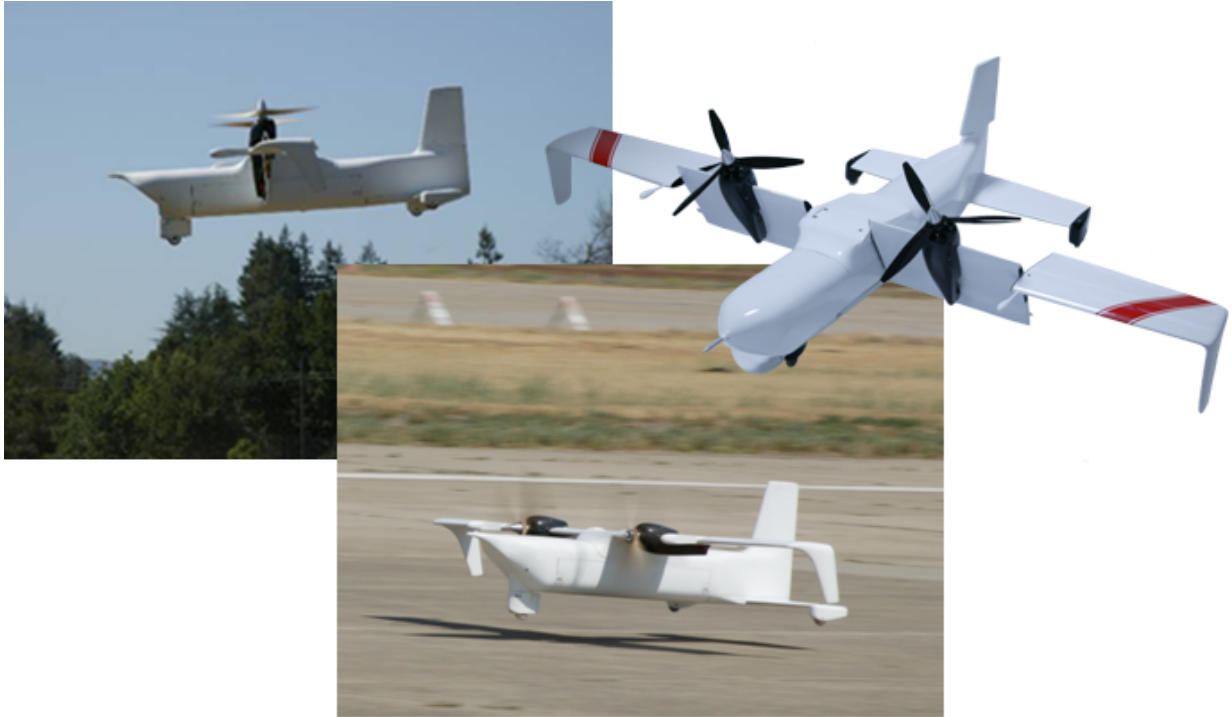


# AT-10 Electric/HF Hybrid VTOL UAS

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## Summary

The AT-10 is a tactical size hybrid propulsion VTOL UAS with a nose camera mount and a large payload bay. Propulsion is provided by twin electric motors and batteries installed in the wings. The inner section of each wing rotates for the transition between vertical and forward flight. For flights of two hours or less, additional batteries in the upper fuselage provide all-electric propulsion. For longer endurance a heavy fuel generator, fuel cell, or other energy conversion system may be included in the aft fuselage. Analysis shows that this configuration is lighter and more efficient than using internal combustion engine(s) for both VTOL and forward cruise, and this advantage will increase as electric power technology evolves. In addition, the electric power system can provide over 1000 Watts of power for payloads. Unlike many runway-independent UAS, the AT-10 requires no catapult or arresting gear.

Acuity is seeking R&D / EMD funding to develop the AT-10 into an operational VTOL UAS based on fuel/electric hybrid propulsion. The components of the planned system are

- The air vehicle with electric motors, batteries, and battery charge/balance controller.
- An on-board heavy fuel base small engine based generator, which can be used in flight and on the ground.
- Flight control computer, sensors, and software for vertical and forward flight.
- Ground station for flight operations, simulation and pilot training.
- Payload: Sensors and communication equipment integrated with the vehicle and ground station.

Acuity has tested the AT-10 in hovering and forward flight. A flight video is available at [www.acuitytx.com/](http://www.acuitytx.com/)

## Capabilities

- Autonomous vertical takeoff, landing: No catapult or arresting gear
- Land under GPS, DGPS, or optical beacon guidance
- Loiter in hover or low-power, low noise forward flight
- Patrol at 15,000 feet fully loaded
- Heavy fuel generator supplying electric propulsion system
- Landing gear built into flight surfaces: No retracts needed
- Accommodates up to 9" EO/IR turret and 30 lb payload
- Max Speed: 135 kt Vne, 125 kt max level
- Climb: 1200 fpm SL
- Ceiling: 15,000 ft

## Specifications

Wing Area:	9.5 sq ft
Wingspan:	9.3 ft
Fuselage Length:	8 ft
Payload/Fuel Bay:	10" by 10" (3" corner radii) by 36", plus nose camera turret
Batteries, Fuel:	40 lb
Max Gross Weight:	120 lb Forward Takeoff, 100 lb Vertical Takeoff
Max Range Cruise Speed:	83 kt
Max Endurance Loiter Speed:	58 kt
Stall Speed:	53 kt
Cruise Fuel Consumption:	3.75 lb/hr
Loiter Fuel Consumption:	1.75 lb/hr

## Background

Low cost easy to use long endurance unmanned air systems are needed for military, homeland security, law enforcement and commercial purposes. To date several factors have impeded the deployment of such vehicles. These include the availability of easy to use small powerplants and the need for prepared launch and recovery sites or cumbersome launch and recovery equipment. Many UAS developers are moving toward catapult launch and arresting gear or

parachute recovery, since conventional helicopters have speed, endurance, and safety limitations. However, a catapult multiplies the size and weight of the system, reducing launch-anywhere capability and restricting remote landing site options.

Although battery and fuel cell technology is not currently adequate to support long endurance UAS missions, this is expected to change in the next 3 to 5 years. The ease of use, quiet operation, and high power to weight ratio of brushless motors make electric power one of the key enabling technologies for widespread use of small UASs. The characteristic of high torque at low rpm in electric motors makes VTOL and high speed forward flight practical without variable pitch props or gearboxes. Electric motors, in addition to being easier to use and maintain than small engines, also produce less vibration and noise. This is a significant advantage in unobtrusive, high resolution surveillance missions.

For long endurance flights, a small internal combustion driven generator which can be turned on and off in flight can provide electric power for cruise propulsion, recharging batteries, and high power payloads such as LADAR, SAR, and GPR systems. Unlike combustion engines used directly for propulsion, this engine and its generator can be well isolated in all axes, essentially eliminating vibration and torque effects in the airframe.

### **Takeoff/Landing Navigation**

If the landing location and control station are fixed, precision vertical landings using DGPS are possible. For all fixed locations GPS can be used if the landing area is large enough to accommodate GPS error. Touchdown point error is less than 10% of that of a forward landing UAS under GPS, as the interaction of vertical GPS uncertainty with glide slope does not come into play.

For mobile platforms such as a ship or cutter where ground station position and direction relative to the landing point are available to the UAS, DGPS can also be used. Optical/IR beacons or reflectors with directional sensors on the aircraft for precision landings may also be used. Acuity has extensive experience designing and producing laser based optical/ IR sensor systems, and plans to investigate the potential of an optically based landing control system. This would have the advantage of operating in radio silence and in GPS-denied conditions. Manually guided landings are possible as a backup to automatic systems, using the AT-10's planned stabilized pilot guided mode of flight.

Forward takeoff can increase gross weight and payload capacity where a runway is available. In the event of heavy loading, one-engine-out, or other atypical conditions, forward landings are also possible.

### **Ground Station**

Commercially available ground station software will be adapted and extended for use with the AT-10. Several ground stations and remote video terminals are available, and Acuity is investigating the maturity, and extensibility of each. The ground station must be able to accommodate vertical takeoffs and landings as well as hovering flight, and allow the operator to control the vehicle subject to hover time and battery capacity constraints. The ground station

should also be configurable to work with software or hardware based simulation of the AT-10 and its characteristics. All ground stations being considered implement the STANAG 4586 standard for autonomous systems.

Acuity will ensure that common remote video terminals such as AAI's One System® Remote Video Terminal (OSRVT) are compatible with the avionics and radio systems in the AT-10. Military and perhaps DHS communications systems will be based on mini-TCDL systems such as those from L-3 West Systems.

## **Transportation and Storage**

Unlike many runway-independent UAS, the AT-10 requires no catapult or arresting gear. The wings are removed from the fuselage as one piece and stored alongside the fuselage. Similarly, the horizontal tail/landing gear assembly is removed with two bolts. The left and right wingtips can also be removed for more compact storage. Together with a rugged laptop based ground station, transfective or high brightness indoor/outdoor display, radio control transmitter, battery charger, spare parts and toolkit, the entire system can be transported in a 2 ft by 2 ft by 8 ft container weighing less than 150 pounds.

## **AT-10 Present Status**

Acuity has designed, constructed, and begun flight testing the prototype AT-10 shown above. Propeller testing resulted in selection of three bladed propellers generating 50 lb of static thrust per engine. Flight testing began in May 2009. To date it has encompassed low altitude vertical flight and forward takeoff and landing flights. All flights have been under direct pilot control with gyro-based attitude stabilization. The AT-10 has proven easy to fly manually in both vertical and forward flight, augering well for velocity and position loop closure in fully automated flight.

The autopilot / flight control system in development is based on a proven RTOS and COTS hardware. Vehicle state estimation hardware, sensors, and software have been flight tested on other aircraft. Integration in to the AT-10 and a control algorithm are the next steps in flight avionics development.

## **Heavy Fuel Engine**

Acuity has had discussions with Cosworth LTD regarding use of their AE1 or similar heavy fuel engine as a power generation source for in-flight battery recharge. The AE1 can supply 3.5 HP for the level flight cruise requirement of the AT-10, payload power, and in-flight battery recharging. Power for vertical takeoffs and landings is supplied by lithium batteries in the wings.

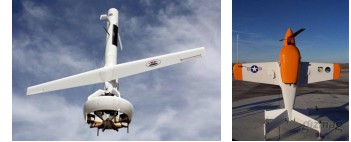
## AT-10 Tiltwing Design Advantages Over Other VTOL Aircraft

### Relative to helicopters:

The AT-10 wingspan is smaller than the rotor diameter of helicopters with the same payload. Endurance with generator is several times that of helicopters. The AT-10 is less susceptible to rotor/propeller strikes since the wings and fuselage surround the propellers. Descending winglets with skids protect the propellers in the event of roll excursions on takeoff or landing.

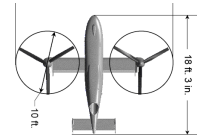
### Relative to tail-down VTOLs:

With a lower center of gravity and wider landing gear, the AT-10 is less susceptible to wind and pitching, rolling ship decks. The vertically oriented wing area is limited to the area in the propwash, and only when wings are in position for vertical flight.



### Relative to tiltrotors:

A fixed wing and pivoting propellers and/or engines define a tiltrotor. There are no small tiltrotor UASs known to Acuity at present. Larger tiltrotor vehicles such as the Eagle Eye UAS and the Osprey have small wing area and limited low power loiter and endurance. The hazard from tip-mounted rotors is also greater than that from the AT-10's inboard propellers.



**Bell Eagle Eye**

For more information see [www.acuitytx.com](http://www.acuitytx.com) or contact Robert Clark.