



# ACAS II Bulletin

June 2016 | N°20

## Low level events

### WELCOME

This issue of ACAS II Bulletin is dedicated to operations at low altitudes.

In proximity to the ground, TCAS II operates somewhat differently; for instance radio (radar) altimeter is used as an additional source of altitude information and some alerts are inhibited. As it is important that TCAS II limitations at low altitudes are understood, we will cover the key points in the opening article and illustrate some of them with six operational events.

The first four events serve as a reminder that below the alert inhibition altitudes, and also against non-altitude reporting aircraft, the pilot will not benefit from the full collision avoidance protection normally offered by TCAS II. That includes small drones (Remotely Piloted Aircraft Systems) which normally are not transponder equipped.

In the next two events at low altitude, TCAS II provided the pilot with collision resolution advice. In one event the pilot responded to the RA, which resulted in an increased vertical separation from co-altitude to 500 feet. However, in the other event the pilot did not respond to the RA and the spacing between the aircraft dropped to 0.7 NM and 75 feet.

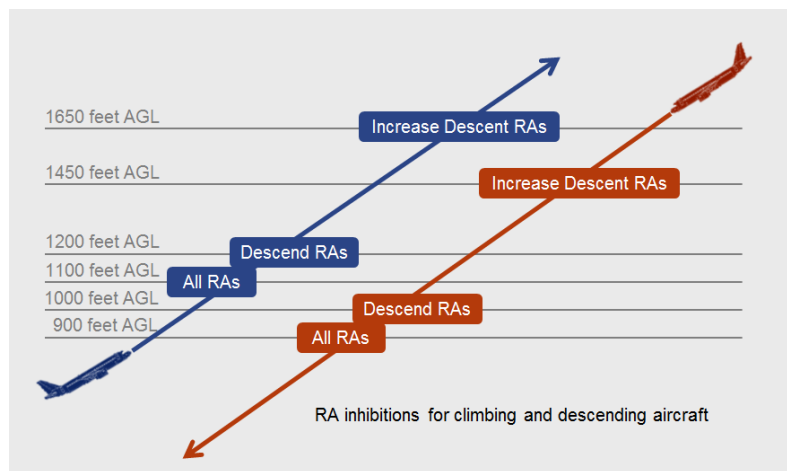
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### Principles of TCAS Operations at Low Altitudes

**RA Inhibitions:** To prevent collisions with terrain, Resolution Advisories (RAs) are inhibited based on radio (radar) altimeter reported heights AGL (Above Ground Level) as follows:

- Increase Descent RA: 1550 feet ( $\pm 100$  feet) AGL
- Descend RA: 1100 feet ( $\pm 100$  feet) AGL
- All RAs: 1000 feet ( $\pm 100$  feet) AGL.

Hysteresis values of  $\pm 100$  feet ensure that the inhibition state does not oscillate rapidly should the aircraft be flying over hilly terrain.



**Aural annunciations inhibition:** All TCAS aural annunciations are inhibited below 500 feet ( $\pm 100$  feet) AGL.

Moreover, when a GPWS (Ground Proximity Warning System), TAWS (Terrain Avoidance Warning System) or wind shear detection warning have been activated, TCAS will automatically be placed into TA-only mode and Traffic Advisory (TA) aural annunciation is suppressed. TCAS will remain in TA-only mode for 10 seconds after the GPWS/TAWS or wind shear warning is removed. During this 10 second suppression period, the TA aural annunciation is not suppressed.

**Radio altimeter:** Aircraft's radio altimeter provides inputs to TCAS to inhibit RAs when the aircraft is in proximity to the ground. If there is no valid radar altimeter input, TCAS will continue to function but it will set the ground level as  $-100,000$  feet. Consequently, none of the low-altitude inhibitions will be activated.

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**Timing of alerts:** The time thresholds for generation of alerts are shorter at lower altitudes. For instance, between 1000 and 2350 feet AGL, the nominal times for generation of TAs and RAs are, 25 and 15 seconds, respectively, while the same times between 2350 feet AGL and FL 50 are 30 and 20 seconds.

**Alerts against non-altitude reporting aircraft:** TCAS II only tracks Mode S and Mode A/C altitude reporting aircraft. Aircraft equipped with only Mode A transponders are neither tracked nor detected by TCAS II because TCAS II does not use Mode A interrogations.

If the intruding aircraft is equipped with a Mode A/C transponder but does not provide altitude information (Mode C), this aircraft will be tracked as a non-altitude reporting target using range and bearing information. It will be shown on the TCAS traffic display when own aircraft is below FL155. Neither a data tag nor a trend arrow will be shown with the traffic symbol for an aircraft that is not reporting altitude. TAs will be generated against non-altitude reporting aircraft when the range test for TA generation is satisfied. Non-altitude reporting aircraft are deemed to be at the same altitude as own aircraft (i.e. the worst case scenario).

## Event 1: No RA at low altitude

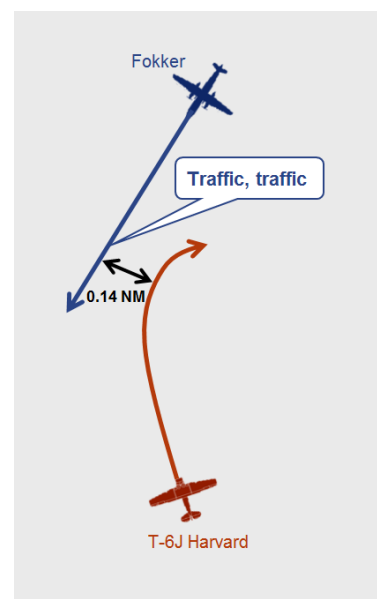
A light vintage aircraft (T-6J Harvard) is on a VFR flight and receives a clearance to cross the control zone of an airfield at 1200 feet. At the same time, a Fokker F27 is approaching the same airfield from the north-east side and is cleared for straight-in approach runway 21. The light aircraft is instructed to report one minute before crossing overhead the airfield.

When the light aircraft pilot calls the tower to notify that the crossing is imminent, the controller instructs him to remain well east of the airfield and clear of final runway 21 because of the Fokker on final approach.

The pilot acknowledges the instruction and informs the tower controller that he is making a right-hand turn. The approach controller who is watching the developing situation on the radar screen anticipates that both tracks will cross and tells the tower controller about it. The tower controller instructs the light aircraft pilot to turn east immediately. The pilot confirms that he is already turning right. The tower controller mistakenly believes that the light aircraft is a helicopter and anticipates that it will make much tighter turns.

In the meantime the crew of the Fokker is transferred to the tower frequency and can hear the conversation between the tower controller and the pilot of the light aircraft. The Fokker continues its ILS approach and they receive traffic information. When the Fokker is passing through 1350 feet (approximately 875 feet AGL) a TA is generated.

At the Closest Point of Approach the distance between the two aircraft was 0.14 NM at almost the same altitude. The generation criteria for an RA were met but since the Fokker has descended below 900 feet AGL, the RA was inhibited. Neither of the pilots saw the other aircraft.



### Learning points:

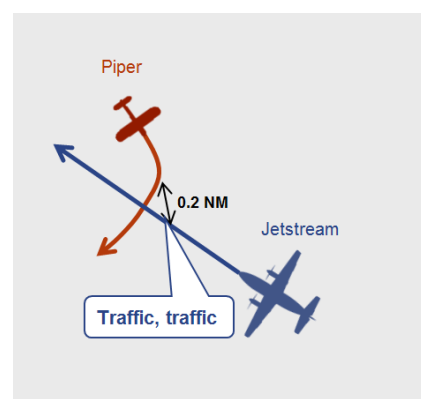
- All RAs are inhibited below 900 feet AGL.
- TAs are inhibited below 500 feet AGL.

## Event 2: Non-altitude reporting aircraft

A Piper PA-28 pilot prepares his aircraft, which is not TCAS II equipped, for VFR flight in the vicinity of the airfield (located virtually at sea-level). His aircraft is equipped with a Mode A/C transponder. The pilot sets an SSR code at the transponder, but does not switch it to "Alt position" (Mode C). Consequently, the transponder does not transmit any altitude reports. The Piper pilot departs and after a while he climbs to 2700 feet without a clearance, which brings him into controlled airspace. At the same time a TCAS II equipped Jetstream J32 is approaching the airfield and is cleared to 1700 feet.

When both aircraft are about to cross and the Jetstream passes 2800 feet descending, its TCAS generates a TA ("Traffic, traffic") against the Piper. The Jetstream pilots, based on the information on the TCAS traffic display, get visual contact with the threat. Assessing the traffic proximity, the Jetstream pilots stop the descent and climb to 3200 feet. The aircraft pass with a vertical spacing of 400 feet and horizontal spacing of 0.2 NM. The Piper pilot could see the Jetstream only after the aircraft had passed each other.

Although the aircraft got very close, TCAS II did not generate an RA as the Piper pilot had not switched the transponder to Mode C.



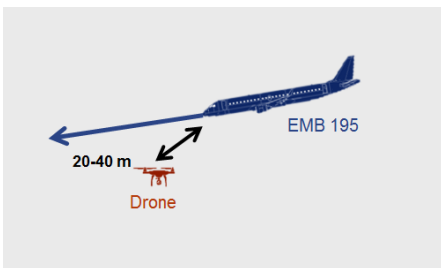
**Learning points:**

- If equipped, all aircraft shall operate altitude reporting transponders at all times. Without altitude reports TCAS, as well as ATC safety nets, will not provide appropriate alerts.
- An intruder whose transponder is not providing altitude information may cause TAs to be generated on other aircraft; however, neither data tag nor a trend arrow will be displayed. Both aircraft are deemed to be at the same altitude.

### Event 3: Encounter with a drone

An Embraer 195 is conducting an ILS approach to its destination. While descending through 2500 feet (approximately 2150 feet AGL) the crew observes a drone (quadcopter) passing at 20-40 metres from their aircraft.

The drone has not been shown on the TCAS traffic display and no TCAS alert has been generated. Generally, small drones (or Remoted Piloted Aircraft Systems) are not transponder equipped and, therefore, will not be detected by TCAS or visible to ATC on secondary radars. Moreover, due to their small size, they will remain undetected by ATC primary radars.



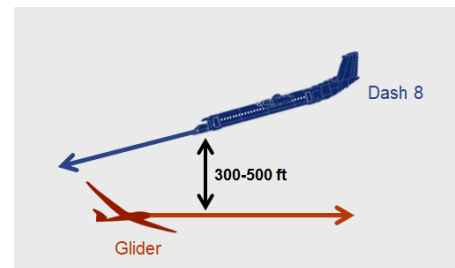
**Learning point:**

TCAS will only detect intruders that are equipped and operating an altitude reporting transponder.

### Event 4: Encounter with a glider

A Dash 8 is descending towards its destination heading south. At 3000 feet (approximately 2900 feet AGL) as they turn onto a westerly heading to intercept the ILS localizer, a glider passes 300-500 feet underneath them heading north.

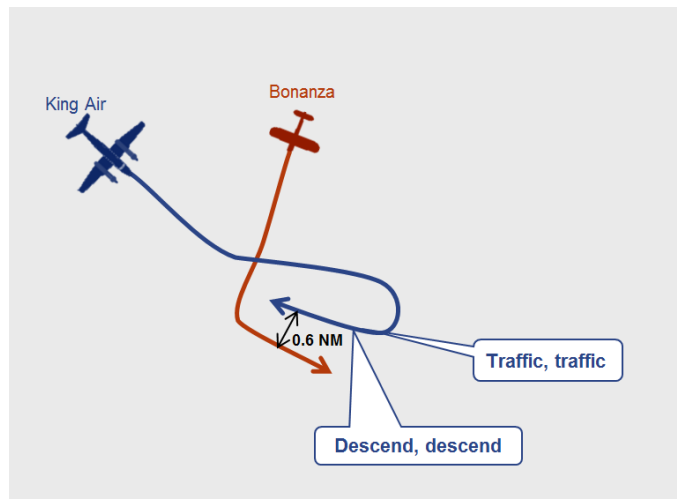
As the glider was not transponder equipped, it has not been shown on the TCAS traffic display and no TCAS alert has been generated against it.



### Event 5: RA followed

A Beechcraft Bonanza, which is not TCAS equipped, is on an instrument rating check flight while a Beechcraft King Air, which is TCAS II equipped, is conducting an instrument training flight in the vicinity of the same airfield (located virtually at sea-level). Mistakenly, ATC clears both aircraft to 1700 feet. Initially, the aircraft are separated horizontally and although their tracks initially cross there is sufficient spacing. Eventually, following their planned turns, they fly on opposite headings with a horizontal spacing of 0.6 NM.

The King Air gets a TA and soon after a "Descend, descend" RA. The pilot responds immediately to the RA, starts a descent and reports the TCAS manoeuvre to ATC. The King Air descends approximately 500 feet before it gets a "Clear of conflict". The Bonanza pilot reported seeing the King Air passing below while the King Air crew never acquired the intruder visually.



**Learning point:**

RAs when followed promptly provide mitigation against the risk of midair collision.

## Event 6: Visual acquisition and RA not followed

A Fokker 100 is approaching its destination (elevation approximately 1700 feet) and is cleared for a visual approach. At the same time, a Eurocopter EC145 helicopter receives a clearance to cross the control zone at the altitude of 4500 feet. Traffic information is given to both crews. The F100 is TCAS II equipped while the EC145 has a traffic awareness system installed (it generates information about nearby traffic but does not generate any resolution advice).

The EC145 pilot acquires the F100 visually based on the information from the TAS system and subsequently informs ATC that he will cross behind the F100 and initiates a 40° left turn.

Due to hazy visibility and direct sunlight the F100 co-pilot has some difficulties acquiring the EC145 visually. When he can see the helicopter he reports to ATC "...the helicopter is in sight and we're avoiding". At this time, the F100 is passing through 5000 feet on final and the spacing between the aircraft is 2.8 NM and 675 feet. At approximately the same time as visual contact is established by the F100 co-pilot, TCAS generates a TA. Subsequently, the F100 commander (pilot flying), reduces the rate of descent.

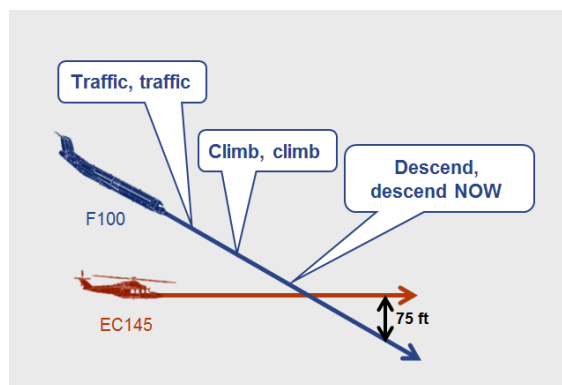
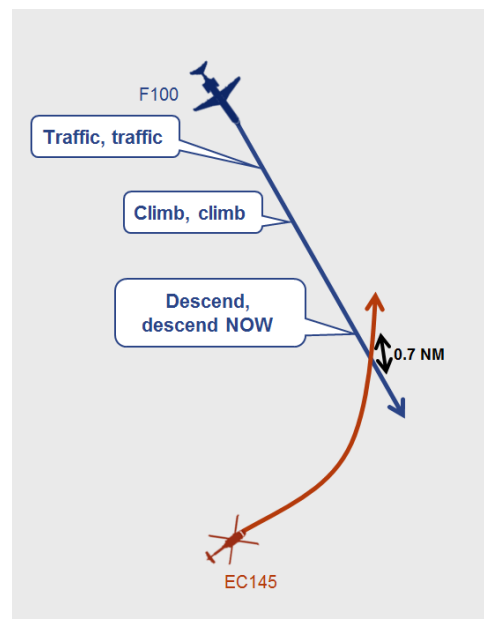
Just 16 seconds later, as the distance between the aircraft further erodes to 1.8 NM and 288 feet, TCAS on F100 issues a "Climb, climb" RA. The F100 commander decides not to comply with the RA and continues descending as the co-pilot has visual contact with the helicopter which is observed turning north.

After 12 seconds, the Climb RA is reversed to "Descend, descend NOW". At this time the aircraft are 1 NM and 20 feet apart. A few seconds later the two aircraft cross with a lateral distance of 0.7 NM and an altitude difference of 75 feet.

Subsequent analysis of this incident indicated that a correct response to the first RA by the F100 pilot (assuming the nominal response time and acceleration) would have given the vertical miss-distance of 579 feet.

It should also be noted that the F100 crew could not have known if the helicopter was TCAS II equipped. Had the helicopter been equipped, it would have received a complimentary RA which, given the opposite reaction to the initial RA by the F100 crew, would have brought the aircraft even closer.

This event bears a striking resemblance to the Event 2 ("*Visual acquisition and RA not followed*") covered in [ACAS Bulletin no. 18](#) of May 2015. It needs to be emphasized once again that avoidance manoeuvres based on visual acquisition and, especially, manoeuvres contrary to the RA may not always ensure successful collision avoidance due to wrong traffic identification or potential responses to RAs by other aircraft.



### Learning points:

- Never manoeuvre in the opposite sense to an RA.
- Visual assessment of traffic can be misleading.

## Key learning points this issue:

- **TCAS operates differently at low altitudes. Radio altimeter is used as an additional source of altitude information.**
- **Some RAs will not be issued below 1650 feet AGL and all RAs will be inhibited below 900 feet AGL.**
- **GPWS/TAWS alerts take precedence over TCAS RAs.**
- **RA will only be generated against altitude reporting intruders.**
- **In some circumstances TAs may be generated against non-altitude reporting aircraft.**
- **All RAs must be followed, even if the suspected intruder is in sight.**