Considerations for Electronic Conspicuity

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If you don't know your TAS[1] from your TCAS[2], or what to do when they give you a warning, then you're not alone. In this article I'll try to help sort out the sometimes baffling assortment of information concerning these systems. My aim is to give a brief and non-technical overview so that, by the time you've finished, you'll hopefully have a clearer understanding of how the various systems operate, have an appreciation of practical considerations from insights we have gained at the Airprox Board, and might even be tempted to buy one! Here goes.

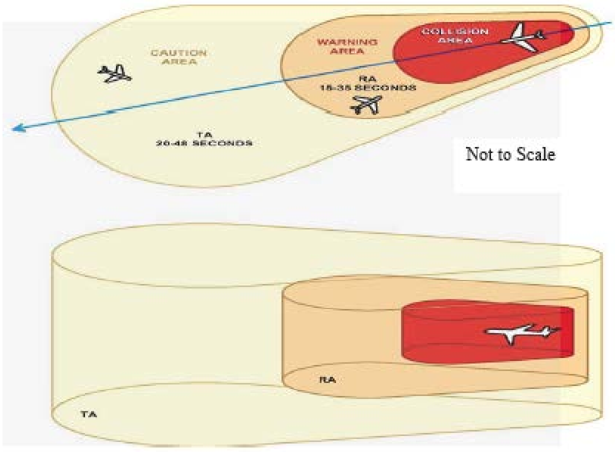
TCAS is an implementation of the ICAO Airborne Collision Avoidance System (ACAS) standard. In fact, it's currently the only implementation of the ACAS so the two terms, TCAS and ACAS, are often used interchangeably. TCAS gives Traffic Information about other 'cooperating' aircraft which are displayed as various symbols, in various colours, depending on system parameters (as shown in the info box), and will tell you how to get out of the way, as long as the other aircraft is 'cooperating'.

Generic TCAS Display

In the example shown here, our own aircraft is situated at the aircraft symbol just below the centre of the display, with a 2nm radius circle around it formed by short dashes. We have: 'Other traffic'(empty blue diamond) in the left 11 o'clock at about 3nm, 1800ft above and level; 'Intruding traffic' (yellow circle) in the right 1 o'clock, 6nm, 200ft below and descending; 'Proximate traffic' (filled blue diamond) right 1.30, 3nm, 1000ft below and descending and 'Threat traffic' (red square) right 3 o'clock, 2nm, 200ft below.

For traffic which is assessed to be converging in plan and altitude, TCAS will first provide a 'Traffic Alert' (TA), highlighting the traffic, followed by a Resolution Advisory (RA), which is the 'getting out the way' bit. The outer ring of the display, shown mostly in red in our example, indicates an RA 'Climb' is required; the pilot has to pitch up to put the vertical speed needle on the green bit of the arc (at the top), or at least get it off the red bit. Following events such as the Überlingen mid-air collision[3] in July 2002, it is now mandatory for commercial air transport pilots to follow a TCAS RA demanded rate of climb or descent. In that tragedy, amongst many other factors, one crew of 2 converging airliners followed their TCAS 'Descend' RA and the other followed ATC instructions to descend, contrary to their TCAS 'Climb' RA.

So how does TCAS work? Rather than take up the rest of this magazine with the subject, I'll just cover the basics. The first important fact to know is that TCAS operates independently of any ground equipment; it is a cooperative system that uses SSR transponders to gather and derive information such as bearing, location, altitude, slant-range and closure rate. Using this information, it then applies anti-collision logic to calculate alerts based on time-to-go to the predicted Closest Point of Approach (CPA) between the aircraft (known as tau). TAs and RAs are triggered at defined tau values which, in effect, provide protected volumes around the aircraft. But it's important to know that TAs and RAs may be inhibited by the system logic; for example,



[1] Traffic Advisory/Alerting System.

[2] Traffic Alert and Collision Avoidance System.

[3] http://www.bfu-web.de/EN/Publications/Investigation%20Report/2002/Report_02_AX001-1-2_Ueberlingen_Report.pdf?__blob=publicationFile is the German accident investigation report. Note that some TCAS regulations stated in the report have since changed.

at low height when on the final stages of an approach, or for a more 'important' alert such as a ground proximity warning – as a result, you need to get into the TCAS manuals to understand when these warnings will be inhibited so that you are not relying on something that may not be generated.

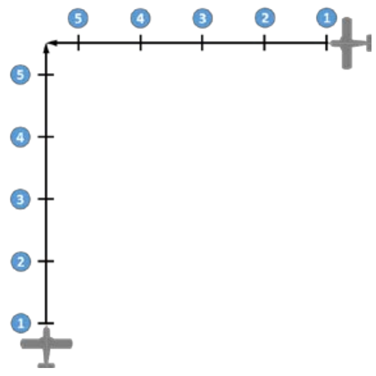
So that's TCAS, but what's TAS all about then? TAS is a broad definition that covers all the systems which tell you where some of the traffic is, but won't tell you how to get out the way. Some examples are FLARM/PowerFLARM (FLight alARM); Avidyne TAS600; Garmin GTS800; and f.u.n.k.e. TM250. TAS use a variety of data to generate traffic information and warnings or alerts. The obvious data source is SSR information, but systems also typically use GPS in conjunction. For example, PowerFLARM uses GPS-derived data, SSR Mode C and S information and ADS-B 'out' data to give a hybrid picture. How this information is displayed varies from model to model, and some displays are quite 'TCASy', but it's important to remember that the only 'getting out the way' algorithm with these systems is in your brain.

ADS-B

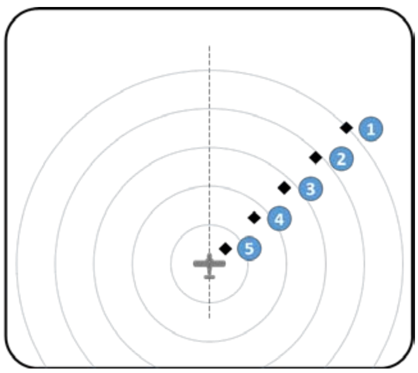
ADS-B (Automatic Dependent Surveillance - Broadcast) uses GPS to transmit own aircraft position, much like FLARM. This is the ADS-B 'out' bit. The technology emerged from the need to provide surveillance without having to build hundreds of expensive radar heads across large areas. The ADS-B 'out' signals are received by ground stations and integrated to provide surveillance-based services to pilots (and internet flight trackers!). ADS-B 'out' and 'in' can be separate bits of kit so it's quite feasible to fit ADS-B 'out' only. If your aircraft is equipped with ADS-B 'in' then you'll be able to receive position data from other aircraft for processing (it can also receive in-flight information such as weather updates or warnings, although currently only in the US).

The cost of installing TCAS means that it's not common in anything other than airliners or major commercial fleets, where its fitment is mandated or deemed essential to operations. So, for the vast majority of GA, any equipment installed will probably be a TAS. Because your input is required to resolve conflictions shown on TAS, Airprox Board experience indicates that it's worth having a good think about how to interpret and assimilate the information, formulate a plan of action, and carry out an appropriate avoidance manoeuvre, if required. Remember, in doing so, you're also still required to operate in compliance with the Rules of the Air/SERA, so you have to think about how you'd respond to TAS indications with that in mind too.

A common misconception is that TCAS/TAS will show track geometry, whereas what it actually displays is the bearing of the other aircraft. As an example, let's consider an aircraft approaching from the right-hand side, perpendicular to our track, at the same airspeed and altitude, and on a collision course. What would that look like on a TAS screen? Let's examine this hypothetical situation and an associated TAS display with the same time-based positions shown. We're in the aircraft travelling from bottom to top, with equivalent positions of both aircraft marked by the same number (i.e. at time '3' both aircraft will be at their respective position '3'). At time '1', the other aircraft will be 45° right of the nose. At time '2' the other aircraft will still be 45° right of the nose, but now at a reduced range. Similarly, at times '3', '4' and '5', the other aircraft will remain 45° right of the nose with range continually decreasing. Plotting all that on a TAS screen in one go produces the picture shown, with time positions also annotated; although the effect in reality would be of the contact moving diagonally down the screen towards us.



Aircraft Geometry



Corresponding TAS Display

So, in looking at the TAS display, you have to interpret the moving dot over time: is that an aircraft crossing right to left, or is it an aircraft heading straight for you? How will your perception of its track affect your decision to turn? Will you turn right or left? Does your decision conform to the Rules of the Air/SERA? If, like me, you lose 50% of your ability to think properly as soon as you step into an aircraft, these issues are best considered in the bath rather than whilst closing with other traffic! You'll be pleased to hear that there's a simple rule: if the other contact is on a constant bearing, at the same altitude, you're on a collision course - so change something. A small change in altitude is probably the quickest effective action although there are other options. If time permits, perhaps request a Traffic or Deconfliction Service? Or, if that isn't possible, simply request Traffic Information? How about putting in a 45° turn for 30sec and then reversing back to track? It won't significantly delay arrival at your destination, but it will break the collision geometry. Airprox **2014126** is a great example of where Power-FLARM saved the day for a Jetstream and some gliders through intelligent interpretation of the displayed information.

Another important consideration is the effect that a new bit of kit will have on your lookout. Perhaps counter-intuitively, putting a shiny new TAS into your aircraft can seriously hamper lookout. One of the Airprox quotes that stand out in my mind is "*the traffic indicated inside a mile, so I turned the scale up*". Or in other words, the traffic was so close, I looked inside the cockpit, found the scale control knob, turned it in the correct direction to change the scale and looked at the display to try and resolve the other aircraft's position. Really?! Getting your eyes outside the cockpit would be my priority in this circumstance, but it's amazing how seductive a new display in the cockpit can be. Many TAS have the option of an audio output, which strikes me as an excellent investment; the less you need to look inside the better. Also, where will your TAS display be located? Buried at the base of the instrument panel on the other side of the cockpit would not be useful. Mounted in your eye-line, on top of the coaming, may also just get in the way of your visual scan. There's no easy answer, but it's a question that needs thinking about carefully.

That's a very brief look at TCAS and TAS, and here's the 'take-home' message: clearly, if SSR isn't selected on, TCAS can't react to it at all; and if Mode C or S isn't selected on, an RA can't be generated because the TCAS doesn't know the altitude of the other aircraft. Hence the Airprox Board's almost monthly reiteration of the importance of selecting the SSR on, with all available Modes. Squawk 7000 plus Mode C in Class G airspace, even when you're not getting a service: it might just save you if the other aircraft has a TCAS or TAS fitted even if you don't. Give TCAS, and TAS, a chance! But, equally, be aware that your flight vector may well cause problems for other aircraft that are TCAS equipped. Remember, if they are commercial aircraft then their pilots are mandated to follow any TCAS RA commands so, if you are operating near them, please have consideration about pointing at them, or flying close to them, lest you cause a TCAS RA (and subsequent likely Airprox report!). See Airprox **2014058** and **2014207** which illustrate the point!