TCAS SAFETY BULLETIN

RTCA SC-147 was reactivated in April 2004 and charged with developing changes to the reversal logic as well as investigating opposite responses to some TCAS resolution advisories (RAs). As a result of this work, the committee agrees that operators of TCAS II equipment should ensure that their TCAS training programs provide the proper emphasis on assuring that flight crews properly respond to those initial RAs that require a reduction in vertical speed. SC-147 has prepared this bulletin to advise all operators equipped with TCAS II/ACAS II, that there have been events where the crew improperly responded to the RA announced as "Adjust Vertical Speed Adjust" (AVSA). This negative RA requires a reduction in vertical speed to either 2000, 1000, 500, or 0 feet per minute. The incorrect responses occur when the crew responds to the RA by **increasing** vertical speed, rather than **reducing** vertical speed. In other words, the crew responds in the opposite direction to the commanded RA.

Air France experienced several serious incidents of this type and aggressively investigated the causes and developed corrective actions. The incorrect responses at Air France were noted only in Airbus 320 type aircraft. However, other operators have observed opposite responses to these types of RAs when the RA guidance is displayed using limited analog vertical speed tapes and indicators in Primary Flight Displays (PFD). Air France initiated focused TCAS training for its crews, began discussions with Airbus to investigate PFD display issues, and developed a Digital Flight Data Recorder (DFDR) algorithm to specifically examine recorded data for other instances of this incorrect RA response. Lufthansa noted similar cases and began monitoring DFDR data using Air France's algorithm.

In response to these data Lufthansa also instituted crew-training programs and a new procedure of requiring crews to reduce their vertical speed to no greater than 1500 feet per minute in the last 1000 ft. of climb or descent. While the direct effects of the new procedure on reducing the number of opposite direction responses to the AVSA RA are difficult to determine, the procedure has had a dramatic effect on the total number of RAs experienced by its crews. Lufthansa has noted that crews that reduced the vertical speed approaching an assigned altitude experienced only 1/3 the number of RAs as those not using this procedure.

Even after the efforts previously discussed, both airlines continued to find instances of this incorrect RA response.

EXAMPLES OF TCAS AVSA RA ENCOUNTERS

These examples, excerpted from EUROCONTROL Safety Bulletins, show both correct and incorrect crew responses to the TCAS AVSA RA. Safety Bulletins published by EUROCONTROL on this and other subjects are recommended reading for the professional flight crew and can be found at:
http://www.eurocontrol.int/acas/acas@eurocontrol.int.

EXAMPLE 1
WRONG WAY RA RESPONSE TO AVSA RA

The following TCAS event illustrates how reaction incorrectly to the AVSA RA can greatly increase the risk of a mid-air collision occurring:

An A320 is level at FL270, heading South.

A second A320 is cleared to climb to FL260, heading North. Its rate of climb is about 3300 fpm. When passing through FL253, its TCAS triggers an **initial "Adjust Vertical Speed" RA** requiring a reduction in the rate of climb to 1000 fpm.

However, **the flight crew misinterprets the RA and reacts opposite to it:** the rate of climb is increased to more than 6000 fpm instead of being reduced. The closure rate increases between the two aircraft and the RA is strengthened to a "Descend" RA. The flight crew follows this second RA but the manoeuvre takes time to be effective.

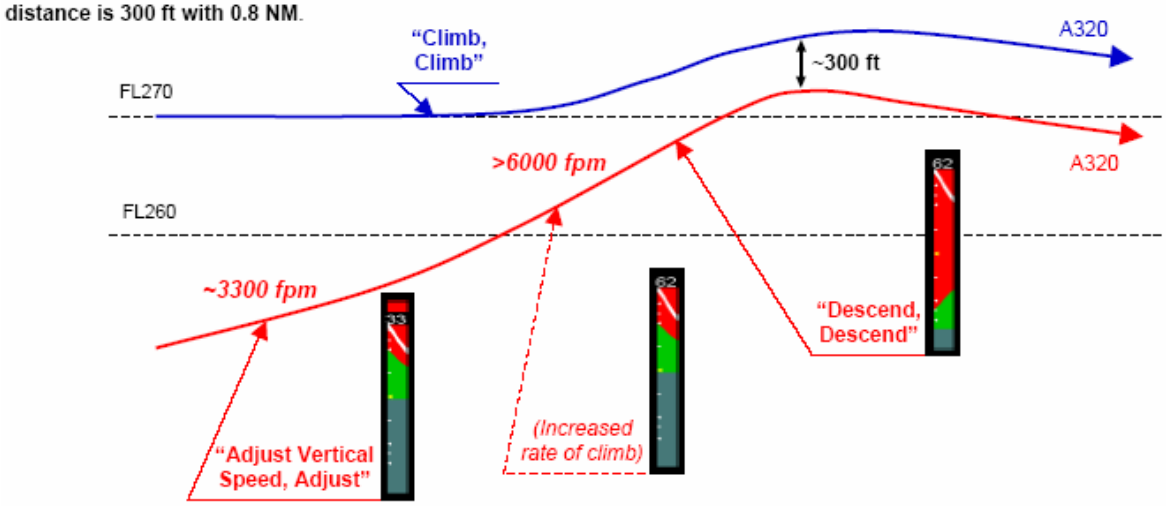
As a result of the wrong reaction to the "Adjust Vertical Speed" RA, the climbing A320 busts its flight level by 1200 ft and the level A320 receives a "Climb" RA, which the flight crew follows. **The vertical distance is 300 ft with 0.8 NM**.

If the flight crew had correctly reduced the rate of climb as required by TCAS, simulations show that not only would the climbing A320 have levelled off correctly, but that the level A320 would not have received an RA.

Investigation of this incident revealed that **two factors** combined to contribute to misinterpretation of the RA :

- the **RA display on the vertical speed tape** is small and could be difficult to interpret and to follow
- the **"Adjust Vertical Speed, Adjust" aural message** does not specify the sense of the required manoeuvre

Several occurrences have been identified by operational monitoring programmes.



EXAMPLE 2
CORRECT RESPONSE TO TCAS AVSA RA

The following is an example of a flight crew reacting correctly:

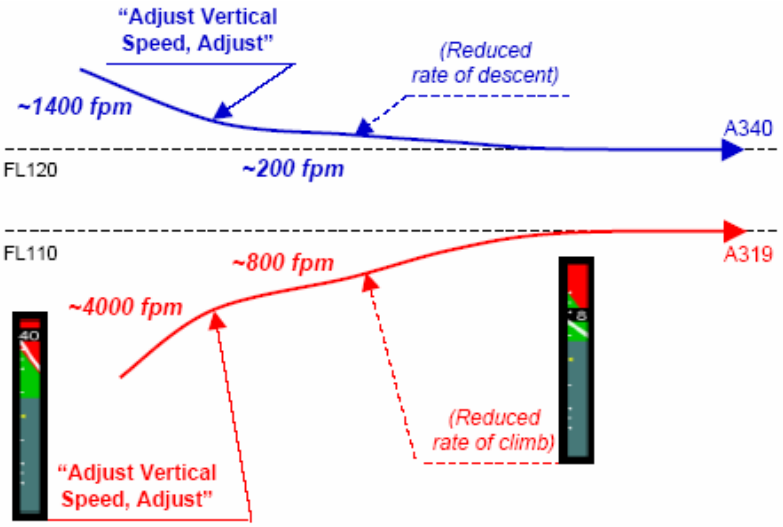
An A340 on approach is descending from FL140 to FL120 with a moderate vertical speed (about 1400 fpm).

An A319 is climbing on departure to FL110 with a high vertical speed (about 4000 fpm).

The aircraft are converging and will pass 0.1 NM apart but at cleared flight levels separated by 1000 ft.

The simultaneous horizontal and high rate of vertical convergence causes TCAS II to trigger "Adjust Vertical Speed" RAs before the aircraft have levelled off at their cleared flight levels:

- the A340 is required to reduce its rate of descent to 1000 fpm;
- the A319 is required to reduce its rate of climb to 2000 fpm.



The flight crews correctly follow these RAs, reducing their vertical speed below the maximum value required by TCAS II.

As a result, both aircraft continue to climb and descend with reduced vertical speeds. Then they level off at their cleared flight level; there is no disruption to ATC.

RESULTS OF REDUCING VERTICAL SPEED
WHEN CONFLICTING TRAFFIC IS PRESENT

The Aeronautical Information Manual, 4-4-9 (d) says "…Descend or climb at an optimum rate consistent with the operating characteristics of the aircraft to 1000 feet above or below the assigned altitude, and then attempt to descend or climb at a rate of between 500 and 1500 fpm until the assigned altitude is reached." Similar guidance is found in the FAA's AC120-55B, "Air Carrier Operational Approval and Use of TCAS II." Modern Flight Management Systems (FMS) designed for optimum efficiency do not comply with these guidelines. Many TCAS operational experts believe that as a minimum, crews should follow this procedure when they are aware of conflicting traffic either by advice from Air Traffic Control, information from the TCAS traffic display, or by having received a TCAS Traffic Advisory. The International Civil Aviation Organization (ICAO) has had discussions on this issue since 2000. As a result of these discussions, the 7th meeting of the Operations Panel, held in May 2006, agreed to recommend the following amendment to International Standards and Practices (PANS-OPS):

> *When the pilot is made aware of an aircraft at an adjacent altitude or flight level by an airborne traffic display, the pilot should consider using appropriate procedures to ensure that a rate of climb or descent of less than 8 m/sec (1500 ft/min) is achieved at least 300 m (1 000 ft) before the assigned level.*

An additional recommendation proposed by the Operations Panel requires operators to specify the procedures for complying with the procedure.

Some operators of modern highly automated aircraft have reservations about having crews interfere with the aircraft automation. TCAS monitoring programs show that reducing the vertical speed nearing level off altitude, especially when the crew is aware that there is another aircraft in close proximity at an adjacent altitude, greatly reduces the probability of an aircraft receiving any RA.

Limited surveys of airline crews show that most airlines do not teach this procedure. However many crews have adopted this technique and are comfortable employing it. Many unnecessary TCAS II advisories are generated when aircraft approach their cleared level-off altitude with a high vertical speed rate when another aircraft is in close proximity at an adjacent cruise altitude. A recent study has concluded that reducing vertical speed during the last 1000 feet of a climb or descent to 1500fpm or less may reduce RAs in European airspace by at least 22%, and the number of "nuisance" RAs by at least 43%. Data collected by Lufthansa demonstrates that crews who reduce their vertical speed when approaching an assigned altitude realize a 67% reduction in the number of RAs received when compared to those crews that do not reduce their vertical speed approaching an altitude.

In the encounter number 2 above, had both crews reduced their vertical speed approaching their assigned altitudes, neither aircraft would have received an RA.

RECOMMENDATIONS

1. All pilot training programs should address the proper response to AVSA RAs. This training should cover the following points:

- **When "Traffic Traffic" is announced and followed by the RA "Adjust Vertical Speed Adjust," follow AFM procedures and then**
- **Comply with the RA commanded Vertical Speed, which in ALL CASES will be a reduction in vertical speed to either 2000, 1000, 500, or 0 fpm.**

Pilots should also periodically review TCAS training material and operators should ensure that proper response to TCAS RAs is included during recurrent training. Additional training material in the form of a booklet, "Introduction to TCAS II Version 7," published by the FAA, can be found at http://www.arinc.com/tcas. Additional training material, in the form of EUROCONTROL ACAS II Safety Bulletins, is available at http://www.eurocontrol.int/acas/acas@eurocontrol.int.

2. Unless prohibited by the AFM, pilots are encouraged to reduce vertical speed nearing an assigned altitude in the following manner:

- **When climbing or descending, reduce Vertical Speed to between 500 and 1500 feet per minute in the last 1000 feet of climb or descent when aware of nearby traffic at an adjacent cruise altitude.** This will greatly reduce the probability of receiving an RA, and will have established the correct direction for a vertical speed correction if an AVSA RA is issued.
- **Operators are encouraged to incorporate this procedure into operating procedures and training programs.**