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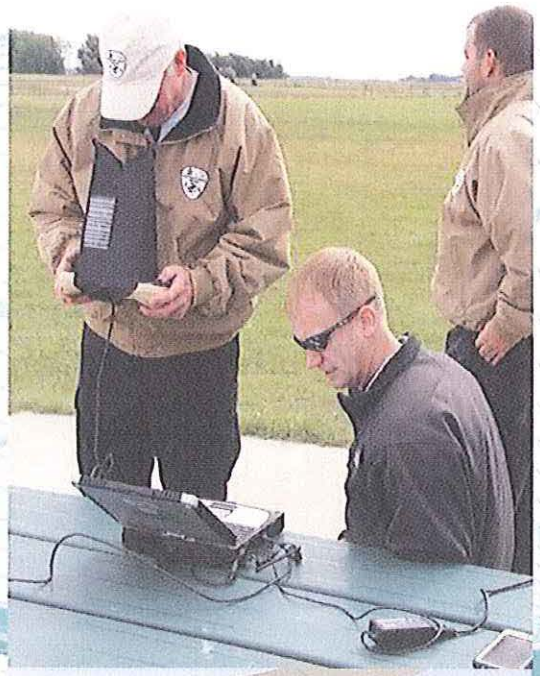

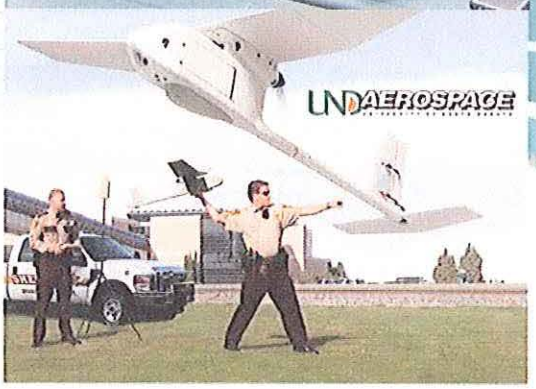

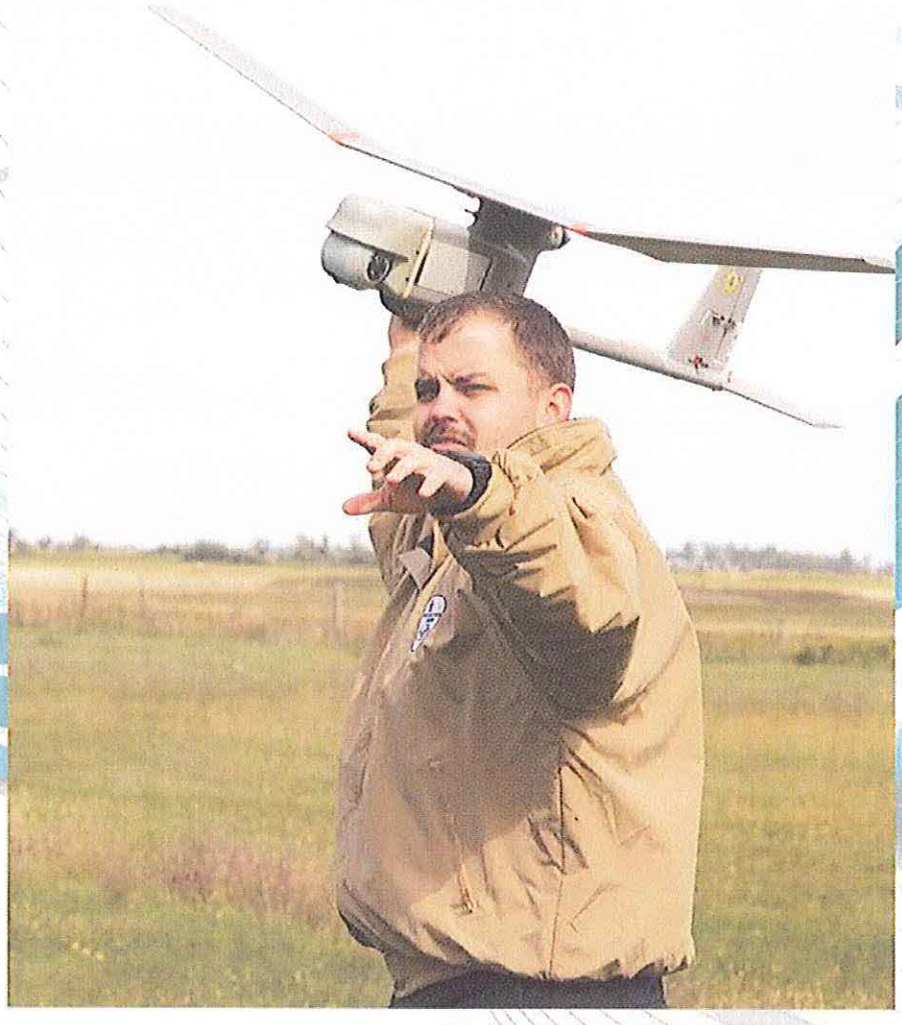

FIXED-WING SUAS:

First Look at AeroVironment Raven-DDL

By Alan Frazier, Deputy Sheriff, Grand Forks (ND) County Sheriff's Office, Assistant Professor, University of North Dakota's John D. Odegard School of Aerospace Sciences Photos courtesy of Brenda Riskey, UND Aerospace

Not all small unmanned aircraft systems (sUAS) are rotorcraft. Several very capable sUAS are traditional fixed-wing platforms. In comparison to rotorcraft sUAS, fixed-wing platforms generally have longer endurances, faster cruise speeds and greater payload capacity. The price paid for these advantages is the need for larger takeoff and landing areas and the inability to hover at a fixed point.

The most widely used sUAS fixed-wing platform (albeit primarily by the military) is the AeroVironment Raven (military designation RQ-11). The Raven entered production in 2002. Since then, AeroVironment (AV) has manufactured more than 20,000 Ravens. AV is an innovative and diverse company whose sUAS development and manufacturing facilities are located in Simi Valley, CA. Established in 1971 by visionary aeronautical engineer Paul MacCready, AV has grown to be a leader in the sUAS industry. In addition to the Raven, the AV complement of sUAS includes the Wasp, Puma and Qube. AV's primary sUAS customer has been the U.S. Department of Defense (DOD). However, recognizing the vast potential of emerging civilian market, AV has begun to establish a greater presence at civilian conventions and trade shows, such as the Association for Unmanned Vehicle Systems International and ALEA annual conferences.

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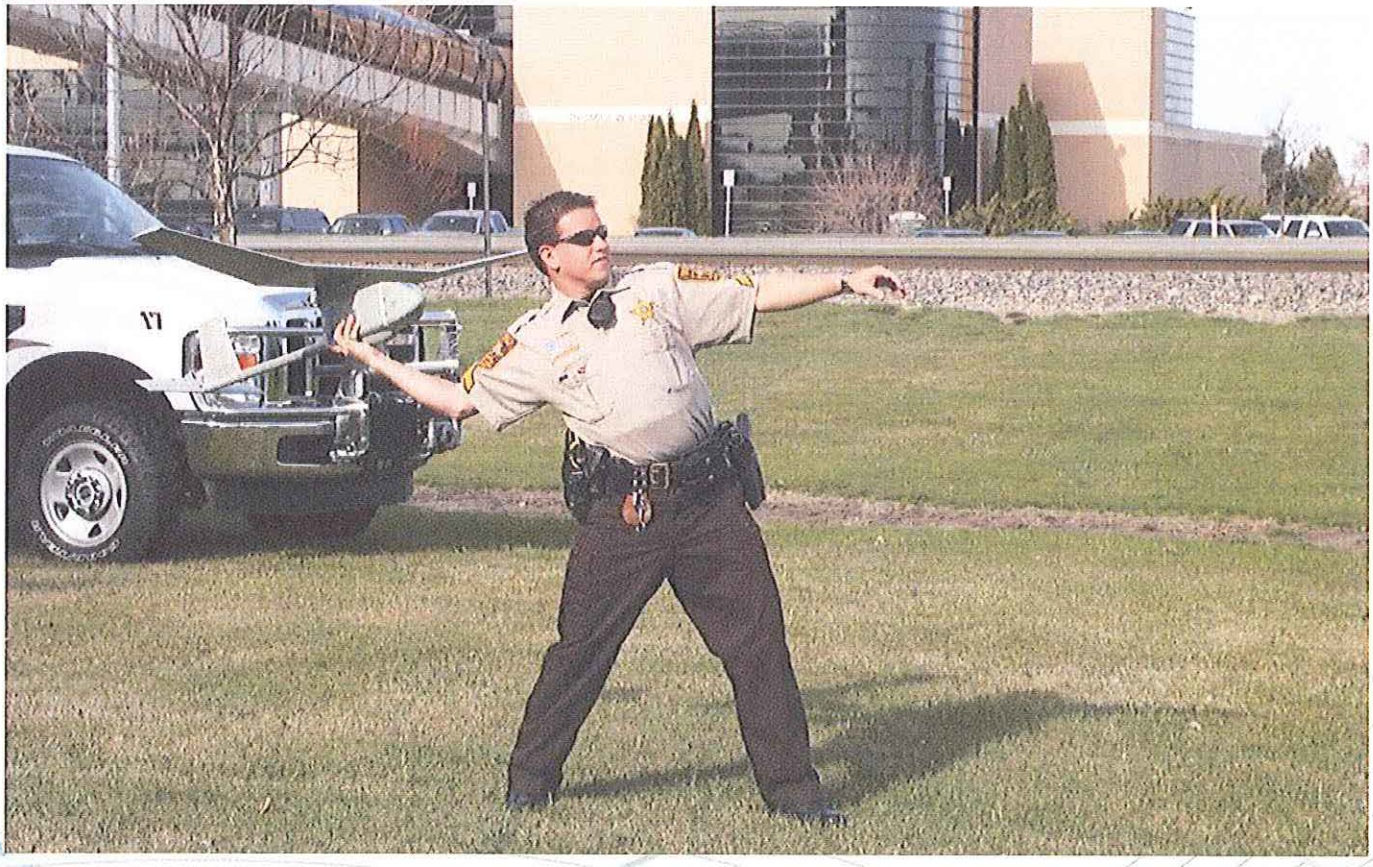
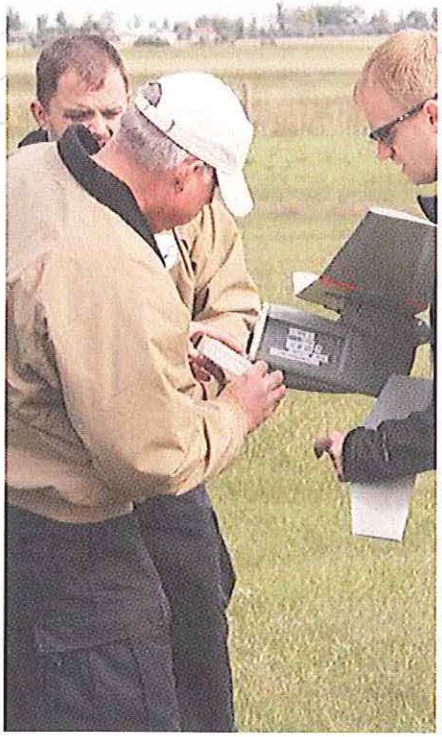
The transition from a DOD-centric company to one that serves the civilian market has not been without growing pains. AV's suggested price for the Raven is "$100,000-$200,000." Although that type of pricing structure may work for DOD contracts, it is problematic for law enforcement agencies wishing to acquire an sUAS. Being forced to list such a broad equipment range cost in initial sUAS unit and grant proposals reduces them to vague guesses at how much money will be needed to fund the program. In order to fully integrate into the civilian market, AV must establish fixed-base prices for their sUAS as well as for options like more-advanced sensor systems. In addition, the current AV policy is to sell the Raven as a "system," which includes three airframes and two ground control stations (GCS), which places it beyond the affordability for many agencies. Pricing should be established for a single airframe and GCS.

The Grand Forks (ND) Sheriff's Department (GFSD) UAS Unit has been flying the Raven since 2010. The present airframe has accumulated over 50 accident- and incident-free flight hours. Unit members refer to the Raven as the "Eveready Bunny" because it is so robust and reliable. Hand-launched by the mission operator (MO) and flown by the vehicle operator (VO), the Raven is capable of 70-90-minute flights powered by a mid-sized lithium-ion battery. Minimum dimensions for the landing area are 75 x 150 feet of unobstructed, relatively level





ground. The sUAS can be flown in a traditional remote control manner utilizing a hand-controller, but is more commonly operated with both the hand-controller and a Panasonic Toughbook computer in the loop. The MO utilizes FalconView, an open source mapping application developed by the Georgia Tech Research Institute, to plan the mission. Using a touchscreen or entry of coordinates into a table, the MO manages four waypoints and three orbit points. The points are all programmed prior to the mission but can easily be changed as events unfold. The VO utilizes the hand controller to implement the mission planning entered by the mission operator. During GFSD Raven flights, the MO and VO are in close proximity and engage in frequent dialog regarding the flight. The MO also serves as the FAA-required visual observer.

Initially, GFSD's Raven was equipped with separate electro-optical (EO) and infrared (IR) sensor payloads. The payloads had fixed cameras, side- and forward-looking for EO and side-looking only for IR. To switch from EO to IR, it was necessary to land the aircraft and physically swap the payloads. This was inefficient and not conducive to law enforcement operations.

In 2012, AV developed a gimbaled payload for Raven. The gimbal includes a 5-megapixel EO and 640 x 480 IR sensor.

> "Although on the higher cost side of currently available sUAS, agencies searching for a reliable, robust, long mission capable sUAS with very good optics will find a solution in Raven."

The gimbal is capable of 360-degree pan and can also pitch +10 degrees/-95 degrees. In May 2014, GFSD upgraded from fixed camera payloads to the gimbaled payload. This proved to be a game-changing upgrade. The gimbal is agile, possesses excellent resolution from very good EO and IR sensors, and enables a loiter mode. In loiter mode, the VO simply utilizes a toggle on the hand controller to focus the gimbal on an object of interest. The gimbal and Raven then maneuver appropriately to keep the object in view. This is a huge benefit to the UAS crew as it relieves them of the need to maneuver the aircraft to keep the object in view. When GFSD upgraded to the gimbaled payload, an AV trainer travelled to Grand Forks and provided three days of classroom and flight training to unit personnel.

During mission planning, a loss-of-link (LOL) waypoint, altitude and protocol are programmed. If the command and control link is compromised, depending on which option is programmed, the Raven will return to the LOL waypoint or continue the pre-programmed mission, returning to the LOL waypoint upon conclusion of the mission.

Landings are usually automated, with the VO commanding the aircraft to fly to a pre-programmed entry point after which the Raven will initiate a full-stall auto-landing to a pre-programmed point. For first-time observers, Raven landings are a bit unusual, as the aircraft pitches up and then "flutters" to the ground. The airframe and payload consist of six components which are designed to dissipate landing forces by detaching upon impact with the surface. The sight of the Raven separating into multiple components upon landing has caused more than a few observers to cringe. However, GFSD has never experi-

enced loss of or damage to a major Raven component during landing. The worst damage that has occurred to the GFSD Raven is a broken plastic mounting clip, which was field replaced in less than five minutes. The Raven routinely reaches the landing point with remarkable accuracy.

The Raven's payload cameras are capable of streaming video to the computer serving as the ground control station, as well as to a remote video terminal located within range (approximately six miles, depending on terrain and aircraft altitude). Photographs can be captured simply by pressing a button on the VO's hand controller. All video and photographs are stored on the MO's computer.

AeroVironment factory training for the Raven consists of 10 days of classroom and flight training. The classroom portion for GFSD was primarily focused on Raven systems and use of a Raven simulator, which utilized the actual Raven hand controller. Flight training began with assembly, basic launching, landing and commanding the aircraft to proceed to waypoints. Advanced topics included emergency procedures and night operations. The training was well-organized and professionally conducted by AV trainers. AV has recently released the Visualization and Mission Planning Integrated Rehearsal Environment (VAMPIRE), a powerful mission simulation software solution. VAMPIRE provides full flight training operations and mission rehearsal in realistic 3-D terrain with detailed builds of selected manmade features, moving humans and vehicles. VAMPIRE can also support custom building of scenarios utilizing satellite imagery.

Raven is not as simple to operate as some sUAS utilized by GFSD. FalconView is a moderately complex program which requires frequent use to remain current. Agencies who consider utilizing Raven should plan to mandate that operators conduct at least three takeoffs and landings (including actual or simulated missions) every 90 days. Anything less than the recommended minimum flights will result in operators not possessing sufficient currency to safely and efficiently operate the system.

Preliminary findings of the University of North Dakota's Unmanned Aircraft Systems Research Project indicate that the Raven excels in the areas of robustness, mission duration, wind penetration capability, large area search and covert surveillance capabilities. Areas for improvement include the relative complexity of system operations, need for large takeoff and landing area and cost.

Raven-B at a glance

Wingspan: 4.5 feet

Length: 3 feet

Weight: 4.2 pounds

Engine: Aveox 27/26/7-AV brushless electric motor

Power Source: Lithium ion battery

Cruising speed (approximate): 30 knots/hour

Range: 6.2 miles

Endurance (approximate): 60-90 minutes

Sensor: Gimbal with EO/IR cameras
Cost: $100,000-$200,000 per system*

**Cost information provided by AeroVironment. A system consists of three Raven airframes, one gimbaled EO/IR payload and two ground control stations.*