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HARDWARE-SOFTWARE COMPLEX FOR NAVIGATION SATELLITE SYSTEMS AVAILABILITY PREDICTION

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Abstract. *Development of a hardware-software complex for calculation navigation systems availability in order to improve flight safety aircraft which use satellite navigation.*

Keywords: availability; dilution of precision; hardware-software complex; prediction; satellite navigation.

1. Introduction

In the next years satellite navigation becomes a one way of air navigation for service civil and military aviation for almost all over the world including countries of the European Union and USA [5, 6, 8, 10].

Resource bases for transition to satellite air navigation are global navigation satellite system GPS and GLONASS, developed satellite-based augmentation system WAAS (USA), EGNOS (European Union), MSAS (Japan), GAGAN (India), local area augmentation system LAAS (USA) ground-based augmentation system GRAS, navigation system GALILEO built by the European Union, additional navigation aids (aerodrome) for precision approach.

Powerful impetus to satellite navigation transition is possibility of alternate route flight, essential decrease of ground-based navigation equipment cost, and opening of satellite navigation devices trade.

There is a problem of improving flight safety aircraft that use satellite navigation device due to intensive adoption of satellite navigation means in aviation.

One of effective means of improving flight safety and decrease of air crash risk is a method of satellite navigation availability calculation by means of accuracy characteristics prediction in any route segment with the help of data that obtained from navigation satellites directly before flight.

2. Analysis of recent research and publications

There aren't the systems of navigation satellites availability estimation in Ukraine.

It should be noted that Trimble Navigation, Ltd spreads Planning software [9].

Trimble's Planning Software was developed for availability predict of different satellite constellation.

Planning Software predicts the availability of navigation satellites for just one fixed position of the user, and does not provide prediction of navigation satellites availability for objects which coordinates are constantly changing over time such as aircraft.

So at present in Ukraine there are no systems to predict the navigation satellites availability on the aircraft route.

3. The goal of the article formulation

In given paper the hardware-software complex for calculation navigation systems availability is observed.

The main task of this complex is improving flight safety aircraft which use satellite navigation devices due to satellite navigation availability prediction in any time and route segment.

4. The main material

The best method of satellite navigation availability prediction is a hardware-software complex.

This hardware-software complex includes multichannel satellite navigational receiver, object-oriented environment and personal computer that calculate obtained data from navigation satellites. Main component of the hardware-software complex is the unique software which data processing with the help of special algorithm.

Dilution of precision is computed by the hardware-software complex using obtained data from navigation satellite Availability criteria of satellite navigation system is produced according to dilution of precision for any route segment.

Main construction principle of the hardware-software complex is modularity.

Data processing and prediction is provided by the personal computer.

Modularity means almost independent constructions for master functional devices.

These devices connect with each other by coaxial cable or multipath communication line which link bit-serial interface ports (RS-232 or RS-422) together.

As well as modularity provides usage of multichannel satellite navigation receiver as a separate device with independent structure compatible with the personal computer.

Modularity applies to software to. It means that software can be upgraded and updated as modernization necessary.

Multichannel satellite navigation receiver is one of the main functional elements of hardware-software complex.

At first one can focus on modern navigation GNSS sensor, which was created by affiliate "Orizon-Navigation" (Ukraine), for example CH-3700 [4] or it can be choosing navigation receiver ProPak-V3 was developed by "NovAtel" (Canada) [7].

Due to modularity of hardware-software complex it may be substituted for higher-end satellite navigation receiver as necessary.

The software was developed in consideration of the data obtained from the navigation receiver and transformed to an appropriate format.

For this purpose was developed suitable convectors.

Operable state of these convectors was confirmed by previous modulation.

The hardware-software complex consists of the functional part and elements shown on a Fig. 1.

In the antenna-feeder device receives signals from navigation satellites GPS and GLONASS on the L1 frequency. Gain navigation signal moves to multichannel navigation receiver by transmission interface.

After data processing in navigation receiver signal moves to main processor and saves in dedicated folder according to data collection protocol.

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Almanac file obtained from the Internet come to main processor with the help of Internet adapter.

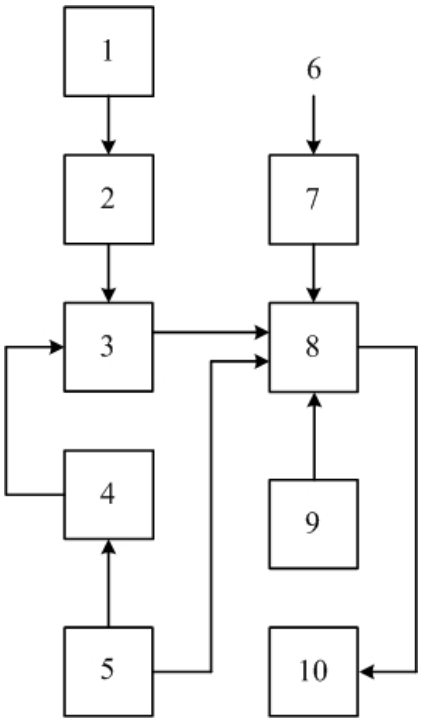


Fig. 1. The hardware-software complex block diagram:

1 – antenna;
2 – cable;
3 – multi-channel receiver;
4 – receiver power supply;
5 – uninterruptible power supply;
6 – internet;
7 – internet adaptor;
8 – main processor;
9 – software;
10 – printer

Almanac file can be finding on different independent sources.

Navigation information obtained from satellite multichannel receiver carrying out of operations on data by main processor and producing availability prediction of satellite navigation system.

Received information can be printed and submitted data in hard-copy form

Also can be record directly onto a CD disc using a PC CD writer.

Power supply of the hardware-software complex (personal computer and navigation receiver) makes available because of uninterruptible power supply and power unit of navigation receiver.

Special component of the hardware-software complex is the software which processing of data, obtained from navigational satellites.

First of all software calculates dilution of precision and then produce availability prediction for different navigation system in any time on the rout.

Core modules and data flow of the hardware-software complex are shown in Fig. 2.

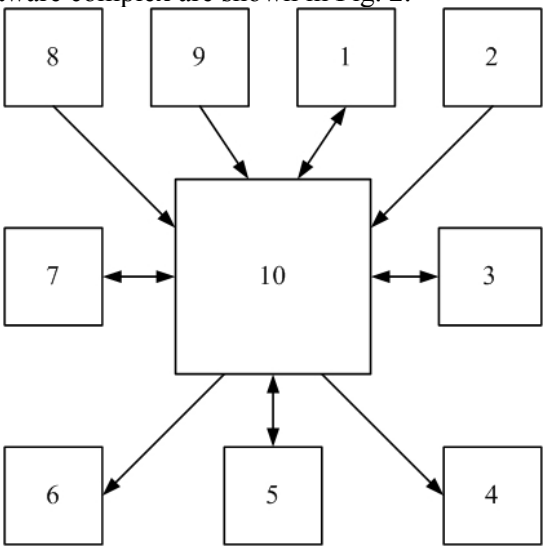


Fig. 2. Core modules of the hardware-software complex:

1 – internet;
2 – other sources (logical file);
3 – mathematical server;
4 – logical file;
5 – interface console;
6 – printer;
7 – mySQL database;
8 – navigation receiver;
9 – jeppesen software;
10 – manager Program

Manager program of hardware-software complex performs request and generation of input and output data, procedure of data flow direction between navigation receiver, data bases, specific program Jeppesen, Internet and other program functions which take part in calculation, solving and display results on the monitor and/or on paper.

Mathematical server of hardware-software complex calculates dilution of precision, visibility angles, orbit parameters availability of navigational satellites and availability of the aircraft route.

Interface console of the hardware-software complex displays satellite availability data and availability of the aircraft route in automatic and manual mode.

Also interface has a function of representation satellites visibility angles (angle of elevation and azimuth), classification of satellites navigation availability by time and aircraft coordinates, filter for simulation random failures.

Specific program Jeppesen serves for generation of coordinate-time information on the route (exactly position of the aircraft).

MySQL database is intended for save and organization of easy-to-use access for following data:

– Aircraft route information that is a position of the aircraft produced by Jeppesen;

– Output data from the navigational receiver, which contain almanac;

– Satellites availability data calculated on the aircraft route.

Navigation receiver allows user to obtain almanac from GPS and GLONASS navigation satellites, estimate health of GPS and GLONASS satellites system. Internet is an alternative source of almanac.

Hardware-software complex model was constructed from hardware resources of National Aviation University.

This model provides navigational satellites and route availability parameters estimated using different mode of operation.

It can be used only GPS satellite, or used only GLONASS satellite or it can operate data sharing GPS and GLONASS satellites (Fig. 3).

Model of the hardware-software complex consist of aerial which burns up multipath energy, base station ProPak-V3, 14-chanal navigation receiver CH-3700 (by Orizon-Navigation) and personal computer.

Model was assembled in order to test software of the hardware-software complex.

Together with the unique software model of the hardware-software complex has the following specifications:

Receive navigation data from GPS satellites.

Receive navigation data from GLONASS satellites in the form of logical files.

Receive GPS almanac data from Internet.

Receive air travel plan generated using a specific program Jeppesen [1].

Data processing according to interface control documents GPS and GLONASS [2, 3].

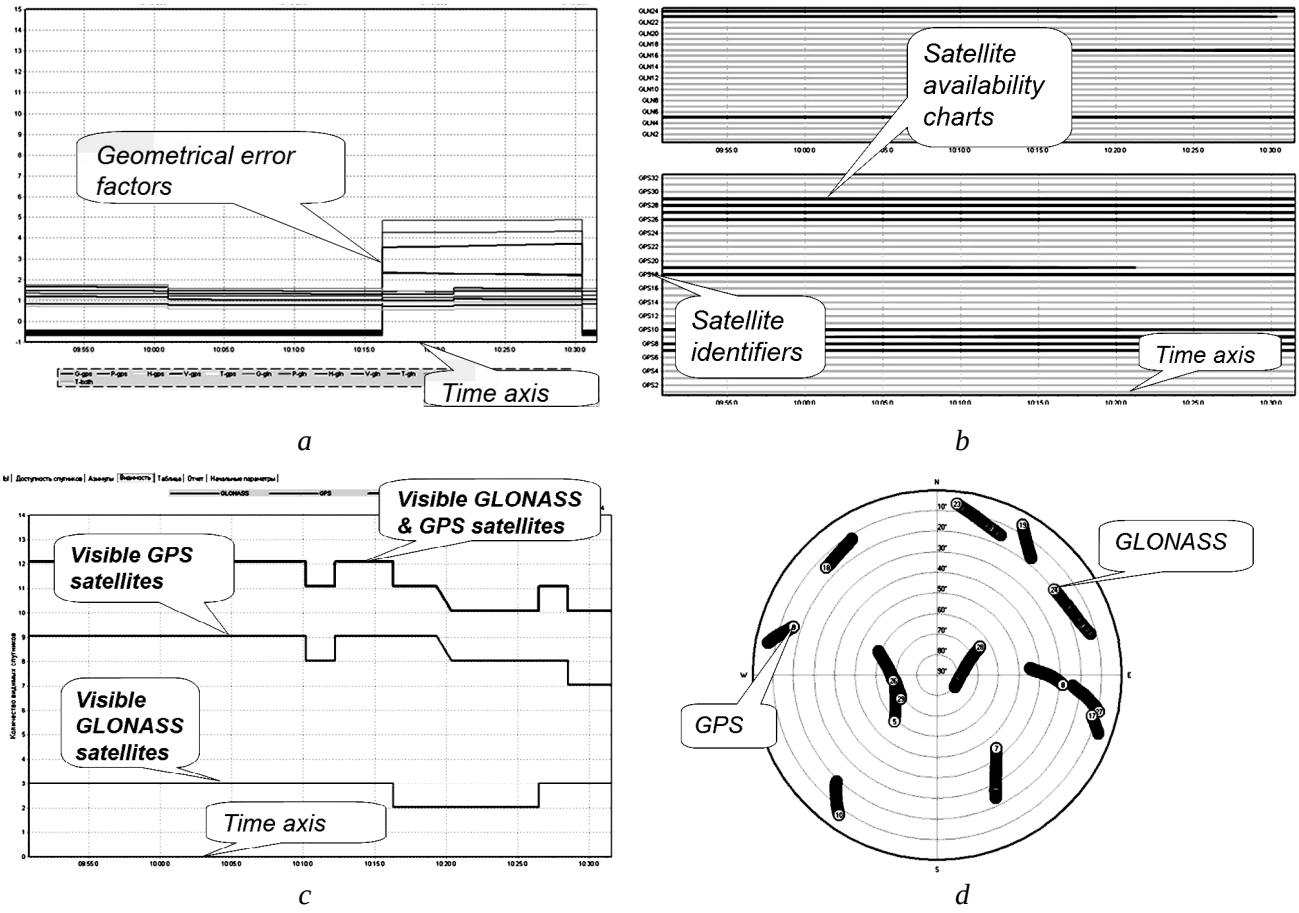
Time takes to solving the availability task is less than 2 min.

Time takes to downloads navigation data from satellites is less than 2 min.

Time takes to estimating and documenting of aircraft routing availability problem is less than 10 min.

Time takes to simulation of random failure is less than 1 min.

Elaborated complex of satellite navigation availability prediction to allow of estimation satellite availability in any time and an aircraft route due to operational (at two hours before flight) satellite navigation availability prediction.



a *b* *c* *d*

Fig. 3. Results of the hardware-software complex operation on the route:
a – Dilution of precision;
b – Satellite availability;
c – Satellite visible;
d – Satellite position

5. Conclusions

Application of satellite navigational technique as additional facilities increasing flight safety level can be effective if the introduced hardware environment satisfy the requirements of accuracy, integrity, continuity and operating availability, which proposed according to ICAO standard and in world practice; regulations which control of navigation system maintenance; scientifically grounded estimated parameter of ground and airborne navigation aids.

Use of the hardware-software complex in airlines and aviation agency permits to increase flight safety level owing to satellite navigation availability prediction at the stage of preparation for flights and to privies case of random and unregulated failure of navigational satellites.

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О.П. Сушич[1], І.А. Приходько[2]. Апаратно-програмний комплекс прогнозування доступності навігаційної супутникової системи

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Запропоновано концепцію апаратно-програмного комплексу прогнозування доступності навігаційних супутникових систем для забезпечення користувачів інформацією про можливість її застосування.

Ключові слова: апаратно-програмний комплекс; доступність; погіршення точності; прогнозування; супутникова навігація.

А.П. Сушич[1], И.А. Приходько[2]. Аппаратно-программный комплекс прогнозирования доступности навигационной спутниковой системы

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Предложена концепция аппаратно-программного комплекса прогнозирования доступности навигационных спутниковых систем для обеспечения информацией пользователей о возможности ее применения.

Ключевые слова: аппаратно-программный комплекс; доступность; прогнозирование; спутниковая навигация; ухудшение точности.

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