

ACAS II Bulletin

Not so fast...

WELCOME

Recently, we have received a number of reports regarding incidents in which RAs (Resolution Advisory) were generated due to high vertical rates in the last 1000 feet before reaching the cleared level, against aircraft at the adjacent levels. Operationally, these RAs are unnecessary and cause distraction and additional workload to all involved.

This topic has already been covered in ACAS Bulletin no. 2 published in March 2003. In November 2008 ICAO published a recommendation to reduce the vertical rate to 1500 ft/min in the above situations. However, monitoring shows that there is no significant change to the frequency of such RAs so it is timely to highlight this issue again.

In this Bulletin we present the subject providing background information and illustrative examples of recent events. Events 1 and 2 demonstrate how high vertical rates caused RAs which could have been avoided. In event 3 we discuss a case in which a high vertical rate resulted in an RA to which the pilot reacted incorrectly, busting the cleared level by 1500 feet.

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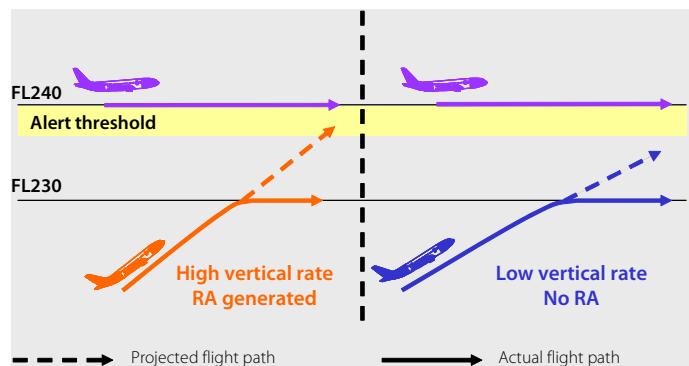
Unnecessary RAs due to high vertical rates before level-off

The performance of modern aircraft allows pilots to climb and descend with high vertical rates. While this can provide operational benefits (i.e. fuel or time savings), it can become problematic when aircraft continue to climb/descend with a high vertical rate close to their cleared level.

TCAS will issue an RA when it calculates a risk of collision based on the closing speed and vertical rates. A high vertical rate before level-off may cause the TCAS logic to predict a conflict with another aircraft even when appropriate ATC instructions are being correctly followed by each crew. This is because TCAS does not know aircraft intentions – autopilot or flight management system inputs are not taken into account because TCAS must remain an independent safety net.

If, simultaneously, another aircraft is approaching an adjacent level, the combined vertical rates make RAs even more likely. The majority of all RAs occur within 2000 feet before level-off at the cleared level.

Pilots and controllers often judge these RAs as operationally not required and refer to them as "nuisance" RAs. However, in real time the pilot cannot (and should not) assess whether the RA is in fact operationally required. It is best to avoid approaching the cleared level with a high vertical rate when the pilot is aware of another aircraft at the adjacent level – based on ATC traffic information, observation on the TCAS traffic display or as a result of a Traffic Advisory (TA). In this way the occurrence of nuisance RAs can be minimised.



- 1-2 Unnecessary RAs due to high vertical rates before level-off
- 2 Event 1 – High descent rate causes an RA
- 3 Event 2 – High climb rate and RA not followed
- 3 Event 3 – High climb rate and opposite response to RA
- 4 Incorrect responses to the "Adjust vertical speed, adjust" RAs
- 4 Recommended actions to reduce the frequency of high vertical rate RAs

Once an RA has been issued it must be followed without delay and it takes precedence over any ATC instructions. Importantly, the pilot should not assume that the other aircraft, even if acquired visually, is going to level-off at the adjacent level.

Any deviation from the intended flight path, resulting from the RA, causes additional workload to all involved and can be disruptive to ATC traffic flow and planning. But there is also a risk that the situation may deteriorate if the RA is not followed correctly.

Moreover, in congested airspace there is a possibility that more aircraft may become involved (a 'domino effect'). In such cases, TCAS will mitigate the risk of collision by assessing the situation every second and changing RAs as appropriate.

When a TCAS-equipped aircraft is approaching its cleared level with a high vertical rate, TCAS will typically generate: an "Adjust vertical speed, adjust" RA (in version 7.0) which requires a reduction of the vertical rate as indicated on the flight instruments; or a "Level off, level off" RA (in version 7.1) which requires

the reduction of the vertical rate to 0 ft/min (i.e. a level-off). If both aircraft are TCAS-equipped and one aircraft is climbing or descending and the other one is in level flight, an RA will typically be issued first to the climbing/descending aircraft and to the aircraft in level flight only if a response to the initial RA is not satisfactory. However, in cases of very high rates or when both aircraft are climbing and descending, RAs will be issued to both aircraft. The precise sequence of RAs may be different if one of the aircraft is not TCAS-equipped.

In extreme cases, involving very high vertical rates (particularly if both aircraft are approaching their cleared level with a high vertical rate or are intending to level off abruptly) TCAS may diagnose that insufficient time remains to assure safe separation by a reduction in vertical rate. In these cases TCAS may calculate that the best way to achieve the desired separation is to require the aircraft to maintain its high vertical rate and pass through the altitude of the other aircraft – a crossing RA, announced in the

cockpit as "Maintain vertical speed, crossing maintain". Although crossing RAs are rare they could be particularly disruptive to ATC as they result in the relative altitudes of the two aircraft being inverted compared to the controller's plan.

In order to reduce the number of RAs caused by high vertical rates before level-off, ICAO in November 2008 published a provision recommending that vertical rates are reduced to 1500 ft/min or less in the last 1000 feet before level-off, when the pilot is made aware of another aircraft at or approaching an adjacent flight level, unless instructed by ATC to maintain a certain vertical rate. Some States have published or consider publishing similar or even more restrictive measures to be applicable in their airspace.

In order to prevent unnecessary RAs, it is important that pilots, in line with ICAO recommendations or local requirements, limit vertical rates when approaching their cleared level (unless instructed otherwise by ATC).

Learning point:

It is best to reduce vertical rate to 1500 ft/min or less in the last 1000 feet before level-off. Especially, if you are aware of another aircraft at an adjacent flight level.

Event 1 – High descent rate causes an RA

An Airbus A300, heading north-west is cleared to descend from FL300 to FL180. The clearance has been correctly acknowledged by the crew. The descent rate increases steadily while the aircraft is descending, reaching 4000 ft/min when the A300 is passing through FL240.

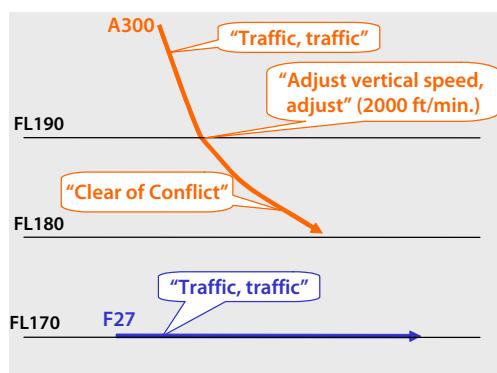
Meanwhile, a Fokker F27 is in level flight at FL170 heading east on a crossing

track. The predicted minimum horizontal separation is less than 1 NM.

When the A300 is passing through FL198 and the aircraft are 6 NM apart, both receive TAs. The A300 continues its descent at 4000 ft/min and when it is passing FL190 (i.e. being just 1000 feet from its cleared level), it receives an "Adjust vertical speed, adjust" RA (in this

case requiring the crew to limit the descent rate to 2000 ft/min).

The A300 descent rate is reduced quickly in compliance with the RA and when the aircraft is passing through FL183 a "Clear of conflict" is posted. As the A300 crew correctly follows the RA and reduces the vertical rate, there is no RA generated on the F27.



Learning points:

- The A300 **crew approached its cleared level with too high a vertical rate**.
- The RA (being followed correctly) had no influence on the other traffic nor ATC operations but caused unnecessary distraction and workload for the A300 crew.
- A simulation indicates that if the A300 crew had started to reduce their vertical rate in order to achieve the rate of 1500 ft/min at 1000 feet before their cleared level, **there would be no RA generated**.

Event 2 – High climb rate and RA not followed

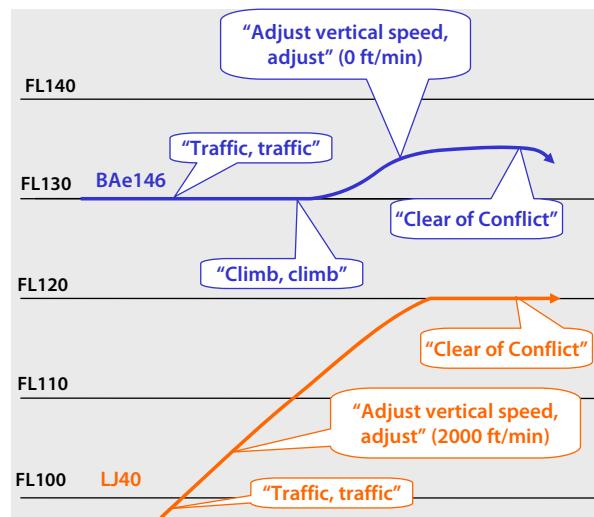
A BAe146 is maintaining FL130 while a Learjet 40, on a crossing track, is climbing to FL120 with a vertical rate of 4500 ft/min. The predicted minimum horizontal separation is just under 0.5 NM.

When the Learjet is passing through FL98 it receives a TA against the BAe146 above. After the TA, the vertical rate of the Learjet increases to almost 5500 ft/min. Subsequently, the BAe146 crew receives a TA. When the Learjet is passing FL104, it receives an "Adjust vertical speed, adjust" RA (requiring the crew to limit the climb rate to 2000 ft/min). Following the RA, the Learjet's vertical rate reduces slightly.

When the Learjet is 1000 feet away from its cleared level and still climbing

with the rate of 4500 ft/min, a "Climb, climb" RA is generated by TCAS on the BAe146. The BAe146 responds to the RA without a delay, and the aircraft starts to climb, soon reaching the required vertical rate of 1500 ft/min.

Just before the Learjet levels off at FL120, its cleared level, the RA on the BAe146 weakens to "Adjust vertical speed, adjust" (required vertical rate 0 ft/min). The BAe146 levels off at FL135 and soon after "Clear of conflict" messages are posted on both aircraft.



Learning points:

- The Learjet **crew approached its cleared level with too high a vertical rate**.
- The Learjet **crew did not respond to the initial RA**.
- The consequent RA on the BAe146 caused the **aircraft to depart from its cleared level**. That potentially could have been disruptive to ATC traffic planning and could have been a source of a subsequent conflict against other traffic.

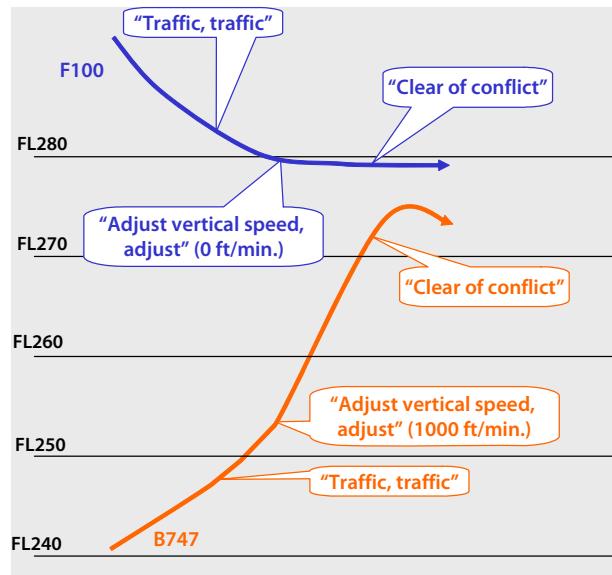
Event 3 – High climb rate and opposite response to RA

A Boeing 747 is climbing to FL260, while a Fokker F100 on the opposite track is descending to FL270. When the B747 is passing through FL236 with a vertical rate of over 2000 ft/min, the controller reminds the pilot to stop the climb at FL260 and provides traffic information.

The B747 receives a TA when it passes through FL247. Subsequently, when the aircraft is passing FL252, still climbing with a rate of over 2000 ft/min, it receives an "Adjust vertical speed, adjust" RA (in this case requiring the crew to limit the climb rate to 1000 ft/min). The B747 pilot responds incorrectly to the "Adjust vertical speed, adjust" RA, increasing the vertical rate rather than reducing it.

Eleven seconds later, while passing through FL279, the F100 crew receives an "Adjust vertical speed, adjust" RA (requiring a vertical rate of 0 ft/min) to which they respond correctly reducing the vertical rate and levelling-off.

The aircraft pass each other 12 sec. later with the vertical separation of 350 feet and "Clear of conflict" annunciations are given to both aircraft. Even after that the B747 continues to climb, reaching FL275 (i.e. 1500 feet above its cleared level).



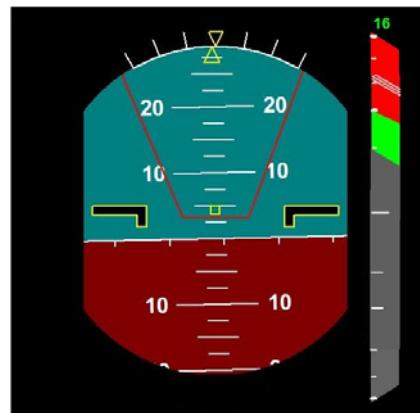
Learning points:

- The B747 **crew approached its cleared level with too high a vertical rate** despite being informed about another aircraft 1000 feet above their cleared level.
- The response to the resulting RA was opposite to that required – the vertical rate was increased rather than reduced which caused a deterioration of the situation.
- **The "Adjust vertical speed, adjust" RA always requires a reduction of vertical rate, never an increase.**
- New TCAS II software version 7.1 that is being phased in will replace the "Adjust vertical speed, adjust" RAs with a "Level off, level off" RA. For more information see [ACAS Bulletin no. 14](#) on the EUROCONTROL ACAS website (www.eurocontrol.int/acas).

Incorrect responses to the "Adjust vertical speed, adjust" RAs

The "Adjust vertical speed, adjust" RA is the most common RA, representing up to two-thirds of total RAs. It is also an RA which is quite often incorrectly responded to (as illustrated in Event 3 overleaf). The "Adjust vertical speed, adjust" RAs will be phased out with the implementation of TCAS II version 7.1; till then a potential for incorrect responses remains.

On TCAS instruments the vertical rates to be avoided are displayed with a red area and the required ones with a green area. The reduction of rate of climb will put the vertical speed needle into the green area.



Adjust Vertical Speed as shown on IVSI and EFIS displays
(in this example reduction to 1000 ft/min against a threat above)

ICAO Recommendation:

Unless otherwise specified in an air traffic control instruction, to avoid unnecessary airborne collision avoidance system (ACAS II) resolution advisories in aircraft at or approaching adjacent altitudes or flight levels, operators should specify procedures by which an aeroplane climbing or descending to an assigned altitude or flight level, especially with an autopilot engaged, may do so at a rate less than 8 m/sec or 1 500 ft/min (depending on the instrumentation available) throughout the last 300 m (1 000 ft) of climb or descent to the assigned level when the pilot is made aware of another aircraft at or approaching an adjacent altitude or flight level.

Source: ICAO Annex 6, part I, 4.4.10

Recommended actions to reduce the frequency of high vertical rate RAs

Pilots

- Reduce vertical rates as required by company procedures or local regulations.
- When climbing/descending, maintain situational awareness of aircraft at the adjacent levels.
- Note that "Adjust vertical speed, adjust" RA always requires a reduction of vertical rate, never an increase.

Airlines

- Include in Operating Manuals a procedure to reduce vertical rate when approaching the cleared level, in line with ICAO recommendation or to comply with any local regulations.
- Include such scenarios in simulator based training for pilots.

Controllers

- If possible, provide traffic information about aircraft at the level adjacent to the cleared level, especially if both aircraft are climbing and descending.
- Unless necessary for separation do not require aircraft to continue high rate climbs or descents to their cleared level

Conclusions:

- TCAS II will generate RAs in 1000-foot level-off encounters **if aircraft approach their cleared levels with high vertical rates**.
- All **RAs must be followed** even though they may appear as operationally unnecessary.
- RAs caused by high vertical rates can be **disruptive for ATC** and **cause unnecessary workload to flight crews**.
- To avoid RAs in level-off situations reduce vertical rates to **1500 ft/min or less at least 1000 feet before your cleared level**.