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ACAS II Bulletin

"Level off, level off" RA

WELCOME

TCAS II version 7.1 has been introduced in European airspace from 1 March 2012, through a phased-in mandate. By 1 December 2015, all civil aeroplanes over 5700 kg MTOM or over 19 passenger seats will have to be equipped. It is estimated that only up to 20% of the mandated aircraft have been upgraded to the new version. All the changes brought by version 7.1 were described in ACAS Bulletin 14 (January 2012).

Operationally, the most significant change introduced in version 7.1, is the replacement of the "Adjust vertical speed, adjust" RA with a new "Level off, level off" RA. Monitoring in core European airspace has shown that in some cases pilots overact while responding to Level Off RAs – instead of bringing the aircraft into level flight they start to descend (while climbing) or start to climb (while descending), sometimes at significant rates. These responses created a potential for a follow up conflict. In this Bulletin we discuss how to respond to the Level Off RA in two possible scenarios: when it is issued as an initial RA; and as a weakening RA.

To support pilot training we have produced a short animation demonstrating a correct response to a Level Off RA (link on page 3).

Finally, as a refresher we provide a brief overview of various implementations of RA displays and explain how "fly to" and "avoid" vertical rates are displayed during an RA.

Stanislaw Drozdowski
EUROCONTROL
Email: acas@eurocontrol.int

"Level off, level off" RA

In TCAS II version 7.1, the "Adjust vertical speed, adjust" RA has been replaced with a new "Level off, level off" RA. It always requires a reduction of vertical rate to 0 ft/min., i.e. a level off. The level off is to be achieved promptly, and the aircraft shall stay in level flight until a TCAS "Clear of conflict" message or another RA is issued.

The "Level off, level off" RA may be issued as an initial RA (as illustrated in Figure 1). Here the high vertical rate, while approaching the cleared level, causes the TCAS logic to predict a conflict with the aircraft on the adjacent flight level, even though appropriate ATC instructions are being correctly followed by each flight crew. That is because TCAS calculates a risk of collision based on the closing speed and vertical rate, without taking into account ATC clearances. Of course, in the case of a level bust or other operational errors, the RA will provide the pilot with essential collision avoidance advice.

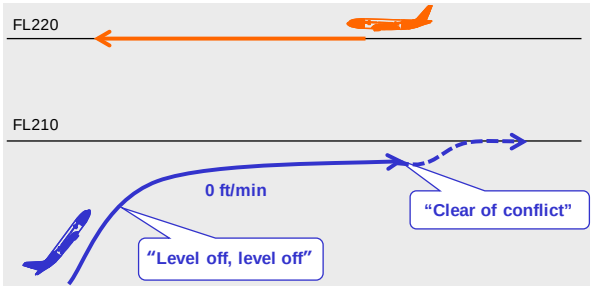

Figure 1: Initial Level Off RA

Like with all RAs, the aim is to promptly get the vertical rate needle out of the red area and fly into the green area. In the case of the Level Off RA the green area is showing a vertical rate range between –300 and 0 ft/min. (for the aircraft that received a Level Off RA in the climb – see Figures 2 & 3) and 0 and 300 ft/min. (if the aircraft were descending). While the display permits a shallow descent or climb, the vertical rate should be kept as close as possible to 0 ft/min.

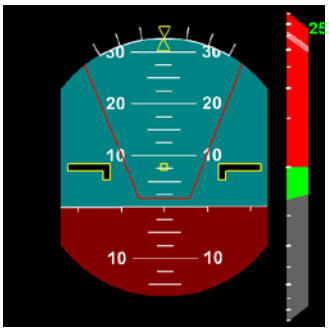

Figure 2: Initial Level Off RA as shown on a generic EFIS display (with rate tape and pitch cue).

Figure 3: Initial Level Off RA as shown on a generic IVSI display (incorporating a traffic display).

The Level Off RA can also be issued as a weakening RA following, for instance, a "Climb, climb" or "Descend, descend" RA (see Figure 4) when the vertical separation between the aircraft starts to increase and there is no need to increase the separation further. The required response is the same: the vertical rate shall be promptly reduced, as close as possible to 0 ft/min.

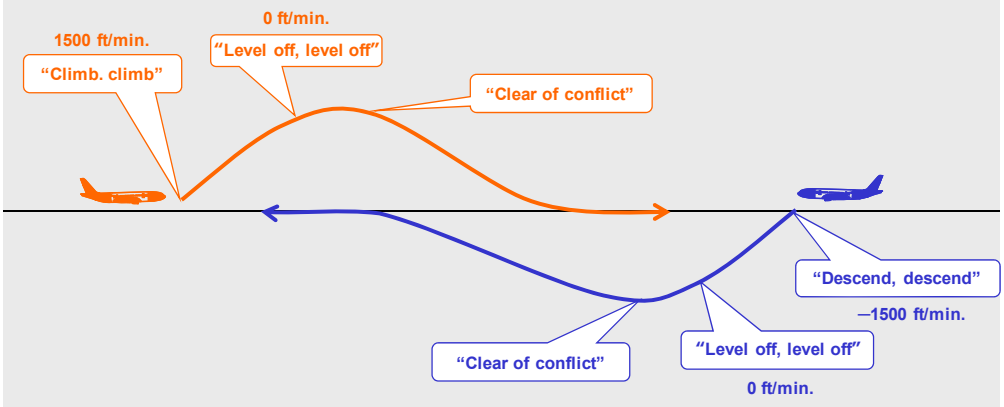

Figure 4: Weakening Level Off RA

Figures 5 and 6 below illustrate how the weakening Level Off RA is indicated on cockpit instruments.

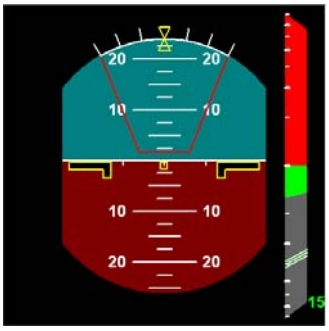

Figure 5: Weakening Level Off RA as shown on a generic EFIS display (with rate tape and pitch cue).

Figure 6: Weakening Level Off RA as shown on a generic IVSI display (incorporating a traffic display.)

Learning points:

- **Response to "Level off, level off" RA: Reduce the vertical rate – as close as possible - to 0 ft/min (i.e. level off).**
- The level off must be achieved promptly, not at the next flight level.
- Aircraft shall stay in level flight until a TCAS "Clear of conflict" message or another RA is issued.
- Any other response will have a negative impact on ATC operations and may even increase the risk of mid-air collision with other traffic.

Event 1: Example of response to initial Level Off RA.

In this example we illustrate the sequence of events and pilot responses (from one aircraft's point of view) when the Level Off RA is issued as an initial RA.

Our aircraft is climbing to FL250, with a vertical rate of over 2000 ft/min. Another aircraft is above, descending to FL260.

As explained above, the high vertical rate while approaching the cleared level can cause the TCAS logic to predict a conflict with the aircraft above, even though appropriate ATC instructions are being correctly followed by each crew (as TCAS does not take into account ATC clearances).

When our aircraft is passing FL233, the other aircraft is 8 miles away, flying in the opposite direction descending through FL265. A few seconds later, as we are passing FL236 a Traffic Advisory is generated. Just 13 seconds later, when we are through FL240, a "Level off, level off" RA is issued.

Within 5 seconds of the receipt of the Level Off RA, we start to reduce the vertical rate until the aircraft levels off at FL244. As the RA causes us to depart from our ATC clearance, we also advise the

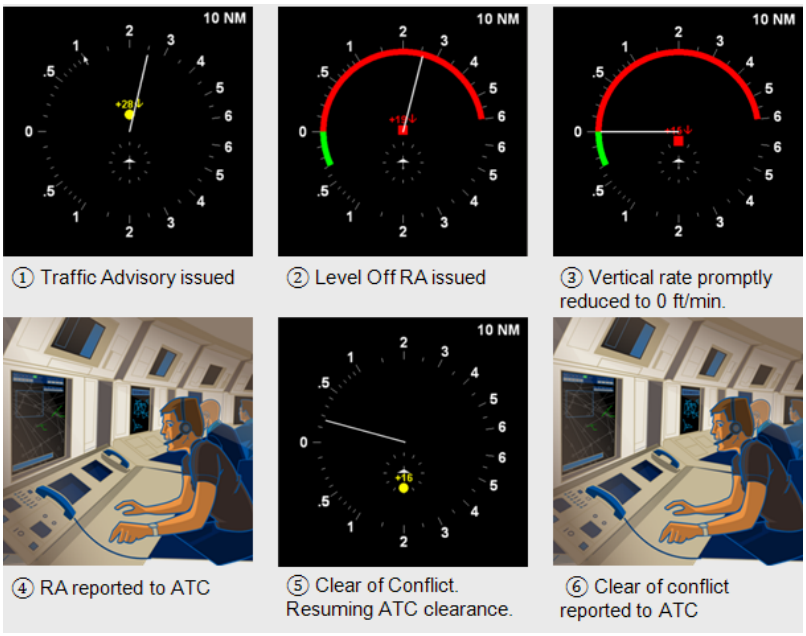

Figure 7: Event 1- sequence of events

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controller of the RA using the standard phraseology: ***"[callsign] TCAS RA"***. A "Clear of conflict" message is posted 40 seconds after the RA, after the other aircraft passes above. That permits us to resume the climb to our cleared level, i.e. FL250. While we commence the climb, we notify ATC: ***"[callsign] clear of conflict, returning to FL250"***.

Note: ICAO recommends limiting vertical rates to 1500 ft/min. or less in the last 1000 feet before the cleared level in order to avoid unnecessary RAs. Some States may impose stricter limits.

Event 2: Example of response to weakening Level Off RA.

In this example we illustrate the sequence of events and pilot responses (from one aircraft's point of view) when the Level Off RA is issued as a weakening RA.

We are maintaining FL320 proceeding westbound. Due to an ATC error, another aircraft on a crossing northerly heading, is also maintaining FL320. When the other aircraft is 6 miles away in our 10 o'clock position, we receive a Traffic Advisory. It is followed by a "Descend, descend" RA 13 seconds later when the horizontal distance between the two aircraft decreases to 4.5 miles.

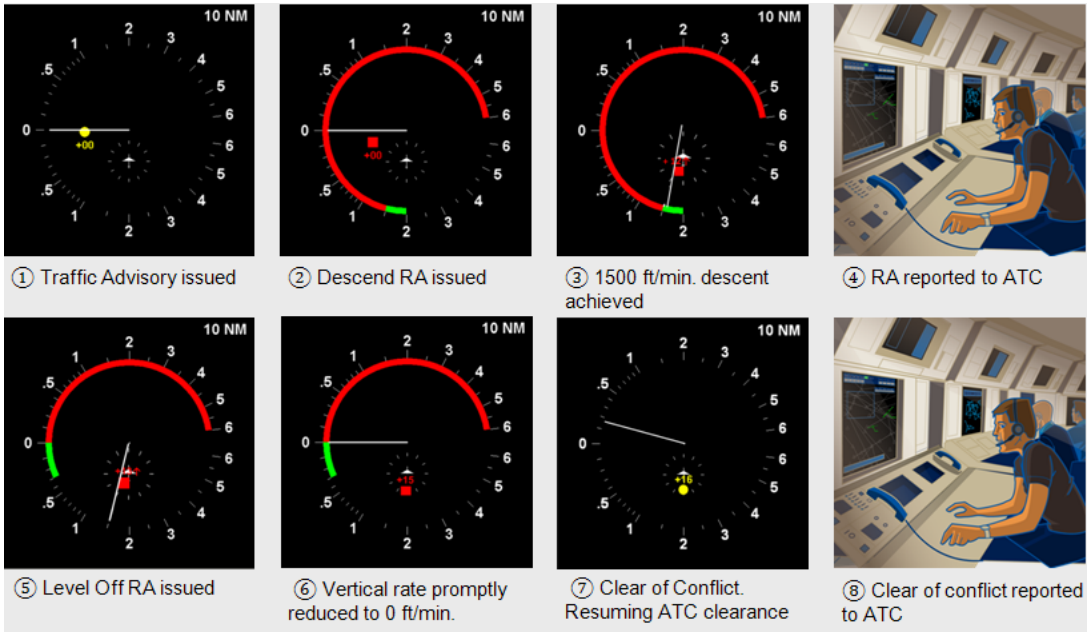


Figure 8: Event 2- sequence of events

Within 5 seconds of the receipt of the Descend RA, we start to descend to reach 1500 ft/min. As the RA causes us to depart from our ATC clearance, we also advise the controller of the RA using the standard phraseology: ***"[callsign] TCAS RA".***

While we follow the RA, the vertical spacing between us and the other aircraft starts to increase and 34 seconds after the initial RA, as we pass FL313, the RA weakens to "Level off, level off". The other aircraft is passing half a mile behind us 1200 feet above. Responding the Level Off RA, we reduce our vertical rate to 0 ft/min. bringing our aircraft to level flight. As we level off at FL312, a "Clear of conflict" announcement is made by TCAS.

That permits us to return to our cleared level, i.e. FL320. While we commence the climb, we notify ATC: ***"[callsign] clear of conflict, returning to FL320".***

Animation: "Level off, level off" RA

This short animated movie explains the optimal reactions to "Level off, level off" RA (both in the case of initial and weakening RAs).

The movie can be viewed by clicking on this link or on EUROCONTROL's YouTube channel (www.youtube.com/user/EUROCONTROLTV/videos).

The movie is an illustration of Event 1 (described on page 2).

continued overleaf

Display of RAs

There are various implementations of the RA display that have been approved for use, and each implementation has its unique characteristics. However, all of them follow the same design principles.

For round dial vertical rate indicators, the vertical rates to be flown and avoided are shown using a series of red and green arcs displayed around the periphery of the vertical rate indicator. The red arcs indicate the vertical rate range that must be avoided to maintain or achieve the desired vertical miss distance from one or more threats. A green "fly-to" arc is used to provide a target vertical rate whenever a change in the existing vertical rate is desired or when an existing vertical rate must be maintained. The length of the red and green arcs is adjusted as appropriate when the RA is strengthened or weakened (see Figure 9).

The same principles apply to the display of red and green vertical rate tape indications on a primary flight display (see Figure 9).

In the case of pitch cues displayed on the Primary Flight Display (PFD), pitch angles to be flown and/or avoided while responding to an RA are shown. A red trapezoid overlaying the other information on the PFD indicates the range of pitch angles that must be avoided to maintain or achieve the desired vertical miss distance. The trapezoid begins at the bottom of the PFD and extends upward to the desired pitch angle for up-sense RAs; for down-sense RAs, the trapezoid begins at the top of the PFD and extends downwards to the desired pitch angle. The closed end of the trapezoid corresponds to the pitch angle that will provide the vertical rate required by the RA.

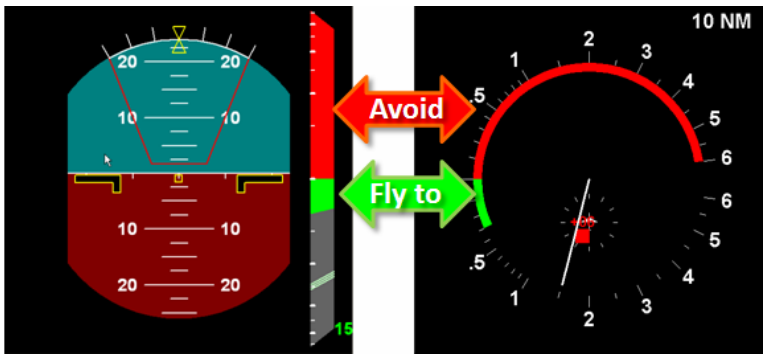


Figure 9: Green "fly to" and red "avoid" areas as shown a generic EFIS display (speed tape) and on a round dial generic IVSI display.

For head-up displays (HUD) the vertical flight path to be flown and avoided during an RA is shown using a unique display symbology on the HUD. A trapezoid overlaying the other information on the HUD indicates the flight path that must be flown to maintain or achieve the desired vertical miss distance from the threat(s).

Key learning points in this issue

- **Respond to a "Level off, level off" RA by reducing the vertical speed as close as possible to 0 ft/min.**
- Maintain level flight until a TCAS "Clear of conflict" message or another RA is issued.
- Red areas on the vertical speed indicators show the vertical speeds to be avoided during an RA, while green areas indicate "fly to" vertical speeds.

Other learning points

- RA causing a deviation from ATC clearance or instruction shall be reported to ATC as soon as possible.
- Limiting vertical speed to 1500 ft/min. or less in the last 1000 feet before the cleared level (as per ICAO recommendation) will help to avoid unnecessary RAs.

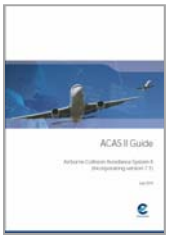
Recommended actions for aircraft operators/training facilities:

- Ensure that pilots are aware of the Level Off RA before the new TCAS version is introduced on the fleet.
- Include version 7.1, with emphasis on the new Level Off RA, in recurrent training modules.
- Upgrade existing flight simulators to be compliant with version 7.1, so appropriate flight simulator training can be carried out.
- Note that all aircraft must be fitted with TCAS II version 7.1 by 1 December 2015 in order to operate in European airspace.

Additional training resources at www.skybrary.aero

TCAS II version 7.1: EUROCONTROL ACAS II Bulletin no. 14

ACAS II Guide (updated July 2014)



Presentation: ACAS II overview (updated July 2014)

Contact

Email: acas@eurocontrol.int

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