The Global Voice of Pilots

IFALPA

POSITION PAPER

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Geometric Altitude

POSITION

IFALPA supports research into a possible future transition from Barometric Altitude to using Geometric Altitude for sub transition level en route, and approach operations.

With the increasing equipage of Global Navigation Satellite System (GNSS) in commercial air transports, and the growing constellation of GNSS, the future use of Geometric Altitude throughout the flight profile might be possible and will bring added benefits such as reduced vertical separation and complementing trajectory flight paths. Geometric Altitude might be introduced above 15,000 metres because all aircraft able to reach these levels are GNSS equipped, but biggest benefit is seen during approach and departure.

PREAMBLE

a. Use of barometric altitude has several well-understood and accepted shortcomings.
   - Position Error
   - Mechanical Error
   - Density Error
   - Hysteresis Error
   - Reversal Error

   These contribute collectively to Altimeter System Error, the greatest component of which is Density Error.

b. The inaccuracy of Barometric altimetry is known and documented. Absolute accuracy at cruising levels is no better than 500m. A similar value can be found when considering very low temperature error correction at 5000 ft. This is nonetheless adequate for the purposes of vertical separation (because neighbouring users experience very similar errors), but undesirable for approach operations as it reduces terrain clearance.

c. With the commercial industry's increased use of GNSS for lateral positioning, these errors would be eradicated if vertical positioning were also derived and used from satellite data. Note that GBAS (Ground Based Augmentation System) has already been proved to meet Cat I minima, i.e. 16m horizontal and 4 m vertical accuracy requirement.

   Active stations exist in the US and Europe. SBAS (Satellite- Based Augmentation System) utilizes additional satellites such as EGNOS (European Geo-Stationary Navigation Overlay Service) to enable enroute RNP 0.3 in serviced areas and CAT I approach minima, but without the requirement of the ground pseudolite. SBAS is a key component of Europe’s SESAR and the FAA Next Gen projects.

d. Altimeter Setting Error, a failure to set the altimeter's subscale correctly, should be eliminated.

SAFETY AND OPERATIONAL BENEFITS

a. In any area with multiple airfields each on different QNH's, using Geometric Altitude would place all aircraft on a common datum.

b. The use of Geometric Altitude by aircraft and other airspace users such as UAS could provide a common datum reference, which could be a prerequisite for the safe integration of such airspace users.

c. In airspace where use of forecast regional pressure settings is utilised, using Geometric Altitude would place all aircraft on a common datum.

d. Current altimetry procedures require the use of transition altitudes meaning that the gap between the lowest usable flight level and the next lower altitude is more than 1000ft, and can be as much as 2000ft, resulting in wasted airspace capacity. These transition-procedures also increase the complexity of the operation for pilots.

e. The requirement to calculate Cold Temperature Error Correction for all approaches would be eradicated.

f. Altimeter Setting Error would be eradicated.

g. RNAV approaches currently constructed as Baro, while being retained as standby approaches could be upgraded to APV type.

h. Barometric pressure sensing systems require stringent and comprehensive maintenance to ensure accuracy and reliability. GNSS systems less so.

DEFICIENCIES

1. Aircraft performance is based on atmospheric conditions only, thus still relying on actual pressure altitude, which should be considered, especially during cruise. Impact might lead to:
    - Significant differences between geometric and pressure altitude, leading to possible exceedances of the operating envelope,
    - Deviations of fuel consumption,
    - Cabin altitude will change frequently.
2. Definition of master source when position information is diverging
3. Security issues (GPS spoofing)
4. Contingency and failure procedures, especially in remote airspaces
5. Accuracy

a. GNSS is already in widespread use determining clearance over obstacles, as an input to TAWS (Terrain Avoidance Warning System). GPS is also used to determine Altimeter System Error for height monitoring purposes. For example, GPS uses WGS84 ellipsoid as an approximation to the MSL, which could have errors between -100m and 70m with respect to the geoid, depending on location on the globe. The geoid is the best definition of the MSL, which is used as the reference for pressure altitude.

b. Since 2008 the Performance Standard for User Equivalent Ranging Error (UERE) has been 4m RMS, with the actual achieved figure being now less than 1m. This is an order of magnitude better than barometric altimeters can achieve. Since the major errors in geo height are common to all receivers in the same area (ionospheric and geometry), there is every reason to expect that the relative accuracy would also be orders of magnitude better than is currently possible with barometric altitude.

c. To reduce the effects of space weather, all new GPS satellites broadcast should provide ranging signals for civil on two frequencies, instead of just one. Multi-constellation GNSS availability will also increase accuracy, with the combination of multi-constellation and multiple frequencies providing adequate Receiver Autonomous Integrity Monitoring (RAIM). The use of SBAS available globally will further enhance the vertical accuracy and the integrity of GNSS.

d. It is acknowledged that even the use of multiple frequencies remains vulnerable to hostile interference. Therefore, some elements of today's current navigation procedures would be required as a backup to such interference.

SYSTEM REQUIREMENTS PRIOR TO IMPLEMENTING GEOMETRIC ALTITUDE

a. Define transition and procedures for non-compliant aircraft/areas.

b. Access to multiple constellations must be available to aircraft systems.

c. Global SBAS availability.

d. Aircraft systems and flight procedures for all aircraft on a global level would need to be in place prior to any such transition.

e. Backup systems and flight procedures for all aircraft on a global level would need to be implemented as well.

f. All terrain maps, obstacles, airfield elevations, would need to be evaluated at the new Geometric Altitude values.

g. Technology would be required to ensure that the GNSS signals are protected from hostile interference and possible harmful effects of space weather fully mitigated.

h. Ensure high altitude performance operating limitations, including maximum operating altitude for the current ambient conditions, would need to be developed.

TRANSITION TO GEOMETRIC ALTITUDE

a. If and when the transition to Geometric Altitude becomes a reality, all stakeholders should be included in the procedures to be developed.

b. The change to Geometric Altitude should occur in stages, perhaps using Geometric Altitude above current RVSM levels in the first stage, allowing some time to evaluate the effect of the change, in the area where barometric altimeters experience the greatest errors. Initially altitudes above 15,000 metres might be used with a Transition Level above RVSM pressure levels introduced. Eventually all altitudes should be included.

c. Guidance should be sought from the Separation and Airspace Safety Panel (SASP) and the Navigation Systems Panel (NSP) of ICAO.

d. Considerations should be made regarding the implementation of Geometric Altitude, making provisions for both aircraft equipped and non-equipped throughout all stages.