Statement of Work for Sustainable Land Imaging (SLI)

Reduced Instrument Envelope Study

1. Background:

For more than 40 years, Landsat satellites and associated U.S. Government ground processing, distribution, and archiving systems have acquired and made available global, moderate-resolution (15-120m), multispectral measurements of land and coastal regions, providing humankind's longest record of our planet from space. NASA and the U.S. Geological Survey (USGS) of the Department of the Interior (DOI) fully recognize that this information is a national asset, providing an important and unique capability that benefits a broad community, including Federal, state, and local governments; global change science, academia, and the private sector. Landsat data provide a consistent and reliable foundation for research on land use change, forest health, and carbon inventories, and changes to our environment, climate, and natural resources. Additionally Landsat data is free and openly available to users both inside and outside of the Government. More information on Landsat can be found at http://landsat.gsfc.nasa.gov/ and http://landsat.usgs.gov/.

Current Spaceborne Missions

The USGS currently operates two Government-owned spacecraft, Landsats-7 and -8, both developed by NASA for USGS. Each spacecraft is in a Sun synchronous, 705 km orbit, with an equatorial crossing time of 10:00 a.m. + or – 15 minutes, and (nadir) revisit of 16 days. Landsat-7 was launched in April 1999. It has been flying with degraded Enhanced Thermal Mapper Plus performance since May 2003 and is expected to be decommissioned in 2018. Landsat-8, formerly known as the Landsat Data Continuity Mission (LDCM), was launched in February 2013 and has a mission design life of five years for both the spacecraft and the primary instrument, the Operational Land Imager (OLI). The Thermal Infrared Sensor (TIRS) has a design life of three years. The Landsat-8 Observatory is carrying sufficient fuel for a mission duration of more than 10 years.

Beyond Landsat-8

Recognizing the importance, demonstrated utility, and future potential value of multi-decadal, continuous, global measurements of our planet's land cover properties, the U.S. intends to design and implement a robust land imaging system to ensure that necessary data are collected, processed into useful and efficient information products, archived, and broadly distributed for use by the wide range of interested communities. This spaceborne system may include alternative sources for Landsat-quality data, either procured through commercial approaches or through partnership agreements, as they become available.

In Fiscal Year 2014, NASA has been leading, and the USGS has been supporting, the design of a system architecture for a sustainable, realistic, and affordable program that will provide future land imaging data compatible with the existing Landsat data record and specifically as consistent with the characteristics of the data stream currently produced by Landsat-8, as practical. The agencies will cooperate in the establishment of a Sustainable Land Imaging (SLI) Program, including development, launch, and operation of spaceborne assets and their associated ground systems. The agencies will also

cooperate in the planning and other preparations for continuing the acquisition and distribution of moderate resolution spectral data, as required, in the post Landsat-8 era. The NASA budget for the design and implementation of this sustainable land imaging architecture is specified in the President's FY 2014 Budget, submitted to Congress on April 10, 2013.

NASA, in cooperation with USGS, intends to initiate the first SLI mission to follow Landsat 8 in FY15 based on the findings of the FY14 architecture study.

To further inform the agencies as to potential future implementations within the SLI program beyond the first mission (notionally referred to as the "mid-term" time frame), a study contract with multiple potential awards will be issued to investigate mid-term capabilities and technologies for instruments that may enable more efficient implementation of the SLI program requirements. The results of FY14 architecture studies indicate that efficiencies can be gained by moving toward smaller, lower-cost missions (aka, "smallsats") that can take advantage of lower cost launch options. FY14 studies also indicate that recent advances in focal plane technologies may enable smaller, lower-cost imaging instruments that can satisfy SLI performance requirements. These study contract awards will enable contractors to perform a more detailed investigation of techniques and trends that lead to reduction in size and mass of spaceborne Earth-imaging instruments, potentially resulting in cost savings to the U.S. Government while still meeting the SLI program requirements.

2. Summary of Work:

The contractor shall perform one or more conceptual designs of imager instruments targeting a reduced volume, mass, and power envelope that can satisfy Land Imaging performance requirements (document NASA-SLI-001 "Land Imaging Performance Study Requirements"), and meet NPR 8705.4 Risk Class B standards

The contractor shall assume the following while developing the conceptual designs:

- The concept of operations for the instrument is:
  - Nadir imaging
  - Goal of imaging all land and coastal area in the instruments' field of view, every orbit.
  - Onboard calibration activities should be arranged such that the impact on the ability to image all land and coastal areas is minimized (i.e. perform solar cal & cold space cals over ocean, perform lunar cal while in eclipse, minimize frequency of dark/shutter cals, etc.
- The instrument(s) will be flying on a spacecraft bus platform with the following parameters:
  - Orbit: 705 km, circular, sun-synchronous, 10:15 AM MLT-DN.
    - The observatory will follow the WRS-2 ground track (see NASA-GSFC document # 427-02-07 Landsat Worldwide Reference System-2 (WRS-2) Definition).
  - Agility:
    - The spacecraft is capable of performing maneuvers using reaction wheel assemblies or other appropriate mechanisms to point the instrument for calibration activities if necessary.
  - Mechanical interface to S/C:
    - The spacecraft provides a stiff instrument deck for instrument mounting.
  - Thermal interface to S/C:

        - The spacecraft is thermally isolated (radiative and conductive) from the instrument mounting, i.e. heat transfer between spacecraft and instrument is minimal.
    - Electrical interface to S/C:
        - Power: The spacecraft can accommodate the peak and sustained power requirements of the instrument.
        - Data: The spacecraft can accommodate the peak and sustained data rates provided by the instrument.
        - Command: The spacecraft can accommodate the instrument interfaces for commanding and telemetry

As part of this design the contractor shall perform analysis and provide study products addressing at a minimum:

1. Assessment of SLI performance requirements to identify the drivers for mass, volume, and power, and cost for future mid-term instrument designs.
    a. Identify where specific performance requirement relaxation may allow reductions in technical envelope and cost. Characterize the benefits of performing these relaxations.
    b. To what degree does the requirement for one or more 15m bands drive the design? Consider the degree to which changing one of the other bands to 15m instead of having a separate panchromatic band, or complete elimination of a 15m requirement would enable instrument envelope reductions.
2. Assessment of how small the instrument(s) can be made with existing or near-term technology and where specific performance requirement risks emerge as size and mass decrease.
3. Detailed assessment of optical design and focal plane performance relative to SLI performance requirements.
4. Thermal control, including techniques and technologies for detector cooling and stabilization, accommodation of potentially large radiator areas on a smallsat platform, assessment of passive vs. active cooling on a smallsat platform.
5. The ability to accommodate on-board reflective and thermal band calibration sources to satisfy performance requirements.
    a. Discuss calibration approach and develop a calibration error budget
6. Identification of emerging technologies and techniques to further enable implementation efficiency and a schedule for potential infusion into SLI.
7. The degree to which reliability and risk class (NPR 8705.4) influence the instrument envelope. Assess the impact on the envelope and reliability if Class C or D development were allowed.
8. An assessment of whether a compliant, full-spectrum instrument capability can fit within (or close to within) the following notional instrument envelope associated with a notional smallsat implementation. If a full spectrum instrument capability cannot be packaged within this envelope, assess whether disaggregating the instrument into separate reflective band and thermal band instruments might individually fit within this instrument envelope on separate smallsats, and how the disaggregated data can maintain band-to-band and image-to-image registration requirements. Identify spacecraft interface assumptions, including those for attitude control and line of sight stability, and rationale for satisfying imaging requirements.

- Volume allocated for stowed payload not to exceed approximately 500 mm - 500 mm – 500 mm, including radiators.
- Mass of no more than approximately 50 kg.
- Orbit average power no more than approximately 50 W assuming continuous imaging/calibration operation.

3. Period of Performance

This effort is estimated to begin on August 1, 2014 with a six-month period of performance nominally ending on January 31, 2015.

4. Deliverable Items and Schedules

- The contractor shall deliver short (5-10 charts) monthly updated status packages in PowerPoint format to accompany a status teleconference.
- The contractor shall host a kickoff meeting within two weeks ARO of approximately 4-8 hours duration.
    - The contractor's chart package shall be delivered to the Government electronically at least 2 business days prior to the meeting. The main purpose of this meeting is for the contractor to demonstrate that requirements are clearly understood, and demonstrate how the study is to be accomplished.
- The contractor shall support a preliminary results (midterm) review at GSFC approximately 2-3 months ARO of approximately 4-8 hours duration.
    - The review chart package shall be delivered to the Government electronically at least 2 business days prior to the review.
    - The Government will provide feedback on these initial results for consideration by the contractor to guide the activities for the remaining period of performance.
    - This review would be in lieu of that month's status briefing/telecon.
- The contractor shall host a final results review approximately 6 months ARO of approximately 8 hours duration.
    - The review chart package shall be delivered to the Government electronically at least 2 business days prior to the review.
    - This review would be in lieu of that month's status briefing/telecon.
- Deliverable analyses
    - Radiometric math model and analysis
        - SNR
        - Dynamic Range (DNR)
        - Calibration
            - Absolute Radiometric Uncertainty
            - Radiometric Stability: 1 minute, 45 minutes, 16 days, 5 years
        - Pixel-to-pixel uniformity
    - Optical design and performance analysis
        - Relative Edge Response
        - Geometric stability
            - Geometric and spatial error budget, including spacecraft assumptions for pointing knowledge, pointing, control, ephemeris knowledge, and onboard jitter

        - Absolute Line-of-sight (LOS)
        - Relative LOS
    - Basic Stray light analysis identifying key contributors and mitigation strategies:
        - Diffused/scattered stray light
        - Ghosting/coherent stray light
  - Relative spectral response analysis
    - Spectral out of band
  - Performance margin analysis
    - End-of-life degradation considerations

5. Travel

The contractor is required to travel for 1 trip to the GSFC site for the preliminary results (midterm) meeting. The meeting will be of one-day duration or less.

6. Work Location

The activity shall be primarily performed at the contractor's location with communication via email and telecom, with the exception of the planned travel.

7. Reporting Requirements

In addition to reporting requirements provided in Section 4, the contractor is welcome to propose weekly or ad hoc teleconferences with the government to discuss study progress if it feels such interaction would be in the best interest of the study.

8. Reference Documents

Reference documents for this study are available at:
http://sustainablelandimaging.gsfc.nasa.gov/referencedocuments.html

- NASA-GSFC document # 427-02-07 Landsat Worldwide Reference System-2 (WRS-2) Definition
- NASA-GSFC document # 427-04-01 Landsat Data Continuity Mission Operational Land Imager Top of Atmosphere (TOA) Radiance Spectra