



Airbus AP/FD TCAS mode:

a new step towards safety Improvement



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1 | Introduction

The Traffic Collision Avoidance System (TCAS) has been introduced to reduce the risks associated with mid-air collision threats. Today this safety goal has globally been reached.

However, surprise and stress created by TCAS Resolution Advisories may lead to non-optimum crew response, resulting in a lack of proper communication with ATC, undue aircraft altitude deviations, injuries in the cabin and the jeopardizing of the aircraft's safety.

This article will review the current TCAS interface and procedures. It will then present the Auto Pilot/ Flight Director (AP/FD) TCAS mode function developed by Airbus, and its numerous operational benefits, which further enhance the pilot interfaces.

2 | Current TCAS interface and procedures

Traffic Advisory (TA)

When the TCAS considers an intruder to be a potential threat, it generates a TA.

This advisory aims at alerting crews to the intruder's position. TAs are indicated to the crew by:

- An aural message, "Traffic, Traffic"
- Specific amber cues on the Navigation Display, which highlight the intruder's position.

No specific action is expected from the crew following a TA.

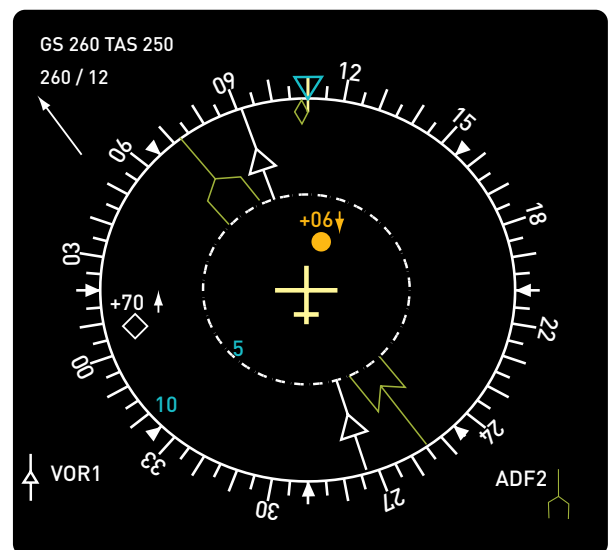


Figure 1: Navigation Display in case of TCAS TA

Resolution Advisory (RA)

If the TCAS considers an intruder to be a real collision threat, it generates an RA.

In most cases, the TCAS will trigger a Traffic Advisory before a Resolution Advisory.

RAs are indicated to the pilots by:

- An aural message specifying the type of vertical order (Climb, Descent, Monitor, Adjust...)
- Specific red cues on the Navigation Display materializing the intruder

- Green / red zones on the Vertical Speed Indicator (VSI) specifying the type of maneuver the pilot has to perform.

In order to fly the required maneuver, the pilot selects both the Auto Pilot (AP) and Flight Directors (FD) to OFF, and adjusts the pitch attitude of the aircraft as required, so as to reach the proper Vertical Speed (V/S). This unfamiliar flying technique increases the stress level already induced by the triggering of the Resolution Advisory.

||| "Adjust V/S, Adjust"



Figure 2: TCAS RA HMI without AP/FD TCAS mode



3 | AP/FD TCAS mode concept

Airbus has carried out an in-depth analysis of:

- Needs expressed by airline pilots
- Human factor studies linked to the TCAS system
- Recommendations given by airworthiness authorities.

This resulted in the development of a new concept called AP/FD TCAS guidance, via the Auto Flight System (AFS), to support pilots flying TCAS RAs.

The AP/FD TCAS mode is a vertical guidance mode built into the Auto Flight computer. It controls the vertical speed (V/S) of the aircraft on a vertical speed target adapted to each RA, which is acquired from TCAS.

With the Auto Pilot engaged, it allows the pilot to fly the TCAS RA manoeuvre automatically.

With the Auto Pilot disengaged, the pilot can fly the TCAS RA manoeuvre manually, by following the TCAS Flight Director pitch bar guidance.

It has to be considered as an add-on to the existing TCAS features (traffic on Navigation Display, aural alerts, vertical speed green / red zones materializing the RA on the Vertical Speed Indicator).

In case of a TCAS RA, the AP/FD TCAS mode automatically triggers the following:

- **If both AP and FDs are engaged**, the AP/FD vertical mode reverts to TCAS mode, which provides the necessary guidance for the Auto Pilot to automatically fly the TCAS manoeuvre
- **If the AP is disengaged and FDs are engaged**, the TCAS mode automatically engages as the new FD guidance. The FD pitch bar provides an unambiguous order to the pilot, who simply has to centre the pitch bar, to bring the V/S of the aircraft on the V/S target (green zone)
- **If both AP and FDs are OFF**, the FD bars will automatically reappear with TCAS mode guiding as above.

Note: At any time, the crew keeps the possibility to disconnect the AP and the FDs, and is capable to respond manually to a TCAS RA by flying according to the "conventional" TCAS procedure (i.e. flying the vertical speed out of the red band).

The AP/FD TCAS mode will behave differently depending on the kind of alert triggered by the TCAS:

- **In case of Traffic Advisory (TA)**, the AP/FD TCAS mode is automatically armed, in order to bring crew awareness on the TCAS mode engagement if the TA turned into an RA.
- **In case of Corrective RA** ("CLIMB", "DESCEND", "ADJUST", etc aural alerts), the aircraft vertical speed is initially within the red VSI zone. The requirement is to fly out of this red zone to reach the boundary of the red / green V/S zone.
Consequently:
 - The TCAS longitudinal mode engages. It ensures a vertical guidance to a vertical speed target equal to the red / green boundary value (to minimize altitude deviation) ± 200 ft/min within the green vertical speed zone, with a pitch authority increased to 0.3g
 - All previously armed longitudinal modes are automatically disarmed, except the altitude capture mode (ALT*) in case of an "ADJUST V/S" alert. This prevents an undue altitude excursion: indeed, in this type of RA, reaching 0 ft/min is always safe, as this value is never within the red vertical speed zone. Therefore, if the altitude capture conditions are met, the TCAS mode will safely allow to capture the targeted flight level
 - The Auto Thrust engages in speed control mode (SPEED/MACH) to ensure a safe speed during the manoeuvre
 - The current engaged lateral mode remains unchanged.

🔊 "Adjust V/S, Adjust"

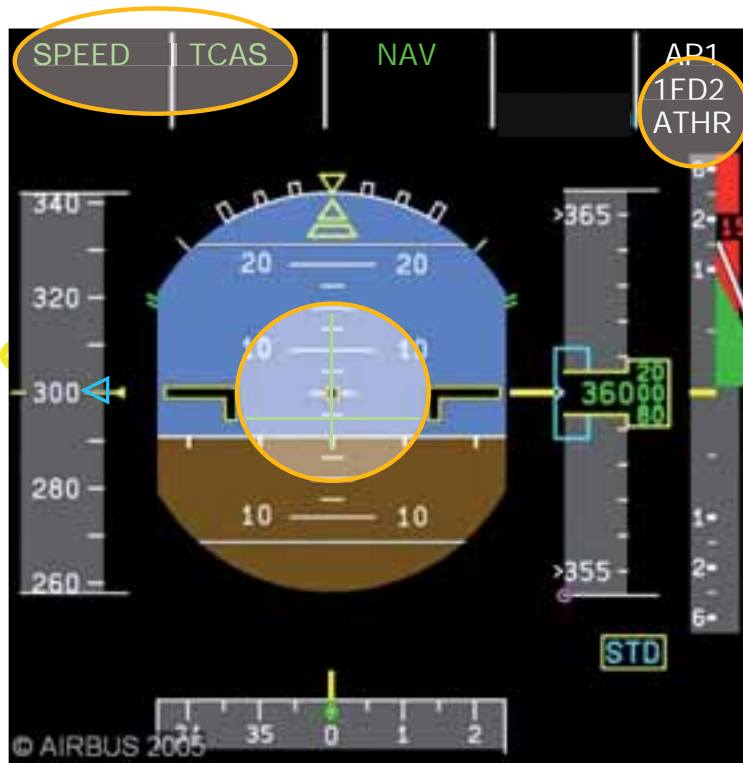


Figure 3: PFD upon a Corrective TCAS RA with AP/FD TCAS mode

- In case of Preventive RA (e.g. "MONITOR V/S" aural alert), the aircraft vertical speed is initially out of the red VSI zone. The requirement is to maintain the current vertical speed
Consequently:
 - The TCAS longitudinal mode engages to maintain the current safe aircraft vertical speed target
 - All previously armed longitudinal modes are automatically disarmed, except the altitude capture mode (ALT*). Indeed, as for an "ADJUST V/S" RA, levelling-off during a Preventive RA will always maintain the vertical speed outside of the red area. So if the altitude capture conditions are met, the TCAS mode will allow to safely capture the targeted level, thus preventing an undue altitude excursion
 - The Auto Thrust engages in speed control mode (SPEED/MACH) to ensure a safe speed during the maneuver
 - The current engaged lateral mode remains unchanged.
- Once Clear of Conflict, vertical navigation is resumed as follows :
 - The AP/FD longitudinal mode reverts to the "vertical speed" (V/S) mode, with a smooth vertical speed target towards the FCU target altitude. The ALT mode is armed to reach the FCU target altitude (ATC cleared altitude)
 - If an altitude capture occurred in the course of a TCAS RA event, once Clear of Conflict, the AP/FD longitudinal mode reverts to the altitude capture (ALT*) or to the altitude hold (ALT) mode
 - The lateral mode remains unchanged.



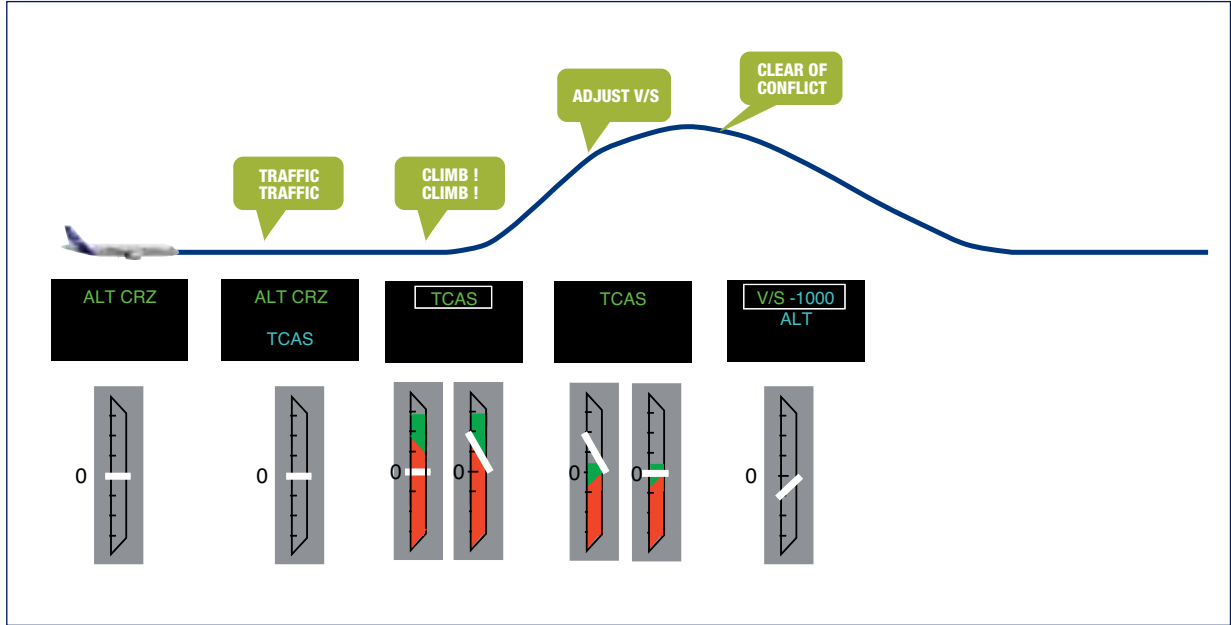
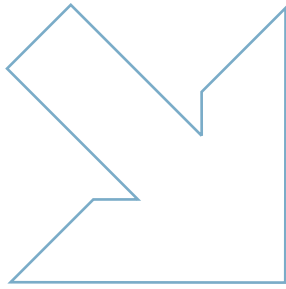


Figure 4: FMA and VSI during a TCAS sequence with AP/FD TCAS mode

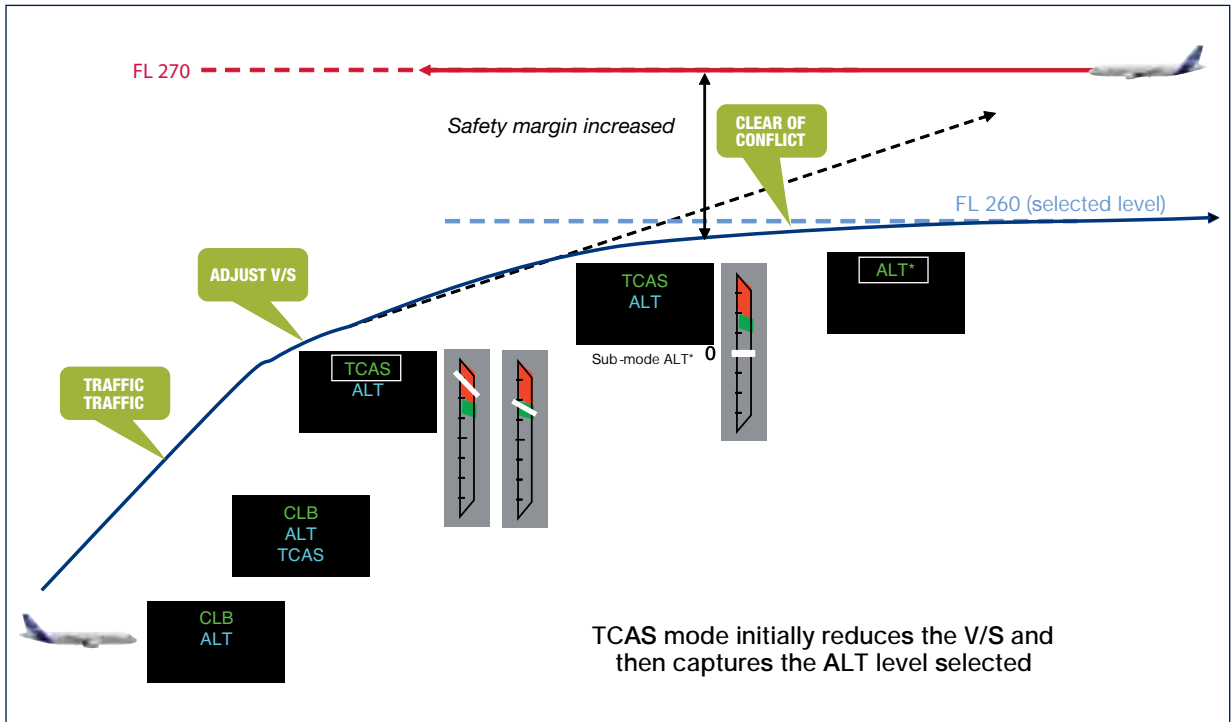


Figure 5: Safe altitude capture in TCAS mode

4 | Operational benefits

The operational benefits of the AP/FD TCAS mode solution are numerous; the system addresses most of the concerns raised by in-line experience feedbacks:

- It provides an unambiguous flying order to the pilot
- The flying order is adjusted to the severity of the RA; it thus reduces the risks of overreaction by the crew, minimizes the deviations from trajectories initially cleared by ATC, and adapts the load factor of the manoeuvre
- The availability of the AP/FD TCAS mode makes it possible to define simple procedures for the aircrews, eliminating any disruption in their flying technique: the procedure is simply to monitor the AP, or to manually fly the FD bars, when the TCAS mode engages, while monitoring the VSI.

By reducing the crews' workload and stress level, the AP/FD TCAS mode should therefore significantly reduce:

- Inappropriate reactions in case of Resolution Advisory (late, over or opposite reactions)
- Misbehaviours when Clear of Conflict
- Lack of adequate communications with ATC.

Note: For ATC controllers, the AP/FD TCAS mode is totally transparent in terms of expected aircraft reactions.

The AP/FD TCAS mode was demonstrated to a large panel of pilots from various airlines, and was perceived by them as a very simple and intuitive solution. It was deemed to be consistent with the Airbus cockpit philosophy and Auto Flight system.

All agree that the AP/FD TCAS mode represents a safety improvement.

5 | Certification schedule

The certification of the AP/FD TCAS mode function is expected:

- On the A380: by May 2009
- On the A320 family:
 - with CFM engines, by end 2009
 - with IAE engines, by July 2010
- On the A330/A340, depending on the aircraft type, from the beginning of 2010 (A330 PW/RR) to the end of 2011 (A340-500/600).

The certification dates for all required retrofit standards are not yet frozen.



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The Airbus Safety Magazine
For the enhancement of safe flight through
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Safety First
07 February 2009

Safety First is published
by Airbus S.A.S
1, rond point Maurice Bellonte
31707 Blagnac Cedex / France

Editor:
Yannick Malinge,
Vice President Flight Safety

Concept Design by
MULTI MEDIA SUPPORT 20090053

Computer Graphic by Quat'coul

Copyright: GSE 420 0046/09

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Printed in France by AMADIO

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