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STRUCTURING PERSPECTIVE NAVIGATIONAL AND LANDING ONBOARD COMPLEX FOR COMMUTER-SIZE AIRCRAFT

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У статті розглянуто концепцію формування бортового навігаційно-посадкового комплексу повітряних суден місцевих авіаліній, визначені його складові та їх взаємозв'язки.

Ключові слова: повітряне судно, місцеві авіалінії, навігаційно-посадковий комплекс.

In article considers the concept formation of airborne navigation and landing of aircraft complex local airlines, identified its components and their interconnections.

Keyword: aircraft, local airline, navigation-landing facility.

Introduction

The basis of the solution of the modern and perspective navigation and landing problems of an aircraft lies in providing of its movement along the most favorable trajectory. Let us regard that a trajectory is a spatial curve along which the centre of mass of an aircraft moves as a result of its maneuvering. The projection of the flight trajectory on the earth surface is a path line (a route). The stated path line corresponds to the stated flight trajectory during the pre-landing stage. The projection of the flight trajectory on the vertical surface is called the profile of the flight. The point on the earth surface above which an aircraft is located is called the location.

The main tasks of the on-board radiolocation-navigation-landing complex (RNLC) are facilitation of precise maneuvering of an aircraft according to regulated norms along the stated trajectory, its delivery to the point of starting of diving, maintaining of the course and glissade directions during the landing-stage movement of an aircraft.

In order to solve these problems successfully it is necessary to have the answers on the following questions:

- Where an aircraft is located at a given moment of time;
- Where an aircraft has to move to in order to reach the given point of the runway;
- How exactly does an aircraft have to move to the given point?

For the sake of answering these questions RNLC determines the current coordinates of an aircraft by means of different methods including requesting and non-requesting, range and angular measurements followed by microprocessor calculations of a complex.

In general radiolocation-navigation-landing system appears as the channel of observation and the

channel of signals and information processing (CSIP). To the input of the observation channel the current values of the state of an object enter, which are represented by the random process of changing of coordinates. At the output of the observation channel after the transformations (linear) of the random processes of the change of the coordinates (of an object) the physical processes of the electric nature are formed, which contain in their parameters the values of the state of an object which are connected non-linearly to the parameters.

Physical processes enter the input of CSIP and they are processed in order to extract the information while assessing its reliability and making the decision if the results of the aircraft coordinates change should accepted.

In case of such organization of the process of the evaluation of coordinates change the decisions about the choice of the optimal structures of observation are required, as well as the algorithm of the signal processing and the systems of displaying the results of the information processing by CSIP with the aid of means of electronic indications.

Since one of the main factors of development and effective functioning of manned and pilotless aircraft appears to be air navigation-landing software, the given scientific-technical branch is very urgent because of the intense growth of demand in receiving the navigational-landing information product by the operational structures of local airlines (LA).

Stating the problem. The concept of construction of a cockpit RNLC of aircraft of local airlines

Wider limits of application of aviation which are used to solve different problems have led to the growth of intensity of air traffic, and high density of aircrafts in air. Just due to this, new requirements

concerning aviation radio-electronic aids which provide safety and concerning necessity of constant modernization of these aids are established.

The essence of the requirements lies in providing more rational use of airspace, increasing traffic capacity of systems of air traffic control (ATC) and airports, subsequent increasing of integrity of systems and organization of wide exchange of information between aircrafts and ground-based centers.

Nowadays, there are three directions in this concept development, strategy of development, implementation of new means and usage of current types equipment, including their organization and interaction. These kinds of radiolocation technology influence sharply on the processes of its creation as well as on the implementation in mass exploitation, besides on further increasing of safety and effectiveness of aviation transportation.

The first direction stands for installation of the recent achievements of microelectronics, computer science, new materials, which allow to increase abilities of the cockpit equipment of ATC, navigation and landing.

Along with implementation of new technologies all constituent elements of aviation radio electronic equipment, especially antenna-feeder devices, receivers and transmitters and signal processors undergo remarkable changes.

By applying the achievements of modern technology it becomes possible to speed up the performance of computing devices, enlarge memory, switch to the high-speed methods of digital data transfer, and create systems with distributed processing and control. The implementation of these technologies in its turn allows to realize modern methods of signal processing, optimal interconnecting of heterogeneous sensors on aircraft.

The second direction of development of new technologies is connected with the improvement of new systems and creation of new systems, which supplement each other and remarkably expand ability of flight procedure in cases of different weather conditions anywhere on the Earth.

The ways of perfection of existing and development of new systems of ATC, navigation and landing during the nearest future are defined by the documents of the international committee of ICAO concerning the perspective systems.

Speaking about the development of existing systems of local operation it should be mentioned that the growth in the accuracy of detection of navigational data, including realization in the systems of short-range navigation the mode of precise navigational identification with aid of two or more long-range channels using also (if it is possible) goniometrical and height measuring channels.

Although the local systems which exist nowadays form big fields of distribution of sources of radio

navigation information, they are, however, limited in solving problems of subsequent increasing of safety and effectiveness of using of aviation in several zones of airspace of the Earth, especially over the maritime and oceanic areas, deserts, mountain regions and other hard-to-reach areas, where placing of local ground-based is impossible and economically not profitable. That is why the perspective means of further expanding of the abilities of using airspace is the satellite system of communication navigation and observation.

The application of systems working globally, in contrast to the existing means, appears to be the revolutionary moment in development of aviation means of ATC, navigation and landing.

However, right now it is impossible to solve all the problems of ATC, navigation and landing only with the aid of the satellite system.

Adoption of the perspective global system of communication, navigation and observation for the needs aviation, along with the existing traditional systems which are being developed, states the problem of the optimal combination and organization of interaction radio navigation, radiolocation and radio communication fields of locally distributed systems and global satellite system.

That is why one of the main problems of development of new types of technologies intended for radio electronic aviation equipment is the development of conception of a single system, which rationally combines and unites the fields of the existing and improving traditional local radio electronic means and satellite communication systems, navigation and observation for the needs of aviation.

Due to the above mentioned reasons *the third direction* of the development of new technologies appears - creation of new principles of organization and interaction of various systems of communication navigation and observation.

Here, we are talking about the choice of optimal configurations and integration of navigation systems and systems of the exchange of information including both local and global systems.

Such system can have the adaptive configuration depending on the allocation and using of radio navigational fields and provide pilots with navigation and other information regardless of range and state borders.

History and modern development of aviation radio electronic means show that nowadays we practically deal with huge system of means of communication, navigation and observation, consisting of various subsystems, organically supplementing each other in order to solve functional problems. In fact, such system may be characterized as the developing system, built on the basis of principles of hierarchical autonomy.

The appearance of new means, as a general rule, does not lead to rejection of the existing old means. Thus, the appearance of beacons of short-range navigation VOR, DME did not cause the rejection from homing beacons, and the appearance of means of long-range navigation — from VOR, DME, inertial systems etc. In reality, these systems exist nowadays, mutually supplementing each other and in some cases backup each other in order to increase the level of integrity of system.

Due to this the equipment of consumers must be used in corresponding packaging depending on the class of aircrafts, reliability and integrity of the system in certain region.

The process of formation of the cockpit aircraft equipment of the consumers of the information fields of local and global systems is carried out with a glance on “removal” of so-called “odd” kinds of equipment in the process of the changing situation of the configuration of navigation fields.

Radiolocation-navigation complex RNLS of aircrafts of LA

Proceeding from the above mentioned concept, crate of the airborne equipment of ATC, navigation and landing aircrafts of LA — it is reasonable to form radiolocation-navigation-landing complex in the following basic packaging [2], see figure:

- antenna-feeder and receiver-transmitter devices for subsystems:
 - radiolocation (including radio beacon multipositional landing) — RLS;
 - navigational radio beacon — VOR;
 - navigational satellite — SNS:GPS, GLONASS;
 - navigational-landing marker — NLM;
 - navigational-landing (including radio beacon multipositional landing) — DME;
 - landing instrumental — ILS, LS.
- unit of radio electronic indication of radiolocation and radio navigation information, which increases the reliability of its usage by pilots and navigators;
- unit — calculator of complex processing of radiolocation and radio navigational signals which optimizes instrument and programming-mathematical solutions, which choose the priority of the problems being solved;
- control panel located on instrument board provides the reverse communication of a pilot with the information data of physical sensors of radiolocation and radio navigation situation;
- unit of signal processing and control over modes of navigation satellite system, producing the coordinate information concerning the location of aircraft and service data for flight control;
- unit of signal processing and control over modes of radiolocation system producing data concerning air and ground radiolocation situation in space of aircraft displacement, angle and range measuring

information, including radio beacon navigational-landing systems;

- unit of signal processing of systems of short-range navigation based on the radio beacons like VOR, which supplies RNLS with signals concerning the deviation of aircraft from the stated course;
- unit of signal processing of long-range system based on the beacons like DME, supplying RNLS with data for calculating of coordinate information;
- module of signal processing of NLM, which records the flight of an aircraft over the navigational and landing marker beacons;
- module of signal processing of instrumental landing system based on the beacons like ILS, LS, supplying RNLS with data for performance of landing of an aircrafts due to I, II, III categories of ICAO.

This minimal set of equipment supplies the safe flight of an aircraft with information signals in modes of navigation and landing on aerodromes which are either equipped with standard systems or not equipped with ones.

Along with it, in the laws of the International committee of ICAO, the intersystem duplication and the data processing from different sensors are stated. For example, by interconnecting the data of navigational landing systems VOR, DME, SNS, RLS it is possible to increase the validity of navigational information for successful flight performance including automatic mode. What is more, when an aircraft leaves the navigation field of any system it does not threaten the loss of information about its location as there is always the information from the duplicating systems.

In the mode of instrumental landing (ILS, LS), in addition to traditional displaying the information about the deviation of an aircraft from the stated course and glissade, on the screen of indicator the radiolocational (or mathematical) image of runway is added, which allows a pilot to orientate more securely, especially during adverse weather conditions, in other words to increase safety in conditions of landing of aircraft.

The presence on a board of aircraft the calculation base which is powerful enough allows to use range-angle-height measuring information for the realization of route updating in the mode of navigation and to perform landing on the non-equipped with the standard systems aerodromes and landing areas.

The ability to use radiolocation information concerning dangerous weather phenomena in order to plan the safest routes of aircraft with the aid of prompt input on the screen of indicator transitional points of route (TPR), markings between them, flight routes and motion of aircraft along these routes, including automatic mode, with the accuracy of keeping on a route sticking to the regulated requirements concerning precision characteristics of laws of navigation.

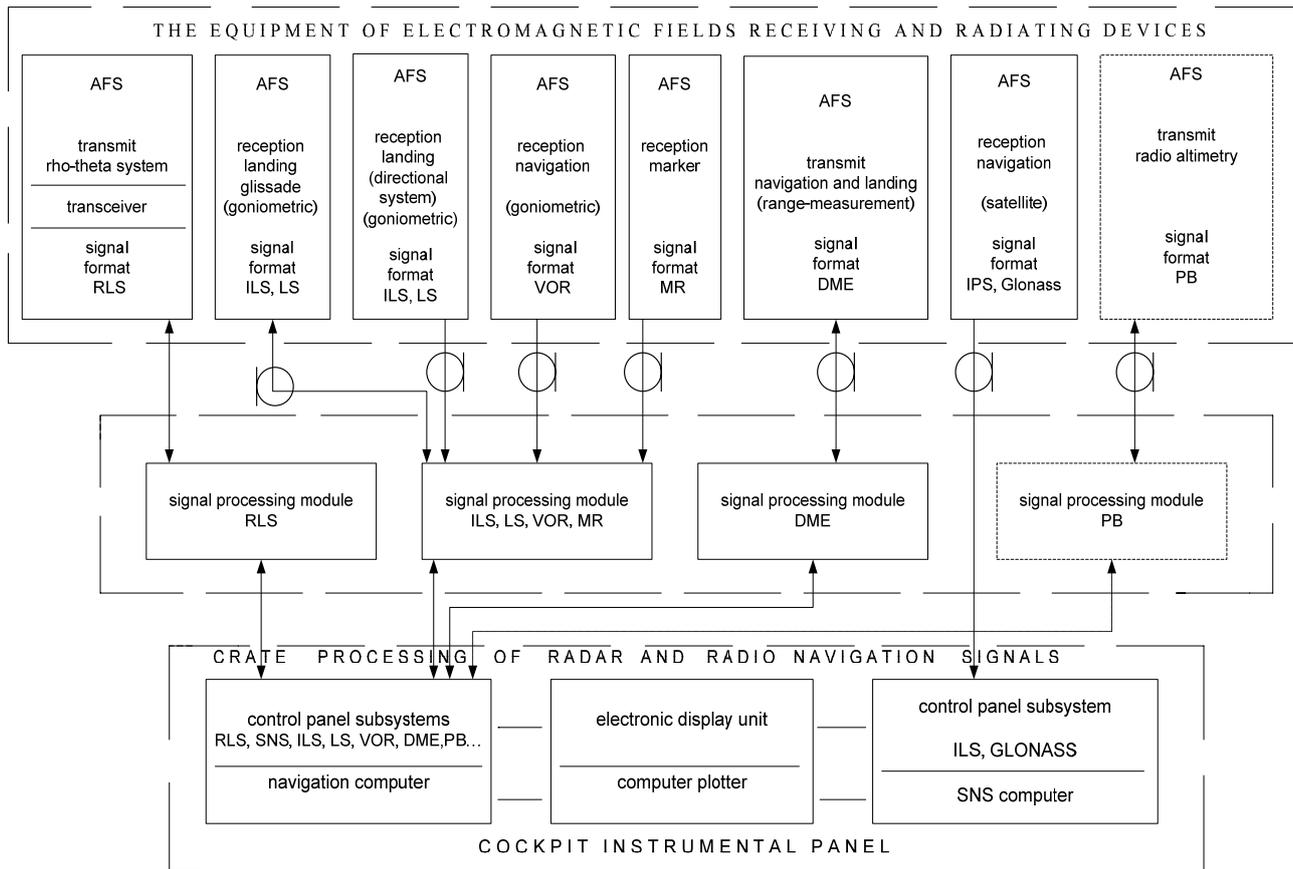


Fig. Structural scheme of radiolocation-navigation-landing complex of aircrafts

Modular systematic and constructive performance of RNLS allows to increase its functional abilities in the expense of implementing new equipment (radio-barometric altimeter, aircraft transponders, traffic collision avoidance system and others) sufficient for this or that information of aircraft.

Depending on the demands of flight safety conditions of the particular types of aircraft RNLS, and also its certain components, can be constructed by duplex or triplex variant.

Besides, the shortening of the nomenclature of the RNLS subsystem will be possible provided that in some conditions they become redundant.

In condition of saving functional abilities of the complex of the standard digital navigational-landing equipment (CSDNLE) for aircrafts IL-96, TU-204, IL-114, AN-218, and others the described above PJHIIK weighs as 2-2.5 times less than older RNLS, thanks to optimization of systemic functions, modern element and calculation basis, application of new materials and technological methods.

Moreover, in addition to compulsory, regulated by ICAO functions, can perform the following:

- categorized landing of aircraft on non-equipped aerodromes and landing areas, and also correction of trajectory of flight of aircraft on the basis of long-range, angle measuring radio technical information

- from small ground-based portable beacon-transponders (with signals format: DME, RLS), of height measuring and satellite information [3];
- performance of inter-aircrafts navigation within the grouped flight and maneuvering of aircraft based on the signals of RLS, SNS, and also cockpit small receivers-transponders of electromagnetic field.

The most reasonable assumption would be to use such complex of equipment for new generation of aircraft.

Conclusion

The results of this work have the applied importance: in different fragments they can be realized during designing navigational-landing complexes of perspective aircraft like AN-38 (single or duplex variant of complex).

The basic system solutions are performed by the methods of mathematical modeling.

The received basic results can be applied in other branches of national economy:

a) *in maritime and river navigation* especially during bad weather, for instance:

- when ships are maneuvering in narrow, long, sinuous bays, where visual orientation is unreliable and problematic;
- while emergency works during automatic movement of coastguard ships and others into the stated

point of water area, designated by the beacon-transponder out in there;

б) *in terms of helicopter and parachute landing of cargo*, or people to the stated point (temporary landing area) in conditions of forest fire, borings, arctic and Antarctic missions, geological prospecting, work on the oil areas and maritime platforms, geodetic connection of “special points” in hard-to-reach regions;

в) *in terms of automatic standing patrolling of fields* on the stated optimized trajectories with the aim of ecological and economical cultivation and other tasks.

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