Transponders in Sailplanes

by Eric Greenwell
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Introduction

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If you discover any errors of fact, additions that should be made, or think there might be a better way to present the information, please contact the author:

Eric Greenwell
222 Thayer Dr
Richland, WA 99352

509-943-9065

engreenwell@charter.net

A Glider Pilot's Primer for Transponders

Transponders are much discussed lately. Most power planes have them; rather few gliders do. Many pilots, especially those who fly in busy airspace, are taking a close look at these devices and what they can mean to glider pilots.

This is the first of two articles that will examine transponders from a glider pilot's point of view. This article deals with the basics -- what transponders are, how they work, and how to decide if you should be using one. The second article will look at choosing, installing and using a transponder.

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, and 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.
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 about half 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 1200 -- the standard code for VFR 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:"

- 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 and expensive system, the reply signal also includes information identifying the aircraft, and other data.

Of these, small aircraft use the first two.

On their own, ATC radars don't present altitude information for the targets they are tracking -- they need the help of Mode C or Mode S transponders. If you have a Mode A transponder, ATC will see you; with Mode C, they'll also know how high you are. For effective collision avoidance, 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 several levels of TCAS:

- TCAS I - provides traffic advisories to the pilot.
- TCAS II - provides traffic advisories and resolution advisories in the vertical plane.

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.

But 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 even be suitable for use in gliders, and could potentially warn of approaching transponder-equipped aircraft.

Should *YOU* have a transponder?

Are you worried about a collision with an airliner?

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,

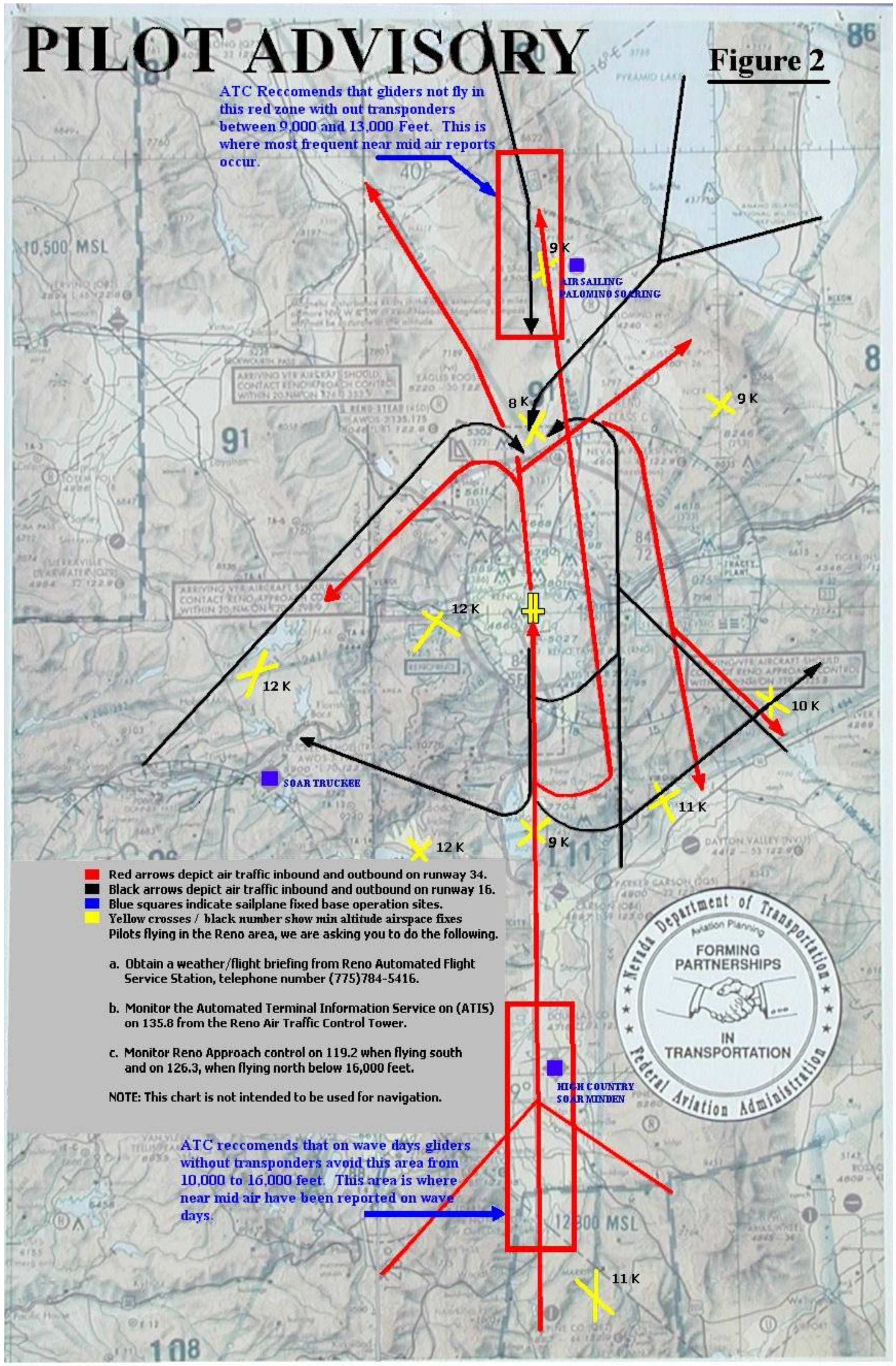

Figure 1 Pilot advisory chart for operation in the vicinity of Reno, Nevada. This is an area that sees both significant glider traffic and many commercal flights.

especially in these post-Sept. 11 days, when any airplane, even a small one, can be considered a threat.

A glider, even a turning glider, 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 higher above that. Primary radar is unreliable for detecting a glider due to the low reflectivity of gliders and normal ground clutter (reflections from buildings, vehicles, hills, etc. Besides looking about frequently and carefully, what can we do? A transponder may be the answer.

A transponder makes you visible both on ATC radar screens and to the TCAS systems on larger aircraft (primarily airliners). ATC can direct aircraft around you; TCAS-equipped aircraft can avoid you even without the help of ATC.

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 distinguish the airline's name when you see the airliner go by. Chicago and Las Vegas are some 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, which do use TCAS, but not from tactical aircraft like fighters that don't use TCAS.

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.

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

Under some circumstances, ATC computer tapes 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 my next article, but in general terms figure on at least $1500 to $2000 for the hardware, plus installation costs.

Transponders are power-hungry. Since they're mostly sold for powered aircraft, transponders tend use power as if it's freely available -- they don't have batteries in mind as the sole power source. Power drain is 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 is an issue (some of us already have trouble keeping our radios going through a long flight).

Installation isn't a snap. You have to find room for the transponder in your panel; an altitude encoder will connect to the glider's static system and the transponder;and you'll need to install an antenna. You might not get by with the batteries you now carry, and you might need a new altimeter if you plan to fly other than VFR.

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

Summary

A transponder doesn't help you see or avoid other traffic -- your own eyes still have to do that job. A transponder does help other traffic (especially passenger-carrying aircraft) see and avoid *you*. Any aircraft in contact with ATC or equipped with TCAS will be alerted to your presence and usually be given advice about whether and how to maneuver to avoid problems.

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 altitudes you might reach, it's time to give serious thought to a transponder. Most of us probably lie somewhere between these two extremes, and will have to make our own evaluation.

I’d like to thank Mike Greenwald, Karol Hines, Carl Herold for their contributions to this article.

Choosing, Installing, & Using a Transponder

The second of two articles on transponders and their installation and use in sailplanes sailplanes (originally published in **Soaring** *magazine, Mar 2002, and updated Dec 2004).*

Last month we looked at the basics: what transponders are, how they work and why a sailplne pilot might want one. In this article, we’ll consider how to choose, install and use a transponder.

Choosing the equipment

A transponder installation consistes of the transponder, an altitude encoder, an antenna, as well as a “large enough” battery, and an altimeter. Your present battery and altimeter might be acceptable, but some pilots will have to change at least one of them.

Transponder

As of this writing (Dec 2004), there are two suitable new units for gliders, and one used unit. A third new unit may become available in the USA next year, as it was recently certified in Europe.

The two new units are made by Becker and Microair. 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 voltage range of about 10-30 volts, so a standard 12-volt battery pack is sufficient. Each has an

LCD to display the code setting, encoder altitude reading, and a number of other values.

Becker ATC 4401 (available in two versions):

- 175 watt output power (ATC-4401-175):
    - Operating altitude to 35,000 feet
    - Maximum current drain about 0.44 amps on 12 volts (not including the encoder required for mode C operation)
    - Encoder required for Mode C operation
    - Price: about $1800 from dealers (Dec 2004)
- 250 watt output power (ATC-4401-250):
    - Operating altitude to 35,000 feet
    - Maximum current drain about 0.55 amps on 12 volts (not including the encoder required for mode C operation)
    - Encoder required for Mode C operation
    - Price: about $2000 from dealers. (Dec 2004)

Microair T2000

- 200 watt output (nominal)
- Operating altitude to 55,000'
- Maximum current drain about 0.46 amps on 12 volts (not including the encoder required for mode C operation)
- Encoder required for Mode C operation
- Price: about $1600 from dealers (Dec 2004)

Filser TRT 600

- Currently available only in Europe (Dec 2004), but may be certified for use in the US in 2005
- This is a Mode S transponder, which has some advantages over the mode A/C types like the Becker and Microaire
- Current drain: about 0.45 amps *including* the integral encoder
- Since encoder is integral, a separate $200 encoder is not required, nor does it require mounting.
- Price: expected to "about" $2600 (Dec 2004)

Used units are sometimes available and are cheaper. The most desirable used unit is the Terra TRT 250D, but these units are no longer made and the company was sold to Trimble, who then sold some of the line itself. Parts and service are increasingly hard to find, and may not be available at all by now (Dec 2004). It appears the TRT 250D unit (but not earlier versions) can still be serviced by Free Flight Systems (www.freeflightsystems.com), which now owns the Terra line.

Terra TRT 250D (used only)

- 200 watt output power
- Operating altitude to 55,000 feet
- Maximum current drain about 0.75 amps
- 12 volt battery is satisfactory
- Small but rectangular panel: 3.124" wide and 1.625" high
- About 11.5" deep (check space carefully)
- Encoder required for Mode C operation
- Some ads show about $1100 for reconditioned units (Dec 2004)

The older unit (TRT 250) had similar specifications, but with some important differences:

- Oldest units (thumbwheel inputs) can not meet TCAS signal requirements
- Some units need to comply with an AD to respond to all TCAS signals
- Code selection and display uses pushbutton switches and mechanical readouts instead of the knob and a gas discharge display of the D model (push button parts are difficult to find – Dec 2002)
- Shorter length makes installation easier

"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. Here is a better than typical unit:

Garmin GTX-320A

- Current drain: 1.0+ amps at 12 volts
- Panel size: 6.3"W x 1.7""H (8.2" deep)
- Weight: 2.2 lbs (0.5 lbs more than the Becker)
- Encoder required for Mode C operation
- Price: about $1250 from dealers (Dec 2004)

Encoder

Typical encoders are about half the size of a medium pocket book, 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 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 ATCRBS (ground 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:

Altitude Encoder Characteristics

Encoder Model (30,000' units)	Ma at –4º F	Typical dealer price
Ameri-King AK-350	~240	$160
ACK Technologies A-30	~90	$180
Trans-Cal SSD120-30A	~400	$200
Trans-Cal D120-P2T30	~50	$550

For the determined high altitude pilot, Trans-Cal makes the SSD-120-50A, an unheated unit that draws less than 100 ma at all temperatures and is good to 50,000'! It's about $1000.

Antenna

Rod antenna

Blade or Fin antenna

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.

Antenna Characteristics

Type	Mounting	Ground plane req'd	Drag	Damage possible?	Cost
Rod	External/internal bolt-on	Yes	Some	Likely only to antenna	$40-$60

Blade/Fin	External bolt-on	Yes	Low	Might damage fuselage	$140-$160
Dipole	Internal with adhesive	No	None	No	$80-$90

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 damage avoidance, and mounting access.

While the transmissions of a transponder are very high at 150-250 watts, the transmissions are very short, making the average power about the same as a sailplane radio when it is transmitting. It's not possible 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 can provide this shielding if there is structure between the pilot and the antenna, but fiberglass gliders will not. Some pilots have used the antenna on the glare shield without apparent ill effects.

Mounting the antenna on the bottom of an aircraft gives it the best signal distribution, but the antenna has been successfully used inside the tail boom on fiberglass gliders, on top of the tail boom about half way back, in the nose of the glider, and on top of the glare shield.
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.

A bottom-mounted antenna can be placed in the upward curve of the fuselage a little ways behind the landing gear, where it avoids these problems. A bottom-mounted rod style antenna can be made easily removable, but then there is the possibility of forgetting to attach it (the transponder won't work, of course, and the transponder could be damaged).

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.
Contact your dealer or manufacturer first, as the antenna problem may already be solved; next, ask other owners of your model of glider. 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!

Battery

The power requirements of the transponder can exceed the total of all the other equipment, so you must ensure the battery capacity is adequate. This section assumes you are using the usual sealed lead/acid battery like most gliders do.

Will you need a 14-volt battery? No! Some pilots, usually those with older 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. The only advantage to using a 14-volt battery for the transponder will be a 15% reduction in the current required.

Likely battery solutions:

The absolute minimum is a single 12 volt, 6 amp-hour (AH) battery in new condition, just enough to power the typical glider with one of the new Becker, Microair, or Filser transponders continuously for about 5-6 hours in warm conditions. 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.

A more practical solution, if you have the room for it, will be the original battery for the original instruments, and an additional 6 to 8 AH battery for the transponder, giving an operation time of about 10 to12 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 will last at least twice as many years.

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 sheet. Other factors we'll consider 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:

1. Put a 0-500 ma or 0-1000 ma meter in series with the battery lead.

2. Turn on all equipment that will is normally used in flight, except the motor controller in a powered sailplane.

3. Read the current.

4. 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…

1. Add in the transponder and encoder current requirements.

2. Decide on the maximum flight duration, assuming an "always on" transponder.

3. Pick your "Cold Weather Factor": 1.0 for 60º F and up, 0.8 for 32º F, 0.6 for 0º F (batteries don't deliver their full capacity when cold).

4. Minimum capacity required = (total equipment current in amps) x (duration in hours) / (cold weather factor)

Other capacity factors:

How many years do you want the battery to last? At least double the minimum size for optimum lifespan.

How often do you want to charge the battery? Multiply the minimum size 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 factory and especially with other owners of your type. 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 for retrofitting.

FAR 91.215(c) requires aircraft with a properly functioning transponder to operate it at all times while flying. We understand 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, or being without a radio and other instruments.

Altimeter

Unless you stay out of airspace where Mode C is <u>usually</u> 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 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, and some transponder warranties have special requirements to keep them in force, such as dealer installation, so check it before installation is started.

Transponder

Most gliders will have the panel space for a 2 ¼" transponder (and even the shorter but wider Terra units), though some might have to remove a seldom used instrument. In extreme cases, pilots have mounted units on top of the glare shield when visibility wouldn't be affected. This approach works well with a Terra unit, because it is only 1.6" high.

Encoder

The encoder can be placed almost anywhere under the glare shield behind the panel, as it's adjustments will be used at most every two years. The required connections are the plastic tubing to the static system and the 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 were covered in the "Choosing the Equipment" section. With the location already selected, the actual mounting is straightforward. Ensure the installation manual is followed carefully, with adequate wire and fusing. In particular, use proper coaxial cable with good connectors for the antenna lead. Because the transmitted pulses are such high power, poorly shielded cable can cause interference on the radio and even the other instruments.

Testing of the installed system

FAR local avionics shop said this was about a $50 procedure for testing to Mode A requirements (no encoder); Mode C operation for VFR flying requires testing and calibration of the encoder (ensuring that the altitude is transmitted correctly), adding another $50-$75 to the cost.

If you will be flying IFR (as some glider pilots do) or in "IFR" airspace, such as Class A [but not including "wave windows"], B, or C airspace, then you must adhere to the more stringent requirements of Part 43 Appendix E. My shop said this adds $150-$200 beyond the Mode A testing, as these additional tests are required (his estimates were based on airplane experience):

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

Continuing maintenance requirements

FAR 91.413 requires testing of the transponder (including the encoder, if used) every 24 months to ensure it still meets the standards, or its use is not allowed.

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 is available as book or CD from the local airport or catalog dealers, or you can get the specific section from FAA website (http://www.faa.gov/ATpubs/AIM). The following are the basics, but the specifics will vary equipment and area you fly:

The standard transponder controls are:

- 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 identifiable by brightening it on the controllers radar display

Typical displays are:

- Active code: the code being transmitted
- Reply indicator: flashes to indicate the unit is replying to interrogations
- Encoder altitude: shows the pressure altimeter that the encoder is reporting

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

When you are ready to fly

- Select Standby when you are on the flight line as part of your pre-takeoff checklist. Confirm that the transponder code displayed is 1200, for VFR flying. Local agreements with ATC may require a different code (Reno area pilots generally use 0440).
- Select On (no encoder) or Altitude (with encoder). If you are flying from a towered field, you would generally only do this after takeoff to avoid confusing reflections to ATC radar.
- Continue to use “see and avoid” even with your transponder in operation. Other gliders and most 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. The SSA is working for a modification to the rule to avoid this conflict between safety and regulations.
- Turn off the transponder immediately after landing, to avoid confusing reflections to ATC radar and to preserve the hard-working battery.
- Charge the battery as soon as possible. This will increase its life and ensure it’s ready for the next flight.

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 1200, 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, so changes aren't transmitted until the entire "standby" code is exchanged with the "active" code with a single button push.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.

Glossary

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 the specific section you need from the FAA websire (www.faa.govl ATpubs/AIM).

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.

FARs Federal Aviation Regulations - the rules that U.S. aircraft and pilots must follow. Rules pertaining to transponders are found in FARs 91.215, 91.217 and 91.413.

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, pilots not in touch with ATC squawk 1200 -- the standard VFR code.

TCAS Traffic Alert and Collision Avoidance System -- a device found on most commercial passenger-carrying aircraft that interrogates nearby transponder-equipped aircraft and displays traffic advisories.

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 possibly altitude and other information.

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. (see http://av-info.faa~gov/tso/). When a device is "TSO'ed", it has been certified to conform to applicable standards and is thus legal to install and use in aircraft.

For the future: More ATC, radar, and transponder facts and discusssions…

If you have suggestions for this section, please let me know:

Eric Greenwell
222 Thayer Dr
Richland, WA 99352

509-943-9065

engreenwell@charter.net