SAFETY FLASH

ACAS II bulletin No 11

EUROCONTROL

ACAS world is moving on

Editorial

ICAO's worldwide ACAS II equipage mandate became effective in January 2005 for all civil fixed-wing turbine-engined aeroplanes with a maximum certificated take-off mass in excess of 5,700 kg or authorised to carry more than 19 passengers. Consequently, the number of ACAS-II-equipped aircraft increased significantly. In addition, some aircraft not subject to the mandate (e.g. business jets and military transport aircraft) have voluntarily been equipped for the added safety benefit.

ACAS II is a well established safety net to prevent mid-air and near-mid-air collisions, but the ACAS world is moving on.

In this Bulletin, we inform you of recent and planned changes to ACAS II procedures and equipment. It also brings to your attention selected recent events illustrating the effectiveness of ACAS, highlighting recurrent problems from which lessons should be learned.

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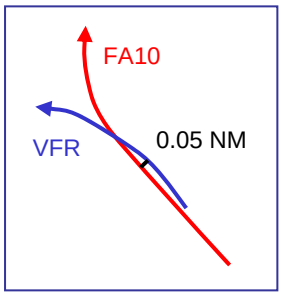
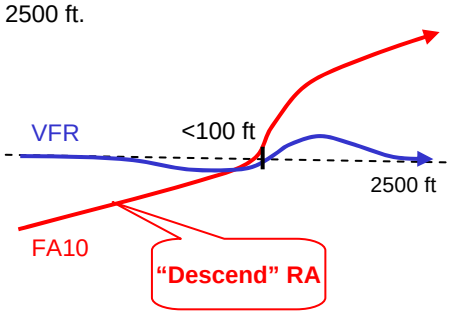
EUROCONTROL
March 2010

Event 1: RA not followed leading to near mid-air collision with a VFR



A Falcon 100 has departed from a medium-sized airport under IFR and is heading north-west. A piston-engined aircraft flying VFR is north of the airport at 2500 ft, also heading north-west.

Owing to the difference in speeds, the Falcon is rapidly catching up the VFR aircraft and as it climbs through 2300 ft, it receives a "Descend" RA. However, the pilot of the Falcon does not react to the RA and continues to climb. A few seconds before the Closest Point of Approach (CPA), the pilot of the Falcon increases the climb rate to more than 3000 fpm to avoid the VFR traffic. Simultaneously, the pilot of VFR aircraft starts to climb but then descends back to 2500 ft.



The Falcon passes just to the left of the VFR aircraft, at **a distance of 0.05 NM and a vertical separation of less than 100 ft,** according to radar data. It is unknown whether the pilots saw each other.

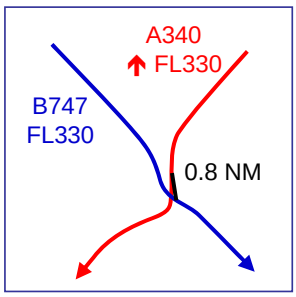
If the Falcon pilot had responded correctly to the RA, the Falcon would have passed about 300 ft below the VFR aircraft.

Event 2: Loss of separation but prompt reactions to RAs

A B747, heading south-east, is in level flight at FL330. An A340 is climbing to FL330 on a crossing track and is expected to pass behind the B747. However, the controller has cleared the A340 direct to a waypoint further on the route and this clearance leads the A340 to converge with the B747.

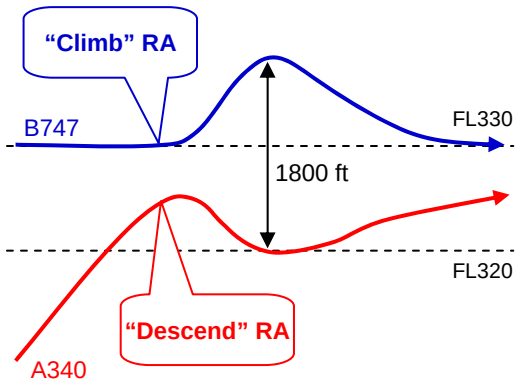
Consequently, a Short Term Conflict Alert (STCA) is displayed to the controller, who then gives avoiding instructions: a 40 degree left turn for the A340, then a 40 degree right turn for the B747. At the same time, both aircraft receive coordinated RAs:

- The B747 pilot responds immediately to a "Climb" RA and reports the RA to ATC.
- The A340 pilot starts turning late, but reacts promptly to a "Descend" RA.



ATC separation was lost, but at the CPA, the aircraft were separated by 1800 ft, with only 0.8 NM in the horizontal plane.

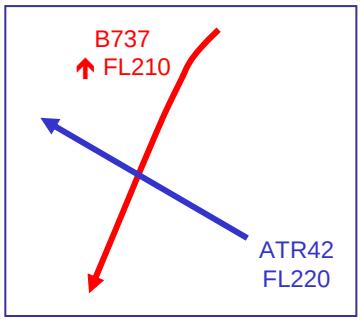
In this event, the prompt and effective reaction by both pilots to the RAs resulted in safe vertical separation at the CPA. The ATC avoiding action was given too late to be effective. Nevertheless, the ATC horizontal instructions did not affect the reactions to the RAs.



For maximum safety benefits of TCAS II, follow RAs promptly and accurately

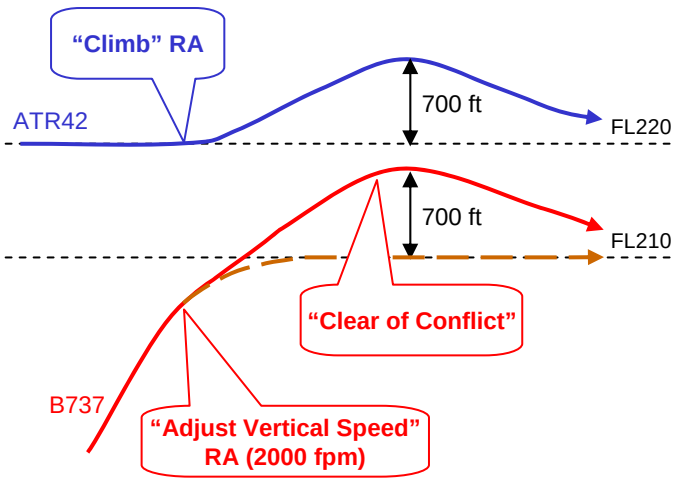
Event 3: Level bust while following an RA ("Fly-the-green" behaviour)

A B737, heading south, is climbing to FL210. An ATR42 is in level flight at FL220 on a crossing track.



Despite traffic information from the controller about the ATR42 and confirmation of the clearance, the pilot of the B737 is still climbing at 2600 fpm when passing FL205. This high rate of climb results in the TCAS on both aircraft issuing coordinated RAs: a "Climb" for the ATR42 and an "Adjust Vertical Speed" to limit the climb rate to 2000 fpm for the B737.

The ATR pilot follows the RA and advises ATC of his "Climb" RA. The B737 pilot also follows the RA and reduces the vertical speed. However, he continues climbing, maintaining the vertical speed needle in the green area, even after having passed through his cleared flight level. He does not stop climbing until TCAS generates the "Clear of Conflict" message. Afterwards, the B737 pilot reports to ATC that he also received a "TCAS RA to climb".



As a result, the B737 climbed through its cleared flight level by 700 ft, reaching FL217. Meanwhile, the ATR also deviated by 700 ft from its cruising level.

This type of level bust is the consequence of pilots maintaining the vertical speed needle in the green area of the RA display or the pitch angle at the base of the red trapezoid while responding to the "Adjust Vertical Speed" RA.

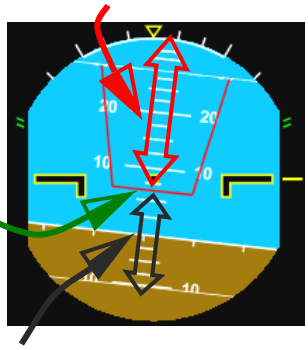
An "Adjust Vertical Speed" RA always requires a reduction in the vertical speed (which was performed correctly by the B737 pilot). However, the "ACAS Manoeuvre Training" section of ICAO PANS-OPS Doc 8168 states: *"when possible, an ATC clearance is complied with while responding to an RA. For example, if the aircraft can level at the assigned altitude while responding to a reduce climb or reduce descent RA, it should be done."* This does not require that a pilot maintains the achieved vertical speed (i.e. 2000 fpm in this case) if a further reduction in the vertical speed would allow him to comply with the ATC clearance.

Display of "Adjust Vertical Speed" RAs and associated response

The examples below show an "Adjust Vertical Speed" RA requiring a reduction in the vertical speed to 2000 fpm or less, displayed on an Electronic Attitude Display Indicator (red trapezoid as pitch guidance), a vertical speed tape (with red and green areas) and a round-dial Instantaneous Vertical Speed Indicator (IVSI). Other possible required vertical speed reductions can be 1000, 500, 0 fpm.

Using the pitch guidance, the minimum required action is to set the pitch angle to the base of the red trapezoid. This will result in achieving 2000 fpm, but pitch angles outside the red trapezoid are also compliant with the RA, allowing a pilot to level off, for example.

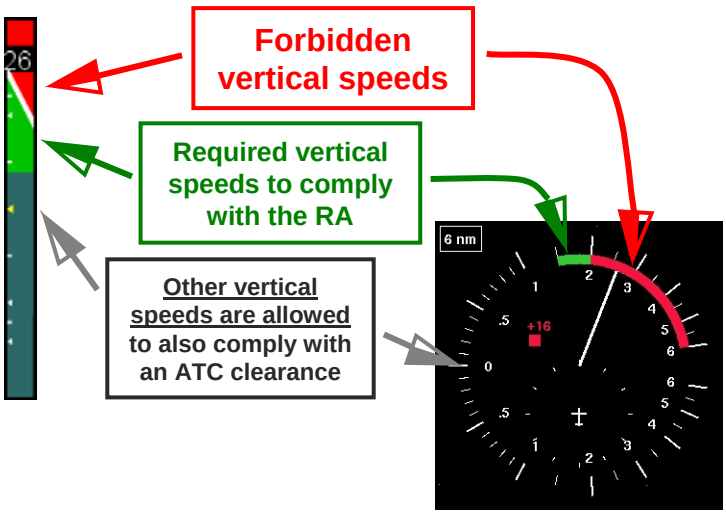
Forbidden pitch values



Required minimum pitch adjustment to comply with the RA

All pitch values outside the red trapezoid are allowed to also comply with an ATC clearance

Using the vertical speed tape or IVSI, the minimum required action is to set the needle at least in the green area, but vertical speeds in the grey or black area (on the vertical speed tape or the IVSI respectively) are also compliant with the RA, allowing a pilot to level off, for example.



It should be noted that both the new TCAS II version 7.1 (through the introduction of a new "Level-off, Level-off" RA) and the new "AP/FD TCAS" mode on some Airbus aircraft (through automatic compliance with the Selected Flight Level) will prevent level busts while pilots are complying with an initial "Adjust Vertical Speed" RA.

Event 4: Unintentional opposite reaction to an "Adjust Vertical Speed" RA

An A320, heading north-west, is cruising at FL340. A Gulfstream 3 (GLF3) is climbing to FL330 at a rate of 2500 fpm, heading south-east, on an almost opposite track.

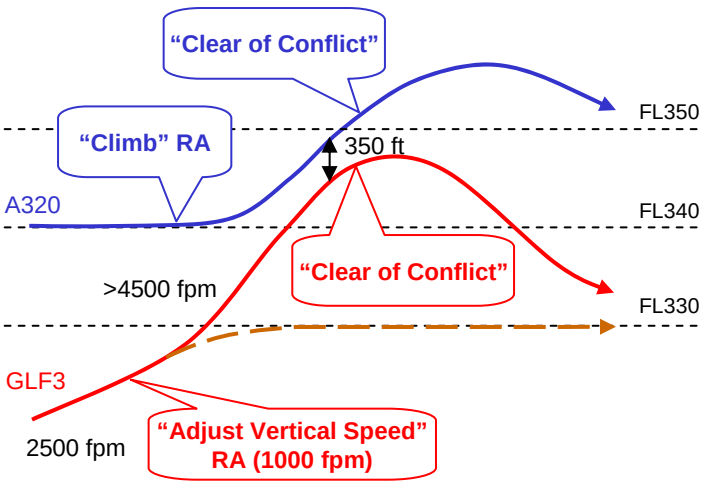
When passing through FL322, the GLF3 receives a TA, followed at FL325 by an "Adjust Vertical Speed" RA, which in this case requires a reduction in the vertical speed to 1000 fpm or less. After a few seconds, the A320 receives a coordinated "Climb" RA.

Misinterpreting the RA, the GLF3 pilot increases the vertical speed to more than 4500 fpm instead of reducing it. This initial RA subsequently strengthens to a "Descend" RA and an "Increase Descent" RA. The GLF3 pilot keeps on climbing until TCAS generates a "Clear of Conflict" message.

On the other hand, the A320 pilot follows the "Climb" RA and the subsequent "Increase Climb" RA, and at some point climbs at 3200 fpm which actually helps to increase the vertical spacing between the aircraft.

As a result of the opposite manoeuvre to the RAs, the GLF3 **climbed 1700 ft above its cleared flight level**, passing through the A320's cruising flight level (i.e. FL340). At the CPA, the aircraft passed each other at **0.9 NM and 350 ft**.

After the "Clear of Conflict" message, the GLF3 pilot merely reported to the controller that he "had a resolution, traffic alert".



More examples of unintentional opposite reactions to "Adjust Vertical Speed" RAs can be found in ACAS Bulletins No. 3 and No. 7. TCAS II version 7.1 includes a modification of these RAs to address this issue (see the yellow box to the right).

A new TCAS II version

To address known safety issues with TCAS II version 7, a new version, named TCAS II version 7.1, was developed and approved in 2008. It will provide two major improvements.

- *Enhanced "reversal RA logic". The objective is to better address the situations where it is necessary to revert the sense of the RA. For instance, when one of two TCAS-equipped aircraft manoeuvres in a sense opposite to its RA, or when the manoeuvres of a non-TCAS equipped intruder are contrary to the collision avoidance logic projections. Although, this capability already exists in TCAS II version 7, in some situations it fails to generate reversal RAs. With this enhanced logic, reversal RAs will be issued, if required, in a more appropriate and timely manner.*
- *Simplified and more intuitive "Level-off, Level-off" RA instead of "Adjust Vertical Speed, Adjust" RAs. Operational monitoring programmes have identified the fact that some pilots, who are confused by the aural message and the display of the "Adjust Vertical Speed" RAs, unintentionally react in the opposite manner to that required by the RA. The new "Level-off, Level-off" RA is intended to prevent these unintentional opposite reactions thanks to an explicit aural message indicating the sense and strength of the manoeuvre and a simplified display of the RA. This new RA will also contribute to preventing level busts caused by pilots passing through their cleared flight level as they maintain the vertical speed needle in the green area.*

In Europe, EASA (the European Aviation Safety Agency) has initiated a rule-making task to develop an "…Implementing Rule requiring the carriage of TCAS II with software version 7.1 as the minimum standard for aircraft operating within European Airspace".

Vertical speed reduction when levelling off 1000 ft from another aircraft

In November 2008, as a measure to reduce the number of non-desired RAs when levelling off at 1000 ft from another aircraft, ICAO included in PANS-OPS Doc 8168 a procedure which recommends **a reduction in the vertical speed to 1500 fpm throughout the last 1000 ft before the assigned altitude or flight level** when the pilot is made aware of another aircraft at or approaching an adjacent altitude or flight level. A similar procedure had already been applied with success by several major airlines prior to 2008.

Other enhancement of TCAS operations

- EASA has recently certified a new Auto-Pilot/Flight Director (AP/FD) TCAS mode for the Airbus A380. This system allows the aircraft to automatically follow all the RAs generated by TCAS and also to resume the previously selected flight level after the "Clear of Conflict" message. This enhanced TCAS mode avoids potential overreactions or opposite reactions to the RAs. However, if the pilot decides to fly the RA manually, the Flight Director bars provide an intuitive display and guide the pilot to fly the manoeuvre required by the RA. This AP/FD TCAS mode will also become available for retrofitting to other Airbus fly-by-wire aircraft in the coming years.
- Airbus is working on a new altitude capture law to help prevent non-desired RAs when aircraft are about to level off 1000 ft above or below a close converging aircraft. See the yellow box "Vertical speed reduction when levelling off 1000 ft from another aircraft" for additional information.
- Some ANSPs in Europe are considering the capability to downlink RAs for display on the controller's radar screen. A workshop was organised in Berlin in October 2009 to discuss the subject. For more information visit: http://www.eurocontrol.int/ra-downlink/.

Event 4: Mid-air collision over Brazil in 2006

A Legacy 600 Business Jet and a B737 are cruising in opposite directions on the same route. Unfortunately, following several problems related to ATC and communications, both aircraft are maintaining the same flight level (FL370), while ATC expected the Legacy to be at FL360 or FL380.

Moreover, the Legacy transponder has been inadvertently set to “Stand-by” (i.e. it is no longer operating). This has three consequences:

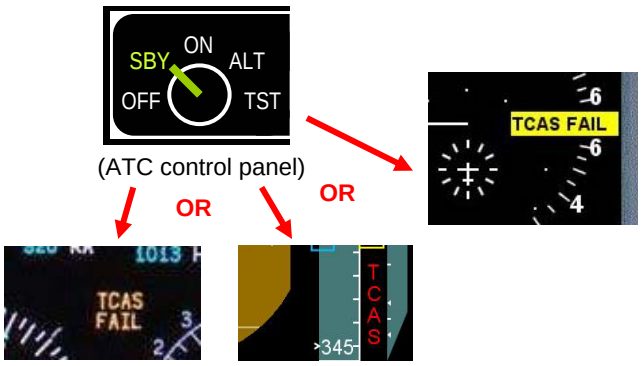
(1) ATC has lost SSR radar contact with the aircraft (including Mode C information), and consequently the current flight level is not seen by the controllers.
(2) The TCAS on board the Legacy has become automatically inoperative.
(3) The Legacy cannot be detected by the TCAS on other aircraft, including the B737.

As a result, the airborne collision avoidance safety net is unable to protect these two aircraft. Moreover, neither of the pilots is aware of the other aircraft’s presence and they do not see the opposite traffic despite daylight and good weather conditions.

The aircraft collide head-on at FL370.

TCAS II provides safety benefits between aircraft with active altitude-reporting transponders only

Own aircraft transponder



If own aircraft transponder is OFF or SBY, then own TCAS fails and the intruder aircraft cannot be detected.

Other aircraft TCAS

When an intruder aircraft transponder is OFF or SBY, the intruder aircraft is NOT detected by TCAS.

Conclusions

The ACAS world is moving on.

The community must take into account the following changes:

- More aircraft are now equipped with TCAS II, in particular business jets, but also some light jets, very light jets and helicopters.
- Instances of RAs at low altitudes against VFR traffic have increased, as operations at secondary airport grow.
- Enhancements aimed at improving TCAS II operations are, or will be, available in the near future: AP/FD TCAS mode, new altitude capture laws and most importantly, TCAS II version 7.1.

To maximize the safety benefits which ACAS provides, pilots must:

- Ensure that the transponder is ON and that TCAS is in the RA/TA mode;
- Follow RAs promptly and accurately, including those occurring at low altitudes;
- Promptly report to ATC any RAs requiring a deviation from the current clearance, using standard phraseology (i.e. “TCAS RA”);
- While following an “Adjust Vertical Speed” RA, whenever possible try to comply with the ATC clearance (if not contrary to the RA).

Moreover, it is important that all pilots undergo initial and refresher TCAS training, which is essential in order to achieve maximum safety benefits from TCAS II.

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