ACAS II bulletin

EUROCONTROL

SAFETY FLASH

FOLLOW THE RA !

Editorial

The ACAS II equipment, known as TCAS II, provides a last resort safety net designed to prevent mid-air collisions between aircraft. It is now in widespread operational service. To achieve the full safety benefit of TCAS II, ***it is critical that pilots respond accurately and promptly to Resolution Advisories (RAs)****. This is emphasised in EUROCONTROL ACAS training material.*

Recent EUROCONTROL safety studies have confirmed the significant safety benefit afforded by TCAS II, but have also revealed that it would be seriously degraded by a deficient response to RAs. Operational monitoring programmes have highlighted, in numerous actual events, the significant TCAS II contribution to improved flight safety. It has also been shown that in some events where the responses of pilots to RAs have been inadequate, and where manoeuvres opposite to the RAs have been identified, that the safety benefit is eroded.

The content of this ACAS Bulletin emphasises the relevance of the information contained in the EUROCONTROL ACAS training material, in line with ICAO and JAA provisions and guidance, developed by the ACAS Programme for the use of air traffic control organisations and for the use of aircraft operators. ACAS training material and related issues were discussed during several recent seminars across Europe on ACAS operations; the conclusions of those seminars also reinforced the need to follow RAs.

Events 1-5 show that an inadequate response to RAs degrades safety. However, Events 6 and 7 illustrate that ***an accurate response to an RA greatly improves safety****.*

TCAS II should be operated at all times, and all flight crews should follow RAs. Training courses should be reviewed to ensure that these areas are addressed.

The preparation of this ACAS Bulletin was overtaken by the Bodensee mid-air collision. Our sympathy goes to all those affected. ***Safety must continue to be the priority; the safety benefit which TCAS II provides must be maximised.***

John Law
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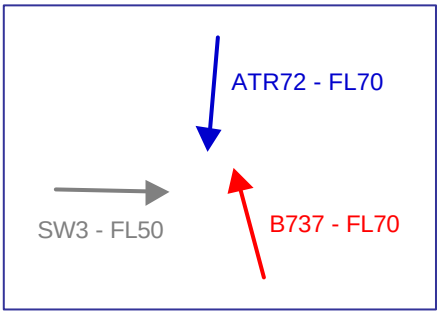
EUROCONTROL *July 2002*

Event 1: ATC avoiding instruction opposite to RA

Two aircraft level at FL70 are being radar vectored by the approach controller:

- an ATR72 is heading 185°
- a B737 is on opposite track heading 345°

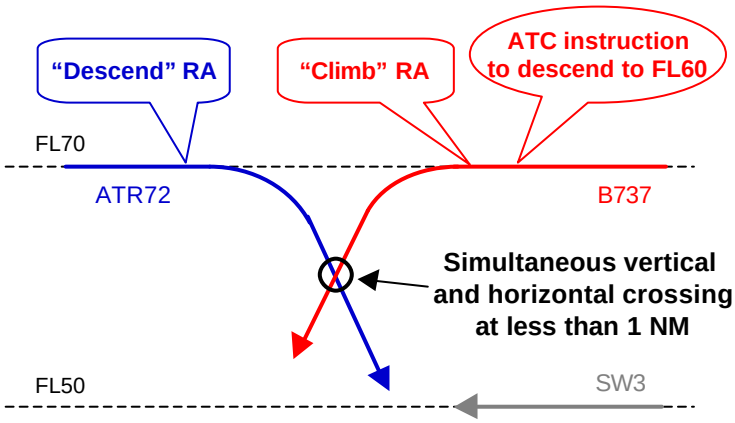
A third aircraft (SW3) level at FL50 is heading east. All aircraft are in IMC.



Because the controller is occupied with the resolution of another conflict, the B737 is instructed, late, to descend to FL60 when the aircraft are slightly less than 5 NM head on.

Both aircraft are at the same level and converging quickly. The TCAS II of each aircraft triggers a coordinated RA a few seconds later:

- the ATR72 pilot receives a “Descend” RA that he follows
- the B737 pilot receives a “Climb” RA that he does not follow. He continues to comply with the ATC instruction



The ATR72 pilot immediately informs the controller that he has a “Descend” RA using the standard phraseology. However just after, the controller repeats to the B737 the instruction to descend to FL60 for avoiding action.

The B737 pilot, who has reported afterwards that he *'had to avoid TCAS alert*”, descends through FL60. This opposite reaction to his “Climb” RA induces an “Increase Descent” RA on-board the ATR72, which leads the pilot to deviate much more than initially required by TCAS II. This large vertical deviation induces a new TCAS conflict with the SW3 level at FL50.

If the B737 pilot had responded correctly to his “Climb” RA, the vertical separation between the ATR72 and the B737 would have been 600 ft (i.e. 300 ft vertical deviation for each).

The Air Traffic Controller and TCAS II as a "last resort safety net"

*When a **loss of separation** is likely to occur or has occurred, the **controller** has to:*

- *detect the conflict using the available tools (e.g. radar display, Short Term Conflict Alert)*
- *assess the situation*
- *develop a solution in a very short period of time*
- *communicate this solution to the aircrew as quickly and clearly as possible.*

The detection of the conflict may be delayed due to tasks with other aircraft under his control. Communications with conflicting aircraft may also be delayed due to RTF congestion or misunderstandings between the controller and the pilots.

***TCAS II** automatically detects any **risk of collision**. When a risk of collision is detected, it calculates the necessary manoeuvre and communicates the solution directly to the flight crew via the RA display and an aural message attention getter. It does this in less than one second.*

*Whenever both aircraft are operating TCAS II in RA mode, **TCAS II coordinates the RAs.***

Event 2: ATC avoiding instruction opposite to RA

A B737 is level at FL280 flying a north-west route. An A321 is climbing cleared to FL270 and flying a southbound route. Due to a misunderstanding with the controller, the A321 pilot busts his altitude and continues to climb to FL290.

The controller detects the altitude bust and takes corrective actions. He instructs the A321 to descend immediately to FL270 (it is displayed on the radar at FL274) and the B737 to climb to FL290. The B737 pilot initiates the climb manoeuvre but the A321 pilot continues to climb instead of descending back to FL270.

A few seconds later, the TCAS II of each aircraft triggers a coordinated RA: a "Climb" RA for the A321 (it is now 300 ft above the B737) and a "Descend" RA for the B737.

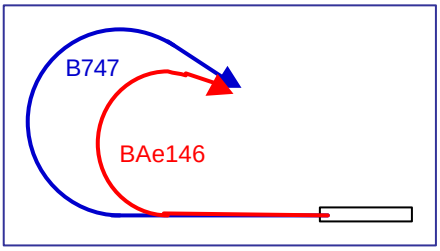
The B737 pilot follows his RA and starts to descend. However, the A321 pilot eventually complies with the ATC instruction, stops the climb and starts to descend despite his "Climb" RA. In addition, the A321 pilot reported that he preferred to avoid the B737 visually.

As a result, both aircraft pass less than 2 NM apart, with only 100 ft vertical separation.

Event 3: Erroneous traffic information and incorrect visual perception

Two aircraft are departing from the same airport, on the westerly runway. The first one is a long-haul B747, which is turning right to heading 150°. The second one is a short-haul BAe146, which is turning to the east, after a steep initial climb. Both aircraft are cleared to FL190.

Due to the good climb performance of the BAe146, the controller gives it an early right turn. This clearance induces a conflict between the BAe146 and the B747.



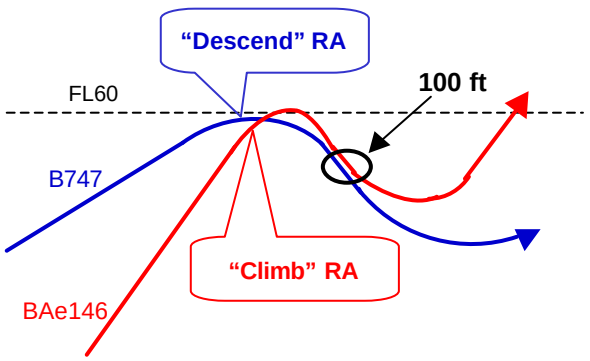
The controller detects the conflict and provides the B747 with traffic information about the BAe146. The pilot replies "we are passing *6000 feet*". Then, the controller instructs the BAe146 to "stop climb *flight level 60*", advising the pilot that a B747 is "1000 ft above climbing". However, two elements have not been taken into account:

- the pressure is high (QNH 1032), so that the 6000 ft altitude is actually FL54, and FL60 is 6600 ft altitude
- both aircraft are TCAS II equipped so that the TCAS II of each aircraft triggers a coordinated RA

The B747 pilot receives a "Descend" RA that he follows: he stops his climb and starts to descend.

The BAe146 pilot has the B747 in visual contact. However, due to the actual B747 flight configuration, the descent manoeuvre is difficult to detect visually (positive pitch). As he is also mislead by the erroneous traffic information, he **decides to descend visually** to avoid the B747 despite his "Climb" RA.

As the B747 is also descending in response to his "Descend" RA, the aircraft continue to get closer.



Because the BAe146 pilot did not follow his "Climb" RA, the B747 deviated by 1200 ft. **However, despite this large vertical deviation, the B747 pilot reported that the two aircraft passed "*very, very, very close*" (i.e. 100 ft and 0.5 NM).**

Event 4: Inefficient visual avoiding manoeuvre

A B747 and a DC10 flying on converging tracks are both cleared to FL370 by mistake. When the controller detects the conflict, he tries to instruct the DC10 to descend to FL350 but uses a mixed callsign.

The B747 pilot wrongly takes the clearance and initiates a descent. At the same time, his TCAS II issues a "Climb" RA. However, the pilot decides not to follow the RA because he has the visual acquisition on the DC10 (at the time of the incident, his airline standard operating procedures stated that manoeuvres based on visual acquisition took precedence over RAs) and he continues to descend.

The DC10 pilot who has also the B747 in sight, receives a coordinated "Descend" RA that he follows. At the last moment, he stops his descent when he perceives the B747 to be at the same altitude and descending.

At the very last second, the B747 pilot performs a sudden and violent escape manoeuvre, injuring a number of passengers and flight attendants.

As a result, the B747 passes just beneath the DC10 (by 10 metres reported), with no lateral separation.

TCAS II altitude data is better than ATC's

*The **ATC** radar displays are usually provided with data by a Radar Data Processing System (RDPS), whose inputs come from Secondary Surveillance Radars (SSR) with:*

- *an update rate of several seconds (from 4 to 10 s)*
- *altitude data in 100 ft increments*

Sudden vertical manoeuvres may not be displayed immediately. For instance, the altitudes displayed for a manoeuvring aircraft may lag by as much as 500 ft. In addition, the displayed vertical tendency may be erroneous in some cases.

***TCAS II** interrogates all surrounding transponders every second, making the update 4 to 10 times quicker than SSRs. Mode S equipped aircraft provide TCAS II with 25 ft increments making it 4 times more accurate.*

Therefore, for aircraft in close proximity, the TCAS II knowledge of the vertical situation is much better than the ATC one. It can be considered to be at least 4 times more accurate, and 4 times more up-to-date.

Visual acquisition - Limitations

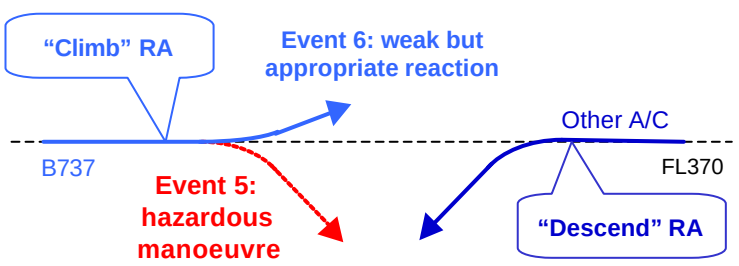
- *The visual assessment of traffic can be misleading. At high altitude, it is difficult to assess the range and heading of traffic as well as its relative height. At low altitude, the heavy aircraft attitude at low speed makes it difficult to assess whether it is climbing or descending.*
- *Visual acquisition does not provide any information about the intent of other traffic.*
- *The traffic in visual contact may not be the threat that triggers the RA. A visual manoeuvre relative to the wrong visual traffic may degrade the situation against the real threat.*

Events 5 & 6: "Climb" RA at the maximum certified flight level

Two events involving a B737 level at FL370 (i.e. the maximum certified flight level for this specific aircraft type) have been identified where the pilot reaction to the "Climb" RA has been different. In both these events, the B737 was flying towards another aircraft level at the same altitude due to an ATC mistake and the TCAS II generated a "Climb" RA.

Event 5: the B737 pilot decided not to climb in response to the RA as the aircraft was flying at the maximum certified flight level. However, as he wanted to react to the TCAS alert, he then decided to descend. He did not take into account that the other aircraft would receive a coordinated "Descend" RA. As a result, the B737 pilot descended towards the other aircraft, which was correctly descending in accordance with his own RA.

Event 6: the B737 pilot climbed in response to his RA, but as one could expect, he was not able to comply with the normal 1500 fpm vertical rate requested by the RA. He climbed only about 100 ft. However, even this slight climb was beneficial as the other aircraft received a coordinated "Descend" RA, which was correctly followed by the pilot. The vertical separation achieved was the vertical deviation of the descending aircraft PLUS the 100 ft achieved by the B737.



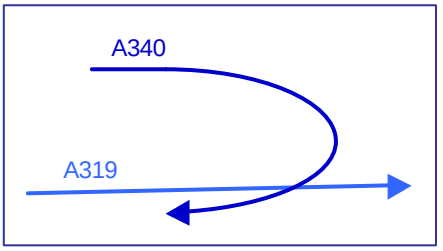
In conclusion, DO NOT react contrary to an RA: if there is some doubt of the ability to respond to a "Climb" RA, at least remain level, do not descend.

Event 7: Correct responses to RAs by both pilots

An A340 and an A319, which are departing from two different airports, are in contact with different controllers but in the same airspace.

The A340, in contact with the departure controller, is cleared to climb to FL150 with an initial heading 090°. The A340 climbs slowly and is planned to climb above the A319.

The A319, which is level at FL90 and also heading east, is already in contact with the en-route centre.

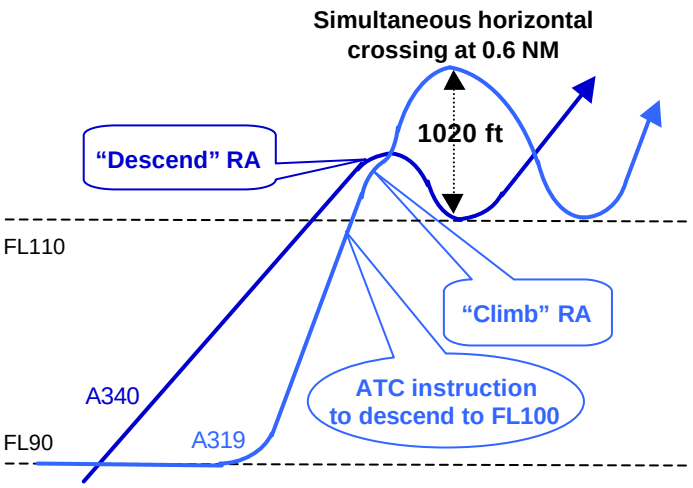


When passing through FL100, the A340 is turned to the right by the departure controller. At the same time, the A319 is cleared by mistake by the en-route controller to climb to FL210, which induces a conflict with the A340. The en-route controller detects the conflict and instructs the A319 to stop climb at FL100. The A319 pilot replies that he has already passed FL100 and that he is descending back to FL100.

However, because of the simultaneous horizontal and vertical convergence, the TCAS II of each aircraft triggers a coordinated RA:

- the A340 receives a "Descend" RA that he follows correctly despite the clearance to climb to FL150
- the A319 receives a "Climb" RA that he also follows correctly even though he has already started his manoeuvre to descend back to FL100

In this event, the correct responses to the RAs by both pilots provide more than the TCAS II vertical separation objective.



Conclusion

TCAS II is a last resort system, which operates with very short time thresholds before a potential near mid-air collision. It assesses the situation every second, based on accurate surveillance in range and altitude. For maximum efficiency, when both aircraft are operating TCAS II in RA mode, TCAS II coordinates the RAs. TCAS II is extremely effective.

It is important that pilots follow all RAs even when there is:

- **an opposite avoiding instruction by the controller.** If the RA is not followed, it can adversely affect safety when the other aircraft responds to a coordinated RA.
- **conflict close to the top of the operating envelope.** If a "Climb" RA is generated, it may be possible to climb at least a little but do not descend, opposite to the RA.
- **traffic information from the controller.** The slower update rate of the radar display, even with RDPS multi-radar data, means that the vertical situation seen by the controller may be inaccurate, particularly when aircraft are rapidly climbing or descending.
- **visual acquisition.** The wrong aircraft could be identified and the situation may be wrongly assessed.

It is recognised that workload is often high during a TCAS RA encounter, nonetheless **pilots shall notify ATC as soon as possible** using the standard phraseology (e.g. "[callsign] TCAS CLIMB").
This information will help the controller in his task (cf. ICAO Doc 4444, PANS-ATM). When a controller is informed that a pilot is following an RA, the controller shall not attempt to modify the aircraft flight path until the pilot reports returning to the clearance. He shall provide traffic information as appropriate.

For maximum safety benefit from TCAS II, follow RAs promptly and accurately.

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This is one of a series of ACAS Bulletins planned to address specific TCAS operational issues. For more detailed information on ACAS and TCAS, please refer to the ACAS II brochure and training material available on the ACAS Programme website

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