**STATEMENT OF WORK (SOW) for One Off-axis Pressure-tuned Interferometric Spectral Filter for High Spectral Resolution Lidar at 467 nm**

## 1.0 Introduction/Background:

This is a description of the deliverables and performance metrics required for the design and building of one field-widened Michelson interferometer with an operating wavelength of 467 nm, intended for use in airborne High Spectral Resolution Lidar (HSRL) for atmospheric and oceanic measurements. Lab testing will be performed in vacuum chambers at NASA Langley Research Center (LaRC); therefore, all hardware shall be compatible with high vacuum environment.

## 2.0 Scope of Work:

This SOW covers the fabrication, testing, assembly, wavefront correction, and delivery of one off-axis, pressure-tuned, field-widened Michelson interferometric spectral filter for HSRL at 467 nm along with supporting/mounting hardware.

## 3.0 Objectives:

The objective of this work is to build one off-axis, pressure-tuned, field-widened interferometric spectral filter for high spectral resolution lidar that can:

- **3.1** Be tuned to match backscatter signals by controlling the pressure in the air arm of the interferometer.
- **3.2** Operate on aircraft at temperatures up to 45 degrees C.
- **3.3** Survive vibration testing to 6.8 g-RMS or better.
- **3.4** Survive thermal cycling between -20 degrees C to + 55 degrees C or better.

## 4.0 Description of Work and Technical Requirements:

**4.1** <u>Overall Michelson Interferometer Requirements:</u>

- **4.1.1** One complete, fully assembled interferometer (beam splitter, solid arm, free-space arm, and mounting hardware) shall be built and delivered to the customer.
- **4.1.2** The operational wavelength of the interferometer shall be 467 nm.
- **4.1.3** The Free Spectral Range (FSR) of the interferometer shall be targeted for 1.576 GHz +/- 0.020 GHz at 467 nm. The finalized FSR shall be measured and reported to NASA LaRC. *The final FSR target shall be provided by NASA prior to machining arms.*

**4.1.4** The Michelson is designed with a maximum science beam diameter of 36 mm on-axis throughout the system. The interferometer shall have a clear aperture of greater than or equal to 36 mm.

**4.1.5** Interferometer Field of View: The interferometer shall be field-widened such that the contrast does not degrade appreciably (goal < 1 %) for an input beam divergence of up to 25 mrad.

**4.1.6** Contrast: The interferometer shall have a contrast > 100:1 (goal > 200:1) for a 26 mm beam centered on the interferometer aperture.

**4.1.7** The Michelson will be operated in an off-axis configuration. It shall be designed to operate in a +/- 1.50-degree angle range centered and optimized for 1.50 degrees of overall off-axis tilt.

**4.1.8** The input beam shall enter the input beamsplitter face off-center such that it impinges on the center of the free-space and solid arm mirror surfaces downstream.

**4.1.9** All optical coatings shall be optimized for s-polarized light, radiation-tolerant, and suitable for high-vacuum and space use.

**4.1.10** Mirror Reflectivity: The reflectivity of both the solid arm and free-space arm mirrors shall be > 99% at 467 nm.

**4.1.11** The absorption of the optical glass at 467 nm shall be accounted for designing the beamsplitter split ratio and/or the reflectance of the free-space arm and solid arm mirrors to maximize throughput and fringe contrast.

**4.1.12** Input WFE requirements: The interferometer shall perform to the specifications listed in this document for the wavefront error of the input beam of < 10 waves.

**4.1.13** Optically contacted surfaces: Optical inclusions at the optically contacted surfaces shall be less than or equal to one (1) inclusion and have an inclusion area less than 0.5 square-mm.

**4.1.14** Fluid Jet Polishing: LightMachinery shall support three (3) rounds of iterative wavefront error correction on the free-space arm mirror with NASA LaRC.

**4.1.15** Output Wavefront Error Requirements: RMS wavefront of 10 nm or better with 22 nm of tilt or less across the central 26 mm diameter, at the elevated instrument operating temperature [TBD], as measured by NASA LaRC.

**4.1.16** LightMachinery shall cover shipping the assembled Michelson interferometer to NASA LaRC four (4) times and back from NASA to LightMachinery three (3) times to support all three of the wavefront correction polishing iterations. The interferometer shall be shipped in custom, shock-absorbing, reusable packaging designed to protect the optical contacts and alignment from shock and vibration during transit. The packaging shall contain shock indicators.

**4.1.17** The following optical materials shall be used for the corresponding components:

**4.1.17.1** Beamsplitter: fused silica (3D/prism grade Corning 7980 0A)

**4.1.17.2** Glass Solid Arm: fused silica (Corning 7980 0A)

**4.1.17.3** Free-space arm glass spacer: fused silica (Corning 7980 0A)

**4.1.17.4** Free-space arm mirror: fused silica (Corning 7980 0A)

**4.2** <u>Beamsplitter Requirements:</u>

**4.2.1** The beamsplitter shall be a 50 mm cube.

**4.2.2** Beamsplitter zero-path condition: The beamsplitter unit shall be polished such that the dimensions are within two microns of the zero-path condition.

**4.2.3** Anti-reflective (AR) coating reflectivity: The AR coating over the science signal aperture on the beamsplitter cube shall have a reflectivity of <0.25 % (goal <0.1%) at 467 nm.

**4.2.4** LightMachinery shall test the actual beamsplitter for the split ratio as a function of angle to verify that the beamsplitter coating meets specifications prior to assembling the interferometer.

**4.3** <u>Free-space Arm Requirements:</u>

**4.3.1** The fused silica free-space arm shall have the necessary holes drilled in it for pressure tuning capability. Size and location are TBD and shall be provided by NASA prior to implementation.

**4.3.2** The free-space arm shall be polished parallel such that the assembled interferometer achieves the output/overall wavefront error requirement.

**4.3.3** The fused silica free-space arm spacer shall be [TBD] in length (NOT including the length of the mirror). *Prior to manufacturing, the final length dimension shall be calculated by LightMachinery and agreed to by NASA.*

**4.3.4** The fused silica free-space arm mirror shall be 50 mm in diameter and 10 mm thick.

**4.3.5** LightMachinery shall perform a sodium-hydroxide assisted optical contact at the interface of the free-space arm and the beamsplitter, and seal it with a [TBD] low-CTE epoxy bead around the edges. *NASA will specify the approved epoxy prior to assembly.*

**4.3.6** The free-space arm mirror shall be contacted using a standard optical contact such that it can be removed for wavefront corrective fluid jet polishing.

**4.4** Solid Glass Arm Requirements:

**4.4.1** The solid glass arm shall be fabricated from fused silica (Corning 7980 0A).

**4.4.2** The solid glass arm shall be a TBD geometry. *Final geometry shall be provided by NASA prior to manufacturing.*

**4.5** Support Structure and Mounting Hardware Requirements:

**4.5.1** LightMachinery shall manufacture the Bonding Plates and Tension Rods from Invar-36 per the technical drawings provided by NASA.

**4.5.2** The bond plates shall be nickel-plated for corrosion resistance.

**4.5.3** LightMachinery shall mount the finished interferometer to the Bonding Plates using Dow Corning 6-1104 CV space-grade silicone sealant (unless otherwise specified by NASA) per the drawings provided by NASA.

**4.6** Thermal Cycling Requirements:

**4.6.1** After fabrication but before coating, the solid glass arm shall be thermally cycled in the range of 60°C to negative (-) 30°C for three (3) full cycles.

**4.6.2** After fabrication, the fused silica free space arm spacer shall be thermally cycled in the range of 60°C to negative (-) 30°C for three (3) full cycles.

**4.6.3** After fabrication but before coating, the beamsplitter halves shall be thermally cycled in the range of 60°C to negative (-) 30°C for three (3) full cycles.

**4.6.4** After fabrication but before coating, the mirror shall be thermally cycled in the range of 60°C to negative (-) 30°C for three (3) full cycles.

**5.0 Deliverables:**

LightMachinery shall:

**5.1** Build Invar-36 Bond Plates and Tension Rods.
**5.2** Build one fully coated/functional beamsplitter cube.
**5.3** Build one fully coated/functional solid glass arm.
**5.4** Build one free-space arm.
**5.5** Assemble one complete interferometer unit, to include bonding the interferometer to the Bond Plates.
**5.6** Perform three (3) iterations of wavefront correction mirror polishing.
**5.7** Deliver a fully assembled, wavefront corrected interferometer.
**5.8** Provide a final metrology report documenting the assembled interferometer's Free Spectral Range (FSR), beamsplitter split ratio, and final mirror surface profile.
**5.9** Provide documentation confirming the successful completion of the bare-glass thermal cycling requirements.

**6.0 Milestones:**

**6.1** Completion beamsplitter cube fabrication and satisfactory report of beamsplitter performance.
**6.2** Initial delivery of 1 complete interferometer (line 1 in LightMachinery-provided quote), payment of amount in line 1 of quote.
**6.3** Completion of mirror phase correction 1.
**6.4** Completion of mirror phase correction 2.
**6.5** Completion of mirror phase correction 3 and delivery of operational 467 nm pressure-tunable field widened Michelson HSRL spectral filter.

**7.0 Government-furnished information:**

**7.1** Technical drawings and .STP files for bond plates and tension rods/trusses.
**7.2** Technical drawings and .STP files for interferometer and components.
**7.3** Specifications for materials used in fabrication of components.
**7.4** Heat treatment procedures for invar parts.
**7.5** Thermal stress-relief cycling procedures.

**PERIOD OF PERFORMANCE is June 2026 – September 30, 2027.**