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LARGE-SCALE UAS DATA COLLECTION, PROCESSING AND MANAGEMENT FOR FIELD CROP MANAGEMENT

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Abstract. *North Dakota State University research and Extension personnel are collaborating with Elbit Systems of America to compare the usefulness and economics of imagery collected from a large unmanned aircraft systems (UAS), small UAS and satellite imagery. Project personnel are using a large UAS powered with an internal combustion engine to collect high-resolution imagery over 100,000 acres twice each month during the crop growing season. Four-band multispectral Imagery is also being collected twice each month with the large UAS at 4,000', 6,000' and 8,000' altitude over the 4x40 mile corridor. Researchers are using small UAS to collect imagery of selected* *fields within the flight corridor. Since current US Federal Aviation Administration regulations require UAS line-of-sight operation, project personnel are flying a manned aircraft chase plane within visual line of sight of the UAS with a visual observer onboard. Agricultural research objectives include using the various types and sources of imagery to detect selected crop diseases, nutrient deficiencies in corn, wheat and soybeans, and impacts of excess soil moisture on crop development. Collaborating farmers are sharing detailed soil analyses and field observations, in-field optical sensor data, and crop harvest yield data in selected fields. All project imagery is transferred to, and securely stored, on NDSU Center for Computationally Assisted Science and Technology (CCAST) computers. Image processing and analyses is conducted using desktop computers. All imagery collected on the project is being made available to each land owner and agricultural producers within the image collection corridor. The project is funded jointly by the North Dakota Department of Commerce and Elbit Systems of America.*

Keywords. *UAS, unmanned aircraft systems, UAS, remote sensing, precision agriculture. List both specific and general terms that will aid in searches.*

Description

This project use a large unmanned aircraft systems (UAS) in conjunction with small UAS to collect high-resolution imagery for use in precision field crop management decisions. Project personnel compare the usefulness and economics of imagery collected from UAS operated at various elevations with satellite imagery to detect selected sugar beet diseases, nutrient deficiencies in corn, wheat and sugarbeets, and impacts of excess soil moisture on crop development. Project personnel collaborate with selected crop producers to correlate the aerial imagery to detailed soil analyses and field observations, in-field optical sensor data, and crop harvest yield data in selected fields. The researchers use color, infrared, thermal, multispectral and hyperspectral sensors onboard the UAS to collect the remotely sensed data.

Equipment

The large UAS is a Hermes 450 (Fig. 1) owned and operated for this project by Elbit Systems of America. The sensor on the Hermes 450 is a Vision Map A3 Edge Sensor. Imagery is created from the data collected by the sensor by post-processing with Vision Map software.

Figure 1. Hermes 450

Since the United States Federal Aviation Administration (FAA) currently requires all UASs to be operated within visual line of site, we are employing a visual observer in a manned chase plane flying within one-half mile of the Hermes during all flights. The chase plane support service is provided by the Civil Air Patrol.

The small UASs used in this project include: 1) Trimble UX5; 2) Troybuilt RF70; 3) 3DR X8; and 4) Phantom Pro 3 and Pro 4.

The small UAS sensors include: 1) ICI 9640 Thermal Sensor; 2) Sentera Quad Band Sensor: 3) Sentera Dual Band Sensor; 4) Sony NEX 5 IR Camera; 5) Canon DSLR Infrared Converted Camera; and 6) Rikola VIS-VNIR Snapshot Hyperspectral Camera.

UAS Operations

All large and small UAS flights are coordinated and overseen by the Northern Plains UAS Test Site. The Hermes 450 is operated by Elbit Systems of America personnel, with an onsite Northern Plains UAS Test Site mission commander.

Location

All small and large UAS flights are based in the Hillsboro Municipal Airport located at Hillsboro, North Dakota.

The image collection corridor is a 4x40-mile corridor in Traill and Steel Counties in eastern North Dakota (Fig. 2).

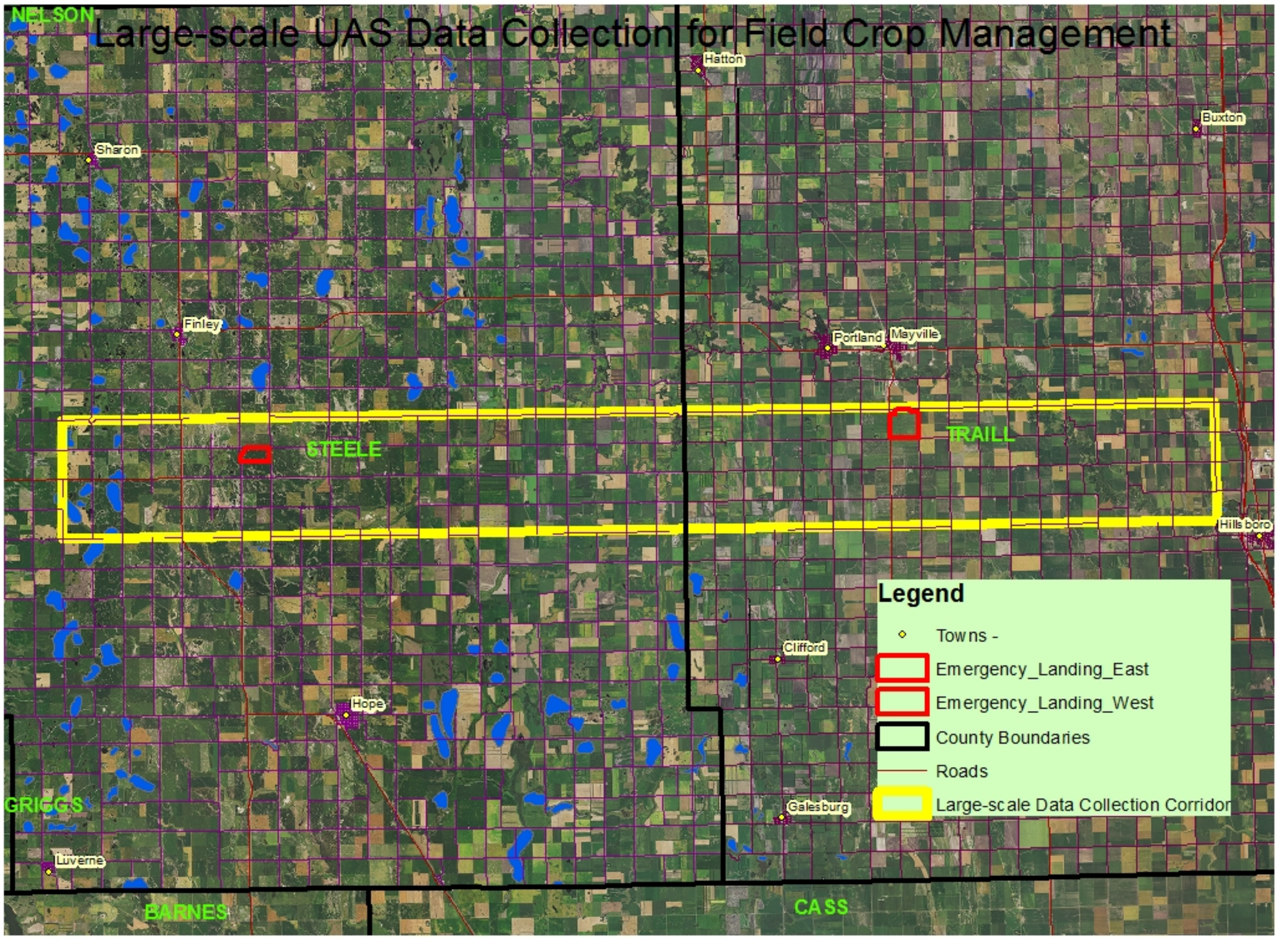

Figure 2. Image Collection Corridor, a 40 mile by 4 mile area spanning Traill and Steele counties in North Dakota.

Coordination with Landowners and Farmers

There are approximately 500 landowners within the image collection corridor. The NDSU Extension faculty provides leadership to communicate with the landowners and farmers within the corridor. This includes coordinating information about the project, conducting public information meetings, and being the conduit to share imagery and information between the landowners, farmers and project personnel.

Figure 3. Extension Public Meeting

Objectives and Procedure

1. Use a large UAS to collect RGB and infrared imagery at 4,000’, 6,000’ and 8,000’ altitude of a 4x40-mile flight corridor two times each month during May, June, July and August. Different types of imagery collected regularly at the three designated elevations during the crop growing season facilitates comparing the utility of various temporal, spatial and radio metrical remotely sensed data for crop management. Operating the large UAS beyond ground visual range above 400’ elevation is also demonstrating how UAS’s can operate effectively for agricultural applications within the National Airspace.

   Project personnel notified the local population and residents within the flight corridor of the UAS operations using public notices and local public meetings. We contacted each land owner within the flight collection corridor by printed letter.

   The project included an option for landowners and farmers to not have imagery created over their land.

   Upon request through the NDSU County Extension Office, each landowner or farmer is provided imagery and selected analyses over their land from each image collection.

2. Use a small UAS to collect multispectral and infrared imagery at 400’ or lower altitude of selected fields.

   High spatial resolution color and infrared imagery collected at the same time as the UAS imagery at 4,000’, 56000’ and 8,000’ altitudes facilitates comparing the utility and economics of the two data collection systems for crop management. Commercial UAS, data management and analyses companies, and agricultural producers will be able to use the comparison results to build future business models.

Project personnel Identified farmer/cooperators who have fields within the project flight corridor willing to share locations and crop production data with project investigators.

We used small UAS to collect color and infrared imagery on the selected fields on the same days, or as close as possible as the imagery is collected at higher elevations with the larger UAS.

3. Transfer all remotely sensed data from UAS's to the Center for Computationally Assisted Science and Technology (CCAST) computer storage system.

   The raw digital data collected with the Vision Map sensor onboard the Hermes 450 UAS is physically transferred from the UAS to a Vision Map post-processing computer at the NDSU campus.

   After the post-processing is finished and imagery created from the large UAS, the imagery is transferred to NDSU CCAST computer servers, securely stored, and make it available to collaborating researchers only by username and password. The imagery from the small UAS is handled similarly.

4. Collect ground data on each of the selected fields on the same days as the image acquisition dates.

   Ground data includes active optical sensor collection on one flight date, and visual observations on each UAS image acquisition date. The ground data provides a basis to correlate the imagery. NDSU project personnel use optical sensors technology to collect NDVI values from each test field on of the image acquisition days. Project personnel will correlate the NDVI values collected in the fields with NDVI values of the large and small UAS and satellite imagery.

   Project personnel use each imagery set to predict corn grain yield for each test field. Yield predictions are accomplished by incorporating NDVI values from each imagery data set into existing NDSU active optical sensor algorithms developed to direct side-dress N rates in corn.

5. Compare UAS imagery collected at 400', 4,000', 6,000' and 8,000' with satellite imagery for use in crop management practices.

   Project personnel use the UAS imagery to prepare digital elevation models of selected fields each week. The digital elevation models taken at the beginning of the season are used to identify surface drainage patterns on selected fields within the image collection corridor. The digital elevation models will be correlated to yield at the end of the season to establish the relations between both surface elevation and crop.

   Image mosaics are prepared of all UAS imagery collected throughout the project.

   Photogrammetry techniques are used to prepare digital elevation models for selected fields during the crop growing season.

Results

At the time this paper is being submitted the project was only half completed. Actual results will be shared at a later conference. Examples of current analyses and results are shared here.

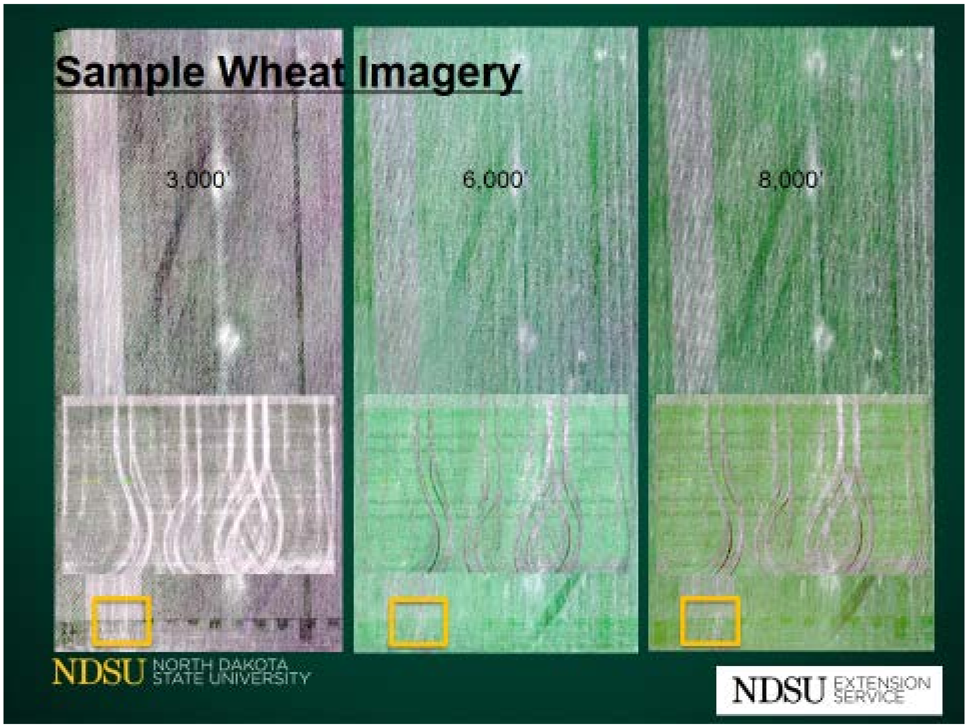

Figure 4. Example Images of Wheat Field collected at three different elevations of 3000, 6000, and 8000 ft in May 2016

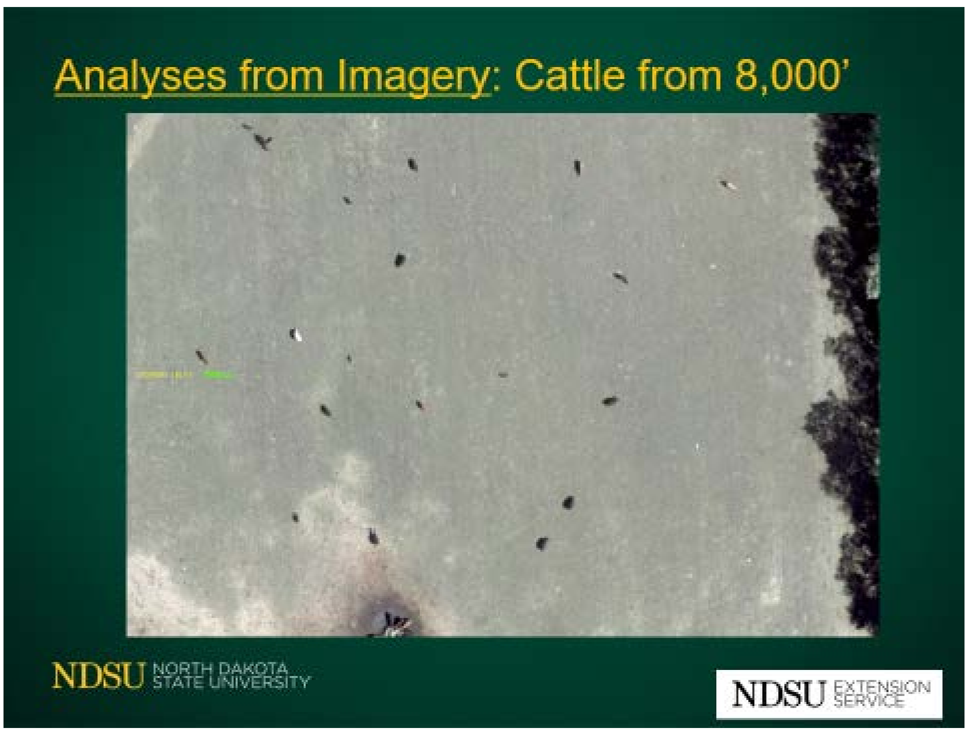

Figure 5. An Image of Cattle on a Pasture, Acquired from 8,000' Altitude

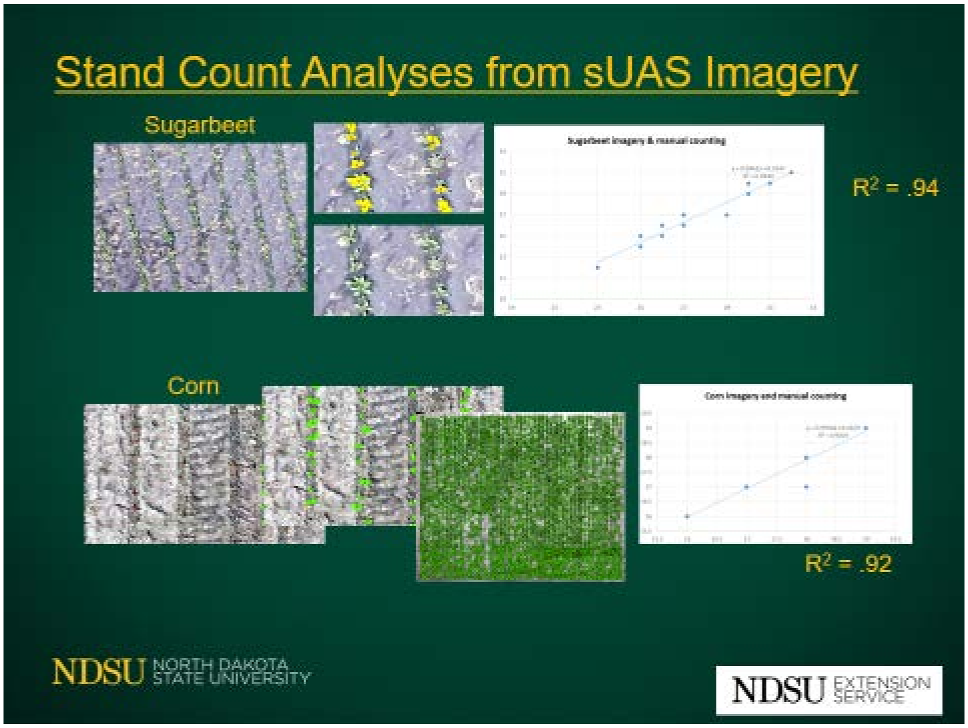

Figure 6. Plant Stand Count Mapping Using sUAS Imagery Acquired at 50' Elevation

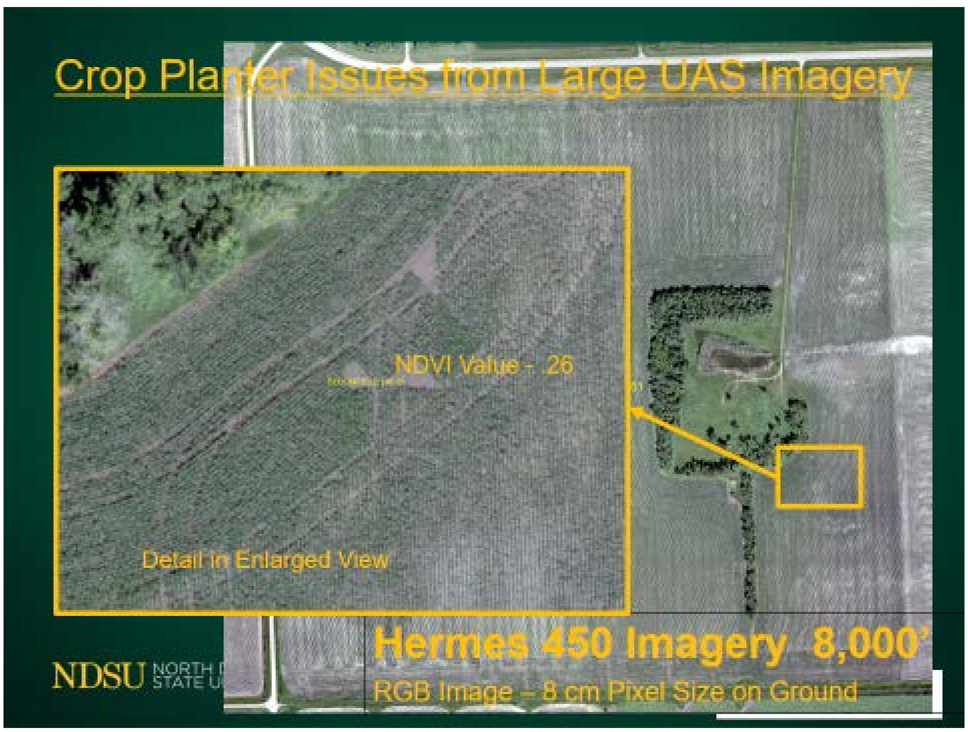

Figure 7. Large UAS Imagery Acquired at 8000' Showing Planter Issues

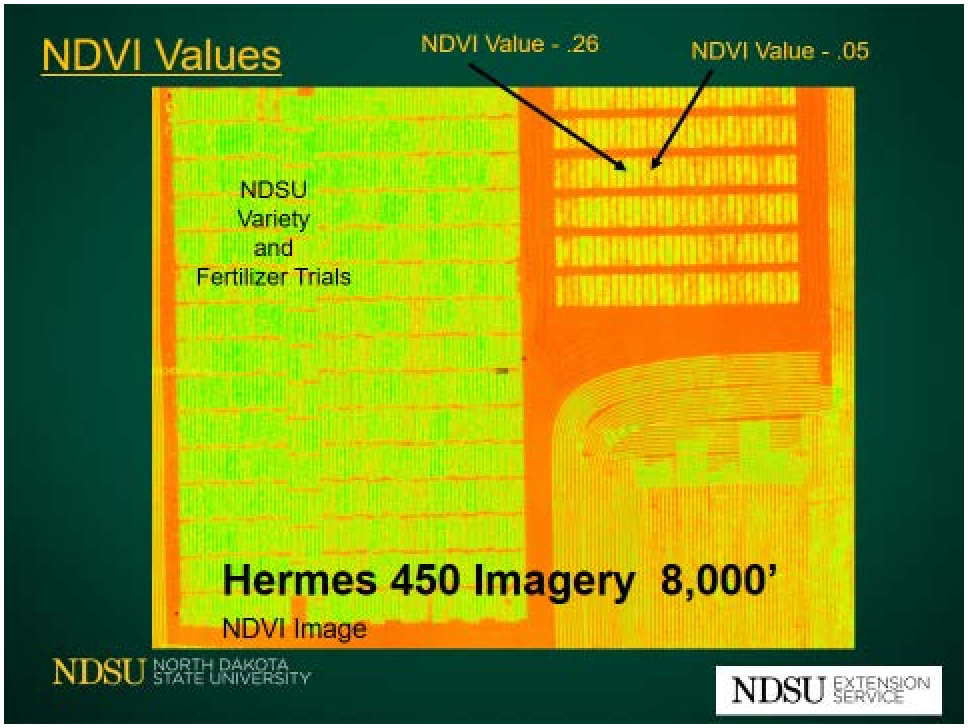

Figure 8. NDVI Map of A Variety × Fertilizer Trial Field Created from Large UAS Imagery Collected at 8,000'

Summary

The large UAS data collection campaigns were held in May and June, acquiring one set of data in each month. Weather, equipment and regulatory issues interfered with the original plan to collect data twice each month during the crop season. Generation of mosaicked and orthorectified image from the raw data took much more time than the originally anticipated 24-48 hours. Image data size has created issues with actual application of the data by farmers in their precision ag software system. We were able to exclude land areas where people opted out from being imaged, and share data with those farmers who requested them. Several educational events were held during the weeks of data collection in May and June. The large UAS data did not have high enough resolution to implement previously developed algorithm to count plant stand. Other applications of the data are slowly being developed.