Unmanned Aircraft Research is Taking Off at Nebraska

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Wayne Woldt – Extension Environmental Engineer

As interest in unmanned aircraft systems (UAS) continues to grow across the nation, faculty at the University of Nebraska are embracing state-of-the-art research and extension across a breadth of applications. This work spans the University's campuses at Lincoln, Omaha, and Kearney and is briefly outlined below.

Improving Agricultural Production and Natural Resource Management

Flight of unmanned aircraft officially began at the University of Nebraska in September 2013 when the first FAA-approved Certificate of Authorization was issued to Wayne Woldt, associate professor in UNL's Department of Biological Systems Engineering. Woldt's research and extension programs focus on using UAS to improve management of agricultural and natural resources. He works with a team of faculty in the Nebraska Unmanned Aircraft Innovation, Research and Education (NU-AIRE) Lab to develop a UAS-enabled methodology for early detection of moisture stress in agricultural crops.

In this case, single-engine fixed-wing UAS provide a highly mobile sensor platform that can be flown over fields to gather real-time data on crop status. Early stages of this research are assessing aircraft performance as a sensor platform by measuring dynamic behavior of the airframe with respect to altitude, airspeed, and position, relative to the desired values programmed into the autopilot.

Woldt, who leads a national eXtension.org project to transfer UAS research and development information to Extension educators, is also studying ways to increase UAS safety. The program seeks to develop a beacon that UAS operators can use to provide an early warning to low flying manned aircraft with directional information that UAS flight operations are being conducted in a given area.

Mitch Maguire, Graduate Research Assistant in the UNL Department of Biological Systems Engineering, completes a preflight check on a Tempest unmanned aircraft prior to flying an agricultural research mission. (Photo courtesy of NU-AIRE Laboratory.)

Richard Ferguson, professor in the UNL Department of Agronomy and Horticulture, is a true pioneer in the use of small remote-controlled aircraft to observe agricultural systems, and was one of the first researchers to experiment in the use of cameras mounted on remote controlled model aircraft. This was prior to the current concept of "unmanned aircraft with autonomous navigation systems."

Ferguson uses UAS for research in crop stress, primarily related to nitrogen and to a lesser extent water. His focus is on improving nitrogen use efficiency, particularly in irrigated maize. Improved nitrogen use will result in increased profit for

farmers and reduced environmental impact from nitrogen losses. Ferguson and his team have used a variety of UAS platforms, including fixed wing, single, and multirotor systems. He also uses a range of passive and active optical sensors.

While Ferguson discusses his research with growers and their advisors, current regulations do not allow demonstration and training on UAS use for commercial agricultural purposes. Once commercial UAS use in agriculture is allowed, he expects significant demand for Nebraska Extension to advise and train producers in UAS use.

Researching Remote Sensing Applications

Another area of emerging UAS research involves remote sensing using UAS. Brian Wardlow, associate professor in the UNL School of Natural Resources and Director of the Center for Advanced Land Management Information Technologies (CALMIT), is preparing to pioneer UAS-based remote sensing approaches for monitoring the state and condition of plants, with application to crops, grasslands, and other vegetation. CALMIT does not currently fly a UAS, but anticipates development of a major research and development track in agricultural and natural resource monitoring. CALMIT views this as a high priority because it expects UAS will fill an information gap that would complement spectral observations from ground-, aircraft-, and satellite-based sensors.

This research also involves Art Zygielbaum, research associate professor in CALMIT. He studies the mechanisms plants use to handle excess energy through photosynthetic processes and how these processes may be restricted due to lack of water or nutrients, or biotic/abiotic contamination. This research requires measurement several times a day, a good use of UAS, which can collect this data more frequently over a larger area than is currently possible.

CALMIT anticipates integrating a UAS-based remote sensing component into a field course being developed for students and professionals throughout the world to learn how to acquire, evaluate, and apply scientific-grade spectral data to agricultural and natural resource management and environmental monitoring.

Stay Up-to-Date with UAS Advancements

National eXtension is hosting a series of monthly one-hour webinars looking at research, extension and use of unmanned aircraft systems in agriculture. Follow the event to get updates when new webinar announcements or sessions are posted. Here are a few of the titles available:

Unmanned Aircraft in Agriculture: Dynamic Technologies and Record Keeping, Nov. 18
Unmanned Aircraft Systems in Agriculture: Applications and Updates, Jan. 20
Unmanned Aircraft in Agriculture: Pest Management and Flight Performance, March 16
Unmanned Aircraft in Agriculture: Sensor Integration/Commercial Production and Field Research, April 21
Unmanned Aircraft in Agriculture: UAS Technology/USA in Education (recent FAA memo), May 18
Unmanned Aircraft and Animal Agriculture, June 17

Developing Complex UAS Software

One of the key, enabling technologies for UAS involves complex computer algorithms and integrated autopilot systems that stem from advances in computing. Carrick Detweiler, assistant professor, and Sebastian Elbaum, professor, both in the UNL Department of Computer Science and Engineering and founders of the Nebraska MoBile Unmanned Systems (NIMBUS) Lab, focus on developing software and systems to increase the robustness and reliability of UAS when operating close to the environment.

The next generation of UAS will do more than observe. Carrick and his team are developing UAS capable of a diverse array of missions, such as:

- taking water samples and acquiring sensor data from remote locations
- precisely surveying crop systems by flying extremely close to sense canopy structure and growth data
- developing wireless power transfer systems that enable UASs to charge sensors in remote locations; and
- developing software that can automatically detect and correct system errors to reduce risk and increase safety of UAS.

Another computer science professor, Raj Dasgupta, UNO, is pursuing another aspect of UAS. Dasgupta, who leads the CMANTIC lab, is studying multi-robot systems using integrated UAS and ground robots for rapid response in critical missions using UAS teams, or swarms, to perform complex operations (e.g., formation flight, wireless connectivity maintenance) for agricultural applications (e.g., aerial vegetation survey), and civilian applications (e.g., crowd/traffic management via aerial surveillance).

Weather and Emergency Management Assessment

Unmanned aircraft systems also can be found at the nexus of technology and aviation. Terry Gibbs, director of the UNK Aviation Systems Management Program, is pursuing research into the structure of a statewide emergency management information gathering network with county-level UAS capable of gathering images, infrared, chemical sensors, and radiation. This system could be rapidly deployable by local emergency management personnel to provide real-time emergency management information.

Adam Houston, UNL associate professor of Earth and Atmospheric Sciences, has been involved in atmospheric science-focused missions using UAS since 2007. Houston and his principal collaborators at the Research and Engineering Center for Unmanned Vehicles at the University of Colorado Boulder have been responsible for a number of firsts in the application of unmanned aircraft to atmospheric science. Houston is also the co-director of the UAS and Severe Storms Research Group, a consortium of public and private collaborators led by UNL and the University of Colorado.

UAS as Journalists

A particularly interesting area of UAS research and teaching is being pioneered by Matt Waite, UNL professor of practice in the College of Journalism. Waite is interested in teaching students how to use UAS to report news, and the potential legal, ethical, and safety issues involved. The FAA has denied Waite's applications for a Certificate of Authority for UAS in journalism education. He has been working to secure his pilot certificate so he can apply for a Section 333 exemption to conduct UAS flights to achieve research and teaching goals.

Writing University UAS Policies

Given the scope of this research and the University's potential to be a national leader in agricultural and natural resource applications, University administration realized the importance of ensuring that all UAS activities are conducted in a legal and ethical manner. Toward this end, the President of the University of Nebraska charged a committee with developing a system-wide UAS policy, which they just completed (University of Nebraska Policy on Unmanned Aircraft Systems). The committee represented an array of interested parties and established a policy that minimizes barriers, while assuring safety of the national air space as well as people on the ground. The university looks forward to working with Nebraska aviators, as well as partners and innovators, to advance the safe and beneficial deployment of UAS across the beautiful skies of the Cornhusker state.

About Robert Wright

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