ACAS II bulletin No 4
EUROCONTROL

TCAS II and VFR traffic

Editorial

The drive for TCAS II development in the US was from mid-air collisions involving light aircraft - between a B727 and a Cessna 172 at San Diego in 1978, and between a DC9 and a Piper at Cerritos, California, in 1986. In Europe, extensive safety analyses showed that TCAS II systems would provide significant safety benefit in all the airspace. Resulting mandates mean that most airliners and many business jets are now equipped with TCAS II.

Operationally TCAS has proven to be very effective, and this includes encounters with VFR traffic squawking altitude. However, pilots and controllers often question the value of TCAS where IFR and VFR traffic is mixed:

- Does TCAS only cause problems between IFR and VFR traffic or does it give good protection?

- Does VFR traffic require a transponder for some TCAS protection?

- Although IFR and VFR traffic are "correctly separated by 500 ft", TCAS triggers alerts. Are these false alerts, or are they normal?

- Does TCAS still work when aircraft are flying in the aerodrome traffic pattern?

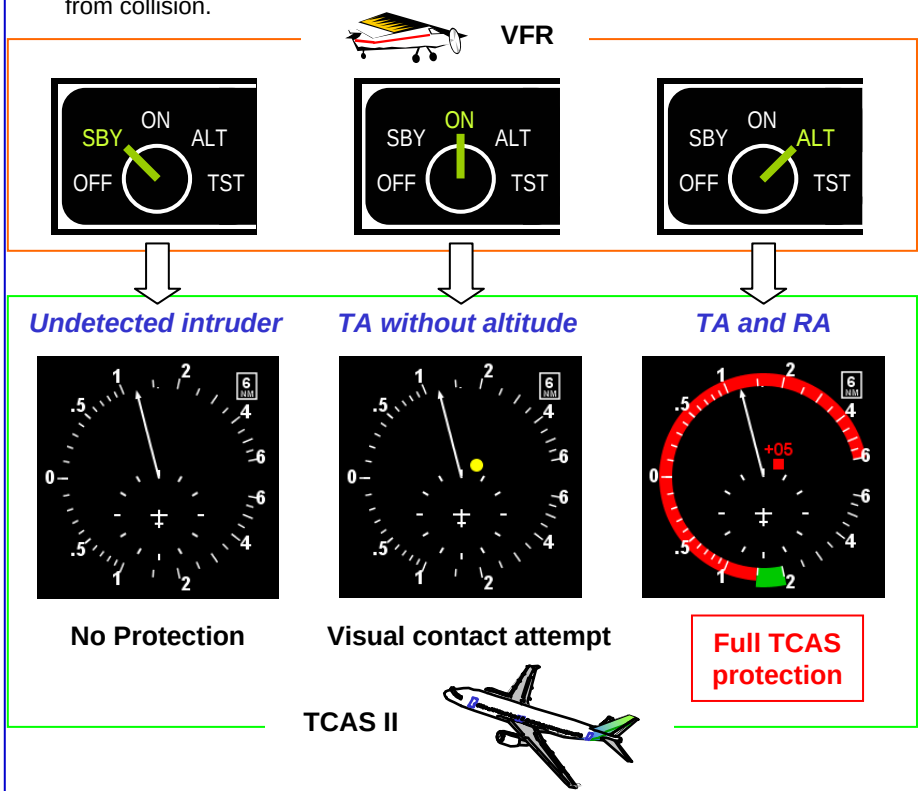
The objective of this Bulletin is to provide answers to these sorts of questions.

John Law
ACAS Programme Manager,
EUROCONTROL *May 2004*

VFR traffic transponder mode and TCAS II alerts

The alerts triggered by TCAS II depend on the transponder mode of the intruder.

- "**OFF**" or "**STAND-BY**": TCAS II cannot detect the intruder and therefore there is no alert at all.
- "**ON**", i.e. without altitude reporting: TCAS II will only generate a Traffic Advisory (TA) to help the pilot achieve visual contact. However, the TA is unable to show whether the aircraft are at the same altitude or not!
- "**ALT**": TCAS II can trigger TAs and Resolution Advisories (RAs). An RA, if followed, protects the VFR traffic as well as the traffic equipped with TCAS II from collision.



For maximum safety benefit from TCAS II, VFR traffic must squawk altitude

Collision between an Airbus A320 and a glider (France, 12 February 1999)

An A320 was descending through Class G airspace to FL80 on approach to Montpellier. The ATIS reported gliding activity in this area.

Despite keeping a good look out, a G103 glider at FL86 was seen just ahead, at a very late stage. The A320 took vigorous avoiding action. Within 2 seconds the aircraft achieved 36° bank, but the leading edge of the left wing hit the glider's tail. The G103 pilot had not seen the A320. Fortunately, both aircraft landed safely at their destination airport.

This collision occurred before the European ACAS II mandate and the A320 was not yet TCAS II equipped. The results of the investigation underlined the need for widespread equipage of TCAS II on passenger aircraft and recommended mandatory use of altitude reporting transponder for all aircraft including VFR.

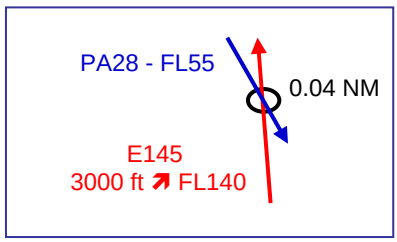
If the glider had had an altitude reporting transponder and if the A320 had been equipped with TCAS II, it is likely that the collision would have been avoided.

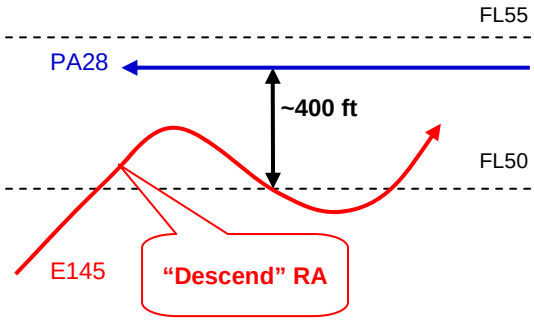
Event 1: TCAS resolution between IFR and VFR traffic in Class D

A PA28 flying VFR is transiting a TMA, in Class D airspace. It is level at FL55 (mode C reports show FL54).

An E145 is climbing on departure, on a reciprocal heading, passing 3000 ft.

The E145 is cleared to climb to FL140 by the Approach controller and "to expedite through 5500 ft due to VFR traffic at 12 o'clock, 10 NM, opposite route".





The controller also provides traffic information to the PA28 about the E145, "12 o'clock, opposite route, passing your altitude". Then, he provides further traffic information to the E145 (traffic at 12 o'clock 4 NM). About 15 seconds later, the E145 receives a **"Descend" RA**, when passing FL51. The pilot follows the RA correctly and initiates a descent.

4 seconds before passing the E145, the PA28 pilot reports visual contact.

As a result of following the "Descend" RA, the E145 passed about 400 ft below the PA28. Simulations indicate that **without TCAS the separation between the aircraft would have only been about 100 ft and 0.04 NM**.

The E145 pilot, **who never saw the VFR traffic**, filed an Airprox report because IFR separation was not provided against the VFR PA28. The controller remarked that he had provided the appropriate and correct traffic information. The controller reported that the Airprox was unjustified because the PA28 had visually acquired the E145 and reported that it had passed clear.

Although the approved procedures appeared to have been applied, it is clear that TCAS II helped to solve a real risk of collision.

Extract from ICAO Annex 11 – ATS airspace classes

Airspace Class	Service provided between IFR and VFR	Radio communication for VFR
A	No VFR permitted	
B	Separation	Required
C	Separation	Required
D	Traffic information (and traffic avoidance advice on request)	Required
E	Traffic information as far as possible	Not required
F	Flight information service	Not required
G	Flight information service	Not required

Event 2: VFR traffic penetrating Class A

In Class A airspace, a B737 is descending on the glide path for the final approach.

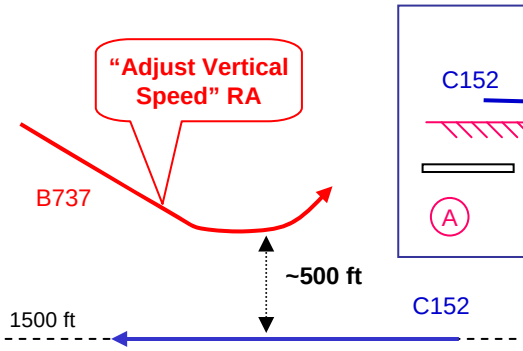
Due to a navigation error, a C152, flying VFR and level at 1500 ft QNH, is crossing the ILS axis at 4 NM from the runway threshold instead of at about 10 NM. The C152 has **an active altitude reporting transponder**.

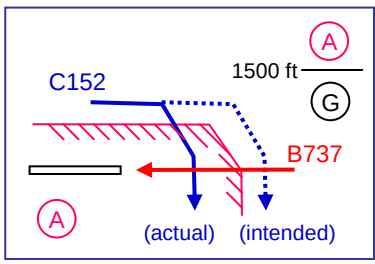
The controller, who is not in radio contact with the C152, provides traffic information to the B737 pilot.

The B737 pilot gets visual contact on the VFR traffic and continues the approach. As it passes through 2000 ft, the B737 receives an "Adjust Vertical Speed" RA.

In response to the RA, the pilot stops the descent and then initiates a go-around. The vertical distance between the aircraft is about 500 ft.

Simulations show that if the B737 had continued the descent, **the separation would have been less than 300 ft and 0.08 NM**.





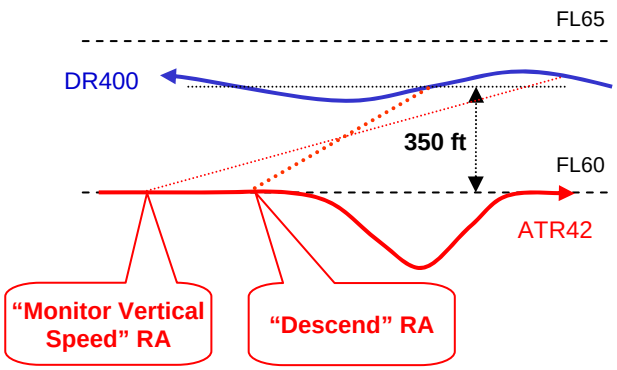
To improve flight safety, VFR traffic should operate an altitude reporting transponder in all airspace classes, including Class G.

Event 3: IFR and VFR traffic crossing at 500 ft

In Class D airspace, an ATR42 is held at FL60 after departure, heading east, against a VFR DR400, on a reciprocal track, supposedly "level" at FL65.

The DR400 is not maintaining level flight and its altitude is actually **oscillating** between FL63 and FL64.

Shortly after levelling off, the ATR42 receives a **"Monitor Vertical Speed" RA** to prevent further climb when the DR400 is 2.20 NM ahead and 400 ft above.



Subsequently, the RA is strengthened into a **"Descend" RA** when the vertical separation between the aircraft becomes less than 350 ft. The pilot follows the RA and descends to FL57 before climbing back to FL60.

TCAS ensured that there was no risk of collision resulting from poor altitude keeping of the DR400.

Separation of IFR traffic from VFR traffic

IFR traffic is separated from VFR traffic by ATC in Class B and C airspaces only *(VFR is not permitted in Class A).*

In the other classes of airspace, "own separation" between IFR and VFR traffic is the responsibility of the pilots concerned and is usually based upon visual acquisition (Note: ICAO Annex 2 states that an aircraft shall not be operated in such proximity to other aircraft as to create a collision hazard).

A 500 ft vertical offset applied by VFR traffic from IFR flight levels does not, in itself, ensure separation from either IFR traffic or other VFR traffic. It should be considered as a basic strategic organisation aimed at reducing the risk of collision.

The application of this offset does not absolve pilots from maintaining a good look out at all times as the flight path of other aircraft can be unpredictable (climbing, descending or manoeuvring aircraft).

Operational feedback from a major European airline

Over a period of approximately 2 years of TCAS II operational monitoring, 8.3% of the RAs reported by pilots of a major European airline were generated against VFR traffic (about 1 per week).

85% of these RAs, which occurred in both Europe and the United States, were considered necessary and useful by the pilots.

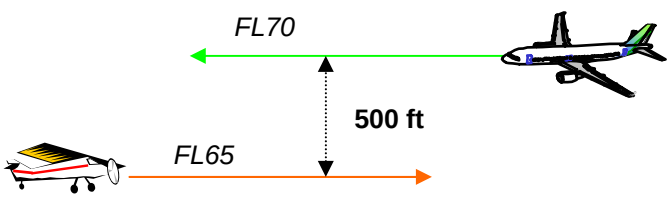
Type of RAs between IFR and VFR traffic "separated" by 500 ft

In the normal operating altitudes of VFR traffic, RAs will be caused if VFR traffic operates in the close proximity to IFR traffic with 500 ft separation.

Depending upon the TCAS II altitude thresholds and the current vertical separation between the IFR and VFR traffic, different types of RAs can be generated as shown below.

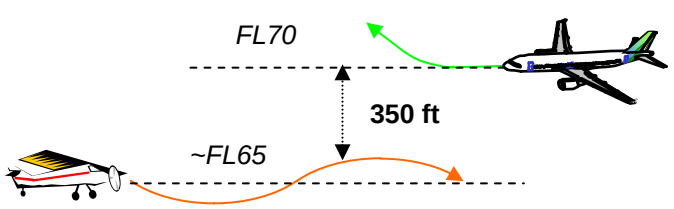
"Monitor Vertical Speed"

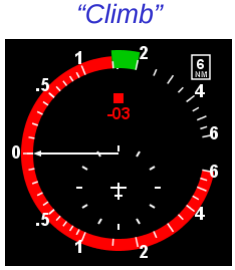
In both Class D and Class E airspaces, a frequent encounter between IFR and VFR traffic is when **both aircraft are level and "separated" by 500 ft**. In these encounters, TCAS will generate a "Monitor Vertical Speed" RA, which does not require a vertical deviation.



"Climb"

Operational experience shows that **VFR traffic sometimes do not maintain level flight perfectly**. If there is a significant vertical deviation, Climb" or "Descend" RAs will be generated on-board the TCAS-equipped aircraft.





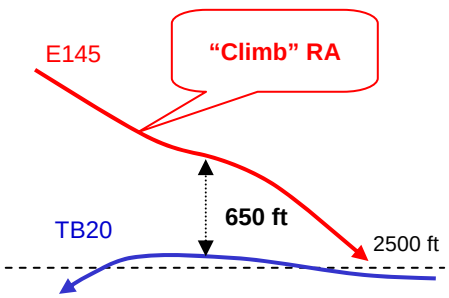
Event 4: VFR in the aerodrome traffic pattern

An E145, on approach in Class D airspace, is cleared to descend to 2800 ft QNH and to intercept the glide path.

A TB20, flying VFR and in radio contact with another controller, is crossing the runway centreline cleared at 2000 ft QNH. However, the pilot has entered the wrong altimeter setting and is actually at 2500 ft QNH.

The controller instructs the E145 to stop its descent at 3500 ft and provides a traffic information about the VFR. Because the pilot reports visual contact on the VFR, he is cleared to continue the descent on the glide path. However, the E145 then receives a "Climb" RA triggered by the TB20, which is crossing directly underneath his track.

The E145 pilot responds slowly to the RA, reducing the rate of descent. Although not achieving a rate of climb, he passes the VFR traffic at 650 ft and no more than 0.2 NM.



In this event, the high risk of collision resulting from an undetected altimeter setting error was resolved by TCAS, even though the pilot of the E145 did not achieve the vertical speed required by the RA.

The TCAS II safety net is effective both on approach and at low altitude.

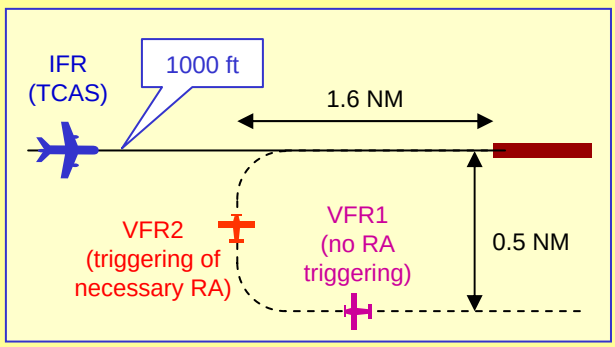
TCAS and aerodrome traffic pattern

Feedback from controllers and pilots shows a perception that RAs generated in the aerodrome traffic pattern are unnecessary and sometimes disruptive.

***However**, the TCAS alert time in this environment is only 15 seconds before a possible collision, the aircraft are in very close proximity (less than 1 NM) and the time for an effective avoiding manoeuvre is very short.*

In the example shown in the diagram below, provided that the lateral distance between the final approach path and the downwind leg is at least 0.5 NM, the VFR traffic on the downwind leg (VFR1) will not trigger an RA on board the TCAS-equipped IFR traffic on the final approach. (In addition, TCAS does not generate any RA below 1000 ft.)

If the IFR on the final approach receives an RA, this confirms that the separation with the VFR traffic on the base leg (VFR2) is inadequate.



Conclusion

ACAS monitoring programmes have highlighted a significant number of TCAS events involving TCAS-equipped IFR traffic encountering VFR traffic. In these events, **the day was saved because the RAs were followed**!

Where IFR and VFR traffic are not separated by ATC, e.g. in Class D and Class E airspace, and where VFR traffic operates in close proximity to the IFR traffic (often at vertical separation of 500 ft or less) there is a high probability that RAs will be generated. Monitoring has confirmed that these RAs significantly enhance safety.

RAs generated in the aerodrome environment **should not** be dismissed as unnecessary and disruptive. They demonstrate that a risk of collision exists.

Pilots must maintain a good look out, not relying on TCAS to prevent an unsafe situation from developing. **TCAS provides last resort collision avoidance**, not normal separation standards.

To trigger RAs, **TCAS needs intruders to squawk altitude**. VFR traffic should be strongly encouraged to operate an altitude reporting transponder in all classes of airspace.

TCAS II provides safety benefits to both IFR and VFR traffic

Contact: **John Law**
EUROCONTROL
ACAS Programme Manager
96, rue de la Fusée
B-1130 Brussels

This is one of a series of ACAS Bulletins planned to address specific TCAS operational issues. For more detailed information on ACAS and TCAS, please refer to the ACAS II brochure and training material available on the ACAS Programme website

Tel: +32 2 729 37 66
Fax: +32 2 729 37 19
http://www.eurocontrol.int/acas/
acas@eurocontrol.int