

An effective safety net

Airborne collision avoidance system

The following article explains ACAS – a key airborne safety net – and its role in improving safety in Europe's increasingly busy skies.

In air traffic control, the safe separation and sequencing of aircraft is essential to the maintenance of public confidence in aviation. In consequence, the continued growth of air transport means that proactive steps must be taken to ensure that European ATM safety is not only maintained, but enhanced.

For European airspace, the common policy for Airborne Collision Avoidance Systems (ACAS), agreed by all States, requires the mandatory carriage and operation of an ACAS II for the majority of public transport and cargo aircraft (fixed wing and turbine-engined). To achieve this, an extensive pan-European implementation was coordinated and progressed by the EUROCONTROL ACAS Programme. The successful completion of ACAS II implementation, in two phases, culminating in March 2006, brought a very significant improvement to European ATM safety.

What is ACAS?

ACAS is an on-board aircraft system designed to improve air safety by reducing the risk of mid-air collision or near mid-air collision. It acts as a safety-net system of 'last-resort'. Two types of alert can be issued:

- Traffic advisories (TAs), which are designed to help the flight crew acquire the intruder aircraft visually and alert them to be ready for a potential resolution advisory.
- Resolution advisories (RAs), which are avoidance manoeuvres in the vertical plane provided to the flight crew.

Importantly, ACAS is designed to work both autonomously and independently of the aircraft navigation equipment and ground systems used for the provision of air traffic services. When a risk of collision is detected, it provides pilots with manoeuvre advice in the vertical plane to prevent a mid-air or near mid-air collision.

ACAS operates by interrogating the transponders of all aircraft in the vicinity, through antennas mounted on the top and bottom of an aircraft fuselage. ACAS actually uses the Mode S transponder to perform these transactions. Based upon the replies received, it tracks the slant range, altitude (when provided) and bearing of surrounding traffic.

The key to ACAS is that it functions according to time criteria and not distance. Thus time to closest point of approach (CPA) of the intruder is the main parameter. An advisory is triggered when a range test and an altitude test are both satisfied. These tests are performed on each altitude-reporting target, every second.

There are limitations – if an aircraft transponder does not provide an altitude report, then an ACAS II cannot generate an RA. If an aircraft transponder is not serviceable, or not fitted at all, then that aircraft will be invisible to ACAS.

The actual avionic equipment fitted to aircraft is known as a Traffic Alert and Collision Avoidance System (TCAS). TCAS II version 7 is currently the only equipment which complies fully with the

ACAS II Standards and Recommended Practices (SARPs) defined by ICAO. Therefore TCAS II version 7 is the equipment which is fitted to aircraft to meet the ACAS II mandate in Europe.

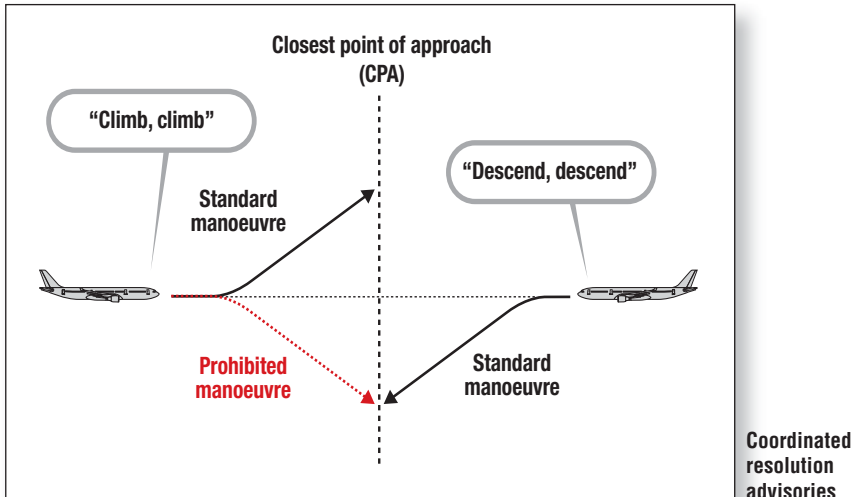
TCAS II operations

Phase 1 of the ACAS II implementation has required the mandatory carriage and operation of a TCAS II for large civil aircraft since January 2000. However, European experience of TCAS II operations commenced in the early 1990s, when some categories of aircraft were required, by the United States' authorities, to fit an early version of TCAS II for flying in US airspace. This extensive operational experience resulted in modifications to TCAS II, culminating in the introduction of the mature equipment, TCAS II version 7, which is in widespread service today.

Operational experience has shown TCAS II to be highly effective, in particular where both aircraft are equipped. This is because, when the intruder aircraft is also fitted with an TCAS II system, both TCAS equipments coordinate their RAs through a data link, in order to select a complementary RA direction. Therefore, it is very important that the correct procedures are applied by the flight crew and that RAs are followed as accurately as possible. Safety studies show that responding inaccurately to an RA, failing to respond, or worse, if a manoeuvre is undertaken in the opposite direction to an RA, seriously degrades the safety benefit available from TCAS II. This is the single most important factor affecting TCAS II performance.

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This has been underlined by some serious incidents, and in the Überlingen mid-air collision it is known that one of the aircraft made a manoeuvre which was opposite to the RA issued.

Training

Clearly, training in the use of TCAS II is very important, both from the point of view of the flight crew who need to react to the alerts which are provided, and also for the controllers who need to apply the correct procedures when an incident occurs involving TCAS II. Training guidance material has been disseminated by ICAO, and in Europe also by the Joint Aviation Authorities (JAA). In addition, the EUROCONTROL ACAS Programme has provided guidance and advice on best practice. This includes the development and distribution of a powerful computer-based training tool, which enables the operation of TCAS II to be correctly understood within the context of air traffic management as a whole. This training tool is known as RITA2.

Using recorded TCAS II events chosen for their relevance to training

issues, RITA2 shows on one screen, time-synchronised, the TCAS II display seen by the pilot, the radar display seen by the controller, and the radio transmissions between the controller and the flight crew.

Finally, a series of ACAS II safety bulletins is being published, focussing on operational issues and using actual operational incident data to illustrate and explain the issue and the appropriate actions required.

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The primary means of ensuring separation between aircraft is ATC, and safety analyses are required to prove that an acceptable level of safety is achieved. Each day ATC safely handles several thousands of aircraft flights within European airspace.

ATC radars commonly interrogate to obtain identity codes and altitude data, from aircraft transponders. These radars normally have an update rate of between 4 and 8 secs. Aircraft target position data, and altitude data at 100ft, is then provided through a sophisticated radar processing system, to the controllers' displays. However, sudden vertical manoeuvres by aircraft might not be shown on controller displays immediately, and altitudes displayed from a manoeuvring aircraft sometimes lag the actual altitude by several hundred feet.

A ground-based safety net, such as short-term conflict alert, is often employed to alert controllers to a conflict caused by an impending loss of

The display of the computer-based training tool, RITA 2



ATC separation between aircraft which might not have been observed.

For collision avoidance, TCAS II information is more accurate and up-to-date than the information displayed to the controller. It interrogates all nearby aircraft transponders every second, and can utilise altitude data provided at 25ft intervals. The altitude data for own aircraft is utilised at 1ft intervals.

Therefore, for aircraft in close proximity, the TCAS II knowledge of the vertical situation is much better than that of the controller.

TCAS II sometimes triggers RAs when aircraft in proximity are climbing, or descending, to a level which is separated by 1000ft. 1000ft vertical separation has been in use for many years, and in these circumstances controllers can find it difficult to understand why TCAS triggers RAs when their job is being performed correctly. However, TCAS does not know aircraft intent, on purpose, since intent can fail to be achieved. For example, modern jet aircraft can sometimes climb or descend at a rate of 5000ft per minute, or more. In these circumstances, 1000ft only represents 12 secs flying time. If the aircraft failed to level-off, for whatever reason, 12 secs is too short an interval for avoiding action, in response to an RA, to achieve an acceptable minimum separation distance. Of course, it should be remembered that a significant proportion of RAs do not require an aircraft to deviate from its ATC clearance. These RAs are compatible with ATC scenario and effectively reinforce an ATC clearance.

Operational monitoring and experience shows that TCAS II has provided significant safety benefit in European air-

space, in line with, and in some airspace environments, exceeding, expectations from the safety analyses. However, there are some aspects where performance can be improved. EUROCONTROL has taken the lead in developing and validating improvements, and in vigorously promoting their adoption. As a result, work finalising some significant safety performance improvements to the TCAS II collision avoidance system reversal logic, and revising the operation of one type of RA, is now drawing to a conclusion. A new version of TCAS II, known as TCAS II Version 7.1 will soon be released, incorporating these safety improvements.

ACAS is not intended to replace the functions of a controller, and the provision of separation between aircraft remains the primary responsibility of ATC.

Conclusion

ACAS II collision avoidance parameters are not related to ATC separation minima. It will neither provide warning of a loss of standard ATC separation, nor will it necessarily prevent aircraft coming close together. Therefore, it is essential that ATC procedures and systems are designed to provide acceptable levels of safety without resorting to any reliance upon the use of an airborne collision avoidance safety net.

ACAS is not intended to replace the functions of a controller, and the provision of separation between aircraft remains the primary responsibility of

ATC. It is intended to provide an additional layer of safety, as a last resort when the primary separation system has failed, for whatever reason.

In view of the need to ensure that TCAS II can provide an RA in sufficient time so that a manoeuvre would be effective, and of its independence, it is inevitable that there will be some interaction with the ATC system. By careful choice of parameters relating to the generation of TCAS II alerts, that interaction has been minimised to an acceptable level. Minor operational constraints do remain, but they are a small price to pay in return for improved safety. In addition, in order to maximise the safety performance of the ACAS safety net, airspace design and procedure development needs to take TCAS II performance into account.

Finally, of course, it would be wrong to consider that TCAS II is perfect – it cannot entirely eliminate all risks of collision, and it does have limitations. However, the system continues to be improved, and some important TCAS II safety performance enhancements are being finalised.

Operational monitoring confirms that the widespread use of TCAS II, in accordance with appropriate procedures, enhances flight safety significantly. ■

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