THE HONOURABLE COMPANY OF AIR PILOTS
incorporating Air Navigators

THE HONOURABLE COMPANY OF
AIR PILOTS

Tel: +44 (0) 20 7404 4032
Fax: +44 (0) 20 7404 4035
office@airpilots.org
www.airpilots.org

# DISCUSSION PAPER

# THE CASE FOR GEOMETRIC ALTIMETRY

## BY
## Captain A B FISHER OBE MA

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**Position Papers** - official Air Pilot opinion on the matters concerned

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# THE CASE FOR GEOMETRIC ALTIMETRY

## Introduction

Barometric Altimetry (Baro) has served aviation since aeronauts travelled in balloons (see Figure 1). It is, however, no longer the only option, and now that the ability exists to measure the altitude of aircraft directly relatively easily by satellite means, it is time to consider change. The new Alternative is provided by Global Navigation Satellite Systems (GNSS), which provide both lateral and vertical positioning.

**Figure 1 - Dr John Jeffries who, with Jean Pierre Blanchard, made the first successful voyage by air across the English Channel on 7 January 1785**

## Why Change?

**Safety:** Number one cause of level busts is failure to revert to or from standard pressure setting and QNH, only exacerbated by the failure to agree a common transition altitude in Europe never mind globally. Abandoning Baro, would finally end such arguments. Similarly, confusion over Baro setting is a potential ground collision cause, particularly in General Aviation. It was reported at the UK Flight Safety Committee that the CAA's Controlled Flight into Ground (CFIT) Task Force had noted altimeters miss-set on landing 23 times in 2013.

**Capacity:** the need to allow for high and low QNH means the loss of one or two available levels at lower altitudes, where the need is greatest; these would be regained by the use of Geo height. As Geo sensitivity does not decrease with altitude, more levels may be available at high altitude than currently with RVSM. Ultimately, the increased accuracy of GNSS should translate into higher traffic density.

**Operational:** The (perceived) need to allow for varying temperature complicates the design and presentation of Baro RNAV approaches and would be unnecessary with Geo; one approach would suffice for all temperatures.

**Reliability:** Baro sensing is inherently difficult and is only brought to an acceptable standard by extensive maintenance of surface condition near the static ports and close attention to condensation traps and drains.

**Future Proofing:** Trajectory based operations (TBO) will surely need a single datum for the disparate tracks to be properly separated. Use of Geo will simplify the introduction of these and other advanced concepts yet to be developed.

## Perceived Difficulties

**Accuracy:** While accuracy is important, what matters most in an air traffic control context is the repeatability of the measurement in the sense of how closely will two observers in the same place estimate their positions. The accuracy of Baro altimetry is of course appalling, depending as it does on assumed average altitude/pressure calibration curves, with absolute accuracy at cruising level being no better than 500m, but it is nonetheless adequate for the purposes of vertical separation (because neighbouring users experience very similar errors). GPS is already in widespread use determining clearance over obstacles, as a prime input to EGPWS. The suggestion is frequently made that GPS accuracy is insufficient with critics pointing out that guaranteed 100m accuracy, can be further worsened by 'dilution of Position' (DOP), a function of satellite geometry. But since 2008 the Performance Standard for individual ranging error (UERE) has been 4m RMS, with the actual achieved figure being now less than 1m as reported in http://www.gps.gov/systems/gps/performance/accuracy/URE.pdf. Not only is this good, it is orders of magnitude better than Baro. Since the major errors in geo height are common to all receivers in the same area, ionospheric and geometry, there is every reason to suppose that relative accuracy would also be orders of magnitude better than is possible with Baro.

**Availability and Security:** GPS is vulnerable but the risks due to outage from natural and human sources have already been accepted in the switch to GPS for lateral navigation. Note that whereas the fall back to a GPS outage in an area with few or no conventional aids, is a reduction in lateral accuracy from metres to miles, in the vertical plane, the back up source is of course Baro itself, a far smaller step. Techniques commonly employed in multisensor FMS are applicable to the problem of smoothly transferring from one sensor to another when the first shows signs of failure, and would be applicable when GNSS becomes the prime sensor. Such techniques would also be applicable in the initial switch over (see **Transition** below)

**Aircraft envelope constraints:** Aircraft performance is a function of, inter alia, density altitude. Although strictly pressure altitude is not the same, it is close enough for crews to observe altitude/mach number limitations based on pressure altitude. Geo altitude is even less closely related to density altitude, so pressure altitude will still need to be measure and displayed, or made available to the control system to keep the aircraft within its operating envelope.

**Transition:** There are two principle issues related to transition, strategic and tactical:

- **Strategic.** Obviously the transition cannot take place until for practical purposes all aircraft are equipped with GNSS height measurement. GNSS is the norm in all current production aircraft, so the basics are widespread, but there will be necessary changes to FMS to handle reversion to Baro in a sensible way, and for envelope protection. These do not sound very difficult but they will need time to percolate through. While a global transition would be ideal, it is not absolutely necessary; just as the industry copes with metric altimetry across the former USSR and China, there could conceivably be geo and Baro regions for a time with transition zones in between. This is far from ideal, but the point is made to forestall negative arguments that the global nature of the problem automatically requires a simultaneous global solution, which is then claimed to be impossible.

- **Tactical**. How to handle the change from one datum to another ‘on the day’ . This could conceivably be managed by the same error management referred to above. At the appropriate time, the Altimeter Source select would be switched from Baro to GNSS and the aircraft would drift up to the equivalent Geo level over a period of, say, 5 minutes at a modest rate; aircraft previously correctly separated would remain so during and after the transition time. International coordination would be needed to do this, but is not inherently more difficult than the transitions to RVSM were.

## Conclusion

Clearly the opportunity to change height measurement is now there for the taking. Potential benefits may not seem overwhelming at present, just as doubtless the case for closed cockpits did not seem particularly pressing or overwhelming in the late 1920s, but aren’t we glad now we did it.