ADS-B and TCAS

What are the functions of these two systems in aircraft?

1. Introduction

TCAS (the Traffic Alert and Collision Avoidance System) is a collision avoidance system designed to operate when normal air traffic management procedures fail to maintain adequate separation between aircraft. TCAS is an airborne system that operates independently of ground systems.

ADS-B (Automatic Dependent Surveillance Broadcast) is the regular transmission of identity, position, velocity and other information by an aircraft. Since ADS-B signals are broadcast, any party that receives the signals can decode the messages to track the position of the transmitting aircraft. The information obtained through ADS-B can be used by air traffic controllers to manage air traffic, and can equally be processed on board other aircraft to determine the identity, proximity, and trajectory of surrounding traffic.

The use of ADS-B in airborne applications has inevitably led to discussions about the relation between ADS-B and TCAS. This paper explains how the two systems are being integrated in aircraft, and looks at other airborne applications of ADS-B.

2. TCAS

TCAS tracks surrounding aircraft and highlights any potential threats to the flight crew. If the situation deteriorates, TCAS will recommend vertical manoeuvres called Resolution Advisories (RAs) to avoid a collision. In situations where both aircraft are equipped with TCAS (a coordinated encounter) information is exchanged by the TCAS units to ensure the flight crew are provided with complementary RAs.

A graphical indication of the required manoeuvre in response to a TCAS RA is normally provided either on the aircraft's Instantaneous Vertical Speed Indicator (IVSI) or on the Electronic Attitude Display Indicator (EADI). TCAS installations also include a traffic display that helps the flight crew to determine the location of the threat aircraft, and improve their situational awareness.

TCAS determines the altitude and range of surrounding aircraft by interrogating their SSR transponders and processing the resulting replies. It is therefore important for all aircraft, even those not fitted with TCAS, to operate their transponders at all times to enable them to be detected by TCAS equipped aircraft. Where possible, SSR transponders should be operated in altitude reporting mode to provide TCAS with the altitude information it requires to determine RAs.

Modern TCAS units typically determine the bearing of surrounding aircraft to an accuracy of 4 or 5 degrees. This is adequate since TCAS resolves conflicts with vertical manoeuvres.

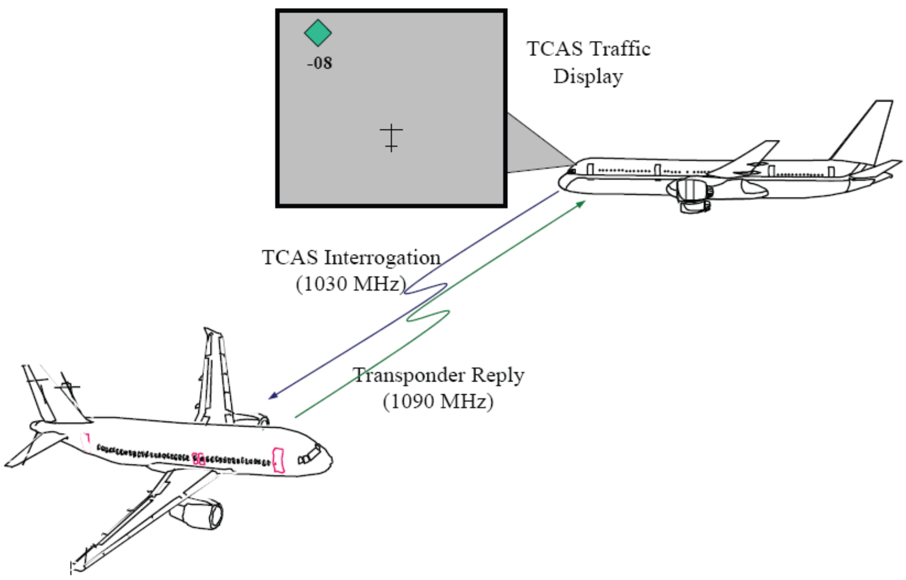

Figure 1 – TCAS active surveillance

The Australian Civil Aviation Safety Authority (CASA) currently requires TCAS to be fitted on all aircraft carrying more than 30 passengers or with an MTOW in excess of 15,000 kg.

3. TCAS use of ADS-B data

TCAS may use ADS-B data to improve its surveillance and traffic display. A technique known as *hybrid surveillance* has been developed for this purpose. In this scheme, TCAS initially verifies the received ADS-B position by performing an active interrogation. If the two measurements agree, then TCAS will continue to track the aircraft based on the received ADS-B transmissions provided it does not become a near threat. If the other aircraft becomes a near threat then TCAS will start to interrogate its transponder once every ten seconds to validate the received ADS-B position. Finally, if the intruding aircraft becomes a threat TCAS will revert to full active interrogation once every second. The collision avoidance function within TCAS remains unchanged with Hybrid Surveillance. ADS-B information is not used as an input to the calculation of RAs. This means that critical TCAS functions do not need to be re-certified while taking advantage of the additional information provided by ADS-B.

The use of ADS-B data enables TCAS traffic displays to more accurately depict the bearing and velocity of surrounding aircraft. The identity information received through ADS-B allows other aircraft to be labelled on the traffic display, allowing easier identification by the flight crew and improving situational awareness. ADS-B allows TCAS to track aircraft at greater ranges – in excess of 100 NM compared with about 40 NM using active surveillance. Hybrid surveillance, with its ability to track aircraft passively, leads to a reduction in the number of transmitted RF signals and hence reduces the possibility of signals interfering with each other making them difficult to decode. This is especially important in environments with high aircraft densities.

TCAS manufacturers are currently offering products that incorporate hybrid surveillance, and traffic displays that present ADS-B information. These displays are able to present much more information than conventional TCAS traffic displays. ICAO has developed guidelines for using hybrid surveillance, and the US Radio Technical Commission for Aeronautics (RTCA) is working on more detailed Minimum Operational Performance Standards (MOPS).

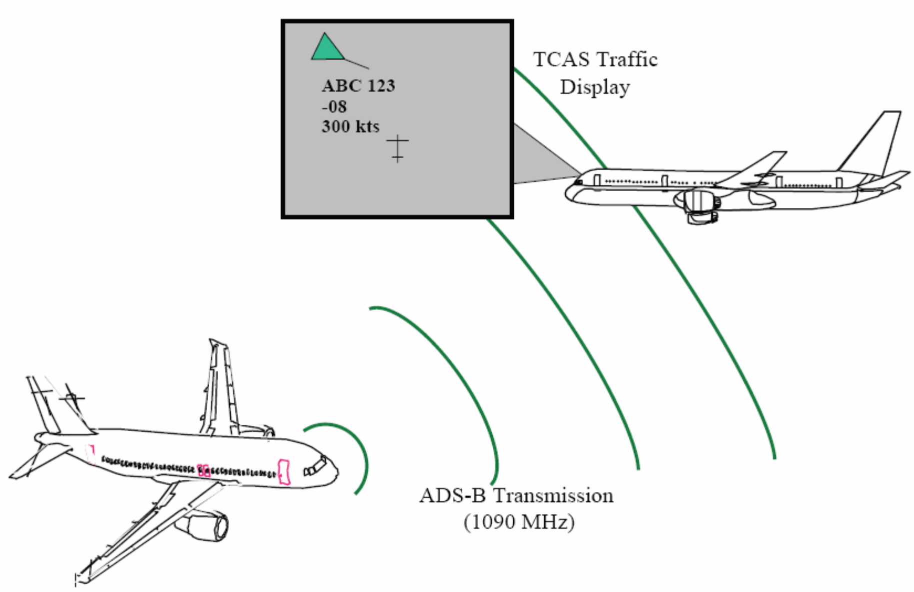

Figure 2 - TCAS passive surveillance using ADS-B

4. Airborne applications of ADS-B

A number of airborne applications are currently under study, the objectives being to increase the traffic handling capacity of the airspace while maintaining adequate levels of safety. These applications are known as Airborne Separation Assistance System (ASAS) applications. ASAS describes a wide range of applications varying from the simple use of ADS-B to provide a traffic display to improve a flight crew's situational awareness (*traffic situational awareness*), through to more demanding *self separation* based on the ability of the flight crew to ensure adequate separation standards between aircraft are maintained independently of air traffic control (ATC). ASAS involves varying levels of delegation of the responsibility for separation from ATC to the flight crew.

It is generally considered that ADS-B is the system that will provide the surveillance necessary for ASAS applications. ASAS applications may also require additional systems, both on-board the aircraft and for the controller, to help ensure that the requirements of a particular application are met.

On the airport surface a traffic display can be provided in the cockpit showing all the aircraft taxiing on the manoeuvring area and within the terminal area. Coupled with a background airport map this would improve the pilot's situational awareness, reduce the risk of runway incursions, and assist flight crew to navigate around an unfamiliar airport especially during conditions of reduced visibility.

Another ASAS application is *sequencing and merging* on approach to an airport. In this case an aircraft identifies a designated target aircraft, merges at a particular point (e.g. feeder fix) behind that aircraft and maintains a given time separation in relation to the target. A series of aircraft following this procedure will ensure an orderly and efficient flow of traffic in the approach phase. The flight crew will be assisted by a traffic display, and may be able to program the required separation into the flight management system. The controller will remain responsible for separation, although the role would be one of monitoring the situation and dealing with exceptions rather than active control. In this way a higher number of aircraft may be safely managed thereby increasing the throughput of traffic in the terminal area.

ASAS applications are currently under development and will require extensive trials before being implemented on a wide scale. They promise to deliver the efficiency and flexibility that many in the industry are calling for.

5. TCAS traffic display and ADS-B CDTI display

The main role of TCAS is the detection and generation of Resolution advisories (RA). Aural traffic advisories were created to pre-arm the pilot to a possible TCAS RA. The traffic display is installed on most aircraft but is actually an optional component of TCAS .

The information generated by TCAS for the traffic display is

- slant range
- bearing of nearby aircraft (to an accuracy of 4 or 5 degrees)
- relative altitude

The TCAS traffic advisory function can operate to a range of approximately 40 Nm from ownship.

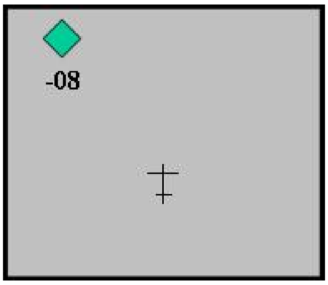

Figure 3 - TCAS Traffic Display

The traffic display is a simple and shows a proximate position and relative altitude only. No indication of the direction of flight or other information about the other aircraft is provided.

The information generated by an ADS-B airborne receiver is

- Position which when compared to ownship position gives a very accurate positional display of the other aircraft out to a range in excess of 100 nautical miles if required.
- Velocity vector to indicate the heading/speed of the other aircraft which can be useful to determine the intent of the other aircraft.
- Callsign which can be used to initiate radio communication
- Aircraft category (heavy, light etc)
- Relative altitude

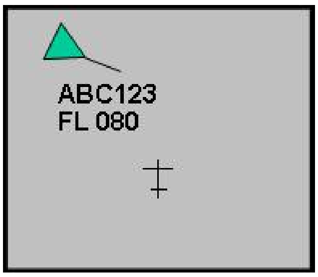

Figure 4 – ADS-B Traffic Display

Some ADS-B based traffic displays show aircraft position symbols and other data near the position symbol (see Figure 4).

Others display position and altitude only with additional data in a special area for a “selected” aircraft (see Figure 5) to reduce screen clutter.

The data display can typically include readout of callsign, relative speed, distance, closing speed, aircraft category etc.

More advanced applications will use this date to guide aircraft-aircraft spacing, merging and other similar applications.

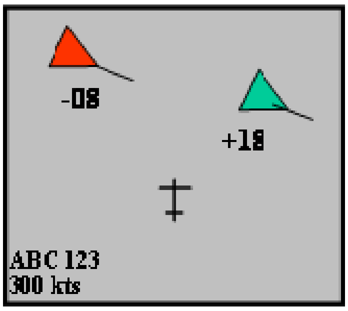

Figure 5 – ADS-B Traffic Display with selected aircraft readout

6. Conclusion

This paper describes the functions of TCAS and ADS-B in aircraft. TCAS is a collision avoidance system, while ADS-B may be used to provide the aircraft surveillance required for both air traffic control and airborne applications. ADS-B displays provide more data and more accurate position data than TCAS traffic displays. A number of airborne applications are being developed to take advantage of the surveillance provided by ADS-B. These applications are called ASAS applications. It is envisaged that TCAS will continue to play an important role in an environment where ASAS applications are being implemented.

If you have any questions or comments on this article, please submit it via the “Feedback” link on the main ADS-B webpage.