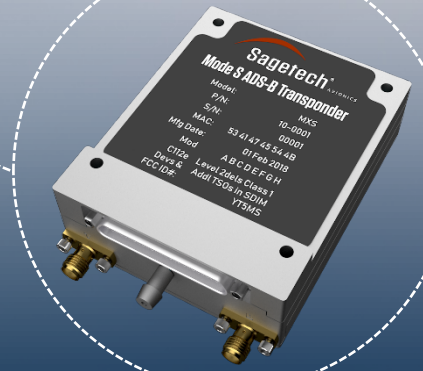
Sagetech AVIONICS

UAS Transponder Requirements and Guidelines

For 2020 and Beyond



INTRODUCTION

Sagetech spent the last decade empowering unmanned aerial systems (UAS) for safe flight by providing miniature, certified transponders to global OEMs for use on a wide variety of military and civil programs. With the continuous growth of the unmanned aircraft industry, and the anticipated trajectory to come with urban air mobility solutions, commercial civil applications, and more, we often get asked, **"Does my UAS need a transponder?"** This guide will provide some answers, guidelines, and context so that you can make an informed decision on incorporating transponders into your aircraft.

THE STANDARDS TODAY

In a word, the standards today are "emerging." To date, there is no single chart from any global agency that sums up the requirements for transponders on unmanned aircraft of all types, for all classes of airspace, in all geographies.

Therefore, this guide brings together the current best practices and knowledge from around the industry to serve as a reference as you create new unmanned aerial systems and vehicles. Consider the guidance, do your research, and make your own decisions based on your own UAS requirements.

Please note that this guide does not address recreational drone products or civil individual owner/operators. Those standards do exist in the United States and are provided for individual drone pilots by the FAA on their website.[1]

Rather, this article addresses transponder needs for the fleets of UAS serving in public safety, commercial, industrial, and military applications, which may require flight in controlled airspace, and which are greater than 20 pounds. For the purposes of discussion, we use both the terms UAS as well as Unmanned Aerial Vehicle (UAV) here.

Finally, this guide centers on the FAA guidance from the United States. Most countries adopt FAA rules by way of bilateral agreements, so for the purposes of discussion we will use the FAA as our cornerstone.

DOES YOUR UNMANNED AIRCRAFT NEED A TRANSPONDER?

An aeronautical transponder (short for *trans*mitter-re*sponder)* is defined as an electronic device that produces a response when it receives a radio-frequency interrogation. Aircraft have transponders to assist in identifying them on air traffic control (ATC) radar. Collision avoidance systems have been developed to use transponder transmissions as a means of detecting aircraft at risk of colliding with each other. The transponder receives interrogation from the Secondary Surveillance Radar on 1030 MHz and replies on 1090 MHz.[2] Transponders provide vital information to ATC, the Traffic Alert and Collision Avoidance System (TCAS, also known as ACAS), and potentially other aircraft.

Additionally, ADS-B is transforming aircraft communications. Recently, ADS-B Out was made a requirement on all aircraft flying in controlled airspace. According to the FAA, "Real-time precision, shared situational awareness, advanced applications for pilots and controllers alike – these are the hallmarks of ADS-B NextGen surveillance. Real-time ADS-B is now the preferred method of surveillance for air traffic control in the National Airspace System (NAS)."[3]

Advanced transponders today offer these technologies, ideally integrated into a single electronic device, to satisfy aircraft airworthiness requirements.

In answer to the question, "Does your UAS need a transponder," the short answer is: it depends. Next we'll discuss how the mix of your mission parameters and airspace requirements plays into your transponder decision.

CONSIDERATION PARAMETERS

When our customers ask if a program requires a transponder, we respond with a set of parameters to help them decide.

1. How big is your aircraft?
Typically, aircraft that need to fly in controlled airspace are of significant size and weight, usually more than 55 pounds. Smaller aircraft, perhaps down to 20 pounds, may also operate under Part 91 rules if they are flying beyond visual line of sight (BVLOS) in National Airspace, above 400 feet AGL. To incorporate a UAV transponder, which is about the size of a deck of cards, along with its antenna(s), the UAS must be large enough.

The U.S. Department of Defense classifies UAS into five groups, shown below, with each category increasing in capability.

Typically, civil UAS that align with groups 2-5 can have missions requiring integration into controlled airspace and if so, will require a transponder for visibility by ATC and TCAS. For military UAS, transponder need is determined by military mission controllers.

2. What kind of aircraft is it?
Beyond size and weight, UAS can come in many formats, ranging from the familiar military surveillance drone to weather balloons, high altitude pseudo-satellites, eVTOLs, and a whole host of other aircraft classes that are currently flying or in design. With airspace increasingly crowded, if your aircraft of any kind will fly or operate in or through controlled airspace, you and others will need to keep track of it for safety reasons and you will need a transponder, unless otherwise directed by the FAA.

3. How far will you fly your aircraft?
UAV operation falls into two scenarios – those flown within line of sight and those flown beyond the visual line of sight (BVLOS). If your program requires vehicle flight BVLOS, regardless of height or other restrictions, a transponder will most likely be required for keeping track of it as well as increasing the safety of nearby aircraft.

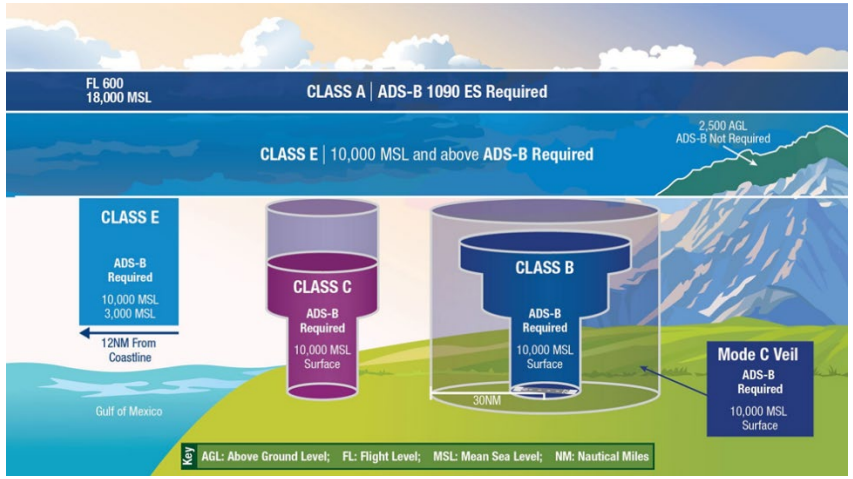
UAS Group	Maximum Weight (lb) (MTOW)	Nominal Operating Altitude (ft)	Speed (kn)	Representative UAS
Group 1	0-20	< 1,200 AGL	100	RQ-11, Raven, WASP
Group 2	21-55	< 3,500 AGL	< 250	ScanEagle, Flexrotor, SIC5
Group 3	< 1,320	< FL 180	< 250	V-BAT, RQ-7B Shadow, RQ-21 Blackjack, Navmar RQ-23 Tigershark, Arcturus - UAV Jump 20, Arcturus T-20, AATI Resolute Eagle, SIC25
Group 4	> 1,320	< FL 180	Any airspeed	MQ-8B Fire Scout, MQ-1A/B Predator, MQ-1C Gray Eagle
Group 5	> 1,320	> FL 180	Any airspeed	MQ-9 Reaper, RQ-4 Global Hawk, MQ-4C Triton

U.S. Department of Defense

4. How high are you flying?

U.S. airspace is organized by altitude and proximity to airports. According to the FAA, "Operations in Class G airspace are allowed without air traffic control permission. Operations in Class B, C, D and E airspace need ATC authorization." In addition to a transponder, the FAA mandates: "You must be equipped with ADS-B Out to fly in most controlled airspace."[4]

If your aircraft flight plan requires ATC services, it will need a transponder to provide visibility to ATC.



"If you fly in this airspace you must be equipped with ADS-B." FAA.gov

Airspace	Altitude
Class A	All.
Class B	Generally, from surface to 10,000 feet mean sea level (MSL) including the airspace from portions of Class Bravo that extend beyond the Mode C Veil up to 10,000 feet MSL (e.g. LAX, LAS, PHX).
Class C	Generally, from surface up to 4,000 feet MSL including the airspace above the horizontal boundary up to 10,000 feet MSL.
Class E	Above 10,000 feet MSL over the 48 states and DC, excluding airspace at and below 2,500 feet AGL. Over the Gulf of Mexico at and above 3,000 feet MSL within 12 nautical miles of the coastline of the United States.
Mode C Veil	Airspace within a 30 NM radius of any airport listed in Appendix D, Section 1 of Part 91 (e.g. SEA, CLE, PHX) from the surface up to 10,000 feet MSL.

5. What airspace rules apply to your program?
The military defines its own Military Operations Area (MOA) airspace requirements for unmanned drone operation. In the United States, civilian and military pilots have equal rights to MOA airspace, and both have equal responsibility to see and avoid other air traffic. MOAs serve as a warning, since military aircraft often fly at high speeds and are intentionally difficult to see.[5] If your aircraft will fly through an MOA, you should include a transponder.

For civil programs, the FAA offers rules under 14 CFR 107 and 14 CFR 89 (the new Remote ID rule) that define the rules for aircraft flying at low (< 400 ft AGL) altitudes. Operations under Part 107 or Part 89 do not require a transponder. Some unmanned aircraft fly under FAA Part 91 guidelines (or Part 135 for cargo aircraft) in Class A-E airspace, or BVLOS above 400 ft AGL in Class G airspace. If this is the case, a type certification or FAA waiver will probably be required as well as a transponder with ADS-B.

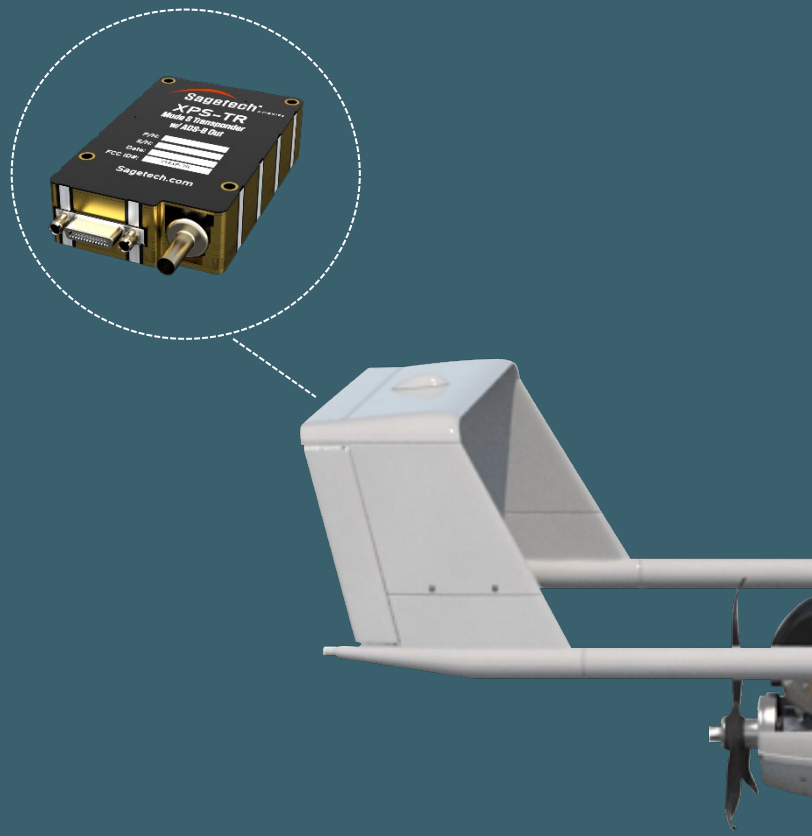
Military Airspace	Part 89 and Part 107 Airspace	Part 91 and 135 Airspace
Include IFF transponder	No transponder necessary	Include transponder with ADS-B

These airspace requirements are the base set of requirements in the United States. Sagetech recommends you check with your own country's air authority to ensure you comply with their requirements as well. Below are some non-U.S. references for some of the larger unmanned aircraft markets around the world.

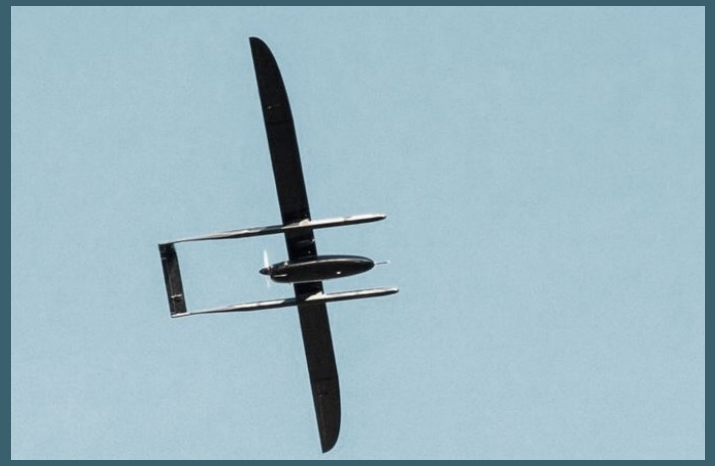
Reference sources 7,.8, 9

Agency	Document	Summary
EASA, European Union	Easy Access Rules for Unmanned Aircraft Systems	Transponder use may be required depending on flight plans, may be required to make a waiver safety case.
Transport Canada	Part IX – Remotely Piloted Aircraft Systems, 601.03, 605.35, 901.46	Transponder use is required in anything classified as "transponder airspace," which includes Classes A, B, C and can be specified in Classes D and E. Balloons or gliders may be exempt. Since Transport Canada uses a satellite-based ADS-B infrastructure, it is highly recommended to use a diversity (top and bottom antenna) ADS-B transponder for adequate flight path visibility.
CASA, Australia	Remotely piloted aircraft systems - licensing and operations.	Similar rules to the FAA regarding requirements >400 AGL and BVLOS.

A transponder on board supports the safety justification requirement for an FAA waiver.



WHAT CAN HAPPEN?



Latvian Drone Fueled for Days Goes Missing, Restricting Airspace

The Latvian aviation authorities were required to restrict flights below 19,500 feet for days while they searched for the lost UAV. The drone was eventually found in a tree. With a transponder on board, air traffic control plus the operators would have understood immediately where the drone was last seen, saving the country four days of airspace restrictions plus the human resources to hunt down the drone's location.[10]

Source: BBC. Read the full article.

6. Finally, how "disposable" is your UAV?
If your UAV collects sensitive intelligence, or carries munitions, or is otherwise considered to provide potentially sensitive information for your organization, Sagetech recommends it carry a transponder for accurate tracking and retrieval in the event of a failure.

We recommend transponders that include ADS-B for use in aircraft that fly above 400 feet, in any class of airspace, controlled or not controlled, for visibility to your own operators as well as for public safety.

WHAT TRANSPONDER FUNCTIONALITY WILL MY UAV NEED?

Aviation transponders provide several RF communications protocols, or "Modes," for communication. Select the transponder type according to FAA and DoD AIMS requirements for your mission.

Additionally, there are two S mode functions of ADS-B: In and Out, which can be packaged together in an integrated transponder. From the FAA:

"ADS-B Out works by broadcasting information about an aircraft's GPS location, altitude, ground speed and other data to ground stations and other aircraft. Air traffic controllers and aircraft equipped with ADS-B In can immediately receive this information. This offers more precise tracking of aircraft compared to radar technology, which sweeps for position information every 5 to 12 seconds. Aircraft operating in most controlled U.S. airspace must be equipped with ADS-B Out.

"ADS-B In provides operators of properly equipped aircraft with weather and traffic position information delivered directly to the cockpit."[11]

Whereas ADS-B Out is a requirement on UAVs in manned airspace, equipping the aircraft with integrated ADS-B In provides the additional situational awareness of other aircraft operating in the vicinity of the UAV.

Sagetech offers products that support all current transponder modes, and some models offer ADS-B In and Out or just ADS-B Out. For a complete discussion of transponder technical considerations, view our whitepaper.

NATO requirements, source 12

Military Mode	Civilian Mode	Description
1		Provides 2-digit 5-bit mission code (cockpit selectable).
2		Provides 4-digit octal unit code (set on ground for fighters, can be changed in flight by transport aircraft).
3	A	Provides a 4-digit octal identification code for the aircraft, set in the cockpit but assigned by the air traffic controller. Mode 3/A is often combined with Mode C to provide altitude information as well.
	C	Provides the aircraft's pressure altitude and is usually combined with Mode 3A to provide a combination of a 4-digit octal code and altitude as Mode 3 A/C, often referred to as Mode A and C.
4		Provides an e-pulse reply, delay is based on the encrypted challenge. This mode is now obsolete.
5		Provides a cryptographically secured version of Mode S and ADS-B GPS position.
S		Provides multiple information formats to a selective interrogation. Each aircraft is assigned a fixed 24-bit address.

LOOKING AHEAD TO FUTURE REQUIREMENTS

New Remote ID Requirements. The FAA has recently published the final Remote ID rule via the Federal Register, which will take effect in mid-Q1 2021. This rule defines an "electronic license plate" technology for aircraft broadcast identification, and also specifies that ADS-B will NOT be used for Remote ID. UAS operating under Part 91 or Part 135 rules, with a flight plan and in communication with ATC will not utilize Remote ID, and will need transponders, ADS-B, and probably an appropriate ACAS-based detect and avoid system in order to achieve aircraft type certification.

Steve Dickson, the FAA Administrator, gave an update at the Commercial UAV Expo on September 15, 2020: "Now what's becoming clear is that anyone can do Part 107, but that's not enough. We're seeing its limits now. When we talk about integration, the future of expanded business opportunities will be in repeatable, scalable, and economically viable Beyond Visual Line of Sight operations; what we call BVLOS. Routine BVLOS and operations over people will need to meet the higher standards of Part 91 and Part 135, where type certification is required."[13]

Urban Air Mobility (UAM). As the industry considers the integration of UAM aircraft into manned airspace, Sagetech believes that transponders and interrogators will serve as core technology enablers for future detect and avoid (DAA) systems required on autonomous aircraft. At the Commercial UAV Expo in September of 2020, Steve Dickson, the FAA Administrator, explained, "Expanded drone operations will also require detect and avoid capability. Manned aircraft have always operated under the principle of see and avoid to remain clear of other manned aircraft, and now in some cases to remain clear of unmanned aircraft as well. Thus far, unmanned aircraft can't do this. The FAA is working with industry to research detect and avoid technology. Reliable detect and avoid systems, either on board, ground-based, or from a third-party provider, will enable us to integrate more complex unmanned operations along with traditional manned operations. This will be a game changer."[13]

Sagetech is currently bringing together its technology capabilities plus a partner ecosystem to create certifiable DAA systems relevant to future UAS and UAM aircraft. To discuss our DAA roadmap, contact us.

"Routine BVLOS and operations over people will need to meet the higher standards of Part 91 and Part 135, where type certification is required."

-- Steve Dickson,, FAA Administrator
Commercial UAV Expo Keynote, 15 September 2020

CONCLUSION

Unmanned aviation is exciting, with emerging standards, new technologies, and a new world of possibilities. Use this guide to start your research and discussion about incorporating transponders as safety equipment on your next UAS or UAV.

SAGETECH EXPERTISE

Sagetech sits on industry committees, attends industry conferences, and presents at various industry events to ensure its technology solutions are positioned to meet the needs of UAS programs today and tomorrow. Check with us on any of your questions, and we will do our best to provide the most up-to-date information and resources to assist you with selecting transponder, DAA, and related technology solutions for your program.

ABOUT SAGETECH

Sagetech is an aerospace technology company, empowering safe flight in unmanned aircraft with the world's most reliable UAV transponders. Currently serving military and civil duty on most small to medium UAVs, Sagetech solutions are mission-proven and offer decades of program experience, certifications, and millions of flight hours to deliver maximum value over the life of an unmanned platform. Today Sagetech is expanding its technology platform to create comprehensive unmanned aircraft situational awareness systems, such as detect and avoid solutions. Sagetech works in concert with its extensive ecosystem of OEM customers, technology partners, and resellers to ensure UAVs fly safer with Sagetech on board.

Learn more at www.sagetech.com.

RESOURCES AND REFERENCES

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Sagetech Avionics offers this advice based on known information at the time. This publication may be updated frequently as rules emerge and guidelines change.

Sagetech AVIONICS

1000 E. Jewett Road
White Salmon, WA
P: +1.541.490.8332
E: sales@sagetech.com

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