

451 / LASER COMMUNICATIONS RELAY DEMONSTRATION PROJECT

**Laser Communications Relay
Demonstration (LCRD)
Performance Specifications
Retroreflector Substrate**

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Preface

This document is under configuration management by the Laser Communications Relay Demonstration (LCRD) Project.

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Section 1. Scope

Goddard Space Flight Center (GSFC) requires a Retroreflector for a space qualified optical system.

This specification describes the substrate for a retro-reflecting solid corner cube (Retroreflector or RCC). The RCC will be used in a collimated beam to reflect circularly polarized light. Distortion of the polarization state upon reflection must be kept to a minimum.

This document describes technical requirements and the responsibilities of GSFC and the vendor.

The statement of work document, LCRD-PYLD-OM-SOW-0006, describes the contractual responsibilities of GSFC and the vendor.

Section 2. Applicable Documents

All documents identified here shall apply in the situations where they are referenced.

LCRD-PYLD-OM-SOW-0006	Statement of Work, Retroreflector Substrate
IEST-STD-CC1246D	Institute of Environmental Sciences and Technology Product Cleanliness Levels and Contamination Control Program
MIL-PRF-13830B	Optical Components for Fire Control Instruments; General Specification Governing the Manufacture , Assembly and Inspection of (Scratch/Dig Requirements, paragraphs 3.5, 4.2.2, 6.3.2, 6.3.2)

Section 4. Technical Requirements

4.1 Mechanical Requirements

4.1.1 Dimensions

Each RCC shall conform to GSFC Drawing 2188880, which includes physical size and tolerances. The vendor shall provide a mechanical inspection report showing compliance with all dimensions and tolerances for each delivered RCC.

4.1.2 Material

The RCC shall be fabricated using material meeting the requirements shown in Table 4-1 below. The vendor shall obtain the material for the RCC and witness blanks. The vendor shall provide material certifications and glass melt sheets. Substrates and witness blanks shall meet the requirements shown in Table 4-1.

Requirement	Specification
Glass	Fused Silica
Refractive Index Homogeneity	< 4e-6 in 3 directions
Striae	Grade A per MIL-F-146
Stress Birefringence	< 4 nm/cm
Bubbles and Inclusions Class	$\leq 0.01 \text{ mm}^2/100 \text{ cm}^3$

Table 4-1: Material Requirements

4.1.3 Residual Material Stress

All RCC surfaces, including the cylindrical outer surface, edges, and chamfers, shall be controlled ground and polished to eliminate subsurface damage. See Item 5 of Table 4-2.

The cylindrical outer surface of the RCC will be used as a mounting interface. This surface shall be stress relieved prior to final figuring. An acid etch is preferred. Procedures to ensure adequate stress relief shall be submitted to GSFC for review and approval prior to use.

4.1.4 Marking and Labeling

Each RCC shall be assigned a common part number and a unique serial number (or combined part/serial number). The same unique identifier shall clearly link all testing and qualification data to the unit under test. If the optic requires labeling during fabrication at the vendor's facility, it shall be marked on the cylindrical outer surface (bonding surface) with a removable method that will not damage the bonding surface. If marked, the vendor shall provide a removal process for the marking. Each RCC will be delivered in its own packaging, which shall be marked with the part number, unique serial number, optic drawing number and revision letter.)

4.2 Optical Requirements

All optical specifications in Table 4-2 shall be met for the finished RCC substrate and shall be met over the full optical clear aperture.

4.2.1 General Optical Requirements

#	Requirement	Units	Specification	Notes
1	Clear Aperture, R1	inches (mm)	≥ 1.30 (≥ 33)	The clear apertures of surfaces R2, R3, and R4 shall be consistent with achieving the specification requirements over the clear aperture of R1. See Section 4.2.2 for definition. See GSFC drawing 2188880.
2	Retro-Reflected Wavefront Error	$\lambda @ 1550 \text{ nm}$	$\leq 0.02 \text{ rms}$ $\leq 0.13 \text{ PV}$	See Section 5.2.1 for special test requirements.
3	Scratch / Dig (R1, R2, R3, R4)	-	20-10	Per MIL-PRF-13830B. The vendor shall provide a scratch dig map. High intensity lamp should be used.
4	Surface Roughness (R1, R2, R3, R4)	Å rms	≤ 15	See Section 5.2.2 for special test requirements
5	Stress Relief/ Subsurface Damage	The vendor shall provide for a controlled grind and polish process for all surfaces including the cylindrical outer surface, edges, and chamfers to eliminate subsurface damage and scatter when viewed with a high intensity lamp as described in standard MIL-PRF-13830B, paragraph 4.2.2.2, Inspection method No.2.		

Table 4-2: Summary of RCC Optical Requirements

4.2.2 Clear Aperture Definition

The clear aperture defines the region over which Numbers 2 through 4 in Table 2 apply.

4.2.3 Retroreflector Beam Deviation

A collimated beam of light entering the prism normal to R1 shall exit the prism normal to R1 within 2 arc seconds. See Section 5.2.1 for special test requirements.

4.2.4 Witness Samples

The vendor shall fabricate eight (8) witness samples. The witness samples shall be fabricated from the same material as the RCCs. The witness samples must be fabricated under the same conditions and using the same processes used to fabricate the RCC. The physical dimensions of the witness samples shall be [diameter = 1.5 inches and thickness = 0.25 inches]. The witness

samples shall meet the performance requirements 2 through 5, as listed in Table 4-2. The witness samples shall be delivered in the same manner as the RCC.

4.3 End of Life

The RCC shall meet all performance requirements at the end of life. The end-of-life for the RCC shall be at least ten (10) years.

4.4 Shipping

The vendor is responsible for the delivery of the RCCs to GSFC. The packaged RCCs shall not sustain any physical damage or deterioration of functional performance when subjected to shock and vibration levels expected during handling and transportation to GSFC. The vendor shall ensure that each RCC shall not experience humidity greater than 65% RH during shipping. The vendor shall provide a shipping plan to GSFC as indicated in LCRD-PYLD-OM-SOW-0006 Tables 4-1 and 5-1. The shipping plan, at a minimum, shall include shipping container materials and design, methods for protection of the RCC to the shipping environment, and the exact method of shipment from the vendor's facility to GSFC.

Section 5. Acceptance Testing and Quality Assurance

The vendor shall perform all tests, inspections and analysis required to show the RCC meets all requirements. Quality assurance verification shall be conducted by the vendor prior to GSFC acceptance of the RCC. The verification shall ensure that the performance and design are in accordance with the requirements of this specification.

The methods necessary to verify each requirement are presented in the Acceptance Verification Matrix, Table 5-1. Section 5.4 contains further detail for the more complicated acceptance tests requiring specific descriptions.

Testing anomalies shall be reported to per Section 4.2.1 of LCRD-PYLD-OM-SOW-0006.

GSFC may witness any or all acceptance testing.

5.1 Standard Test Conditions

Unless otherwise specified, testing shall be carried out under the following conditions:

Pressure	1 atm
Temperature	19° C - 22°C
Relative Humidity	45% to 65%

5.2 Special Test Details

5.2.1 Retro-Reflected Wavefront

A full aperture, industry accepted, phase-measuring interferometer shall be used to measure the RCC retro-reflected wavefront error. The RCC shall be supported kinematically in a mount supplied by the vendor during wavefront measurements.

Interferometric measurement sampling spacing for the RCC shall be equal to or less than the optical clear aperture divided by 400. The vendor must use an application similar to the ZYGO corner cube measurement application for determining retro-reflected wavefront error and beam deviation error. The vendor may perform the transmitted wavefront measurements at 633nm but must report the results at 1550nm.

5.2.2 Surface Roughness

The surface roughness of the RCC shall be measured at a minimum of three (3) locations on the front face (R1) and two (2) locations on each of the three facets (R2, R3, and R4). The surface roughness shall be less than the values specified in Table 2 at all locations. Surface roughness measurements shall be made over a spatial bandwidth of 1.0 μm to 75 μm at each measurement location.

The surface roughness shall be measured by a ZYGO New View surface profiler or another industry-accepted, non-contact surface roughness measurement system which reports results equivalent to a calibrated ZYGO New View surface profiler, and which is mutually-accepted to GSFC and the fabrication vendor.

5.3 Verification Methods

The following methods are used to verify the requirements stated in this specification.

5.3.1 Analysis

Analysis is a process used in lieu of or in addition to testing, to verify compliance with specifications. The technique typically includes an interpretation, or interpolation and extrapolation of analytical or empirical data under defined conditions or reasoning, to show theoretical compliance with stated requirements.

5.3.2 Similarity

Similarity is an analysis process of comparing a current item with a previous item, which takes into consideration configuration, test data, application and environment. The evaluation shall be documented and shall include: the test procedures/reports of the item to which similarity is claimed and a description of the differences between the items and the rationale for verification by similarity. All operational experience shall be documented and available for review.

5.3.3 Inspection

Inspection is an observation or examination of the item against the applicable documentation to confirm compliance with requirements.

5.3.4 Test

Test is an action by which the operability, supportability, performance capability or other specified qualities of an item are verified when subjected to controlled conditions that are real or simulated. These verifications may require the use of special test equipment and instrumentation to obtain quantitative data for analysis as well as qualitative data derived from displays and indicators inherent in the item for monitor and control.

5.4 Acceptance Verification Matrix

Test (T), Analysis (A), Inspection (I), Similarity (S)

Section	Requirement	Verification Method	Special Test Instructions
Material Requirements			
4.1.1	Dimensions	I	
4.1.2	Material Certification and Glass Melt Sheets	I	
Optical Requirements			
Table 4-2, #1	Clear Aperture	T	
Table 4-2, #2	Retro-Reflected Wavefront Error	T	See Section 5.2.1
Table 4-2, #3	Scratch / Dig	I	
Table 4-2, #4	Surface Roughness	T	See Section 5.2.2
Table 4-2, #5	Stress Relief / Subsurface Damage	I	
4.2.3	Retro-Reflected Beam Deviation	I	See Section 5.2.1; ZYGO corner cube measurement application or equivalent
End of Life			
4.3	End of Life	S	
Shipping			
4.4	Shipping	A	Verified per IEST-STD-CC1246D Section 6

Table 5-1: Acceptance Verification Matrix

Appendix A. Abbreviations and Acronyms

Acronym	Definition
AOI	Angle of Incidence
AR	Anti-Reflective
CO	Contracting Officer
COC	Certificate of Conformance
DCN	Document Change Notice
EIDP	End Item Data Package
GSFC	Goddard Space Flight Center
LCRD	Laser Communication Relay Demonstration
OM	Optical Module
PO	Purchase Order
NASA	National Aeronautics and Space Administration
NGIN	Next Generation Integrated Network
PV	Peak-to-Valley
RCC	Retroreflecting Corner Cube
RH	Relative Humidity
SOW	Statement of Work
WFE	Wavefront Error