Sagetech, Arcturus Demonstrate Joint Manned, Unmanned Aircraft Operations using COTS NextGen ADS-B Tracking

Executive Summary

Sagetech Corporation, an avionics company, and unmanned aircraft manufacturer Arcturus UAV will demonstrate the use of the "NextGen" Automatic Dependent Surveillance-Broadcast (ADS-B) system to facilitate joint operations between unmanned and manned aircraft by providing operators and pilots in-flight tracking of all participating aircraft. The event will be staged from McMillan Airfield in Camp Roberts, California, on October 24, 2012.

Aircraft will use Sagetech XP transponders to broadcast ADS-B position messages. These messages are received by Sagetech Clarity ADS-B receivers, which relay them via Wi-Fi link to an iPad for display with Hilton Software's WingX Electronic Flight Bag (EFB) app. The demonstration employs low cost COTS equipment of a type now readily available as a result of ADS-B system deployment coupled with a surge in popularity among general aviation (GA) pilots of inexpensive receivers that work with an iPad.

One goal of the demonstration is to show that joint manned/unmanned aircraft operations are feasible now, in circumstances where use of this equipment kit can be assured. Examples are aircraft firefighting operations within TFR (Temporary Flight Restriction) controlled airspace and military range operations.

Figure 1- Inexpensive COTS equipment is used to track aircraft during joint manned/unmanned aircraft operations. Aircraft transmit location using the NextGen ADS-B system via tiny Sagetech Transponders. Sagetech Clarity ADS-B Receivers working with iPads receive location signals and display aircraft as icons overlaid on aviation charts. Pilots, UAV Operators, and Mobile Ground Personnel easily maintain awareness of real-time aircraft positions and flight paths.

Overview

The Value Proposition

The ability to see and avoid aircraft is a fundamental challenge with combined unmanned/manned aircraft operation. Unless the unmanned aerial vehicle (UAV) is equipped with a sophisticated camera system, it's nearly impossible for the UAV operator to gain awareness of the locations of other aircraft. Pilots of manned aircraft have difficulty visually detecting drones because they are generally small and hard to see. The ADS-B Out system can simplify locating other aircraft by providing pilots and operators real-time overlays of aircraft location, making visual detection less important in the task of assuring separation and collision avoidance.

Sagetech and Arcturus will demonstrate the combination of a new FAA NextGen ADS-B system and off-the-shelf hardware and software to show how manned and unmanned aircraft can jointly operate in the same airspace. Drone operations can be enhanced, for example, without penalizing manned aircraft by further restricting airspace. Using inexpensive equipment like iPads that are already finding use in GA cockpits, operators, range personnel, and others can readily track unmanned aircraft. We do not suggest this is a complete Sense and Avoid solution that allows for broad use of drones in the civil airspace. Rather, this demonstration is intended to spark ideas and nurture creative approaches to how we can take small steps toward combined unmanned/manned operations.

Applications where this unique combination can be used to enhance the usefulness of UAV missions are numerous. Military ranges can now track use of their airspace by guest organizations simply by adding a small transponder brick weighing only a few ounces that enables Range Control personnel to track guest drones using stand-alone, independent systems.

Forest fire areas of operation, in which TFRs (Temporary Flight Restrictions) restrict aircraft, can now replace expensive helicopters with drones that will help manage ground-based and aircraft firefighting strategies and monitor their effectiveness. Flight crews and ground personnel can be issued easy to use iPads and ADS-B receivers, allowing pilots to monitor locations of drones, and ground personnel to see the locations of all aircraft as firefighting operations progress, increasing safety and situational awareness.

Domestic Demand for Drones

Unmanned air vehicles (UAVs) have come of age on the battlefield, and here at home there is pressure on the FAA to create rules for the use of UAVs in civil airspace. Indeed, Congress has mandated that the FAA allow civil and military drones in civilian airspace by 2015.

Law enforcement and border patrol organizations have become early adopters among civil users of unmanned aircraft. Use of drones by law enforcement is presently limited, with line-of-sight control of small quad-rotor hover vehicles offering only marginally more capability than simple aircraft long used by R/C (radio control) hobby enthusiasts. Customs and Border Patrol are using more capable aircraft and operate nine Predator drones as of this writing. The Department of Defense is the primary force behind drone popularization, and they themselves have need for increased access to airspace for training.

ADS-B NextGen, Simple Effective Flight Tracking

Meanwhile, the FAA has been busy upgrading the way Air Traffic Control locates airplanes, adding the "NextGen" ADS-B system infrastructure to their existing legacy radar systems. The ADS-B system is a world standard inspired by the success of a similar maritime system allowing ships to electronically track one another to avoid collision.

The NextGen concept is simple. Aircraft transmit GPS position and fight information reports by way of "ADS-B Out" messages. ADS-B Out capability will be required of virtually all aircraft in the US by Jan 1, 2020. Europe, Australia and the world in general are also adopting ADS-B Out requirements.

One major benefit of the NextGen ADS-B system is that the equipment required to send and receive aircraft position reports can be inexpensive. Sagetech makes an ADS-B transponder that weighs just 3.5 oz. (100g), making it feasible for use in drones as small as 10 lbs.

A Confluence of Technology

Small ADS-B data receivers are available, enabling surrounding ADS-B Out equipped aircraft to be displayed using increasingly popular "Electronic Flight Bag" apps running on Apple iPads. ADS-B receivers allow pilots to access free in-flight weather data broadcast from FAA ADS-B ground stations, a service previously available only by paid subscription to Sirius Satellite Radio. Some of these ADS-B receivers, like Sagetech's Clarity, are capable of receiving ADS-B Out position reports.

Drone and manned aircraft alike can be tracked anywhere within an operations area up to 100 miles in diameter using inexpensive equipment:

- Small transponders on drones and manned aircraft
- iPads and EFB apps for pilots and ground personnel
- Portable low cost ADS-B receivers

These facilitate the ability for UAV operators and pilots to self-deconflict flight paths, and this is what will be demonstrated on Oct 24, 2012 at Camp Roberts, CA.

Aircraft and Equipment

The Arcturus T-20 Unmanned Aircraft

Arcturus UAV operators will operate a T-20 unmanned aerial vehicle (UAV) outfitted with a Sagetech XPST Mode S ADS-B Out Transponder from McMillan Airfield. The T-20 UAV will be controlled by radio-link with a Cloud Cap Piccolo Autopilot. The transponder will periodically (twice/second – more often and timely than what radar itself can provide) broadcast the flight position of the Arcturus T-20 UAV using the ADS-B Out system protocol. Additionally, the transponder will provide replies (squawk code and Mode-C altitude reports) to ATC radar interrogations. The squawk code and operation of the Sagetech XPS-TR transponder is controlled via the Piccolo autopilot ground station.

T-20 Relevant Equipment

- Non-certified Cloud Cap Piccolo Autopilot
- Non-certified Novatel GPS receiver provides ADS-B position
- Non-certified, compliant XPS-TR Transponder (presently undergoing TSO certification)
  - Squitters ADS-B Out position reports
  - Replies to SSR interrogations
  - Uses non-certified, compliant altitude encoder for Mode C replies (presently undergoing TSO certification)

Arcturus T-20 UAV (unmanned air vehicle)

Wingspan:	17.5 feet
Gross Takeoff Weight:	175 lbs.
Aircrew for Demonstration:	N/A
Ground Crew location:	McMillan Airfield, Camp Roberts, CA

Operated from McMillan Airfield inside Restricted Airspace R-2504 at 2,500' MSL and below

Figure 2 - The Arcturus T-20 Unmanned Aircraft is controlled by Cloud Cap's 7.9oz. Piccolo II Autopilot and carries a 3.5oz Sagetech XPS-TR Mode S ADB-Out Transponder which broadcasts position reports using the NextGen ADS-B protocol.

Piloted Cirrus SR-22

A standard, piloted Cirrus SR-22 aircraft will takeoff from Paso Robles airfield to conduct simultaneous flight operations with the Arcturus T-20 UAV. The Cirrus will also be equipped with an XPS-GPS transponder, with GPS receiver, which will broadcast the flight position of the Cirrus SR-22 using the ADS-B Out system protocol. The XPS-GPS transponder will be configured to suppress replies to ATC Radar interrogations. The XPST transponder/GPS receiver will be operated as equipment under 14 CFR Part 91.21, Portable Electronic Devices. The Cirrus SR-22 will be equipped with a TSO-certified Garmin GTX 327 Mode C transponder which will reply to ATC interrogations.

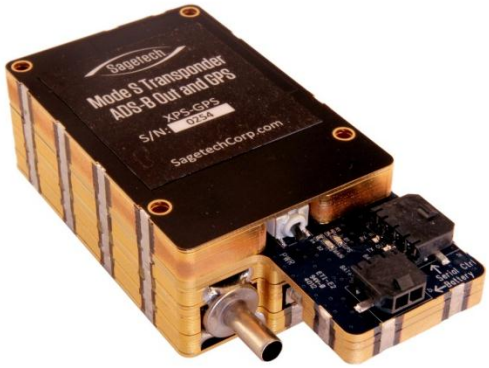
SR-22 Relevant Equipment

- Non-certified, compliant XPS-TR Transponder (presently undergoing TSO certification)
  - Squitters ADS-B Out position reports. Position derived from non-certified COTS GPS receiver
  - Will not reply to SSR interrogations
- Certified Garmin GTX 327, certified altitude encoder that replies to SSR interrogations

Cirrus SR-22

Wingspan	38.3 feet
Gross Takeoff Weight:	3,400 lbs.
Aircrew for Demonstration:	1 pilot
Ground Crew location:	N/A

Operated outside Restricted Airspace, 3500' MSL and above, 1 nm from Restricted Airspace boundary. Operated under 14 CFR Part 91 Rules.



ADS-B Out position reports broadcast from Sagetech XPS-GPS Standalone Transponder, operated as a 14 CFR Part 91.21 Portable Electronic Device

ATC Secondary Surveillance Radar (SSR) replies will be by a TSO-certified Garmin GTX-327

Figure 3 - In the SR-22, a Sagetech XPS-GPS Standalone Transponder will provide ADS-B Out position reports operating as portable electronic equipment. An installed Garmin GTX 327 will reply to ATC Radar Interrogations

Sagetech XPS Transponders

Two variants of the Sagetech XPS-TR transponder will be used. In the UAV, the XPS-TR will be connected to the Cloud Cap Piccolo autopilot and will receive position information from a Novatel GPS receiver.

The Cirrus SR-22 will carry the Sagetech XPS-GPS Standalone Transponder, powered by a battery pack. This transponder powers up in the last stored configuration simplifying in-flight operation to use of a simple power switch. The XPS-GPS will be configured to transmit ADS-B Out position messages, but to suppress replies to ATC SSR (secondary surveillance radar) interrogations. It has an internal GPS receiver and GPS antenna, and employs a small whip-antenna for 1090MHz ADS-B Out transmissions. The ultra-compact form factor makes it feasible for use even on a skydiver.

The ADS-B Out messages broadcast from each of the two aircraft are called "Squitter" messages because they are broadcast at will, rather than in reply to interrogations. The ADS-B Squitter messages will be sent from the XPS transponder on each respective aircraft twice per second. The messages will include their respective aircraft position, course, velocity, and altitude.

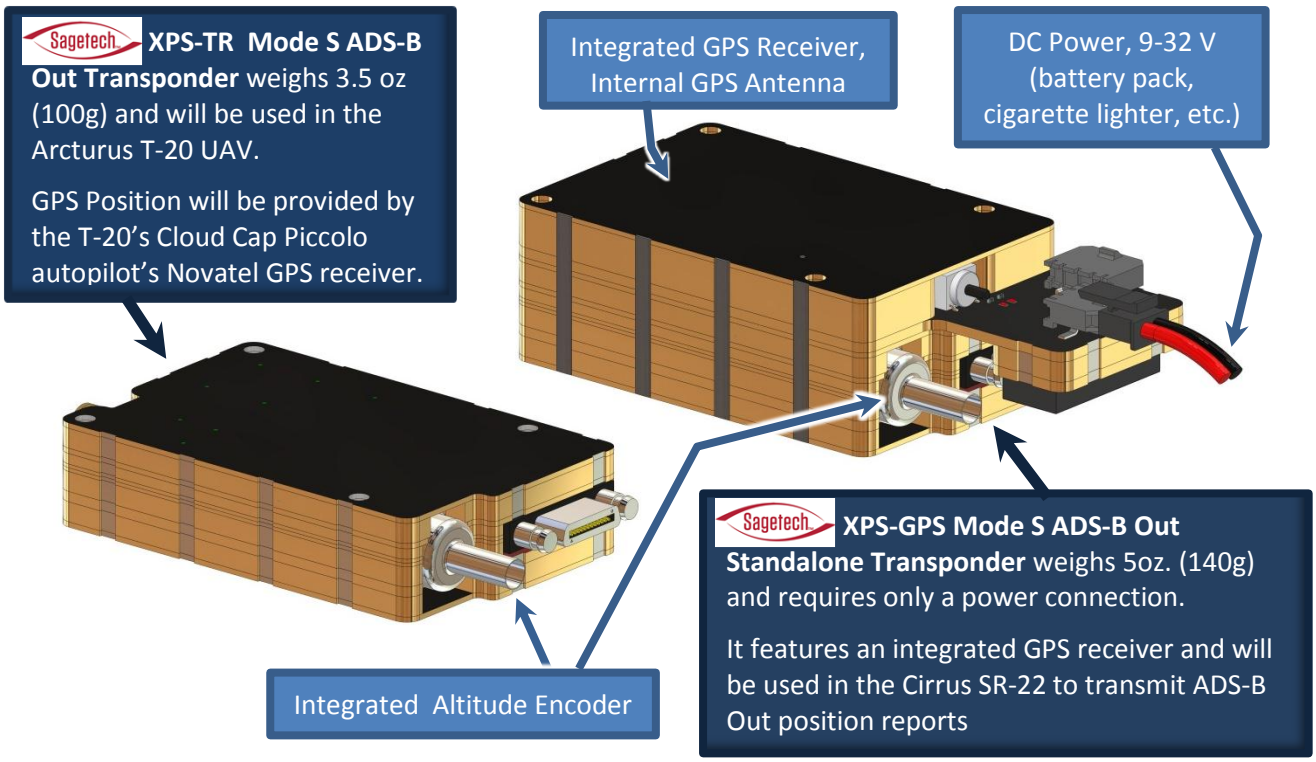


Figure 4 - The Arcturus T-20 UAV will be equipped with a Sagetech XPS-TR Mode S ADS-B Out Transponder (left) to reply to ATC interrogations and "squitter" ADS-B Out position reports. The Cirrus SR-22 will use a Sagetech XPS-GPS ADS-B Out Transponder w/ GPS (right) to "squitter" ADS-B Out position reports.

Clarity ADS-B Receiver / iPad

Arcturus operators, the Cirrus pilot, and mobile ground personnel will be provided with Sagetech Clarity ADS-B receivers and Apple iPads that allow for tracking of all participating aircraft. UAV operators and pilots can easily self-separate, avoiding the need for panicky collision avoidance maneuvers. Ground personnel can maintain situational awareness as a mission progresses thanks to seeing aircraft locations in real-time.

The signal chain is straight forward. Aircraft XP transponders transmit ADS-B Out position messages. These messages are received at ranges up to 100 miles by portable Clarity ADS-B receivers. The Clarity instantly relays the position message over a Wi-Fi link to a nearby Apple iPad. The iPad, running Hilton WingX software, processes the position report message and plots as a chart-overlay the location of the aircraft as well as additional information about flight path and altitude.

Figure 5 - The Sagetech Clarity ADS-B Receiver is a COTS part that receives ADS-B broadcasts of location from the SR-22 and T-20 for display on an iPad (shown with WingX EFB software), overlaid on a VFR Sectional Chart

Schedule and Operations

Arcturus personnel will conduct general flight testing of the T-20 UAV from Monday, Oct 22, 2012 through Wednesday Oct 24, 2012. Sagetech will arrive on Monday Oct 22, and begin preliminary checks and coordination.

Flights in preparation for the demonstration will take place on Monday and/or Tuesday. There may be opportunities to witness the system in action during this time.

The Primary demonstration will take place on Wednesday Oct 24. Nominal Schedule:

- 0800 Preflight briefing, McMillan Airfield
- 1000 Launch of T-20 from McMillan Airfield; SR-22 Takeoff from Paso Robles Airfield
- 1000-1100 Demonstration of ADS-B Out operations
- 1230 PM Out-brief, McMillan Airfield

The Arcturus T-20 UAV will launch from / recover to McMillan Airfield and conduct flight within the confines of R-2504, at or below 2,500' MSL.

The Cirrus SR-22 will launch from / recover to Paso Robles Airfield and will remain at least 1 nautical mile from the boundary of R-2504. The SR-22 will maintain altitude at or above 3,500' MSL, except during takeoff and landing at Paso Robles Airfield.

This will provide a nominal lateral separation of at least 1 nautical mile and a vertical separation of at least 1,000 feet.

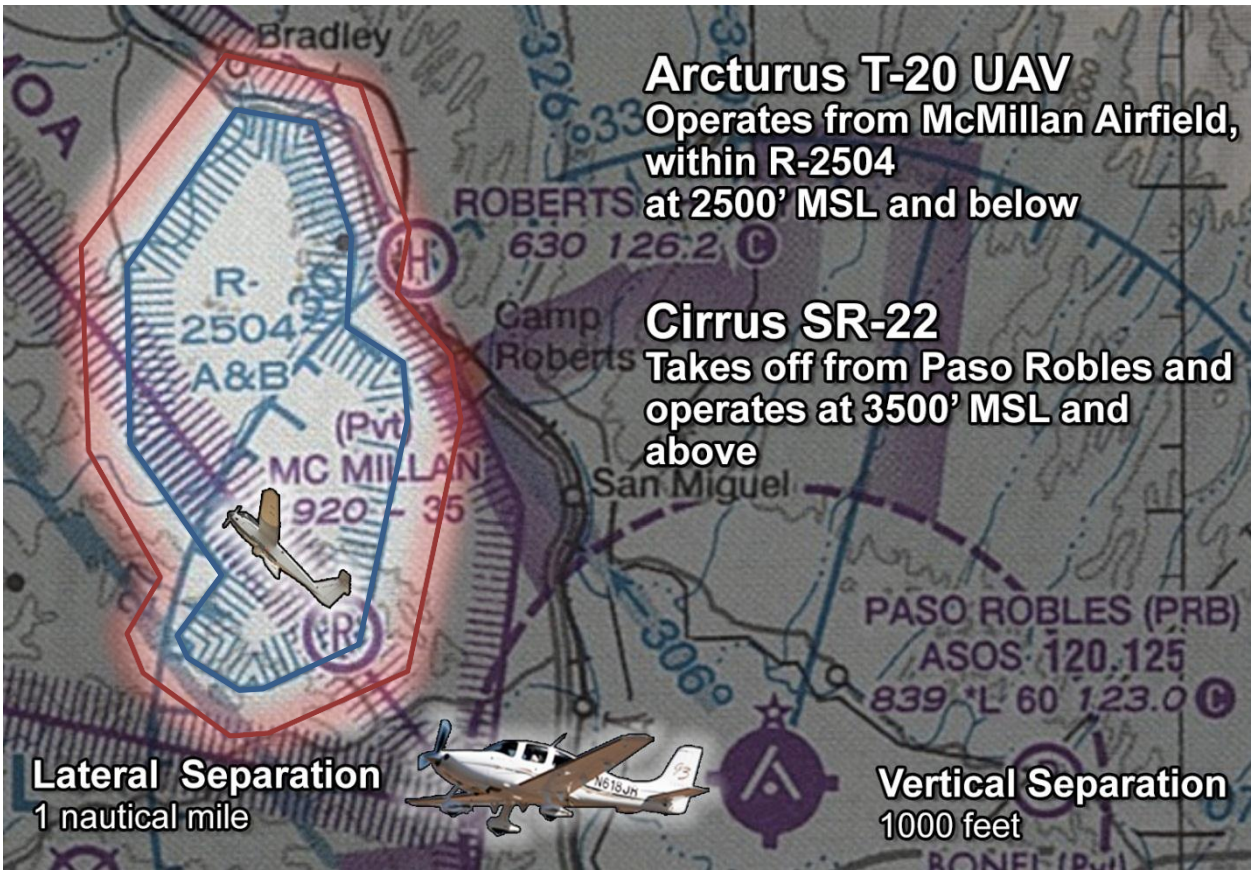


Figure 6 - The Arcturus T-20 UAV and Cirrus SR-22 piloted aircraft will maintain 1000' vertical separation and 1 nautical mile lateral separation.

Personnel on Site

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About Arcturus UAV

Arcturus UAV has been designing, manufacturing, and flying UAVs for nearly a decade. Specializing in composite material engineering and construction with materials such as carbon fiber and Kevlar, Arcturus UAV reduces aircraft weight while increasing strength and rigidity. System integration and ease of payload changes through the use of interchangeable pallets has made Arcturus UAV the platform of choice for missions requiring specialized airborne equipment. More information is available at www.arcturus-uav.com.

About Sagetech Corporation

Sagetech Corp. provides world-class engineering and manufacturing of key avionics components to the aviation industry. The company currently designs and builds the world's smallest transponder for the UAV market. Sagetech was founded in 1998 and is a service-disabled, veteran-owned small business. It operates out of four facilities in Hood River, Oregon and White Salmon, Washington.