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Pierre Labro is an accident investigator within the Product Safety team of Airbus, since 2021. As one of the investigation team, he is an Airbus technical advisor to the Bureau d'Enquête et d'Analyse of France (BEA) and to the Transportation Safety Board of Canada (TSB) for the A220. His scope of activities involves any aircraft of the Airbus fleet whatever the nature of the investigation.

Prior to becoming an incident/accident investigator, Pierre was a flight data recorders specialist and analyst and was involved in a number of major cases, for 6 years.
Before, Pierre was working for the flight test department and was involved in the A380 certification phase and deliveries to Customers for 10 years.
Since joining Airbus in 2002, he has accumulated over 20 years of experience within maintenance, systems, flight test, engineering, flight data recorders and product safety domains.

Incorrect QNH during a barometric approach

INTRODUCTION

Using an erroneous barometric reference setting during approach may cause the aircraft to fly lower than the published approach path, when the vertical guidance and trajectory deviations use the barometric reference. This can lead to a risk of controlled flight into terrain in poor visibility conditions or at night.

This article explains the potential consequences of an erroneous barometric reference. It also provides guidance to flight crews on how to detect it, and describes the available system enhancements to alert flight crews when an erroneous BARO reference is detected.

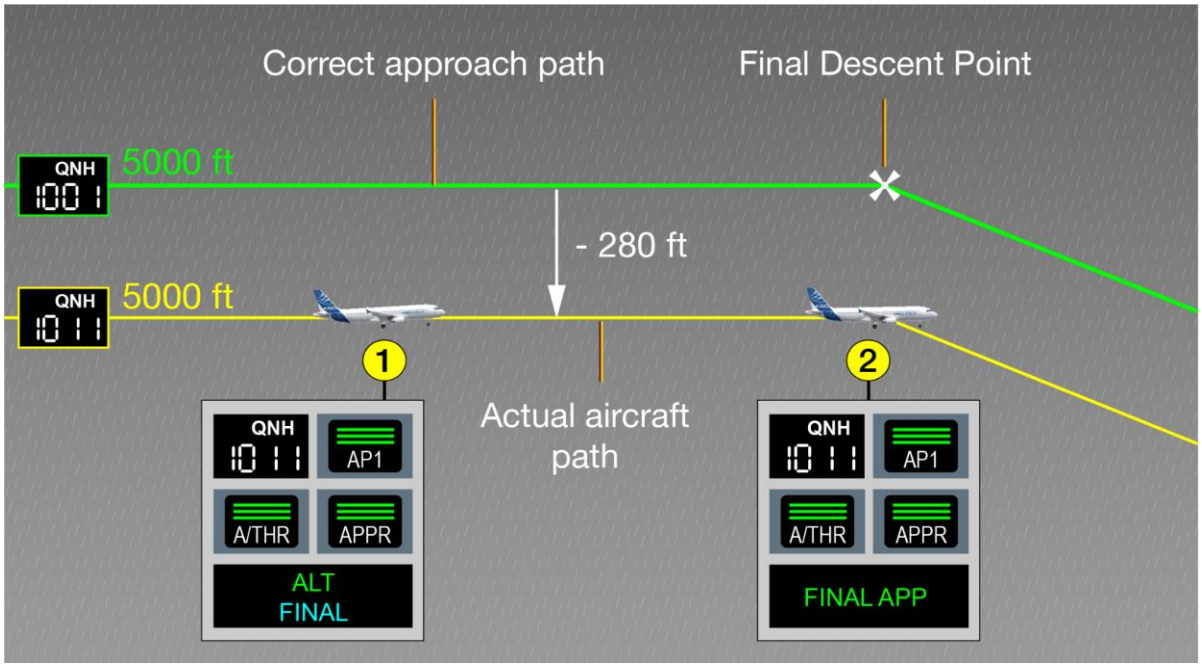
CASE STUDY

Event Description

The flight crew of an A320 was preparing for an RNP approach with LNAV/VNAV minima toward its destination airport, before initiating descent from their cruise Flight Level. The ATIS provided them with an airport QNH of 1001 hPa.

During the descent, ATC cleared the flight crew to descend to 6000 ft QNH 1011 hPa, followed 2 minutes later by a clearance down to 5000 ft QNH 1011 hPa. The flight crew acknowledged both clearances repeating the erroneous 1011 hPa QNH, which was 10 hPa above the current QNH of the airport.

① The aircraft leveled off at 5000 ft QNH 1011 hPa. This placed it approximately 280 ft below the intended altitude of 5000 ft with a correct QNH of 1001 hPa. With autopilot and autothrust ON, the A320 reached its Final Descent Point (FDP) and ② commenced its final descent using FINAL APP guidance mode. The aircraft was flying with no visual reference and light turbulence through a rain shower.



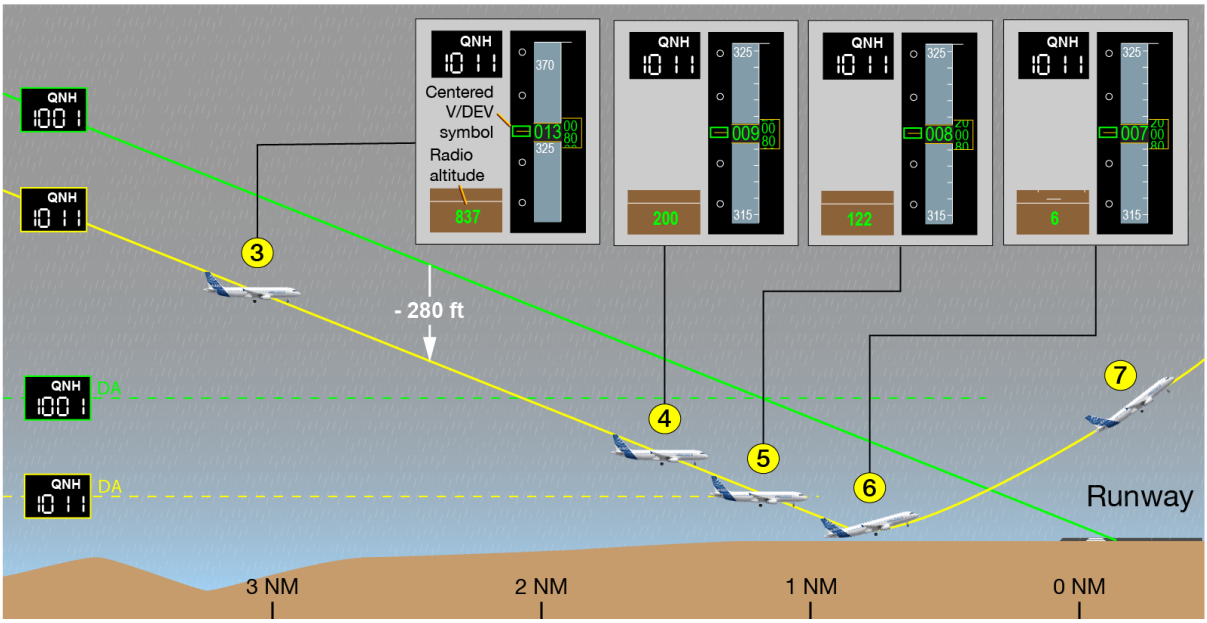
(fig.1) The aircraft commenced its approach 280 ft below the published approach

③ At 1392 ft indicated altitude (1000 ft above the airfield altitude), the aircraft was stabilized in CONF FULL at Vapp and the ND and PFD indicated that it was on its expected horizontal and vertical flight path.

④ ATC received a Minimum Safety Altitude Warning (MSAW) when the aircraft was 1.53 NM from the runway threshold and had an indicated altitude of 891 ft.

⑤ The aircraft passed an 802 ft indicated altitude, corresponding to the Decision Altitude (DA) of the published approach plus 50 ft as per the airline policy. ATC transmitted a warning to the flight crew stating that they had an MSAW and asked the flight crew to confirm they had the runway in sight. The PF initiated a go-around 6 seconds after crossing the DA, at 735 ft indicated altitude.

⑥ The aircraft radio altitude indicated a descent to 6ft during the go-around maneuver. ⑦ The flight crew announced the go-around seconds later and were vectored for a second approach.



(fig.2) After the initiation of the go-around, the aircraft descended as low as 6ft radio altitude before climbing

The second approach was also performed using the erroneous 1011 QNH value. ATC received another MSAW alert and alerted the flight crew. The flight crew had established visual contact with the runway on this approach. They disconnected the autopilot at 572 ft RA, used the PAPI indication to correct their trajectory, and they performed a manual landing.

Event Analysis

During the final approach, the flight crew did not detect the erroneous vertical position because:

- The vertical deviation symbol was centered
- Altitude vs. distance checks were correct
- There was no Terrain Avoidance Warning System (TAWS) alert.

Several RA auto-callouts should have been triggered according to the aircraft configuration. However, the cockpit voice recorder data was deleted during subsequent flights, and was therefore not available to confirm if the auto-callouts were triggered or not.

The runway approach lights were not turned ON for their first approach attempt in poor weather conditions, which made it extremely difficult for the flight crew to visually detect the runway. The lights were switched to ON before the second approach, and the flight crew was able to see the runway and correct their trajectory.

EFFECTS OF AN ERRONEOUS BARO SETTING

An erroneous QNH/QFE value can seriously affect the safety of the flight as presented in the close call event described above.

Barometric altitude shift effect

From the altimetry basics, **a 1 hPa difference in the QNH/QFE value creates a 28 ft shift of the barometric altitude** displayed on the PFD.

Effect on final approach guidance modes

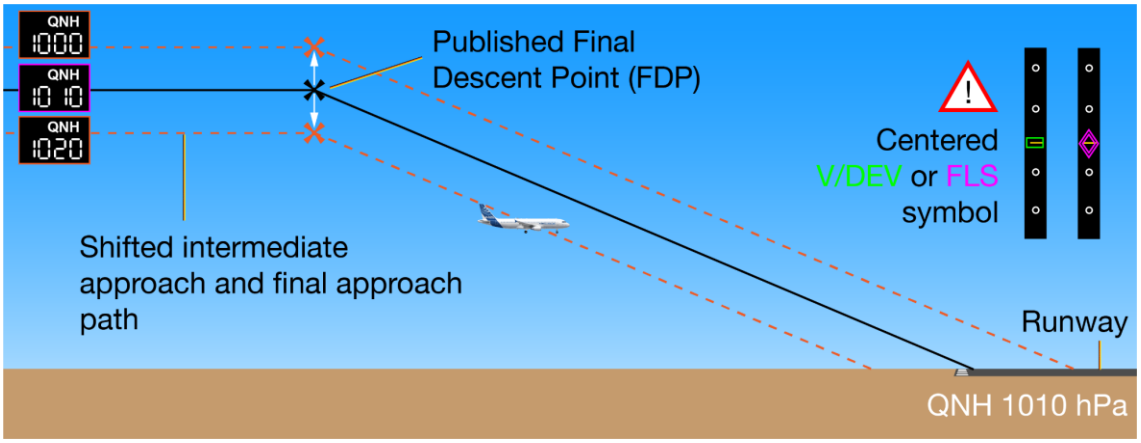
All final approach guidance modes that use the barometric reference are affected by an erroneous entry on the QNH selector.

Selected modes	FPA	V/SPD PITCH	V/S	FPA

(*) Only when RNP is selected for VNAV

Managed guidance

The FMS uses the aircraft barometric altitude to compute the deviation of the aircraft trajectory with the computed final descent path. If an erroneous barometric altitude is used, the aircraft will follow a flight path that is parallel to the published path but is shifted either above or below it. The vertical deviation symbol, or the FLS symbol, will indicate that the aircraft is on the correct flight path even if it is not the case.



(fig.3) Example of the effects of an incorrect BARO setting on A320 family aircraft

Selected guidance

An erroneous barometric setting will also cause the FDP height above ground to be incorrect when using selected guidance. The flight crew is likely to commence final descent from an incorrect height above ground and therefore fly an approach path that is too high or too low.

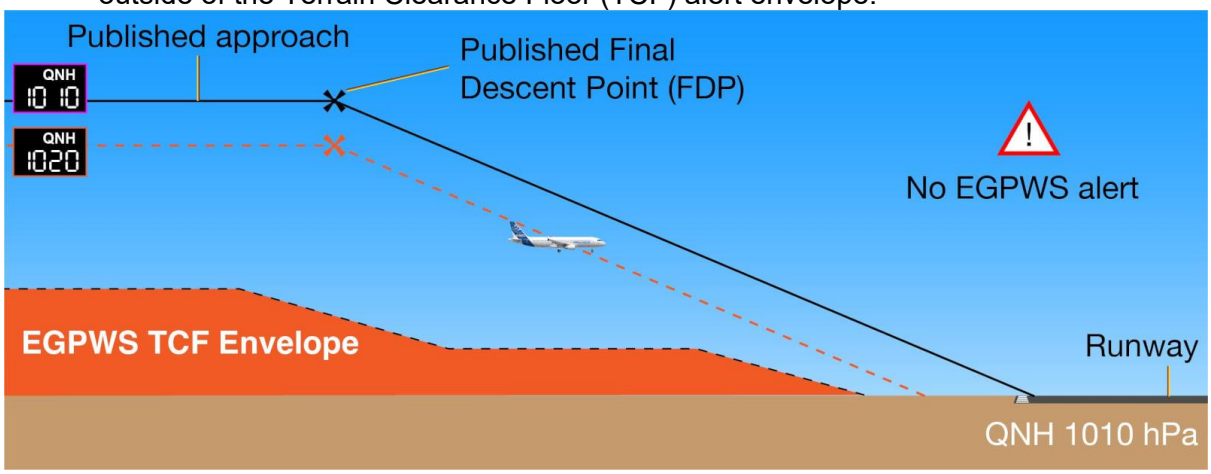
Effect on altitude-vs-distance checks

The flight crew will not detect an incorrect flight path with altitude-vs-distance checks if the barometric setting is erroneous. These checks use the displayed barometric altitude, which is based on the erroneous barometric setting. The effect is the flight crew will observe that they are at the expected altitude for each distance value, even if the aircraft is flying above or below the published flight path.

Potential absence of TAWS alert

- **Honeywell EGPWS/AESS**

  The relative proximity of the actual flight path to the published path may prevent the TOO LOW TERRAIN EGPWS alert from triggering, because the path remains outside of the Terrain Clearance Floor (TCF) alert envelope.



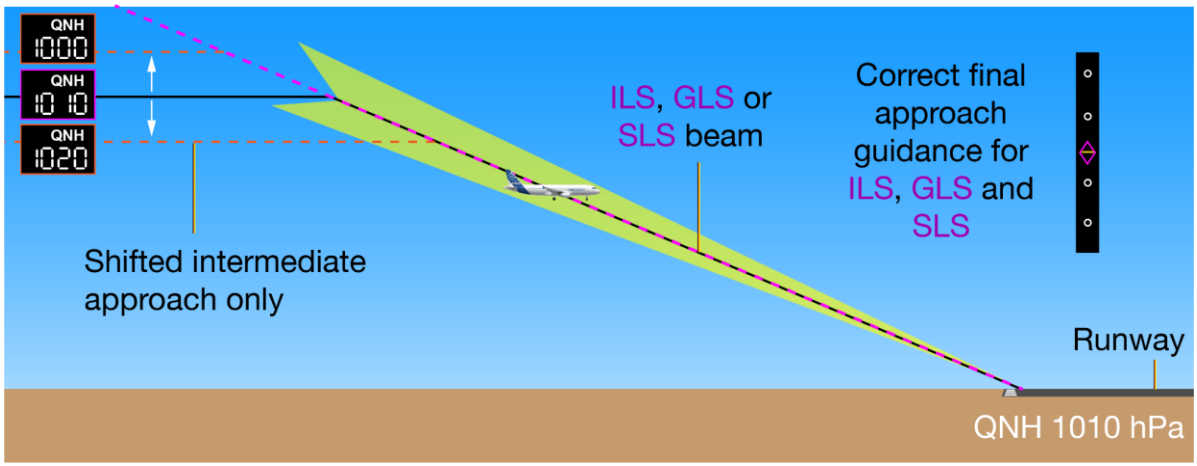
(fig.4) The TAWS may not detect a too low flight path

- **ACSS T2CAS and T3CAS**

  The Premature Descent Alert (PDA) of the T2CAS and T3CAS may also not be triggered depending on the situation.

G/S vertical guidance mode is not affected

The final approach path of approaches using ILS, GLS, or SLS guidance are not affected, because the G/S guidance mode uses the ILS signal or a beam computed with an augmented GPS altitude. The final approach path will remain aligned with the correct ILS/GLS/SLS beam even if the intermediate approach segment shifts due to the erroneous barometric setting.



(fig.5) The final descent path of ILS, GLS, and SLS modes is not affected by an erroneous barometric setting

OPERATIONAL CONSIDERATIONS

Flight crews have two opportunities to detect a barometric reference setting discrepancy. The first is during descent and the second is during final approach.

- **Crosscheck the barometric reference**

  During descent, when cleared to an altitude, the flight crew should pay attention to a barometric reference that significantly differs from the ATIS barometric reference used for the approach preparation. Such a difference could be a symptom of barometric reference error. In this case, the flight crew should confirm that they have the correct barometric reference from all available sources.

- **Unexpected low RA callouts in final approach**

  An abnormally decreasing RA audio callout while the barometric altitude is still high above airfield elevation is a clue that the aircraft may be too low on its final approach path. This can be due to a barometric reference discrepancy. However, RA callouts depend on the terrain profile and therefore may not be present if low terrain is located before the runway.

SYSTEM ENHANCEMENTS

ALTimeter Setting Monitoring (ALTSM) function

The ALTSM function, currently available on some Honeywell EGPWS standards (called CAM-BTA), **compares the barometric altitude on the captain side with the GPS altitude**. If the difference exceeds a threshold, the EGPWS emits an “ALTIMETER SETTING” alert, and it is repeated if an incorrect barometric setting is still detected after some time.

CONCLUSION

An undetected erroneous BARO setting can cause an aircraft to fly above or below the published final approach flight path when following approach guidance that uses a barometric reference. Vertical deviation indications are shown as correct, even if the aircraft is not on the correct flight path, with an incorrect BARO setting. Standard altitude-vs-distance checks will also wrongly confirm that an aircraft is on the correct trajectory, because it uses the same erroneous barometric reference. If visual conditions are not sufficient, the flight crew may not be able to detect that their aircraft is on an incorrect flight path in time to adjust their trajectory or perform a go-around.

Flight crew can detect a potential erroneous barometric reference by comparing the barometric reference provided by the ATC at the first altitude clearance during descent, with the value provided by the ATIS during descent preparation. If there is a significant discrepancy between the two values, the flight crew should crosscheck the barometric references with all available sources.

Depending on the terrain configuration, abnormally decreasing RA audio callouts while the barometric altitude is still high above airfield elevation might also help the flight crew to diagnose an issue with the barometric reference.

The ALTimeter Setting Monitoring (ALTSM) function is currently available on some TAWS computer standards. It compares the barometric altitude on the captain side with the GPS altitude and warns the flight crew if the difference exceeds a threshold. Airbus is working on an update of the ALTSM function that will be available for more TAWS computer standards and will provide a visual alert in addition to the current audio alert.