

Airbus Industrie Flight Safety

A320 Accident - Bangalore

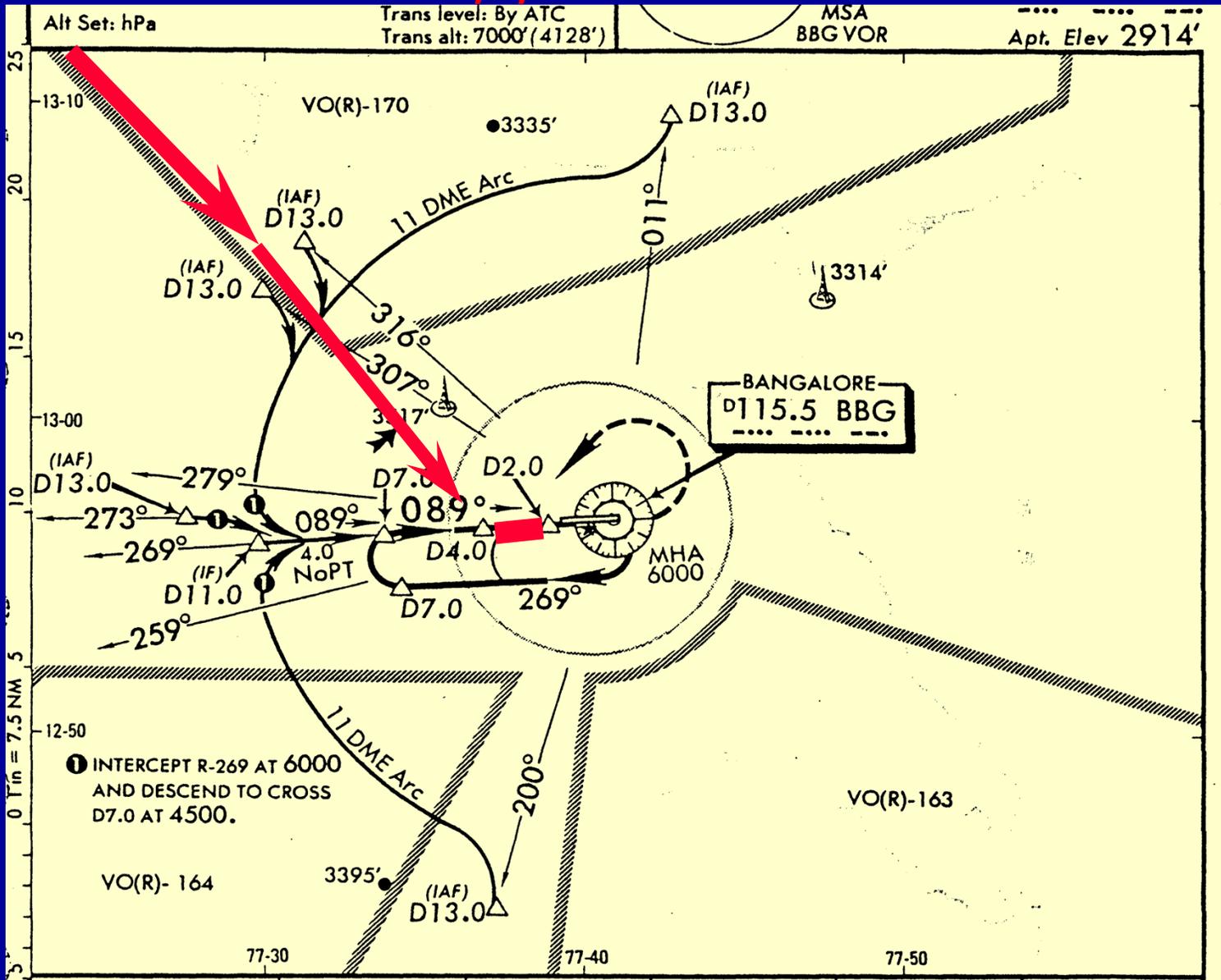
14 February 1990

Accident Scenario

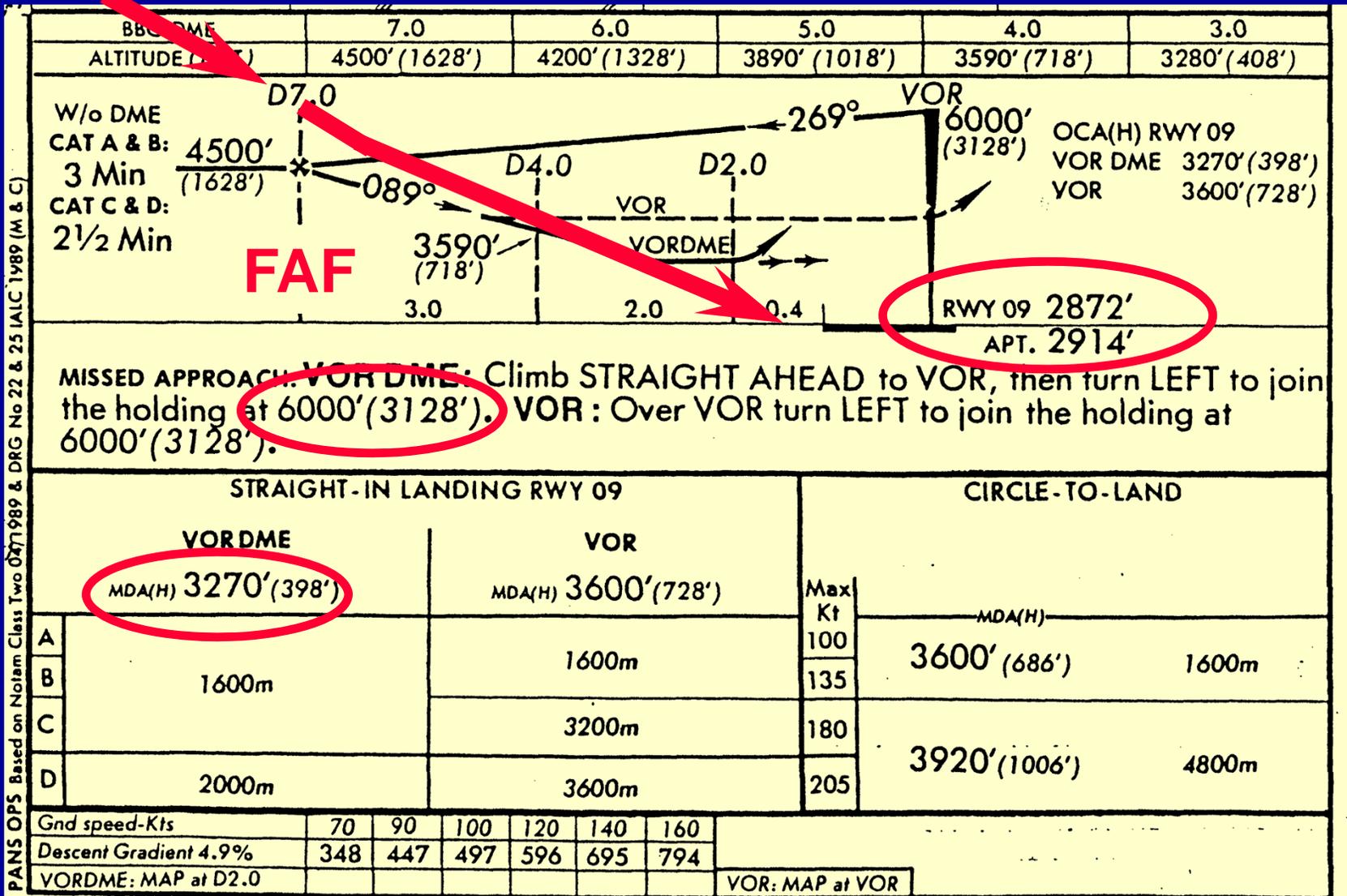
The accident scenario was as follows:

- The aircraft was radar vectored to a visual approach to Runway 09, which was served by a VOR/DME approach.
- It was daylight and the weather was CAVOK.
- The Captain in the left seat (the pilot flying) was undergoing the first of 10 route checks required for qualification as Captain.
- During final approach, the aircraft descended below the normal approach path and crashed about 700 meters prior to the runway threshold.
- 92 people were fatally injured, 54 survived.

VOR / DME 09 Approach



VOR DME RWY 09 (Cont.)



PANS OPS Based on Notam Class Two 0471989 & DRG No 22 & 25 IALC 1989 (M & C)

CHANGES: Arrival route. Thresh elev.

© JEPPESEN SANDERSON, INC., 1985, 1989. ALL RIGHTS RESERVED.

Initial Flight Profile

- **At about 40 DME northwest of the airport, the aircraft was cleared to descent to 6000 feet and vectored for a visual approach to Runway 09.**
- **The approach checklist was initiated when the aircraft passed 8500 feet.**
- **At 10 miles from touchdown, the aircraft was cleared to descend to 4600 feet (1700 AGL).**
 - **FAF = 4500.**
- **The Autopilot and the Autothrust system were engaged and the aircraft was descending in “Idle - Open Descent” mode.**

Initial Flight Profile

- **At 7 miles west, the flight was cleared for the visual approach.**
 - The Auto Pilot was disconnected.
 - The Captain in the left seat started hand flying.
 - The Flight Directors and Auto Thrust system were in the “Idle - Open Descent” mode.
- **At this point, the aircraft was significantly above the desired descent path.**
 - The aircraft was descending at about 135 knots with Flaps Full and Gear Down.
- **At about 5 nm, the aircraft was descending through 2100 feet QFE (about 5000 MSL).**

Intermediate Flight Profile

- At this point (2100 QFE), the ALT* mode activated to capture the FCU selected altitude of 4600 feet.
- Shortly thereafter, the PF requested “Go Around altitude 6000 feet”.
- The Check Airman apparently selected 3300 feet (minimums for the VOR/DME approach) in the FCU altitude window.
- The Check Airman then suggested that the PF use Vertical Speed mode to continue the descent.
- The PF told the PNF to select minus 1000 fpm.

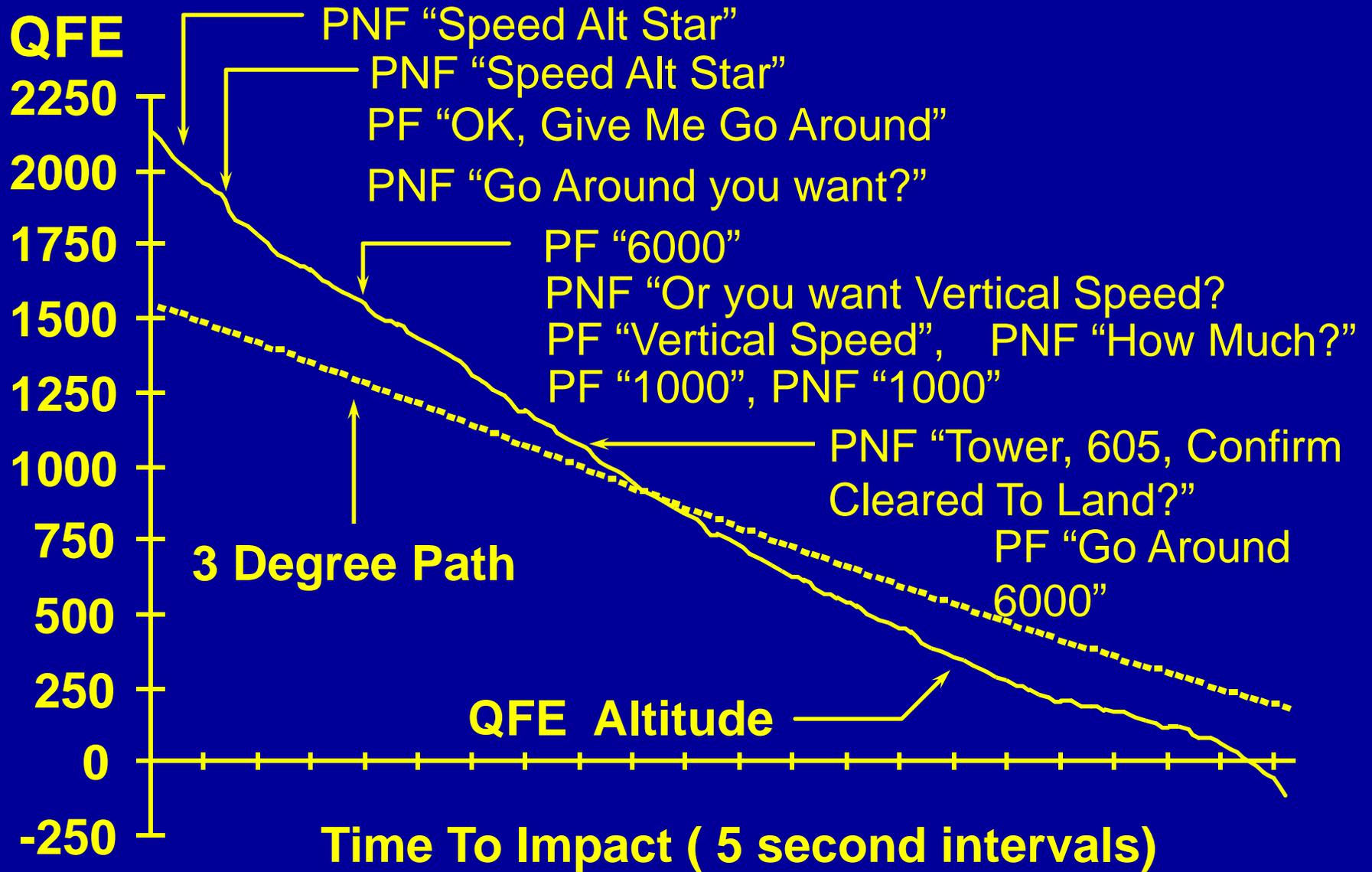
Intermediate Flight Profile

- At about 1300 feet QFE (4200 QNH), the PF again requested “Go Around altitude 6000 feet”.
- For reasons unknown, the Check Airman never acknowledged this request and did not change the FCU selected altitude.
- At about 1000 feet QFE (3900 QNH), the flight was cleared to land and the landing checks were completed.

Intermediate Flight Profile

- At about this point, the aircraft was passing through the desired 3 degree approach path.
- The FD and ATHR systems were in “Speed - Vertical Speed” mode with 132 knots and minus 1000 fpm selected.
- Apparently the PF was not following the Flight Director commands because the actual speeds were stable at about 142 knots and 1500 fpm.
- This meant that the engines were commanded to idle.

Final Approach Profile



The Last 1000 Feet

- **At about 600 feet QFE (3500 QNH):**
 - The aircraft was about 130 feet below the desired flight path.
 - The Auto Thrust system was in Speed mode.
 - The Flight Director was in Vertical Speed mode.
 - The CAS was 136 knots ($V_{APP} = 132$).
 - The Rate of Descent was about minus 1000 fpm.
- **At this point, several things happened very close together.**
- **First, the Flight Director engaged in ALT* mode because the Check Airman had apparently set 3300 feet in the FCU Altitude Select window.**

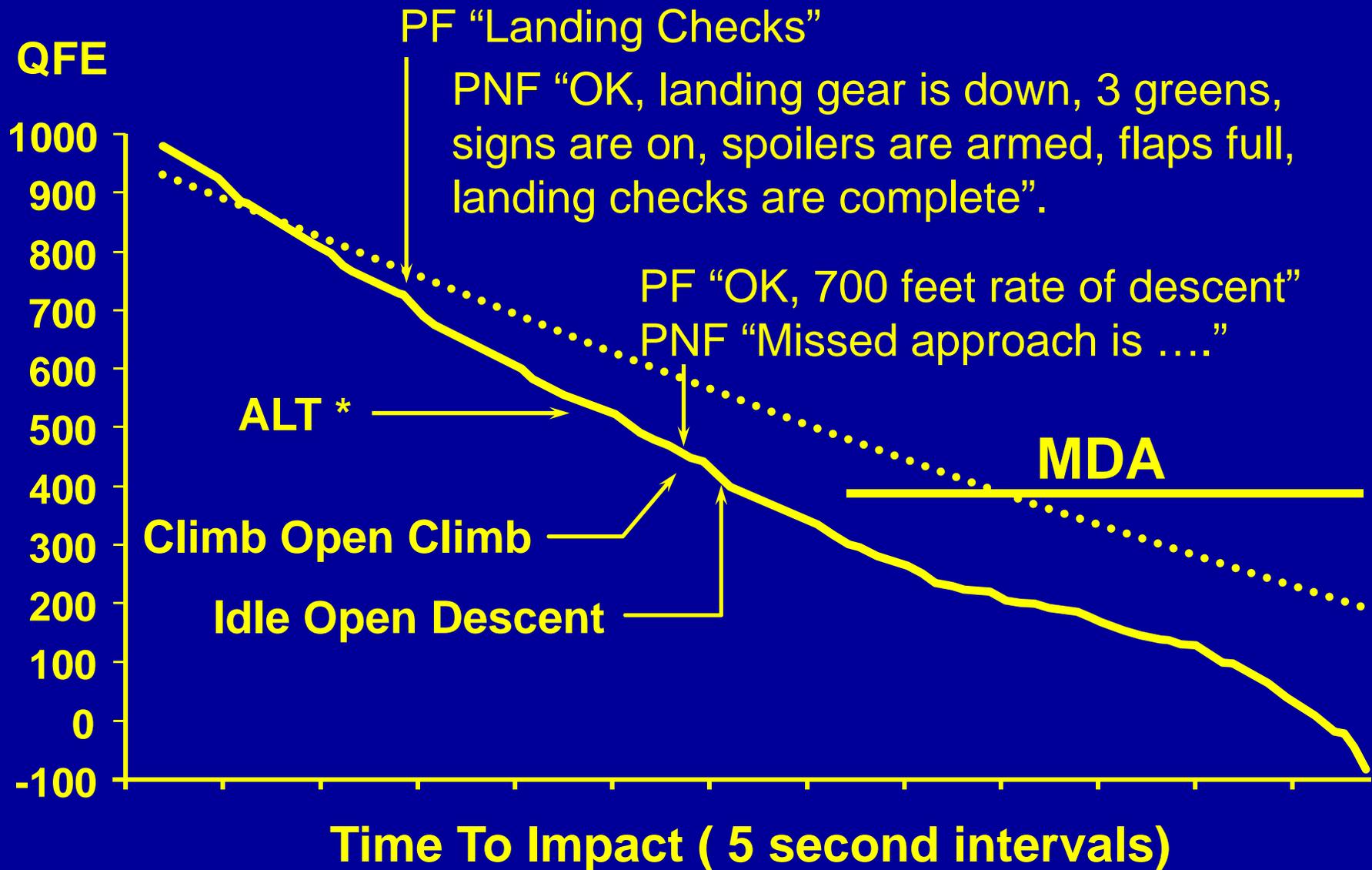
FD / ATHR Mode Changes

- The Pilot Flying then asked for “Vertical Speed 700 ft/min”.
- The Check Airman said “Missed Approach is”, but did not acknowledge the PF request or comply with it.
- At this point, it appears that the FD / ATHR system momentarily engaged in “Climb - Open Climb” mode. This caused the thrust to increase slightly for a brief period.
- The most likely reason for this is that the Check Airman started to set 6000 feet in the FCU while the system was in ALT* mode.

FD / ATHR Mode Changes (Cont.)

- **This would cause the system to automatically revert to “Climb - Open Climb” mode.**
- **Evidently this error was quickly detected by the Check Airman.**
- **The Check Airman then selected an FCU altitude that was below Field Elevation.**
 - This caused the FD and ATHR to engage in “Idle - Open Descent” mode.
 - This mode change was identified a short time later.
 - However, the crew did not change the mode.
 - The use of “Idle - Open Descent” mode was prohibited below 1000 feet AGL.

Flight Profile Below 1000 QFE



The Last 500 Feet

- **At 500 feet AGL, the speed was about V_{APP} and the aircraft was 161 feet below the desired approach path, with the speed decreasing, because:**
 - The Pilot Flying was not following the Flight Director commands (descending about 1200 fpm).
 - The “Idle - Open Descent” mode commanded the thrust to Idle.
- **At the 400 feet auto-callout, the aircraft was:**
 - About 174 feet below the desired approach path.
 - 3 knots slower than V_{app} .
 - Descending about 1000 fpm.

The Last 500 Feet

- **At the 300 feet auto-callout, the aircraft:**
 - Was about 193 feet below the approach path.
 - Was 7 knots slower than V_{app} .
 - Had a vertical speed of about minus 700 fpm.
- **Almost simultaneous with the 300 feet radio altimeter auto-callout, the Check Airman said “You are descending on Idle Open Descent, ha, all this time”.**
 - The Pilot Flying immediately turned off his Flight Director.

The Last 500 Feet (Cont)

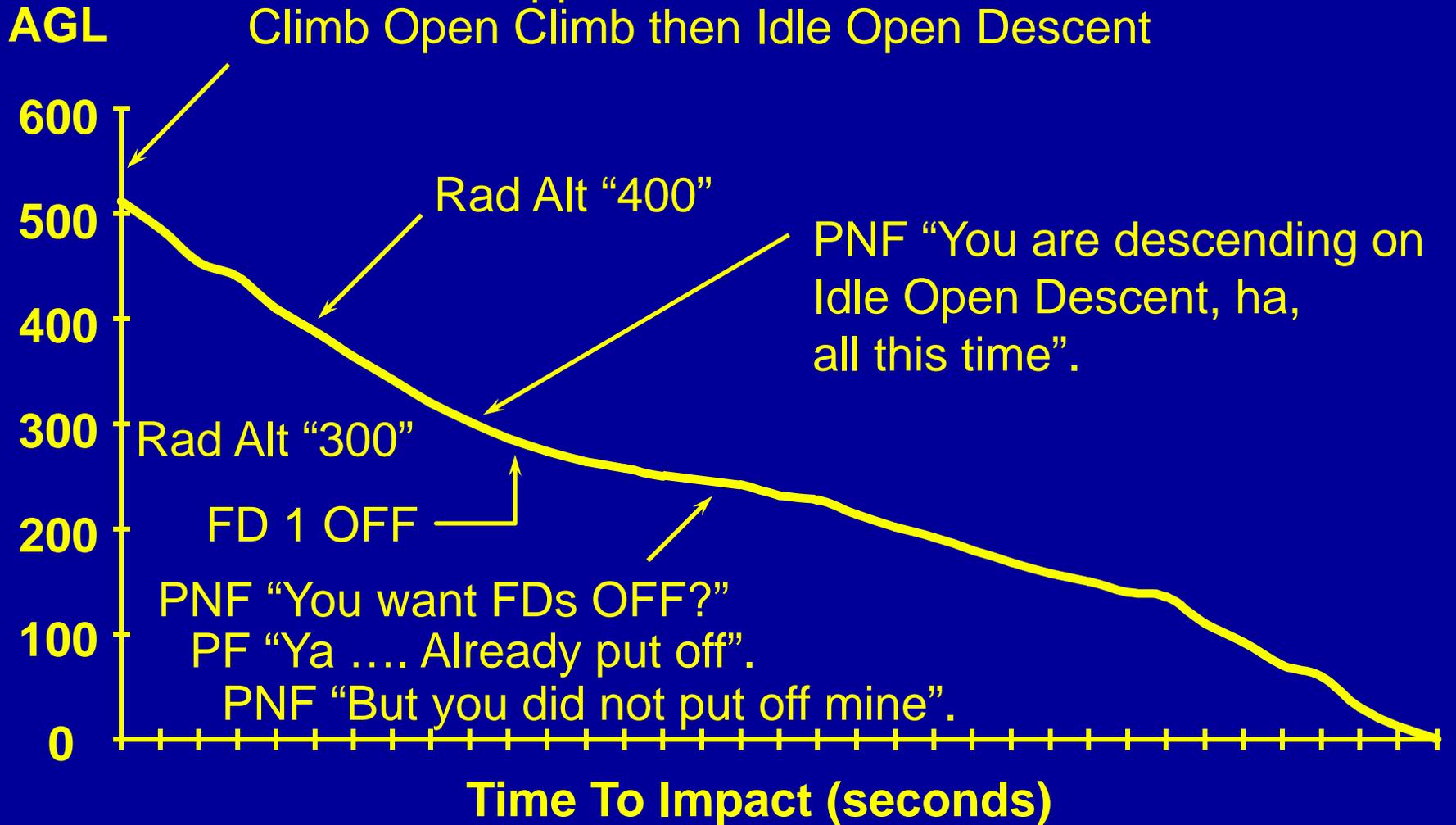
- **The following exchange occurred between the 300 and 200 foot radio altimeter auto-callouts:**
 - Check Airman: “You want FD’s Off now?”
 - PF: “Ya....., already put it off”.
 - Check Airman: “But you did not put off mine”.
- **Between 300 and 200 feet, the aircraft:**
 - Had descended to about 174 feet below the desired approach path.
 - Had decelerated to 118 knots ($V_{APP} - 14$ knots) with the engines still at Idle.
 - Was descending at about 600 fpm.

Last 500 Feet

PF "700 feet rate of descent"

PNF "Missed approach is"

Climb Open Climb then Idle Open Descent



The Last 200 Feet

- **Alpha Prot (Angle of Attack Protection) was activated at about 175 feet AGL.**
 - CAS 114 knots ($V_{APP} - 18$ kts).
 - Engines were still at Idle.
 - Descending about 700 fpm.
- **At about 160 feet AGL, the Check Airman said “You are on the Autopilot still?”**
 - The Pilot Flying says “No, it is OFF”.

Below 200 Feet

- **The reason for this strange comment is unknown. There are at least two possibilities.**
 - The Check Airman was trying to determine why the system was still in “IDLE - OPEN DESCENT” mode.
 - The Check Airman was trying to get the PF to check the FMA and FCU and in doing so realize that the system was still in “IDLE - OPEN DESCENT” because he had not turned the PNF’s FD to OFF.
- **One second later, Alpha Floor (Thrust Protection) activated at about 135 feet AGL.**
 - CAS = 109 kts ($V_{APP} - 23$ kts).
 - Engines were still at Idle.

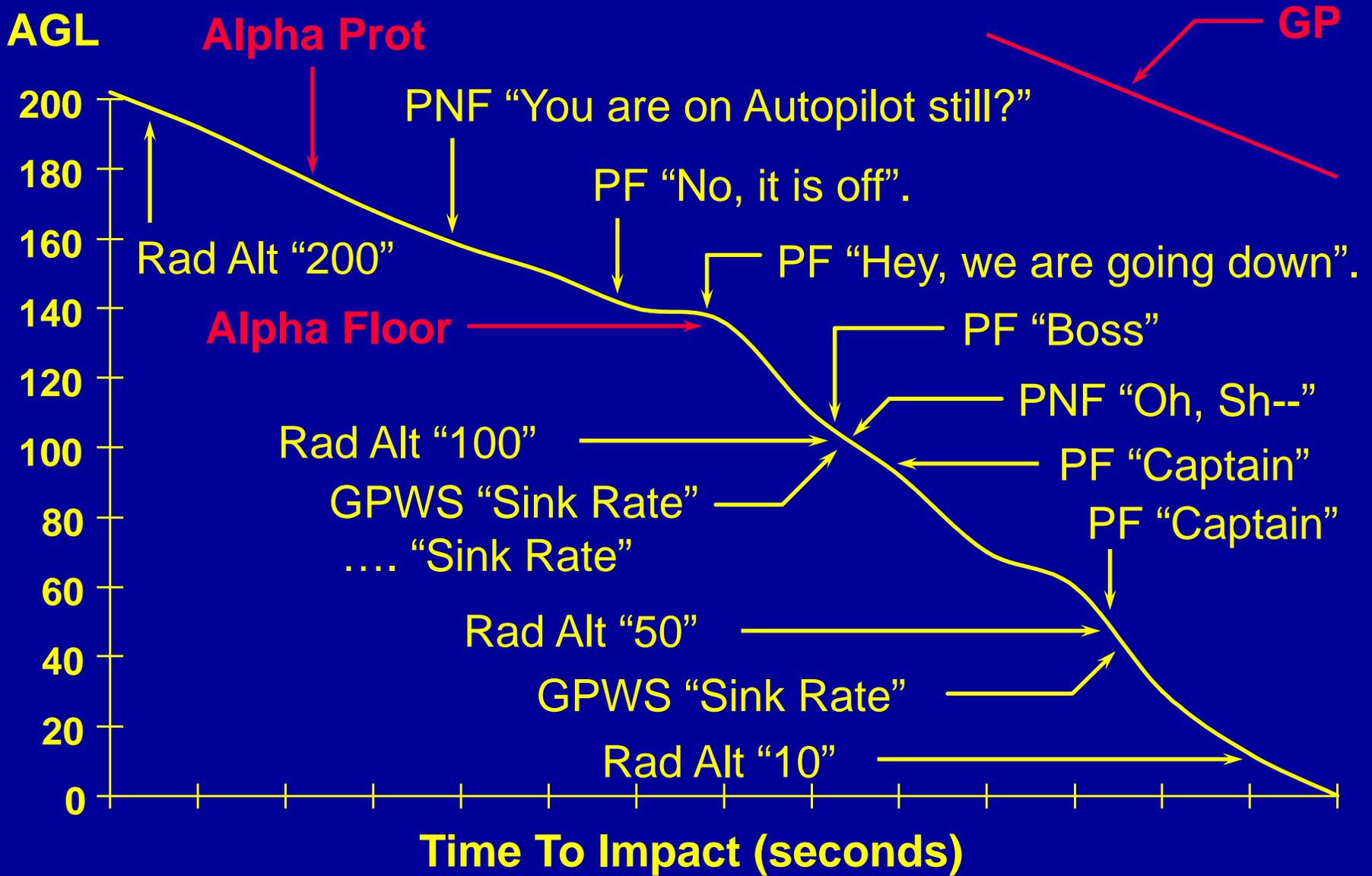
The Last 200 Feet (Cont)

- **Almost immediately thereafter, the Pilot Flying reached full aft stick input and said: “Hey, we are going down”.**
 - The descent rate increased to about 1300 fpm.
- **At the 100 feet radio altimeter callout, the Check Airman said: “Oh S...” and the GPWS “Sink Rate” warning was activated.**
- **The Thrust Levers were also rapidly moved to TOGA.**
 - However, this had no practical effect since the Alpha Floor function had already commanded maximum thrust and the engines were responding normally.

The Last 50 Feet

- **Simultaneous with TOGA selection, the Check Airman applied full aft stick input.**
 - However, this had no practical effect since the Pilot Flying had been applying full back stick input ever since the aircraft descended below 100 feet.
- **The aircraft touched down firmly on a golf course with a CAS of about 113 knots with the engines spooling up normally.**
- **The aircraft bounced and impacted a dike about 700 meters prior to the runway threshold. Both engines were sheared off and the aircraft caught fire.**

Flight Profile - Last 200' AGL



Probable Cause

- **The Commission of Investigation determined that the cause of the accident was as follows:**
 - “Failure of the pilots to realize the gravity of the situation and respond immediately towards proper action of moving the throttles (even after callouts of 400, 300, and 200 feet) in spite of knowing that the plane was in Idle Open Descent mode.”

Contributing Factors

- **In addition to the probable cause, the following factors contributed to the accident.**
- **Failure of the crew to monitor speed and approach path, apply normal approach procedures, and take timely action to initiate go-around.**
- **Inadequate communications between the pilots:**
 - Normal procedures and checklist items were not complied with resulting in failure to callout deviations in approach profile and speed.

Contributing Factors (Cont)

- **Use of an unapproved mode of the Flight Directors and Auto Thrust System during the approach.**
 - This mode was identified and called out, but no action was taken to change the mode.
- **The Captain trainee in the left seat stopped acting as Captain and the Check Airman stopped acting as First Officer.**

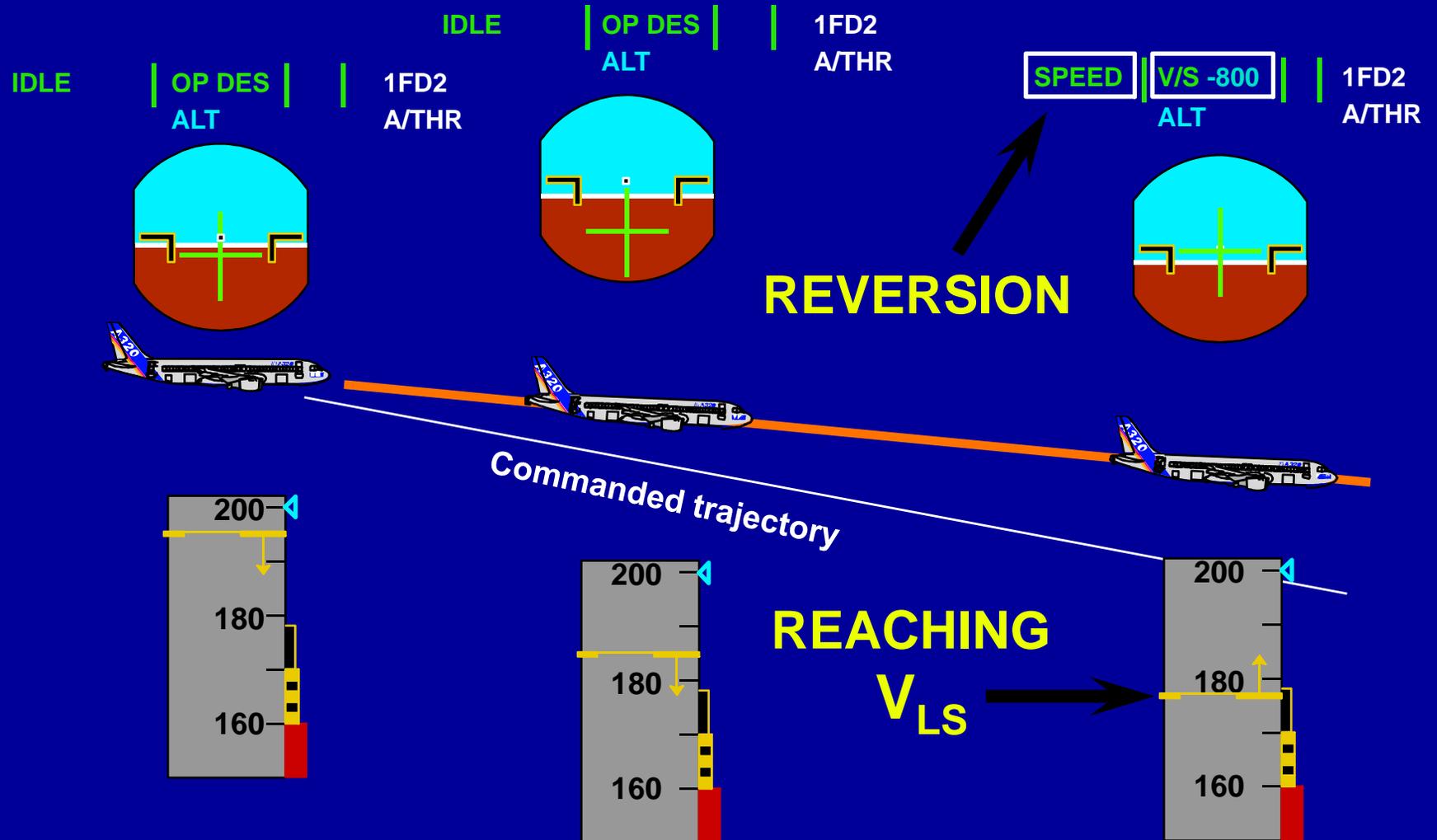
Safety Enhancements

- Airbus Industrie developed several modifications to enhance safety.
- The first modification will change the Flight Director mode from “Idle - Open Descent” to “Speed - Vertical Speed” if the Speed decreases to V_{LS} .
 - The ATS then maintains the selected speed and the FD provides commands to maintain the actual vertical speed at the time of the reversion.

Reversion At V_{LS}

F/D and A/THR reversion from THRUST to SPEED mode at V_{LS}/V_{MO}

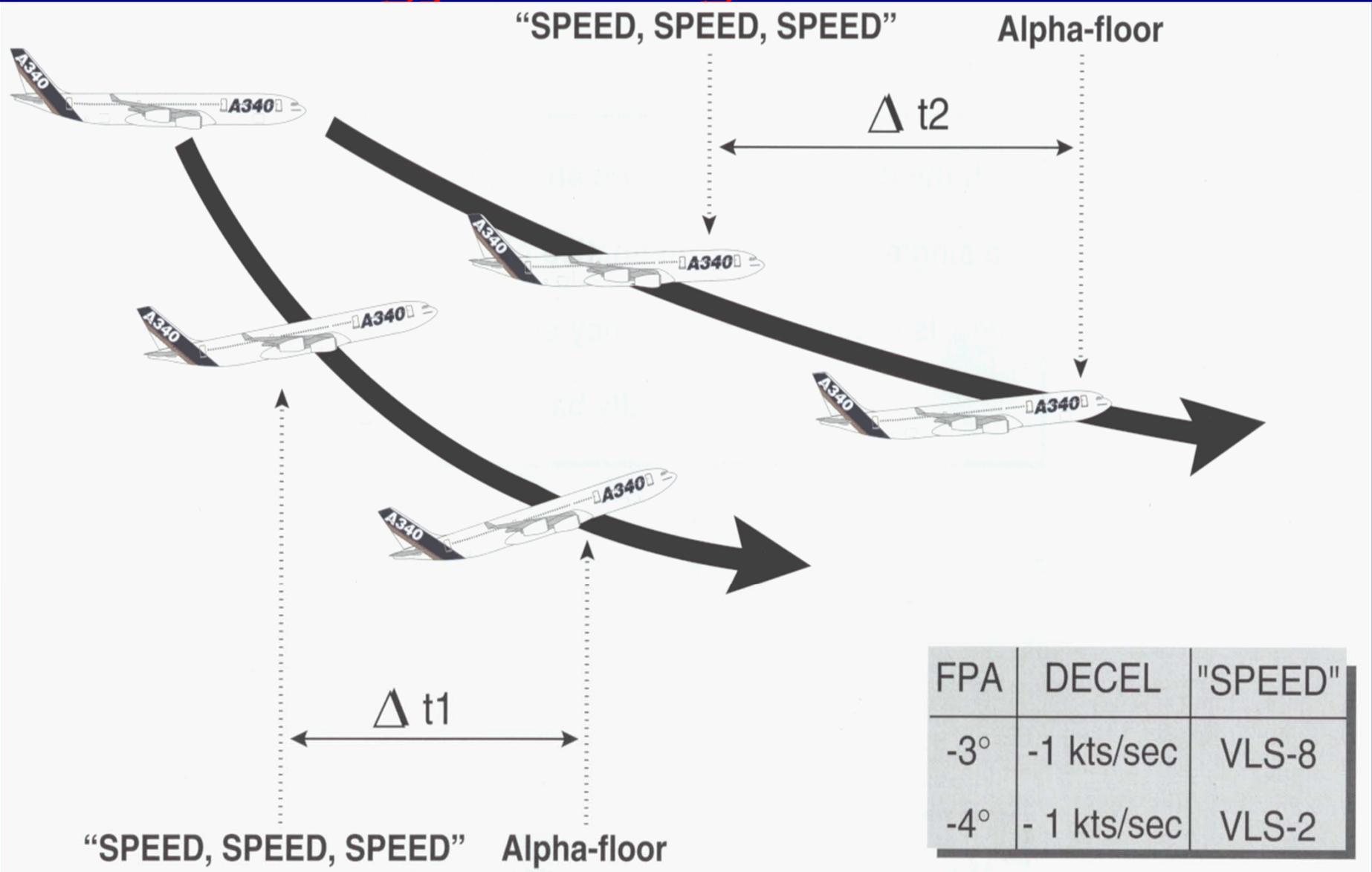
- On A320



Safety Enhancements (Cont)

- A second modification was developed to enhance “low energy awareness”.
- This change provides an automatic callout “Speed, Speed, Speed” to increase speed awareness when the CAS decreases below the Low Energy Warning Threshold.
 - V_{LS} minus 2 knots for a -3 degree flight path and deceleration of 1 kt/sec.

Low Energy Warning

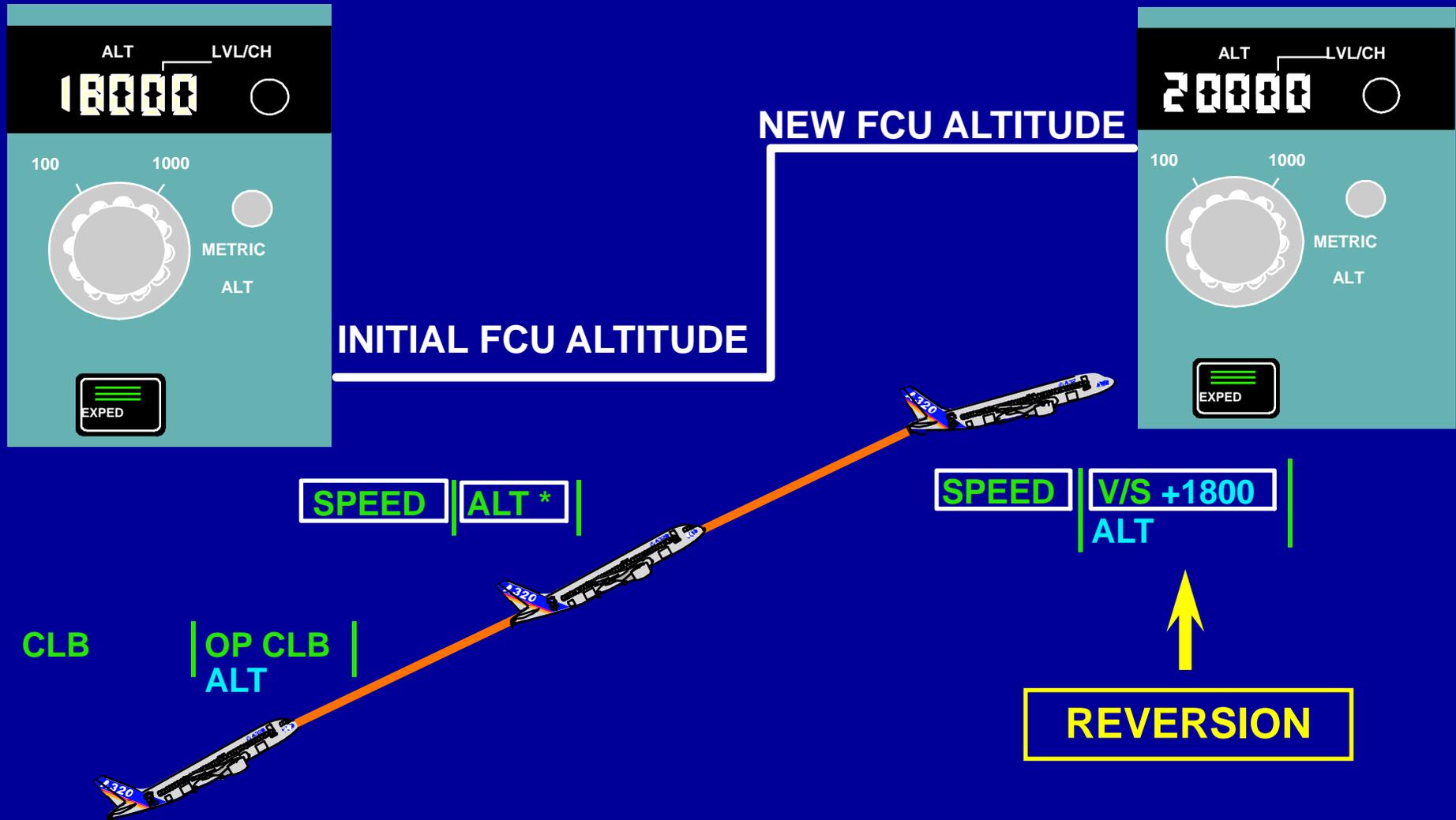


Inhibit "Idle - Open Descent"

- **Another modification changes the reversion which occurs when the selected altitude is changed while in ALT*.**
 - Before mod: Reversion to Idle Open Descent
 - After mod: Reversion to V/S with target V/S = V/S at time of reversion.

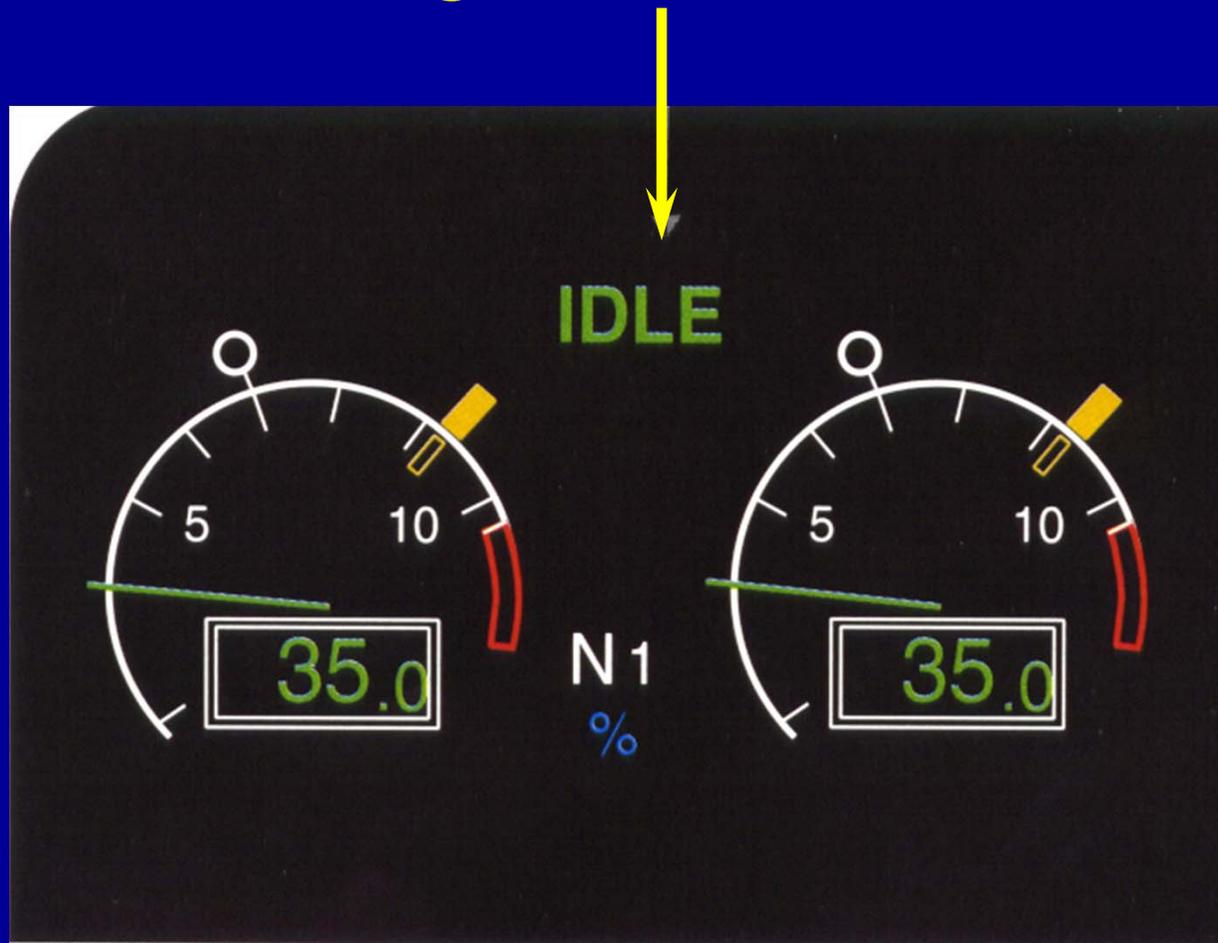
Inhibit "Idle - Open Descent"

Reversion from ALT* to V/S due to FCU selected altitude change



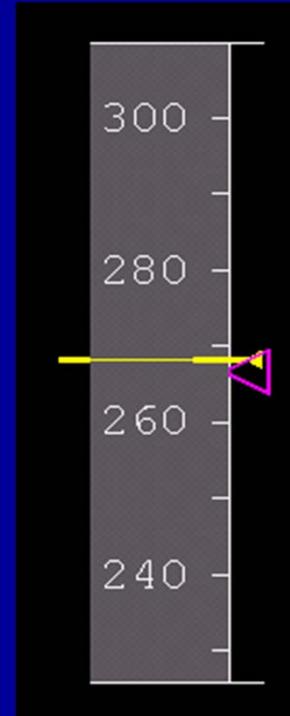
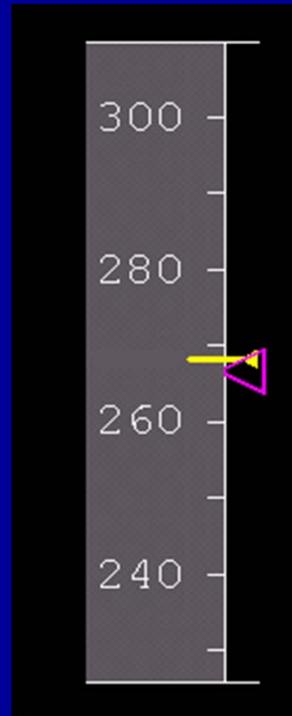
Enhanced IDLE Indication

- A modification was introduced to enhance the Idle Indication on the engine instrumentation.



Other Miscellaneous Modifications

- **Enhance the readability of the CAS lubber line on the PFD.**



Other Miscellaneous Modifications

- **Increase the Approach Idle setting for the V2500 engines by 2.5%.**
 - This modification was associated with CAT III certification and was not specifically related to the Bangalore event.

Implementation of Modifications

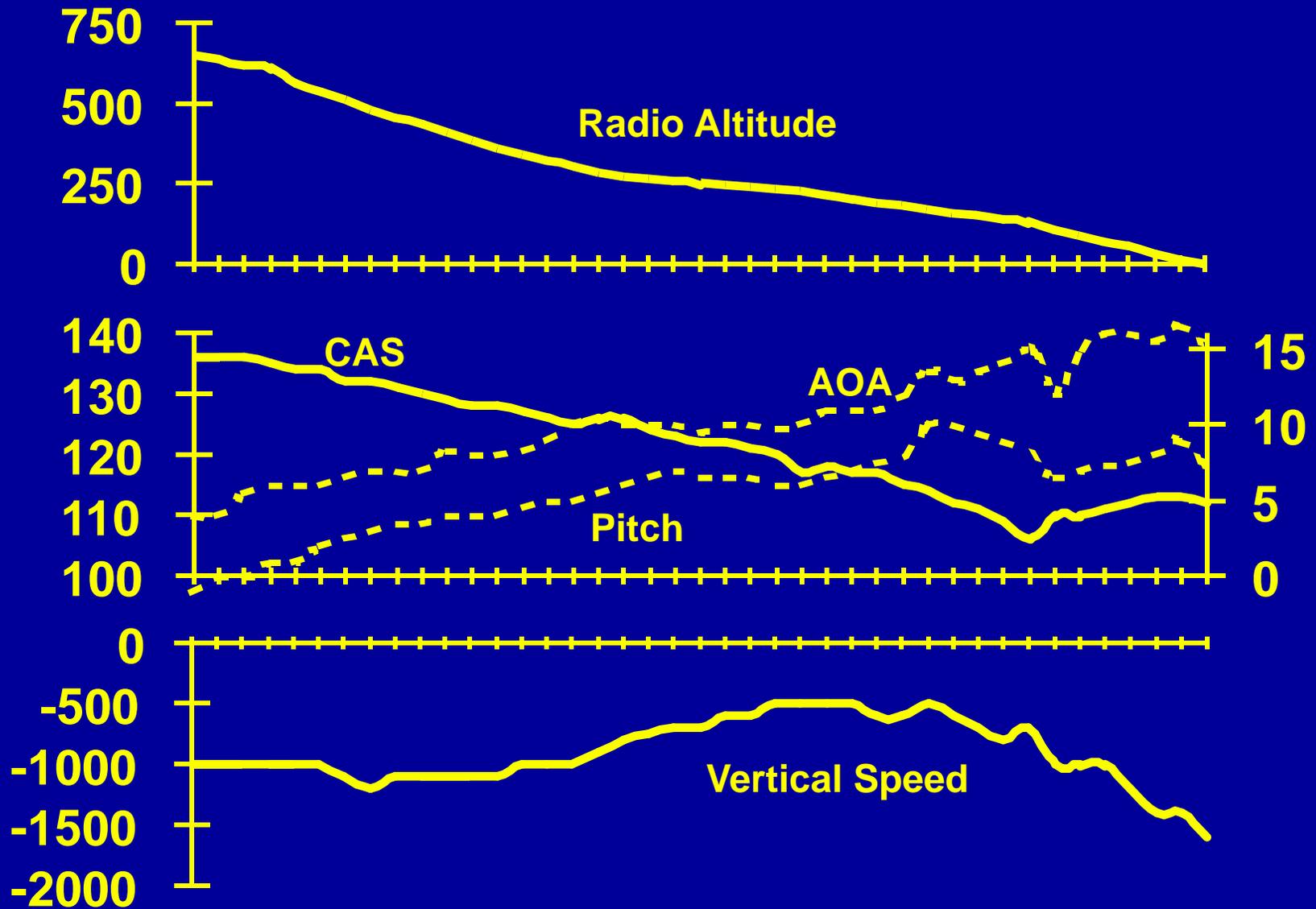
- All of these modifications are incorporated in newly manufactured aircraft.
- These modifications are also available to retrofit existing aircraft.

A320 Accident - Bangalore

Thank You For Your Attention

Do You Have Any Questions?

DFDR Data - Final Approach



DFDR Data - Final Approach (Cont)

