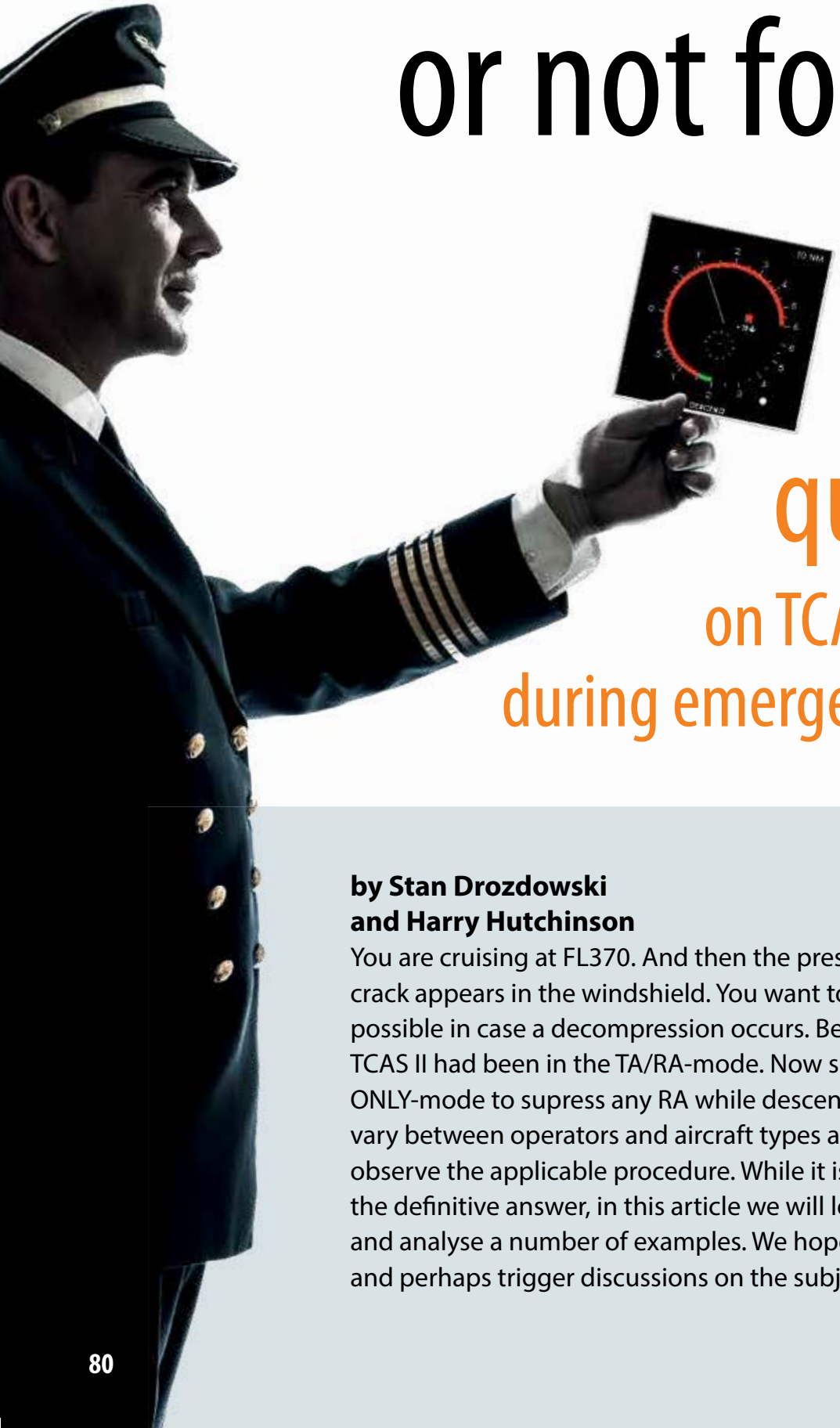
To follow or not follow...



is that really a question?

on TCAS operations during emergency descents

by Stan Drozdowski
and Harry Hutchinson

You are cruising at FL370. And then the pressurisation fails or a large crack appears in the windshield. You want to get lower as soon as possible in case a decompression occurs. Before the crack appeared, TCAS II had been in the TA/RA-mode. Now should you switch it to TA-ONLY-mode to supress any RA while descending? Operational practices vary between operators and aircraft types and pilots must always observe the applicable procedure. While it is quite difficult to provide the definitive answer, in this article we will look into various scenarios and analyse a number of examples. We hope it will be food for thought and perhaps trigger discussions on the subject!

There is no automation in place to switch between TCAS operating modes – this action will always require the pilot's manual input. However, on an everyday basis, most pilots will change from STAND-BY to TA/RA before a flight and back again afterward. Below we outline a scenario which may have severe safety consequences if no action is taken (i.e. changing the TCAS mode) and for which there is no automation available to support the crew[45].

Stanislaw Drozdowski is an ATM Expert at EUROCONTROL HQ in Brussels, working in the area of ground and airborne safety nets. Previously, he worked as a system engineer with Northrop Grumman and as an Air Traffic Controller in Poland and New Zealand.

Harry Hutchinson is an ACAS expert at QinetiQ in Great Malvern, UK. Harry trained as a physicist at the University of Bristol and moved to RSRE (the predecessor to QinetiQ) to work on semiconductor physics, before moving into the field of ATM research.

TCAS MODES OF OPERATION

Most TCAS II installations will have the following modes of operation available: STAND-BY, TA-ONLY, and TA/RA.

When STAND-BY mode is selected, the TCAS equipment does not transmit interrogations. Normally, this mode is used when the aircraft is on the ground or when there is a system malfunction.

In TA-ONLY mode, the TCAS equipment performs the surveillance function. However, only TAs will be generated and RAs are suppressed. A TA-ONLY aircraft will be 'seen' by other TCAS II aircraft as if it has no TCAS fitted. Thus, an aircraft operating in the TA-only mode is denied the full benefit of collision avoidance capability if another aircraft comes into conflict – it will be a passive target and resolving the conflict will be left to the other aircraft.

Circumstances in which TCAS II should be operated in the TA-ONLY mode may be detailed in the pilot's Operations Manual and are usually limited to specific in-flight failures and operational conditions.

The full TCAS II functionality provided by the TA/RA-mode will be what is almost always selected when airborne. However, this selection indicates to other TCAS II-equipped aircraft that the crew is likely to follow any RA generated. Not to do so would not only deny one's own aircraft the safety benefit provided by the RA, but would also compromise the effectiveness of a coordinated RA generated in conjunction with the other aircraft. In other words, if it is intended that any RA will not be followed due to a particular circumstance or procedure, then TCAS should be set immediately to TA-ONLY mode.

45- Some aircraft types may have built-in system protections that will inhibit Climb RAs if an engine fails.

TCAS (ACAS) II – an aircraft system based on Secondary Surveillance Radar (SSR) transponder signals. TCAS II interrogates the Mode C and Mode S transponders of nearby aircraft ('intruders') and from the replies tracks their altitude, range, and bearing, and issues alerts to the pilots, as appropriate.

TRAFFIC ADVISORY (TA) – An indication given to the flight crew that a certain intruder is a potential threat.

RESOLUTION ADVISORY (RA) – An indication given to the flight crew recommending: a manoeuvre intended to provide separation from all threats; or a manoeuvre restriction intended to maintain existing separation. RAs are coordinated between equipped aircraft.

To follow or not follow – is that really a question?
on TCAS operations during emergency descents (cont'd)

TA-ONLY-MODE vs. TA/RA-MODE

As recommended by ICAO ACAS Manual (Doc. 9863), TCAS II should be operated in the TA-ONLY mode "in the event of particular in-flight failures or performance limiting conditions". In these circumstances the pilot's ability or willingness to respond to an RA will be limited, either due to impaired aircraft performance or a concern that a response to an RA may aggravate the original problem (e.g. stall while responding to an RA, due to insufficient power to perform a Climb RA, or prolonging the time period when the aircraft stays at higher altitudes following a decompression).

The question is, of course, which option offers least overall risk. In order to give an answer we need to examine the probability of encountering other aircraft while performing an emergency descent or operating with an engine out.

Some will argue that in the absence of an RA, a TA may aid visual acquisition and that the pilot can then execute a successful "see-and-avoid" manoeuvre. However, if the aircraft is in TA-only mode because of an impairing condition, the pilot may well be even less able to execute a successful "see-and-avoid" manoeuvre than would normally be the case. It is also worth considering the practicality and the willingness of the pilot to achieve a correct response to an RA in the presence of such an impairing condition. If you are flying on one engine or performing an emergency descent, would you be able and inclined to respond a Climb RA at the required rate of 1500 ft/min? And let's not forget that such an RA may very likely strengthen to an Increase Climb RA requiring 2500 ft/min.

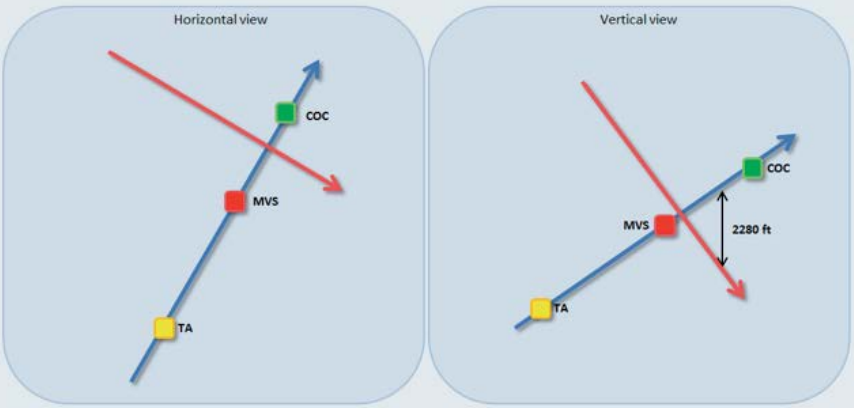
Not responding to RAs

A coordinated TCAS II encounter (that is an encounter with another TCAS II-equipped aircraft) is, so to speak, a social contract: if your own aircraft is in TA/RA-mode, the other aircraft in the encounter will be relying on you to follow your RAs, because the sense of the RAs in both aircraft will be coordinated. In uncoordinated encounters (i.e. where both aircraft have transponders but only one has TA/RA selected, the TCAS II-equipped aircraft has full freedom (and the full responsibility) to select the most effective de-confliction response.

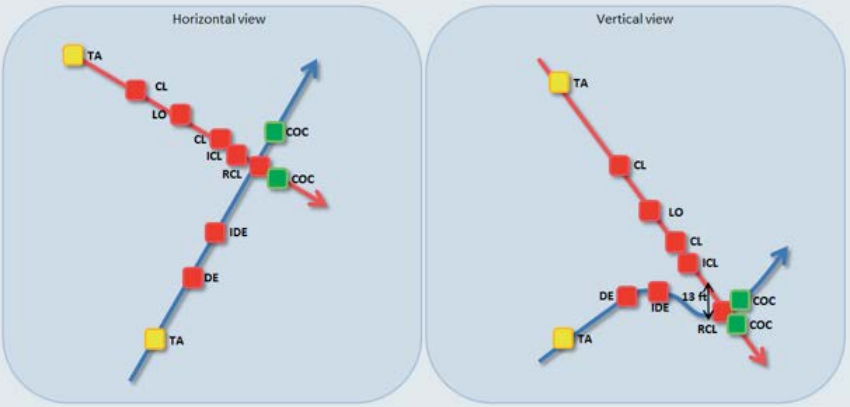
If the pilot does not intend to follow or is incapable of following an RA that may be generated on their own aircraft, then they should select TA-only mode so as to make their aircraft appear as unequipped and allowing the TCAS II-equipped aircraft to choose the most effective RA.

EXAMPLES

We will now look at the emergency descent case in two scenarios. At the beginning of our event, the Red aircraft is making an emergency descent through FL200 at 6000 ft/min. The Blue aircraft is climbing through FL140 at 3000 ft/min. The predicted horizontal miss distance is 0.1 NM.



SCENARIO 1



SCENARIO 2

In **SCENARIO 1** the Red aircraft is in TA-only mode while carrying out its emergency descent. Blue receives a Traffic Advisory (TA), followed by a preventive Monitor Vertical Speed (MVS) RA[46] and at the Closest Point of Approach (CPA) is already 2280 feet above Red. A Clear of Conflict (COC) message is posted soon afterwards.

In **SCENARIO 2** the Red aircraft is in TA/RA mode carrying out its emergency descent. It receives a TA and then a Climb (CL) RA, to which it does not respond and subsequently also ignores a Level Off (LO) and subsequently Climb (CL) and Increase Climb (ICL) RAs. The Blue aircraft gets a Descend (DE) RA, to which it responds. This strengthens to an Increase Descent (IDE). Just after the CPA, the RA for the Blue aircraft reverses to a Climb RA (RCL) before a Clear of Conflict (COC) is announced. Although the Blue aircraft is following its RAs as required – and in reality such RA sequences are a challenge to fly and rarely performed 'by the book' – at the CPA the vertical miss distance is only, 13 feet. To put this number in perspective, the height of a Boeing 737-800 is 42 feet.

Although, it is not applicable in the scenario described above, swapping the Mode S addresses[47] in lots of similar geometries may produce totally different outcomes.

Conclusion

The Scenario above has been intentionally constructed to show why remaining in full TA/RA-mode during in an emergency descent might increase any risk of collision. Of course, an almost unlimited number of scenarios of this type can be invented which will cover a wide range of horizontal and vertical geometries. Types of RAs and their timing will be different, but many other cases are also likely to produce challenging RA sequences.

The risk of receiving an RA and not following it cannot be overstated. It puts both aircraft at increased risk and is likely to generate difficult-to-follow RA sequences on the other aircraft. It is fully recognised that the risk of collision is only one of many factors that needs to be considered while developing operational procedures for emergency descents but, undoubtedly, it is an important factor.

46- Monitor Vertical Speed does not require any manoeuvre; it just requires 'no change' in the current vertical speed.
47- In coordinated encounters only the aircraft with the higher Mode S address is permitted to declare a reversal.