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Bizjets are amongst us

WELCOME

In this issue of ACAS II Bulletin we will look into events involving business jets. Their operations are often quite different from airline operations. Bizjets frequently operate outside controlled airspace which increases the risk of getting involved in an encounter with another aircraft, often general aviation or military. Also, they fly regularly to smaller airports, with limited or no ATC services. Consequently they can experience RAs at lower altitudes where alerts are generated with relatively short warning times, as illustrated by Events 1, 2, and 3.

High climb and descent performance of many business jets make them more susceptible to receiving RAs due to high vertical speeds in some cases (Event 4). Even when the vertical rates are reduced, as recommended by ICAO, RAs will be issued in some circumstances (Event 5).

Not all business aviation aircraft are TCAS equipped as, due to their weight or the number of passenger seats, they fall outside the equipage mandate. Even unequipped, aircraft will benefit from the collision avoidance protection offered by TCAS II, if they encounter an equipped aircraft (Event 6), provided they operate an altitude reporting transponder.

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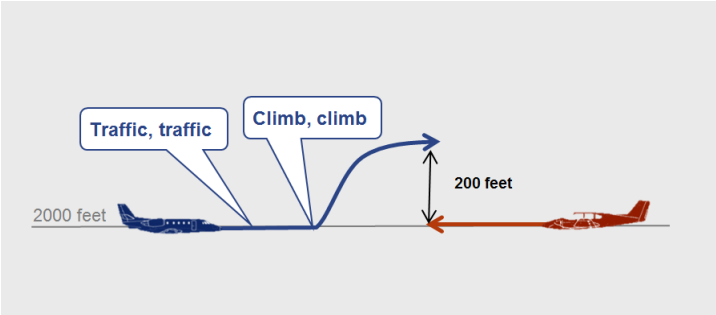
Event 1: TCAS saves the day

A TCAS II equipped Cessna Citation 560 is conducting a positioning flight outside controlled airspace, maintaining 2000 feet. A Piper Seminole is flying in the exact opposite direction, also maintaining 2000 feet. Neither pilot is aware of the other aircraft. When the aircraft are some 3 NM apart, head-on, with no predicted vertical separation, TCAS II on the Citation generates a TA (announced as "*Traffic, traffic*"). About 10 seconds later when the distance between the aircraft is just under 2 NM, the Citation gets a "*Climb, climb*" RA. The crew responds to the RA by climbing, as required, 1500 ft/min. When the Citation passes above the Seminole the vertical spacing between the aircraft is 200 feet.



Conclusions: The Cessna Citation crew's prompt response to the RA likely prevented a collision. At lower altitudes, to prevent nuisance alerts, TCAS nominally generates TAs and RAs with less warning time compared to alerts at higher altitudes. Between 1000 and 2350 feet AGL, the nominal warning time is 25 and 15 seconds for TAs and RAs respectively. Therefore, with this short alerting time it is particularly important that RAs are flown promptly and accurately.

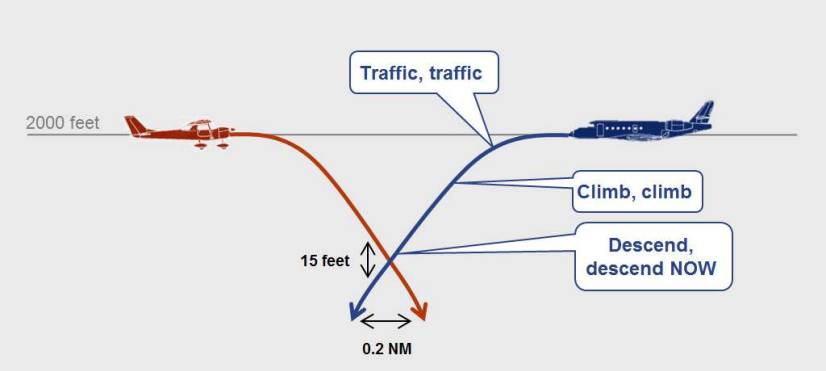
Learning points:

- TCAS provided resolution advice which prevented a possible mid-air collision.
- RAs mitigate a risk of mid-air collision when followed promptly and correctly.

Event 2: RA not followed

A British Aerospace 125 business jet is approaching its destination (located outside controlled airspace), maintaining 2000 feet on the extended runway centreline and getting ready to descend on visual approach. A Cessna 152 on a VFR flight on a perpendicular track is also maintaining 2000 feet. Neither pilot is aware of the other aircraft.

When the Cessna is approaching the extended runway centreline, it makes a turn away from the airport. That puts both aircraft on a head-on track at the same altitude.



Soon after the BAe125 starts its descent for landing. Almost simultaneously, the Cessna also starts to descend. When both are passing 1900 feet, the BAe125 gets a TA against the Cessna. Some 10 seconds later, when both are descending through 1700 feet, the BAe125 gets a "*Climb, climb*" RA. The BAe125 crew does not respond to the RA continuing the descent as they have the Cessna in sight. After 13 seconds, as the aircraft continue to descend head-on, the RA reverses to "*Descend, descend NOW*". Soon after, they pass each other with a horizontal spacing of 0.2 NM and vertical of 15 feet.

Had the initial RA been followed, the vertical miss distance between the aircraft would have increased to over 250 feet.

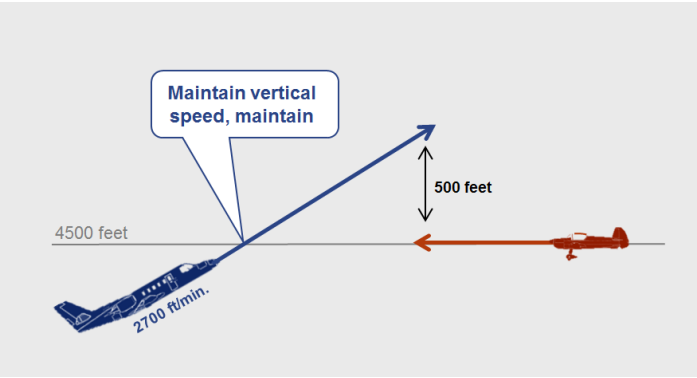
Conclusions: The RA was not followed and that led to the reduction of the vertical miss distance between the aircraft compared to what following the RA would have achieved. Collision avoidance on visual acquisition and manoeuvres contrary to the RA may not always ensure achieving safe miss distances.

Learning points:

- All RAs must be followed, even if the suspected intruder is in sight.
- Visual assessment of traffic can be misleading.

Event 3: Maintain Vertical Speed RA

A small aerobatic trainer aircraft is conducting a training exercise between 5000 and 7000 feet above the airport in Class D airspace.



A few minutes later a TCAS II equipped Cessna Citation 550 is cleared for take-off and instructed to climb to 11,000 feet. Less than a minute later, the aerobatic trainer crew reports that they have completed their exercises and are in the descent for landing, proceeding away from the field before turning to the downwind leg. Now the trajectories of both aircraft are crossing. The tower controller does not issue traffic information to either of the crews.

The climbing Citation receives a TA against the aerobatic trainer and when the Citation is passing through 4500 feet it receives a "*Maintain vertical speed, maintain*" RA. The Citation is climbing at 2700 ft/min. and the pilot follows the RA maintaining the vertical speed. When the Citation is above the aerobatic trainer, the RA is terminated and a "*Clear of Conflict*" annunciation is made.

Conclusions: The Citation crew correctly responded to the RA. When the trajectories crossed the Citation was 500 feet higher than the aerobatic trainer.

Learning points:

- Maintain Vertical Speed (or Crossing Maintain Vertical Speed, when intruder's altitude will be crossed) are only issued when the aircraft is already climbing or descending (in the correct vertical sense) at more than 1500 ft/min.
- The vertical rate required by the RA will be shown on the TCAS instruments.

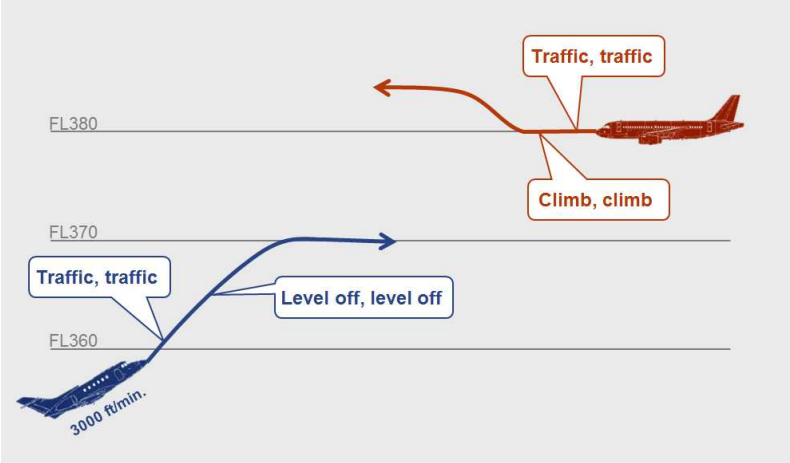
High vertical rates. *The performance of many business jets allows them to climb and descend with high vertical rates. While this provides benefits like fuel or time savings, it can create problems when aircraft continue to climb/descend with a high vertical rate close to their cleared level.*

TCAS will issue an RA when it calculates a risk of collision based on the closing speed and vertical rates. That may happen even if 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.

Event 4: High vertical rate while approaching the cleared level

A British Aerospace 125 is climbing to FL370. Its requested level is FL390 but ATC has restricted it to FL370 due to an Airbus 319 flying in the opposite direction and maintaining FL380.

The BAe125 climbs at the rate of 3000 ft/min. When it is passing FL361 it receives a TA against the A319. Simultaneously, a TA is issued in the A319. When six seconds later the BAe125 is passing FL365 it gets a "*Level off, level off*" RA. The BAe125 crew slowly starts to reduce the vertical rate but given the closure speed, three seconds later TCAS on the A319 issues a "*Climb, climb*" RA. At this time the aircraft are separated 1400 feet vertically and 3.8 NM horizontally.



The A319 crew responds to the "*Climb, climb*" RA promptly and establishes the required 1500 ft/min. climb rate. In the meantime, the BAe125 levels off at FL370 and the A319 passes above. When the A319 reaches FL384, both RAs terminate and both aircraft return to their cleared levels.

Conclusions: The BAe125 crew approached their cleared level with too high a vertical rate and were slow in reducing their rate in response to the "*Level off, level off*" RA. The resulting RA on the A319 caused this aircraft to depart from its cleared level. That in turn could have caused an encounter with another aircraft. Furthermore, any unexpected departures from ATC clearances are disruptive to air traffic controllers and a source of additional workload for everybody involved.

Learning points:

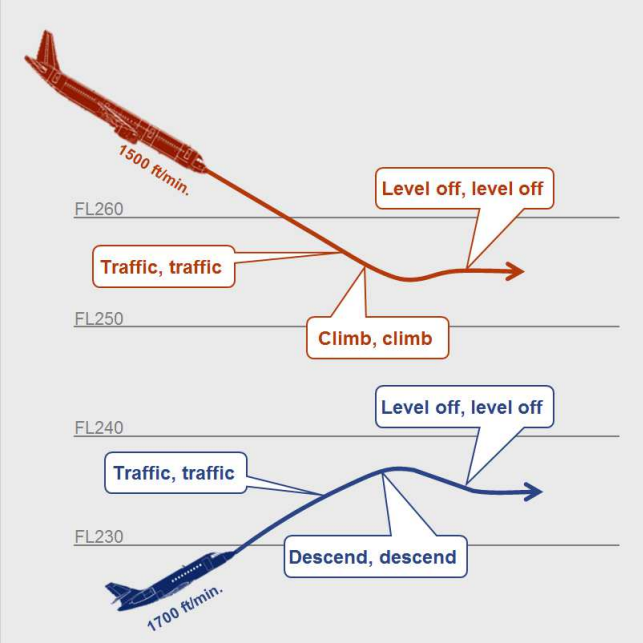
- As per ICAO recommendation, the vertical rate should be reduced to 1500 ft/min or less in the last 1000 feet before level-off, especially when the pilot is aware of another aircraft at an adjacent flight level. Local or company regulations may impose different restrictions.
- Respond to a "*Level off, level off*" RA by promptly reducing the vertical rate to 0 ft/min. (i.e. achieve a level off).

Event 5: Combined vertical rates

A Dassault Falcon 2000 is climbing to FL240 at a rate of 1700 ft/min. while an Airbus 321 on the perpendicular track is descending to FL250 at the rate of 1500 ft/min. The Falcon is expected to pass 3.5 NM behind the A321 and the predicted minimum horizontal distance is 1.7 NM.

When they are 9.8 NM apart, with the Falcon passing through FL234 and the A321 passing through FL255, both aircraft get a TA. Both aircraft reduce their vertical rate while they approach their respective cleared levels. When they are 7.1 NM apart, the Falcon is passing through FL237 and gets a "*Descend, descend*" RA. Simultaneously, the A321 is passing FL252 and gets a "*Climb, climb*" RA.

Both crews respond to their RAs promptly and soon after the Falcon starts to descend and the A321 starts to climb, the RAs weaken to "*Level off, level off*" on both aircraft. The Falcon levels off at FL235 and the A321 at FL252. After 26 seconds when they are 1.9 NM apart both get "*Clear of conflict*" annunciations and return to their cleared levels.



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Conclusions: If two aircraft are simultaneously approaching adjacent levels and the horizontal miss distance is relatively small, the combined vertical rates make RAs more likely, even if the vertical rates are not excessive. Pilots and controllers often judge these RAs as operationally not required and refer to them as "nuisance" RAs. While this sentiment if fully understood, it needs to be noted that in real time the pilots cannot (and should not) assess whether the RA is in fact operationally required. Once an RA has been issued it must be followed without delay, as illustrated in the example above.

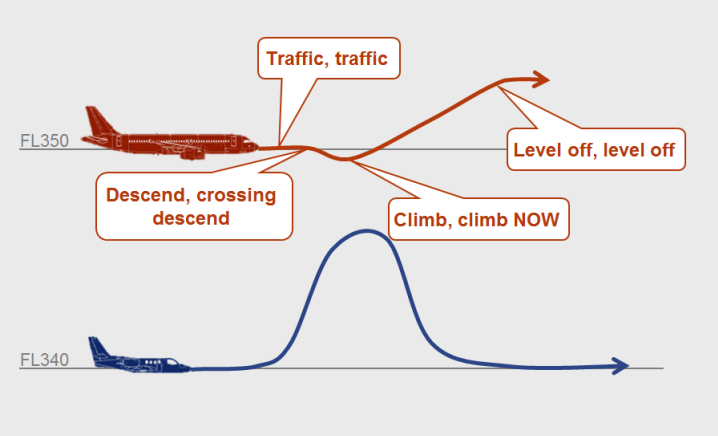
Learning point:

- All RAs must be followed even though they may appear being operationally unnecessary.

Event 6: Level bust by bizjet not equipped with TCAS

An Airbus 320 is maintaining FL350 proceeding southeast; while a Cessna Citation I heading southwest is level at FL340. The A320 is TCAS II equipped and the Citation is not equipped nor required to be equipped (due to its maximum take-off weight).

When the aircraft are some 7 NM apart, the Citation unexpectedly encounters problems with maintaining its cleared level and starts climbing towards the A320 at a rate of approximately 1000 ft/min. When the Citation is passing FL345, the A320 gets a TA against it which is followed 5 seconds later by a "*Descend, Crossing Descend*" RA. A Crossing Descend RA is issued, rather than a Climb RA, because given the current vertical rate of the Cessna TCAS assesses that the target vertical separation value will not be achieved otherwise.



The A320 crew starts to respond to the Crossing Descend RA. Simultaneously, the controller instructs the Citation to maintain the assigned level (i.e. FL340). A few seconds later, after climbing as high as FL346 the Citation starts to descend back to its cleared level. TCAS II on the A320 continuously assesses the geometry of the conflict and, four seconds after the initial RA, it determines that a vertical sense reversal should be issued (announced as "*Climb, climb NOW*"). The A320 crew stops the descent and starts to climb, at the same time reporting the RA to the controller.

The Citation descends back to FL340 and the RA on the A320 weakens to "*Level off, level off*". As the Citation passes 1.5 NM behind the A320 a "*Clear of conflict*" message is announced. At the Closest Point of Approach the spacing between the aircraft was 0.76 NM horizontally and approximately 1400 feet vertically.

Conclusion: The Citation, although not equipped with TCAS, benefited from the collision avoidance offered by TCAS II as the crew A320 responded promptly and correctly to the RAs.

Learning points:

- TCAS II provides collision avoidance protection also when an aircraft not equipped with TCAS causes a separation violation.
- An RA can be generated against all aircraft equipped with an altitude reporting transponder (Mode S or Mode A/C). The intruder does not need to be fitted with ACAS II.

Key learning points this issue:

- **All RAs must be followed. The traffic in visual contact may not be the threat that triggers the RA.**
- **TCAS II will generate RAs in 1000-foot level-off encounters if aircraft approach their cleared levels with high vertical rates or due to combined vertical rates.**
- **To reduce the chance of unwanted RAs, reduce the vertical rate to 1500 ft/min. or less in the last 1000 feet before level-off. Particularly, if another aircraft is at an adjacent flight level.**
- **TCAS II will issue RAs against all threat aircraft with altitude reporting transponders.**

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