AVIATION IN THE XXI-ST CENTURY

NATIONAL ACADEMY OF SCIENCES OF UKRAINE
MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
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PROCEEDINGS

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

“Safety in Aviation and Space Technologies”

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Timing problem of multi DME/DME approach

The main problem of multi DME/DME positioning approach has been discussed. Timing problem related to avionics structure of civil aircraft that is result of possibility of operation with one pair of DMEs at one time. Recurrent investigation was proposed to solve the timing problem.

Introduction.

Detection of aircraft location is one of the most important tasks in air navigation. Each navigation task is grounded on positioning method. Successful movement depends on accuracy of coordinate detection of the vehicle. In air navigation sphere availability and accuracy of positioning provides flight safety. Nowadays Global Navigation Satellite System (GNSS) provides more accurate global position data than other techniques. GNSS is represented by GPS, GLONASS and GALILEO. Each airspace user has to use GNSS equipment for positioning purposes as the main source of coordinate location. But, sometimes in some regions an accuracy of positioning may be not enough to guarantee the required level of flight safety. It is a result of influence of different factors like pure satellite geometry, process inside of ionosphere, interference etc [1]. There are some specific techniques to solve this problem on board of each modern aircraft.

Nowadays many manufactures of GNSS receivers integrate inertial principle inside of equipment to improve positioning accuracy and increase availability of coordinate data. There are several different approaches to use inertial principle into different levels of data computation inside of receivers. Besides, positive effect of such kind of integration is limited in operation time. Inertial navigation can be useful only in limited time period according to additional nature of errors.

In case of high errors of inertial navigation and absence of data from GNSS, positioning by NAVAIDS is used [2-4]. Many modern flight management systems (FMS) have preinstalled algorithms of location detection by distance and angle data from Automatic directional finder (ADF), on-board part of Distance measurement equipment (DME) or receivers of VOR [2-4]. Usually, it includes the following geometrical principles: DME/DME, DME/VOR, VOR/VOR, NDB/NDB, etc.

In classical scheme of avionics structure (fig. 1) FMS will find radio beacons according to flight planed trajectory and send this data to Radio management equipment that will tune radio navigational equipment of aircraft. Result of measurements will come back to FMS directly from DME, VOR, ADF [5]. Two blocks of each equipment should to be installed on-board of aircraft according to the main avionics requirements. Each equipment of NAVAIDS can operate only with one ground equipment at time. Therefore, at least two distance to DMEs, two angles to VOR and NDB can be proceed at one moment of time.

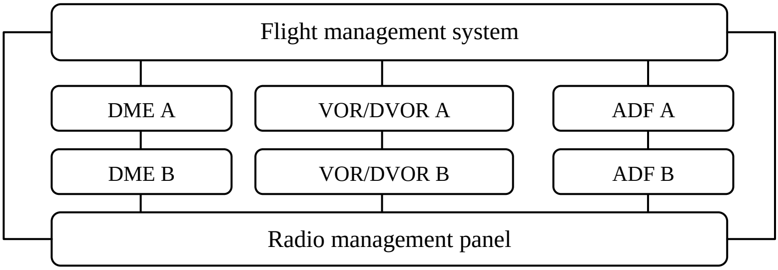

Fig.1. Interchange of NAVAIDS data inside of on-board equipment

Timing in DME/DME positioning

According to data limitation only one pair of DMEs can be used to aircraft location detection. In [3] the main limitation for pairs of DME choosing has been discussed. The direction crossing angle in 30-150˚ is strongly required for RNAV.

Many investigations indicate increasing accuracy of positioning in the result of using multi DME approach. In this case the possibility to get data on board of aircraft from all available DME in operational range is regarded. But multi DME approach can not be realized in hardware, because it will be the result of increasing sizes and prices for equipment. In other hand, there are some mathematical approaches to use multi DME approach. The main problem in multi DME approach is timing. Let's discus a situation with four DMEs (fig.2) and aircraft that flies in their operational range.

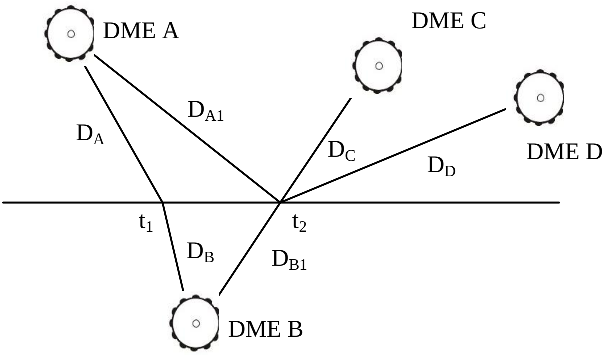

Fig. 2. DME pairs operation

FMS operates with ground stations A and B at time t1, because at one time FMS can get information only from two DMEs. As a result distances DA and DB can be measured. Later at time t2 FMS tune DME equipment for operation with the next pair of DMEs which is represented by C and D ground stations. After distance measurement DC and DD will appear. Also, at time t2 data from previous DME pair are not active, because aircraft has changed the location. Therefore, distances

$D_A \neq D_{A1}$ and $D_B \neq D_{B1}$ and as a result can not be used in multi DME approach together with a second pair CD.

Many algorithms loose difference between D_A and D_{A1} and consider a result in total errors.

In other hand timing problem of multi DME can be solved by using classical approach to predict distances D_{A1} and D_{B1} by previous measurements.

If we can use that aircraft acceleration is absent, we can estimate aircraft location by two previous measurements. But, at first we should use data from the first DME pair to calculate radial speed:

$$V_D=(D_i-D_{i-1})/T,$$

where

i – iteration number,

T – time of observation.

After second observation we can use radial speed to extrapolate DME data for the next period of time:

$$Di=D_{i-1}+V_D T.$$

Extrapolated distance for DME A and DME B can be used together with distances to DME C and DME D in multi DME approach.

Conclusion

Multi DME/DME approach in positioning is more accurate than positioning by pairs of DMEs. Represented approach can be easily used in typical avionics structure to use multi DME algorithms inside of FMS.

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