Making Sense of Traffic Advisory Systems

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This year I started flying in New York City. In this high traffic area, I discovered how beneficial an on-board traffic advisory system can be for situational awareness. But after flying for months with the technology, I still had no idea how the data was coming into the cockpit and what were its limitations. And I had more questions: What are its modes of failure? Which components in the airplane intervene in detecting traffic? How reliable is the system? Is this ADS/B? Does this rely on ground stations? Will it still work when I fly to Canada?

So I ended up doing a fair amount of research and this page documents my findings. I'm doing my best to find accurate information and organize it in a sensible manner, but in no way am I an expert, so please let me know if something on here is incorrect.

Let's jump in.

Airborne Radar


NAT

A NATO AWACS E-3 Sentry aircraft with airborne radar.By Jwh (Own work) [CC BY-SA 3.0 lu], via Wikimedia CommonsPerhaps the most conceptually simple way to add traffic detection to an aircraft would be to equip it with a radar. In the military world, that is sometimes how it's done. And that makes sense, since it's a very autonomous technology:

- it's independent from any services on the ground
- it doesn't require any systems to be installed on the other aircraft for them to be detectable

Airborne radar is too expensive for light aircraft, but these are two key advantages worth keeping in mind when looking at the competing, cheaper technologies that are found on civilian aircraft. First we'll talk quickly about the TCAS systems found in heavier aircraft to establish a baseline of the great things that money can buy, then we'll go over what can be found in light aircraft and how it compares.

ACAS / TCAS

We tend to see these two acronyms interchangeably. Technically, ACAS (Airborne collision avoidance system) is the standard and TCAS (traffic collision avoidance system) is the implementation. This system is installed mostly in airliners and large airplanes.

Operationally, the system does two things: it plots the surrounding traffic on a screen along with its relative alitude, and emits vocal commands (such as "climb" or "descend") to resolve conflicts. Such TCAS alerts take precedence over ATC instructions.

A TCAS system is said to be *active*, meaning that it detects other aircraft by actively interrogating their transponders, just like the ATC radar does. When it receives a reply from a Mode S, C or A transponder, it plots the location and altitude (if available) on the display.

For non-pilots: a transponder is a device in the aircraft which transmits extra information to radars that detect it. It sends a numeric code set by the pilot at the controller's request that allows the controller to differentiate among the multiple aircraft on the screen. Most transponders also transmit the altitude.

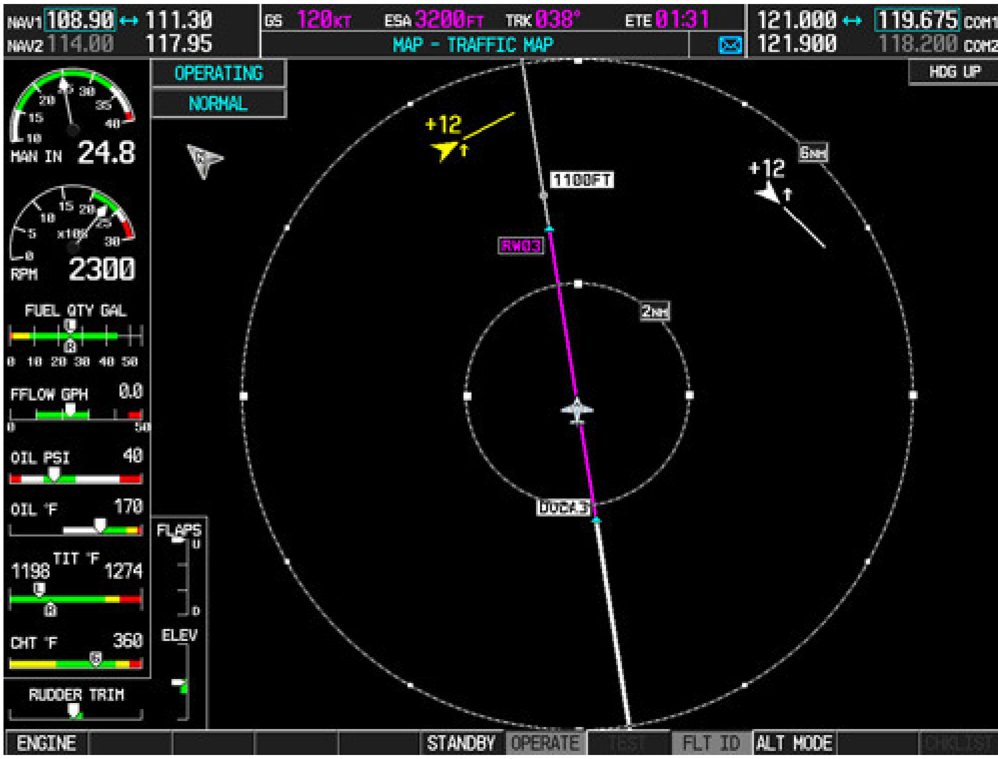
Due to the fact that it actively interrogates transponders, TCAS is completely independent of ground-based equipment and it can operate anywhere. However, it also requires the other aircraft to have an active transponder in order to see them.

Light Aircraft

TCAS systems tend to be too complex and expensive to be installed in most light aircraft. Instead, technologies that are cheaper but have more limits are used.

Perhaps the most common setup these days, found on some modern Cessna 172's for example, involves displaying TIS (*Traffic Information Services)* traffic. TIS (also known as TIS-A) is a technology in which the ATC radar, which has the full picture of the traffic in the area, sends a report (or "uplink") to the in-flight aircraft about the traffic that surrounds it.

A Garmin 430 GPS with traffic display, commonly found on light aircraft. It displays traffic provided to it by other avionics installed in the aircraft. The diamonds and circle indicate traffic, along with the relative altitude in hundreds of feet.



A Garmin G900X MFD showing traffic.

[According to the FAA](), the result is a picture updated nominally every 5 seconds. Aircraft reported are those within a 7-mile horizontal radius, and within -3000ft to +3500ft vertically. The maximum number of targets reported to each "client" is 8.

Like TCAS, TIS-A will only show aircraft that have a mode A, C or S transponder, since it needs to be visible by the ATC radar. It will also only function if you are in a zone which is covered by a radar which offers this service and which isn't out of order.

Unlike TCAS, TIS-A will not provide resolution advisories (vocal commands such as "climb" or "descend"). Further, as tempting as it may be, it is not authorized to perform avoidance manoeuvers based solely on the presence of traffic on the screen. The intent of the system is for pilots to use the information it provides as an aid to locate visually the other aircraft. Only after having established visual contact may they perform an avoidance manoeuver.

I wasn't able to find any indication that TIS-A is offered anywhere outside of the United States.

TIS-A is not ADS/B. ADS/B, a newer technology, has its own version of TIS called TIS-B, but that's a different story which we'll talk about in the section about ADS/B below.

From an avionics perspective, what is required to receive TIS-A? Typically, the traffic data would be received by a mode S transponder, such as the Garmin GTX 330 family, or its faceplate-less equivalent often found in G1000 aircraft, the GTX 33. The transponder is connected to a GPS (such as the Garmin 430) or an MFD (in like the Garmin G1000) which plots the traffic on a map.

The Garmin GTX 330 Mode S transponder, able to receive TIS-A and commonly found in small aircraft

The Garmin GTX 33 faceplate-less mode S transponder, able to receive TIS-A and commonly found on light aircraft with a glass cockpit like the G1000.

TIS-A is said to be in the process of being phased out and replaced by ADS/B.

Doing it with ADS/B

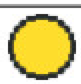
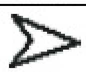
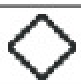
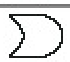
ADS/B (Automatic dependent surveillance – broadcast) is a new technology that aims at replacing the radar system, and do much more as well. In particular, it provides a new generation of technology for traffic avoidance.

The backbone of ADS/B is the broadcasts that aircraft do which inform ATC and other aircraft of their location, direction, altitude, and more. This data can be received passively by nearby aircraft. There is no need for interrogation since each aircraft periodically and spontaneously broadcasts its information.

But for light aircraft, these broadcasts are currently of very limited use. This is because among the aircraft that fly below 10,000 ft, only a small portion are already equipped with the fairly new ADS/B technology and send the broadcasts.

However, upgrading to ADS/B from TIS-A is fine because it has its own version of TIS, called TIS-B. The concept is analogous: ground stations connected to ATC radars and ADS/B in equipment broadcast traffic information to airborne aircraft. TIS-B provides the location of traffic detected by ADS/B as well as by secondary radar (mode A, C or S transponders). Comparatively, TIS-B provides faster updates, is more precise and supports more simultaneous targets than TIS-A. Typically, equipment which is capable of ADS/B in functionality can also receive TIS-B messages.

With some traffic advisories originating from ADS/B participants and others from the radar system through TIS-B, the quality and precision of the advisories can vary. Knowing the source of the data can be useful to pilots. As an example, Garmin avionics use the symbols below to make these differences clear to the pilot.

Symbol	Description
	Traffic Advisory (TA) arrow with ADS-B directional information. Points in the direction of the intruder aircraft track. (Not available in all installations.)
	Traffic Advisory without ADS-B directional information.
	Traffic Advisory out of the selected display range. Displayed at outer range ring at proper bearing.
	Proximity Advisory (PA) arrow with ADS-B directional information. Points in the direction of the aircraft track. (Not available in all installations.)
	Proximity Advisory without ADS-B directional information.
	Non-threat traffic arrow with ADS-B directional information. Points in the direction of the intruder aircraft track. (Not available in all installations.)
	Non-Threat Traffic without ADS-B directional information
	PA or Non-threat traffic arrow with ADS-B directional information, but positional accuracy is degraded. Points in the direction of the aircraft track. (Not available in all installations.)

Traffic symbols found on Garmin displays. Note how ADS/B traffic has directional information in the form of arrows. Source: G1000 Cessna Nav III manual

ADS/B equipment generally operates on one of two bands, UAT or 1090 ES. ADS/B in equipment supporting the UAT band can also get FIS-B weather broadcasts. Equipment which supports only one of the two bands will see only the traffic which broadcasts on that band. But since TIS-B sends a full picture of an aircraft's neighboring traffic, this only becomes a concern when TIS-B ground stations are unavailable. There is also another ground-based technology, ADS-R, which relays ADS/B broadcasts from one band to the other when a ground station is in range.

Per se, ADS/B avionics will not provide vocal resolution advisories and do not save pilots from establishing visual contact with the traffic. ADS/B may be integrated in TCAS systems to provide these features, but basic ADS/B avionics do not.

To support TIS-B, one would need to upgrade from their TIS-A avionics to ADS/B avionics. An example of avionics that provide ADS/B in capability and interfaces with GPS's and MFD's is the Garmin GDL 88.

The Garmin GDL 88 provides ADS/B traffic in and out support

Affordable, portable devices also exist which plot ADS/B and TIS-B traffic on tablets and smart phones, such as the Garmin GDL 39 3D or the Dual XGPS170.

There is a major caveat however with using these units, as well as any other avionics configuration which doesn't have ADS/B out capability. TIS-B messages are only transmitted by ground stations to aircraft in response to their ADS/B out broadcast. In other words, an aircraft needs to be ADS/B out equipped in order to receive TIS-B advisories.

Sometimes, there can be an ADS/B out equipped aircraft in the vicinity which will cause TIS-B advisories to be sent to it. Most ADS/B in equipment, including the portable units, can use and display the traffic reported in these transmissions meant for other aircraft. Unless it is in the immediate vicinity however, its traffic advisories may not be relevant. If there are no ADS/B out equipped aircraft nearby, then there will be no transmissions. This Garmin brochure explains the problem.

The Garmin GDL 39 3D is a portable ADS/B receiver

These portable units will however receive direct broadcasts from aircraft in the vicinity which have ADS/B out functionality. Like we said though, within the GA community, these are limited.

The XPGS 170, a portable ADS/B receiver option

An important consideration for TIS-B is the ground station coverage. ADS/B coverage in the United States is excellent, but is generally poor in the rest of the world as of early 2015. And having ADS/B coverage by no means indicates that TIS-B will be available. In Australia, the country is progressively rolling out ADS/B but has elected not to provide TIS-B due to technical and financial considerations. Information can be difficult to find. Canada for example has ADS/B coverage in some areas in the north, but I haven't been able to find documentation about whether TIS-B is offered at all in these areas.

In essence, today, ADS/B doesn't make one any less dependent on ground stations because one needs them to see mode A/C/S equipped aircraft as much as when using TIS-A. If no ground stations are available, ADS/B in allows one to receive direct broadcasts from nearby, ADS/B out equipped aircraft, but those are not very common in the general aviation community. So from an operational perspective, it makes little difference to me whether I conduct a flight with a TIS-A or ADS-B equipped aircraft today. Making a purchase decision however might be more complex because ADS/B is expected to become proeminent in the coming years, and theoretically TIS-A should be phased out.

Being Ground Station-Independent

For those willing to invest in more capable equipment, it is possible to install a system which performs active interrogation of other aircraft, whether they have a mode S, C or A transponder.

Whether an aircraft is equipped with TIS-A or TIS-B (or no TIS at all), it will benefit from such avionics, as it will enable detection of other aircraft regardless of whether TIS is available in the area. When flying outside the US, this seems like it would be the most reliable way to see traffic advisories.

This is one of the key advantages of the more expensive TCAS systems. However, unlike TCAS avionics, they do not provide vocal resolution advisories and pilots still have to establish visual contact with the traffic.

An example of such a system is the Garmin GTS 800 family. Another is the Avidyne TAS600 family.

The Avidyne TAS 600 interrogating traffic advisory system. It detects aircraft with a Mode A, C or S transponder. It can also be optionally upgraded to support ADS/B.

PCAS – An In-Between

PCAS is an interesting in-between. Sold in a portable form factor, it is similar to active interrogation equipment, in that it listens for mode A/C and S transponder replies from surrounding traffic. The difference however is that it doesn’t interrogate transponders, it waits for other equipment (such as an ATC radar or TCAS system) to query them, then listens for the reply.

In ideal conditions, this means the same benefits as an expensive active traffic interrogation system. There are, however, additional caveats.

First, someone has to query the other transponder. Concretely, this means that if there are only aircraft with passive avionics in the vicinity and that the area has no radar coverage, then the PCAS unit will not detect any traffic.

Second, some reviewers say that the PCAS is not particularly good at detecting traffic behind the aircraft. Some also say that the passive technology has glitches which limits its usefulness.

PCAS, as much as the name seems to imply it, is not a portable version of TCAS. Its goal is only to provide additional situational awareness and it does not save the pilot from establishing visual contact with other aircraft.

PCAS is more expensive then portable ADS-B in units, but unlike them, it isn't dependent on TIS to detect mode A, C and S traffic. So my understanding is that it would be particularly useful in regions where there is radar, but no TIS. This would be the case in many locations outside of the United States.

Conclusion

Now I know that the Cessna 172S and SP I fly use TIS-A and will likely provide traffic all over the northestern US where I hang out. I expect traffic will stop functioning if I go up to Canada, although I've had trouble finding information about the status of TIS outside the the US.

On the other hand, the Piper Archer II I fly which is equipped with a fancy Avidyne TAS600 should keep providing traffic advisories across the border since it performs active interrogation.

It's important to keep in mind that a huge blind spot of all these systems is that they do not detect aircraft which don't have a transponder or whose transponder is not operative. For that purpose, flight following remains the best backup to see-and-avoid, as controllers are able to see primary targets on their radar.


Try figuring out what type of traffic avoidance system this aircraft has…

This research has only convinced me further that the technology for traffic avoidance is a mess right now. It's complex, and it's hard to find information about it. Even figuring out what are the capabilities of an aircraft you are sitting in is not easy and requires intimate knowledge of the various avionics product lines. POH's were useless to me in this regard. Yet in aviation, safety is a strong function of knowledge. So let's hope that as this technology becomes more common, we pilots gain a high level of familiarity with it.

Again, I'm just an private pilot doing my best to collect accurate information, so please let me know if this article can be improved.

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