A Guide to Transponders in Sailplanes - 2014A

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Note: Significant changes from version 2010B are indicated with a vertical line in the left margin

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Introduction

Significant changes to this version of the article are marked with a vertical line to the left of the paragraph with the changes.
A Glider Pilot’s Guide to Transponders

A transponder makes you visible to air traffic control and visible to the collision-avoidance systems on all larger aircraft. It can make it easier for properly equipped smaller aircraft, even gliders, to detect your presence. Generally, it does not, by itself, provide other benefits.

Most power planes have them; fewer gliders do. Many glider pilots, especially those who fly in busy airspace, are taking a closer look at these devices. This article will examine transponders (and some alternatives) from a glider pilot's point of view.

What is a Transponder?

Basically, it's a radio whose purpose is to help an aircraft be "seen" by the Air Traffic Control (ATC) system. Here's what the Aeronautical Information Manual (AIM) has to say (paraphrased):

The ATC Radar Beacon System (ATCRBS) consists of three main components:

1. Interrogator: Primary radar relies on a signal being transmitted from the radar site, reflected from an aircraft, received by the radar site, then displayed as a "target" on a radarscope. In the ATCRBS, the Interrogator (a radar beacon transmitter-receiver) transmits discrete radio signals, which repetitiously request all transponders to reply.
2. Transponder: This airborne transmitter-receiver automatically receives the signals from the Interrogator and selectively replies with a specific code only to those interrogations received on the mode to which it is set. These transponder replies are independent of, and much stronger than, a primary radar return.

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Note: SSA members can always find my current contact information (including email address) on the SSA website, using the Member Locator.
3. Radarscope: The radarscope can display returns from both the primary radar system and the ATCRBS. These returns, called targets, are used in the control and separation of traffic.

Physically and electrically, transponders are similar to the VHF communications radios we are all familiar with, though they use a higher frequency and so have smaller antennas. The newest units mount in standard 2-¼” instrument cutouts and have half or less than the current drain of older units. Frequency is not selectable, but the pilot sets the transmitted code, which consists of four digits from 0 through 7 (gliders most often use 1202 -- the standard code for VFR glider flying). Instead of a small dot on the radar screen, a controller sees a bright target with the 4-digit code clearly displayed.

Transponder Modes

Not all transponders are created equal. There are three "modes" for civilian use:

- Mode A - the basic transponder ability to reply to interrogations with a 4-digit code (no altitude information)
- Mode C - the reply signal includes both a 4-digit code and the aircraft's pressure altitude, usually obtained from a separate altitude encoder connected to the static system like the altimeter.
- Mode S - a more sophisticated system, the reply signal also includes information identifying the aircraft, and other data.

Most small aircraft use Mode C and Mode S.

On their own, ATC radars don't determine altitude information for the targets they are tracking -- they need the help of the Mode C or Mode S transponders. If you have a Mode A transponder, ATC will detect you; with Mode C or S, they'll also know how high you are. For effective collision avoidance and efficient traffic control, altitude information has obvious value.

TCAS - Traffic Alert and Collision Avoidance System

This is a complex device found in larger passenger-carrying airplanes that assists the pilot in avoiding conflicting traffic. It sends out its own interrogations and processes the signals from transponders that reply. Because it doesn’t depend on ground radar or a controller to alert the pilot, it provides an additional layer of safety from conflicts with transponder-equipped aircraft.

There are two levels of TCAS:
- TCAS I - provides traffic advisories to the pilot.
- TCAS II - provides traffic advisories (warnings) and resolution advisories (commands to the pilot to “push” or “pull”)

US air carriers have been required to have TCAS since 1992. Many corporate aircraft use it as well. Unfortunately, TCAS is expensive and unsuitable for installation in small aircraft.
There are also passive airborne traffic alert systems that receive and process signals from nearby transponders replying to interrogations from ATC or TCAS. While not as effective as TCAS systems, they do provide additional protection from collisions with transponder-equipped aircraft. Some are suitable for use in gliders, and can warn of approaching transponder-equipped airplanes and gliders.

**Should YOU have a transponder?**

Take a look at this diagram of arrival and departure paths for the Reno airport.

![Figure 1 Pilot reminder chart for operation in the vicinity of Reno, Nevada. This is an area that sees both significant glider traffic and many commercial flights.](image-url)
It's easy to see how conflicts could arise between gliders and jet traffic using the Reno airport; in fact, there was collision between a glider and a Hawker corporate jet in 2006 (remarkably, no fatalities). The glider did not have an operating transponder, and neither aircraft saw the other in time to avoid the collision. While Minden has a high potential for conflicts, it’s not the only area, as there are many other airports, and areas between airports, with a lot of traffic.

**Are you worried about a collision with an airliner or other aircraft?**

As you can imagine, a collision with an airliner would likely be a disaster for you and its passengers. Further, it could easily lead to restrictions on our sport, especially in these post-Sept. 11 days, when any aircraft, even a small one, can be considered a threat.

A glider, cruising or turning, is often difficult to see, even from another glider. For the pilot of an airliner, it is more difficult because cockpit visibility isn’t as good and speeds are much higher -- as high as 300 knots TAS (one statute mile in 10 seconds) below 10,000’, and much higher above that. Primary radar is unreliable for detecting a glider due to the low reflectivity of gliders, normal ground clutter (reflections from buildings, vehicles, hills, etc), and typical radar settings that emphasize transponder tracking. Besides looking about frequently and carefully, what can we do? A transponder is one answer.

A transponder makes you visible both on ATC radar screens and to the TCAS systems on larger aircraft (primarily airliners and business jets). ATC can direct aircraft around you, while TCAS-equipped aircraft can avoid you even without the help of ATC; in fact, TCAS systems will work even where there is no ATC radar coverage.

Some areas have such heavy “heavy” (airliner) traffic that it's difficult to fly there safely without a transponder. By “safely”, I mean, somewhat humorously, staying far enough away that you can’t read the airline's name when you see the airliner go by. Chicago and Las Vegas are two of these places. Near most Class B airspace, and even some Class C airspace (like the Reno area), qualifies.

A transponder will also provide protection from military aircraft that are coordinating with ATC, and from some types of transport aircraft equipped with TCAS, but not from tactical aircraft like fighters that don't use TCAS.

And finally, your transponder can also alert pilots of small planes, including other glider pilots, to your presence if they are using “flight following” (ATC radar advisories while flying VFR), or if they are using a portable collision avoidance system (PCAS/TPAS units – see Glossary) that can detect transponders.

**Do you want access to more airspace?**

Unless otherwise authorized by ATC, flying in Class A, B, and C airspace requires a Mode C transponder, as does flying above Class B and C airspace below 10,000’. Transponder-equipped gliders can and do operate in these places. Note: Class A flight generally requires IFR ratings, unless you are in
a “wave window” or other operating area were the requirements are waived by a Letter of Agreement with the FAA.

**Do you want to be found quicker if you go down?**

Under some circumstances, ATC computer recordings can be useful in constructing the radar history of a downed or crashed aircraft. This will reduce the area that must be searched, which can speed up rescue operations considerably.

**Transponder Disadvantages**

Transponders aren't cheap. I'll get into details in the next section, but figure on at least $2000 to $2500 for the hardware, plus installation costs (2014 costs).

Since they're mostly sold for powered aircraft, almost all transponders use power as if it's freely available -- they don't have batteries in mind as the sole power source. Power drain is also affected by how often a transponder is interrogated -- something that a pilot can't control. New models on the market since 2002 do considerably better than older ones, but many glider pilots will find that providing adequate battery power beyond the radio, vario, GPS, and flight computer they already have is an issue.

Installation can vary from easy to difficult. You have to find room for the transponder in your panel; a place for the altitude encoder behind the panel; and you'll need to install an antenna and the cable to it. You might need more battery power, and you might need a new altimeter if you plan to fly IFR.

Once installed, a transponder and encoder must be tested to ensure it meets standards, and retested every 24 months.

**Summary**

A transponder doesn't help you detect or avoid other traffic\(^1\) -- your own eyes still have to do that job. A transponder can help other traffic (especially passenger-carrying aircraft) detect and avoid *you*. Any aircraft in contact with ATC or equipped with TCAS will be alerted to your presence and usually be given advice (by ATC or the airplane’s TCAS) about whether and how to maneuver to avoid conflicts.

The benefit of a transponder thus has a lot to do with how often conflicts between you and ATC-controlled or TCAS-equipped aircraft might happen. If you exclusively fly close to a remote rural field where airliners are never seen at glider altitudes, a transponder is probably a waste of time and money. If you often fly near a large metropolitan area and frequently see airliners at the altitudes you fly, it's time to give serious thought to a transponder. Most of us probably lie somewhere between these two extremes, and each will have to make their own evaluation.

For a more technically detailed explanation of transponders and ADS-B, see: [http://www.gliderpilot.org/FLARM-Transponders](http://www.gliderpilot.org/FLARM-Transponders)

\(^1\) PCAS units WILL help you do that – the last section covers them

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Choosing the equipment

A transponder installation consists of the transponder, an altitude encoder (some units have an integral encoder, simplifying installation), an antenna, as well as a “large enough” battery. Your present battery might be acceptable, but some pilots will have to replace it with a larger one, or add another one.

Transponder

As of this writing there are several suitable units for gliders that are certified and sold for use in the USA. Other units are available in Europe that are attractive, but are not certified or sold for use in the USA.

The Trig TT21 is currently the most attractive unit unit for glider pilots, but Becker, Microair and others are also used. All these units mount in a standard 2.25” cutout, are relatively short at about 7”-8”, and have low current drain compared to other units. They work over a wide input voltage range of about 10-30 volts, so a standard 12-volt battery pack has sufficient voltage (a 14 volt pack is not needed). Each has an LCD to display the code setting, encoder altitude reading, and a number of other values.

NOTE: specifications can and do change, so use a current data sheet, and consult the dealer or manufacturer for the latest information.

What output power should I get?

Transponders are available in two “altitude ranges”:

- for a maximum altitude below 15,000’: power rating under ~175 watts
- for a maximum altitude above 15,000’: power rating above ~200 watts

The TSO certification requires a somewhat higher power output and reply rate for operation above 15,000 feet. Practically speaking, the units are otherwise identical. Many glider pilots that don’t exceed 18,000 feet except in a “wave window” opt for the 15,000' rated unit to save money and power. If you intend to fly IFR in Class A airspace outside of a “window”, the 250 watt version would be a better choice.

With the 2020 mandate for aircraft to equip with ADS-B, some pilots are choosing the high power (“Class 1”) units, as the lower power (“Class 2”) units will not meet the requirements. Currently, gliders aren't included in the 2020 mandate, but “who knows what will happen”, so the few hundred extra dollars in purchase price might be justified.

Here are units typically installed in gliders:
Trig TT21 and TT22 Mode S Transponders

- 130 watts nominal output power - TT21
  - Rated operating altitude to 15,000 feet
  - Integral altitude encoder
  - Separate easy-to-install control head (fits more panels) and remote transponder unit
  - Maximum current drain about 0.30 amps on 12 volts including encoder
  - ADS-B out capability when connected to a suitable GPS
  - Price: about $2500 from dealers (Jan. 2015)

- 250 watts nominal output power - TT22:
  - Same as the TT21, except maximum current drain about 0.36 amps on 12 volts including encoder
  - Price: about $2700 (Jan. 2015)

Becker ATC 4401 Mode C Transponder

- 175 watt output power (ATC-4401-175):
  - Rated operating altitude to 15,000 feet
  - Maximum current drain about 0.44 amps on 12 volts (not including an encoder)
  - Separate encoder required for Mode C operation
  - Price: about $2900+encoder from dealers (Dec. 2014)

- 250 watt output power (ATC-4401-250):
  - Operating altitude to 50,000 feet
  - Maximum current drain about 0.55 amps on 12 volts (not including an encoder)
  - Separate encoder required for Mode C operation
  - Price: about $3400+encoder from dealers. (Dec. 2014)

Microair T2000 Mode C Transponder
• 200 watt output (nominal)
• Operating altitude to 35,000' (perhaps more – data sheet is incomplete)
• Maximum current drain about 0.46 amps on 12 volts (not including the encoder)
• Encoder required for Mode C operation
• Price: about $2300+encoder from dealers (Dec. 2014)

Units typically NOT installed in a glider

“Airplane” units by Bendix, Garmin, Narco, etc, are generally too big and too power-hungry to be desirable, and the cheaper units don’t have the encoder readout and other features of the new designs.

Mode S transponders

Mode S transponders are more attractive to glider pilots, compared to the Mode C units, because they typically have:

1. lower current drain
2. an encoder is built into the transponder, eliminating the purchase, mounting, and wiring of a separate encoder
3. support of “ADS-B out” when connected to a suitable GPS source
4. reception of TIS (Traffic Information Service – see below) until it is phased out by the FAA

The Trig TT21 has all of these (except TIS), and a decent price (~$2500 Dec 2014) besides, making it not just the favored Mode S transponder, but about the price the older Mode C variety. The Becker BXP6401 is another “glider friendly” Mode S unit currently available in the USA. It does require an external encoder. It’s current drain in operation will be slightly less than the Becker ATC4401 (Mode C unit) in low traffic areas, but perhaps as much as 0.3 amps less in areas with lots of radars and traffic (~$2900+encoder, Jan 2010).

The Dittel KTX2, f.u.n.k.e. AVIONICS TRT800H, and Garrecht VT-01 Mode S transponders are also attractive because they have a built-in encoders, and perhaps lower power consumption than the Becker BXP6401.

The TIS system provides position data of transponder-equipped traffic near your aircraft, but is only
available within a 55 NM radius from about 100 sites in “busy” locations. Traffic info from TIS has some delay, and the position of aircraft will be different from the display. Weather radar images are also transmitted by the TIS.

Besides the TIS-capable Mode S transponder, a display is required to see the data. This can be a Garmin Aera 510 (~$600), or an even more expensive multifunction display. The FAA has been shutting down TIS sites over the last few years, and it’s not clear what their 5 to 10 year commitment to the remaining TIS sites will be. Eventually, the service will be taken over by the ADS-B system.

For pilots that routinely fly in the TIS covered areas, the traffic information and the radar images might make a Mode S transponder and display worth the extra cost.

If you also fly your glider in Europe, you’ll need a Mode S unit to do so.

**Encoder**

Remember, the new transponders have integral encoders, so you don't need to buy and install an external encoder.

Typical encoders are about half the size of a medium pocket book, are powered by the sailplane’s battery, and connected to the static system and the transponder. Inside the box, a well-insulated, temperature stabilized, solid state pressure sensor measures the static pressure, then other circuitry converts the sensor voltage to a digital altitude signal with 100 foot increments. The digital signal is sent to the transponder, which adds this data to the reply it transmits when interrogated by the ATC radar.

Encoders are available with maximum altitudes from 20,000’ to far higher than a sailplane has gone. The typical temperature range is –4º F to +131ºF, sufficient for most people’s summer thermal and winter wave flying. A 30,000’ unit is the minimum recommended, as there is little cost savings for lower altitude units.

The encoder circuitry itself doesn’t consume much power, but the heater that temperature stabilizes the pressure sensor does. Typical units draw about 300-500 ma during warm-up, then drop to about 80-100 ma after a few minutes. Operating current will be greater in cold temperatures as the heater works harder. Here are the factory figures and typical dealer prices for some popular units:

<table>
<thead>
<tr>
<th>Encoder Model</th>
<th>Ma at –4ºF</th>
<th>Typical dealer price (1/2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ameri-King AK-350</td>
<td>~240</td>
<td>$370</td>
</tr>
<tr>
<td>ACK Technologies A-30</td>
<td>~90</td>
<td>$240</td>
</tr>
<tr>
<td>Trans-Cal SSD120-30A</td>
<td>~400</td>
<td>$240</td>
</tr>
<tr>
<td>Microair EC2002</td>
<td>~100</td>
<td>$310</td>
</tr>
</tbody>
</table>

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Most glider manufacturers now provide technical bulletins for transponder antenna installations in their gliders. The antenna is a critical part of the system, so get those bulletins and follow them for your best chance of a successful installation. It's required for a certified glider, but even an experimentally licensed glider will benefit from a tested design.

There are basically three types of antennas, two of which require a ground plane (typically, a 6”-12” diameter thin metal sheet), and an internally mounted type that doesn’t require a ground plane. Note that internally mounted antennas are not suitable in locations that have metal or carbon construction, but wood, glass (or Kevlar) fiber are fine.

The following remarks may help pilots whose gliders do not have factory approved installations.

<table>
<thead>
<tr>
<th>Antenna Characteristics</th>
</tr>
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<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Rod</td>
</tr>
<tr>
<td>Blade/Fin</td>
</tr>
<tr>
<td>Dipole</td>
</tr>
</tbody>
</table>

Which antenna is best for you depends mainly on where you want to mount it, and that depends on your trade-offs between health concerns, signal distribution, antenna/fuselage damage potential, and mounting access.
While the transmitting power of a transponder is rated at a relatively high 150-250 watts, the transmissions are very short, making the average power less than a sailplane radio when it is transmitting. It’s not easy to determine the health risk, since there is little documentation about the health effects of the transponder signal. The usual recommendation is at least 6’ from the pilot, or to provide shielding if it’s closer. Metal and carbon fiber gliders may provide this shielding if there is structure between the pilot and the antenna, but fiberglass gliders will not.

Transponder antennas must be mounted so they are as close to vertical as possible during flight (the transponder radio signal is vertically polarized), though up to 10 degrees off vertical won't have a significant effect. Mounting the antenna on the bottom of an aircraft (the usual recommendation) gives it the “best” signal distribution, but the antenna has been successfully used inside the tail boom on fiberglass gliders, on top of the turtle deck or the tail boom, and in the nose of the glider. Mounting a transponder antenna on the glare shield is absolutely not recommended. Ideally, the antenna will be mounted so it isn’t susceptible to damage when the fuselage is moved from/into the trailer, during rigging, or by careless bystanders, outlandings, and gear-up landings.

Battery

The power requirements of the typical Mode C transponder can exceed the total of the radio, vario, and GPS, though most flight computers might draw as much, so you must ensure the battery capacity is adequate.

Will you need a 14-volt battery? No! Some pilots, usually those with really old radios, use 14-volt batteries. The new transponders use “switching” style power supplies and operate properly over a wide input voltage range of at least 10 to 30 volts. So, if you are using a 14 volt battery, you can continue to use it.

Likely battery solutions:

The absolute minimum is a single 12 volt, 7 amp-hour sealed lead acid (SLA) battery in new condition with the standard Mode C transponders. That will be barely enough to power the typical glider with one of the Becker Microair, or Trig transponders continuously for about 5-6 hours (the Trig somewhat longer) in warm conditions, in addition to the radio, vario, and GPS. You’ll have to charge it after every flight and buy a new battery every couple of years as it loses it’s peak capacity, but that might be the easiest, cheapest solution for your glider.

There are a few higher capacity batteries are the same size, and even one or two even higher than those that fit the same footprint, but are taller. These may be good options it they fit in your battery box. Lithium batteries, specifically the lithium-iron-phosphate (LiFePO4) type, are becoming popular now that they are available in sizes commonly used in gliders.

Another method is adding solar panels, which will reduce the drain on the batteries while you are flying.
An easier solution, if you have the room for it, will be the original battery for the original instruments, and an additional 7 AH battery (bigger if you can manage it) for the transponder, giving an operation time of about 10 to 12 hours in warm conditions, and about half that in cold conditions when the battery is a few years old. You’d have the “oomph” for longer flights, you might not have to charge after every flight, and your batteries won’t need replacement as often.

If you use Trig TT21 (and perhaps the Garrecht VT-01, or other Mode S transponder), the power drain should be low enough that even a 4 amp-hour battery would be adequate - not ideal, but adequate for 8-10 hour flights in cold weather. At a size that is 40% less weight and volume than the usual 7 amp-hour battery, almost everyone should be able to mount a battery just for the transponder, if needed.

Determining your actual capacity requirements:

If you’ve decided increasing your battery capacity is worthwhile, you’ll need to determine how much current you are using now. If you’ve already decided to you will use a separate battery for the transponder and encoder, you’ll just need the current values for the transponder and encoder from the specification sheets or installation manuals. Other factors are the length of your flights, battery lifespan, and how frequently you want to charge the battery. Temperature is also important, as the cold in high altitude waves or winter soaring reduces nominal battery capacity 20% at 32º F, and 40% at 0º F.

To measure the current your glider uses now:

• Put a meter in series with the battery wire going to the instruments. A 1 or 2 amp scale will be needed)
• Turn on all the instruments you use in flight (but not the engine controller, if you have one)
• Read the current.
• Add 10% for radio transmissions and more vario audio volume while flying.
• Or, add it up if you don’t have the glider handy, like a new one on order: Soaring computer, vario, flight recorder, radio, etc, but not the motor controller in a powered sailplane. Then…
• Add in the transponder and encoder current requirements.
• Decide on the maximum flight duration, assuming an “always on” transponder.
• Pick your “Cold Weather Factor”: 1.0 for 60º F and up, 1.25 for 32º F, 1.7 for 0º F (batteries don’t deliver their full capacity when cold).
• Minimum capacity required for one flight = (total equipment current in amps) x (duration in hours) x (cold weather factor)

Other capacity factors:

1. How many years do you want the battery to last? At least double the minimum size for optimum lifespan.
2. How often do you want to charge the battery? Multiply size you got in 1) by the number of flights you want per charge.

Can’t figure out how to install enough batteries?
Each glider type poses a different challenge – consult with the dealer, the factory, and especially with other owners of your type.

1. There are batteries (8 to 9 AH) now available that fit the same space as the typical 7 AH battery (and other common sizes, too). This is the cheapest and easiest way to get more capacity.
2. If your battery mount will accept a taller battery, you can get a 10.5 AH battery in the same “footprint” as your original battery.
3. You may be able to use solar cells to extend capacity sufficiently. Some gliders can be ordered with them, or the cells obtained from the factory, the dealer, or the manufacturer of the cells for retrofitting. With typical instruments plus transponder drawing at least 0.8 amps, you will need solar panels delivering 0.4 amps average for a meaningful (50%) increase in duration. The solar panel will need to be rated at about 0.8 amps to compensate for poor alignment with the sun while flying, and time in the shadow under clouds. Cost will be in the $500-$1000 range, unmounted, for Strobl's small, high efficiency, flexible panels that are widely used on gliders. Cheaper panels are significantly larger, rigid or both.

What about using Lithium batteries?

Lithium batteries are potentially more dangerous than sealed lead-acid batteries (SLA) – remember all the laptop battery recalls? So, DON’T cobble up a Lithium battery for your glider!

For lithium batteries, look at what the soaring vendors are selling. They are likely to pick suitable units, and save you the trouble of being a “pioneer” in battery design or selection.

Can I turn the transponder off to save the battery?

FAR 91.215(c) requires aircraft with a properly functioning transponder to operate it at all times while flying. We all know that some transponder-equipped sailplane owners conserve their battery by using the transponder only in areas where traffic is heaviest, and there have been no official reprimands so far. This is better than having a dead battery later on in the flight, when a transponder might be most useful, and being without a radio and other instruments. The best solution is still to have enough capacity to last more the entire flight.

Altimeter

Unless you stay out of airspace where Mode C is usually required for gliders (Class A outside a wave window, B, and C), you might need a new altimeter that can meet the requirements of FAR Part 43 Appendix E. Generally, however, this only applies to IFR operations.

If your present altimeter isn’t sufficiently accurate, your best bet (for a mechanical unit) is to replace it with a 3.125” face, TSO’d unit having the altitude range you are interested in. The 2.25” units and non-TSO’d 3.125” units are much less likely to meet the requirements initially or hold their calibration over the years.
Installing the equipment

Be sure to follow the normal procedures for installing new equipment in your glider. As usual, this will vary depending on its certification. A weight and balance calculation is particularly valuable (and required in any case) if you add or change the batteries.

Transponder

Most gliders will have the panel space for a 2 ¼” transponder, though some might have to remove a seldom used instrument. The main issue for some gliders, like the DG series, is the depth behind the panel may not be sufficient, except in one particular spot on the panel or pedestal; however, some (like the Trig units) have a separate, small control head that can be easily mounted in shallow locations.

Encoder

The encoder is small enough that a mounting place can usually be easily found under the glare shield behind the panel. Its adjustments will be used at most every two years, so good access isn’t needed. The required connections are the flexible tubing to the static system and the electrical cable to the transponder. If the transponder doesn’t provide power to the encoder, separate connections to a fuse, switch and battery will be required. Note that the altimeter must also be connected to the static system, and not cockpit static.

Antenna

Mounting considerations (style of antenna and location) were covered earlier in this section. Keep in mind the performance of the system depends critically on the cable loss (transponder to antenna), location of the antenna, and it's orientation (vertical – though up to 20 degree tilt is acceptable)

If the glider has fiberglass or wood fuselage (these are transparent to transponder frequencies), the antenna can be mounted internally. This protects it from weather and mechanical damage, but it still needs to be mounted vertically. With the location selected, the actual mounting is straightforward, but running the coaxial cable can be tedious. You might be able to avoid this aggravation if your transponder is a two part system, with a separate control head (panel mounted) and hardware box (mounted elsewhere). “Elsewhere” can be near the antenna, so only a few feet of coax cable is required, possibly allowing use of lower-cost coax. The transponder control head and main unit are connected by a cable that is cheaper and more tolerant of length and routing positioning.

If you are ordering a new glider, order it with the antenna and coax cable already installed, even if you aren’t planning on a transponder initially. Ensure the installation manual is followed carefully. In particular, use proper coaxial cable with good connectors for the antenna lead. The high frequency (1090 MHz) requires a much better cable than our lower communications frequencies (123 MHz) to avoid substantial power loss. Low-loss cable is expensive ($5- $10 a foot), but DON’T be tempted to buy
cheap cable – why restrict the output of your $2500 transponder to save $50 on the cable? The low-cost RG-58 coax cable often used for communication radio antenna connections is generally not suitable for transponders.

A bottom-mounted antenna can be placed in the upward curve of the fuselage a short distance behind the landing gear doors, which usually gives enough clearance to avoid damage when going in/out of the trailer (and even a wheel up landing). A rod style antenna will bend before causing damage to the fuselage (especially the flexible damage-resistant types), but the stiffer fin/blade style probably won’t. Some pilots make the bottom-mounted rod style antenna easily removable, but then there is the possibility of forgetting to attach it (the transponder won’t transmit, of course, and the transponder could be damaged when it tries to transmit).

Good access to the mounting area will make it easier to route the coaxial cable and install the ground plane, if required. The actual “bolting on” of the antenna is easy once these are done. Mounting it in the front of the cockpit is easy, but exposes the pilot to more RF radiation (the position of the ground plane helps in this case) and the battery in this glider partially shields the antenna from receiving/sending signals towards the right side.
A flexible antenna by Filser (Transflex03) is available, and should be more damage-resistant.

Contact your dealer or manufacturer first, as the antenna problem may already be solved; next, ask other owners of your model of glider locally or on an owners newsgroup. A posting on the newsgroups (rec.aviation.soaring and others) will often bring a solution. If you do come up with a good solution, please pass it on to your dealer for the next pilot!

**Testing the installed system**

This is a simple procedure for VFR aircraft, taking less than an hour and typically costing $50-$100.

If you will be flying IFR (as some glider pilots do), then you must adhere to the more stringent requirements of Part 43 Appendix E. My shop said this adds $200-$250 beyond the VFR testing, as these additional tests are required (his estimate was based on his experience with airplanes in 2009):

- Static system: moisture, restrictions, and leakage
- Altimeter: scale error, hysteresis, after effect, friction, case leakage, and barometric scale error to the maximum desired altitude
- Encoder: agreement with the altimeter to the same altitude
- Transponder: correct transmission of the encoder altitude signal

The most important test is done while you are flying: contact ATC, and ask them if your transponder is displaying properly. This check is cheap, easy, can be done any time you fly, so you should do it several times a year. If ATC can’t detect you, you need to determine why, as you may have an equipment or procedural problem.

**Continuing maintenance requirements**

FAR 91.413 requires testing of the transponder (including the encoder) every 24 months to ensure it still meets the standards, or its use is not allowed. Again, for VFR use, quick, easy, and cheap.
Using the transponder

Transponders are easy to operate, though proper use requires some knowledge that airplane pilots usually have, but glider pilots usually don’t. The basics are covered in AIM 4-1-19 (Transponder Operation). The AIM (Aeronautical Information Manual) is available as a book or CD from the local airport or catalog dealers, or you can download it free from the FAA website. The following are the basics, but the specifics will vary a bit with your equipment and the area you fly.

Standard transponder controls:

- Mode selector
  - Off: unit is off
  - Standby: warm up with no transmissions
  - On: unit replies to interrogations but without the altitude information
  - Altitude: the replies include altitude information from the encoder
- Code selector: Changes the transmitted code (older units); changes the standby code (newer units)
- Ident: pressing this button makes your blip easily identifiable by brightening it on the controller's radar display

Typical displays are:

- Active code: the code being transmitted
- Reply indicator: flashes when the unit is replying to interrogations
- Encoder altitude: shows the pressure altimeter that the encoder is reporting (equivalent to an altimeter set to 29.92)

Study the transponder manual carefully, as each model will implement these features a little differently, and all have additional features.

When you fly

- Select Standby when you are on the flight line as part of your pre-takeoff checklist. Confirm that the transponder code displayed is 1202, for VFR glider flying. Local agreements with ATC may allow/require a different code.
- Select ALT after you release (or before you launch if the towplane does not have transponder), especially if you are flying from a towered field, to avoid interfering with the signal from the towplane's transponder
- Continue to use “see and avoid” even with your transponder in operation. Other gliders and most smaller airplanes are NOT under the control of ATC and do not have TCAS. Transponders operate “line of sight” so even aircraft operating in contact with the ATC system might not be warned of your presence if a ridge blocks the radar beam.
- If practical, leave the transponder on the entire flight. Some pilots do conserve the battery by using
the transponder only in areas where traffic is heaviest, and there have been no official reprimands so far. This should be considered a “work-around” until you can improve your battery duration

Beyond the basics: the material in AIM 4-1-19 reminds you of several important rules (but be sure to read it yourself):

- You are not required to contact ATC as long as you remain VFR. Don’t use a code other than 1202, except by local agreement, or unless you are in contact with an ATC facility by radio and are specifically asked to do so. If you do wish to contact ATC, be sure you have read the relevant sections of the AIM and are familiar with the terminology to use, ask a pilot who is ATC fluent for help, or even consider the taking (or at least reviewing the material for) the part of an “airplane” ground school that covers ATC communication.
- If you use an older unit where the code being changed is also the code transmitted, be especially careful to avoid changing codes through 7500 (hijack code), 7600 (radio failure), 7700 (emergency), or 7777 (military intercept). All will draw ATC’s immediate attention. Newer units make the code change to the “standby” code, or after a delay, so changes aren’t transmitted until the entire code is entered.
- Don’t use the “Ident” button unless requested by ATC. The button causes an additional signal to be sent to ground controllers and will not be welcome unless requested.

## Alternatives to transponders

These devices (and one procedure) can reduce your collision risk, and they can all be used with a transponder for even more risk reduction. Which one (or combination) will provide satisfactory risk reduction depends very much on where you fly and what else is flying in the same airspace. My personal choice is a transponder and a PowerFLARM.

### Contact ATC

This can be surprisingly effective. In the Eastern Washington State where I usually fly, glider pilots without transponders can contact, by radio, the ATC approach controllers for the area, and ATC can usually spot and follow us on their radar. Sometimes they’ll even offer Flight Following! Generally we do this when near a towered airport or on a busy airway, when it’s value is the highest.

Contacting ATC will almost always help, but how much depends a lot on how busy they are. Keeping track of unequipped aircraft is harder and takes more time; e.g., the radar can display your location but not your altitude. Still, it’s worth attempting. At worst, it will make ATC aware of the extra “stealth” traffic, and they can pass that info on to the airplanes in their airspace; at best, you’ll get most of the benefit of having a transponder for just the cost of a few radio calls.

### Portable Transponder Detectors

These are also called PCAS (Portable Collision Avoidance System – trademark of Zaon Flight Systems) or TPAS (Traffic Proximity Alert System – trademark of SureCheck Aviation). They all use the same
basic technique: detecting transponder replies from nearby aircraft to ATC radar and TCAS interrogations. PowerFLARM (to be discussed later) also includes this function, as does the Proxalert R5.

**How they work**

The received transponder signal strength is used to calculate the approximate distance; altitude is determined by reading the Mode C (altitude) code in the transponder signal. By tracking the distance and relative altitude of other aircraft, the unit estimates when a collision threat might exist, then warns the pilot with a combination of audible alerts and displays of the target distance and relative altitude.

**Limitations**

PCAS/TPAS units do not alert other aircraft to your presence; for that, a transponder is still required. They can only detect aircraft with a properly operating transponder. This includes almost all airplanes, but only some gliders, so you still need to scan for other aircraft. In addition, the other aircraft must be within radar coverage (or interrogated by a TCAS in an airplane), or its transponder will never transmit a reply. In areas without radar coverage, there will be no replies to the radar, and your warning device won't work; for example, mountainous areas often have poor radar coverage.

Of course, you also need to visually find an aircraft after receiving an alert/warning, so you can avoid it if necessary. You don’t know the direction, which makes it harder to visually find the target, but you do know the relative altitude and distance, so you do know the approximate vertical angle to the target. With use, it becomes easier, but it sometimes means making a 90 degree turn to see behind you.

Typical detection distances are 5 miles horizontally and 2000 to 5000 feet above and below you. These distances can be significantly affected by antenna location (on each aircraft), transponder output power, and even antenna cleanliness. Generally, an airliner will be detected farther away than a small airplane, because it has a higher power transponder and multiple antennas.

**Should I get one?**

My personal experience and reports from other pilots (glider and airplane) indicate that they work well. By “well”, I mean they alert the pilot to aircraft that would otherwise not be seen at all, or not seen as soon as desirable. “Not seen” doesn’t mean the aircraft was so far away the pilot couldn’t see it! Aircraft can approach from behind (especially while we are cruising), and one coming directly at us, even from ahead, can be almost as hard to see. Small, fast aircraft can be upon us in the 30 seconds or so it takes to look a map, punch a new task into our soaring computer, or other distractions from scanning.

My suggestion: if you are “surprised” by at least one airplane every year you fly, it means you are missing traffic you ought to see, and a PCAS/TPAS unit or PowerFLARM can help you eliminate these surprises. Even if you have a transponder, these units are useful; remember, the majority of airplanes don’t have TCAS and aren’t in contact with ATC, so they will not be alerted to your presence.
Note that all of these units can be easily transferred to your airplane or a borrowed/rented glider, and some will run on self-contained batteries in addition to the aircraft power.

**Which one should I get?**

In addition to PowerFLARM, there are currently two PCAS units in production (Dec. 2014), one that is available used, and other units may be available on the used market. Because these are portable units, they do not require installation or periodic testing. In order of list price:

*MRX (Zaon Flight Systems - $549 when new)*

No longer produced, this one was popular with glider pilots. It does a good job of distinguishing between nearby aircraft that are potential threats and those that aren’t. The built-in altitude sensor means you don’t need a transponder to get relative altitude.

*ATD-300 Traffic Watch (Monroy Aerospace - $700)*

This unit does not have a built-in altimeter, so it can’t provide relative altitude unless your glider has a transponder with encoder. Without a transponder in your glider, alerts will be based on distance only, so you receive the same warning for an airplane a mile directly above you that you do for the one a mile away at the same altitude. It is not as versatile as the Zaon MRX, uses twice the current, and I’m not aware of any glider pilot using it. Visit monroyaero.com for more information.
Proxalert (Proxalert - $800)

This unit displays up to three targets, including their squawk code, and monitors up to ten aircraft at once. This extra information might be useful in high traffic areas, where many airplanes will have codes besides 1200 (VFR for airplanes). While larger than the MRX or ATD-300, it still fits well on the top of a glider glare shield. Visit proxalert.com for more information.

**ADS-B**

From an AOPA article:

ADS-B, or Automatic Dependent Surveillance-Broadcast, is a cornerstone of NextGen air traffic modernization, and the FAA has mandated that aircraft operating in airspace that now requires a Mode C transponder must be equipped with ADS-B Out by [Jan. 1, 2020](https://www.aopa.org/whatsnew/air_traffic/ads-b.html).

ADS-B Out transmits information about altitude, airspeed, and location derived through GPS from an equipped aircraft to ground stations and to other equipped aircraft in the vicinity. Air traffic controllers use the information to “see” participating aircraft in real time with the goal of improving traffic management.

ADS-B in, which is not part of the mandate and requires additional equipment, allows participating aircraft to receive traffic and weather information from ADS-B ground stations and nearby aircraft broadcasting their positions through ADS-B Out. This information can be displayed in the cockpit to improve situational awareness [but will not show all traffic (note: PowerFLARM includes ASD-B In 1090)](https://www.aopa.org/whatsnew/air_traffic/ads-b.html).

Read the entire article - [www.aopa.org/whatsnew/air_traffic/ads-b.html](https://www.aopa.org/whatsnew/air_traffic/ads-b.html)

As of May 2014, the “48 state” coverage had very few gaps at 1500' AGL, and almost complete coverage 8000' AGL. My touring motorglider has “ADS-B in”, and I very pleased with the traffic display, weather information, and radar images. It's like magic, and cost less than $1000 to add to my panel. ADS-B out, as the AOPA article explains, would cost five times as much.

**FLARM and PowerFLARM**
FLARM (it’s name is not an acronym) is a portable, low-cost (~$800), low-power anti-collision system originally developed for gliders flying in Europe. It is a remarkable system that is spreading to other aircraft and other continents, with over 30,000 now in use (as of Dec 2014).

A FLARM unit detects other FLARM units within a few miles, tracks their position, and issues warnings and collision avoidance guidance; in essence, a “mini-TCAS”! Besides it’s use in gliders, it can be installed in towplanes for more protection at busy airfields, and used on the ground at the club, where it can track the location of the club gliders, and even provide towing and club aircraft usage data to an automated billing system.

PowerFLARM adds ADSB-in 1090 and PCAS functions to basic FLARM, and is suitable for use in USA. Please note older FLARM models are not approved for use in USA and have greatly reduced range here. FLARM is most effective where many gliders are flying, and most are equipped with it. If airliners and business aircraft are real concerns, then a transponder will more effectively reduce your collision risk, though PowerFLARM's PCAS function will alert you to approaching transponder-equipped traffic.

An excellent description of the PowerFLARM units (Portable and Core) is available at http://www.gliderpilot.org/FlarmHome. I encourage every glider pilot to become familiar with what it can do to increase our safety while flying, and to consider using one in the gliders they fly.

“ Myth-information” about transponders

There are a number of myths circulating about transponders and the ATC system they operate in. Usually, people that aren’t familiar with the ATC system pass them on; surprisingly, I sometimes hear them from pilots that should know better, including very experienced airline pilots. It demonstrates that the ability to turn the right knob, flick the right switch, and say the right things, all at the right time, does not require a technical understanding of the system!

Here are some that are the worst myths, because they might cause a pilot to forego installing a transponder when he would benefit from one.

**Mode A/C Transponders aren’t detected by TCAS**

This myth makes the claim that only Mode S transmissions are used by TCAS; in fact, TCAS does detect Mode A/C transponders. While many airplanes have Mode S, almost all airplanes at least have Mode A/C, so a “Mode S only” TCAS would not protect against a lot of airplanes. Doesn’t make sense, does it?

Perhaps this myth comes from the fact that airliners do use Mode S transponders, and the fact that the TCAS responds differently to TCAS equipped and non-TCAS equipped aircraft. If the both aircraft have TCAS II, the pilots in both planes will be given resolution advisories (commands to the pilot to “push” or “pull”); otherwise, the pilots in the TCAS equipped aircraft are given traffic advisories (warnings).
ATC ignores/can’t detect VFR code 1200

ATC can detect the VFR code 1200, but there are a few very high traffic places when ATC will filter out 1200 codes. These are NOT places where IFR and VFR traffic are flying in the same airspace, but where heavily used, but separate, VFR and IFR airspace are next to each other. This happens in the Los Angeles area, for example, and most areas like it aren’t where you’ll find many gliders in the air!

You aren’t detected when circling or standing still in a wave

This won’t happen to a transponder equipped glider, but it can happen if the glider doesn’t have a transponder, because ATC must use primary radar to detect the glider. Primary radar uses filters to eliminate the display clutter caused by reflections from stationary objects (building, mountains, etc) and slow-moving vehicles (trucks, cars, etc). If you aren’t moving very fast, you might be filtered out. If ATC knows you are out there, they may be able to adjust the filtering so you still display on their screen (a good reason to contact them when near a busy airport or airway if you don't have a transponder).

Why Doesn’t the SSA …?

These are the top three questions that SSA directors get asked about the transponder situation.

… get an exemption from the “always on” rule?

Summarizing what an SSA director involved with SSA/FAA matters told me years ago:

> What we spent years doing was trying to get the FAA to agree that we could turn them [transponders] off if necessary. The irony here is that we are asking the FAA to legalize is what the pilots are already doing, and the FAA knows they are doing it.

> The conversation basically went something like this...

SSA: "The pilots are turning them off to save battery power and keep the radio operating".

FAA: "Yeah, we know".

SSA: "We think they should be allowed to do it in remote areas".

FAA: "We agree".

SSA: "How do we legalize this?"

FAA: "File a petition".
So the FAA wanted us to submit a petition for "legal" reasons, and we did (Jan. 2004). We have glider pilots throughout the FAA building in DC and they already know all about low power transponders. We know that ATC has even told pilots to leave them on and turn the radio off - we all agree that's nuts, but it's what the rule says. They also have told us that the day after a mid-air between a glider and a commercial transport, we will lose our exemption. What we're trying to do is get agreed to procedures and policies in place before that day happens.

Currently (Dec 2014), the petition is still has received no response from the FAA.

... get the 0440 code for the entire country?

This used to be a popular question, but now that the 1202 code for gliders is available everywhere and used in the Reno area instead of the 0440 code formerly used, it's asked very infrequently.

... get someone to build a cheap, low power transponder?

Again summarizing what an SSA director involved with SSA/FAA matters told me:

*The basic problem is that the FAA, like other nations, is prevented by international agreements from certifying transponders that do not meet the current standards. Without being able to obtain certification, there is no business case. A foreign manufacturer several years ago did develop a prototype handheld transponder unit but was unable to obtain certification from any country because the power output was too low.*

*Even if low power units were legal, developing a "cheap, low power transponder" is a market driven decision; the SSA can only make manufacturers aware of the market. The development costs for such a limited market make them expensive, as we've seen with the newer transponder units developed for gliders that have entered the market place in the last several years. In addition, ADS-B will render transponders obsolete as a technology within the next decade or so, further eroding the potential marketplace for new designs.*

It now makes more sense to work for “cheap, low power” ADS-B equipment, and the SSA, EAA, AOPA, and others are pursuing this strategy. Wish them luck, we'll need it.

Appendix

Glossary

**ADS-B** “Automatic Dependent Surveillance – Broadcast” A GPS based system to replace ATC radar and transponders. For a detailed discussion of ADS-B, see: [http://www.gliderpilot.org/FLARM-About-Transponders-And-ADSB](http://www.gliderpilot.org/FLARM-About-Transponders-And-ADSB)

**AH** amp-hours; ampere-hours: a measurement of a battery’s current duration capacity
AIM “Aeronautical Information Manual” -- the FAA’s official guide to basic flight information and ATC procedures. The AIM is available as book or CD from the local airport or catalog dealers, or you can get it from the FAA website under “Manuals” at:

www.faa.gov/airports_airtraffic/air_traffic/publications/

AOPA Aircraft Owners and Pilots Association (www.aopa.org)

ATC Air Traffic Control

ATCRBS ATC Radar Beacon System - the system of interrogators, airborne transponders and display screens that allows ATC personnel to track aircraft.

Encoder A device that measures pressure altitude and reports it to a transponder.

FAR Federal Aviation Regulations - the rules that U.S. aircraft and pilots must follow. Rules pertaining to transponders are found in FAR 91.215, 91.217 and 91.413. You can read these on the FAA website at: tinyurl.com/2dp9hr

FLARM the name (not an acronym) of a collision avoidance system originally developed for gliders (see www.flarm.com).

Flight Following Getting VFR radar advisories from ATC.

ma milliamperes; milliamps: 1 amp = 1000 ma

PCAS “Portable Collision Avoidance System” – trademark of Zaon Flight Systems, used to describe portable devices that detect transponder signals and warn users of their presence.

Primary radar Radar that uses the radar signal’s reflection from the aircraft to detect it.

SLA “Sealed Lead Acid” – refers to lead acid batteries that are “sealed”, so they don’t leak, can be used in almost any position, and fluid can not be added. Normal charging doesn’t release any gas from the battery, but a safety valve prevents excessive pressure if a problem develops. The most common type of battery used in our gliders.

Squawk The term used by ATC to specify a transponder code. A pilot told to “Squawk 1234” sets the transponder code to 1234. Except by special arrangement, glider pilots not in touch with ATC squawk 1202 -- the standard VFR code for gliders.

TAS True airspeed.

TCAS “Traffic Alert and Collision Avoidance System” – a device found on most commercial passenger-carrying aircraft that interrogates nearby transponder-equipped aircraft and provides traffic advisories to the pilots.

TIS “Traffic Information Service” - a first-generation traffic system that supports cockpit depiction of traffic, using a TIS service available from about 100 Mode S terminal radars. It's now being phased out by the FAA.

**Transponder** A device that receives and then transmits a signal. In an aircraft, a transponder receives a signal from ATC or a TCAS-equipped aircraft and responds with a signal that includes a numeric code and normally altitude and other information. For a technically detailed explanation of transponder operation, see: [http://www.gliderpilot.org/FLARM-Transponders](http://www.gliderpilot.org/FLARM-Transponders)

**TSO** “Technical Standard Order” - a minimum performance standard issued by the FAA for specified materials, parts, processes, and appliances (e.g., instruments and avionics) used on civil aircraft. When a device is “TSO’d”, it has been certified to conform to applicable standards and is thus legal to install and use in aircraft. For brain numbing detail, see: [www.faa.gov/aircraft/air_cert/design_approvals/tso/](http://www.faa.gov/aircraft/air_cert/design_approvals/tso/)