1.0 TECHNOLOGY NAME:

Silicon Carbide Optics and Structures

2.0 SPONSORSHIP:

Goddard Space Flight Center

2.1 IPDT Sponsor

Instrument Technologies and Architectures

2.2 Team Members

Goddard Space Flight Center, Massachusetts Institute of technology /Lincoln Laboratory, and Sensor Systems Group

3.0 OVERVIEW (Summary of Validation Plan):

The silicon carbide optics validation plan on the EO-1 Program include a time phased sequence of demonstrations and qualifications. The first demonstration was a fabrication of two 2/3-scale mirror blanks. These mirrors had a flat surface figure so that they could be easily figured in bare SiC. They were tested for thermal survival and operation from room temperature to a 100° Kelvin. They performed well within expectations and consistent with the requirements of the ALI Telescope on EO-1. The second step will be the construction of an engineering testbed unit. This unit will be full size replica of the flight system. It will serve as a validation test for the structural design of the optical system. It will include full size and shape optical substrates that will be mounted as in the flight system. Shake and thermal testing will be performed to validate the analytical models. The flight system will provide the final validation. Complete component level testing will be performed on each mirror. The system will be then assembled and tested as an optical bench. This will undergo full system level optical level testing including shake and thermal vacuum.

4.0 INTRODUCTION (Contribution of 21st Century Science):

The impact on the 21st Century Science will be quite profound. SiC optics and structures have the potential of lowering optical system weights an order of magnitude over current conventional systems. This lowering of weight means smaller and lighter payloads. This leads to the potential for more missions for a given funding level.

5.0 TECHONOLOGY DESCRIPTION:

Silicon carbide offers the advantage of very high stiffness to density ratio and very high conductivity to heat capacity ratio. These characteristics are superior to currently used materials for reflective optical systems. The high stiffness to density ratio allows mirrors of very low weight to be designed and still maintain the necessary surface figure to provide the performance required for high-resolution optical imaging. Lightweight optics lead to lightweight optical metering structures required to support them. This in turn leads to lighter instruments and therefore lighter payloads. Currently, only beryllium can compete with SiC for the lowest mass for a given optic size. SiC has the additional advantage of high thermal conductivity with relatively low thermal heat capacity. This property allows minimal thermal gradients for a given heat load. This is an advantage for an optical system in a low Earth Orbit that experiences changes in thermal boundary conditions on regular basis. SiC performs without competition in this arena. This leads to an optimum optical system design of SiC optics with a SiC optical metering structure. Using high stiffness to weigh ratio, a very low weight optical system can be constructed.

6.0 TECHNICAL VALIDATION OBJECTIVES:

6.1 Technical Validation Objective # 1

The first objective would be to validate the performance of the SiC optics over the EO-1 operating environment. This would require verification of the stable system wavefront over wide field view.

6.1.1 Required data and necessary measurements

To validate performance it is required to have wavefront measurements of the aligned optical system over the field of view, during and after thermal excursions, and survival of launch loads.

6.1.2 Approach

The approach is to assemble and align the optical system. A full baseline set of optical performance data will be taken. The optical system will then undergo a series of sine sweeps, random vibrations and shocks to simulate the launch experience. After the test a full set of optical data will again be taken to verify a stable optical system. The optical system will then be placed in a thermal-vacuum chamber. It will be subjected to survival thermal extremes and remeasured to verify survival. Its wavefront will then be monitored over the operating thermal range to verify stable performance over temperature extremes and simulated gradients.

6.1.3 Anticipated results

Successes criteria will be developed that will compare results against. The optical system must meet the minimum performance requirements for the EO-1 mission at the extreme conditions simulated in the test program.

6-1.4 Supporting I&T data

Further less rigorous testing can be performed at the integrated sensor level during instrument level qualification. Wavefront data cannot be obtained, but limited imaging data can be obtained during the I&T phase that can provide good indication of stable optical performance.

6.1.5 Rationale (How the results prove the objective)

The test program simulates the operational environment fairly accurately and thus it is a good test of the technology performance under operational conditions.

6.2 Technical Validation Objective #2

A second objective is to validate that lightweight optical elements can be achieved. Since the primary objective will validate the technology, the secondary objective is validated to the extend the EO-1 mirrors are lightweight. A further extension of this ideal would be to fabricate lighter weight mirrors and retest them until a limit is found. This is beyond the scope of the EO-1 ALI Telescope program.

7.0 SCIENTIFIC VALIDATION OBHECTIVES:

7.1 Scientific Validation Objective # 1

There are not direct scientific objectives of this technology. This technology enables an instrument utilizing SiC to achieve meaningful scientific results at a lower cost.

7.1.1 Required data and necessary measurements

7.1.2 Approach

7.1.3 Anticipated results

7.1.4 Supporting I&T data

7.1.5 Rationale

7.2 Scientific Validation Objective #2

8.0 SCHEDULE:

1.0 REQUIRED MANPOWER:

2.0 REQUIRED FACILITIES:

All key required facilities are available at SSG and MIT/LL.

11. SIGNATURES:

IPDT Provider
Project Scientist
Project Manger
GSFC Program Manager
NMP Program Manager