

UAV Transponders: Essential Technical Considerations for Your Next Program

UAV manufacturers are sifting through new and emerging technology requirements for transponder surveillance solutions to enable missions in civil and military airspace. Technical considerations are of serious consequence. There have been horror stories – UAVs lost for days, requiring airspace shutdown. Or, UAVs who lost transponder power and therefore went invisible to other aircraft while still in flight. Transponders are critical to the safety of manned and unmanned aircraft alike.

With careful attention to transponder specifications, manufacturers can avoid letting their programs become history lessons for future programs.

The Initial Set of UAV Transponder Considerations

Based on Sagetech's hands-on knowledge, as well as in-depth customer research, there are several technical parameters that should be evaluated during the initial due diligence phase.

Reliability. Integrating a transponder and syncing it with an autopilot and other systems requires significant engineering. Ensure you only need to do it once by selecting a highly reliable, proven product. For military applications, it's best to select equipment that is purpose-built to survive the most severe military environments. For civil applications, the specific use case will determine the reliability requirements. If it's mission-critical civil applications, such as firefighting, consider selecting a commercial-grade model that's built on proven military heritage technology.

In addition to performance, ask your supplier about quality. For example, over the last decade, what was the unit return rate for quality issues?

Output power over the full temperature range. Sagetech advises customers to watch for output power and power droop issues. This is essential for a transponder to be seen by ATC- or TCAS-equipped aircraft. At hot temperatures the transponders'

output power is likely to be reduced, which decreases the detection range. At cold temperatures, the max output power tends to increase, however droop during a transmission can be significant. If transmission droops out of spec (2dB), then ATC or TCAS ADS-B receivers will reject an aircraft's transmissions. If the transponder maintains full power over the specified operating temperature range and never falls below 2dB droop, its aircraft will remain visible.

Multiple communication ports. Essentially, plan for every current or future need. Having more than one communication port provides more flexibility for integration, such as one for GPS and one for command and control.

Autopilot integration. Integrating with various autopilots can cost significant time and expense. To get a program off the ground faster, ensure the selected transponder offers integration code and instructions for every major autopilot for fast, flexible integration.



The Next Level: Technical Considerations for Mission-Critical UAVs

For operation of unmanned aircraft in controlled airspace, where failure is not an option, consider these factors.

Multi-mode capabilities. Many UAV platforms perform civil and military missions; look for one transponder that can support both. To satisfy both sets of requirements, the transponder will need military modes 1,2,3 and 5, and civilian modes A, C, S and ADS-B out. Mode 5 is the newest NATO requirement for military programs, where the transponder communicates with a crypto computer to provide secure Identify Friend or Foe (IFF) functionality. [See Sagetech's article explaining Mode 5.](#)

Integrated ADS-B In. Often customers try to piece together a transponder with an external ADS-B In module, requiring time-consuming integration. Look for a transponder that includes this capability within the unit to simplify the system in terms of size, weight, and connections.

Demands continue to increase for ADS-B In. ADS-B In provides airspace situational awareness to enable proper decision-making, helping to avoid mid-air collisions. Having a certified ADS-B In receiver is the first step in making a safety case to fly BVLOS. Certified ADS-B In capability is an FAA requirement for Detect and Avoid Systems.

Ethernet connectivity. Ethernet provides a more robust and reliable solution than RS-232 or even some traditional military bus architectures. With ethernet, it is easy to implement communication redundancy and have more advanced diagnostics for failure isolation. Most major OEMs have shifted recently to ethernet for a more flexible system design and a lower overall SWaP solution. When reliability is a priority, make sure the transponder provides ethernet.

Visibility by ATC. Not all ADS-B messages can be seen by ATC. If the transponder and the GPS do not hold TSOs, then there are certain integrity fields in an ADS-B message that must be set to represent that. These fields are the Source Integrity Level (SIL) and System Data Assurance (SDA). If a system is uncertified, then these fields must be set below a 3 and a 2 respectively. However, when these fields are below a 3 and a 2, ATC discards the ADS-B message as it is not trustworthy. UAVs without certified equipment have an increased probability of transmitting a false position, which could lead to a mid-air collision. It is better just to rely on the traditional secondary surveillance radar and using Mode A/C functionality than it is to potentially transmit a false and misleading position.

Visibility by TCAS. Unlike ATC, TCAS systems will still receive ADS-B messages if the SIL and SDA values are below 3 and 2. The important parameter here to ensure visibility with TCAS is power droop during a transmission. TCAS (and ATC) systems will reject any transmission that droops more than 2dB during a transmission. This requirement is easy to meet at high temperatures but as temperature goes down, the effective capacitance is decreased. Transponders use large capacitor banks to store energy for the very high power and short transmissions. A lot of micro transponders remove too much capacitance to shrink their size and weight, but this typically results in too much power droop at colder temps. Study the datasheet to ensure power droops do not occur at colder temps in your transponder.



Ensure your transponder offers an existing autopilot integration to save engineering time and expense.

Antenna diversity. Top and bottom antennas provide more visibility above and below an aircraft. This enables the aircraft to be visible by space-based ADS-B systems as well as air traffic control on the ground. It gives everyone visibility of an aircraft's location while satisfying air traffic control with full situational awareness. Some transponders use a dipole antenna; however, the radiation is significantly reduced which provides less distance in each direction. Dedicated dual antennas provides greater reach and visibility for any mission-critical UAV, including reception by satellite-based ADS-B systems.

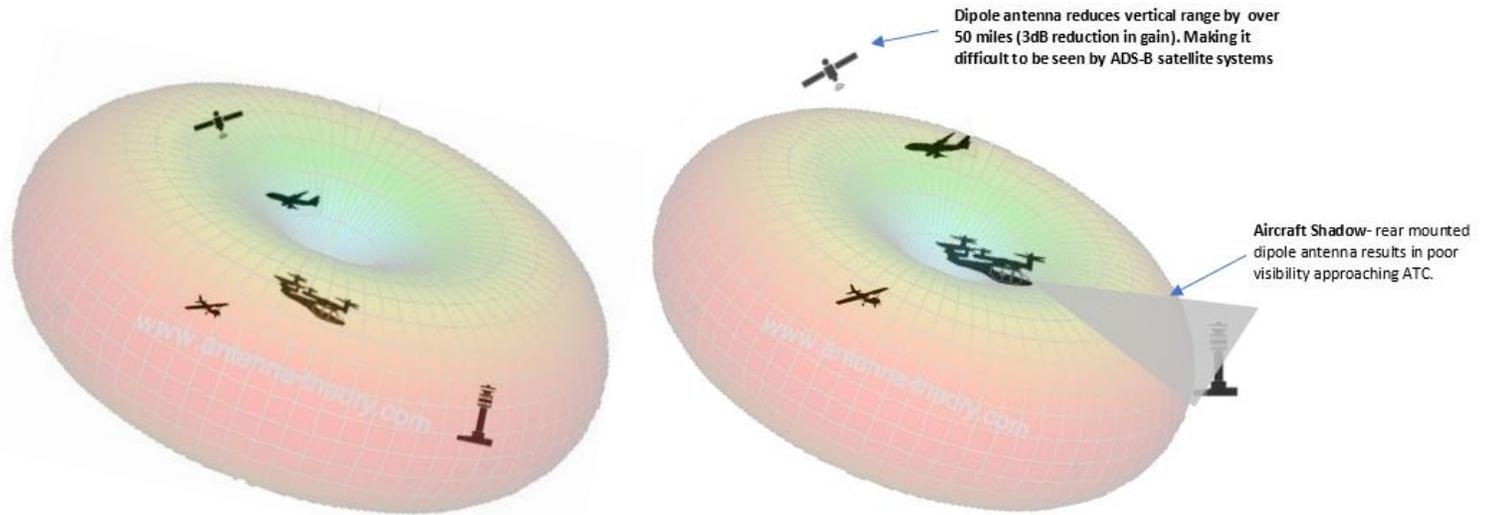
DO-160G compliant. DO-160G is a set of environmental specifications for hardware design certification. Make sure to scrutinize the category levels at which equipment is tested to ensure it meets the needs of your platform. Being able to

survive power surges, indirect lightning transients, and EMI susceptibilities are all critical to ensure a UAV remains visible in the airspace.

Other user-friendly features. Mutual suppression, maintenance mode, weight on wheels, configurable serial protocol and optional power down pins are all more I/O options that enable easier installations. Supplying a GUI for command and control or assisting in autopilot integration also helps streamline that process.

Finally, always ask customers about the support they receive. Does your supplier offer engineering support by phone or chat? Will they help you with integrations? With these complex systems, support can streamline and speed your development process.

True Antenna Diversity vs. Dipole Antenna



Top and Bottom Monopole Antenna

Dipole Antenna

Market forces are coming together to make transponders an increasingly important decision in future UAV programs. With the mix of transponders available, emerging standards and requirements, and the rapidly growing types of vehicles, this whitepaper should help you navigate the complexities and select the best transponder for your program needs.

About the Author

Matthew Hamilton serves as the CTO for Sagetech Avionics. In addition to his current role in transponder development, he's held previous roles where he developed and certified numerous transponders for unmanned aircraft.

For additional information on mission-critical transponders for UAVs, visit www.sagetech.com.

Essential Transponder Features to Consider

Basic Parameters		Advanced Parameters	
Parameter	Review Recommendation	Parameter	Review Recommendation
Reliability	Hours flown, quality returns	Capabilities	Modes you may need: A/C/S, 1-5
Output power	Constant power over full temp range with no droop	Integrated ADS-B Out	Mandated to fly in the NAS
Serial comms ports	Multiple protocols and ports	Integrated ADS-B In	Increase safety of your mission with situational awareness.
Autopilot integration	Ensure native integration with your selected autopilot	Ethernet connectivity	More robust, lower SWaP
Customer support	E2E phone/email support	TCAS visibility	Ensure there is no droop at cold temps
Certification	Levels you may need, such as DoD AIMS, FCC, etc.	Antenna diversity	Is space-based ADS-B coverage needed, is full airspace coverage needed
		DO-160G	Environmental requirements for the UAV
		Other	Mutual suppression Maintenance mode Weight on wheels Configurable serial protocol Others

Sagetech Avionics empowers safe flight in unmanned aircraft with the world's most reliable miniature transponders and related avionics solutions.

Sagetech's solutions are mission-proven with decades of program experience, certifications, and millions of flight hours, delivering dependable performance for military and civil programs.

Serving as customers' advisors and collaborators, Sagetech works in partnership to deliver compliant, innovative solutions that maximize value over the life of situational awareness systems.

Every day, UAVs worldwide fly safer with Sagetech on board.



1000 E. Jewett Road
White Salmon, WA
P: +1.509.281.3189
E: sales@sagetech.com

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