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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- National Aviation Academy "Azerbaijan Hava Yollari" Closed Joint-Stock Company, Azerbaijan
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* Authors are responsible for the content of the report

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1.2. Modern technologies of aircrafts airworthiness support
1.3. Fatigue and fracture of aircraft structures
1.4. Modern tribotechnologies in aircraft and general-purpose mechanical engineering
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1.7. Automated process control systems
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UDC 537.612.2(045)

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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.

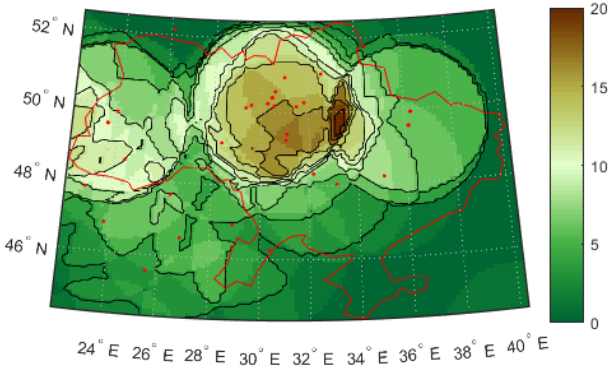

Fig. 1. Amount of available DME station

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.

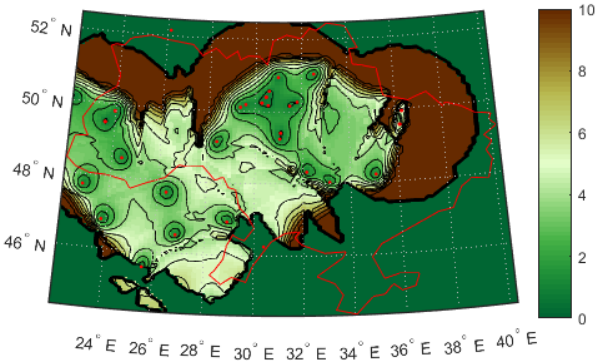

Fig. 2. HDOP

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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