Altitude Reference System for Small Unmanned Aircraft Systems to Resolve Altitude Discrepancies with Manned Aircraft

ICAO's DRONE ENABLE/3
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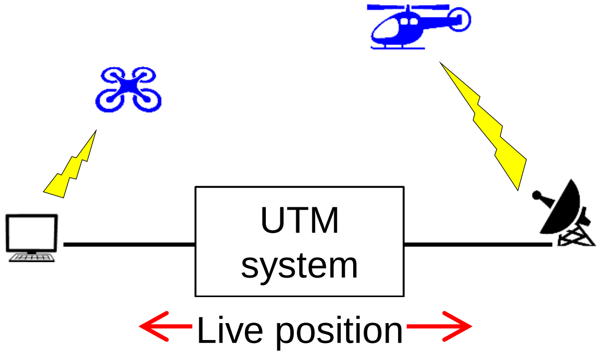
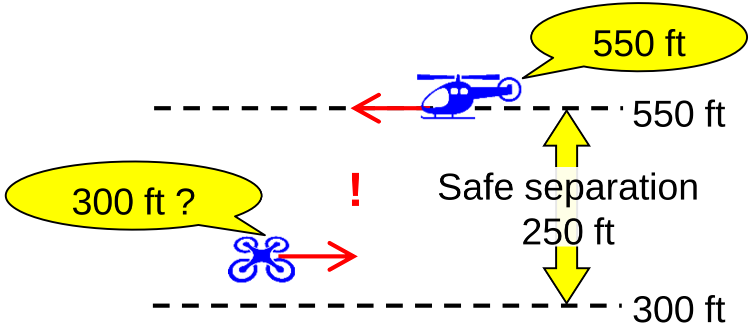
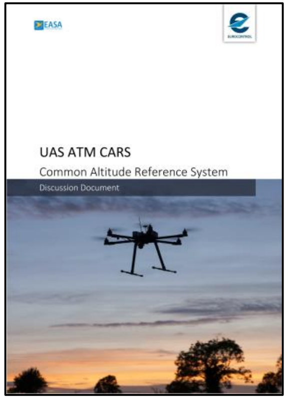
Problem statement

Altitude discrepancy between manned aircraft and sUAS





- Sensor to measure the altitude
  Manned aircraft: barometric altimeter
  Drone: Various sensors
  (GNSS, barometric sensor, lidar)
- Altitude reference system
  Manned aircraft: Flight level and QNH
  Drone: Depending on drone products



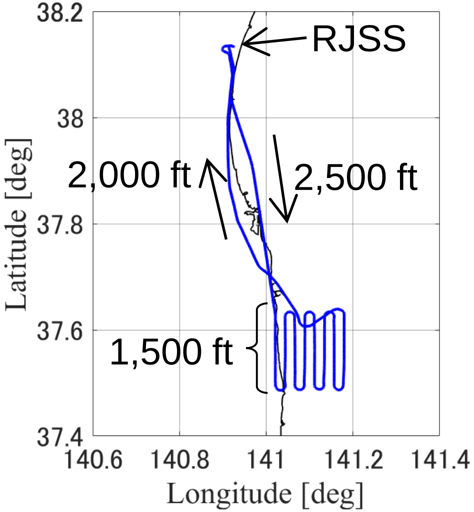
Reference:
EUROCONTROL, “UAS ATM CARS, Common Altitude Reference System”, Discussion Document, 2018.

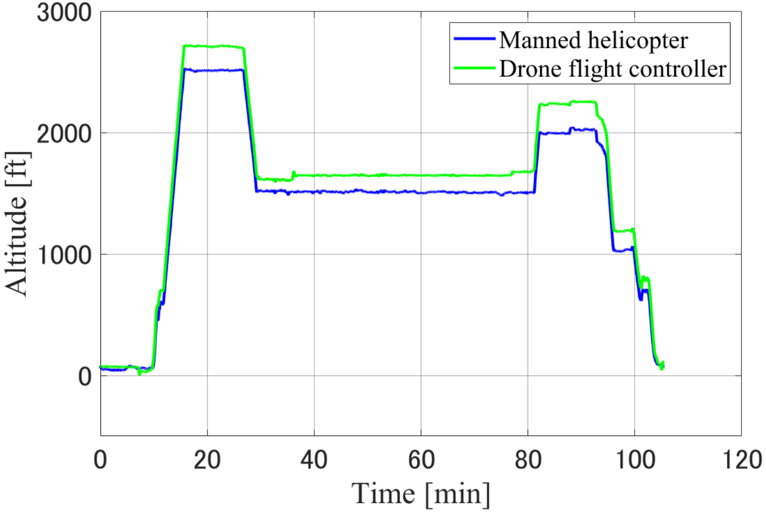
Experimental result

Manned helicopter (BK117C-2)

Flight controller (pixhawk)

- The drone flight controller measures the altitude combining the GNSS receiver and barometric sensor.
- There is discrepancy of the measured altitude between the helicopter and drone.

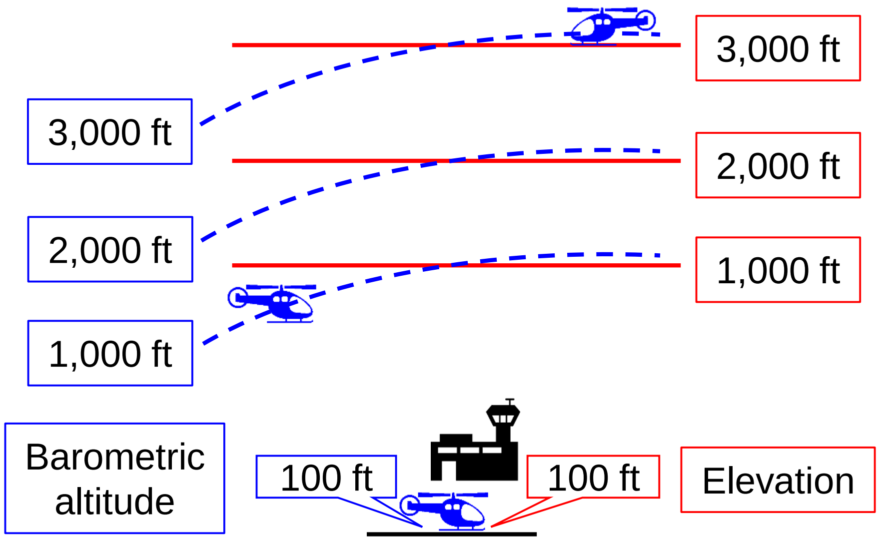




Altitude correction method for drone

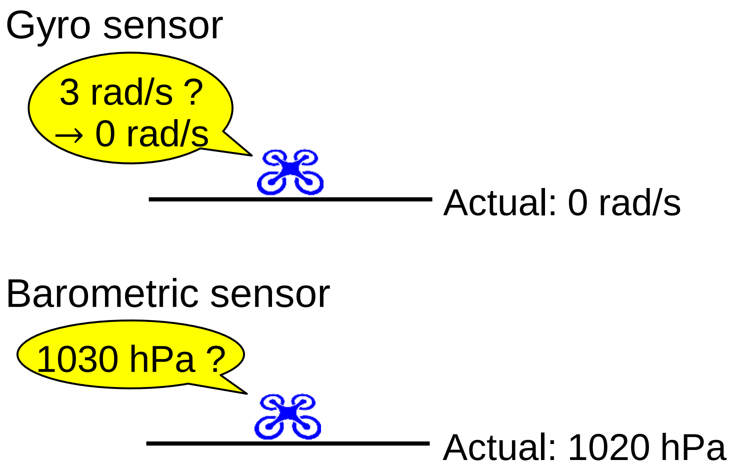
Sources of the discrepancy

i. Altitude reference system



- manned aircraft can share the altitude information appropriately through using same QNH setting.

ii. Bias error



- The barometric pressure varies depending on time and place.
- A drone cannot calibrate the bias error by itself.

Altitude correction method for drone

i. Deriving QNH from the nearest airport and the elevation at the takeoff point.

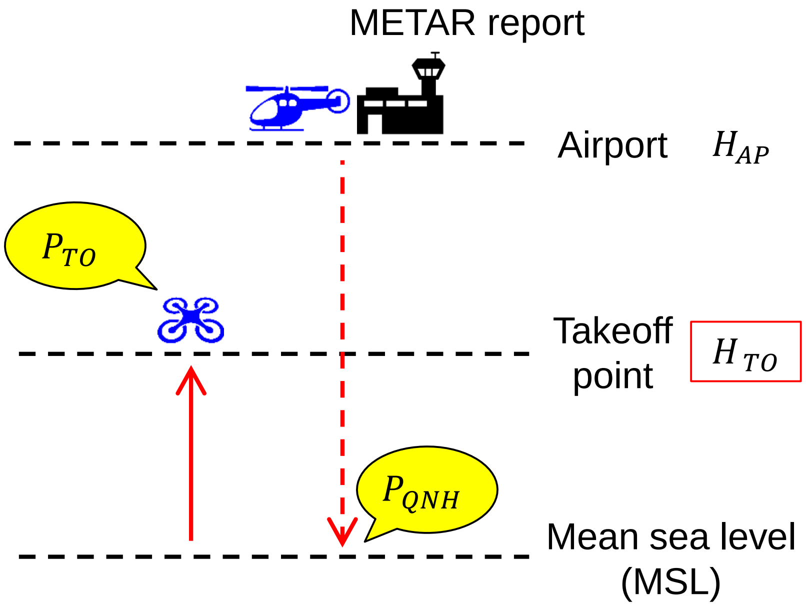
ii. Calculating the barometric pressure at H_{TO} according to the International Standard Atmosphere (ISA) model based on P_{QNH}.

iii. Calibrating the barometric pressure sensor with P_{TO}.

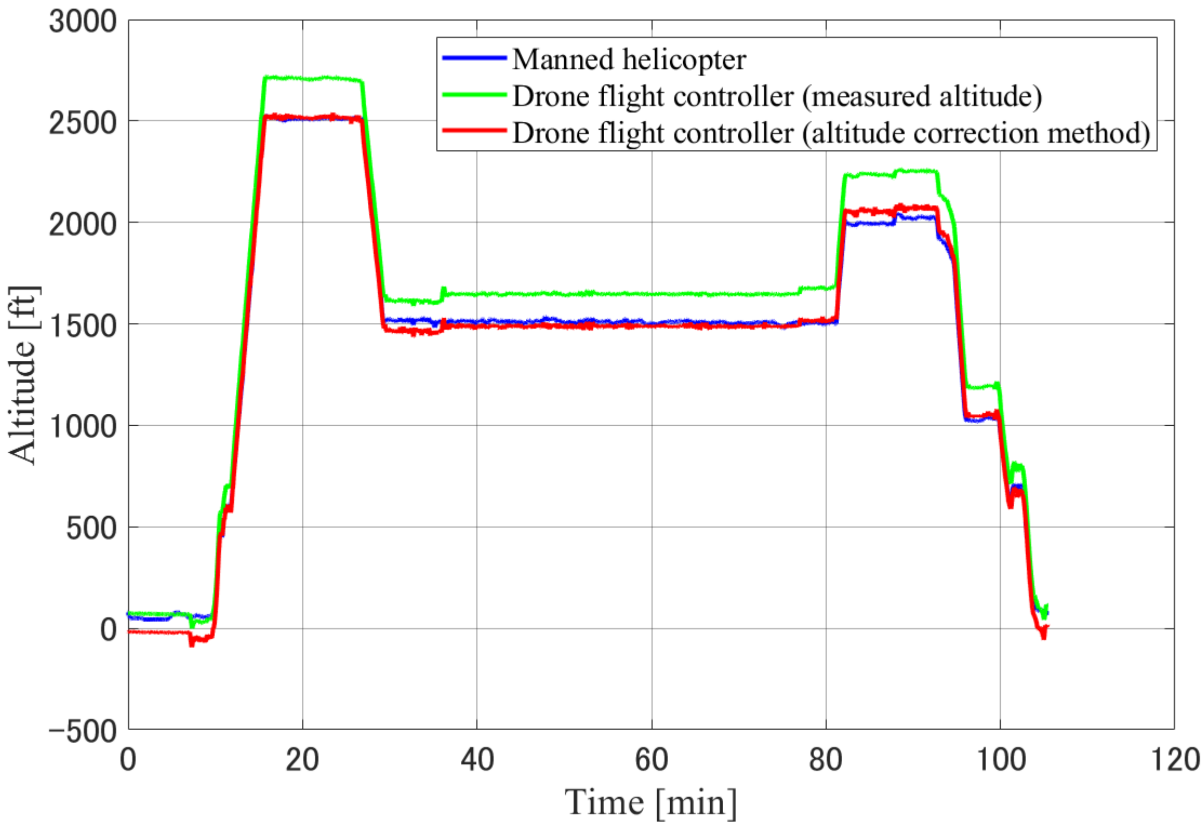
iv. The pressure altitude with the QNH setting can be calculated as follows:

$$H_{P_{QNH}} = \frac{T_0}{\beta}\left[\left(\frac{p}{P_{\mathrm{QNH}}}\right)^{-\frac{\beta R}{g}} - 1\right]$$

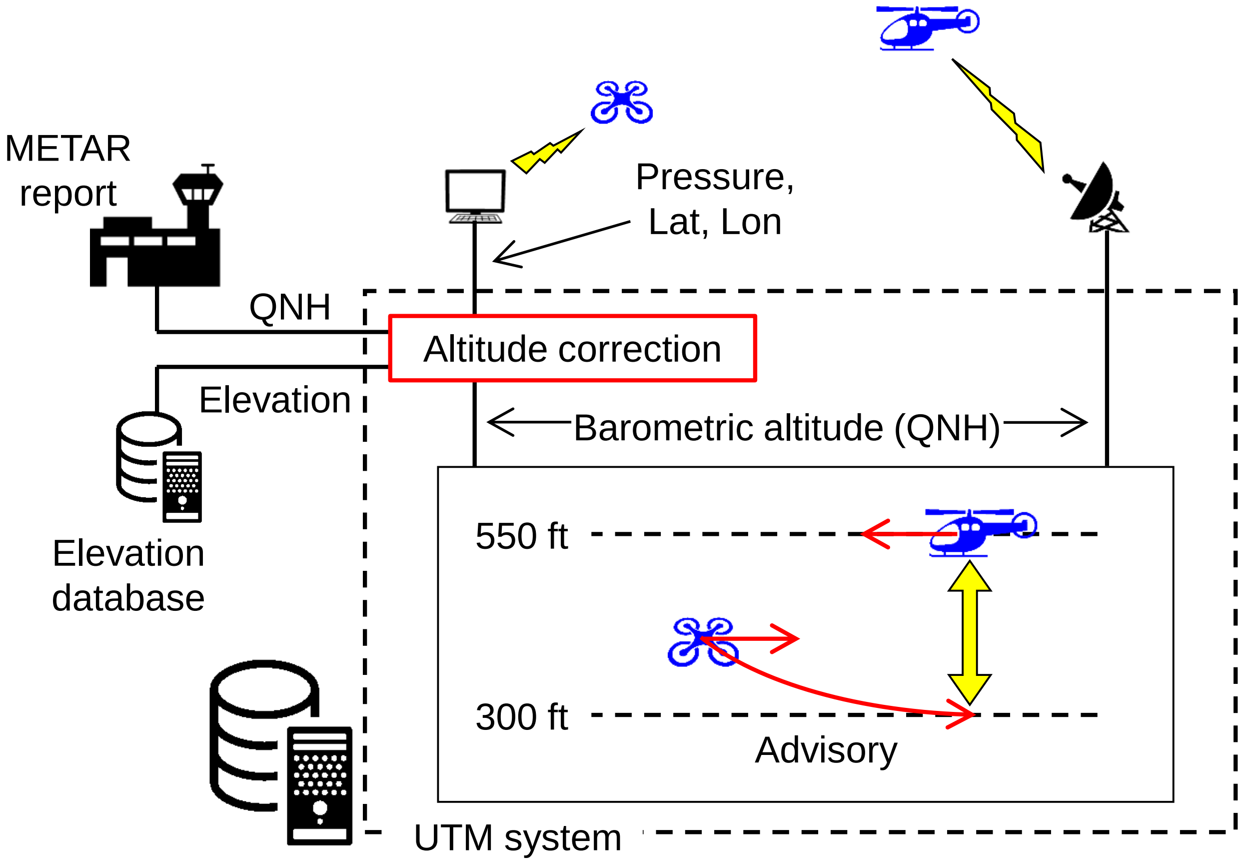
H: Elevation Hp: Pressure altitude P: Pressure
T: Temperature β: ISA temperature gradient
p: Pressure measured by drone
R: Real gas constant g: Gravitational acceleration
$_{AP}$: Airport $_{TO}$: Takeoff point $_{QNH}$: QNH



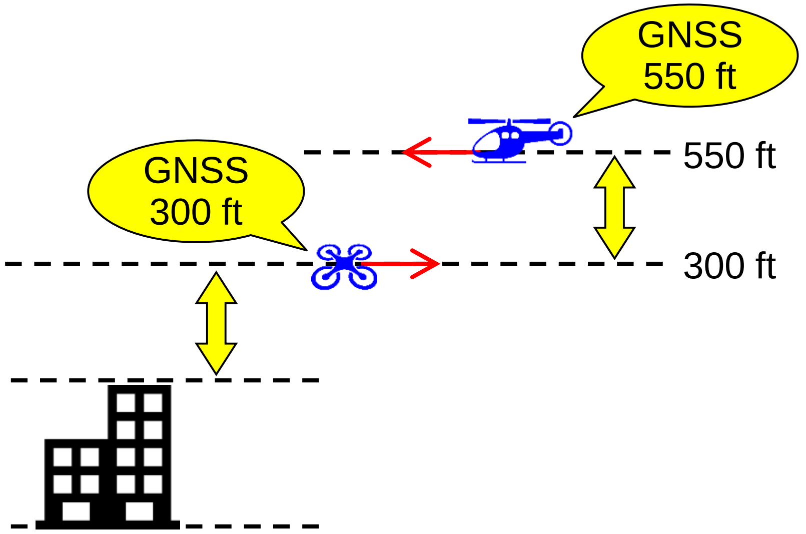
Altitude correction method for drone

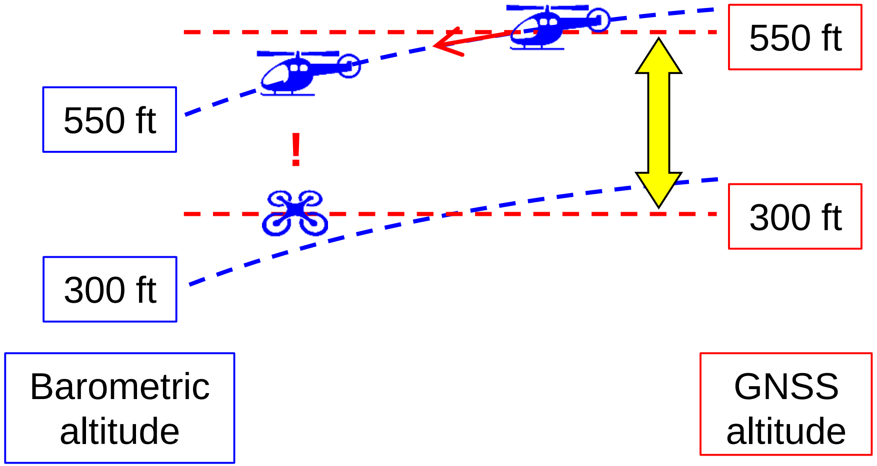


Implementation of the altitude correction method



How about using the GNSS altitude?





- Both manned aircraft and drone use the GNSS altitude to maintain separation.
- The GNSS altitude is useful for maintaining separation from the terrain and buildings.

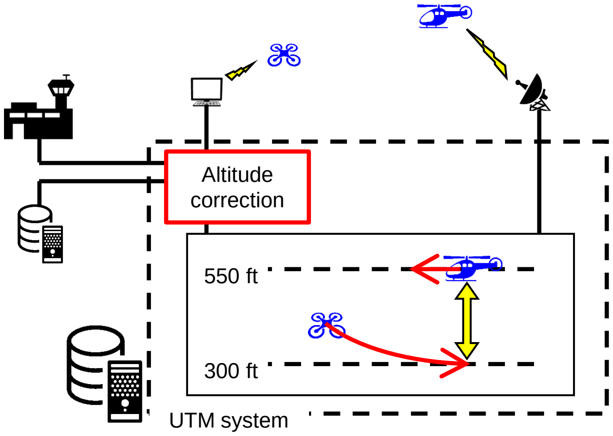
Drawback

- The altitude discrepancy can lead to unintentional violation of separation, even though sufficient separation has been achieved.

Summary and conclusion

- Altitude discrepancy can be occurred between the manned aircraft and drone due to the difference of the altitude measurement method.
- To investigate the altitude discrepancy, several flight tests were conducted.
- An altitude correction method was proposed. The altitude discrepancy can be significantly reduced by applying the altitude correction method.

Maintaining separation with manned aircraft
→ Barometric altitude



Marinating separation from the terrain/buildings
→ GNSS altitude