



EUROPEAN AVIATION SYSTEM PLANNING GROUP

FOURTH MEETING

(Paris, France, 29 November - 1 December 2022)

Agenda Item 3: Safety

Agenda Item 4: Air Navigation Planning and Implementation

BARO-VNAV APPROACHES

(Presented by France)

SUMMARY

Baro-VNAV approaches provide significant safety benefits over legacy LOC, NDB and VOR approaches. They can also enhance safety at unequipped runway ends.

Baro-VNAV approaches are however significantly less robust than geometric PBN approaches enabled by SBAS, and GBAS, as evidenced by several Baro-VNAV related issues in France.

The main vulnerability of baro-VNAV approaches lies in their dependence on correct altimeter setting, which involves multiple human interventions. Other vulnerabilities exist, such as the risk of overestimating the precision of the vertical guidance.

It is proposed that an ICAO EUR bulletin be published, and also sent to States and international organizations, with a view to sensitizing the EUR aviation community to vulnerabilities of baro-VNAV approaches, in particular their dependence on correct altimeter setting.

1. Introduction

1.1 The use of baroVNAV to fly vertically guided PBN approaches is currently supported by the PBN Manual as RNP APCH down to LNAV or LNAV/VNAV minima and is included in GANP ASBU element NAVS-B03. The navigation technologies used for these approaches are GPS ABAS for lateral guidance, and a barometric system for vertical guidance.

1.2 This approach and landing capability is available over a large segment of the transport category aircraft (mostly Airbus/Boeing).

1.3 It is one of the enablers of PBN with vertical guidance approaches, and brings real safety benefits over LOC, NDB and VOR approaches.

1.4 Baro-VNAV based approaches are however significantly less robust than geometric PBN approaches enabled by GBAS (GANP ASBU element NAVS-B01) and SBAS (GANP ASBU element NAVS-B02).

2. Discussion

2.1 Barometric vertical guidance was initially designed to fly continuous descents within TMAs. It was later promoted as an advisory system during laterally guided approaches, and eventually a final approach landing PBN system, in the mid-2000, as an opportunity to address some pressing safety shortcomings (such as suboptimal vertical situational awareness along LOC, NDB, VOR approaches, and unequipped runway ends).

2.2 Baro-VNAV was not designed as a self-standing approach and landing system, by contrast to geometric vertical guidance systems such as ILS, GBAS and SBAS.

2.3 In the same way that VOR and NDB in their time brought progress at runway ends with no landing aids, barometric guidance represents another step of progress at this point in aviation history.

2.4 As evidenced by several serious incidents, baro-VNAV approaches are however significantly less robust than ILS approaches and geometric PBN approaches enabled by GBAS and SBAS.

2.5 The main vulnerability of baro-VNAV approaches lies in their dependence on correct altimeter setting.

2.6 Correct altimeter setting involves multiple human interventions (e.g. determination of the local QNH by the meteorological service provider, publication of the local QNH in ATIS, transmission of the local QNH by ATC to the flight crew, altimeter setting by the flight crew, correction for the effects of temperature on the atmospheric pressure at aircraft altitude).

2.7 It is noteworthy that ILS, GBAS and SBAS are required by ICAO Standards to be designed and certified to meet an integrity risk lower than 10^{-7} per approach (which means that these systems should not create an out of tolerance positioning error, without alerting the air crew, more frequently than once every 10 million approaches). The inherent integrity risk of baro-VNAV approaches is certainly on a much lower level. For instance, a 1998 study (Judith Bürki-Cohen https://flightsafety.org/ao/ao_jan_feb98.pdf) published by the Flight Safety Foundation showed that the altimeter setting error rate was on the order of a few percentage points, depending on factors such as the complexity of the clearance.

3. Examples of baro-VNAV related issues experienced in France.

3.1 Example 1:

On June 25th, 2021 a Vueling flight crew to Nantes Atlantique Airport miscopied as 1017 mb the 1007 mb ATIS QNH. The flight crew stated having experienced adverse weather conditions, with cumulonimbus clouds, during descent and approach, and been very focused on weather avoidance. The flight crew correctly readback 1007 QNH to the air traffic controller, without correcting the altimeter setting. The MSAW system alarmed. The air traffic controller used the emergency MSAW phraseology. The flight crew, who was in VMC conditions by then, immediately corrected the altimeter setting and was able to stabilize the approach.

3.2 Example 2:

In 2013, the French meteorological service provider misset the QNH measuring unit at Biarritz Pays Basque airport during a routine maintenance operation. As a result, the local ATC broadcast, during half a day, QNH with a 7 mb error up. The weather conditions were good

on that particular day, and the error was detected by airspace users who were too low on approach (NB: 7 mb error = 196 ft error). No incidents/accidents occurred.

3.3 Example 3 :

On October 10, 2021, before starting the RNP approach to runway 21 at Nantes Atlantique Airport, the air traffic control unit cleared the crew of an Air France Hop CRJ 1000 aircraft to descend to 3 000 ft QNH 1002. The flight crew read back QNH 1021. During the final approach, the MSAW alarmed, and an investigation by the French Civil Aviation Safety Investigation and Analysis Bureau (BEA) into this serious incident is underway.

3.4 Example 4 :

- a) An Air Hub Airbus A320 flight performed on May 23, 2022 a baro-VNAV approach to Paris CDG Runway 27R. The air traffic controller erroneously advised the flight crew that the QNH was 1011, while it was correctly broadcast 1001 on the ATIS. The aircraft performed its approach about 280 ft below the nominal descent profile, in clouds according to the flight crew.
- b) At an indicated altitude of 891 ft QNH 1011 (617 ft actual altitude QNH 1001), 1.53 NM from the runway threshold, the MSAW system alarmed.
- c) At 1.2 NM from the runway threshold, and with a vertical speed of -717 ft/min, the aircraft passed the indicated altitude of 802 ft QNH 1011 (537 ft QNH 1001, 122 ft RA), which corresponded to the Decision Altitude (DA) for the crew (Point 2 Figure 1).
- d) The flight crew stated that arriving at the minima, they did not acquire visual references and consequently performed a go-around.
- e) At an indicated altitude of 735 ft QNH 1011 (461 ft QNH 1001, 52 ft Radio Altimeter), and at 1 NM from the runway threshold, the autopilot was disengaged, and the captain pitched up.
- f) Three seconds later, at an indicated altitude of 679 ft QNH 1011 (405 ft QNH 1001), and 0.8 NM from the runway threshold, the minimum radio-altimeter height was recorded at 6 ft above the ground, and an investigation by the French Civil Aviation Safety Investigation and Analysis Bureau (BEA) into this serious incident is underway:

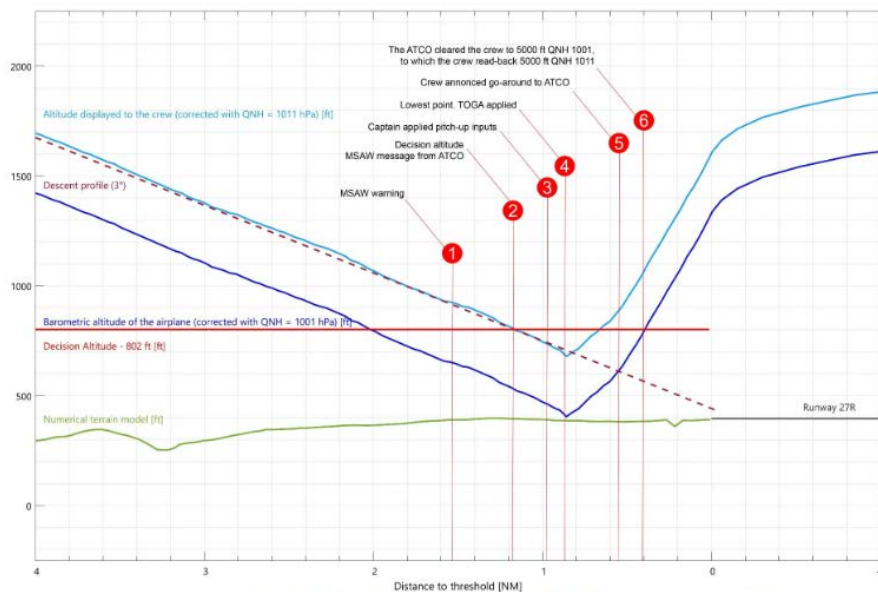


Figure 1: First approach profile, flight path computed from recorded flight parameters (source: BEA)

4. Conclusion

4.1 The safety of baro-VNAV approaches is dependent on correct altimeter setting, a process which requires multiple human interventions, and can lead to serious incidents as stated above.

4.2 Other vulnerabilities of the baro-VNAV technology, such as the risk that flight crews overestimate the precision of the baro-VNAV vertical guidance and conduct an unstabilized approach path, exist.

4.3 By contrast, ILS, SBAS and GBAS geometric approaches are not dependent on altimeter setting, are designed and certified to meet a 10⁻⁷ integrity risk, and have logically proven safer in operations, by eliminating the type of errors involved in the above mentioned incidents, than baro-VNAV approaches.

4.4 In Europe, and other regions of the world, a non-exhaustive search through databases (BEA, Skybrary, NASA ASR, ...) reveal occurrences of altimeter setting related incidents/accidents such as reported here for France.

4.5 Proactive safety management is about looking for safety weaknesses and preventing accidents before they occur.

4.6 France is of the view that in the mid/long terms only geometric vertical guidance enabled by ILS, GBAS and SBAS can provide the needed level of safety for the expected traffic growth and increased use of PBN approaches.

4.7 Based on the foregoing, the following is proposed:

Why	Avoid baro-VNAV incidents and accidents
What	Publish, and send to States and international organizations, an ICAO regional bulletin with a view to sensitizing the EUR aviation community to vulnerabilities of the baro-VNAV technology, in particular its dependence on correct altimeter setting.
Who	The Regional Director
When	In 2023

Draft EASPG Decision 4/#_easpg04wp22/1 – Publication of a Regional Bulletin on baro-VNAV approaches

That the ICAO Regional Director, Europe and North Atlantic:

Publish, and send to States and international organizations, an ICAO EUR bulletin with a view to sensitizing the EUR aviation community to vulnerabilities of baro-VNAV approaches, in particular their dependence on correct altimeter setting.

5. Action by the Meeting

5.1 The meeting is invited to:

- a) note the information provided;
- b) amend as necessary and endorse the Decision in paragraph 4.7; and
- c) provide direction as deemed necessary.

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