



RSA-11

RASG-PA Safety Advisory

USE OF THE TRAFFIC COLLISION AVOIDANCE SYSTEM (TCAS)

RECOMMENDATIONS FOR OPERATORS

Document Abstract	This advisory provides guidance on using the Traffic Collision Avoidance System (TCAS) to prevent mid-air collisions. It highlights TCAS functionality, pilot response requirements, and improvements in TCAS II.
Purpose	Provide operators with recommendations on the use of the Traffic Collision Avoidance System (TCAS).
Target Audience	Air Operators
Occurrence Category	Mid-air Collision (MAC)
Key Recommendations	Recommendations include pilot training, procedural updates, and event analysis to enhance safety and align with ICAO standards.
Date of publication	18/11/2024

1. Background

The development and implementation of TCAS was driven by aviation accidents. TCAS is an airborne system designed to provide collision advice against suitably equipped intruders and to increase awareness of the flight crew of nearby aircraft. TCAS has proven to be very successful at protecting aircraft from mid-air collisions (MAC) and resolving threats.

Currently, TCAS II is the only system that meets the criteria of Airborne Collision Avoidance System (ACAS), which is the International Civil Aviation Organization (ICAO) terminology and is included in the ICAO Standards and Recommended Practices (SARPs).

After its introduction in the late 1990s, TCAS II version 7.0 has been updated. Several issues detected in it led to the development of version 7.1. Version 7.1 incorporated several improvements over version 7.0, one of them was the replacement of the "*Adjust vertical speed, adjust*" with a new "*Level off, level off*" Resolution Advisory (RA).

The recently developed ACAS X system (See **Appendix A**), expected to become operational in the future, is an improved system which development was funded by the United States Federal Aviation Administration (FAA). The ACAS X system is intended to bring enhancements to both surveillance and the advisory logic.

TCAS II works independently of the aircraft navigation, flight management systems (FMS), and Air Traffic Control (ATC) ground systems. While assessing threats, the system does not consider ATC clearance, pilot's intentions nor FMS input. TCAS II is not connected to the autopilot, except in Airbus airplanes equipped with Autopilot/Flight Director (AP/FD) TCAS capability, which provides automated responses to RAs.

RAs are rare events, but when they occur, the situation may be critical, thus correct, and immediate flight crew action is required, unless it would jeopardize safety of the aircraft. Any delayed or incorrect flight crew response may negate the effectiveness of the RA, their actions will be the most important single factor affecting the performance of the TCAS system. If the pilots decide not to respond to an RA, they not only negate the safety benefits provided by its own TCAS system, but also jeopardizing safety of all other aircraft involved in the encounter.

It is important to note that according to EUROCONTROL, 40 to 50% of RAs are wrongly flown. (Eurocontrol, 2022). For Airbus operators, the recommendation to reduce the risk of MAC is the maximization of the use of the Auto Pilot/Flight Director (AP/FD) TCAS mode. This aims at significantly enhancing safety by supporting pilots to fly avoidance manoeuvres requested by TCAS. (See *Airbus Safety First #07, February 2009* <https://shorturl.at/1soWI>)

2. Safety Analysis

Flight Crew Response

For TCAS II to meet its purpose an immediate and correct flight crew response to an RA is required unless it would jeopardize the safety of the aircraft. This means that pilots will at times manoeuvre contrary to ATC instructions or disregard ATC instructions. In accordance with the ICAO Airborne Collision Avoidance System (ACAS) manual (ref ICAO Doc. 9863), ACAS anticipates the following response from pilots to RAs:

- a) the pilot will respond within 5 seconds to the first RA;
- b) the vertical acceleration will be 0.25 g until the required vertical rate is achieved;
- c) for subsequent RAs the pilot will respond within 2 1/2 seconds and with 0.25 g except for RA reversals and increase rate RAs; and
- d) for RA reversals and increase rate RAs, the pilot will respond with 0.35 g.

Pilots must not manoeuvre contrary to the RA as that could result in a collision with the threat aircraft. However, in case of a TCAS RA manoeuvre contrary to other critical cockpit warnings, pilots should respect those other critical warnings — responses to stall warning, wind shear, and Ground Proximity Warning System / Terrain Avoidance and Warning System (GPWS/TAWS) take precedence over an ACAS RA, particularly when the aircraft is less than 2,500 feet above ground level (AGL).

Types of TCAS Alerts

TCAS II can issue two types of alerts which are announced orally and displayed on the relevant cockpit instruments:

Traffic Advisories (TAs), which aim to help the pilots in the visual acquisition of the intruder aircraft, and to alert them to be ready for a potential resolution advisory.

Resolution Advisories (RAs), which are avoidance manoeuvres recommended to the pilot. An RA will tell the pilot the range of vertical rates within which the aircraft should be flown to avoid the threat aircraft. An RA can be generated against all aircraft equipped with an altitude reporting transponder (Mode S or Mode A/C); the intruder does not need to be fitted with TCAS II. When the intruder aircraft is also fitted with a TCAS II system, both systems coordinate their RAs through the Mode S data link. TCAS II does not detect non-transponder equipped aircraft or aircraft with a non-operational transponder. A TCAS II RA takes precedence over any ATC instructions or clearances.

During the encounter, the RA strength is evaluated every second. Occasionally, the threat aircraft manoeuvres vertically in a manner that reduces the effectiveness of the issued RA. In these cases, the initial RA is modified to either increase the strength or reverse the sense of the initial RA (when the initially issued RA is no longer predicted to provide sufficient vertical spacing).

If the TCAS II logic determines that the response to an RA has provided the sufficient vertical distance prior to the closest point of approach (CPA) the initial RA will be weakened. This is done to minimize unnecessary deviations from the original altitude.

The collision avoidance logic sets the minimum time limits on RA duration as follows:

- Minimum RA duration (initial RA to Clear of Conflict) - 5 seconds
- Minimum time before a reversal RA can be issued - 5 seconds
- Minimum time before weakening RA can be issued - 10 seconds

RAs are usually triggered between 15 to 35 seconds from the CPA. The time scales are shorter at lower altitudes. Unexpected or sudden aircraft manoeuvres may cause an RA to be generated with much less lead time.

When the intruder ceases to be a threat or when the logic considers that the horizontal distance at CPA will be sufficient, the resolution advisory is cancelled, and a "Clear of Conflict" annunciation is issued. The flight crew should then return the aircraft to the last ATC assigned level.

In some cases, pilots ignore RAs or they respond in the opposite sense. The main reasons given for the noncompliance are proximity to the ground, presumed TCAS II malfunction, misinterpretation of RA alert, giving priority to ATC instruction or performing own avoidance manoeuvre (based on visual acquisition or own judgement). Inappropriate pilot responses impair TCAS performance and increase the risk of a midair collision.

A TCAS RA takes priority over an ATC instruction and visual acquisition of traffic as it cannot be guaranteed that the aircraft acquired visually is the same as the intruder detected by the TCAS system, or it may not be the only aircraft to which ACAS is responding.

3. Recommendations

- a) Pilots who operate TCAS-equipped aircraft have received relevant training.
- b) Approved pilot training programs are implemented for initial and recurrent training.
- c) If possible, TCAS training manoeuvres should be introduced as a surprise to provide a startle effect.

- d) Procedures are in place for pilots to report a TCAS event and/or problems with TCAS performance; procedures are in place to use correct phraseology for the notification of the manoeuvre in response to an RA. These procedures are contained in the ICAO PANS-ATM (Doc 4444).
- e) Procedures are in place to analyze any reported event and problem, and to provide feedback.
- f) Pilots should use correct phraseology as documented in their SOPs to report RAs and their manoeuvres in response to an RA to ATC.
- g) Pilots should understand the potential risks of an improper response to an RA.
- h) Unless otherwise instructed by ATC, when safe, practical, and in accordance with an operator's approved operating procedures, pilots limit vertical rates to 1500 fpm or less when within 1000 ft of assigned altitudes, this will reduce the frequency of unnecessary RAs.
- i) A systematic review of the TCAS policies and procedures is continuously required. Operators should establish standard operating procedures (SOPs) and standardized training on pilot response to TCAS RAs, including following the RA promptly and accurately even in the presence of contravening ATC instructions.

— END —

Appendix A

ACAS Xa

ACAS Xa is a new collision avoidance system, foreseeing a "drop-in replacement" of TCAS II.

Instead of using a set of hard-coded rules, ACAS Xa alerting logic is based upon a numeric lookup table optimized with respect to a probabilistic model of the airspace and a set of safety and operational considerations. The system uses the same hardware (antennas and displays) as the current TCAS II system and the same range of RAs as in TCAS II version 7. 1.

There are no changes in the way RAs are displayed and announced to the pilot, except for Maintain Vertical Speed and Crossing Maintain Vertical Speed RAs, which in the ACAS Xa installation is announced using the same aural as for Descend or Climb RAs or Reversal Descent or Reversal Climb RAs (if the Maintain Vertical Speed RA is a reversal RA).

Consequently, pilots and controllers would perceive no change in the transition to the new system, which is fully compatible with the current TCAS II system (versions 6.04a, 7.0 and 7.1). The intention is for ACAS Xa to eventually replace TCAS II. However, there is a significant difference between T CAS II and ACAS Xa in the decision as to whether to issue an RA; therefore, the timing and types of alerts may vary from what a pilot would expect.

ACAS Xa standards (RTCA DO-385 and EUROCAE ED-256) were finalized in September 2018. Also, the ICAO Document 9863 Airborne Collision Avoidance System (ACAS) Manual — Third edition was published in 2021 includes ACAS Xa provisions. Any guidance regarding the TCAS performance assessment provided in this document is equally applicable to the ACAS Xa system. ACAS Xa RA shall be assessed in the same way as TCAS II version 7.1 RAs.
