



AIRBUS AP/FD TCAS MODE: A NEW STEP TOWARDS SAFETY IMPROVEMENT

by Paule Botargues

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TCAS has been introduced in order to reduce the risks associated with mid-air collision threats; today this safety goal has been reached. Yet many incidents ("near misses") do still occur despite the presence of TCAS.

The in-line operational feedback analysis shows that there are some opposite reactions, many late reactions and overreactions from aircrews to TCAS Resolution Advisories (RA) leading to injuries in the cabin, undue aircraft trajectory deviations from the latest ATC clearance and even to altitude busts, as well as lack of proper communication from the crew to the ATC when an RA occurs.

This feedback shows that the root cause of such crew misbehaviour is the surprise and stress created by the RA, which directly affects the performance of the pilot.

The present RAs are indicated to the pilots by an aural message specifying the type of the Advisory (Climb, descent, monitor, adjust...), and by green/red zones on the Vertical Speed Indicator (VSI) specifying the manoeuvre the pilot has to fly; in order to fly this required manoeuvre the pilot has to switch both Auto Pilot (AP) and Flight Director (FD) to off, and adjust the pitch of the aircraft so as to get the proper V/S. This flying technique is

quite unfamiliar to pilots, and disrupts the current flying technique they had at the time of the RA occurrence, which adds to their stress level.

AIRBUS has carried out an in-depth analysis of the need expressed by airlines' pilots regarding human factor studies linked to TCAS system and recommendations given by airworthiness authorities. The result of this study is the development of a new concept to support pilots flying TCAS RAs: the AP/FD TCAS mode.

The AP/FD TCAS Mode is a guidance mode built-in the Auto Pilot computer which allows the pilot to automatically fly the RA if the AP is ON or to hand-fly the RA by obeying the Flight Director command bars if the AP is OFF.

The AP/FD TCAS guidance mode controls the vertical speed (V/S) of the aircraft on a vertical speed target adapted to each RA, which is acquired from TCAS. It is designed to respect the TCAS hypothesis regarding the dynamics of the reaction as well as to minimise the deviations from the latest ATC clearance, as recommended by the procedures. The AP/FD "TCAS" mode is automatically triggered in any of the following TCAS RA cases:

- If the AP is ON, the TCAS mode automatically engages on the AP; the AP then guides the airplane to



the V/S target associated to the RA, with the adequate authority.

- If the FD is ON and AP is OFF, the TCAS mode automatically engages on the FD; the FD crossbars provide an unambiguous order to the pilot who has to simply fly and centre the crossbars so as to control the V/S of the aircraft to the V/S target of the RA (into the green "fly to" vertical speed zone and out of the red vertical speed zone).
- If the AP and FDs are OFF at the time of the TCAS RA, the FD bars will then automatically reappear with TCAS mode active, assisting the pilot as here above.

The AP/FD TCAS mode behaviour can now be detailed regarding the kind of RA triggered by the TCAS:

- In case of a Corrective RA (e.g. "CLIMB", "DESCEND", "ADJUST", etc. aural alerts), the aircraft vertical speed is initially within the red VSI zone. The requirement is then to fly out of this red zone to reach the

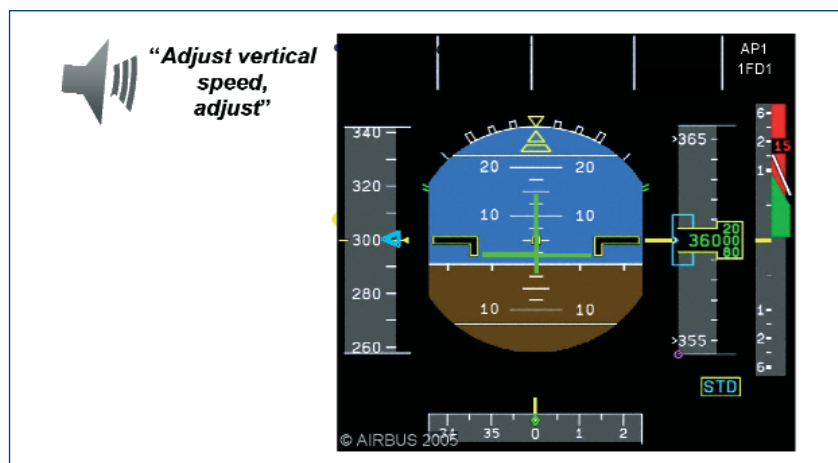


Figure - PFD upon a Corrective TCAS RA "ADJUST V/S, ADJUST"

green one, near the boundary of the red/green V/S zones to minimise the vertical deviation from initial ATC clearance. Consequently in the case of a Corrective RA:

- The TCAS longitudinal mode engages. It ensures a vertical guidance to a vertical speed target equal to red/green boundary value ± 100 ft/min within the green vertical speed zone, with a pitch authority increased up to 0.3g.
 - All previously armed modes are disarmed except the altitude capture mode (ALT) in case of the "ADJUST V/S" RA, which prevents undue altitude busts: the vertical speed 0fpm is never within the Red V/S zone of such RA.
 - The current engaged lateral mode remains unchanged.
- In the case of a Preventive RA (e.g. "MONITOR V/S" aural alert), the aircraft vertical speed is initially out of the red VSI zone. The requirement is then to maintain the aircraft

vertical speed as is, out of this red VSI zone. Consequently in case of a Preventive RA:

- The current AP/FD longitudinal mode is kept, if it ensures that current vertical speed is maintained. If not, the current longitudinal mode reverts to the “vertical speed” (V/S) mode with a target synchronised on the current vertical speed.
- The TCAS mode is automatically armed, in order to raise crew awareness on the RA situation, and because a Preventive RA may turn into a Corrective RA if the collision risk situation gets more severe.
- All previously longitudinal armed modes are automatically disarmed, except for ALT mode; indeed a Preventive RA never forbids a level off, which means that the vertical speed 0fpm is never in the Red VSI zone. Keeping ALT armed thus prevents undue altitude busts.
- Once Clear Of Conflict, the expectation is to resume navigation

in accordance with last ATC clearance:

- The AP/FD longitudinal mode reverts to the “vertical speed” (V/S) mode, with a smooth vertical speed target towards the FCU target altitude (eg +/- 1000 ft/mn).
- The ALT mode is armed to reach the FCU target altitude (last clearance altitude provided by ATC).
- The lateral mode remains unchanged.

This design ensures that the aircraft will be guided back towards the initially cleared altitude by ATC, as expected.

It should be noted that the AP/FD TCAS Mode described above comes in addition to the whole already existing TCAS RA features (traffic on Navigation Display, aural alerts, vertical speed green/red zones materializing the RA on VSI).

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

- It provides an unambiguous flying order to the pilot, and thus eliminates risks of confusion during the RA and once Clear of Conflict.
- The flying order is adjusted to the severity of the RA; thus it reduces the risks of overreaction by the crew, minimises the deviations from trajectories initially cleared by ATC, it adapts the load factor of the manoeuvre and reduces perturbations in the cabin.

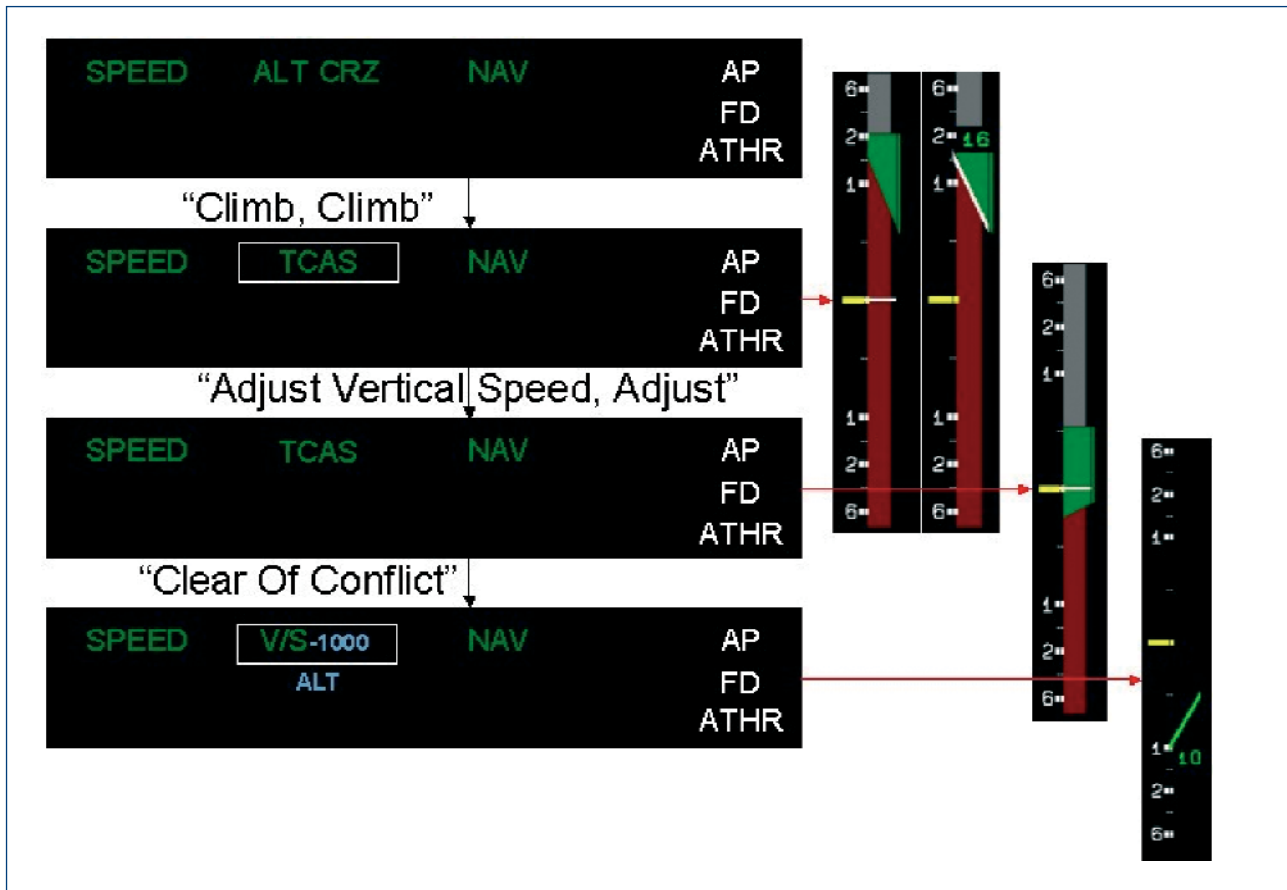


Figure - FMA upon a TCAS RA sequence

- The availability of such an 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 hand-fly the FD bars when TCAS mode engages while monitoring the VSI scale.
- Such simple and straightforward procedures reduce pilot stress and possible associated confusion (as for example with the "Adjust V/S Adjust" RA). Therefore the AP/FD TCAS mode should reduce significantly:
 - late reactions to TCAS RAs
 - overreactions to TCAS RAs
 - opposite reactions to TCAS RAs
 - misbehaviour when CLEAR of CONFLICT
 - lack of adequate communications with ATC.

Finally it is important to underline that the introduction of the AP/FD TCAS mode is transparent from the controller point of view as far as this mode is guiding on (or performing) a manoeuvre, which is the same as the one expected today without such a system.

AP/FD TCAS Mode was demonstrated to a large panel of airlines (Air France, North West Airlines, Lufthansa, British Airways, KLM, SAS, United Airlines) and was perceived by them as a simple and intuitive solution really consistent with current Airbus auto flight system and cockpit philosophy. All of them agreed that AP/FD TCAS Mode represents a fundamental safety improvement in reacting to TCAS-RAs.