EUR OPS BULLETIN

Serial Number: **2023_001** Effective: **27 July 2023**

Subject: Risks related to altimeter setting errors during APV Baro-VNAV and non-precision approach operations

1. Introduction and scope

1.1 Recent incidents have highlighted that an erroneous altimeter setting can have serious consequences on flight safety during final approach operations. After recalling how aircraft barometric altitude is determined and used in certain approach operations, this bulletin lists a set of recommendations to mitigate altimeter setting errors.

2. Barometric altitude

2.1 Barometric altitudes are widely used in aviation today:

- to ensure vertical separation between aircraft and terrain on instrument flight procedures.
- to define certain vertical approach paths.
- to determine all the minimum altitudes, in particular the MDA/DA (Minimum Descent Altitude/Decision Altitude) on non-precision, APV and CAT I precision approaches.

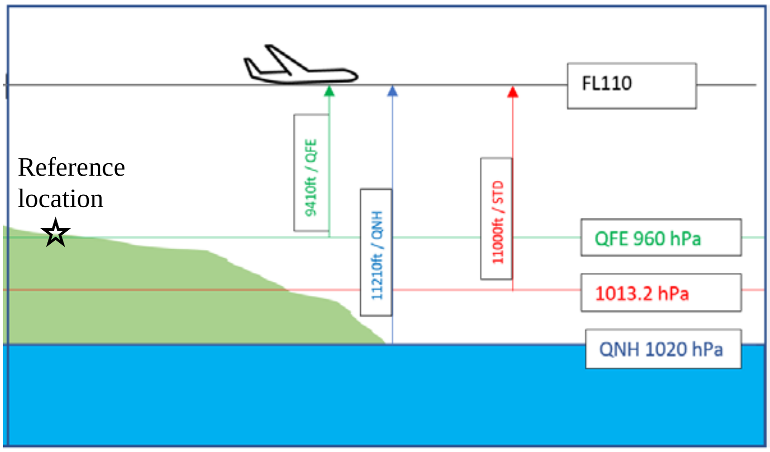

Figure 1 – Altimeter setting

2.2 Aircraft pressure altimeters are calibrated according to the International Standard Atmosphere, to indicate the elevation of the aircraft above a selected datum. The selected datum depends on the barometric reference pressure set on the altimeter sub-scale, which can be:

- QNH or local pressure at a reference location, converted to Mean Sea Level: in this case the altimeter will indicate the altitude of the aircraft.
- 1013.2 hPa: in this case the altimeter will indicate the Flight Level of the aircraft.
- QFE or local pressure at a reference location: in this case the altimeter will indicate the height of the aircraft above that reference location

3. Risks

3.1 The technical characteristics of the altimeter induce two risks that could lead to the determination of an erroneous altitude:

1) The incorrect altimeter setting
2) The temperature effect (difference between the real atmosphere and the standard atmosphere)

3.2 Barometric altimeter setting errors can lead to significant altimeter deviations. Each 1hPa error equates to approximately 30 ft of height difference; therefore, an altimeter setting error of 10 hPa would result in an altitude error of about 300 ft.

3.3 The effects of temperature can be anticipated because they are directly related to the deviation from the standard ISA temperature. They can lead to a reduction of safety margins, but technical solutions exist, as well as operational procedures, already in place, which allow to limit these effects, in particular by cold temperature corrections.

Note – Further guidance on the "RNP approach and RNP AR approach operations in non-standard temperature conditions" is available in the Performance-Based Navigation (PBN) Manual (Doc 9613), Fifth Edition, Volume II, Attachment B.

4. Final approach operations

4.1 The consequences of an erroneous altimeter setting will be more severe on the final segment of the approach for which the obstacle clearance margins are reduced. Most final approach operations can be affected by an erroneous altimeter setting. But they will not all be affected in the same manner.

4.2 ILS CAT I, GLS CAT I, RNP APCH down to LPV minima provide vertical guidance to the runway that is not dependent on barometric altitude. Therefore, once established on the glide path, an altimeter setting error will not affect the vertical profile. As a result, only the Decision Altitude (DA) based on barometric altitude, may still be subject to an error, such that the crew might make the decision either to land or go around higher or lower than expected, depending on the error of the altimeter setting.

4.3 On the other hand, the entire vertical path of non-precision approaches operated as either Dive & Drive (stepdown) or using a Continuous Final Descent Approach (CDFA) technique, as well as RNP APCH to LNAV or LNAV/VNAV minima and RNP AR operations can all be highly impacted by altimeter setting error.

4.4 If the altimeter setting is set incorrectly on the altimeter sub-scale, the aircraft could be significantly above or below the safe vertical profile as determined by the procedure design. The barometric altimeter setting error will also affect the MDA/DA and the possible check of altitude versus distance to the threshold made by the crew will not allow them to detect this type of error.

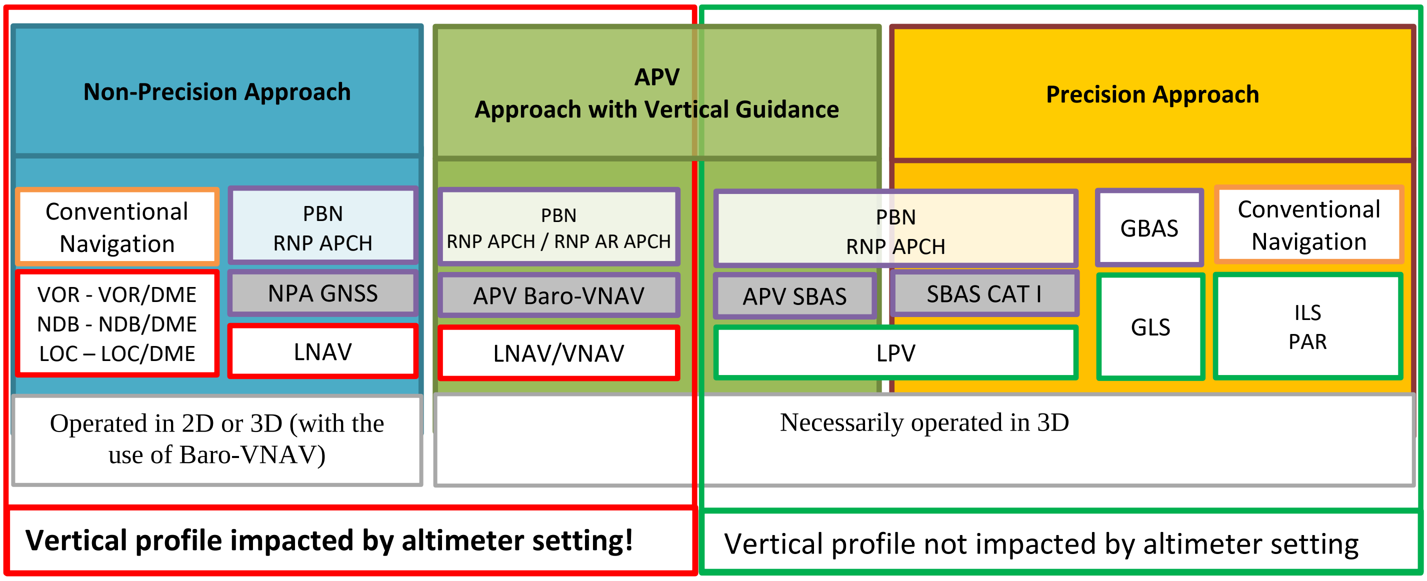

Figure 2 – Approach procedures and Altimeter setting

Note – APVs (Approaches with Vertical Guidance) are usually materialized under two different minima lines on a single RNP approach chart: LNAV/VNAV (using Baro-VNAV technology) versus LPV (using the Satellite Based Augmentation System, SBAS). However, the minima are associated to two different approach technologies since Baro-VNAV relies on barometric altitude to define the vertical path, whereas SBAS is based on geometric altitude. ICAO therefore recommends that the term APV is not used anymore in an operational context. Operators and pilots should be aware of these differences in order to avoid any confusion when considering the minima line.

Focus on Baro-VNAV

4.5 Baro-VNAV offers vertical guidance based on the aircraft's barometric altitude and a vertical profile encoded in the navigation database. It simplifies the CDFA flight technique and provides the same operating mode for crew to perform all non-precision approaches and Baro-VNAV approaches. The way Baro-VNAV information is integrated in the cockpit may make Baro-VNAV operations look like precision approach operations. However, unlike precision approach operations, Baro-VNAV operations are based on barometric references, that is why the altitude versus distance checks, which may allow detection of a final segment vertical path error when operating an ILS, GLS or RNP with LPV minima, are ineffective for Baro-VNAV operations, as the same erroneous information is being used for the vertical profile definition and the altitude check.

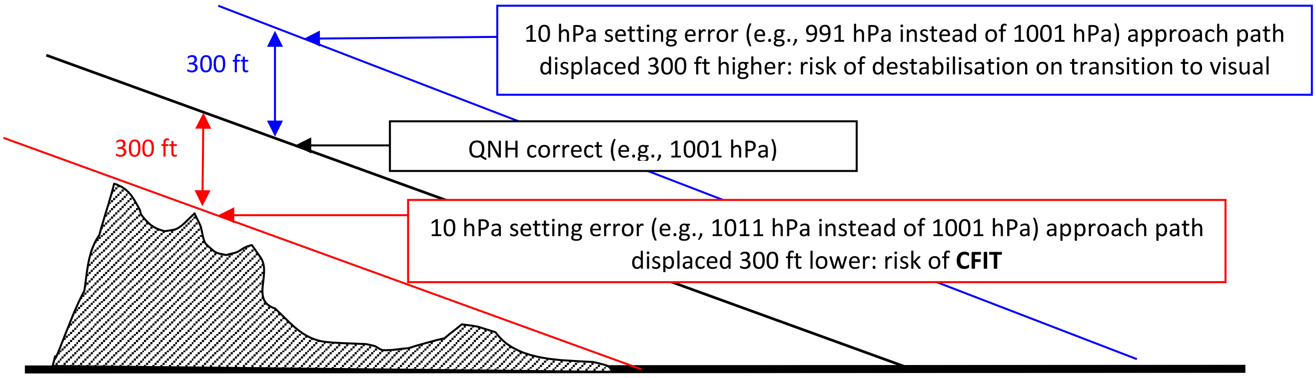

Figure 3 – Example of altitude deviation resulting from altimeter setting error

4.6 As with any non-precision approach operation, it is therefore imperative to ensure the correct altimeter setting when using Baro-VNAV, keeping in mind that both the vertical profile and the DA would be impacted in case of error.

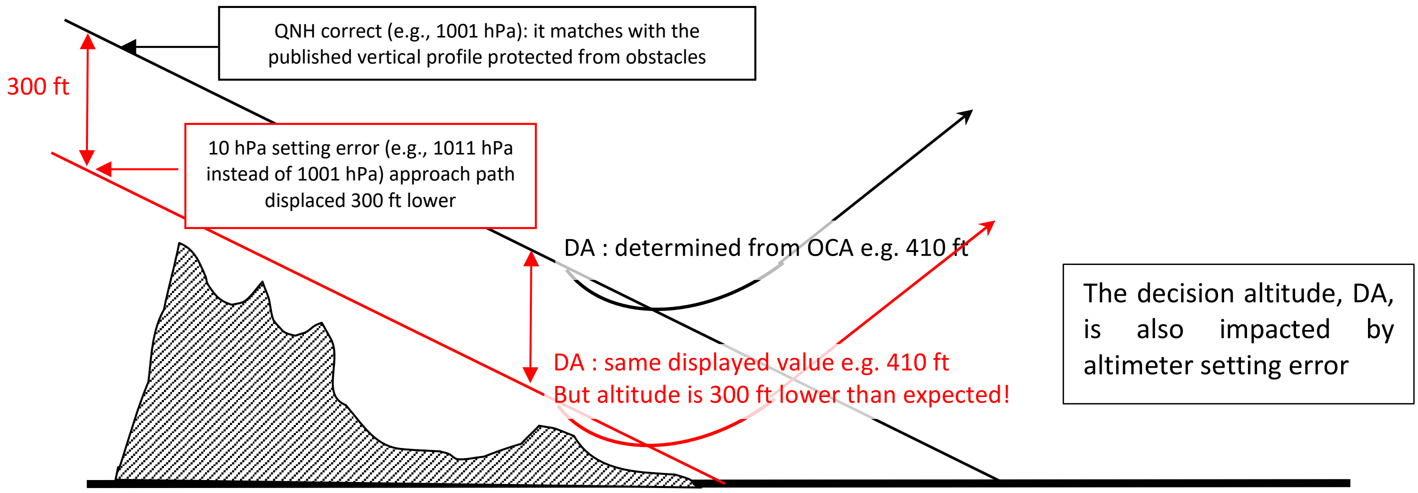

Figure 4 – Example of the impact of an altimeter setting error on DA

5. Root causes

5.1 The altimeter setting involves several steps, which may be subject to errors:

- Incorrect determination of the local barometric pressure, use of regional pressure instead of local barometric pressure values or transmission of a wrong value by the meteorological service provider,
- Provision of incorrect QNH through ATIS (where available)
- Ineffective ATC-Pilot communication, such as: wrong value given by ATC, incorrect read back not detected by ATC, radio/frequency issue, etc.
- Incorrect selection of the altimeter setting by the crew due to different factors such as: high workload, confusion in the unit of the barometric setting (Inch Hg instead of hPa), confusion between QNH and QFE, absence of effective crosscheck between crew members, flight deck system failure, etc.

Transition altitude/level

5.2 The transition level is the lowest flight level available for use above the transition altitude, where altimeter setting is set to 1013.2 hPa. The transition altitude is the level below which the vertical position of an aircraft is controlled by reference to altitudes, where altimeter setting is set to QNH.

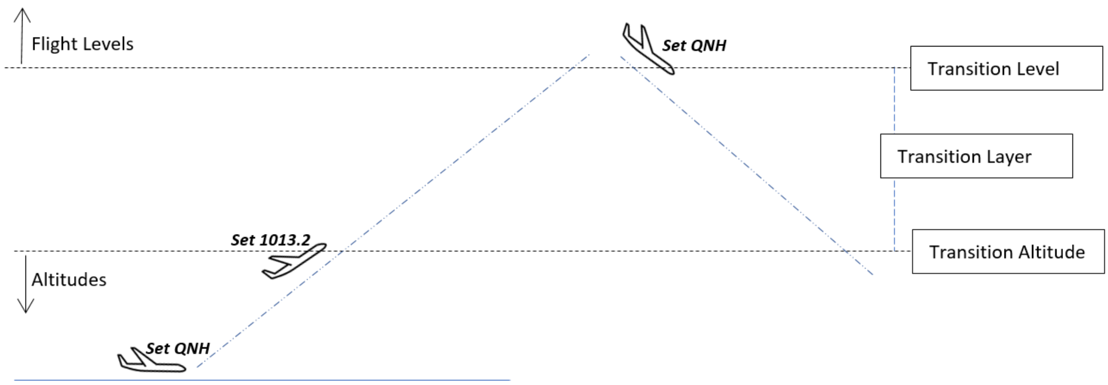

Figure 5 – Transition Altitude/Level

5.3 Altimeter setting error in approach can occur when the crew switches from 1013.2 hPa to QNH and vice versa. Depending on operators' usual area of operation, using variable transition altitude instead of fixed transition altitude may cause crew confusion and result in a premature or late setting of the correct altimeter reference. Furthermore, as the crew's workload intensifies during the descent and landing phase, a low transition altitude/level may require the crew to adjust the altimeter settings when their workload is already high, which can increase the likelihood of altimeter setting errors. In addition, a low transition altitude/level can reduce the opportunity to detect a possible altimeter setting error before the aircraft intercepts the final approach segment.

6. Proposed Mitigations

6.1 Aircraft operators and ANSPs are reminded of the importance of ensuring that the correct barometric altimeter setting is provided and entered in the aircraft's systems.

6.2 Some mitigations are as follows:

<u>At aircraft operator's level</u>

- Encourage the use of those 3D operations where final segment profiles cannot be impacted by wrong barometric altimeter setting (ILS, RNP APCH down to LPV minima, GLS).
- Establishment and strict adherence to the standard operating procedures for the use of the VNAV function.
- Consider adjusting the operating minima by taking into account the operational exposure and/or crew experience with approach procedures that are vulnerable to QNH errors.
- Apply Crew Resource Management techniques, such as cross-checking and monitoring.
- Consider altitude callouts, whereby the aircraft's radio altimeter can provide height callouts to the pilot when passing specific values (e.g. 500 ft and 1000 ft), which can be interpreted to assess whether the

aircraft is deviating from the intended vertical profile. This mitigation is more effective when the terrain is relatively flat.

- Configure correct QNH in all altimeters (main, standby) and FMS. The flight crew should pay attention to a barometric reference that significantly differs from the one used for approach preparation. That could be the symptom of a barometric reference error. The flight crew should consider cross-checking of the barometric references from all available sources (METAR, ATIS and ATS).
- Apply standard communication and phraseology between the pilot and air traffic services.
- Pilots should use effective Threat & Error Management (TEM) techniques to identify and mitigate against incorrect altimetry when preparing to fly an approach that relies directly on an accurate pressure altimeter sub-scale setting (e.g. use of Baro-VNAV, non-precision approaches).

<u>At ANSP level</u>

- Consider fixed and harmonized transition altitudes/levels which can harmonize the switch from 1013.2 hPa to QNH.
- Consider using the barometric pressure settings provided by Mode S EHS (Enhanced Surveillance) and ADS-B equipped aircraft, to enable the timely identification of aircraft operating with incorrect barometric altimeter setting.
- Consider introducing procedures to provide aircraft with the QNH at different phases of approach, including when clearing an aircraft for the approach or at first contact with the tower.
- Apply standard communication and phraseology between the pilot and air traffic services.

<u>Technical solutions</u>

- Consider using those 3D approach procedures where the final segment cannot be impacted by wrong QNH setting (ILS, RNP APCH down to LPV minima or GLS).
- Use of recovery safety nets, such as Minimum Safe Altitude Warning (MSAW) and Approach Path Monitor (APM) by ATC and Terrain Avoidance and Warning System (TAWS) by pilots, which can alert actors and thus lead to recovery actions associated with operational procedures.

  Note – these safety nets are not available in all aircraft or ATS units and their technology varies from one site to another. Their intrinsic characteristics, in particular resulting from choices intended to limit the false alarm rate, lead them, in certain cases, not to be triggered, without this being a malfunction. To get the most consistent alerts, aircraft operators should ensure that the latest available software version and the latest terrain and obstacle database are loaded in the TAWS.
- Consider the use of datalink for transmission of MET information, including QNH, to aircraft.
- Consider other emerging monitoring solutions that would offer comparison between barometric altitude with GNSS-driven altitude.

7. Recommendations

7.1 In order to better manage the risks related to altimeter setting errors, in particular during APV Baro-VNAV and non-precision approach operations, the followings are recommended:

a) General recommendations:

- to ensure that awareness of the risk of altimeter setting errors and their consequences is shared;
- to assess the robustness of the mitigation measures described in the previous point, and to consider implementing them, when relevant;
- to report all situations that have generated deviations in order to improve the visibility of this type of event, preferably with a perspective of the appropriate treatment in each case;
- to contribute collectively to training on this risk, to disseminate best practices and to promote exchanges between domains in order to better understand the limits of the systems;
- MET Service providers to ensure provision of quality-assured MET information to users;
- aircraft operators, to investigate methods to identify incorrect altimeter setting with the Flight Data Monitoring (FDM) Program; and

- Relevant ANC Panel(s), to assess the potential review of APV Baro-VNAV criteria concerning the likelihood of QNH errors.

b) Recommendations on Training:

- Barometric altitude setting is largely dependent on human factors. Therefore, it is recommended to consider appropriate initial and recurrent training subjects to pilots and ATCOs, including the following:

  <u>For pilots:</u>

  - Initial and recurrent training should address the limits of barometric altimetry, and the impact of incorrect barometric pressure settings on vertical position including those factors outlined in this bulletin.
  - Training and/or promotional initiatives on altimeter setting procedures, different impacts of QNH errors between geometric and barometric approaches and possible mitigation measures, use of standard phraseologies, adhering to read back and hear back, etc.
  - Training on 3D operations including the difference between 3D depending on Baro-VNAV and other 3D approach operations, highlighting the critical importance of Barometric setting for Baro-VNAV operations.
  - Training on 3D RNP operations highlighting the RNP chart layout where LNAV/VNAV and LPV minima co-exist.

  <u>For ATCO:</u>

  - Initial and recurrent training should address the limits of barometric altimetry, and the impact of incorrect barometric pressure settings on vertical position including those factors outlined in this bulletin.
  - Training and/or promotional initiatives on altimeter setting procedures, different impacts of QNH errors between geometric and barometric approaches and possible ATC mitigation measures on erroneous setting of altimeter setting by flight crew, use of standard phraseologies for transmitting QNH information to pilots, paying attention to pilots' read back and hear back, etc.

- END -