

The Dos and Don'ts of TCAS II Operations

Editorial

Operationally, the flight safety benefits of ACAS II are well proven. However, operational monitoring has also highlighted a number of TCAS II operational issues which have been addressed in previous editions of this ACAS Safety Bulletin.

As Phase 2 of the European ACAS II implementation (extending the mandatory carriage and operation to smaller aircraft) is drawing to conclusion, it is perhaps an appropriate time to remind all aircraft operators, flight crews, and controllers, of some of the more significant issues, and as importantly, to review the correct and best practice ACAS actions.

This ACAS Safety Bulletin includes a summary of the topics discussed in the previous Bulletins. The events described here are recent. Clearly, if the flight safety benefits of ACAS are to be maximised, it is important that all adhere to the standardised ACAS operational procedures, and that 'best practice' is always applied.

John Law
Mode S and ACAS Programme Manager,
EUROCONTROL
March 2006

Event 1: Coordinated RAs on level bust

A departing E145 is cleared to climb to FL120.

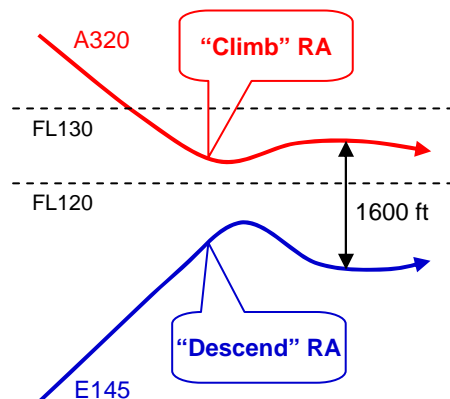
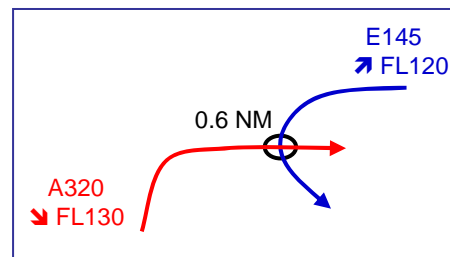
An A320, on approach, is cleared to FL130 and 220 kts. However, due to confusion between the level and the speed clearances, the pilot is descending to FL120.

After the level bust by the A320, the TCAS II of each aircraft triggers a coordinated RA which is correctly followed by the pilots:

- the E145 receives a "Descend" RA when passing FL113
- the A320 receives a "Climb" RA when passing FL122

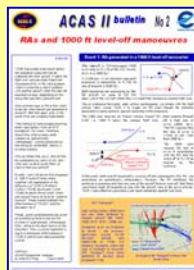
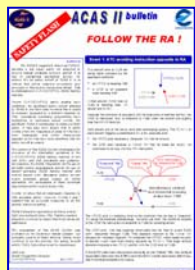
At the same time, a Short Term Conflict Alert is triggered. The controller who is not aware of any RA, instructs the A320 to climb back to FL130 and the E145 to descend to FL110. The A320 pilot reports that they are already following a "Climb" RA. In this case, the ATC instructions happened to be compatible with the RAs.

TCAS II acted perfectly as an efficient safety net for preventing mid-air collision between aircraft. It detected the unsafe situation (one aircraft climbing and the other descending to the same flight level) and generated a coordinated RA to resolve it. The response by both pilots provided a safe vertical separation.



Previous EUROCONTROL ACAS II Bulletins

EUROCONTROL is publishing a series of ACAS II Bulletins, each with a different safety related theme, and intended for a wide aviation audience. Each bulletin focuses on an ACAS II operational issue relevant to both aircrews and air traffic controllers. This one contains references to the six ACAS II Bulletins that have already been published.



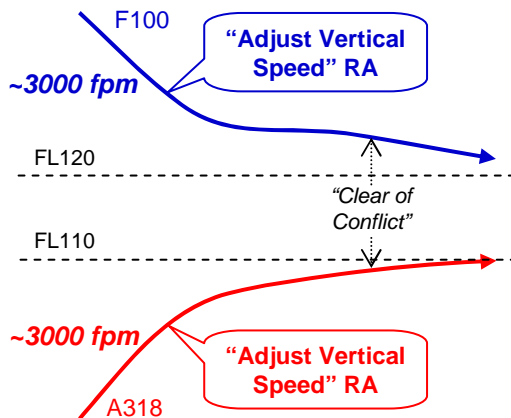
They can be downloaded from the ACAS & Mode S Programme website. Go to www.eurocontrol.int/msa and then follow the link at the bottom of the page, or by clicking on the images above and the hypertext links in the document.

Event 2: Level-off with 1000 ft separation

An A318 is climbing to FL110 at about 3000 fpm. A Fokker 100 is descending to FL120, also at about 3000 fpm.

The aircraft trajectories are converging both horizontally and vertically. Due to the high vertical closure rate (6000 fpm), the A318 and the F100 receive an "Adjust Vertical Speed" RA at respectively 900 and 1000 ft from their cleared flight level. Both RAs request to reduce the vertical speed to 1000 fpm.

- The A318's pilot reduces the rate of climb to less than 1000 fpm.
- The F100's pilot first stops the descent and then descends again at about 1000 fpm.



The **correct reactions to the RAs by both pilots** minimised the impact on ATC.

Level-off with 1000 ft separation: what's new?

TCAS II version 7 contributed to a significant reduction in the number of RAs generated when aircraft are expected to level-off to achieve 1000 ft separation. However, these situations still cause a large majority of RAs. Recent figures from a major European airline show that they represent 70% of RAs generated on its A320 fleet.

The **ACAS Bulletin n°2** describes some solutions to reduce the number of these RAs. Some progress has been made regarding the reduction of the vertical rate approaching the cleared flight level.

Several airlines have modified their standard operating procedures to require the pilots to reduce the vertical rate to less than 1500 fpm within the last 1000 ft before cleared flight level (usually, when the pilot is aware of an aircraft at the adjacent flight level). Data collected by a major European airline show that the likelihood of receiving an RA while levelling off is three times lower when this reduction is implemented.

ICAO is completing its work to include this recommendation in Annex 6, Aircraft operations.

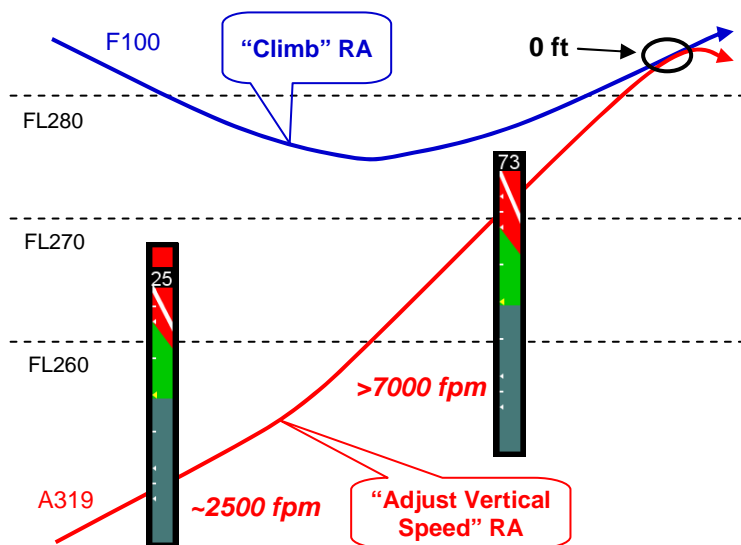
Event 3: Wrong reaction to "Adjust Vertical Speed" RA

An A319 is climbing to FL260 at about 2500 fpm.

When passing through FL251, it receives an "Adjust Vertical Speed" RA requiring a reduction in the rate of climb to 1000 fpm. The RA is triggered against a Fokker 100 descending to FL270 at 2000 fpm on a converging track.

The A319's flight crew misinterprets the RA and **increases the rate of climb to more than 7000 fpm instead of reducing it**. Due to this opposite reaction to the RA and despite a correct response of the Fokker 100 to the coordinated RAs ("Adjust Vertical Speed" then "Climb"), the A319 receives a strengthened "Descend" RA. However, the flight crew continues to climb very quickly until the "Clear of Conflict".

As a result, the A319 busts its cleared flight level by 2200 ft and **the aircraft passed at a distance of 1.6 NM at the same altitude**.



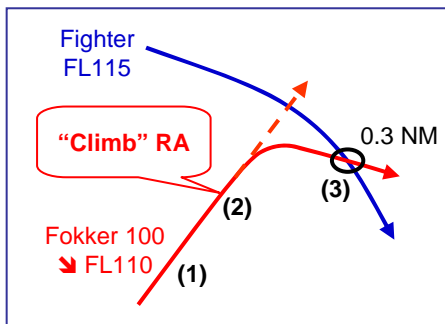
Actions to address the opposite reactions to "Adjust Vertical Speed" RAs

The safety issue of opposite reactions to "Adjust Vertical Speed" RAs whereby pilots believe that they are reacting appropriately was described in detail in the **ACAS Bulletin n°3**. The event above illustrates that such events continue to occur. Due to the severity of this issue, there are several on-going actions to address it, including pilot's training and TCAS II specifications.

- Some airlines have adapted their TCAS II training programmes with respect to this issue. The main objective is to explain clearly to pilots that when an "Adjust Vertical Speed" RA is triggered by TCAS II, the required action is always to **"REDUCE VERTICAL SPEED"**. This enhanced training has contributed in the reduction of the number of occurrences but has not fully eradicated the problem.
- RTCA, the TCAS II standardisation body, is investigating this safety issue and the causes for such opposite reactions have been identified in a recently published report. The work is going on to improve the aural message and the display for these specific RAs. EUROCONTROL, in support of RTCA work, is investigating a possible modification of the "Adjust Vertical Speed, Adjust" aural annunciation, together with a simplification of the TCAS II RA list.

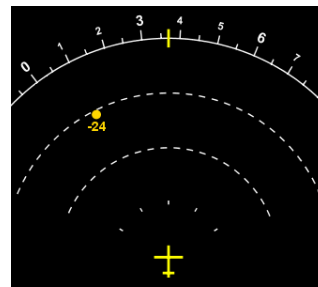
Event 4: Inappropriate turn based on TCAS traffic display

A Fokker 100 is descending to FL110. Its TCAS triggers a "Traffic Advisory" and then a "Climb" RA when passing FL130, against a fighter at FL115. The pilot correctly follows the RA and starts to climb.

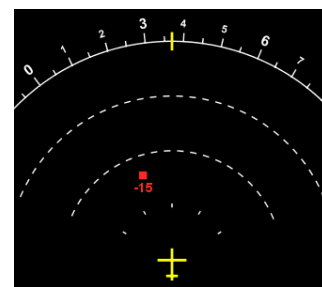


However, the pilot also initiates a 70-degree right turn based on the TCAS traffic display which shows the intruder on the left. The climb provides a safe vertical separation (more than 1000 ft) whereas **the right turn actually reduces the horizontal separation** from 1 NM to 0.3 NM.

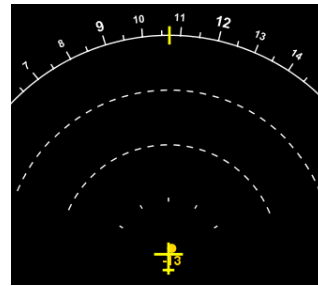
Due to the relative motion of the symbol and the lack of speed vector on the TCAS traffic display, the flight crew incorrectly interpreted that the intruder was converging towards the own aircraft from the left under a bearing of 30°. However, the ground track angle was about 90° as shown on the figure.



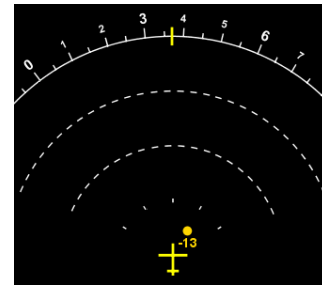
(1) "Traffic, Traffic"



(2) "Climb, Climb"



(3) "Clear of Conflict"



Projected fighter position if no turn executed

TCAS II traffic display is difficult to interpret

The [ACAS Bulletin n°6](#) describes why the TCAS II traffic display is open to misinterpretations.

The display shows only a partial traffic picture, shows no history or past position and has no speed vector for intruders.

It has a moving reference: as the aircraft itself is moving, the displacement of the intruder's symbol does not correspond to the intruder's actual ground track.

The bearing of the intruder's symbol has limited accuracy.

Therefore, pilots must only use it according to its intended function: to assist the visual acquisition of surrounding aircraft.

Incorrect controllers' reactions

In some reported events, it has been identified that controllers have explicitly told pilots to ignore reported RAs:

- Pilot: "TCAS descend"
- ATC: "There is opposite traffic at FL290, at your 12 o'clock, 10 miles, climb immediately please"

In some other events, controller have even anticipated a possible RA:

- ATC: "Descend immediately FL370"
- Pilot: "Roger. Descending FL370"
- ATC: "The [conflicting] traffic [...] will maintain FL380. If you get an ACAS alert, do not follow it"

Controllers must not interfere with pilots' reactions to RAs!

Since the introduction of ACAS II, the ICAO PANS-ATM Doc 4444 has clearly stated that controllers must not interfere with the pilots' reactions to RAs:

"When a pilot reports a manoeuvre induced by an ACAS resolution advisory, the controller shall not attempt to modify the aircraft flight path [...]"

Even when a pilot is appropriately trained to apply the new ACAS procedure requiring to follow all RAs, he can be confused to receive from the controller an instruction opposite to the RA that he has just reported.

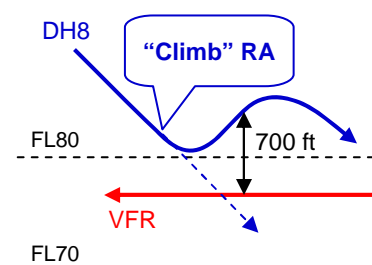
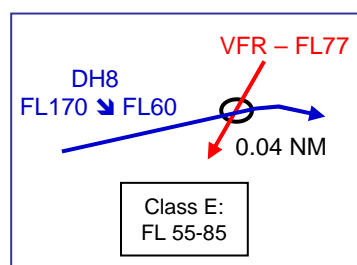
Event 5: Necessary RA against VFR aircraft

A DH8, flying IFR, is descending to FL60. When approaching FL80, it receives a "Climb" RA. The pilot stops the descent and climbs back about 400 ft. The intruder is an uncontrolled altitude transponding VFR aircraft cruising at FL77.

The VFR was flying in class E TMA in radio contact with FIS. The vertical limits of this class E airspace range from FL55 to FL85.

The pilot's reaction to the "Climb" RA enabled the DH8 to pass 700 ft above the VFR. Simulations indicate that without TCAS, the minimum separation between the aircraft **would have only been less than 150 ft and 0.04 NM**.

The safety benefits of TCAS RAs **against altitude transponding VFR traffic** has been shown in the [ACAS Bulletin n°4](#).



A B767 is maintaining FL290 heading West. An A319, heading South-East, is at FL270 on a converging track. The aircraft are controlled by two different ATC units (the vertical boundary is FL285).

The A319's pilot requests for a higher cruising level. Due to a coordination error between the two ATC units, the A319 is cleared to climb to FL290 with the B767 whilst in confliction.

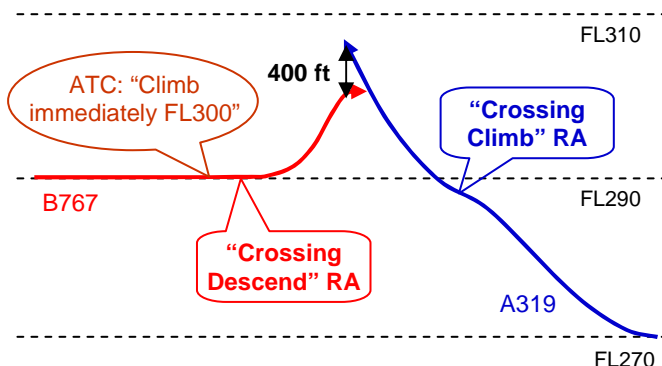
Following Short Term Conflict Alerts triggered in both ATC units, **the B767 is instructed to climb immediately to FL300** and the A319 to "expedite descend FL270".

However, almost at the same time, each aircraft receives a coordinated RA opposite to the ATC instruction.

- The B767 receives a "Crossing Descend" RA. **The pilot disregards the RA and follows the ATC instruction to climb.**
- The A319 receives a "Crossing Climb" RA. The pilot correctly reacts to the RA by increasing the rate of climb.

Because of the B767 pilot's opposite manoeuvre to the RA, the very small vertical separation between the aircraft does not increase. Consequently, the A319 receives an "Increase Climb" RA and the pilot increases the rate of climb to 5000 fpm. The B767's pilot eventually recognises the "Descend" RA and stops the climb just before the "Clear of Conflict".

Despite the large vertical deviation of the A319 (3000 ft), the aircraft passed at **400 ft and 0.3 NM**.



Pilots must follow all RAs!

The ACAS Bulletin n°1 describes several hazardous events where some pilots reacted in the opposite direction of the RA for different reasons (ATC instruction, visual acquisition, stress, etc.).

Previously, the ICAO regulation was not sufficiently explicit. Therefore, ICAO revised the ACAS procedures and pilot training guidelines to require pilots to follow all RAs. The ICAO PANS-OPS Doc 8168 was updated in November 2003 and as described in the ACAS Bulletin n°5, the ACAS procedure now clearly states that:

"Pilots shall respond immediately by following the RA as indicated, unless doing so would jeopardise the safety of the aeroplane"

However, Event 6 shows that there are still some pilots who do not follow RAs, and who even manoeuvre in the opposite sense of the RA, whereas the ICAO PANS-OPS Doc 8168 also states that:

"Pilots shall not manoeuvre in the opposite sense of an RA"

Ten Fundamental Dos and Don'ts

The operational monitoring programmes show that TCAS II is extremely effective to improve safety. To maximise the safety benefits and operational compatibility with ATC, **ten fundamental dos and don'ts must be observed:**

1. TCAS II must be operated in RA mode to provide full safety benefits
2. Pilots must follow all RAs promptly and accurately
3. Pilots must never manoeuvre in the opposite sense of an RA
4. Pilots must report RAs to controllers as soon as possible
5. Controllers must not interfere with pilots' reactions to RAs
6. Vertical speed must be reduced in response to "Adjust Vertical Speed" RAs
7. TCAS traffic displays must not be used for self-separation
8. Vertical speed must be reduced when approaching the cleared flight level
9. VFR pilots must operate their altitude reporting transponder
10. Pilots and controllers must be recurrently trained on ACAS II operations

Refer to the applicable regulatory documents for ACAS II standards and recommended practices.

John Law
EUROCONTROL
Mode S and ACAS
Programme Manager
96, rue de la Fusée
B-1130 Brussels

Contact:

Tel: +32 2 729 37 66
Fax: +32 2 729 37 19
<http://www.eurocontrol.int/acas/>
acas@eurocontrol.int