COLLISION AVOIDANCE

Ways To Watch Out For the Other Guy

BY GARY PICOU

The most feared of all flying calamities is the mid-air collision. Perhaps this fear is out of proportion to the actual threat, it is nonetheless regarded as one of the deadliest of hazards. Psychologically, it is because we fear what we can't control. Midair is a sudden and terrible occurrence, caused by "the other guy."

We all believe we can outrun a storm, survive an engine failure with our exceptional piloting skills, and we would never be so stupid as to plan a flight into rising terrain. But it is those "other" pilots out there who are the cause of midair collisions.

So, we hone our skills and invest in the latest technology to ward off these disasters. With great effect too, midair collisions have decreased steadily, even as air traffic has edged upward.

Collision avoidance doesn't depend on any single gadget or technique, but a whole toolbox of equipment and skills, in diligent use, by everybody in the airspace.

Ryan International's multi-hazard display showing 9900BX Traffic and future interface hazard sensors.

This article is not vide more than a simp "what's the differer written so that a shops or aircraft owners can have a fundamental idea the variety and similarity in each system. Is this over simplified? Hecl yes. Electronic collision avoidance is a marvel of technology, science and higher order mathematics. If you want the gory details, go to www.faa.gov, and search for collision avoidance.

L-3 Avionics Systems SkyWatch System

VISUAL

This is written for the purveyors of the latest in electronic equipment, as an overview to the variety of electronic anti-collision countermeasures, so we will concentrate on the cool gear. But we need to start with the basic tools, eyeballs.

See and avoid is the fundamental collision avoidance tool and the most important. According to the Air Safety Foundation, 78 percent of the midair collisions occurred in the traffic pattern, and 82 percent resulted from a faster aircraft overtaking a slower moving one. This is where the electronic systems lose their effectiveness, airplanes are supposed to be around airports. It's when they don't do what they are supposed to do that we have problems; non-standard pattern actions cause accidents. Studies show that non-standard arrivals greatly increase the risk of midair collisions. That's natural, because when airplanes appear where they aren't expected, where you aren't looking, wham. You join the ranks of statistics.

The effective visual collision avoidance techniques can and do fill volumes and are best left to professionals to teach. However, we wanted to remind the readers that the most sophisticated collision avoidance systems ever invented is the skilled pilot. Without airmanship skills, the electronics are useless.

This system consists of an organic optical receptor, controlled by the flight crew that gathers visual data from the surrounding airspace. This is processed by an organic data center, which will identify and categorize perceived threats. The organic data systems then sends commands to the crew so they will respond appropriately. Price tag—around 150 bucks for a good pair of Ray Bans.

ATCRBS

The most common anti-collision system is Air Traffic Control; they are our first line of defense. Air safety is their mandate, and a job function that the FAA has excelled at for decades.

Still, effective collision avoidance through the ATC system requires operational avionics, such as a transponder, encoder, and comm radios. These must be installed properly, and, importantly, maintained. If the transponder is not aligned correctly, it isn't going to provide accurate, or any, data. If the encoder is inaccurate, the TCAS in the other aircraft will be basing avoidance on erroneous data. You might as well come screaming into the pattern from the wrong direction.

ATCRBS, pronounced "at crabs," for Air Traffic Control Radar Beacon System, has been around since WWII, when it was IFF (for identification, friend or foe.) Technically, we have a ground-based interrogator called secondary surveillance radar (SSR) which is attached to the primary air traffic radar. It transmits a 1030 MHz pulse pair to the aircraft witch causes the transponder to respond with either the ATC-assigned 4-digit code, or a code that represents the aircraft's pressure altitude. This is a pulse stream on 1090 MHz.

The response to the SSR interrogation is combined in the ATC computer and displayed to the controller, who will make course recommendations via an AM communications radio, to maintain separation in four dimensions (latitude, longitude, altitude and time). The flight crew does not have any useful information directly from the transponder/encoder system; it relies on interpretation by somebody in a room, far away.

ATCRABS is so common that we take it for granted. We can't even really tell how well it is working unless controllers give us a hard time about wrong altitudes, or missing radar returns. That is why there is a mandated two-year test (14 CFR 91.413). It can only be verified by the avionics shop.

The regulations require that the transponder and encoder be checked if you are going to USE them in the ATC system. How about the Sunday VFR patch hoppers? They don't need to have a transponder check, but they have them installed, and turned on to squawk 1200. Folks, those transponders can be transmitting erroneous data to the rest of us, from ATC to TCAS to TIS—we all depend on the basic transponder as a source of information. No data is better than misleading data, in our opinion.

The technology here is an L-band system, 1030 MHz receiver, some logic gates and a and a pulse modulated 1090 MHz transmitter. The altitude encoder is a very simple pressure transducer. Cost for an ATCRBS transponder is under $2,000, including the blind encoder. With the advent of modern (as in 1970s) electronics, the very expensive pulse systems have gotten positively cheap. Competition and the ubiquitous nature of transponders has helped, too.

TCAS I on the Bendix/King KMD 850.

TCAD

Although the garden variety ATCRBS system doesn't have any useable cockpit functionality, that doesn't mean that there aren't ways to use it. Signals in space are available that contain the needed information. Paul Ryan developed the first TCAD (Traffic and Collision Alert Device) systems, which represent an affordable way to use the ATCRBS system signals that are out there, as for onboard collision avoidance.

The very first systems were based on the simplest of concepts, if two airplanes aren't at the same altitude, they can't hit. The Ryan TCAD is a passive device which listens to the transponders and altitude encoders in the vicinity. Targets that are close to the airplane's altitude are monitored. If they stay there, and have a strong signal, indicating close proximity, the TCAD sings out a warning.

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Garmin AT's AT2000 showing correlated ADS-B-TCAS Traffic Display with Weather.

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The passive TCAD system depends on other aircraft to transmit in response to interrogations by ATC, or, in later years, other Mode S and TCAS–equipped aircraft. Still, there are occasions when threat aircraft won't be interrogated by anyone else, and the TCAD can't "see" them. The Ryan 9900BX can transmit its own interrogations if necessary (such as when the system doesn't detect any active radar), sort of an "Anybody home?" call. This is called an "active" TCAD system.

Ryan is the brand identified with TCAD. A similar concept is found in L-3's SkyWatch system, which is an active system.

Technologically, the TCAD is a transponder receiver section, with some computational algorithms grafted onto it. That is where the magic happens. Based on the signal strength and rate of change, these systems can detect an impending collision using the signals provided by the most basic of transponder/encoder installations. This is what you are paying for, in the $6,500 range and up, is the science behind the picture. That's science that will save your fuselage.

MODE S

Mode S (Select) is the evolution of the ATCRBS system. Longer data streams allow for data link, and the "Select" function allows Air Traffic to interrogate the aircraft as needed, not with each radar sweep. Each aircraft has a discrete address, and can be polled as necessary to update the data.

Since the interrogation is subject to ATC requirements, it makes the passive TCAD type devices less effective. They won't detect a response, if none is requested. Fortunately, we are many, many years from a Mode S airspace system. Threat aircraft will still be firing off squawks. Mode S even has its own random transmissions, called "squitter" that will alert other aircraft to their presence.

The technology—1030 MHz ground interrogators with long pulse train data link (56 or 112 bits), and selective interrogation by Mode S ground stations; data link to share status information. Sending 112 microseconds of energy out takes more circuitry than the short ATCRBS pulses, and these have a more sophisticated modulation scheme. Costs are at least double that of an ATCRBS system, but you can utilize the data link capability, and derive some value from the unit, and have the knowledge that you are reducing controller workload, and improving air safety in the bargain.

TCAS

A Traffic Collision Avoidance System, or TCAS, is the system envisioned following the 1956 midair disaster over the Grand Canyon. TCAS is the elegant solution created in advanced think tanks like MIT's Lincoln Labs, an engineering solution so advanced that the electronic processing power needed wasn't available when the algorithm was invented.

TCAS uses the SSR radar beacon technology, combined with Mode S data link, and is split into two types, TCAS I and TCAS II.

TCAS I is an advisory system. It shows the relative altitude, bearing and distance to potential threats, but doesn't give any recommendations for evasive action.

TCAS II will provide Resolution Advisories to "Climb" or "Descend" in order to escape the intruder aircraft. If both aircraft are equipped with TCAS II, their maneuvering will be coordinated by the Mode S to make the maneuver "deconflicting." In other words, to prevent two aircraft from going the same direction to get out of each other's way, like that awkward moment in a hallway when you and another person keep dodging each other in the same direction.

TCAS I is mandated (Title 14 CFR Part 135.180) in turbine powered aircraft: between 10 and 30 seats, typically the regional airliners. That doesn't mean that you can't buy one for your Seneca or Baron, if safety is your goal.

TCAS II is required (Title 14 CFR Part 121.131 if you are following along in the regulations) in air transport aircraft with 31 or more seats, but again, there are no rules against installation in a corporate aircraft, and many companies, wanting to protect their executive investments, will install TCAS II.

TCA's technology includes an L-band receiver with top and bottom mounted antennas to detect other aircraft transponders and resolve the azimuth and distance. Decoding the intruders' Mode C will provide altitude information.

TCAS I—$100,000. TCAS II—$200,000. Not bumping into a 747-400 at 35,000 feet over the North Atlantic—Priceless.

TCAS III, originally planned as an altitude and azimuth solution, was shelved, because the technology wasn't accurate enough. Collision avoidance using vertical separation works, however, it isn't efficient. Somebody has to climb, therefore consuming more fuel than simply turning to avoid conflict. That brings us to ADS-B, which is a de facto replacement for TCAS III.

ADS-B

The ultimate in electronic collision avoidance is Automatic Dependent Surveillance-Broadcast, or ADS-B. This is aircraft-to-aircraft communications over data link that coordinates evasive action, much like TCAS II promised, at a fraction of the cost, using a combination of transponder, data link and GPS technology.

Simply, ADS-B-equipped aircraft fly around and transmit their position, heading and ground speed to anybody who cares. The receiving aircraft calculate and determine if they are in danger of occupying the same four dimension location.

ADS-B doesn't depend on ground interrogations or even a direct radio contact with the intruder. As long as the system can "hear" another, and decode the position information, it can avoid the collision. This means that it will work where TCAS can't, close to the ground, out of line of sight—further expanding the protection envelope.

ADS-B is one direction that collision avoidance will take in the quest for a reliable, affordable system.

TIS

Traffic Information Service (TIS) is a system that gives the airborne crew a comprehensive view of the air traffic in the neighborhood. Consider it a representation of the view ATC has on their screen. TIS is made possible by the data link contained in TCAS and Mode S, and probably gives the most bang for the buck.

The disadvantage to TIS it that you need to be in range of the data link transmitter, but most accidents happen in more densely populated airspace. The advantage is that once the data link is established, you can get weather, messages and premium movie channels, too (well, maybe not movies, yet. . .).

TIS requires a data link receiver (Mode S transponder) and a display. The FAAis so far happy to provide the data for free. This is probably a noise abatement policy, because when airplanes come together in flight, there is a tremendous racket that annoys local residents.

Cost for a system will run about $15,000, which, in the case of a Bendix/King IHAS 200 system, includes the weather data radio.

ANTENNAS

Most of the collision avoidance antennas are L-band, either a garden variety transponder antenna or for a directional TCAS systems, like your transponder antenna on steroids. The key thing is there should be antennas on top AND bottom of the airplane, because you need to detect that threat descending from behind.

In a pressurized airplane, the installation of an antenna is seldom an easy thing to do, and collision avoidance antennas require correct placement for optimum performance. In short, believe the STC data.

DISPLAYS

Display symbology has been standardized, but you need to consider where the information will be presented. There are dedicated stand alone displays, there are combined displays. TCAS II is presented on a VSI, showing you the threat, and the escape maneuver.

Some companies will integrate the collision avoidance into a threat or hazard presentation on the multifunction display. This is a great idea because space is always at a premium, and these manufacturers understand the critical nature of the presentation, and integrate the warnings nicely with the entire avionics suite.

WATCH OUT!

Midair collision is such a deep routed fear. We can all identify with that flash of aluminum from out of nowhere, the sign of a close call. In that instant, we are willing to spend whatever it takes to never experience that again.

Avionics manufacturers have responded with increasingly advanced ways of building that electronic shield, to the benefit of themselves, the profile of avionics installed, and the safety of us all.

An individual aircraft owner's choice is limited only by the budget. All of the systems will provide protection from a midair calamity. Is the protection commensurate with the cost? Probably not.

The choice will boil down to the technology available, the aircraft value and available budget, the other installed equipment, and the aircraft mission profile. TIS will not work between Costa Rica and Miami, ADS-B will.

Is a portable device appropriate? Without analytical experience, we cannot say. The FAA-STC on installed systems provides assurance that, if the system is installed by a professional, in accordance with the instructions and the data, it WILL operate as described.

No safety system in the aircraft is as effective as the organic one connected to the controls from takeoff to touchdown. Avionics professionals, and pro pilots need to understand the nature, limitations and characteristics in the systems installed, and this article cannot touch the variety and capability. If an avionics shop cannot provide the technical background, we recommend third party, like ElectronicFlight Solutions, whose $300 interactive course can provide operational insight into the science of collision avoidance.

Finally, collision avoidance is but a piece of the safety puzzle. Many more flyers perish because of poor planning ("we will make it on 15 gallons"), navigation mistakes ("Why are there trees in this clou________________?") and unexpected weather ("My knee says it'll be clear all week!). Spending $15,000 on collision avoidance, while ignoring the weather and TAWS products is a judgment call we don't want to be responsible for. ❑