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Radio Altimeter erroneous values

1. Introduction

In-service events occurred where a Radio Altimeter (RA) provided an erroneous height indication, which was recognized as valid information by the aircraft systems. This resulted in an early flare activation during the approach.

In response to these events, Airbus launched a series of investigation that led to the following conclusions:

in the most critical scenario, an early activation of the flare law may lead to an increase of the Angle of Attack which, if not corrected, could reach the stall value. All Airbus aircraft are affected except the A380.

As a result of these investigations, Airbus published:

- A set of Operator Information Telex/Flight Operations Telex (OIT/FOT) and Red Operations Engineering Bulletins (OEB) describing the operational consequences, and containing recommendations to follow, should a RA provide erroneous height readings.
- New tasks in the Trouble Shooting Manual (TSM) and Maintenance Planning Document (MPD) related to the RA antennas and coaxial cables.

Erroneous RA occurrences should be systematically reported so as to allow proper implementation of the recommended maintenance tasks. These consist in the inspection of the RA antennas coaxial cables, cleaning of the antennas and possibly replacement of the RA.

Design improvements are currently under development on the Radio Altimeter as well as on other aircraft systems, in order to better detect RA errors and to avoid untimely flare engagement.

2. System architecture

All Airbus aircraft, except the A380, are equipped with two RAs, which provide height information to several aircraft systems (fig. 1).

The A380 is fitted with three RAs, which provide the aircraft's systems with a single median height value. As a result of this system architecture, a single erroneous RA height indication is not an issue for the A380.

This article will therefore concentrate on the other members of Airbus' family of aircraft, fitted with two Radio Altimeters.

These two RAs provide height information to the Auto Pilots (AP), Auto Thrust (A/THR), Primary

Flight Displays (PFD)/ Navigation Displays (ND), Weather Radar (WXR), Flight Warning Computers (FWC), Traffic Alert and Collision Avoidance System (TCAS) and all audio indicators.

Height information is received from one RA at a time. In case of detected failure, the remaining RA is used as a back-up.

The following systems are designed to receive an RA signal from only a single source:

- On all aircraft models the Terrain Awareness and Warning System (TAWS) receives signals from RA1 only.
- On the A300B2/B4, A300-600 and A310, the Auto Pilot/ Flight Director use only their on-side RA.

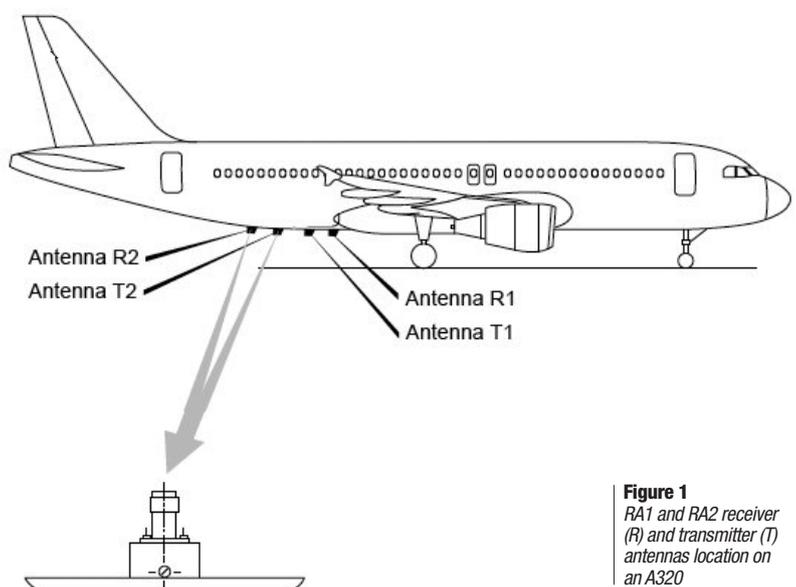


Figure 1
RA1 and RA2 receiver (R) and transmitter (T) antennas location on an A320

3. Typical cause of erroneous RA height indications

In-service experience has shown that a Radio Altimeter may provide erroneous height indications due to a direct link between the transmitter and the receiver antennas, without ground reflection. This can be related to causes that are either internal or external to the RA system.

The internal causes may be linked to:

- ▶ Water flow on the antennas, e.g. due to a defective drain valve.
- ▶ Water ingress into the RA antenna installation affecting the antennas, and potentially the coaxial cables.
- ▶ Carbon dirt or ice accretion on the antennas.
- ▶ Degraded installation at connectors level.

The external causes may be linked to aircraft flying over:

- ▶ Other aircraft, hail clouds or bright spots, i.e. terrain presenting reflectivity variations.
- ▶ Runways contaminated with water or snow.

In these cases, the RA condition may not be detected by the systems, which continue to use the erroneous RA values. A value of -6ft has been observed in a number of events.

4. Operational consequences and recommendations

An erroneous RA height indication may have effects on the:

- ▶ Primary Flight Displays (PFD)
- ▶ Systems Displays (SD)
- ▶ Warnings and callouts
- ▶ Auto Flight System mode changes
- ▶ Aircraft protections, such as the unavailability of the High Angle of Attack Auto Pilot disconnection.

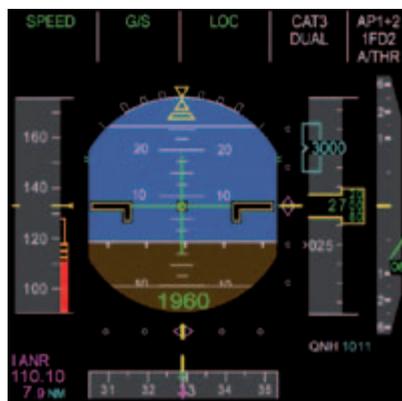
The two following examples illustrate possible effects of an erroneous RA indication on an A320 Family/A330/A340 aircraft:

a) Indication lower than real height on RA1 during an ILS approach, with both APs/FDs engaged:

▶ Figure 2 shows the crew's PFDs before the RA1 issue. Both RAs function properly and provide the same height of 1 960 ft. The vertical mode is on G/S, and the lateral mode is on LOC. The A/THR is engaged in SPEED.

▶ Figure 3 RA 1 provides an erroneous height indication of - 6 ft, while RA 2 delivers the correct height of 1 400 ft.

Figure 2
Both RAs provide correct height of 1 960 ft



AP1+2 Engaged



F/O



Figure 3
Erroneous RA 1 reading is - 6 ft, correct RA 2 reading is 1 400 ft. Both AP/FDs are engaged



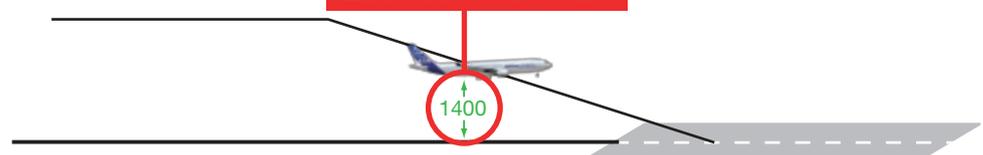
AP1+2 Engaged



Captain

Erroneous RA

F/O



► RA 2 provides height information to PFD 2 and to AP 2.

Therefore:

- The RA reading on PFD 2 is 1 400 ft
- AP 2 is still engaged in G/S vertical mode and LOC lateral mode. PFD 2 therefore displays “G/S” and “LOC” on the FMA.

► AP 1 is engaged in FLARE mode and one RA height goes below 200 feet. In addition, the difference between both RA height indications is greater than 15 feet.

Therefore:

- The AUTOLAND warning lights are activated.



b) Indication lower than real height on RA1 during an ILS approach, with AP 1 and both FDs engaged:

► Figure 4 shows the crew’s PFDs before the RA1 issue. Both RAs function properly and provide the same height of 1 960 ft. The vertical mode is on G/S, and the lateral mode is on LOC. The A/THR is engaged in SPEED.

► Figure 5 shows that RA 1 provides an erroneous height indication of – 6 ft, while RA 2 delivers the correct height of 1 400 ft.

Consequences on the aircraft’s systems:

► RA 1 provides height information to PFD 1, AP 1 and to the A/THR (the A/THR uses the same RA as the master AP).

Therefore:

- The RA reading on PFD 1 is – 6 ft
- AP 1 engages in FLARE mode and displays “FLARE” on the FMAs of PFD 1 and PFD 2.
- The A/THR engages in RETARD mode and displays “THR IDLE” on the FMAs of PFD 1 and PFD 2.

► RA 2 provides height information to PFD 2.

Therefore:

- The RA reading on PFD 2 is 1 400 ft.

► AP 1 is engaged in FLARE mode and one RA height goes below 200 feet. In addition, the difference between both RA height indications is greater than 15 feet.

Therefore:

- The AUTOLAND warning lights are activated.



Figure 4
Both RAs provide correct height of 1 960 ft

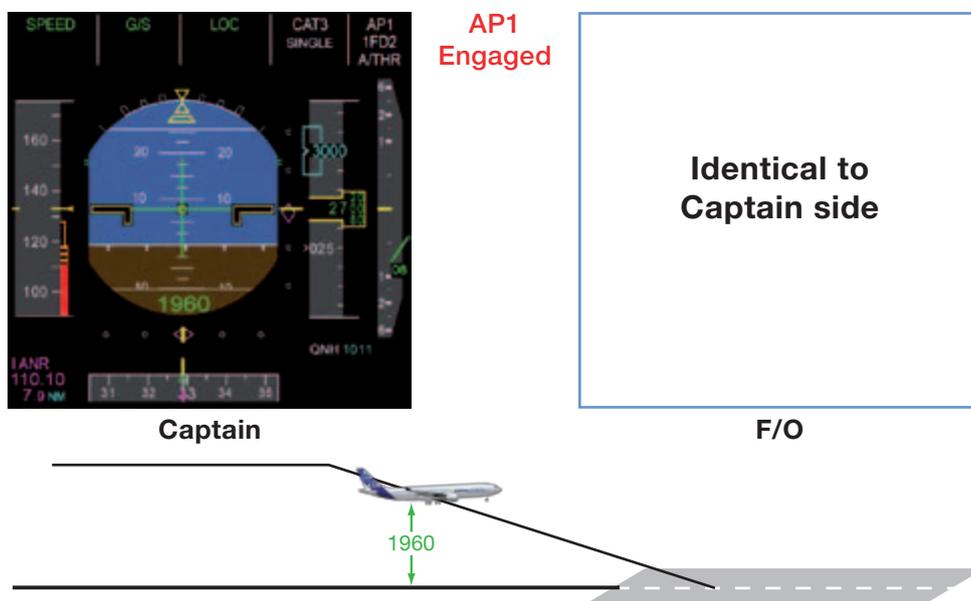
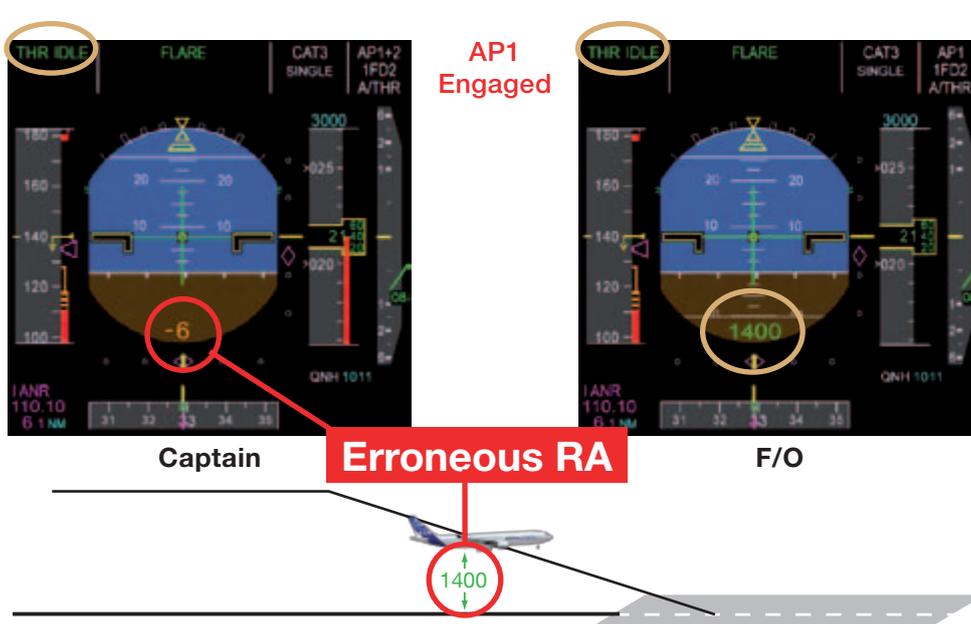


Figure 5
Erroneous RA 1 reading is – 6 ft, correct RA 2 reading is 1 400 ft. AP 1 and both FDs are engaged



In the examples above, the risk of early flare engagement due to the too low height indication is compounded by the possible impact on the aircraft protections. On the A320 Family, for example, the CONF FULL High Angle of Attack Auto Pilot disconnection is not available in the event of a very low erroneous RA height indication.

Therefore, if a manual takeover is not performed when this early flare engagement occurs, the Angle Of Attack will increase and may reach the stall value.

The detailed effects on aircraft protection on the A300/A310, A320 and A330/A340 families can be found in the OIT / FOT and OEB referenced at the end of this article. These documents include as well the following operational recommendations in the event of an erroneous RA height reading:

- ▶ During all phases of flight, the flight crew must monitor and crosscheck all primary flight parameters and FMA indications.
- ▶ During ILS (or MLS, GLS) approach with AP engaged, in the event of an unexpected THR IDLE and FLARE modes engagement, the flight crew must immediately react as follows:
 - **Immediately perform an automatic Go Around** (thrust levers set in TOGA),
- Or
- **Immediately disconnect the AP**, then continue the landing using raw data or visual references (FDs set to OFF) or, perform a manual Go Around with thrust levers set to TOGA (significant longitudinal sides-tick input may be required).

See OEB for detailed procedures

Several symptoms may assist the crew in identifying a potential erroneous RA reading:

- ▶ Untimely ECAM L/G NOT DOWN warnings
- ▶ Untimely or no “RETARD” callout
- ▶ Interruption of, or no RA automatic callout

- ▶ Untimely TAWS alert (“PULL UP” or “TERRAIN AHEAD”)
- ▶ Impossible NAV mode engagement after takeoff
- ▶ Pulsing Cabin Differential Pressure Advisory on ECAM CAB PRESS page.

In addition to the above cockpit indications, RA fault messages from the Electrical Flight Control System (EFCS) may also be recorded in the Post Flight Record.

The Flight crews must report any of the above symptoms in the aircraft technical logbook, in order to ensure no dispatch with an erroneous RA.

5. Maintenance recommendations

If the flight crews report symptoms of an erroneous RA height indication, the following maintenance actions should be performed:

- ▶ Clean the RA antennas and the adjacent area with cleaning agents (Material N° 11.010) and a lint free cloth
- ▶ If, during any subsequent flight, the symptoms persist:
 - Replace the RA antennas
 - Inspect the RA antennas coaxial cables. If they are not in correct conditions, repair or replace them.

These recommendations have been added in the following new TSM tasks:

- ▶ 34-42-00-810-844 (A320 Family)
- ▶ 34-42-00-810-862 (A330/A340)
- ▶ 34-42-00-006-00 (A300/A310).

In addition, scheduled maintenance (MPD) include new tasks related to the RA:

- Every 6 months: RA antenna surface cleaning
- Every 12 years: replacement of RA antennas and RA coaxial cables during the heavy maintenance visit for the structure section.

6. Design Improvements

The following improvements are being implemented in the RA system as well as in the aircraft systems which use the RA information:

- ▶ RA system:
 - A new gel gasket, between the antenna and the aircraft structure, will provide better isolation against water ingress.
 - A digital RA, with self monitoring capability to eliminate the erroneous heights, is under certification.
- ▶ Aircraft systems:
 - Both the Auto Pilot and flight control systems will be enhanced to detect most RA erroneous height values.

7. Conclusion

The aircraft systems may not always detect an erroneous Radio Altimeter value. Depending on the flight phase and AP/FD and A/THR status, prompt action from the crew may be required to prevent the consequences of such situation.

It is essential that the crew identifies the symptoms of an erroneous RA reading so as to:

- ▶ Take immediate actions.
- ▶ Report these symptoms to help maintenance teams troubleshoot erroneous RA readings.

References:

OIT/FOT SE 999.0034/09 dated 4th May 2009 for A320/A330/A340 operators

- ▶ A318/A319/A320/A321: RED OEB 201/2
- ▶ A330: RED OEB 076/2
- ▶ A340: RED OEB 091/2

OIT/FOT SE 999.0035/09 dated 30th April 2009 for A300/A310 operators (no RED OEB as the operational consequences are different than for the A320/A330/A340).

The OIT/FOTs and OEBs are not applicable to the A380.

Safety First

The Airbus Safety Magazine

For the enhancement of safe flight through increased knowledge and communications

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A380
Water pool test

Safety First, #11 January 2011. Safety First is published by Airbus S.A.S., 1, rond point Maurice Bellonte, 31707 Blagnac Cedex/ France. Editor: Yannick Malinge, Chief Product Safety Officer, Nils Fayaud, Director Product Safety Information. Concept Design by Airbus Multi Media Support Ref. 20101536. Computer Graphic by Quat'coul. Copyright: GSn°420.0190/10. Photos copyright Airbus. Photos by ExM Company: H. Berenger, P. Masclat, H. Goussé. Printed in France by Airbus Print Centre.

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