AVIATION IN THE XXI-ST CENTURY

NATIONAL ACADEMY OF SCIENCES OF UKRAINE
MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY


# PROCEEDINGS

## THE SEVENTH WORLD CONGRESS "AVIATION IN THE XXI-st CENTURY"

## "Safety in Aviation and Space Technologies"

**September 19-21, 2016**
**Kyiv, Ukraine**

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**Analysis of DME/DME positioning facility for Ukrainian airspace**

*The questions of DME/DME positioning have been discussed. Availability and accuracy of positioning by DME/DME approach were estimated for Ukrainian airspace. In the article, the analysis of current state of NAVAIDS service in comparison with previous one was indicated.*

**Introduction.**

During the last years Ukrainian Navigation Aids (NAVAIDS) infrastructure has been changing rapidly. Several domestic problems were the reason of this changes. In summer of 2016 four DME ground radiobeacons have been suspended for un-predicted time period in eastern and southern regions of Ukraine. Also, new ground based equipment of NAVAIDS were installed for civil aviation service support.

Detection of aircraft location in the airspace is one of the key problems in aviation. Accuracy and availability of coordinate's detection is valuable part of flight safety. Many different approaches have been using to improve positioning losses on board of aircraft.

The main reason of this investigation has been highlighted by aviation safety, because NAVAIDS positioning algorithm is the main of alternative navigation facilities of aircraft [1-3]. Alternative to global navigation satellite system (GNSS) positioning systems play the key roll in case of some problems with receiving navigation signals from satellites. It can be the result of bad satellite geometry, some processes in ionosphere [4] or radio interference with military equipment.

Flight management system (FMS) uses other positioning methods to determine the coordinates in case of malfunction airborne equipment of GNSS or inability to determine the coordinates. In this case we can use other positioning techniques like inertial navigation or positioning by signals from radio beacons. Inertial Navigation System may be used for limited time in consequence of the additive error [5]. Positioning algorithms of FMS are alternative source of position information. It is based on the usage of information from navigation beacons such as NDB, DME, VOR, DVOR etc. [1-3].

**Analysis of changes in NAVIDS**

Unfortunately, ground based part of DME in eastern and southern areas of Ukrainian airspace has been out of service [6]. It includes the following DME radio beacons [1]:

- DON, Donetsk, 48.0718002319336 N, 37.7359008789062 E;
- SMF, Simferopol, 45.051399230957 N, 33.9793014526367 E;
- KER, Kerch, 45.3708992004395 N, 36.405101776123 E;
- MRP, Mariupol, 47.0750999450684 N, 37.4518013000488 E.

Besides, into the central part of Ukraine eight [6] updated and new DME radio beacons have been installed in last three years. All of new NAVAIDS are providing their services for civil aviation. New DMEs include [6]:

- BAH, Bakhmach, 51.0354 N, 32.5312 E (2016);
- IKI, Kyiv/Zhyliany, 50.23599 N, 30.26265 E (2013);
- IKV, Kyiv/Zhyliany, 50.24040 N, 30.27444 E (2013);
- KSN, Koshany, 50.56455 N, 30.58401 E (2014);
- KVH, Kirovohrad, 48.32405 N, 32.17309 E (2014);
- SLV, Soloviivka, 50.11125 N, 29.34125E (2013);
- STB, Stebliv, 49.24187 N, 31.04364 E (2014);
- YHT, Yahotyn, 50.15544 N, 31.47403 E (2014).

New DME radio beacons fill out the most PBN requirements [7] for air navigation services in Ukrainian airspace and improve navigation facility.

Current NAVAID network in Ukraine consists of twenty DME radio beacons[6] (table. 1.).

*Table 1.*

Ground equipment of DME in Ukrainian NAVAIDS network

| No. | Identi-fication | Name | Latitude | Longitude | Collocated VOR, Identifi-cation | Chan-nel |
|---|---|---|---|---|---|---|
| 1 | BAH | Bakhmach | 51.0354N | 32.5312E | | 114X |
| 2 | BRP | Boryspil | 50.17085N | 30.54035E | BRP | 106X |
| 3 | DNP | Dnipropetrovs'k | 48.21354N | 35.0611E | DNP | 72X |
| 4 | IVF | Ivano-Frankivs'k | 48.5303N | 24.4129E | IVF | 89X |
| 5 | IHA | Kharkiv | 49.55441N | 36.18102E | | 54X |
| 6 | IHR | Kharkiv | 49.55367N | 36.16395E | | 48X |
| 7 | IKI | Kyiv/zhyliany | 50.23599N | 30.26265E | | 54X |
| 8 | IKV | Kyiv/zhyliany | 50.24040N | 30.27444E | | 20X |
| 9 | KHR | Kharkiv | 49.55441N | 36.17256E | KHR | 112X |
| 10 | KSN | Koshany | 50.56455N | 30.58401E | | 23X |
| 11 | KVH | Kirovohrad | 48.32405N | 32.17309E | KVH | 96X |
| 12 | KVR | Kryvyi rih | 48.03036N | 33.12437E | | 107X |
| 13 | LIV | L'viv | 49.4843N | 23.5705E | LIV | 102X |
| 14 | ILO | L'viv | 49.4854N | 23.5653E | | 32X |
| 15 | ILV | L'viv | 49.4805N | 23.5806E | | 40X |
| 16 | ODS | Odesa | 46.2549N | 30.4015E | ODS | 86Y |
| 17 | SLV | Soloviivka | 50.11125N | 29.34125E | SLV | 80X |
| 18 | STB | Stebliv | 49.24187N | 31.04364E | | 77X |
| 19 | VIN | Vinnytsia | 49.1424N | 28.3715E | | 86X |
| 20 | YHT | Yahotyn | 50.15544N | 31.47403E | | 117X |

**Analyses of DME Availability.**

Availability of DME equipment in Ukrainian airspace will be estimated for a net of nodes with a cell in 1 km. For each point of airspace the distance to the DME

ground stations is calculated and compared it with the maximum range of beacons. Radio beacon operational range depends on the class as follows [8]:

- Terminal (T). For the true heights from 305m up to 3658m maximum slant range is 46km;
- Low altitude (L). For the true heights from 305m up to 5486m maximum slant range is 74km;
- High Altitude (H).
    a. For the true heights from 305m up to 4420m maximum slant range is 74 km;
    b. For the true heights from 4420m up to 18288m maximum slant range is 185 km;
    c. For the true heights from 5486m up to 13716m maximum slant range is 241 km.

The horizontal range of the DME activity depends on the aircraft altitude and slant range to the ground radiobeacon location. However, relief also should be consider in DME radio signals availability.

In assessment of positioning availability the grid with nodes will be used. Each of nodes of the grid is equidistant from the surface of global ellipsoid (WGS 84) into distance of investigation height. Quantity of nodes determines the accuracy of assessment. Within the cell an availability is considered as a constant. Availability assessment is performed in the global Cartesian coordinate system ECEF (earth-centered earth-fixed) with the next transformation to geocentric coordinate system LLA (Latitude Longitude Altitude).

The results of accessibility estimation to the altitude of 8000 m is shown in Fig. 1. Areas contour indicate the amount of radio navigation stations available in the airspace.

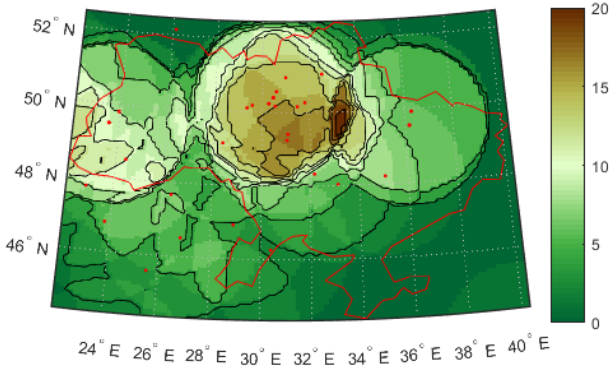


Fig. 1. Amount of available DME station

**Analyses of DME/DME positioning accuracy.**

Accuracy of DME/DME positioning is analyzing by Dilution of precision (DOP) coefficients. There are three main of them for DME/DME positioning:

– HDOP (Horizontal DOP) – accuracy rate of change in the horizontal plane,

– VDOP (Vertical DOP) – accuracy rate of change in the vertical plane,

– PDOP (Position DOP) – total accuracy rate coefficient.

Multi DME methodology [1-2] is used for DOP coefficients estimation. Results of these analyses are represented on fig. 2.

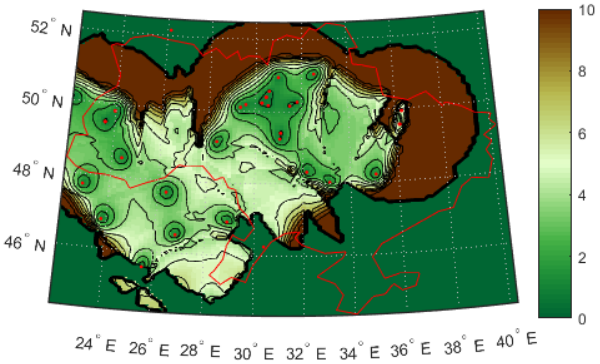


Fig. 2. HDOP

NAVAIDS infrastructure of Ukraine has been changing rapidly for the last three years. Many new equipment has been installed as a result fig.1 and fig. 2 indicates availability of DME/DME positioning with quite good positioning accuracy.

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