

GSFC Spacecraft Metals, Ceramics and Processes List

System	ICESat-2	Subsystem	
Company		Contractor Address	
Prepared by		Phone & Fax #	
GSFC MAE		Project CSO	Nancy Lindsey
Date Prepared		Revision No.	

Part Number	Rev	Nomenclature	Next Assy	MAPTIS Material Code	Material Name	Material Specification	Process Specification	Type/ Class/ Grade/ Color	Comments
EXAMPLE									
2066480	Rev A	Assy, PCAS-ESP3	-	-	-	-	-	-	-
2066481	Rev B EO 01	Frame, PCAS-ESP3	2066480	50669	7075-T7351	ASTM B209 or SAE-AMS-QQ-A-250/12	-	-	-
		Anodic Coating	-	10277	Coating Anodic Type-2	-	MIL-A-8625	Type II, Class 1, Color Clear	-
		Chemical Conversion Coating	-	00666	Coating Corrosion	-	MIL-C-5541	Class 3 Color Gold	nonmetallic
		Plating Nickel Electroless	-	10046	Plating Nickel Electroless	-	SAE-AMS-26074	Class 1 Grade B	same as MIL-C-26074
EXAMPLE									

GSCF Spacecraft Polymers List

System	ICESat-2	Subsystem	
Company		Contractor Address	
Prepared by		Phone & Fax #	
GSCF MAE		Project CSO	Nancy Emsey
Date Prepared		Revision No.	

Amount Code
 Area, cm² Vol, cc wt, gm
 1. 0-1 A. 0-1 a. 0-1
 2. 2-100 B. 2-50 b. 2-50
 3. 101-1000 C. 51-500 c. 51-500
 4. > 1000 D. > 500 d. > 500

Part Number	Rev	Nomenclature	Next Assy	MAPTIS Material Code	Material Name	Material Specification	Process Specification	Type/ Class/ Grade/ Color	Comments	Mix Formula	Cure Details	Amount Code	Expected Environment	ASTM-E-595 Outgassi	
														%TML	%CVC

GSFC Spacecraft Lubrications List

System	MMS	Subsystem	
Company		Contractor Address	
Prepared by		Phone & Fax #	
GSFC MAE	Kamili Jackson	Project CSO	John Blackwood
Date Prepared		Revision No.	

Wear Codes		
Type	# Cycles	Speed
CUR continuous unidirectional rotation	A 1-10 ²	rpm rev/min
CO continuous oscillation	B 10 ² -10 ⁴	opm osc/min
IR intermittent rotation	C 10 ⁴ -10 ⁶	vs variable
IO intermittent oscillation	D >10 ⁶	cpm cm/min
SO small oscillation (<30)		
LO large oscillation (>30)		
CS continuous sliding		
IS intermittent sliding		

Part Number	Rev	Nomenclature	Next Assy	Component Type, Size, and Material	Proposed Lubricant and Amount	Type and # of Wear Cycles	Speed, Temp, & Atm of Operation	Type of Loads and Amount

APPENDIX C. LIST OF APPLICABLE DOCUMENTS

All documentation identified in the SOW shall apply in the SOW sections where they are specifically referenced. All documents are latest version unless otherwise noted.

Document #	Title
ICESat-2-LAS-TN-0173	Definition of Technology Readiness Level (TRL) 6 for Laser Transmitter
ICESAT-2-ATSYS-SPEC-0099	Ice, Cloud, Elevation Satellite Project Laser Systems Specification
SOW APPENDIX D	ICESAT-2 Project Laser Systems Deliverable Items List and Schedule
ICESat-2-ATSYS-PLAN-0297	ATLAS Contamination Control Plan
EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and Derating
MIL-STD-1629A	Procedures for Performing a Failure Mode, Effects and Criticality Analysis
SAE AS9100	Quality Systems Aerospace - Model for Quality Assurance in Design, Development, Production, Installation, and Servicing
NASA-STD-8739.1	WORKMANSHIP STANDARD FOR POLYMERIC APPLICATION ON ELECTRONIC ASSEMBLIES (Revision A with Change 1 of 7/23/09)
NASA-STD-8739.2	Workmanship Standard for Surface Mount Technology
NASA-STD-8739.3	Soldered Electrical Connections
NASA-STD-8739.4	Crimping Inter-connecting Cables, Harnesses, and Wiring
NASA-STD-8739.5	Fiber Optic Terminations, Cable Assemblies, and Installation
IPC-2221	Generic Standard on Printed Board Design
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223	Sectional Design Standard for Flexible Printed Boards
IPC-2225	Sectional Design Standard for Organic Multichip Modules (MCM-L and MCM-L Assemblies)
IPC-A-600	Acceptability of Printed Boards

IPC-6011	Generic Performance Specification for Printed Boards
IPC-6012C	Qualification and Performance Specification for Rigid Printed Boards
IPC-6013	Qualification and Performance Specification for Flexible Printed Boards
IPC-6015	Qualification and Performance Specification for Organic Multichip Module (MCM-L) Mounting and Interconnecting Structures
IPC-6018	Microwave End Product Board Inspection and Test
ANSI/ESD S20.20-2007	Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
ASTM E-595-07	Standard test method for total mass loss and collected volatile condensable materials from outgassing in a vacuum environment
MSFC-STD-3029	GUIDELINES FOR THE SELECTION OF METALLIC MATERIALS FOR STRESS CORROSION CRACKING RESISTANCE IN SODIUM CHLORIDE ENVIRONMENTS
541-PG-8072.1.2	GSFC Fastener Integrity Requirements
NASA-RP-1124-Rev-4	Outgassing Data for Selecting Spacecraft Materials
ICESat-2-THM-IFACE-0214	ATLAS Thermal Interface Control Document
ICESat-2-THM-RPT-0212	ATLAS Thermal Model Delivery Report Template
ANSI Z136.1-2007	Safe Use Of Lasers
MIL-STD-889B	Dissimilar Metals

**APPENDIX D. ENGINEERING CONTRACT DELIVERABLE REQUIREMENTS LIST
(E-CDRL) AND SCHEDULE**

Deliveries shall be made to the GSFC COTR at NASA Goddard. All document deliveries shall be submitted to ICESat-2 MIS via the Signature Control Requests (SCoRes) process.

Line #	Name & Description	Months after Contract Award	SOW Section	QTY	Item Form
1	Weekly Status Report	Starts at first week	1.2.1	1/wk	PDF
2	Monthly Status Report including financial formats	Starts at first month	1.2.2	1/month	PDF with financial reports in XML or MSExcel
3	Monthly Schedule Update	Starts at first month	1.2.2	1/month	MS Project File
4	Preliminary Design Assessment/TRL-6/IBR Slide Package	3 months	1.4.2	1	PDF
5	Preliminary Mechanical Interface Control Documentation	3 months	2.2.3	1	PDF
6	Preliminary Design Assessment/TRL-6 Report	4 months	1.4.2.3	1	PDF
7	Final Mechanical Interface Control Documentation	12 months	2.2.2.1	1	PDF
8	Critical Design Assessment Slide Package	12 months	1.4.3.1	1	PDF
9	Critical Design Assessment Report	12 months	1.4.3.3	1	PDF
10	Pre-Environmental Review Report for Laser Serial #1	21 months	1.4.4.2	1	PDF
11	Pre Ship Review Report & User's Manual for Laser Serial #1	24 months	1.4.5.2	1	PDF
12	Integration and Test Laser (ITL) and User's Manual	23 months	3.2 Item 3A	1	Hardware, documentation & test equipment
13	Pre-Environmental Review Report for Laser Serial #2	24 months	1.4.4.2	1	PDF
14	Pre Ship Review Report for Laser Serial #2 and User's Manual for Laser Serial #2	27 months	1.4.5.2	1	PDF
15	Pre-Environmental Review Report for Laser Serial #3	28 months	1.4.4.2	1	PDF
16	Pre Ship Review Report and User's Manual for Laser Serial #3	30 months	1.4.5.2	1	PDF
17	Pre-Environmental Review Report for Laser Serial #4	32 months	1.4.4.2	1	PDF
18	Pre Ship Review Report and User's	35 months	1.4.5.2	1	PDF

Line #	Name & Description	Months after Contract Award	SOW Section	QTY	Item Form
	Manual for Laser Serial #4				
19	Laser Performance Analysis Report	With each laser delivery	2.1.2	1	PDF
20	Laser Drawing Package	12 months	2.2.3	1	PDF
21	Laser Performance Computer Model Basis Document	12 months	2.1.1.2	1	PDF
22	Laser Design Computer Models (CAD model)	12 months	2.2.4	1	Stp files
23	Structural Analysis Report	12 months	2.3.2	1	PDF
24	Structural Analysis Computer Model at CDA	12 months	2.3.1.1	1	SOW specified format
25	Electrical Analysis Report	12 months	2.4.1	1	PDF
26	Mass Analysis Report	With each laser delivery	2.5	1 per	PDF
27	Thermal Analysis Report	12 months	2.6.2	1	PDF
28	Reduced Thermal Model at PDA	3 months	2.6.1	1	SOW specified format
29	Reduced Thermal Model at CDA	12 months	2.6.1	1	SOW specified format
30	Correlated Thermal Model for SN001	18 months	2.6.1.8	1	SOW specified format
31	Reliability Analysis Report	12 months	2.7.1	1	PDF
32	Failure Modes and Effects Analysis Report	12 months	2.8.1	1	PDF
33	Safety Analysis Report	12 months	2.9.1	1	PDF
34	Connector Savers (one per connector)	With each laser delivery	3.3	1 per	Hardware
35	Mating Connectors (one per connector)	With each laser delivery	3.4.1	1 per	Hardware
36	Breakout Boxes	With each laser delivery	3.4.1	AR	Hardware
37	Test Port Flight Connector Caps	With each laser delivery	3.4.2	AR	Hardware
38	Laser Requirements Verification Plan	12 months	4.1.1	1	PDF
39	Laser Verification Test Procedures	12 months	4.1.1.1	1	PDF
40	Laser Qualification Test Plan	12 months	4.1.2.1	1	PDF
41	Laser Qualification Test Procedures	12 months	4.1.2.2	1	PDF
42	Laser Acceptance Test Plan	12 months	4.1.3.1	1	PDF
43	Laser Acceptance Test Procedures	12 months	4.1.3.2	1	PDF
44	Laser Qualification Test Report	With Serial #1 delivery	4.3.1	1	PDF
45	Laser Acceptance Test Report	With each laser delivery	4.3.2	1 per	PDF
46	Final Trended Parameters List (TPL)	12 months	5.3.1	1	PDF
47	Laser Trend Data	With each laser delivery	5.4	1 per	PDF

Line #	Name & Description	Months after Contract Award	SOW Section	QTY	Item Form
48	Verification Tracking Matrix	12 months	4.1.1	1	PDF
49	Materials and Processes Identification List	Preliminary at PDA, final at the CDA.	5.7.1	1	PDF
50	As-Built Materials & Processes List (ABML)	With each laser delivery	5.7.1	1	PDF
51	Material Usage Agreement (MUA)	Applied for as soon as material is identified in the design process. Status at PDA and CDA.	5.7.1	1	PDF
52	Certificates of Compliance	With each laser delivery	5.9	1	PDF
53	Laser Contamination Control Plan (LCCP)	3 month	5.8.1	1	PDF
54	Shipping containers	With each laser delivery	5.9	4	Shipping containers
55	Flight Laser Serial #1	24 months	ICESAT-2-ATSYS-SPEC-0099	1	Flight hardware and test equipment
56	Flight Laser Serial #2	27 months	ICESAT-2-ATSYS-SPEC-0099	1	Flight hardware and test equipment
57	Flight Laser Serial #3	30 months	ICESAT-2-ATSYS-SPEC-0099	1	Flight hardware and test equipment
58	Flight Laser Serial #4	35 months	ICESAT-2-ATSYS-SPEC-0099	1	Flight hardware and test equipment
59	Laser Mass Model	12 months	ICESAT-2-ATSYS-SPEC-0099, Sections 4.3 and 4.4	1	Test hardware

APPENDIX E. GOVERNMENT FURNISHED PROPERTY (GFP) LIST

1. Government will furnish multi-layer insulation (MLI
- 2.) for space flight applications.

Released Version

**APPENDIX F. LASER SMA CONTRACT DELIVERABLES REQUIREMENTS LIST
(SMA-CDRL) AND SCHEDULE**

All document deliveries shall be submitted to ICESat-2 MIS via the Signature Control Requests (SCoRes) process. NASA will provide access to ICESat-2 MIS at contract award.

Released
Version

SMA-CDRL #	Topic	Due Date Timing
1	MAIP	Submitted with proposal
2	Prev. Dev. Product Compliance	30 working days after identification
3	Quality Manual	Submitted with proposal
4	Reporting MRB Actions	5 working days after meeting
5	Request for deviation or waiver	5 working days after identification
6	Anomaly Report	1 working day after occurrence
7	System Safety Program Plan	15 working days before PDA
8	Safety Req. Compliance Checklist	30 working days prior to PDA
9	Preliminary Hazard Analysis	30 working days after PDA
10	Op. and Support Hazard Analysis	30 working days after CDA
11	PRA and Reliability Plan	60 working days ACA / reports at each review
12	FMEA & CIL	30 working days prior to each review (PDA, CDA, PSR)
13	FTA	30 working days prior to each review (PDA, CDA, PSR)
14	Part Stress Analysis	45 working days prior to CDA
15	Worst Case Analysis	30 working days prior to CDA
16	Reliability Assessments & Predicts	30 working days prior to each review (PDA, CDA, PSR)
17	Limited-Life Items List	30 working days prior to PDA
18	Software Quality Assurance Plan	15 working days prior to PDA
19	Software Ver. And Val. Plan	15 working days prior to CDA
20	Software CM Plan	15 working days prior to CDA
21	Software Version Description Doc.	With each build or release
22	Software Status Report	60 working days ACA / reports at each review
23	Software Reliability Report	At PDA and updated at CDA
24	Risk Management Plan	30 working days ACA
25	Risk List	Monthly with Monthly Report
26	Laser Review Materials	10 working days prior to a review
27	Action Item Responses	30 working days after end of review
28	Peer Review Plan	At PDA
29	System Perf. Verification Plan	30 working days prior to CDA
30	Environmental Verification Plan	30 working days prior to CDA
31	System Performance Verification Matrix	At PDA and updated at CDA
32	Environmental Test Matrix	At PDA and updated at CDA
33	Verification Reports	Prel. within 72 hours of test completion, final 10 working days of test completion
34	System Performance Verification Report	30 working days after PSR for each laser unit
35	ESD Control Plan	30 working days prior to PDA
36	Parts Control Program	30 working days ACA
37	Parts Control Board Procedures	30 working days ACA
38	Parts Identification List (PIL)	10 working days prior to each Part Control Board meeting
39	Project Approved Parts List (PAPL)	10 working days prior to each Part Control Board meeting
40	As Designed Parts List (ADPL)	10 working days prior to each Part Control Board meeting
41	As Built Parts List (ABPL)	10 working days prior to each Part Control Board meeting
42	Mat. And Process. Control Plan	60 working days ACA
43	Life Test Plan for Lubricated Mechanisms	30 working days prior to PDA
44	MUAs	30 working days prior to PDA
45	MIUL	30 working days prior to PDA, revised 30 working days prior to CDA
46	Nondestructive Eval. Plan	30 working days prior to PDA, revised 30 working days prior to CDA
47	PWB Test Coupons	20 working days prior to board assembly&part populating
48	Laser Contamination Control Plan	30 working days prior to PDA, revised 30 working days prior to CDA
49	GIDEP Alert	Within 30 working days of identification
50	Significant parts, matls, and Safety Problems	Within 30 working days of identification
51	End Item Acceptance Data Package	Preliminary 10 working days prior to per unit PSR, and final at unit delivery

Mission Assurance Implementation Plan (MAIP)

<p>Title: Mission Assurance Implementation Plan (MAIP)</p>	<p>LASER SMA CDRL No.: 1</p>
<p>Reference:</p>	
<p>Use: Documents the contractor's plan for implementing a system safety and mission assurance program</p>	
<p>Related Documents:</p>	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Delivered to the GSFC with the contractor's proposal. - Updates shall be delivered to the GSFC COTR within thirty (30) working days of plan changes including but not limited to any prime traceability matrix changes or subcontractor matrix changes (e.g. each subcontractor award or scope change or QMS change) for approval. 	
<p>Preparation Information:</p> <p>The MAIP shall cover all contracts S&MA requirements and be applicable to:</p> <ul style="list-style-type: none"> - All flight hardware and software that is designed, built, or provided by the contractor and its subcontractors, or furnished by the government, from project initiation through launch and mission operations - The ground system that interfaces with flight equipment to the extent necessary to assure the integrity and safety of flight items - The ground data system <p>The MAIP shall include an up-to-date traceability matrix to planned processes for all mission assurance requirements for the prime and suppliers. Specifically, the prime shall document supplier compliance by showing which SOW SMA requirements were allocated to each supplier and how the allocated requirements will be met by each supplier and include these plans in their overall MAIP.</p> <p>Note: supplier documentation may take the form of individual supplier MAIPs, with compliance matrices, referred to in the overall MAIP compliance matrix or individual compliance matrices for each supplier attached to the overall MAIP depending on supplier criticality.</p>	

Previously Developed Product Compliance with Requirements

Title: Previously Developed Product Compliance with Requirements	LASER SMA CDRL No.: 2
Reference:	
Use: Documents the compliance of previously developed product with the requirements of the SOW and the MAIP	
Related Documents: Mission Assurance Implementation Plan	
Place/Time/Purpose of Delivery: - Delivered to the GSFC COTR thirty 30 working days after identification of the previously developed product for approval	
Preparation Information: The document shall identify the requirements that apply to the previously developed product through a requirements compliance matrix for the product's specific characteristics and its development. The document shall address all areas of noncompliance through a waiver or deviation.	

Quality Manual

Title: Quality Manual	LASER SMA CDRL No.: 3
Reference:	
Use: Documents the contractor's quality management system.	
Related Documents: - SAE AS9100 Quality Systems - Aerospace - Model for Quality Assurance in Design, Development, Production, Installation and Servicing - ISO 10013 Quality Manual Development Guide	
Place/Time/Purpose of Delivery: - Provide with proposal for GSFC review - Provide updates to the GSFC COTR 30 working days after contract award for review	
Preparation Information: Prepare a Quality Manual addressing applicable requirements of AS9100; refer to ISO 10013 Quality Manual Development Guide for guidelines on preparation of a quality manual.	

Reporting of MRB actions

<p>Title: Reporting of MRB Actions</p>	<p>LASER SMA CDRL No.: 4</p>
<p>Reference:</p>	
<p>Use: Report MRB actions to the GSFC COTR.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - SAE AS9100 Quality Systems - Aerospace - Model for Quality Assurance in Design, Development, Production, Installation and Servicing 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Major MRB actions: Deliver to the GSFC COTR within five (5) working days of MRB action for approval. <ul style="list-style-type: none"> • A major MRB action is required when there is a failure or significant deficiency in a significant part of the quality system governed by applicable standards. - Minor MRB actions: Deliver to the GSFC COTR within five (5) working days of MRB action for information <ul style="list-style-type: none"> • A minor MRB action is required when there is a failure in some part of the supplier's documented quality system that judgment and experience indicate is not likely to result in the failure of the quality system or reduce its ability to assure controlled processes or products. 	
<p>Preparation Information:</p> <p>The contractor shall document relevant information on a contractor MRB form that includes at least the following:</p> <ul style="list-style-type: none"> - Identification of project, system, or sub-system - Identification of item (e.g., assembly, sub-assembly, or part, to include serial number or part number as applicable) - Description of affected item - Definition of major and minor nonconformances - Identification of next higher assembly - Description of anomaly, including activities leading up to the anomaly - Names and contact information of involved individuals 	

- Status of item
- Contact information for personnel who originated the report
- Date of original submission to the MRB
- Actions taken after approval

Request for a deviation or waiver

<p>Title: Request for a deviation or waiver</p>	<p>LASER SMA CDRL No.: 5</p>
<p>Reference:</p>	
<p>Use: Request government approval of a deviation or waiver.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - SAE AS9100 Quality Systems - Aerospace - Model for Quality Assurance in Design, Development, Production, Installation and Servicing 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver to the GSFC COTR within five (5) working days of identifying the need for a deviation or waiver for approval 	
<p>Preparation Information:</p> <p>The contractor shall identify the requirements that apply to the product and provide specific information regarding the noncompliance of the product with the requirements. The contractor shall identify the effect of the proposed noncompliance on product performance at higher levels of assembly.</p>	

Anomaly Report

<p>Title: Anomaly Report</p>	<p>LASER SMA CDRL No.: 6</p>
<p>Reference:</p>	
<p>Use: Document anomalies, investigative activities, rationale for closure, and corrective and preventive actions.</p>	
<p>Related Documents: - SAE AS9100 Quality Systems - Aerospace - Model for Quality Assurance in Design, Development, Production, Installation and Servicing</p>	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver initial submission to the GSFC COTR within 24 hours of occurrence for information - Deliver notice of a change in status within 24 hours of occurrence for information - Deliver the proposed closure to the GSFC COTR prior to closure for approval - Deliver all records in the electronic format specified below as part End item data packages (EIDP) 	
<p>Preparation Information: Document anomalies, changes in status, or proposed closure to identify the following information:</p> <ul style="list-style-type: none"> - Identification of project, system, or sub-system - Identification of failed item (e.g., assembly, sub-assembly, or part) - Description of item - Identification of next higher assembly - Description of anomaly, including activities leading up to anomaly, if known - Names and contact information of individuals involved in anomaly - Date and time of anomaly - Status of item - Contact information for personnel who originated the report - Date of original submission - Anomaly cause - Corrective actions implemented 	

- Retesting performed and results
- Other items affected
- Risk ratings, mission impact and certainty in corrective actions

Released Version

System Safety Program Plan

<p>Title: System Safety Program Plan</p>	<p>LASER SMA CDRL No.: 7</p>
<p>Reference:</p>	
<p>Use: The System Safety Program Plan (SSPP) describes the tasks and activities of system safety management and engineering required to identify, evaluate, and eliminate or control hazards to the hardware, software, and system design by reducing the associated risk to an acceptable level throughout the system life cycle, including launch range safety requirements.</p>	
<p>Place/Time/Purpose of Delivery: - Deliver to the GSFC COTR fifteen (15) working days prior to PDA for approval</p>	

Preparation Information:

The contractor **shall** prepare a SSPP that describes the development and implementation of a system safety program that complies with the requirements of NPR 8715.3, NPR 8715.7. The contractor **shall**

- Define the roles and responsibilities of personnel
- Define the required documentation, applicable documents, and completion schedules for analyses, reviews, and safety packages
- Address support for Reviews, Safety Working Group Meetings and TIMs
- Provide for early identification and control of hazards to personnel, facilities, support equipment, and the flight system during product development, including design, fabrication, test, transportation, and ground activities.
- Address compliance with the launch range safety requirements
- Address compliance with industrial safety requirements imposed by NASA and OSHA design and operational needs (e.g., NASA-STD-8719.9 Lifting Devices and Equipment) and contractually imposed mission unique obligations
- Address software safety so as to identify and mitigate safety-critical software products in compliance with NASA-STD-8719.13 NASA Software Safety Standard by the following:
 - Identification of software related hazards
 - Identification of hazard controls that are implemented with software
 - Identification and tracking of software safety requirements
 - Verification results and approved waivers and exceptions for software safety requirements
 - Verification of safety discrepancy disposition approvals
 -

Safety Requirements Compliance Checklist

Title: Safety Requirements Compliance Checklist	LASER SMA CDRL No.: 8
Reference:	
Use: The checklist indicates for each requirement whether the proposed design is compliant, non-compliant but meets intent, non-compliant, or if the requirement is not applicable. An indication other than compliant shall include rationale. Note: the contractor shall submit safety waivers for non-compliant design elements	
Related Documents: <ul style="list-style-type: none"> - Mission Related Safety Requirements Documentation 	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none"> - Deliver to the GSFC COTR thirty (30) working days prior to PDA for approval - Updates quarterly 	
Preparation Information: The contractor shall prepare a compliance checklist of all design, test, analysis, and data submittal requirements. The following shall be included: <ul style="list-style-type: none"> - Criteria and requirement. - System - Indication of compliance, noncompliance, or not applicable - Resolution - Reference - Copies of all Range Safety approved non-compliances including waivers and equivalent levels of safety certifications 	

Preliminary HAZARD ANALYSIS

Title: Preliminary Hazard Analysis	LASER SMA CDRL No.: 9
Reference:	
Use: The Preliminary Hazard Analysis (PHA) is used to obtain an initial risk assessment and identify safety critical areas of a concept or system. It is based on the best available data, including mishap data from similar systems and other lessons learned. The contractor shall evaluate hazards associated with the proposed design or function for severity, probability, and operational constraints. The contractor shall identify safety provisions and alternatives that are needed to eliminate hazards or reduce their associated risk to an acceptable level.	
Related Documents: <ul style="list-style-type: none">- NPR 8715.3, NASA General Safety Program Requirements- MIL-STD-882, Standard Practice for System Safety	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Submit the PHA with the Safety Assessment Report to the GSFC COTR no later than thirty (30) working days after PDA for approval	

OPERATING AND SUPPORT HAZARD ANALYSIS

Title: Operating and Support Hazard Analysis (O&SHA)	LASER SMA CDRL No.: 10
Reference:	
Use: The Operating & Support Hazard Analysis (O&SHA) addresses the implementation of safety requirements for personnel, procedures, and equipment used during testing, transportation, storage, and integration operations	
Related Documents: - NPR 8715.3, NASA General Safety Program Requirements	
Place/Time/Purpose of Delivery: - Deliver the results of the O&SHA to the GSFC COTR thirty (30) working days after CDA	

Probabilistic Risk assessment (PRA) and Reliability Plan

Title: PRA and Reliability Plan	LASER SMA CDRL No.: 11
Reference:	
Use: Planning and implementation of Probabilistic Risk Assessment (PRA) and reliability activities.	
Related Documents: <ul style="list-style-type: none">- NPD 8720.1, NASA Reliability and Maintainability (R&M) Program Policy- NASA-STD-8729.1, Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program.- NPR 8705.4 Risk Classification for NASA Payloads- NPR 8705.5 PRA Procedures for NASA Programs and Projects	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Deliver final plans to the GSFC COTR sixty (60) working days after contract award for review- Deliver activity reports related to implementation of the plans at Laser milestone reviews beginning with the CDA	

Failure Mode and Effects Analysis and Critical Items list

<p>Title:</p> <p>Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL)</p>	<p>LASER SMA CDRL No.: 12</p>
<p>Reference:</p>	
<p>Use:</p> <p>Used to evaluate design against requirements, to identify single point failures and hazards, and to identify modes of failure within a system design for the early mitigation of potential catastrophic and critical failures.</p>	
<p>Related Documents</p> <ul style="list-style-type: none"> - GSFC Flight Assurance Procedure, FAP P-322-208, Performing a Failure Mode and Effects Analysis - NPR 8705.4 Risk Classification for NASA Payloads 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver preliminary FMEA to the GSFC COTR thirty (30) working days before PDA for review - Deliver final FMEA to the GSFC COTR thirty (30) working days prior to CDA for approval - Deliver updated FMEA and CIL to the GSFC COTR thirty (working days) prior to each subsequent milestone review leading up to PSR for approval 	
<p>Preparation Information:</p> <p>The FMEA Report shall include the following:</p> <ul style="list-style-type: none"> - A discussion of the approach of the analysis, methodologies, assumptions, results, conclusions, and recommendations. - Objectives - Level of the analysis - Ground rules - Functional description - Functional block diagrams - Reliability block diagrams - Equipment analyzed - Data sources used - Problems identified - Single-point failure analysis, to include the root cause, mitigation, and retention rationale for those with severity categories 1, 1R, 1S, 2, 2S or 2R. - Corrective actions - Work sheets identifying failure modes, causes, severity category, and effects at the item, next higher level, and mission level, detection methods, and mitigating provisions. - Critical Items List (CIL) for severity categories 1, 1R, 1S, 2, and 2R, 	

including item identification, cross-reference to FMEA line items, and retention rationale. Appropriate retention rationale may include design features, historical performance, acceptance testing, manufacturing product assurance, elimination of undesirable failure modes, and failure detection methods.

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Fault Tree Analysis

<p>Title: Fault Tree Analysis (FTA)</p>	<p>LASER SMA CDRL No.: 13</p>
<p>Reference:</p>	
<p>Use: Used to assess mission failure from the top level perspective. Undesired top-level states are identified and combinations of lower-level events are considered to derive credible failure scenarios. The technique provides a methodical approach to identify events or environments that can adversely affect mission success and provides an informed basis for assessing system risks.</p>	
<p>Related Documents</p> <ul style="list-style-type: none"> - NASA Fault Tree Handbook with Aerospace Applications (http://www.hq.nasa.gov/office/codeq/doctree/fthb.pdf) - NPR 8705.4 Risk Classification for NASA Payloads - NPR 8715.3 NASA General Safety Program Requirements 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver preliminary qualitative mission FTA report to GSFC COTR thirty (30) working days prior to PDA for review. - Deliver final qualitative mission FTA report to GSFC COTR thirty (30) working days prior to CDA for approval. - Deliver qualitative mission FTA report to GSFC COTR within thirty (30) working days of updates/changes for approval. - Deliver quantitative FTA report to GSFC COTR in support of pivotal event analysis as part of each PRA report for approval 	
<p>Preparation Information:</p> <p>The mission FTA Report shall contain:</p> <ul style="list-style-type: none"> - Analysis ground rules including definitions of undesirable end states - References to documents and data used - Fault tree diagrams - Results and conclusions <p>Note: Separate FTA reports are not required for fault trees generated in support pivotal event analysis in the PRA report.</p>	

Parts Stress Analysis

<p>Title: Parts Stress Analysis</p>	<p>LASER SMA CDRL No.: 14</p>
<p>Reference:</p>	
<p>Use: Provides EEE parts stress analyses for verifying circuit design conformance to derating requirements; demonstrates that environmental operational stresses on parts comply with project derating requirements.</p>	
<p>Related Documents</p> <ul style="list-style-type: none"> - GSFC EEE-INST-002 <http://nepp.nasa.gov/DocUploads/FFB52B88-36AE-4378-A05B2C084B5EE2CC/EEE-INST-002_add1.pdf> - NASA Parts Selection List <http://nepp.nasa.gov/npsl/index.htm> 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver Parts Stress Analysis Report to GSFC COTR forty-five (45) working days prior to CDA for review - Deliver revisions to GSFC COTR within thirty (30) working days of changes for review 	
<p>Preparation Information:</p> <p>The Parts Stress Analysis Report <u>shall</u> contain:</p> <ul style="list-style-type: none"> - Analysis ground rules - Reference documents and data used - Results and conclusions including: <ul style="list-style-type: none"> o Design trade study results o Parts stress analysis results impacting design or risk decisions - Analysis worksheets; the worksheets at a minimum <u>shall</u> include: <ul style="list-style-type: none"> o Part identification (traceable to circuit diagrams) o Assumed environmental (consider all expected environments) o Rated stress o Applied stress (consider all significant operating parameter stresses at the extremes of anticipated environments) o Ratio of applied-to-rated stress 	

Worst Case Analysis

<p>Title: Worst Case Analysis</p>	<p>LASER SMA CDRL No.: 15</p>
<p>Reference:</p>	
<p>Use: Demonstrate design margins in electronic and electrical circuits, optics, and electromechanical and mechanical items.</p>	
<p>Related Documents</p> <ul style="list-style-type: none"> - NPD 8720.1, NASA Reliability and Maintainability (R&M) Program Policy. - NASA-STD-8729.1, Planning, Developing and Managing an Effective R&M Program. - NPR 8705.4, Risk Classification for NASA Payloads 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver Worst Case Analysis Report to GSFC COTR thirty (30) working days prior to CDA for review - Deliver revisions to Worst Case Analysis Report to GSFC COTR within thirty (30) working days for review 	
<p>Preparation Information: The Worst Case Analysis Report shall include the following:</p> <ul style="list-style-type: none"> - Address worst case conditions performed on each component. - Discuss how each analysis includes the mission life. - Discuss consideration of critical parameters at maximum and minimum limits. - The effect of environmental stresses on the operational parameters being evaluated. 	

Reliability Assessments and Predictions

Title: Reliability Assessments and Predictions	LASER SMA CDRL No.: 16
Reference:	
Use: Used to assist in evaluating alternative designs and to identify potential mission limiting elements that may require special attention.	
Related Documents: <ul style="list-style-type: none">- IEEE Standard Methodology for Reliability Prediction and Assessment for Electronic Systems and Equipment - Std 1413- RADC-TR-85-229, Reliability Prediction for Spacecraft	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Deliver initial report to GSFC COTR thirty (30) working days prior to PDA for review- Deliver final report to GSFC COTR thirty (30) working days prior to CDA for review- Deliver final report to GSFC COTR thirty (30) working days prior to PSR for review	
Preparation Information: The Reliability Assessment and Prediction Report <u>shall</u> include the following: <ul style="list-style-type: none">- The methodology and results of comparative reliability assessments including mathematical models- Reliability block diagrams- Failure rates- Failure definitions- Degraded operating modes- Trade-offs- Assumptions- Any other pertinent information used in the assessment process- A discussion to show reliability was considered as a discriminator in the design process	

Limited-Life Items List

<p>Title: Limited-Life Items List</p>	<p>LASER SMA CDRL No.: 17</p>
<p>Reference:</p>	
<p>Use: Tracks the selection and application of limited-life items and the predicted impact on mission operations</p>	
<p>Related Documents</p>	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver Limited-Life Items List to the GSFC COTR thirty (30) working days prior to PDA for approval - Deliver updates to the GSFC COTR no later than thirty (30) working days after changes are made for approval 	
<p>Preparation Information: The contractor shall prepare and maintain a list of life-limited items and their predicted impact on mission operations. The list shall include expected life, required life, duty cycles, and rationale for selecting and using the item. The list may include such items as structures, thermal control surfaces, solar arrays, electromechanical mechanisms, batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators and scan devices. The environmental or application factors that may affect the items include such things as atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue.</p>	

Software Quality Assurance Plan

Title: Software Quality Assurance Plan	LASER SMA CDRL No.: 18
Reference:	
Use: Documents the contractors Software Quality Assurance roles and responsibilities, surveillance activities, supplier controls, record collection, maintenance and retention, training, and risk management.	
Related Documents: <ul style="list-style-type: none">- IEEE Standard 730-2002, Software Quality Assurance Plans- NASA-STD-8739.8, NASA Standard for Software Assurance	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Deliver baseline plan to the GSFC COTR fifteen (15) working days prior to PDA for approval- Deliver updates to the GSFC COTR fifteen (15) working days prior to implementation for approval	
Preparation Information: The Software Quality Assurance Plan (SAP) shall follow the format: <ul style="list-style-type: none">- Purpose- Reference documents and definitions- Management- Documentation- Standards, practices, conventions, and metrics- Software Reviews- Test- Problem Reporting and Corrective Action- Tools, techniques, and methodologies- Media control- Supplier control- Records, collection, maintenance, and retention- Training- Risk Management- SQAP Change procedure and history	

Software Verification and Validation Plan

<p>Title: Software Verification & Validation Plan</p>	<p>LASER SMA CDRL No.: 19</p>
<p>Reference:</p>	
<p>Use: Documents the software V&V process which determines whether the development products of a given activity conform to the requirements of that activity and whether the software satisfies its intended use and user needs. This determination may include analysis, evaluation, review, inspection, assessment, and testing of the software products and processes. Please note that the V&V process should be performed in parallel with the software development, not at the conclusion of the development effort.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - NPR 7150.2, NASA Software Engineering Requirements - IEEE Standard 1012-2004, Software Verification & Validation - NASA-STD-8739.8, NASA Standard for Software Assurance - IEEE Std 1059-1993, IEEE Guide for Software Verification and Validation Plans 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Baseline document delivered to GSFC COTR fifteen (15) working days prior to CDA for approval 	
<p>Preparation information:</p> <ul style="list-style-type: none"> - Purpose - Referenced documents - Definitions - V&V Overview <ul style="list-style-type: none"> o Organization o Master Schedule o Software integrity level scheme o Resource summary o Responsibilities o Tools, techniques, and methods - V&V Processes <ul style="list-style-type: none"> o Process: Management <ul style="list-style-type: none"> ▪ Activity: Management of V&V o Process: Acquisition <ul style="list-style-type: none"> ▪ Activity: Acquisition of support V&V o Process: Supply <ul style="list-style-type: none"> ▪ Activity: Planning V&V o Process: Development <ul style="list-style-type: none"> ▪ Activity: Concept V&V ▪ Activity: Requirements V&V ▪ Activity: Design V&V ▪ Activity: Implementation V&V ▪ Activity: Test V&V ▪ Activity: Installation and Checkout V&V o Process: Operations <ul style="list-style-type: none"> ▪ Activity: Operations V&V o Process: Maintenance <ul style="list-style-type: none"> ▪ Activity: Maintenance V&V - V&V Reporting Requirements <ul style="list-style-type: none"> o Tasks reports o Activity: summary reports o Anomaly reports o V&V final reports 	

- o Special studies reports (optional)
- o Other reports (optional)
- V&V Administrative requirements
 - o Anomaly resolution and reporting
 - o Task iteration policy
 - o Deviation policy
 - o Control procedures
 - o Standards, practices, and conventions
- V&V test documentation requirements

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Software Configuration Management Plan

<p>Title: Software Configuration Management Plan</p>	<p>LASER SMA CDRL No.: 20</p>
<p>Reference:</p>	
<p>Use: The purpose of the Software Configuration Management Plan is to define the software configuration management system, roles and responsibilities, activities, schedules, resources, and plan maintenance.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - ANSI-IEEE Standard 828-1998, IEEE Standard for Software Configuration Management Plans - ANSI-IEEE Standard 1042-1987, Guide to Software Configuration Management - NPR 7150.2, NASA Software Engineering Requirements 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver baseline plan to the GSFC COTR fifteen (15) working days prior to CDA for approval 	
<p>Preparation Information:</p> <p>The contractor <u>shall</u> develop, maintain, manage, and implement a Software Configuration Management (SCM) system that provides baseline management and control of software requirements, design, source code, data, and documentation. The SCM system <u>shall</u> be applied to all deliverables and designated non-deliverable software products. The contractor <u>shall</u> document the SCM system, and associated tools, within the plan. The plan <u>shall</u> address configuration identification, configuration control, configuration status accounting, and configuration audits and reviews.</p> <p>As part of SCM, the contractor <u>shall</u> employ a source code version control tool (e.g., ClearCase, Starbase) that allows contractors to check in/check out current or previous versions of a source file. The contractor <u>shall</u> also use a requirements management tool (e.g., DOORS) to manage the software requirements baseline. The contractor <u>shall</u> document and implement a process for Software Problem Reporting and Corrective Action that addresses reporting, analyzing, and tracking software non-conformances throughout the development lifecycle. Software Problem Reporting can be included as part of contractors overall project Problem Reporting and Corrective Action Plan.</p> <p>The Software Configuration Management (SCM) Plan <u>shall</u> follow the following format:</p> <ul style="list-style-type: none"> - Introduction - Purpose, scope, definitions and references. - SCM Management Overview - Organization, responsibilities, and interfaces and relationships to software life cycle. - Software Configuration Management Activities: 1) Configuration Identification, 2) Configuration Control, 3) Configuration Status Accounting, 4) Configuration Audits, 5) Interface Control, 6) Subcontractor control. 	

- Software Configuration Management Schedules.
- Software Configuration Management Resources - tools, techniques, equipment, personnel, and training.
- Software Configuration Management Plan Maintenance.

Note: SCM Plan may be contained in contractor Project CM Plan or Software Management Plan.

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Software Version Description Document

<p>Title: Software Version Description Document (VDD)</p>	<p>LASER SMA CDRL No.: 21</p>
<p>Reference:</p>	
<p>Use: A Version Description Document (VDD) is the primary configuration control document used to track and control versions of software released to testing, implementation, or the final operational environment. The VDD identifies and documents the version of the computer software configuration items (CSCI's) and other deliverables that comprise the software build or release, including changes since the last VDD was issued.</p>	
<p>Related Documents: - NPR 7150.2, NASA Software Engineering Requirements Section 5.2.8</p>	
<p>Place/Time/Purpose of Delivery: - Deliver to the GSFC COTR with each build or release for information</p>	
<p>Preparation Information: The Version Description Document shall include/address: - Established Baseline - identifies the delivered system and software (e.g., type, version numbers, release numbers, date, and location) - New Features and/or Requirements Implemented and Delivered - Planned Features Absent from this version - List of Outstanding Change Requests (CRs), Discrepancy Reports (DRs), and workarounds (if applicable) against this release - List of CRs and DR's implemented since the previous version - Any Significant Changes in Operations - Applicable Documents associated with this release (e.g., user guides add other examples) - Installation instructions on how to build the system (including tools, operating systems, assemblers, compilers, libraries, existing software, data files, and delivered software). Note: All version numbers should be provided.</p>	

- Information from any Configuration Audits performed prior to the delivery (to ensure that the correct versions were delivered with the correct functionality)

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Software Status Report

<p>Title: Software Status Report</p>	<p>LASER SMA CDRL No.: 22</p>
<p>Reference:</p>	
<p>Use: Software Assurance Status Report provides information regarding current status and future activities.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - ANSI-IEEE Standard 828-1998, IEEE Standard for Software Configuration Management Plans - ANSI-IEEE Standard 1042-1987, Guide to Software Configuration Management - NPR 7150.2, NASA Software Engineering Requirements - 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Deliver to GSFC COTR monthly beginning sixty (60) working days after contract award for information 	
<p>Preparation Information:</p> <p>As part of the Project Monthly Status Reports, the contractor <u>shall</u> include the following software assurance activities:</p> <ul style="list-style-type: none"> - Organization and key personnel changes - Assurance accomplishments and resulting software assurance metrics (e.g., for activities such as inspection and test, reviews, contractor/subcontractor surveys, and audits) - Subcontractor assurance accomplishments - Trends in software quality metric data (e.g., total number of software problem reports, including the number of problem reports that were opened and closed in that reporting period) - Significant problems or issues - Plans for upcoming software assurance activities - Lessons Learned 	

Software Reliability Report

Title: Software Reliability Report	LASER SMA CDRL No.: 23
Reference:	
Use: Software Reliability Report provides information regarding software reliability assurance plan and results as well as corresponding corrective activities for system risk reduction, design and reliability improvement. Software Reliability Report will be updated as design becomes mature and data becomes available.	
Related Documents: <ul style="list-style-type: none">• NASA NPR 7150.2 NASA Software Engineering Requirements• NASA STD 8739.8 Software Assurance Standard• IEEE-Std- 1633 IEEE Recommended Practice on Software Reliability• IEEE-Std- 982.1 1988 IEEE Standard Dictionary of Measures to Produce Reliable Software• NASA GB 8719.13 NASA Software Safety Guidebook	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">• Deliver preliminary report on software reliability assessment and verification as well as corrective activities for reliability improvement and risk reduction by PDA and updated by CDA for review;	
Preparation Information: The report shall contain: <ul style="list-style-type: none">• Criteria for the selection of software engineering measures/software reliability models for software reliability assessment;• Software defect/failure data collected and tools used;• Assumptions, approximations and any other pertinent information used in the assessment process;• Software reliability assessment results and conclusions;• Corrective activities plans and results for software reliability improvement, design improvement and system risk reduction.	

Risk Management Plan

<p>Title: Risk Management Plan</p>	<p>LASER SMA CDRL No.: 24</p>
<p>Reference:</p>	
<p>Use: Defines the process by which the contractor identifies, evaluates, and mitigates the risks associated with program, project, and/or mission goals</p>	
<p>Related Documents: - NPR 8000.4, Risk Management Procedures and Guidelines</p>	
<p>Place/Time/Purpose of Delivery: - Deliver to the GSFC COTR thirty (30) working days after contract award for approval</p>	
<p>Preparation Information: The Risk Management Plan shall include:</p> <ul style="list-style-type: none"> - Description of contract requirements - Purpose and Scope - Assumptions, Constraints, and Policies - Related Documents and Standards - Risk Management Process Summary (Philosophy, Integration) - Risk Management Organization <ul style="list-style-type: none"> - Roles and Responsibilities - Risk Management Review Board - Standard Practices - Communication - Risk Attributes that shall be used to classify risks <ul style="list-style-type: none"> - As a minimum attributes shall be defined for safety, cost, schedule, and technical or performance areas - Risk buy-down chart (waterfall chart) - Criteria for prioritization of risks - Mitigation plan content - Process Details <ul style="list-style-type: none"> - Baselines - Database (Use, Access, Updates, Responsibilities, etc.) - Identifying Risks - Analyzing Risks - Planning, Actions 	

- Tracking (metrics and their use)
- Control
- Documentation and Reporting

Version

Released

Risk list

<p>Title: Risk List</p>	<p>LASER SMA CDRL No.: 25</p>
<p>Reference:</p>	
<p>Use: Defines the documentation and reporting of risk items.</p>	
<p>Related Documents: - GID 7120.2 GSFC 5x5 Risk Matrix - NPR 8000.4, Agency Risk Management Procedural Requirements</p>	
<p>Place/Time/Purpose of Delivery: - Deliver Monthly Status Reports/List Updates - Deliver to the GSFC COTR fifteen (15) working days prior to each milestone reviews beginning with PDA for review</p>	
<p>Preparation Information: Prepare a prioritized list of risks that includes - Identification number - Title - Current approach (mitigate, watch, accept, research) - Rank - Trend</p> <p>Prepare a chart for each risk that includes: - Identification number - Title - Rank - Risk statement (condition-consequence form) - Brief discussion of: - Current approach - Actions causing change - Current status</p>	

Laser Review Materials

Title: Laser Review Materials	LASER SMA CDRL No.: 26
Reference:	
Use: To provide the Goddard review team with the materials used to conduct the review.	
Related Documents - GSFC-STD-1001 Criteria for Flight Project Critical Milestone Reviews	
Place/Time/Purpose of Delivery: - Provide the review presentation materials to the GSFC COTR ten (10) working days prior to the review for information - Provide review related reference materials to the GSFC COTR at the review for information	
Preparation Information: See the guidelines presented in the related documents.	

Action Item Responses

Title: Action Item Responses	LASER SMA CDRL No.: 27
Reference:	
Use: To respond to action items resulting from the review.	
Related Documents - Project Systems Review Plan (provided by GSFC COTR) - GSFC-STD-1001 Criteria for Flight Project Critical Milestone Reviews	
Place/Time/Purpose of Delivery: - Provide response to action items to the GSFC COTR thirty (30) working days after end of review for approval	
Preparation Information: See the guidelines presented in the related documents.	

Peer Review Plan

<p>Title: Peer Review Plan</p>	<p>LASER SMA CDRL No.: 28</p>
<p>Reference:</p>	
<p>Use: To provide the basis for conducting the contractor's peer review program.</p>	
<p>Related Documents - GPR 8700.6 Engineering Peer Reviews</p>	
<p>Place/Time/Purpose of Delivery: - Provide to the GSFC COTR at PDA for review</p>	
<p>Preparation Information: See the guidelines presented in the related document.</p>	

System Performance Verification Plan

Title: System Performance Verification Plan	LASER SMA CDRL No.: 29
Reference:	
Use: Establishes the System Performance Verification Plan.	
Related Documents: <ul style="list-style-type: none">- GSFC-STD-7000 General Environmental Verification Standard (GEVS) for GSFC Flight Programs and Projects- ICESat-2-ATSYS-REQ-0517, ATLAS Component Environmental Requirement	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Provide final plan to GSFC COTR thirty (30) working days prior to CDA for approval	
Preparation Information: The System Performance Verification Program Plan <u>shall</u> be prepared to comply with the requirements of paragraph 2.1.1.1 of GSFC-STD-7000.	

Environmental Verification Plan

Title: Environmental Verification Plan	LASER SMA CDRL No.: 30
Reference:	
Use: Establishes the Environmental Verification Plan.	
Related Documents: <ul style="list-style-type: none">- GSFC-STD-7000 General Environmental Verification Standard (GEVS) for GSFC Flight Programs and Projects- ICESat-2-ATSYS-REQ-0517, ATLAS Component Environmental Requirement	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Provide final plan to GSFC COTR thirty (30) working days prior to CDA for approval	
Preparation Information: The Environmental Verification Plan shall be prepared to comply with the requirements of paragraph 2.1.1.1.1 of GSFC-STD-7000.	

System Performance Verification matrix

<p>Title: System Performance Verification Matrix</p>	<p>LASER SMA CDRL No.: 31</p>
<p>Reference:</p>	
<p>Use: Establishes the System Performance Verification Matrix.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - GSFC-STD-7000 General Environmental Verification Standard (GEVS) for GSFC Flight Programs and Projects - ICESat-2-ATSYS-REQ-0517, ATLAS Component Environmental Requirement - ICESAT-2-ATSYS-SPEC-0099, Ice, Cloud, Elevation Satellite Project Laser Systems Specification 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - The updated System Performance Verification Matrix shall be included in the data packages for the reviews, beginning with PDA 	
<p>Preparation Information: The System Performance Verification Matrix shall be prepared and maintained per the requirements of paragraph 2.1.1.2 of GSFC-STD-7000.</p>	

Environmental test matrix

<p>Title: Environmental Test Matrix</p>	<p>LASER SMA CDRL No.: 32</p>
<p>Reference:</p>	
<p>Use: Establishes a matrix that summarizes the environmental tests and test status for flight hardware and other equipment.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - GSFC-STD-7000 General Environmental Verification Standard (GEVS) for GSFC Flight Programs and Projects - ICESat-2-ATSYS-REQ-0517, ATLAS Component Environmental Requirement 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - The updated matrix shall be included with the review data package for milestone reviews beginning with PDA for review 	
<p>Preparation Information: Guidelines for environmental test matrices are in paragraph 2.1.1.2.1 of GSFC-STD-7000. An example of an environmental test matrix is given in Figure 2.1-1 of GSFC-STD-7000.</p>	

Verification Reports

<p>Title: Verification Reports</p>	<p>LASER SMA CDRL No.: 33</p>
<p>Reference:</p>	
<p>Use: Establishes the requirement to submit Verification Reports</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - GSFC-STD-7000 General Environmental Verification Standard (GEVS) for GSFC Flight Programs and Projects - ICESat-2-ATSYS-REQ-0517, ATLAS Component Environmental Requirement - ICESAT-2-ATSYS-SPEC-0099, Ice, Cloud, Elevation Satellite Project Laser Systems Specification 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Preliminary verification report <u>shall</u> be provided to GSFC COTR within 72 hours of test completion for information - Final verification report <u>shall</u> be provided to GSFC COTR within ten (10) working days of test completion for information 	
<p>Preparation Information: The Verification Reports <u>shall</u> be prepared to comply with the requirements of paragraph 2.1.1.5 of GSFC-STD-7000.</p>	

System Performance Verification report

<p>Title: System Performance Verification Report</p>	<p>LASER SMA CDRL No.: 34</p>
<p>Reference:</p>	
<p>Use: Establishes a Performance Verification Report that compares hardware/software specifications with the final verified values.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - GSFC-STD-7000 General Environmental Verification Standard (GEVS) for GSFC Flight Programs and Projects - ICESat-2-ATSYS-REQ-0517, ATLAS Component Environmental Requirement - ICESAT-2-ATSYS-SPEC-0099, Ice, Cloud, Elevation Satellite Project Laser Systems Specification 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - The final report <u>shall</u> be submitted within thirty (30) working days after completion each unit PSR. 	
<p>Preparation Information: The System Performance Verification Report <u>shall</u> be prepared and maintained per paragraph 2.1.1.6 of GSFC-STD-7000.</p>	

ESD Control Plan

<p>Title: ESD Control Plan</p>	<p>LASER SMA CDRL No.: 35</p>
<p>Reference:</p>	
<p>Use: Implementation of an ESD control program at the contractor's facility</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - ANSI/ESD S20.20 For the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) 	
<p>Place/Time/Purpose of Delivery:</p> <p>The contractor <u>shall</u> submit an ESD Control Plan to the Project thirty (30) working days prior to PDA for review</p>	

EEE Parts Control Program

Title: EEE Parts Control Program	LASER SMA CDRL No.: 36
Reference:	
Use: Development and implementation of an EEE parts control program that addresses the system requirements for mission lifetime and reliability.	
Related Documents <ul style="list-style-type: none">- GSFC EEE-INST-002 Instructions for EEE Parts Selection, Screening, Qualification, and Derating- S-311-M-70 Specification for Destructive Physical Analysis	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- The contractor shall submit the PCP to the GSFC COTR thirty (30) working days after contract award for approval.	
Preparation Information: The EEE PCP shall address the following: <ul style="list-style-type: none">- Shelf life control plan- Parts application derating- Supplier and manufacturer surveillance- Qualification- ASICs, Gate Arrays, System-on-chip, Custom ICs- Incoming inspection and test- Destructive Physical Analysis- Defective parts controls program.- Radiation hardness assurance- Handling, preservation, and packing- Contamination control- Alternate quality conformance inspection and small lot sampling- Traceability and lot control- Failure analysis	

Parts Control Board Procedures

Title: Parts Control Board Procedures	LASER SMA CDRL No.: 37
Reference:	
Use: Organization and operation of the Parts Control Board regarding the implementation of the Parts Control Program.	
Related Documents	
Place/Time/Purpose of Delivery: The contractor shall submit the Parts Control Board operating procedures to the GSFC COTR thirty (30) working days after contract award for approval.	
Preparation Information: The contractor shall address the following in the Parts Control Board procedures: <ul style="list-style-type: none">- Organization and membership- Meeting schedule- Meeting notices- Distribution of meeting agenda, notes, and minutes- Review and approval responsibilities and processes	

Parts Identification List

Title: Parts Identification List (PIL)	LASER SMA CDRL No.: 38
Reference:	
Use: A list of EEE parts that may be selected for use in flight hardware.	
Related Documents	
Place/Time/Purpose of Delivery: - The contractor shall submit EEE parts to be added to the PIL to the Parts Control Board ten (10) working days prior to the first PCB meeting for approval by the PCB	
Preparation Information: The Parts Identification List shall contain the following information: - Flight component identity to the circuit board level - Complete part number (i.e. DSCC part number, SCD part number, with all suffixes) - Manufacturer's Generic Part number - Manufacturer (not distributor) - Part Description (please include meaningful detail) - FSC - Procurement Specification - Comments and clarifications, as appropriate - Estimated quantity required (for procurement forecasting)	

Project approved Parts, List

Title: Project Approved Parts List (PAPL)	LASER SMA CDRL No.: 39
Reference:	
Use: A list of EEE parts that are approved by the Parts Control Board for use in flight hardware.	
Related Documents	
Place/Time/Purpose of Delivery: - The contractor <u>shall</u> submit EEE parts to be added to the Project Approved Parts List to the Parts Control Board ten (10) working days prior to the PCB meeting at which they <u>shall</u> be presented for approval by the PCB	
Preparation Information: The PAPL <u>shall</u> contain all PIL fields plus the following information: - Procurement Part Number - Flight Part Number (if different from the procurement part number) - Package Style/Designation - Single Event Latch-up (SEL) Hardness/Tolerance and Data Source - Single Event Upset (SEU) Hardness/Tolerance and Data Source - Total Ionizing Dose (TID) Hardness/Tolerance and Data Source - Displacement Damage Hardness/Tolerance and Data Source - Proton Hardness/Tolerance and Data Source - PMPCB Status - PMPCB Approval Date - PMPCB Required Testing/Evaluations	

As designed Parts List

Title: As Designed Parts List (ADPL)	LASER SMA CDRL No.: 40
Reference:	
Use: A list of EEE parts that are designed into in flight hardware.	
Related Documents	
Place/Time/Purpose of Delivery: - The contractor shall submit EEE Parts to be added to the As Designed Parts List to the Parts Control Board ten (10) working days prior to the PCB meeting at which they shall be presented for approval by the PCB	
Preparation Information: The As Designed Parts List (ADPL) shall contain all PAPL fields plus the following information: - Assembly Name/Number - Next Level of Assembly - Need Quantity - Reference Designator(s) - Item number (if applicable)	

As Built Parts List

Title: As Built Parts List (ABPL)	LASER SMA CDRL No.: 41
Reference:	
Use: A list of EEE parts that are used in the flight hardware.	
Related Documents	
Place/Time/Purpose of Delivery: - The contractor shall submit EEE Parts to be added to the As Built Parts List to the Parts Control Board ten (10) working days prior to the PCB meeting at which they shall be reviewed by the PCB	
Preparation Information: The As Built Parts List (ABPL): shall contain all ADPL fields plus the following minimum information: - Assembly serial number - Next Level of Assembly serial number - Lot/Date/Batch/Heat/Manufacturing Code, as applicable - Manufacturer's Cage Code (specific plant location preferred) - Distributor/supplier, if applicable - Part serial number (if applicable)	

Materials and Processes Selection, Control Plan

<p>Title: Materials and Processes Selection, Control Plan</p>	<p>LASER SMA CDRL No.: 42</p>
<p>Reference:</p>	
<p>Use: Defines the implementation of NASA-STD-6016 with the prescribed changes as defined in "Preparation Information" section below.</p>	
<p>Related Documents: NASA-STD-6016 Standard Materials and Processes Requirement for Spacecraft</p>	
<p>Place/Time/Purpose of Delivery: - Provide to the GSFC COTR sixty (60) working days after contract award for approval.</p>	
<p>Preparation Information: For each paragraph in Section 4 of NASA-STD-6016 with the prescribed changes, described below, the plan shall state the requirement from NASA-STD-6016, identify the degree of conformance under the subheading "Degree of Conformance," and identify the method of implementation under the subheading "Method of Implementation."</p> <p>The plan shall address the following:</p> <ul style="list-style-type: none"> - Conformance to the requirements of NASA-STD-6016 with the prescribed changes and describe the method of implementation. - Organizational authority and responsibility for review and approval of M&P specified prior to release of engineering documentation. - Identification and documentation of Materials and Processes (including MUA/MIUL/Etc. process) - Procedures and data documentation for proposed test programs to support materials screening and verification testing - Materials Usage Agreement (MUA) Procedures - Determination of material design properties, including statistical approaches to be employed. - Identification of process specifications used to 	

implement the requirements in NASA-STD-6016.

- In addition to the requirements of paragraph 4.2.2.11, the contractor **shall** implement a lead-free control plan (LFCP) per GEIA-STD-0005-1 and a tin whisker control plan per Level 2C requirements of GEIA-STD-0005-2 for the use of solders or surface finishes that are less than 3% lead by weight.
- In paragraph 4.1.2, the contractor may use GSFC forms or the contractor's equivalent forms in lieu of the MAPTIS format.
- The contractor may use the GSFC outgassing database in addition to MAPTIS (URL <http://outgassing.nasa.gov>).
- The contractor **shall** use AFPCMAN91-710V3 Range Safety Users Requirements Manual section 10.1 in place of paragraph 4.2.1.
- In addition to the requirements of paragraph 4.2.3.4, the contractor **shall** qualify all lubricated mechanisms either by life testing in accordance with a life test plan or heritage with an identical mechanism used in an identical application.
- In addition to the requirements of paragraph 4.2.3.6, the contractor **shall** provide the vacuum bake out schedule for materials that fail outgassing requirements with the MUIL or MUA.
- Paragraph 4.2.3.8 does not apply.
- In paragraph 4.2.5.1, the contractor **shall** develop and implement a Non-Destructive Evaluation only for fracture critical flight hardware.
- In paragraph 4.2.6.5, the contractor **shall** use 541-PG-8072.1.2 GSFC Fastener Specification in place of NASA-STD-(I)-6008.

Life Test Plan for Lubricated Mechanisms

<p>Title: Life Test Plan for Lubricated Mechanisms</p>	<p>LASER SMA CDRL No.: 43</p>
<p>Reference:</p>	
<p>Use: Defines the life test evaluation process, acceptance criteria, and reporting for lubricated mechanisms.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - NASA-STD-6016 Standard Materials and Processes Requirement for Spacecraft - NASA-TM-86556 Lubrication Handbook for the Space Industry (Part A: Solid Lubricants, Part B: Liquid Lubricants) - NASA/CR-2005-213424 Lubrication for Space Applications 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Provide plan to the Project thirty (30) working days prior to PDA for approval 	
<p>Preparation Information: The Life Test Plan for Lubricated Mechanisms shall contain:</p> <ul style="list-style-type: none"> - Table of Contents - Description of lubricated mechanisms, performance functions, summary of subsystem specification, and life requirements. - Heritage of identical mechanisms and descriptions of identical applications. - Design, drawings, and lubrication system used by the mechanism. - Test plan, including vacuum, temperature, and vibration test environmental conditions. - Criteria for a successful test. - Final report. 	

Materials Usage Agreement

Title: Materials Usage Agreement (MUA)	LASER SMA CDRL No.: 44
Reference:	
Use: Establishes the process for submitting a MUA for a material or process that does not meet the requirements of NASA-STD-6016 and does not affect reliability or safety when used per the Materials and Processes Selection, Control, and Implementation Plan.	
Related Documents: <ul style="list-style-type: none">- NASA-STD-6016 Standard Materials and Processes Requirement for Spacecraft- MSFC-STD-3029 Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Provide MUAs to the Project thirty (30) working days prior to PDA for approval- After the initial submission of MUAs, new or revised MUAs shall be provided to the Project within thirty (30) working days of their identification for approval	
Preparation Information: The MUA system shall be defined in the Materials and Processes Selection, Control, and Implementation Plan as approved per paragraph 1.2. The MUA package shall include the technical information required to justify the application. MUAs for stress corrosion shall include a Stress Corrosion Cracking Evaluation Form per MSFC-STD-3029 (see NASA-STD-6016) and a stress analysis.	

Materials Identification and Usage List

Title: Materials Identification and Usage List (MIUL)	LASER SMA CDRL No.: 45
Reference:	
Use: Establishes the Materials Identification and Usage List (MIUL).	
Related Documents: <ul style="list-style-type: none"> - NASA-STD-6016 Standard Materials and Processes Requirement for Spacecraft 	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none"> - Provide to the GSFC COTR thirty (30) working days prior to PDA for review and approval - Provide to the GSFC COTR thirty (30) working days prior to CDA for review and approval. - Provide updates to the GSFC COTR within thirty (30) working days of identification for review and approval 	
Preparation Information: The delivered MIUL <u>shall</u> identify applicable data per NASA-STD-6016 for each material or process listed/proposed.	

Nondestructive evaluation plan

<p>Title: Nondestructive Evaluation Plan</p>	<p>LASER SMA CDRL No.: 46</p>
<p>Reference:</p>	
<p>Use: Establishes the Non-Destructive Evaluation (NDE) plan for the procedures and specifications employed in the inspection of materials.</p>	
<p>Related Documents:</p> <ul style="list-style-type: none"> - NASA-STD-6016 Standard Materials and Processes Requirement for Spacecraft - MIL-HDBK-6870, Inspection Program Requirements, Nondestructive for Aircraft and Missile Materials and Parts - NASA-STD-5009, Nondestructive Evaluation Requirements for Fracture-Critical Metallic Components 	
<p>Place/Time/Purpose of Delivery:</p> <ul style="list-style-type: none"> - Provide to the Project thirty (30) working days prior to PDA for review - Provide to the Project thirty (30) working days prior to CDA for approval 	
<p>Preparation Information:</p> <p>The NDE Plan shall describe the process for establishment, implementation, execution and control of NDE. The plan shall meet the intent of MIL-HDBK-6870, Inspection Program Requirements, Nondestructive for Aircraft and Missile Materials and Parts and NASA-STD-5009, Standard NDE Guidelines and Requirements for Fracture Control Programs, as specified by NASA-STD-6016.</p> <p>The plan shall define NDT planning and requirements to include the following:</p> <ul style="list-style-type: none"> - Hardware Design - Manufacturing Planning - Personnel Training - NDE Reliability Requirements for Fracture Critical Parts - NDE Reporting 	

Printed Wiring Boards Test Coupons

Title: Printed Wiring Board (PWB) Test Coupons	LASER SMA CDRL No.: 47
Reference:	
Use: PWB test coupons are evaluated to validate that PWBs are suitable for use in space flight and mission critical ground applications.	
Related Documents: <ul style="list-style-type: none"> - IPC-6011 Generic Performance Specifications for Printed Boards (Class 3 Requirements) - IPC-6012B Qualification and Performance Specification for Rigid Printed Boards (Class 3/A Requirements /Performance Specification Sheet for Space and Military Avionics) - IPC-6013 Qualification and Performance Specification for Flexible Printed Boards (Class 3) - IPC-6018 Microwave End Product Board Inspection and Test - IPC A-600 Guidelines for Acceptability of Printed Boards (Class 3 Requirements) 	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none"> - The contractor shall deliver test coupons and supporting manufacturing information traceable to the flight boards to GSFC or a GSFC-approved laboratory twenty (20) working days prior to board assembly&part populating for analysis of the printed wiring boards for approval 	
Preparation Information: Notify GSFC regarding shipment of PWB test coupons.	

Laser Contamination Control Plan

Title: Laser Contamination Control Plan	LASER SMA CDRL No.: 48
Reference:	
Use: To establish contamination allowances, methods for controlling contamination, and record test results	
Related Documents: <ul style="list-style-type: none">- GSFC-STD-7000 General Environmental Verification Standard (GEVS)- ICESat-2-ATSYS-REQ-0517, ATLAS Component Environmental Requirement- GSFC-STD-1000 Rules for the Design, Development, Verification, and Operation of Flight Systems- ASTM E595 Standard Test Methods for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment- Outgassing Data for Selecting Spacecraft Materials (URL: http://outgassing.nasa.gov/)	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Provide to the GSFC COTR thirty (30) working days before PDA for GSFC review- Provide to the GSFC COTR thirty (30) working days before the CDA for approval- Final thermal vacuum bakeout results provided to the GSFC COTR within thirty (30) of completion for review- Provide contamination certificate of compliance with End Item Acceptance Data Package	
Preparation Information: The contractor shall provide: material properties data; design features; test data; system tolerance of degraded performance; methods to prevent degradation. The items below shall be addressed in the plan: <ul style="list-style-type: none">- Beginning of life and end of life contamination requirements for contamination sensitive surfaces or subsystems- Methods and procedures used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime (e.g., protective covers, environmental constraints, purges, cleaning/monitoring procedures)- Materials	

- Outgassing as a function of temperature and time.
- Nature of outgassing chemistry.
- Areas, weight, location, view factors of critical surfaces.
- Venting: size, location and relation to external surfaces.
- Thermal vacuum test contamination monitoring plan, to include vacuum test data, QCM location and temperature, pressure data, system temperature profile, and shroud temperature.
- On-orbit spacecraft and instrument performance as affected by contamination deposits.
 - Contamination effect monitor
 - Methods to prevent and recover from contamination in orbit
 - Evaluation of on-orbit degradation
 - Photopolymerization of outgassing products on critical surfaces
 - Space debris risks and protection
 - Atomic oxygen erosion and re-deposition
- Analysis of contamination impact on the satellite on orbit performance
- In orbit contamination impact from other sources such as STS, space station, and adjacent instruments
- Ground/Test support equipment controls to prevent contamination of flight item(s)
- Facility controls and processes to maintain hardware integrity (protection and avoidance)
- Training
- Data package on test results for materials and as-built product

GIDEP ALERT

Title: GIDEP Alert	LASER SMA CDRL No.: 49
Reference:	
Use: Document the contractor's disposition of GIDEP ALERTs; GIDEP SAFE-ALERTs; GIDEP Problem Advisories; GIDEP Agency Action Notices; NASA Advisories and component issues, hereinafter referred to collectively as "Alerts" with respect to parts and materials used in NASA product	
Related Documents: <ul style="list-style-type: none">- GIDEP Operations Manual (S0300- BT-PRO-010)- GIDEP Requirements Guide (S0300-BU-GYD-010)	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Provide disposition of existing Alerts to the GSFC COTR within thirty (30) working days of identification of potential use or use of an EEE part or material for review- Provide disposition of subsequent Alerts to the GSFC COTR regarding EEE parts or materials already approved for use within thirty (30) working days for review	
Preparation Information: The contractor shall submit: <ul style="list-style-type: none">- A list with a notation for each line item as to whether there are applicable Alerts.- The lists submitted shall be updated with Alert information as parts and materials are added.- GSFC Form 4-37, Problem Impact Statement Parts, Materials and Safety or equivalent contractor form, for Alerts provided by the GSFC GSFC COTR.	

Significant Parts, Materials, and Safety Problems

Title: Significant parts, materials, and safety problems	LASER SMA CDRL No.: 50
Reference:	
Use: Document the contractor's identification of significant parts, material, and safety problems and the contractor's actions as required by the GIDEP manual regarding the decision to prepare an Alert, including the type of Alert that is applicable.	
Related Documents: <ul style="list-style-type: none">- GIDEP Operations Manual (S0300- BT-PRO-010)- GIDEP Requirements Guide (S0300-BU-GYD-010)	
Place/Time/Purpose of Delivery: <ul style="list-style-type: none">- Deliver to the GSFC COTR within thirty (30) working days of identification for review	
Preparation Information: The contractor <u>shall</u> submit relevant information (e.g., failure analyses, test reports, root cause and corrective action evaluations).	

End Item Acceptance Data Package

Title: End Item Acceptance Data Package	LASER SMA CDRL No.: 51
Reference:	
Use: The End Item Acceptance Data Package documents the design, fabrication, assembly, test, and integration of the hardware and software being delivered and is included with the end item delivery.	
Related Documents:	
Place/Time/Purpose of Delivery: 1) Provide the preliminary End Item Acceptance Data Package to GSFC COTR ten (10) working days prior to per unit PSR 2) Provide the final End Item Acceptance Data Package to GSFC at delivery.	
Preparation Information: The contractor prepares the End Item Acceptance Data Package as part of design development and implementation such that it is completed prior to delivery. The following items shall be included: <ul style="list-style-type: none">- The deliverable item name, serial number, part number, and classification status (e.g., flight, non-flight, ground support, etc.).- Appropriate approval signatures (e.g., contractor's quality representative, product design lead, government Representative, etc.)- List of shortages or open items at the time of acceptance with supporting rationale.- As-built serialization (electronic format)- As-built configuration (electronic format)- In-process Work Orders (available for review at contractors--not a deliverable)- Final assembly and test Work Order- Nonconformance reports (electronic format)- Acceptance testing procedures and report(s), including environmental testing- Trend data- Anomaly/problem failure reports with in a comma separated values or comparable electronic format.- Operations Manuals- As-built EEE parts list- As-built materials list- Chronological history, including:<ul style="list-style-type: none">- Total operating hours and failure-free hours of operation- Total number of mechanical cycles and remaining cycle life- Limited life items, including data regarding the life used and remaining- As-built final assembly drawings- PWB coupon results- Photographic documentation of hardware (pre and post-conformal coating for printed wiring assemblies, box or unit, subsystem, system, harness, structure, etc.)- Waivers- Certificate of Compliance which were signed by management	

APPENDIX G. LASER WORK BREAKDOWN STRUCTURE (WBS)

Laser WBS			
1.0	Management		
2.0	Design & Analysis		
2.1	Laser Performance Analysis		
2.2	Laser Design		
2.2.1	Drawings		
2.2.2	CAD models		
2.3	Structural & Mass Analysis		
2.4	Electrical Analysis		
2.5	Thermal Analysis		
3.0	Procurement & manufacturing		
3.1	Parts		
3.2	Support Equipment		
3.3	Laser SN #1		
3.3.1	Manufacturing (components & subassemblies)		
3.3.2	Laser integration		
3.4	Laser SN #2		
3.4.1	Manufacturing (components & subassemblies)		
3.4.2	Laser integration		
3.5	Laser SN #3		
3.5.1	Manufacturing (components & subassemblies)		
3.5.2	Laser integration		
3.6	Laser SN #4		
3.6.1	Manufacturing (components & subassemblies)		
3.6.2	Laser integration		
3.7	Integration and Test Laser (ITL)		
3.7.1	Manufacturing (components & subassemblies)		
3.7.2	Laser integration		
4.0	Performance Verification		
4.1	Requirements Verification		
4.2	Qualification Testing		
4.2.1	Laser SN #1 Qualification Testing		
4.3	Acceptance Testing		
4.3.1	Laser SN #2 Acceptance Testing		
4.3.2	Laser SN #3 Acceptance Testing		
4.3.3	Laser SN #4 Acceptance Testing		
4.3.4	Integration & Test Laser Acceptance Testing		
5.0	Quality Assurance		
5.1	Quality Assurance Engineering		
5.2	Safety		
5.3	Reliability Engineering		
5.4	Contamination Control Engineering		
5.5	Handling, Storage, Packaging & Delivery		