Posted in conjunction with the FARMS Sources Sought synopsis released on June 24, 2013, by Satellite Servicing Capabilities Office, NASA's Goddard Space Flight Center

FARMS:
Farmland and Agriculture Remote Measurement Sensor

Imagine the day that a corn farmer in Nebraska and a subsistence farmer in Nigeria are able to dramatically improve their harvests on opposite sides of the globe using data from the exact same tool. The National Aeronautics and Space Administration (NASA) believes that this day is within our reach. With decades of experience in Earth observation and optical technology, NASA is prepared to turn its eye to the ground to uncover secrets of crop nutrition and health and provide the world with a space-based tool for smarter farming.

To ensure success of this first-of-its-kind agrarian endeavor, NASA is searching for partners interested in helping the world with the agricultural challenges that the planet faces. By welding knowledge in space-based technology and on-the-ground farming applications, scientists and engineers at NASA plan to realize an International Space Station imaging instrument that can rapidly deliver information about crop health and yield potential around the world.

This **Farmland and Agriculture Remote Measurement Sensor (FARMS)** is a proposed instrument that will combine the latest in hyperspectral imaging *(see side box on reverse)* and global positioning systems to profile farm acreage with precision, allowing farmers from across the globe to evaluate and remedy the nutritional status of their crops or soil. FARMS takes an incremental development approach to improving our capabilities to farm with precision, deliver valuable data to customers, and help feed the world.

The Need for Better Information

Imaging satellites and hyperspectral data are not new—NASA's Goddard Space Flight Center [and other agencies] has done research in this area for decades. However, the technology has not been specifically designed for the agricultural community to meet their needs for high resolution repeat observations. Significant advancements can be made in imaging technology's accuracy and sensitivity that will allow scientific and practical studies to improve to the advantage of the farmers of the world.

Farmers often measure the status of their plant and soil by using a "boots-on-the-ground" method requiring workers to manually collect and analyze samples: a laborious process that can only be conducted a few times a year. Others rely on

information gathered from an imaging instrument perched on a tower, plane, or satellite—but the data and derivable conclusions are limited by accessibility, significant noise in the data, or the low resolution of the readings. Where information is most needed, such as in developing countries struggling to meet food demand, very little information is available.

FARMS looks to overcome each of these challenges using space-derived data infused with the expertise of agriculture experts, providing a state-of-the-art source of information that delivers:

- **Frequent observations**, especially during the crucial growth periods, providing a better understanding of the following areas, and more:
    - Vegetation structure
    - Environmental forcing function
    - Nutrient status
    - Stress response
    - Water quality and quantity
    - Crop residue quantity and condition
- **Precise pointing**, gathering data from specific points of interest;
- **High signal-to-noise ratio**, increasing the confidence and application of the data;
- **High resolution data**, allowing users to derive more accurate conclusions;
- **Global coverage**, reaching areas worldwide to develop more sophisticated models accommodating to a wide variety of ecosystems;
- **Broad spectral range** (380-2400nm), gathering more complete library of information for users worldwide; and
- **Multi-angled images**, distinguishing plant structure.

Posted in conjunction with the Sources Sought synopsis released on June 21, 2013, by Satellite Servicing Capabilities Office, NASA's Goddard Space Flight Center

The Road to New Possibilities

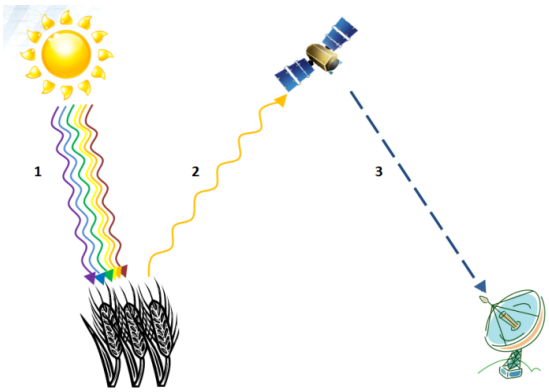
NASA plans to validate and prove this cutting-edge technology over 30 months, starting on the ground and ultimately delivering a refined, vetted instrument to the International Space Station. To shape the developments to meet the greatest need, an agricultural partner has been identified to provide input and unique knowledge. NASA needs the input and unique knowledge of the agricultural applications experts at early stages of development to ensure that the instrument meets the needs of the communities it seeks to benefit.

NASA with one or more commercial partners would develop, refine, and validate FARMS through a staggered approach tailored to deliver maximum technological and data results. NASA would:

1. Build a breadboard to confirm the initial techniques and perform basic performance tests **in the laboratory** at NASA's Goddard Space Flight Center;
2. Based on these findings, use available technology to validate data collected **from a tower** in the agricultural fields of the U.S. Department of Agriculture in Greenbelt, Md.;
3. Continue refining the instrument design by testing the technology over fields **from an airplane,** allowing developers to validate the readings over a broader area; and
4. Launch and mount FARMS **to the International Space Station** to begin gathering, digesting, and developing information to be delivered to farmers around the world.

FARMS: Technical Summary

Peak Signal-to-Noise Ratio	1400
Spatial Resolution	15 m
Spectral Range	380 – 2400 nm
Spectral Resolution	5 nm @380 nm to 20 nm @ 2400 nm
Coverage	Global, within 51° latitude; up to 1000 locations daily



Hyperspectral Remote Imaging

Remote imaging has been employed for decades to provide a rich collection of information about the surface of the Earth from high above, on orbit. Instruments are able to gather a variety of details by reading what is reflected from below. The sun's light, comprised of all colors (waves of light with varying wavelengths), hits objects on the ground (1), which then either absorb or reflect these various waves based on their composition. The remote imaging sensors are able to observe which waves are reflected (2) and communicate this information to receivers below (3). Through research, scientists and model developers are able to identify what properties of these objects reflect which waves. Hyperspectral technology is able to detect more waves, and can therefore provide more information.

Once FARMS confirms its technologies and applications on orbit, the instrument could lead to an even more advanced free-flying satellite committed to informing precision agriculture far and wide. Contributors who laid the groundwork for this application from the beginning would have the privilege of advancing the knowledge and applications available to agriculture.

A Partnership for Smarter Farming

With NASA's experience, technology, and highly advanced development platforms on their side, partners have the opportunity to invest in and shape the future of farming capabilities with minimal risk. FARMS is a unique gathering of knowledge and efforts from the aerospace, astronomic, agronomic, and agricultural communities that will spur a new movement in the fight for a more productive and sustainable world.