NMP/EO-1 TECHNOLOGY DESCRIPTION

1.0 Introduction.

1.1 Title of the Advanced Technology: Wide Field of View Optics

1.2 ADT Lead: **TBR**

1.3 Sponsoring IPDT: Instrument Technologies and Architectures

1.4 Category of Proposed Use: Class I

1.5 Supplying Organization: SSG, under subcontract to MIT/LL.

1.6 Primary Technology Contact

TBR

1.7 Useful Secondary Contacts

TBR

2.0 Background.

2.1 Characterize the Advanced Technology.

The three-mirror design chosen for the EO-1 wide field of view (WFOV) telescope is an all-reflective counterpart to the well-known Cooke Triplet and is, therefore, referred to as the Reflective Triplet (RT). This version of the RT is used on-axis in aperture and off-axis in field. The entrance pupil is virtual, locating some distance behind the primary mirror and centered on the optical axis joining the vertices of the three parent mirrors. The aperture stop of the system is on the secondary mirror. The line-of-sight of the FOV is brought into the primary mirror at an offset angle providing beam clearance throughout the optical train.

The primary and secondary mirrors form a nearly afocal (collimated) beam input to the tertiary mirror. This pseudo-afocal magnification is typically 2x which means that the aperture stop is about one-half the size of the entrance pupil. For compactness, the stop is placed on the front surface of the secondary mirror. Also, the tertiary mirror can be though of as a single element imager with a FOV about twice the system FOV. The spacing between the primary and secondary mirrors is typically about one-half of the system focal length. This property and the use of a fold mirror between the tertiary mirror and the image plane produce a very compact package such as the EO-1 design form which can truly be considered capable of WFOV performance. Depending on the aperture size, line fields-of-view of greater than 30 degrees have been considered. System focal ratios run from f/3 to f/8. The EO-1 design is f/7.52 with a 12.5 cm diameter optical aperture.

In contrast with the Three Mirror Anastigmat (TMA) optical form, the RT is a non-relayed design form. There is no intermediate image formed anywhere in the optical train. So, there is no opportunity for a field stop to help in suppression of stray light from unwanted sources outside the WFOV. This is the why the RT is suited for imaging application where the target to background clutter contrast is already the fundamental detection limiting mechanism. The compact, non-relayed optical form keep the RT to be inferior to the TMA form in above-the-horizon, missile-surveillance applications that requires high degree of out-of-field-of-view straylight rejection.

The EO-1 RT design uses four mirrors to produce low distortion (~0.1%), diffraction limited at visible wavelength (400 to 1000 nanometer), imaging performance over a 1.3 deg x 15 deg FOV. The use of eighth order coefficient on aspheric primary mirror and secondary mirror provide a manufacturing challenge because it requires 1/8 to 1/10 wave of mirror profile accuracy over the primary mirror with approximately 2:1 length to width aspect ratio. In conjunction with the use of silicon carbide for the mirror substrate, the EO-1 WFOV optical design is a very sophisticated solution for demonstration of Earth imaging applications.

2.1 How will the utilization of this technology enhance science in the 21st century?

The WFOV technology will enable a single optical sensor to cover significantly more ground per orbit than conventional sensors. This implies that fewer sensors will need to be flown and therefore costs can be reduced in almost direct proportion.

2.2 Why is this considered a revolutionary Technology?

This technology is revolutionary from the point of view that launches are extremely expensive, and a simple doubling of the sensors field of view will reduce launch costs by a whole launch. The WFOV technology will increase sensor coverage by a factor of 3 to 4. This has the cost impact of many hundreds of millions of dollars.

2.3 Why is a space flight necessary to validate this technology?

Space flight is not necessary to validate this technology, but the SiC optical system is a Class I technology and integration of this technology with that demonstration was crucial to demonstration of the SiC technology.

3.0 Proposed Integration and Validation Approach.

3.1 Describe the approach and justify your categorization

A flight optical system will be developed and tested to full flight qualification levels. A complete ground based evaluation of the WFOV performance can be made over thermal variations and after random shock and vibration.

3.2 Describe the approach presently in the budget.

The demonstration of the WFOV optics is dependent on the success of the SiC optical system demonstration.

3.3 Describe how the approach affects the original, baseline pursued by the flight team.

The approach is totally consistent with the original EO-1 Telescope concept.

3.4 Describe the interface with the spacecraft or ALI.

The optical design is the core of the ALI optical system. Other interfaces include the GIS module and calibration subsystems.

3.5 Describe the impact on the spacecraft or ALI.

There is no specific consequential impact on the spacecraft.

3.6 Describe the proposed integration and test of the technology.

The optical design is fully simulated optically, mechanically and thermally in software simulations. Once the flight optical system is constructed and aligned, a full verification program will be undertaken to validate the models and qualify the design.

3.7 Describe the approach operations and to validation for the technology.

There are no specific operational impact from the technology, other than the actual operation of the ALI instrument and successful taking of science data.

3.8 Describe the impact on spacecraft resources (mass, volume, thermal).

There are no specific impact on resources.

3.9 Describe how you plan to acquire the technology and identify the deliverables.

The technology was acquired during the Phase B portion of the program using industry standard software tools, primarily CODE V.

3.10 Describe any facilities issues or special GSE or FSE.

All required facilities are available at MIT/LL or SSG.

4.0 Availability.

4.1 Identify when an ETU would be deliverable to the flight team.

There will be no ETU of the optical design.

4.2 Identify the earliest date when flight hardware would be deliverable to the flight team.

Delivery of the flight instrument is scheduled for **TBD** after MIT/LL integration of the optical system into the instrument.

5.0 Risk

5.1 Characterize technical risk and risk mitigation for the technology.

The technical risk involved in the WFOV demonstration are linked to the fabrication of the SiC optical elements. The demonstration of that technology is discussed elsewhere. A ground demonstration of this WFOV technology can be performed at the laboratory level using conventional optical materials at fairly low risk.

5.2 Characterize the schedule risk and risk mitigation and "trigger points" that represent decisions to shift to alternate development paths.

Again schedule risk is linked to the SiC optics demonstration.

5.3 Characterize the budget risks and mitigation approaches.

Schedule risk is linked to the SiC optics demonstration.

6.0 Budget.

Determine net cost to incorporate the technology and validate it.

TBR

7.0 Manpower.

7.1 Characterize the team necessary to incorporate the technology into the EO-1 flight.

The key team members are MIT/LL, SSG and SSG's key sub-tier suppliers.

8.0 Recommended Disposition.

Justify the incorporation of the technology into the EO-1 flight The WFOV technology demonstration is a natural adjunct to the SiC optics demonstration and has minimal impact on cost and schedule while offering a flight demonstration of a very high payoff technology.