SAFETY FLASH

ACAS II bulletin No 6

EUROCONTROL

Incorrect use of the TCAS traffic display

Editorial

TCAS II is a last resort safety net designed to prevent mid-air collisions. It alerts the flight crew and provides Resolution Advisory (RA) manoeuvre indications when it computes a risk of collision. The correct use of TCAS II increases the safety of air transport.

The TCAS II traffic display is provided for the purpose of assisting the flight crew in the visual acquisition of aircraft in the vicinity. Of course, it also helps to improve flight crew situational awareness.

However, experience has shown that in some cases, flight crew are tempted to make their own traffic assessment based on the traffic display information, and to manoeuvre in anticipation of ATC instructions.

The TCAS II traffic display can be misinterpreted, since it provides only partial information, it has limited accuracy, and it is based upon a moving reference. It has not been designed for the purposes of self-separation or sequencing, and using it for these purposes is inappropriate, and could also be hazardous.

This ACAS Bulletin includes some actual events where problems arose due to misinterpretation of the TCAS II traffic display, and provides some insight into why these events occurred.

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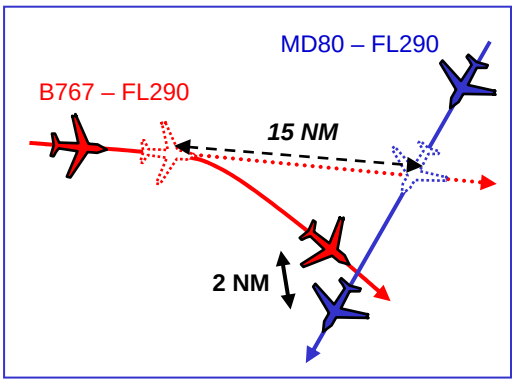
March 2005

Event 1: Loss of separation due to an inappropriate turn

A B767 heading 100 and a MD80 heading 217 are maintaining FL290 on crossing tracks. **The B767 will pass approximately 15 NM behind the MD80** (dotted line on the figure).



For radar separation, when they are still 80 NM apart, the controller instructs both aircraft to maintain their present heading.

One minute before the tracks cross, the controller provides traffic information to the B767 "*eleven o'clock, from left to right, same level, aircraft type MD 80, present time 25 NM, converging*". The B767 pilot starts monitoring a target, which is on the left hand side of the TCAS traffic display.

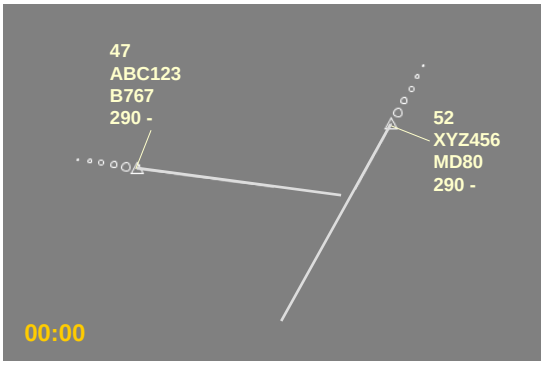
As he assesses that the other traffic is converging head-on, the B767 pilot asks: "***Where is this twelve o'clock traffic going?***" The controller responds with updated traffic information.

However, the B767 pilot says: "***We're going to take a heading here 120***" whilst starting to turn to the right. Due to this turn, which is in the wrong direction, the horizontal separation reduces quickly and a TA is triggered on both aircraft. Whilst starting to descend, the B767 pilot says: "***we'd like to go to [FL] 270***".

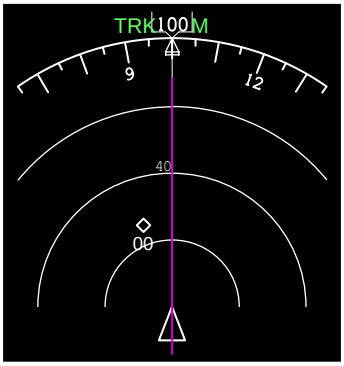
Afterwards, to justify his decision to turn, the B767 pilot said to the controller that "*the traffic was coming right up, so we turn to avoid the traffic*". **This inappropriate turn reduced the separation to only 2 NM**.

So, why did the B767 pilot decide on his own to turn, contrary to the ATC instruction? And why to the right?

The figures below show how the situation was represented on the controller's radar display and the B767 TCAS traffic display, at the time of the initial traffic information.



Controller's radar display



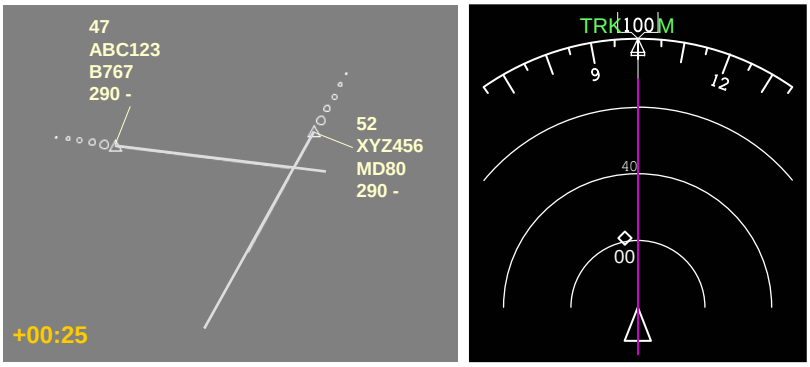
B767 TCAS traffic display

On the controller's display, the 3 minute speed vector (magnetic track and speed) clearly shows that the B767 was going to pass behind the MD80 (which was faster: 520kts vs. 470 kts ground speed). This is not obvious on the TCAS traffic display.

The reason why the B767 pilot was misled is explained on the next page.

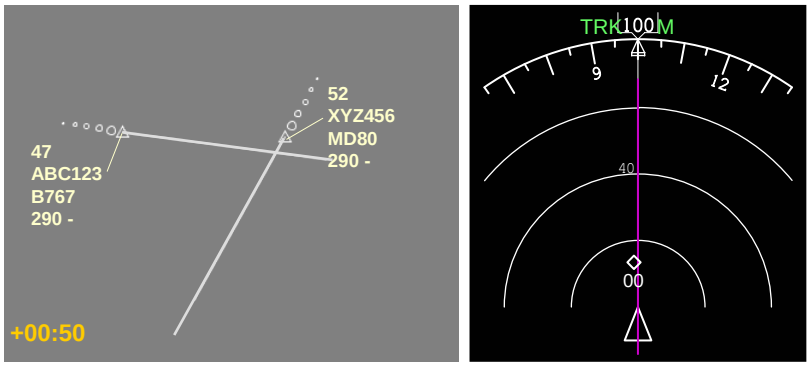
The TCAS traffic display is not a radar display

Due to the relative motion of the symbol and the lack of speed vector, **it is extremely difficult to anticipate the evolution of the situation based solely on the TCAS traffic display** (see explanation on page 3). In the event described on the first page, the B767 pilot related a target on the TCAS traffic display to the initial traffic information. What the pilot could see was a target moving **apparently** on opposite track, slightly on the left. So, he started to question the controller **:**



"Where is this 12 o'clock traffic going?"

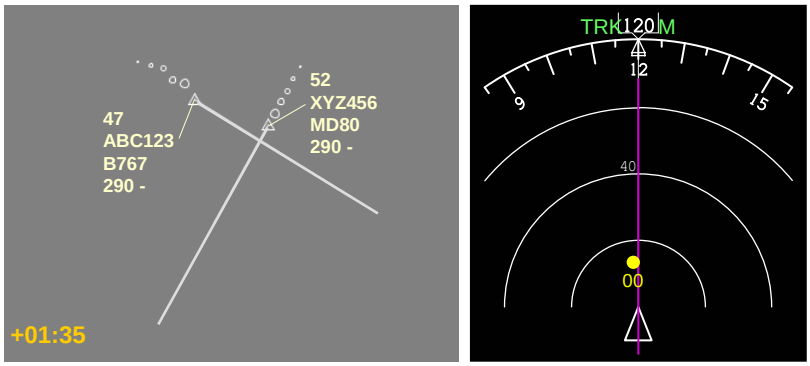
When the target was at 12 o'clock position and less than 20 NM, the B767 pilot decided to turn right to avoid the target on the TCAS traffic display **:**



"We're going to take a heading 120"

The pilot could not relate the direction of the traffic, contained in the controller's traffic information, to the information provided by the TCAS traffic display, so he did not take it into account. But to the controller, it was obvious that this turn to the right would create a loss of separation.

Due to the turn to the right, the target remained on the left hand side on the TCAS traffic display, apparently still on opposite track, and a TA was then triggered. The pilot now decided to descend **:**



"We'd like to go to 270"

A loss of separation then occurred, the reason for this incident was not understood by either the pilot or the controller.

The TCAS traffic display is not designed to support separation manoeuvres, but to aid visual acquisition of an intruder. It gives only a snapshot of **the relative horizontal and vertical position of other aircraft in the vicinity**.

Regulations for the use of the TCAS traffic display

ICAO PANS-OPS, Doc 8168 states that:

"Pilots shall not manoeuvre their aircraft in response to traffic advisories (TAs) only"

This point is emphasized in the ICAO ACAS II Training Guidelines for pilots:

"No manoeuvres are made based solely on the information shown on the ACAS display"

ICAO standards only include phraseology to report RAs. Therefore, ***pilots should not report "TCAS contact" or "we have it on TCAS" after traffic information from ATC****. Indeed, such a report provides no added value to ATC.*

Examples of incorrect use of the TCAS traffic display

Decisions to turn

- A Fokker 100 is cleared to descend to FL110. When passing through FL120, two targets appear on the TCAS traffic display, both "*in front, on the left, at -15*" (i.e. 1500 ft below). A "Climb" RA is triggered. The pilot follows the RA but also decides to turn to the right. Fortunately the pilot's correct reaction to the RA provides safe vertical separation, because the inappropriate turn reduces the horizontal margin to 0.2 NM.
- A B737 is cleared to climb to 3000 ft. A VFR on an opposite track is level at 3500 ft, but offset horizontally. The controller provides traffic information to the B737. The pilot reports two targets on the TCAS traffic display and shortly after reports a left turn to avoid this traffic. Fortunately, the controller instructs the B737 to stop climb at 2500 ft, because the inappropriate turn reduces the separation.

ATC instructions disregarded

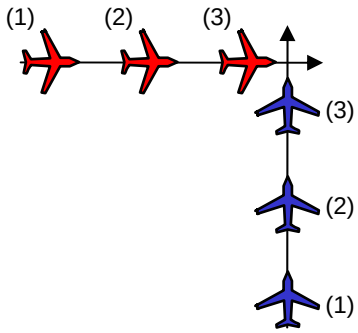
The two following events were reported by controllers at a major European airport.

- "*The A340 reduced its speed on its own, miles too early on approach, to increase the distance from the preceding aircraft [based on the TCAS traffic display]. It messed up the sequence and an A320 was then only 4 NM behind it! I was obliged to make the A320 perform an "S" for delay*".
- "*The pilot did not turn on time onto base leg [because he was monitoring the preceding aircraft on the TCAS traffic display]. After no reply to two instructions to intercept the localizer, I had to instruct [the next aircraft] to climb back to 4000 ft to avoid an Airprox and I had to give headings for delaying action to all the other aircraft [...]. When he finally replies, he tells me "I can't listen to you, I must monitor my TCAS*".

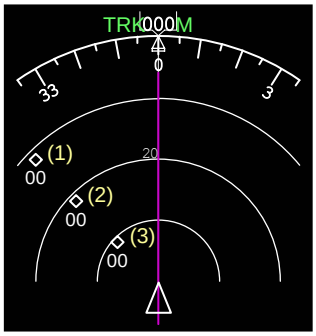
Moving reference display

The reference for the TCAS traffic display is the aircraft own position, which is constantly moving (unlike the controller radar display, which has a fixed reference). This gives a display where the targets are shown in relative motion, which is a major cause of TCAS traffic display misinterpretation.

The most significant illustration of this is when two **aircraft are converging at 90°**. The following figures show that the symbol of an aircraft on a 90° crossing track actually appears to be converging at a **45° angle on the TCAS traffic display**.



Aircraft trajectories converge at 90°



Closure appears to be at 45°

The same issue is also evident when the own aircraft is catching up a slower aircraft flying in the same direction. In this situation, the target is displayed apparently as an intruder on an opposite direction track.

The interpretation of an intruder trajectory on the TCAS traffic display is even more difficult when the own aircraft is manoeuvring since the bearing of the intruder will vary significantly even if its heading is steady.

In addition, the lack of either a speed vector or knowledge of the intent of other aircraft increases the difficulty in the interpretation of the TCAS traffic display.

Furthermore, it is difficult to determine in advance if the aircraft are indeed on a collision course or whether separation will be maintained. For instance, when an extended range is selected, the size of the target symbol can be large, corresponding to a few nautical miles. Therefore, it is much less precise than the controller's radar display.

Partial traffic picture

Although the TCAS traffic display assists to detect the presence of intruders in the close vicinity, flight crews should not be over-reliant on this display. It supports visual acquisition; **it is not a replacement for the out-of-window scan**. One of the main reasons is that the traffic picture provided by the TCAS traffic display is only partial.

TCAS only detects intruders with an active transponder, and does not provide traffic identity information. There may be aircraft in the vicinity even if there is no target on the TCAS traffic display. Therefore, flight crews may get an incorrect perception of the air traffic situation, as illustrated by the following two events.

- A controller advised a pilot approaching his cleared flight level that further descent would be in 4 NM due to traffic. The pilot answered: "*We have him on TCAS*". However, he misidentified the target because the actual conflicting aircraft had a transponder failure; it was shown to the controller on primary radar, only.
- A pilot filed a report due to a TCAS technical fault; it displayed an intruder in descent whereas he had had visual acquisition on a climbing fighter. Actually, TCAS operated perfectly: there were two fighters, the one descending was transponding but the one climbing was not.

TCAS surveillance range may be reduced to 5 NM in high density airspace. Therefore, pilots could observe aircraft in the vicinity, which might not be shown on the TCAS traffic display.

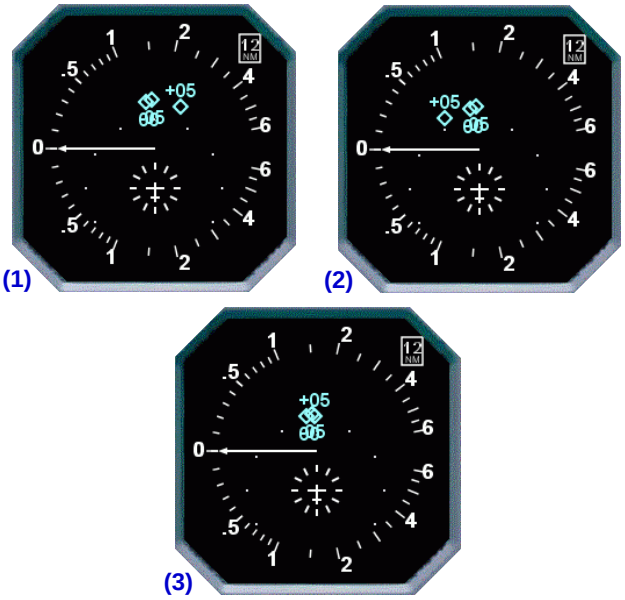
Even if aircraft are detected by TCAS, they may not be displayed. Some installations limit the number of displayed targets to a maximum of 8. In addition, the TCAS traffic display options provide altitude filtering (e.g. NORMAL mode only shows targets within +/- 2700 ft from own aircraft).

Limited accuracy of TCAS bearing information

TCAS II bearing measurement is not very accurate. Usually, the error is no more than 5° but it could be greater than 30°. Due to these errors the target symbol on the display can jump.

The following illustrations show the TCAS traffic displays of an event recorded during a TCAS II trial. There were 3 intruder aircraft, in the 12 o'clock position, but separated by 500 ft vertically. However, the intruder at +05 (i.e. 500 ft above) appears at 6 seconds intervals, on the right of the group of targets (1) and then on the left (2), before being shown in the correct 12 o'clock position (3).

In the worst case, bearing error could cause a target on one side of the aircraft to be displayed to the other. **This emphasises the danger of undertaking a horizontal manoeuvre based solely on the TCAS traffic display.**



Bearing variations from +17° to -26° and then to 02°

Note: TCAS II **does not** need the bearing information for collision avoidance RAs. Bearing is used for the TCAS traffic display.

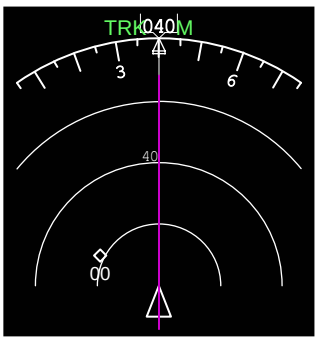
Event 2: Challenge to an ATC turn instruction for separation

A DC10 heading 100 and a B747 heading 040 are level at FL350 on a collision course.

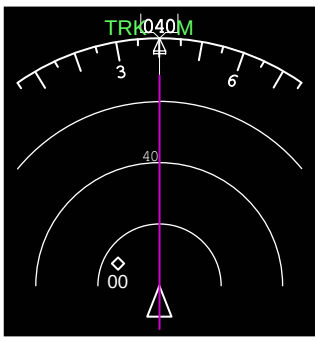
Two and a half minutes before the crossing, the controller instructs the B747 to turn 30 degrees left to achieve 5 NM separation behind the DC10. However, the B747 pilot sees on his TCAS traffic display a target on the left at the same level and so asks "*Confirm 30 degrees left?*" He thinks, wrongly, that **a left turn (which will actually resolve the situation)** will create a risk of collision.

Thirty seconds later, the B747 pilot says "*if we turn 30 degrees left, we will be aiming towards another aircraft at our level*".

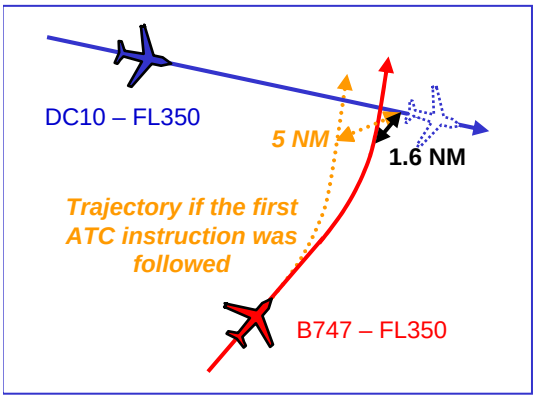
Meanwhile, a Short Term Conflict Alert has been triggered and the controller has instructed the DC10 to descend.



"Confirm 30 degrees left?"



"if we turn 30 degrees left, we will be aiming towards another aircraft at our level"



The controller then provides traffic information to the B747 pilot who asks "*which heading would you like us to take?*" The controller repeats his instruction to "*turn left 30 degrees*". This time, the B747 pilot accepts the instruction and initiates the left turn, but it is too late to maintain separation. The B747 pilot reports a "*TCAS advisory*". **The minimum distance was 1.6 NM**.

Subsequently, the B747 pilot asks the controller to explain the reason for the turn. The controller replies that there was conflicting traffic at the same level. The B747 pilot answers that "***we are filing [a report]; on the TCAS you sent us straight into the aircraft***".

Analysis of this incident confirmed that if the B747 pilot had complied with the initial ATC instruction to turn, 5 NM horizontal separation would have been achieved. (dotted line on the figure).

Conclusion

The TCAS traffic display is designed to assist the visual acquisition of surrounding aircraft.

There is a risk that some aircraft in the vicinity might not be displayed and in addition, due to bearing inaccuracy, a moving reference, and a lack of a speed vector, together with no identity information, flight crews could wrongly attribute a target symbol on the TCAS traffic display.

Air traffic controllers base their actions on the comprehensive information shown on the radar display, which enables them to provide a safe and expeditious air traffic flow. The TCAS traffic display does **not** provide the information necessary for the provision of separation and sequencing.

Manoeuvres initiated solely on the information shown on the TCAS traffic display have often degraded flight safety. Therefore, **pilots should not attempt to self-separate, nor to challenge an ATC instruction, based on the information derived solely from the TCAS traffic display**. It is the controllers' responsibility to separate aircraft.

TCAS II will trigger an RA if there is a risk of collision between aircraft. A principle of TCAS II operation is that **correct reaction to posted RAs will safely resolve such situations**.

The TCAS traffic display must not be used for self-separation

This is one of a series of ACAS II Bulletins addressing specific TCAS operational issues.

"Follow the RA !"
"RAs and 1000 ft level-off manoeuvres"
"Wrong reaction to "Adjust Vertical Speed" RAs"
"TCAS II and VFR traffic"
"Controller and Pilot ACAS regulation and training"

They are available on the ACAS Programme website, as well as an ACAS II brochure and some training material.

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