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The Soil Moisture sUAS, the only aircraft capable of mapping soil moisture content at critical depths for low cost, provides valuable localized high resolution data to augment NASA satellites. //PHOTO COURTESY OF BLACK SWIFT TECHNOLOGIES//

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Water is critical to sustaining life, especially when it comes to the world's food supply. Pinpointing which crops on multi-acre farms need water goes a long way to conserving this precious resource. NASA's Soil Moisture Active Passive (SMAP) mission uses satellite technology to monitor drought, predict flooding and assist in crop productivity. However, the nuances of the Earth's surface can easily be missed by satellite. Obtaining high resolution data in addition to the satellite images would greatly improve NASA's ability to track soil moisture.

PROJECT
Soil Moisture Mapping Unmanned Aircraft System

MISSION DIRECTORATE
Science

PHASE II SUCCESS
$365,000 additional investment for business development of the sUAS.

SNAPSHOT
Black Swift Technologies has designed a low cost sUAS that provides measurements of volumetric soil moisture content over agricultural-plot sized areas to support water management, agriculture, and fire, flood and drought hazard monitoring.

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Colorado-based Black Swift Technologies (BST) created a small unmanned aircraft system (sUAS) to help NASA get a clearer picture of soil moisture through the Small Business Innovation Research (SBIR) program. Soil moisture is defined in terms of volume of water per unit volume of soil. Using BST's sUAS, NASA scientists can gather ground truth measurements for a clearer observation by getting closer to the source. This can help rule out misleading results generated by satellite imagery.

This solution took the sUAS to another level because BST did more than just develop a unique aircraft. They developed an entire customized aircraft system to meet NASA's specifications. The system instruments and software can be used to gather and process data with close to real-time results. The aircraft limits electromagnetic interference from sub-systems like the motor and can handle a specified carrying capacity. In addition, the innovative design provided for easy modification to suit the needs of the mission and could be easily customized.

According to Jack Elston PhD, Founder and CEO of BST, "We base our unmanned aircraft systems on a modular architecture, allowing us to quickly develop supporting electronics and software to accommodate instruments mounted on the aircraft. Our approach allows us to fit the needs of the data gathering mission and NASA's unique requirements. We worked together on designing a solution that could fly at low altitudes to collect data which was crucial to mission success. The lower the altitude, the higher the resolution."

The sUAS included a specialized radiometer with miniature antennas used to detect varying

LEFT
Jack Elston PhD, Founder and CEO of Black Swift, with student.

RIGHT
The University of Colorado Boulder graduate students Eryan Dai (left) and Aravind Venkitasubramony (right) take measurements and notes of the soil and plant characteristics during flight operations.

proportions of energy reflected from the objects the sUAS flies over. This is crucial to determining soil moisture. NASA scientists use the energy reading generated from the BST sUAS, along with additional aircraft sensors, to differentiate between water contained within the soil or vegetation, thus getting a true measurement of only the soil water content.

According to Geoff Bland, BST Soil Moisture Project Technical Monitor, "The sUAS we developed maximizes efficiency. The aircraft can fly up to 90 minutes with a full payload, covering 705 acres using tightly spaced flight patterns at an altitude of 30 meters. This is a significant improvement to a multi-rotor aircraft which are limited to covering around 40 acres for a similar mission."

> "NASA's SBIR program has allowed us to continue our work in using sUAS to better understand the environment with the goal of making a positive change in the world."
>
> **BLACK SWIFT TECHNOLOGIES**
> SOIL MOISTURE PROJECT PI
> MACIEJ STACHURA, PhD

NASA can obtain more data using BST's sUAS than other aircraft for the same flight time. As a result, scientists can get a more complete picture of soil moisture due to the range and amount of data collected.

The data products gathered by the sUAS have potentially far-reaching benefits. Scientists can use this information to improve weather forecasting which in turn can help save lives through water management, and fire, flood and drought hazard monitoring. Farmers can use the data to determine where water is needed most and the level of fertilizer required in the soil row by row. This information can be used to determine when to turn on watering systems at specific sections of the farm. The benefits from this analysis are twofold. Not only will water be conserved, but the ground water can be protected by not over using fertilizer.

"NASA's SBIR program has allowed us to continue our work in using sUAS to better understand the environment with the goal of making a positive change in the world," according to Maciej Stachura PhD, BST Soil Moisture Project PI. "NASA's support was essential in our ability to keep moving the needle on how our technology can support critical efforts from improving food production through precision agriculture to averting or better preparing for natural disasters."

BST is already making great strides in achieving their higher mission. They are further developing their sUAS to help analyze severe weather patterns. The University of Colorado Boulder will be using their new aircraft for climate studies to gather pressure and temperature data on storms and tornadoes.

From their success with the SBIR program, BST is further collaborating with NASA to explore volcanoes in order to improve air traffic management systems. This ambitious initiative aims to minimize major airport shut downs similar to the one caused by the 2010 volcano eruption in Iceland by gathering data for critical ashfall advisories.