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STRUCTURING OF MODEL OF A RADIO SYSTEM FOR NAVIGATION AND LANDING OF HELICOPTERS

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Проведено аналіз вимог, що пред'являються до радіосистеми, яка забезпечує навігаційно-посадкові операції повітряних суден (вертольотів). Дана оцінка можливості застосування для таких операцій існуючих систем, що виконують аналогічні функції. Запропоновано структуру навігаційно-посадкової радіосистеми для літальних апаратів типу «вертоліт».

Ключові слова: повітряне судно, місцеві повітряні лінії, посадкові операції, радіосистема.

The article analyzes the requirements for radio system that provides navigation and landing operations of flying vehicles (helicopters). Assessed the possibility of applying for such operations existing systems that perform similar functions. The structure of navigation and landing radio system for the vehicle type "helicopter" is proposed.

Keywords: aircraft, commuter airlines, landing operation, radio system.

Introduction.

Tactical-economic aspects

As is known, the development of civil aviation in the field of commuter aircrafts flights, including helicopters, consists on one side in the geographical expansion and increasing of intensity of their performance, and on the other side — simultaneous improving efficiency of flights.

Expansion of geography of flights is unambiguously associated not only with the navigational task, but with the requirements for instrumental landing on poorly equipped and unequipped by navigation and landing facilities airfields and landing sites.

Improving operational efficiency of commuter aircrafts along with other factors will depend on the configuration of airfields with landing and navigation radio equipment. At the present time most of the flight tracks of commuter aircrafts are not equipped (or poorly equipped) with navigation radio equipment, and most of the airfields and landing sites of commuter airlines are not equipped (or poorly equipped) with landing radio equipment.

Commuter aircrafts flights are carried out in different geographical areas and under different conditions. However, most of local airlines flights are made by visual flight rules over the terrain difficult to access for maintenance of ground equipment. In some areas, particularly with low population density, local airlines flights are performed seldom and landing on the poorly equipped airfields also performed seldom.

There are also a large number of temporary routes, airfields and landing sites conditioned with

age, consists the specific of flights and operation of commuter aircraft and that such conditions the navigation and landing radio system should be developed.

Economic aspects of equipping of commuter aircrafts with navigation and landing system is that the airborne equipment must have a small weight and dimensional characteristics and relatively low cost. The most expedient way to address this aspect is complexification of existing avionics of commuter aircrafts. With regard to ground-based equipment, the greatest economic benefit will be when it will have the possibility of independent operation, without permanent maintenance, small weight and dimensional characteristics (in the limit - to be portable), easy to deploy and makeready, does not require preliminary overflights, and also be relatively inexpensive. In this case, it will be easier to place ground equipment to service and operate in large quantities.

Such stringent and sometimes conflicting requirements for navigation and landing of commuter aircrafts certainly do not simplify but complicate the development of such systems and, however, make it expedient of their operation in the economic sense.

Further, it should be noted that the amount of the air vehicles (aircraft and helicopters) of commuter airlines is very large, and their types are quite diverse. This imposes significant limitations on the possibility of equipping of commuter aircrafts with new navigation and landing systems.

In economical sense, it is more expedient to make updating of the existing onboard equipment.

From the standpoint of packaging of standard onboard equipment it can be considered three conditional groups of commuter aircrafts:

1. Aircrafts equipped with airborne radars and radar altimeters.

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re-quirements of the national economy. Exactly in this, that is seldom changing of state relatively main-line track-

2. Aircrafts equipped with the airborne distance measuring equipment and radar altimeters.

3. Aircrafts equipped with distance measuring equipment only.

Using of pressure altimeters is not considered here, because it involves an aboard transmitting from ground the information about the “pressures of the day”, that contradicts with direction of development of maintenance-free ground equipment.

General principles for structuring the navigation and landing systems of commuter airlines

Based on these specific of flights and operation of commuter aircrafts and economic aspects and of equipping them with radio systems, the navigation and landing equipment must be designed basing on the following principles [1]:

1. Restricting of introduction of new airborne equipment.

2. Maximal usage of (complexification) of available standard airborne equipment with modifications that do not increase significantly its weight and dimensions.

3. Simplified construction of ground-based equipment, which would includes:

- absence of continuous-mode radiation, i.e., work in the "request-response" mode at the request from aircraft;
- absence of antenna directional diagrams.

4. Simplified maintenance of ground-based equipment, which should includes:

- availability of self-contained power supplies and off-line operation in general. Periodic monitoring of the parameters is carried out by means of free-running tools;
- no need for constant maintenance;
- small weight and dimension characteristics;
- relatively low cost per one transponder beacon.

Consequently, in technical sense the most expedient will be a navigation and landing system for regional flights, which will meets these principles.

Comparative characteristics of navigation and landing systems

Theoretically, we can consider several solutions for equipping of regional routes and airfields with navigation and landing radio systems:

- usage of existing stationary navigation and landing systems type RSN, VOR, LS, ILS;
- usage of microwave landing system ML5;
- development of new navigation and landing systems, including satellite navigation system;
- complexation of standard radio and radar airborne equipment with their improvement and devel-

opment of new ground-based transponder beacons [1].

Multipositioning navigation and landing system MPLS [2], investigated in this work basically involves the interaction of standard airborne equipment (rangefinder with a ground-based omnidirectional transponder beacon on a "request-response" protocol with following aboard calculation of the aircraft location with respect to one or more beacons.

Similar principles are used to solve the special problems [3; 4]. Here it is needed to compare the overall performance characteristics of existing systems and observable system MPLS in relation to regional airlines problems.

Based on the above and taking into account [4], it would that systems VOR, DME, ILS, MLS on their direct and unique purposes are stationary navigation and landing systems that service routes and airports with a high density of flights. All of them work with a continuous radiation of electromagnetic energy and antennas directional diagrams of ground-based equipment and such systems require the airfield electrical supply network. They have large weight and dimensioning characteristics, power consumption and cost both airborne and ground-based equipment.

For these reasons, they can not in any way satisfy the principles of navigation and landing systems for commuter airlines.

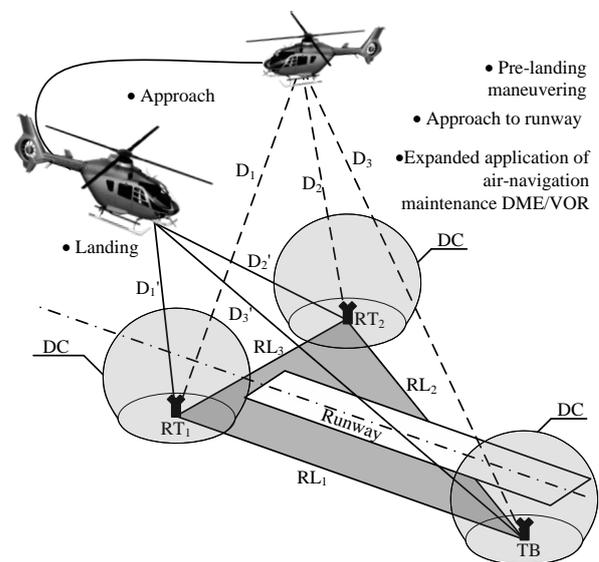


Fig. Operating principle of MPLS

The explored navigation and landing system MPLS is based on using of omnidirectional transponder beacons interacting with the standard airborne equipment — rangefinders, (see fig., where $D_{1,2,3}$ — measured ranges between air vehicle and transponder beacons (TB, $RT_{1,2}$); $RL_{1,2,3}$ — radio links between TB, RT_1 , RT_2 ; DC — antennas directional characteristic of transponder radio beacons).

Note that omnidirectional and maintenance-free beacon that transmits coded response signals only by coded request from the board, is a device with relatively small weight and size characteristics, has no mechanical moving parts and requires no adjustment, promptly make ready, requires no preliminary flights and relatively inexpensive. Aircraft location is calculated on the board with the help of airborne computing device on the basis of coordinate information (ranges, altitudes) measured by standard airborne equipment with respect to the location of beacons and is displayed for aircraft crew.

Such beacons characteristics like low cost, low weight, dimensions, no need in constant maintenance make it possible to place them in the required quantity on the routes, landing sites and unequipped commuter airfields in large enough quantities. These characteristics also allow consider the MPLS system as a redundant or secondary to other navigation and landing systems.

MPLS energy characteristics

The feasibility and effectiveness of navigation and landing system for aircrafts based on the transponded beacons [5] depend on several factors, including, its energy characteristics. *In interrogation path* ("downlink") the required characteristic is the sensitivity of responded beacon's receiver $P_{res\min}^0$. Therefore, the range equation can be represented as:

$$P_{res\min}^0 = \frac{P_{trs} G_{trs} G_{res} \lambda^2 F_{trs} F_{res}}{(4\pi)^2 D^2 LS/N} \quad (1)$$

So as an airborne rangefinder DME like SD-75 can serve as interrogator, the fixed values will be the parameters of such rangefinder: P_{trs} — transmitter pulsed power; G_{trs} — antenna gain; λ — wavelength.

For the system accept: gain of beacon's near-omnidirectional antenna $G_{res} = 3,2$; value of interference factor taking into account the direct and reflected rays $F_{trs} = F_{res} = 0,5$; according to the required area of operation the range in navigation mode $D_{nav} = 100$ km, in landing mode $D_{lan} = 18,5$ km; ratio $S/N = 10$ dB required for the detection of uplink signals rangefinder; generalized loss factor $L = 10$ dB associated with many factors.

Substituting listed above numerical data into (1), we will calculate the required minimum of beacon receiver sensitivity: $P_{res\min}^0 \approx 10^{-12}$ W, it corresponds to the parameters of the hardware SD-75 receiver. From this it follows that the necessary value for

the minimum beacon receiver sensitivity are quite feasible.

In replay path ("uplink") the desired characteristic is the radiation power of beacon transmitter. Then the equation of range:

$$P_{trs}^0 = \frac{D^2 (4\pi)^2 P_{res\min} LS/N}{G_{trs} G_{res} \lambda^2 F_{trs} F_{res}} \quad (2)$$

In equation (2) are retained the same notation as in equation (1) with the difference that the transmitting device is referred to beacon and a receiver is located on board of aircraft (radio rangefinder). Then the values of the required radiation power of the beacon transmitter, which interacts with the onboard equipment DME: in navigating $P_{trs}^0 \approx 630$ W, in landing $P_{trs}^0 \approx 23$ W, which can be implemented on a prospective element base.

Conclusions

Based on the aforesaid, it may be conclude that the multipositioning navigation and landing system based on omnidirectional transponder beacons, operating in the "request-response" mode and used airborne radio range finding equipment is most suitable for problems of navigation and landing of commuter air vehicles, in particular of helicopters.

REFERENCES

1. Кондрашов В. И., Кондрашов Я. В. Выбор новых видов системных технологий для радиоэлектронного авиационного оборудования и пути их реализации // сб. статей Военно-научной конференции, часть 3, Институт военно-воздушных сил, Киев, 1995. — С. 8—12.
2. Kondrashov Ya. V., Fialkina T. S., Ryabets O. P. Principles of construction of the navigation-landing system for aircraft of local airlines // Науковий журнал «Наукоємні технології», Національний авіаційний університет. — Вип. №4 (4), Київ, 2009.
3. Кондрашов В. И., Максименко М. Д., Чижский Б. В., Шульман А. Г. Система определения местоположения самолетов. Авторское свидетельство СССР №1473842 от 8.01.89 г., приоритет 3.07.87 г.
4. Кондрашов В. И., Никонов Е. А., Чижский Б. В., Шульман А. Г. Радиотехническая навигационно-посадочная система с активным запросом-ответом. Авторское свидетельство СССР №1566948 от 22.01.90 г., приоритет 21.03.88 г.
5. Кондрашов В. И. Кондрашов Я. В. Принципы и структуры мобильных многопозиционных навигационно-посадочных аэросистем наземного базирования // Научный Вестник МГТУ ГА, серия «Радиофизика и радиотехника», №76. — М. : 2004. — С. 84—92.

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