Vertical Thinking

Infrastructure-free vertical flight capability has strong appeal to unmanned-aircraft developers

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Almost every conceivable way of taking off and landing vertically has been tried at least once, and most were judged impractical at the time. But technology marches on, and growth in the unmanned-aircraft market has brought with it resurgence in interest—and invention—in vertical flight.

With no need to carry a pilot, fly supersonically or transport passengers, the VTOL barrier to entry has been lowered for unmanned aircraft systems. And the benefits to operational flexibility of being independent of runways—or launch and recovery systems—can be compelling when the penalties in payload and endurance can be minimized, or accepted.

Adding VTOL capability to an existing fixed-wing aircraft is an unusual step, but Arcturus UAV has attached a quadrotor system to its T-series small tactical UAS. The California-based company is offering Jump-15 and -20 versions of its T-15 and T-20 gasoline-powered tactical unmanned aircraft and plans to introduce a smaller VTOL-capable product at the Association of Unmanned Vehicle Systems International (AUVSI) show this month, says founder and President D'milo Hallerberg.

Jump adds two underwing booms containing batteries, electric motors and rotors to provide a vertical-flight capability to the fixed-wing UAV. Latitude Engineering developed the autonomous VTOL control software for the UAV's Cloud Cap Technology Piccolo autopilot. To offset the weight of the booms, Arcturus has removed mass from the airframe as the UAV no longer has to withstand the stresses of a catapult launch and belly landing or net recovery, Hallerberg says. The pods are low drag, the rotors feathering longitudinally when not in use.

While weight and drag penalties are minimized, the VTOL versions still sacrifice some endurance for increased operational flexibility. Where the T-16 and T-20 can fly for 10-12 hr., the VTOL versions have an endurance of 6-8 hr., he says. The Jump-15 in standard configuration carries a Cloud Cap TASE200 stabilized electro-optical/infrared sensor and the Jump-20, a larger TASE400 or equivalent payload.

The VTOL UAV takes off from a small platform with its gasoline engine and propeller turning to provide station-keeping as the aircraft climbs vertically. At transition altitude, the propeller is commanded to full thrust and the Jump software hands over control to the fixed-wing autopilot. To recover, the UAV slows to just above the stall and the rotors start up for an autonomous vertical landing. The batteries in the booms provide enough power for one launch and recovery, with reserve, says Hallerberg.

The ability to recharge the batteries in flight will be available "in the near future," he says. The booms are not removable, but that may be an option if the company decides to develop a longer, lower-g pneumatic launcher. Although VTOL capability adds to the airframe's price, Hallerberg says the complete system will cost less because a launcher and recovery system are not required.

Latitude Engineering unveiled its Hybrid Quadrotor concept in August at last year's AUVSI show and began working with Arcturus late last year, says Hallerberg. "We decided to go directly to production tooling. The first flights were good and no modifications were needed to Latitude's software."

Australian start-up StopRotor Technology is developing a VTOL concept in which the rotor is stopped in flight to form a wing. Not a new idea, but in previous—unsuccessful—stop-rotor designs conversion took place in level flight, with air flowing over the rotor. In StopRotor's Hybrid RotorWing, the aircraft pitches up to a high angle of attack so the air is flowing up through the rotor when it stops and starts.

"A lot of stop-rotor concepts convert in forward flight, at high speed, so the relative airflow is radial, leading to huge asymmetry issues [between the advancing and retreating blades]," says StopRotor founder and inventor Rowan Watkins. In the Hybrid RotorWing design, "high-alpha flight control results in axial flow, through the rotor, which eliminates the instability issues."

The Hybrid RotorWing takes off in rotary-wing mode and flies initially like a compound helicopter, moving lift to fore and aft wings and unloading the rotor as it accelerates in forward flight. At the transition point, the vehicle slows down and pitches up into an autorotative descent, the rotor is powered down and stopped aerodynamically, then locked in place so it exits the transition in fixed-wing mode. The aircraft can land fixed-wing or convert back to rotary wing and land vertically.

The company began flying radio-control models in 2010; in 2013 it com-

BOEING CONCEPT

Boeing's Phantom Swift combines enclosed rotors and ducted fans for speed and efficiency.

pleted the first inflight conversion, taking off in fixed-wing mode and transitioning to rotary-wing flight. Envelope expansion has continued in helicopter and compound-helicopter modes and a prototype has flown with an electric ducted fan to simulate a turbine engine for a larger version, says Managing Director Deanna Watkins.

StopRotor and the Royal Melbourne Institute of Technology have submitted a research proposal to a U.S. organization to build a prototype capable of demonstrating all elements of the design in one mission—vertical takeoff, transition to fixed-wing flight and back to rotary-wing flight for vertical landing—by mid-2015. Included will be an assessment of the scaling feasibility from 10- to 200-kg UAVs, Watkins says.

Aerovel, started by the team behind Insitu's ScanEagle long-endurance small UAS, is developing the Flexrotor VTOL UAS for the civil market. The Flexrotor is a tailsitter, with a large-diameter rotor/propeller and high-aspect-ratio wing. The aircraft takes off vertically and hovers like a helicopter, with stowable wingtip thrusters for flight control, then pitches over into wingborne flight. To recover, the aircraft pulls up into a climb, then descends vertically to land.

STOPROTOR

StopRotor's Hybrid RotorWing prototype pitches up to make its first inflight transition.

The 19.2-kg UAV is designed to fly for more than 40 hr. carrying a 0.9-kg payload. Aerovel has conducted autonomous VTOL flights from an unmanned boat and has begun payload tests of the UAV fitted with a belly-mounted Alticam Vision sensor turret and Cobham video downlink. First customer delivery is planned for early 2015, says founder and President Tad McGeer.

Austrian company Aerie is developing an unmanned aircraft in which the wing spins like a rotor for vertical flight then stops for forward flight. Aerie says its Permafly designs can exceed 24-hr. endurance, three times that of a conventional VTOL design. The aircraft is a "nosesitter"—it takes off and climbs vertically, tail-first in rotor-borne mode, then dives to convert to forward-flying wing-borne flight. To land, the UAV climbs, flips over and descends nose-first in rotor-borne flight. Aerie is working on a range of UAVs, flight testing a prototype of the 25-kg S-25 while designing the 150-kg D-150. In both, the rotor/wing is driven by two small propellers on the leading edges.

The U.S. Defense Advanced Research Projects Agency, meanwhile, is funding design work on several unmanned vertical-lift designs. Carter Aviation Technologies is one of the companies working on the first phase of the Tern program to demonstrate a Predator-class long-endurance UAS able to operate from small ships. Its concept is the Slowed-Rotor/Compound—a re-imagining of the autogyro with VTOL capability.

Under Phase 1 of the VTOL X-Plane program to demonstrate a high-speed vertical-lift aircraft capable of efficient hover and cruise, Boeing is pursuing the Phantom Swift, with a pair of ducted rotors in the fuselage and tilting ducted fans on the wingtips. Other unmanned X-plane designs ranging from tailsitters to tiltrotors are being worked on by Aurora Flight Sciences, Karem Aircraft and a Sikorsky/Lockheed Martin team.

Arcturus UAV's Jump design adds quadrotor VTOL to a fixed-wing tactical UAS.

ARCTURUS UAV

Keeping Watch

After multiple delays, British Army begins flying Watchkeeper UAV

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With its long-awaited flight clearances in place, British Army pilots are now able to support troop training with the Thales Watchkeeper unmanned aerial system (UAS).

It has been a long time coming. Initially due for entry into service three years ago, Watchkeeper has not had an easy introduction, facing extra scrutiny as the first UAS to be certified by the U.K.'s new military air safety body, the Military Aviation Authority (MAA). Meanwhile, the loss of one of its precursors in Afghanistan, a leased-in Hermes 450, has resulted in a radical change in the configuration of the army's UAS operations, to those more closely matching that of a typical flying squadron in the Army Air Corps or the Royal Air Force.

In March, the system was given its interim release to service (RTS) documents, allowing army crews from the Royal Artillery to begin operations under full army control from the Boscombe Down test airfield in Wiltshire. Until then, army pilots had only been able to fly through the use of a Military Flight Test Permit (MFTP) in conjunction with Thales test pilots when flying the aircraft from the Aberporth test center in West Wales. From Boscombe Down, the pilots are able to fly sorties in support of troops training within the vast Salisbury Plain Training Area. Only a handful of flights have taken place each week, but the operational tempo is increasing, according to Col. Mark Thornhill, commander of the British Army's 1st Artillery Brigade.

"The flights are currently overhead [of] the Salisbury Plain, providing imagery, but we can fly anywhere within the Salisbury Plain from Warminster in the west across to Tidworth in the east," said Thornhill, speaking at an army event at the Trenchard Lines garrison in April.

Once all 54 platforms and 14 ground stations are in service, they will be pooled between two front-line active-duty units, the 32 and 47 Regiments of Royal Artillery, each with five flights using five systems each.

Currently, there are no plans for Watchkeeper to be flown by reservist units, because of the training requirements.

All operations are flown from the ground control stations located at Boscombe Down, under radar control provided from that airfield, with missions flown at between 8,000 and 16,000 ft. The Watchkeeper platforms take off and land from a taxiway parallel to the main runway. Prior to takeoff and landing, manned fixed-and rotary-wing movements are halted until the UAS is airborne and away from the airfield. The taxiway is used because of the installation of the arrestor used to bring the Watchkeeper to a halt on landing.

Future Watchkeeper operations will be extended into segregated airspace to the south of the Salisbury Plain, where activities will require Notices to Airman. Flying in these areas will give the army pilots the ability to train using the Watchkeeper's synthetic aperture radar on targets requiring the aircraft to be at a stand-off distance.

If other aircraft do fly into the segregated airspace, the Watchkeeper will be steered away under radar control from any potential conflict.

The aircraft's current release to service documentation is an interim qualification, with full capabilities due to be signed off in 2016.

British Army pilots have now begun Watchkeeper flying over the Salisbury Plain Training Area.

"The current RTS is representative of the current build standard," explained Thornhill. "It's very good, and allows us to use virtually all the capabilities; the only things we lack are the ability to operate from rough surfaces and the anti-icing system."

The current RTS could potentially allow the system to deploy to Afghanistan, but Thornhill said the priority is to establish the Watchkeeper's capabilities and build training and experience on the system for future deployments. An interim training capability is planned for 2015, although some consideration is already being given to deploying the system to other army training areas including the British Army training unit Suffield (Batus) in Canada.

For the MAA, certifying the system has been a challenge. In its annual report, published in early April, the regulator said it had difficulty certifying the system's software because of what it called "difficulty in demonstrating compliance with recognized and approved design standards." The structure inside flying units has also changed, as a result of the accident inquiry into the loss of a Hermes 450 ZK515 in October 2011. Part of this has seen the army's operating responsibilities, particularly in terms of aviation safety, align with those of senior officials within the U.K. Joint Helicopter Command.

The French army maintains a keen interest in the program, and is considering a purchase of 20-30 systems. Several French personnel are training on the system alongside their British counterparts at Larkhill, Wiltshire.