

ACAS II Bulletin

November 2018 | N°24

Investigating RAs

WELCOME

Occasionally, reports are filed that suggest that TCAS II may not have performed as specified. That includes cases when no RA was triggered despite close proximity to the threat aircraft or an RA was triggered in the absence of any credible threat, the RA was inappropriate (e.g. towards rather than away from the threat), unusual RA sequences or technical anomalies.

If it is found that TCAS II performed in such a way, investigations are typically carried out by Aircraft Operators, ATC authorities and, in particularly serious cases, by State investigation bodies. The purpose of these investigations is to find out what happened, establish whether TCAS II has performed as designed, look into all the contributing factors, and finally formulate recommendations in order to prevent similar events in the future.

Investigations should be carried out using all possible data sources. These comprise airborne recordings (e.g. Quick Access Recorders or dedicated TCAS recorders that are available on some aircraft), ATC radar data (including messages downlinked by the aircraft to the ground during the RA), and pilot and controller reports. Only a complete view of the event allows a full analysis of what really happened and makes it possible to draw conclusions. Limiting available evidence to, for instance, only pilot reports is unlikely to provide the answers.

If it is found that TCAS II has not performed as required, the investigation should seek to establish how the problem needs to be addressed. Additionally, the investigation may identify training needs or improvements. Occasionally, pilots or controllers draw their own conclusions on the usefulness of specific RAs from their perspective – however, a full assessment can be done only through the investigation process examining recordings and determining whether TCAS performed as specified.

In order to illustrate these key points we have selected some real-life cases that have been reported and investigated. These investigations allow us to establish what really happened in these events.

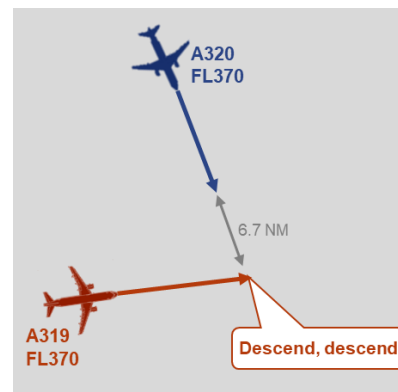
Stanislaw Drozdowski
EUROCONTROL
Email: acas@eurocontrol.int

Event 1 – RA triggered in the absence of credible threat

An Airbus 319 is cruising at FL370. An Airbus A320 on a perpendicular heading, also at FL370 is expected to pass behind the A319. ATC has issued radar headings to both crews to ensure that the radar separation of 5 NM is maintained.

When the A319 passes 6.7 NM in front of the A320, it receives a Descend RA. The A319 crew responds correctly to the RA commencing a descent at 1500 ft/min. and reports the RA to ATC. After 35 seconds the RA weakens to Level Off and soon after terminates with a Clear of Conflict message. By this time the A319 descended to FL362, i.e. 800 feet. The crew informs the controller of Clear of Conflict and returns to the original level.

No TCAS alerts were issued for the A320. Both the A319 pilots and ATC filed reports concerning this event.



- 1: Event 1 – RA triggered in the absence of credible threat
- 2: Event 2 – Blank TCAS traffic display
- 3: Event 3 – Unusual RA ♦ Event 4 – Maintain vs. Monitor Vertical Speed
- 4: Event 5 – Reporting RAs ♦ Event 6 – Altitude fluctuations

Conclusion: An investigation concluded that this RA was caused by the, so-called, hybrid surveillance anomaly.

What is a hybrid surveillance anomaly RA?

The hybrid surveillance function of TCAS has been introduced – as an option – with TCAS II version 7.1 (mandated in Europe from 2015) in order to reduce active interrogations and radio-frequency (RF) pollution.

With the population of hybrid surveillance equipped aircraft increasing, it has been observed that these aircraft are often involved in RAs that under normal circumstances should not have happened. The RAs were typically triggered when two aircraft were crossing at the same level or are in vertical convergence but where conditions for RA generation were not met and ATC standard horizontal separation was assured.

This anomaly only affected some aircraft types that were equipped with a certain type of avionics. The A319 in this event was one of them. The root cause of the problem was identified to be a tracking latency while TCAS was changing from one mode of surveillance to the other. The latency caused a track jump and misled the TCAS logic into believing that the intruder was closing more rapidly. Once an RA has been declared, the TCAS logic will not terminate the RA until the range between the aircraft is diverging significantly.

From a pilot and controller perspective the RAs have been unexpected and unnecessary. The pilots, like the crew of the A319 in this event, have, quite properly, followed the RAs.

The hybrid surveillance problem was identified and subsequently addressed because ANSPs and airlines systematically monitored and investigated RA events and reported unusual events.

Learning points:

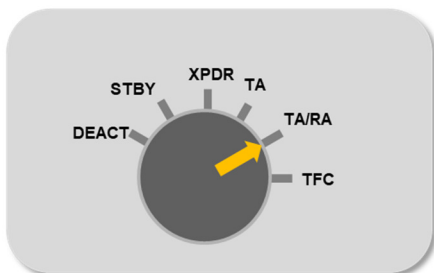
- The A319 crew correctly responded to the RAs and reported the RA and Clear of Conflict to the controller.
- All unusual TCAS events should be reported and investigated. The reports will help to identify potential technical deficiencies and prompt the regulators to take appropriate action.
- Several similar reports filed by pilots and controller, and subsequent investigations, helped to identify the problem and, consequently, led to the path to get it rectified.

Event 2 – Blank TCAS traffic display

A passenger jet is descending to its destination. During the flight, the pilots have observed that no other aircraft have been seen on their TCAS traffic display and they suspect that TCAS has failed.

While the aircraft is vectored for the final approach, there is a misunderstanding between the crew and controller – the aircraft turns onto a different heading from that instructed by ATC that puts it into conflict with another aircraft. The crew is surprised to see suddenly on their traffic display another aircraft already generating a Traffic Advisory. A Descend RA follows and the crew responds to the RA. After a Clear of Conflict message the crew again observes that again no other aircraft are displayed on the Traffic Display. Upon landing, the crew advises their company maintenance that TCAS is not working properly – it seems to be starting and stopping working unexpectedly.

Conclusions: Technical checks of the system determined that TCAS and Traffic Displays worked properly. Investigation determined that prior to departure, the crew had placed the selector on the transponder panel in the “TA/RA” position rather than “TFC”. On TCAS equipment with this feature the former provides only a TCAS pop-up function, i.e. proximate traffic and other intruders are displayed only if a TA or RA is also present. In order to be able to see all nearby traffic at all times, the crew should have selected the “TFC” position.



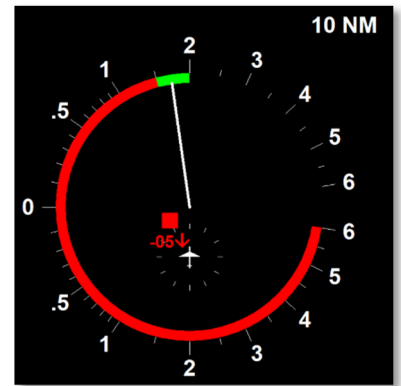
Learning point:

- There are several modes of TCAS operations. Flight crews should be familiar with limitations and advantages of each of the modes available on their specific equipment.

Event 3 – Unusual RA

A pilot reports receiving and following a Climb RA that required the rate of 1100 ft/min.

Conclusions: An investigation determined that a Climb RA was issued. For Climb RAs TCAS indicates red arc (or area) below 1500 ft/min. and green between 1500 and 2000 ft/min. The RA was initially followed correctly (i.e. with the rate above 1500 ft/min.). However, after a few seconds the rate was reduced to 1100 ft/min. (i.e. into the red arc) and maintained until the RA termination. That decreased the achieved vertical separation with the threat.



Learning points:

- Climb RA will always require a vertical speed between 1500 and 2000 ft/min. (indicated in green on the TCAS display).
- Rates below 1500 ft/min. are prohibited (indicated in red).

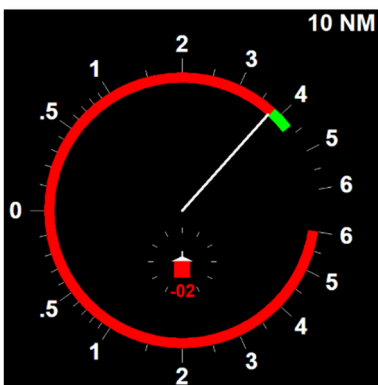
Event 4 – Maintain vs. Monitor Vertical Speed

The crew of an aircraft in level flight reports receiving a Maintain Vertical Speed RA against a VFR intruder 400 feet above. They are uncertain how to respond correctly to such an RA.

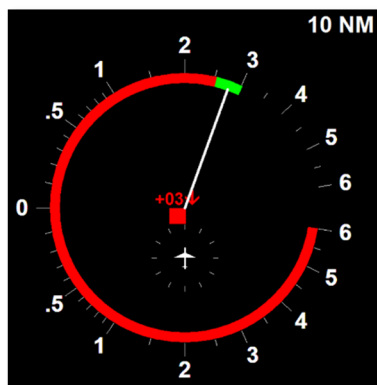
Conclusion: A review of Flight Data Monitoring revealed that the crew in fact received a Monitor Vertical Speed RA (prohibiting a climb but not prescribing any change to the current vertical speed) rather than Maintain Vertical Speed RA.

Learning points:

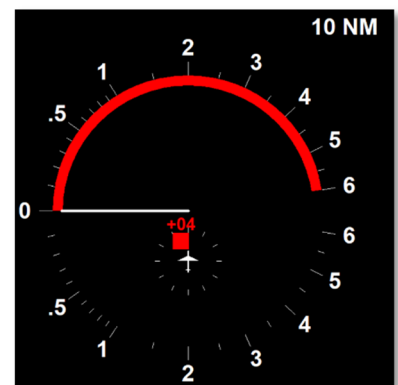
- **Maintain Vertical Speed RAs** only occur when the aircraft is already climbing or descending – in the correct vertical sense from the collision avoidance perspective – at more than 1500 ft/min. The prohibited rates are indicated in red and the target vertical speed in green (ranging from 1500 to 4400 ft/min.) The aural annunciation contains the word “maintain” twice (at the beginning and the end).
- A **Maintain Vertical Speed RA** may be **crossing**, i.e. may require the aircraft to cross the level of the threat (the aural annunciation will then contain the word “crossing”).
- **Monitor Vertical Speed RAs** tell the pilot which vertical speeds are prohibited (indicated in red) but are not prescribing any target vertical speed (no green area is shown). They are typically issued when to prevent an aircraft from climbing or descending towards the threat.



Maintain vertical speed, maintain



Maintain vertical speed, crossing maintain



Monitor vertical speed

Event 5 – Reporting RAs

A business jet is descending from 2500 to 2000 feet and established inbound on the final approach. The pilots hear the controller clearing another aircraft to cross the final approach course. They can observe a target on the Traffic Display, but cannot make visual contact. The crew asks ATC again for traffic information, which is given. Subsequently, the business jet pilot reports receiving and responding to a Climb RA. The aircraft climbs initially to 3000 and then to 3500 feet.

Conclusion: During the investigation it was established that this business jet was not equipped with TCAS II (nor was it required to be equipped) but only with TCAS I. TCAS I is an airborne collision avoidance system that provides only traffic advisories, so as to aid visual acquisition. Unlike TCAS II, TCAS I does not issue any specific collision avoidance advice (i.e. RAs are not issued).

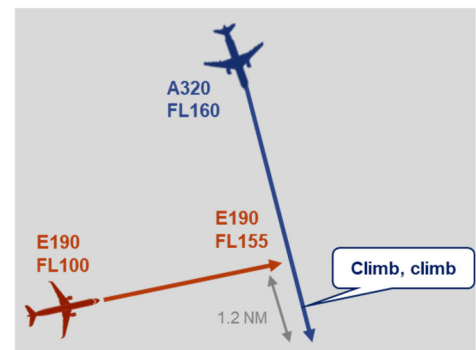
Learning points:

- If a pilot reports a TCAS RA the controller ceases to be responsible for providing separation between that aircraft and any other aircraft affected by the RA manoeuvre, until the pilot reports that he is returning to his ATC clearance.
- Reporting avoidance manoeuvres as if they were issued by TCAS II is misleading to air traffic controllers and **may prevent them from issuing collision avoidance instructions.**

Event 6 – Altitude fluctuations

An Airbus 320 is maintaining FL160 awaiting further descent when the crew receives a Climb RA. The A320 crew responds correctly and reports the RA to the controller. The controller is not aware of any conflicting traffic and both the pilots and the controller file a report.

Conclusion: The examination of radar data (Mode S downlink messages) and the A320 TCAS recorder revealed that the Climb RA received was against an Embraer 190 crossing the A320's path 6000 feet below. It appears that the Embraer's transponder experienced a momentary altitude variation changing its level to FL155. That, combined with a horizontal spacing of just 1.2 NM, triggered the Climb RA. A short duration altitude variation like that can occur between ground update cycles and, therefore, be undetected or even ignored as not credible by the ground system. In this case the reasons for the E190 altitude fluctuations could not be determined but thanks to the examination of data the reasons behind the RA were understood.



Learning point:

- Airborne and ground recordings provide information about the generated RA, the intruder, its position and altitude and can usually explain why the RA was generated.

CONCLUSIONS

RAs are infrequent. When they occur, they evolve quickly and frequently take pilots by surprise. Although pilots are trained to respond to RAs, these events are particularly stressful and involve heavy workload. Since RAs are infrequent events, and since pilots are rightly focused on assuring the safety of their aircraft, their recollection of the precise details of events may be adversely affected. Pilot reports are important input for the investigation process but as they constitute only one strand of the full investigation, they should be considered together with other evidence.

RAs are complex events involving multiple parties who at the time of the event do not have a full picture of all the data and pilots can occasionally misinterpret the aural warnings. Consequently, drawing conclusions on the usefulness of RAs can be reliably done only in hindsight through investigation and examination of recordings and other data. Assessing TCAS II performance requires access to the actual flight paths of both aircraft. The investigation should identify the real causes of the event, and find training shortcomings or operational errors. The conclusion may also reveal previously unknown problems with the equipment.