

Positioning by VOR signals in Ukraine region

Position determination is one of the most important task in navigation technics. Each navigation task is grounded on positioning method. Successful movement depends on accuracy of coordinate detection of vehicle. In air navigation sphere availability and accuracy of positioning provides flight safety. Nowadays Global Navigation Satellite System (GNSS) provides very accurate global position data than other technics. GNSS represents by GPS and GLONASS. Each airspace user has to use GNSS equipment for positioning purposes. But some time in some regions accuracy of positioning may be not enough for guaranteed requite level of flight safety. In this case we can use other positioning technics like inertial positioning or positioning by signals from radio beacons (NDB, DME, VOR, DVOR and e.t.).

Nowadays each aircraft have to be equipped with Very High Frequency Omni Range receiver. This equipment provides bearing data of radio beacon ground station for pilot. On-board flight management computer system can use this bearing data to aircraft position determination. Coordinates of VOR ground station location (x_i, y_i) and bearing angle (α_i) are input data for positioning. VOR station location we can have if will use global beacon data base. Geometrically solve this navigation task is possible in local coordinate system by simple trigonometric ratio in rectangle, by formula:

$$X = \left((A^T A)^{-1} A^T B \right)^T,$$

where $A = [1 \quad tg(\alpha_i)]$, $X = [x_{user} \quad y_{user}]$, $B = [x_i - y_i tg(\alpha_i)]$, $i = 1 \dots n$.

Of course, for solving this equation we have to use more than two navigation signals from different ground station (for 2D navigation or three for 3D).

The accuracy of this navigation principle depends on angle measurement equipment and geometry of ground stations location. Nation aviation department of each country have to estimate availability and accuracy of VOR positioning into country airspace.

The geometric dilution of precision (GDOP) coefficient is shown influence geometry of ground station location on position accuracy. GDOP usually is a part of total precision. Result of Analysis of Ukraine national VOR ground beacon system represents availability to receive VOR signals on 1.8% country territory from 6 beacons; 4,6% – 5; 22,2% – 4; 52,4% – 3 and 19% – less than 2. Therefore navigation by VOR station signals available on 81% of Ukraine area. GDOP coefficient for VORs ground station system in Ukraine region looks like this:

- for 3.8% Ukrainian airspace GDOP coefficient will be less than 1,
- for 78.8% – from 1 to 2;
- for 17.4% – more than 2.

Results have shown good availability this method in Ukrainian airspace for national VORs system.