Technical look at ADS-B in, TCAS, ACAS & TAS

A number of people have asked about ADS-B and in particular, ADS-B in. Couple that with some incorrect advice I've heard and see, and wrong information published on NZ websites and I thought a deeper dive into ADS-B and especially ADS-B in and traffic alerting might be of use.

ADS-B Automatic Dependent Surveillance Broadcast
This is your new transponder. You still need an old style Mode C transponder, but most people are opting for a new ADS-B all in one ADS-B transponder the does the old Mode C too.
ADS-B in short, a high quality GPS source knows where you are and ADS-B broadcasts once a second for anyone to hear a big bucket of information;

- Pressure altitude (like the old SSR transponders in Mode C (ALT)))
- GPS based altitude
- Call sign/flight ID
- Emergency status
- Aircraft category (size/performance)
- Ground speed
- Ground track angle (direction)
- Heading
- Horizontal velocity
- ICAO 24 bit unique address
- IDENT flag (if you push the squawk IDENT button)
- Squawk code (SSR transponder 4 digit code)
- A number of fields indicating the accuracy and integrity of the GPS data

The big thing about ADS-B is your aircraft just sends this data out, all the time, regardless of whether you're inside radar coverage or not.

ADS-B also features a ground mode and this slows down the transmit rate to once every 5 seconds and outputs an additional flag saying your on the ground.

Advantages;

- Fast – once a second broadcast vs 5 seconds for a radar sweep
- Automatic – once a second broadcast, in a valley, behind a hill, always on
- Coverage - much better ATC coverage because all ATC needs is a network of far less expensive listening aerials vs huge cost for a traditional radar network
- Accurate – with the high-quality GPS you location is far more precise than traditional radar
- ADS-B in – anyone can easily receive these ADS-B messages and see the aircraft around them and so any other aircraft with ADS-B in will see other transmitting ADS-B aircraft
- SAR – better coverage and precise position accuracy translates to better SAR response times
- Ground mode – ADS-B understands if you're on the ground and transmits more slowly and a "ground flag", also the concept of airport ground vehicles with ADS-B for airport ground surveillance

Disadvantages;

- Penetration – everyone must have ADS-B to be seen (not dissimilar to old SSR transponder rollout out, same issue, everyone needs it for it to be truly useful)
- Cost – everyone must equip their aircraft (we have the government subsidy to help)
- Relies on GPS – no GPS and ADS-B is dead (backup for NZ is a limited network of old style SSR)
- Weight – but now largely addressed now with very small lightweight units on the market (an example is Trig)
- Accuracy – if the GPS data is rubbish, then your aircraft won't be where your ADS-B says it is, but the high technical standards with FDE below ensure accuracy.

FDE & TSO-C145

The technical standards on the GPS receiver are very high. This is because the GPS must be able to do a number of very clever things;

1. Accuracy - The GPS must understand how accurate it is and report that
2. Robust - It must not give up and stop if a couple of satellites end up throwing out the accuracy

FDE – fault detection and exclusion, using clever maths the GPS can tell if the position accuracy is getting poor, and unlike older IFR GPS with RAIM which just gives up and stops working, FDE can figure out if it throws out one or more satellites out of the equation it can continue with an acceptable position fix.
Now that's smart.

TIS-B, FIS-B, ADS-R, UAT

I've noticed a lot of the above terms are all published on various NZ websites selling ADS-B transponders, and, you'd think reading what they have listed online that this stuff is available in New Zealand.

Let's be very clear – NONE of the following is ever going to be in NZ!

UAT - Universal Access Transceiver (ADS-B using 978 MHz)
TIS-B – Traffic Information Service – ground station traffic broadcast to your plane
FIS-B – Weather & NOTAMS in the cockpit, Flight Information Service Broadcast
ADS-R – ADS-B rebroadcast from a ground station, UAT 978 MHz <> 1090 MHz

Why none of this stuff for NZ?

All of the above operates on a different frequency, 978 MHz and it needs a network of expensive ground stations to broadcast this information. It was determined we don't need 2 frequencies, (normal ADS-B on 1090 MHz and the extra UAT 978 MHz) because NZ is not expected to saturate 1090 MHz like the US is expected to do so.
The cost of using UAT in NZ with the required ground stations for NZ would be huge and with NZ mountainous terrain, our UAT coverage would be poor, like our existing radar (SSR) coverage and we'd need a huge number of ground re broadcast stations.

ADS-B in

This is the best bit of ADS-B.
I strongly encourage you to get the big benefit that ADS-B in offers, the ability to help you locate close by traffic around you and visually acquire them.

A number of solutions offer this, from portable battery powered systems that send the traffic to your tablet to panel mounted solutions from Garmin, L3 and others.

Traffic alerts - TAS, TCAS & ACAS

TCAS/ACAS does not exist for ADS-B. TCAS stands for Traffic Collision Avoidance System and the term is often interchanged for ACAS (Airborne Collision Avoidance Systems) which is essentially the same thing.

TCAS is based on traditional SSR transponder Mode C systems, and found only on big airlines. Just to confuse the issue further, some smaller aircraft like the Piper Meridian, Socata TBM and smaller commercial aircraft have fitted TCAS I, which is really a certified version of TAS.

TCAS type I
Certified SSR mode C based Traffic Alerting (no collision avoidance despite the name)
Generates an audible and/or visual warning of close by aircraft in the form of "Traffic, 11 O'clock, same level, 1 mile"

TCAS type II
Certified SSR mode C based Collision Avoidance System.
Initially generates traffic alerts like TCAS-I and if a collision seems likely tells the pilots how to manoeuvre in the vertical plane to avoid a collision (climb or descend). This is called an RA (Resolution Advisory).

TAS - Traffic **A**lerting **S**ystem
Normally gives you audible and/or visual warning of close by aircraft in the form of "Traffic, 11 O'clock, same level, 1 mile"
TAS does not tell you how to avoid traffic, but, helps you visually acquire the traffic. The goal of TAS is to alert you to close by traffic and help you visually sight the traffic and you then decide what to do.

Typically the system uses the concept of a CPA (closest point of approach) and for TAS in GA that often is anything that will come within a bubble of 20 seconds and ± 600' of your aircraft will generate a TAS alert.
That's quite clever, the faster you go the bigger the bubble and as you slow down, the bubble size shrinks because it's based on time which relates to speed.

TAS can also be old style "active traffic" based on SSR Mode C transponders, or ADS-B in or a combination of both.

The goal of all TCAS, ACAS and TAS systems is to help the pilot visually acquire aircraft.

Proper certified TCAS-II actually states the primary goal of TCAS is situation awareness and to help pilots visually acquire the other aircraft!

Never ever;

Manoeuvre your aircraft in the horizontal plane (turn) to avoid something on your display.
This is because you are moving, your display is moving and so is the target. You have no fixed point of reference unlike a radar controller display and by turning you can easily make a nearby pass by into a collision.
Have a look at this article https://www.skybrary.aero/bookshelf/books/101.pdf for an in depth view on why and pictures showing what can go wrong if you turn by just looking at your display.

TCAS confusion

My take on why the TCAS / ACAS and TAS has become confusing is;

- TCAS as a term has become synonymous for all traffic alerting systems
- Avionics manufacturers interchangeably use TCAS and TAS
- There doesn't seem to be a formal exact definition for TCAS vs TAS
- TCAS-I is functionally equivalent to TAS
- Everyone knows TCAS, and that's the best, so it has become a bit of marketing term

Even with the airlines TCAS-II, although it tells you what to do (climb or descent) the pilot still has to do the actual manoeuvre. One could argue that any TAS system where you are prompted to find the traffic and then you do something to avoid it, is therefore a form of TCAS, because TAS alerted you to the potential collision which was then avoided.
My view is that's how the likes of Lynx and others throughout their manual talk about "TCAS" this and "TCAS" that, even though it is clearly a traffic alerting system (TAS) and absolutely no guidance on how to avoid a collision is provided.

The collision avoidance bit is you!

ADS-B in – TAS

To get TAS with ADS-B in, in addition in receiving ADS-B, you need a traffic processing engine.

Traffic processing does;

- Maps where the other aircraft in the sky are around you
- Determines if any will get too close you based on relative altitude, direction & speed
- Generates audio and visual alerts for close traffic – "Traffic, 2 O'clock, low, 1 mile"

****** Traffic Alerts in your headset is the best bit of ADS-B in. That audio callout, no need to look down at a screen and try and interpret the display, just follow the voice prompt and look**.

ADS-B in vs "Active Traffic"

Active Traffic is the term often used for TAS systems that operate on SSR transponder Mode C interrogations. Like TCAS-I/II – the transponder on the active traffic aircraft interrogates nearby SSR transponders.

Active Traffic – SSR transponder Mode C interrogation

- By timing the interrogation pulse send and the reply, you can determine distance
- A large quadrangle direction antenna (often on the roof) determines the approx. direction that the replay came from
- The Code C pressure altitude reply and compared the active traffic aircraft determines the relative altitude

SSR transponder Active Traffic systems have a large number of drawbacks;

- Frequency clutter (large numbers of interrogations and every transponder for miles around replies)
- High cost
- Imprecise - Direction of the target aircraft is not very accurate and can often bounce around seemingly from out the left of you to the right and back again
- Slow - you need a number of pulses and replies to understand a target
- Close together targets may appear as one
- No concept of ground mode
- No flight ID/ callsign of the target aircraft

ADS-B in has a solved these issues;

- No interrogations at all, less frequency clutter
- You only need to "hear" one single ADS-B out from another aircraft to determine everything, exact position, direction, speed, altitude, flight ID/callsign
- Extremely precise
- Less aerials and no big quadrangle aerial required

ADS-B in – Panel mounted TAS examples

Garmin GTX – 345
This is available with an internal GPS, altitude encoder, ADS-B in/out, old style Mode C transponder and comes with the traffic processing engine. It can output the traffic to be displayed on a wide range of certified equipment.
But even without anything to display traffic on, you'll still get the audio alerts, the most important bit.

Lynx NGT-9000
A bit like the Garmin GTX-345 but also features a small colour screen to display traffic.

However!
It does NOT come with a traffic processing engine. You must add the optional ATAS add on to get traffic processing. Optionally you can also add eTAWS for terrain warning too.

ADS-B in – portable (but no TAS)

Dynon DRX, Stratus 3, Sentry (and more)
Small battery powered portable unit. Listens to ADS-B traffic around you. Then, using wifi it can connect to your tablet running an aviation app (like AvPlan, etc) and that's your display.
Today though, no traffic alerts, because there is no traffic processing engine.

Advantages;

- Cheap
- Portable

Disadvantages;

- No audio callouts of close by traffic and proper alerting
- Danger of constantly looking down at the tablet instead of out the window

Limitations of the see-and-avoid principle

Studies have shown that "…that in the absence of a traffic alert, the probability of a pilot sighting a threat aircraft is generally low until a short time before impact. Traffic alerts were found to increase search effectiveness by a factor of eight"
https://www.atsb.gov.au/media/4050593/see_and_avoid_report_print.pdf

ADS-B in with TAS greatly increases the change of sighting traffic.

Summary

- Equip ADS-B and get ADS-B in
- Get TAS with audio callouts for traffic alerting – it's amazing
- Understand the goal of TAS – look out the windows and sight the other aircraft
- On starting your aircraft that is ADS-B equipped, start the transponder in ALT mode and leave it alone. It will auto switch from ground to airborne mode and back again

Notes

I've used the colloquial term GPS when really, it's GNSS when referring to satellite based navigation systems.
I could have gone deeper again on TCAS and modern TCAS now also cross references ADS-B targets with Mode C, but, It's right to say its based on SST transponders Mode C ponder interrogations.

References

This is not specially written for TAS, it's actually for airlines but it's very relevant for TAS;

- "pilots must not attempt to self-separate…. based on the information derived solely from the traffic display"
- "Due to the relative motion of the symbol and the lack of speed vector, it is extremely difficult to anticipate the evolution of the situation based solely on the traffic display"
- and the pictures that show the difference between a fixed display (proper radar display) and the in cockpit moving reference display is very good.

https://www.skybrary.aero/bookshelf/books/101.pdf

L3 Lynx NGT-9000
https://www.l-3lynx.com/lynx-models/
https://www.l-3lynx.com/wp-content/uploads/2018/08/lynx-brochure-2018-web.pdf

General information on Traffic Avoidance systems
https://en.wikipedia.org/wiki/Traffic_collision_avoidance_system

https://www.aopa.org/training-and-safety/online-learning/safety-advisors-and-safety-briefs/collision-avoidance