UDC: 629.783:629. 735. 33

V.V. Konin, doctor of technical sciences
E.A. Kovalevskiy, senior staff scientist
T. I. Olevinska, graduate student
(National Aviation University, Ukraine)

GNSS TECHNOLOGY LANDING SYSTEM OPTION FOR FLYING MACHINE

The modeling of final approach path by means of Global navigation satellite system is considered in this article.

Introduction

A global aeronavigation plan in reference to CNS/ATM systems designates GNSS system as a key element of communication, navigation, surveillance systems and systems, which are connected with air traffic organization, as well as a basis the governments can improve the air navigation service. GNSS possesses the potential abilities to maintain all flight phases, providing continues global observation. It allows to exclude the need for plenty of ground-based and on-board systems, which were developed for special requirements at a definite flight stages.

Nowadays precision approach procedures in accordance with first category together with corresponding GNSS equipment are authorized. The 2 and 3 categories requirements are being developing.

GNSS precision approach procedure is marked as GLS procedure approach. The GLS flight path is differently, not like by ILS. Data defining the flight path are transmitted onboard via digital data link as a data block FAS (final approach segment). Onboard equipment GNSS based on geometrical ratios calculates flight path parameters and designates homing characteristics similar to other approach systems, ILS for example.

One should take into account there is no available information in literature how to perform geometrical calculations.

Formulation of the problem and model description

The purpose is to reconstruct the procedure of definition of homing parameters without touching upon the problems of integrity, continuity and operational readiness of maintenance and to investigate precision performance of GLS approach and landing system.

Data block FAS is transmitted aboard in a message type 4 from operational supplement GBAS. In order to define final approach phase path the following elements are transmitted: latitude, longitude and height of threshold pass LTP/FTPL, the difference between delta FPAP latitude and delta FPAP longitude of point FPAP of the runway and corresponding parameters of point LTP/FTP, height of crossing of runway threshold TCH, glide path angle, course width and offset delta -distance from the end of the runway to FPAP. Distance D is known. Onboard equipment GNSS provides airplane center-of-gravity coordinates definition in WGS-84 system with occasional errors.

In order to provide approach and landing aircraft position information relatively the runway is necessary.

As it shown in [2], the parameters of the lateral movement of aircraft on landing are the linear Zb and angular epsilon b separations from equivalent signal zone. Zb equals to perpendicular length put from center-of-gravity of airplane to a vertical flatness crossing the runway. Epsilon b angle is defined as the angle between line with points GARP -LTP/FTP and projection to horizontal flatness which contains the RW, a line from center of gravity of aircraft to GARP point.

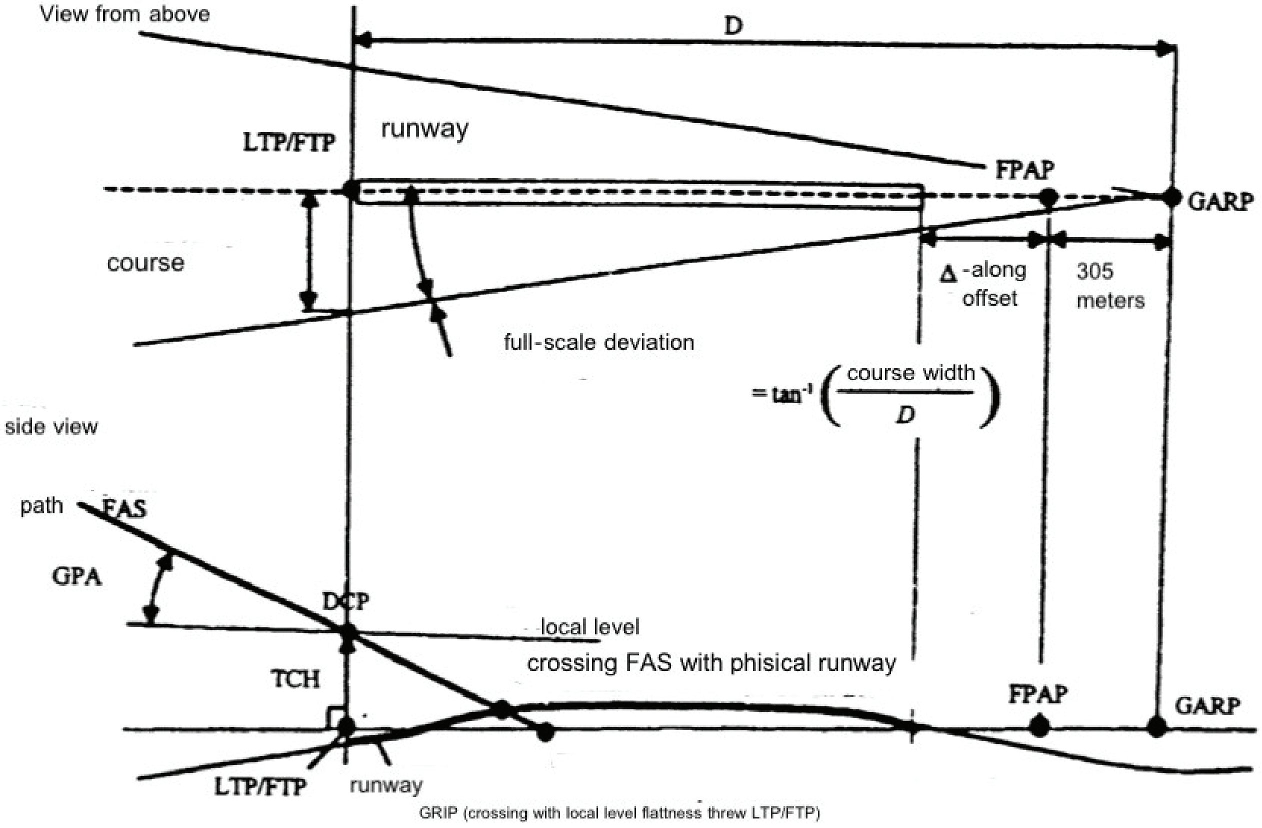

Fig.1. Final approach path

The long across movement parameters of AC on approach are the linear Zp and angular epsilon p separations from equal signal zone of the path

Zh equals to the length of the perpendicular derived from center of gravity of AC to horizontal flatness. Epsilon p angle is defined as the angle between line with points GRIP -DCP and projection the vertical flatness, passing the RW, line with points of center of gravity of AC -GRIP

To perform model investigation the following procedures-functions are developed:

RPM -recounting of spherical coordinates to Decart's;

PLP-calculation of parameters of the common equation of flatness through coordinates of 3points [4];

RTP-calculation of distance from point T to flatness P [4];

PEPP-calculation of coordinates of point of perpendicular crossing from point T to flatness;

RASU -calculation of angle between two vectors in space

Initial data and estimated ratios:

latitude teta L = 50.43 degrees,
longitude -lambda L = 30.43 degrees,
height - hL=200m of point LTP/ FTP,
course width – KS = 140 m,
D = 3000m,
GPA = 3 deg,
TCH = 50m,
FM coordinates: XS = XL – 5000; YS = YL; ZS = ZL + 3000, where XL,YL,ZL are LTP/FTP point coordinates

Latitude – tetaG = tetaL – D/111110;
Longitude – lambdaG = lambdaL;
Height – hG = hL of point GARP.

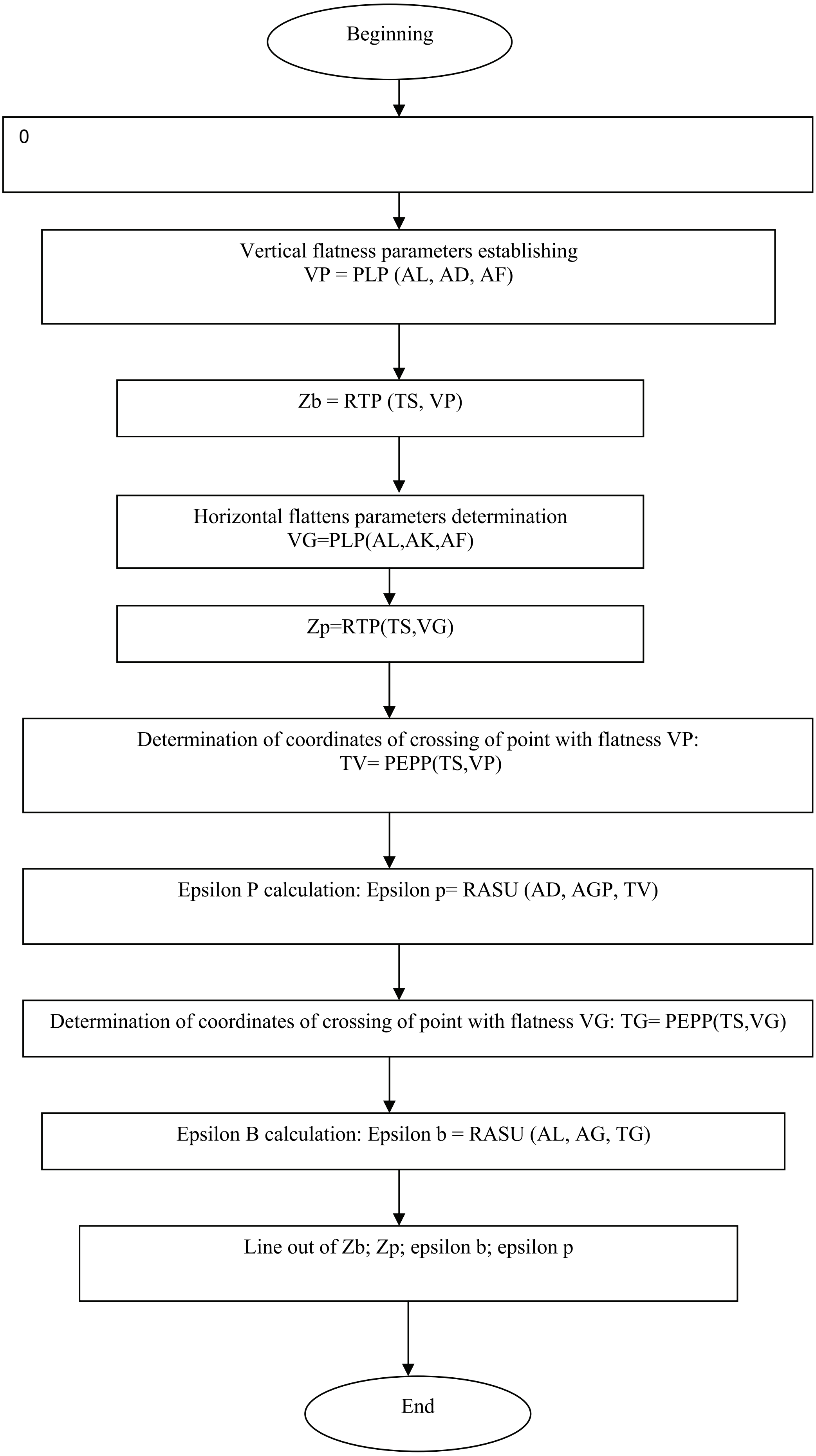

Fig. 2. Block-diagram of program of calculation of homing parameters

Latitude – tetaGP = tetaL – TCH/111110*tg (GPA);
Longitude – lambda GP = lambda L;
Height – hGP = hL of point GRIP.
Latitude – tetaF = tetaL – (D – 305)/111110;
Longitude – lambdaF = lambdaL;
Height – hF = hL of point FPAP.
Latitude – tetaD = tetaL;
Longitude – lambdaD = lambdaL;
Height – hD = hL = TCH of point DCP.

Block-diagram of program of parameters calculation is depicted on figure 2, where AL, AF, AK, AD, AG, AGP -vectors of coordinates of points LTP/FTP, borders KS,DCP, GARP,GRIP accordingly, TS-FM coordinates vector.

Modeling results

The sense of the modeling is the following. For fixed coordinates of FM by means of program (figure 2) the volumes of Zb, Zp, epsilon b, epsilon p are calculated. The occasional mistakes in coordinates calculation by board-based receiver in cycle of realizations added and calculations repeated. The low of mistakes ramification is normal with parameters [0, sD].

The results of declinations of calculated volumes in averaging by 1000 realizations are stated in table, where mZb,mZp,meb, mep are the mathematic expectations, sZb, sZp, seb, sep - mean-square declinations of homing parameters from calculated ones without mistakes introduction. The units of measuring are meters and radians.

Table 1

Results of modeling

sD	10	5	3	1
mZb	- 0.11	- 0.06	- 0.04	0.03
mZp	- 0.06	- 0.09	- 0.05	0.004
meb	$-1.2*10^{-5}$	$-3.8*10^{-6}$	$3.7*10^{-6}$	$3.8*10^{-6}$
mep	$-6.3*10^{-8}$	$-9.0*10^{-8}$	$-5.7*10^{-8}$	$3.8*10^{-9}$
sZb	9.99	5.01	2.99	1
sZp	9.94	5	3.01	1
seb	$3.5*10^{-3}$	$5.4*10^{-4}$	$3.2*10^{-4}$	$1.05*10^{-6}$
sep	$1*10^{-5}$	$5.2*10^{-6}$	$3.2*10^{-6}$	$1.0*10^{-6}$

As derives from the obtained results, the mean-square mistakes in linear homing parameters definitions are equal and the angular ones are proportional to mistakes mean-square declinations in FM coordinates calculation.

Conclusions

The performed investigations show that declared model allows to calculate parameters of FM homing in GNSS approach and landing The model also allows to establish dependence of homing calculation errors from mistakes of board-based receiver calculations of coordinates. The results show that for providing of categorized landing differential mode of navigation calculations implementation is necessary.

Literature

1. International standards and Recommended practice (SARPS). ICAO document C – WP/11519 13/2/01
2. Agajanov P.A., Vorobyov V.G., Kuznetsov A.A., Markovich E.D - Automation of air navigation and air traffic control - Moscow, Transport.
3. V.V. Konin, V.P. Kharchenko – Satellite navigation systems – Kyiv, Holteh, 2010. – 520p.
4. Vygodskiy M.Y. – Guide to Higher Mathematics – Moscow, Science, 1977. – 852p.