PROSPECTS FOR THE DEVELOPMENT OF NAVIGATION SYSTEMS FOR UNMANNED AERIAL VEHICLES

ПЕРСПЕКТИВЫ РАЗВИТИЯ НАВИГАЦИОННЫХ СИСТЕМ ДЛЯ БЕСПИЛОТНЫХ ЛЕТАТЕЛЬНЫХ АППАРАТОВ

УДК 623

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Annotation

The prospects for the production of unmanned aerial vehicles leading countries, development trends and problematic issues of improving the navigational systems of modern unmanned aerial vehicles. The necessity of a functional, information and association navigation hardware meters different physical fields in an integrated navigation system.

Аннотация

Рассмотрены перспективы производства беспилотных летательных аппаратов ведущими государствами, тенденции развития и проблемные вопросы совершенствования навигационных систем современных беспилотных летательных аппаратов. Приведенная необходимость функционального, информационного и аппаратурного объединения навигационных измерителей различных физических полей в интегрированный навигационный комплекс.

Keywords: unmanned aerial vehicle, navigation system, integrated navigation system

Ключевые слова: беспилотный летательный аппарат, навигационная система, интегрированный навигационный комплекс.

Introduction

The main directions of development of unmanned aerial vehicles (UAVs) as an integral weapons system are caused by the need to implement new concepts and improve existing navigation technologies. Requirements for the autonomy of information systems are becoming more stringent and requirements for aviation complexes (AC), including unmanned ones, are expanding.

In the future, by 2025 -2030. the possibility of using UAVs for various purposes as part of mixed aviation groups is being considered. But the methods of navigation and coordinated control of the UAV group have not been sufficiently developed, therefore, constant attention is paid to the improvement of UAV navigation systems.

The purpose of the article is an analysis of trends in the development of UAV navigation systems based on materials from open publications.

Analysis of publications and research. Unmanned aerial vehicles (UAVs) for various purposes are actively developing in the leading countries of the world.

The volume of the world UAV market in the coming decade will amount to 67.3 billion dollars. [3]. $ 35.6 billion will be spent on the production of unmanned vehicles, $ 28 billion - on testing in the field of unmanned vehicles, $ 2-3 billion - on UAV service. In the already manufacturing sector, which will amount to $ 35.6 billion, the costs are distributed as follows: production of medium-altitude long-duration UAVs of the MALE type (Medium-Altitude Long-Endurance) - $ 13.7 billion. (38.5%). The production of tactical UAVs will cost $ 8 billion (24.1%), for high-altitude long-duration UAVs of the HALE type (High-Altitude Long-Endurance) - $ 7.3 billion. (20.5%), for vertical take-off and landing UAVs - $ 3 billion. (8.4%), for attack UAVs such as UCAV (Unmanned Combat Air Vehicle) -

1.7 billion dollars. (4.8%), on UAVs launched from the hand (portable UAVs) - 1, 3 billion dollars. (3.6%).

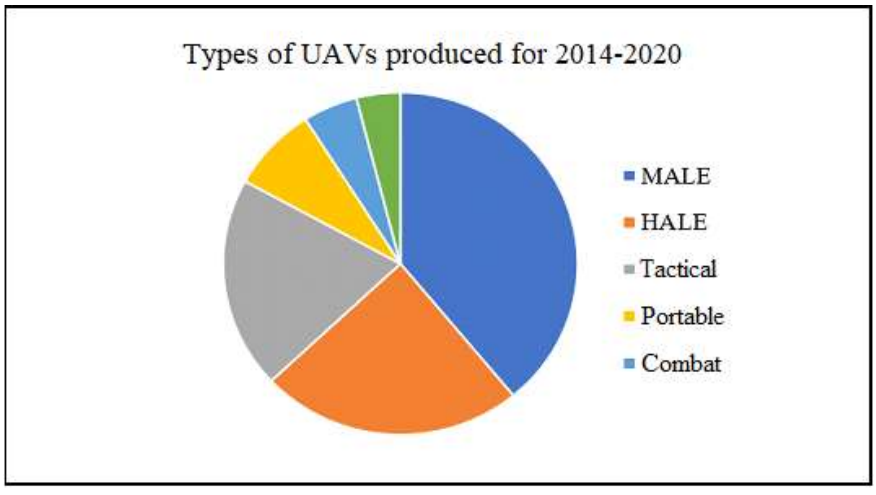
Research results

As shown by the analysis (Table 1), the largest number of UAV types are military vehicles.

Table 1 - Distribution of UAV types by purpose

No.	UAV designation class	Number of types	
		Absolute	Relative,%
1	Civil and commercial	55	10.1
2	Military	397	72.29
3	Double	44	8
4	Research	35	6.43
5	Experienced	219	40.25
Total types of UAVs belonging to classes (1) - (5), including joint projects.		544	> 100

These estimates of the production of the main types of military UAVs are shown in the diagram (Fig. 1).



Pic. 1: Assessment of the production of the main types of military UAVs

The use of UAVs is necessary for solving tasks, the implementation of which is associated with high risks of losses, or tasks that are not implemented by manned aircraft due to various restrictions [1].

The relevance of creating multifunctional unmanned systems is due to [1-4] an increase in the cost of creating and operating manned aircraft; reduction in the number of piloted aircrafts; the danger of losses piloted by AK and flight personnel;

the need to form complex systems with UAVs; the ability to solve shock, fighter, and reconnaissance missions as part of a mixed aviation group; electronic suppression; the need to adopt new high-tech weapon systems and military equipment; the ability to solve various tasks in one UAV flight.

The degree of substitution of the pilot's function for the UAV is given in Table. 2.

Table 2 - The degree of substitution of the pilot's function

AK motion control in flight (choice of trajectory, direction)	< 40%
Decision making on the use of aviation weapons	< 80%
Actions in special cases in case of aircraft failure	< 12%
Conclusion from uncontrolled flight	< 95%
Flight control when it is impossible to perform its functions	< 100%
Search and identification of air targets:	
- close, air	< 25%
- air, at long and medium distances	< 95%
Search and identification of ground (surface) target	< 25%
Takeoff, landing, flight en route	< 45%
Maneuvering, choosing a maneuver, evading a threat.	< 10%
Aircraft control in case of damage to the airframe and its systems	0 ... 5%

It should be noted that the creation of multifunctional complexes with UAVs for various purposes requires the solution of a number of problems, in particular for onboard equipment: development of an intelligent onboard flight control system with the participation of an operator; optimization of operator functions and their role in flight control and mission performance; development of onboard high-precision navigation systems [4].

In the structure of the control system, the navigation system is the basis for the functioning of the automatic control system and is used to assess the state of the UAV and adjust the autopilot for specific flight modes.

The choice of the technical characteristics of the UAV navigation system depends entirely on the tasks assigned to it. Depending on the tasks to be solved, when synthesizing a navigation system, various principles of navigation can be used, which determine the hardware composition of the system.

Navigation method. The main advantages are high targeting accuracy and target recognition reliability; the main disadvantage is weak noise immunity...

Route calculation method. The main advantage is autonomy; the main disadvantage is low accuracy.

Recognition method. The main advantage is autonomy; the main disadvantage is the need to have a large array of initial data.

Positional method. The main advantages are the ability to determine the coordinates of an object without taking into account and knowing the traversed path, speed; the main disadvantages are susceptibility to interference, relatively low accuracy.

The main direction in the development of UAV navigation equipment is the functional, informational and hardware integration of navigation meters of various physical fields into an integrated navigation complex. Not only systems based on different principles of navigation can be combined, but also separate sensors of primary information (pressure sensors, magnetoresistors, accelerometers, etc.), which produce the same parameters [6].

Integrated navigation systems should include the following components:

- inertial module;
- magnetic compass;
- air signal system;
- altimeter;
- temperature sensors;
- non-volatile memory for storing device settings and flight programs;
- GNSS signal receiver (satellite navigation module).
- In order to solve a wider range of tasks (or in the absence of GNSS signals), the base complex should provide for the possibility of expanding the functionality, which includes:
- optical means;
- electronic terrain map with a network of artificial landmarks;
- navigation system with the implementation of the survey method of navigation.

The main goal of the synthesis (combining) of orientation and navigation systems is to improve the accuracy of determining the navigation and angular parameters of UAV orientation [5].

Thus, it is possible to formulate the main directions for improving UAV navigation systems:

1. Improvement of indicators: accuracy, autonomy, versatility, reduction of energy consumption and weight and size characteristics.

2. Transition to sensors of primary information of mini - and micro sizes, as well as the development of modules of measuring devices that provide measurement of speeds and accelerations in six coordinates: three angular and three linear.

3. Development of navigation methods and coordinated flight control of a UAV group, with the possibility of choosing alternative routes and interacting with each other.

4. Solving issues of automatic landing on unequipped sites and UAV rescue;

5. Solving the problem of accelerated, with minimal financial and time costs of the process, the commissioning of a wide range of UAVs.

6. Further improvement of UAV navigation systems by integrating the inertial navigation system with global satellite navigation systems (GNSS), thermal imaging and laser systems, as well as radar systems.

7. The use of machine vision technologies, including methods of the theory of image processing and pattern recognition as an alternative to satellite technologies.

8. Synthesis of more advanced nonlinear algorithms for estimating navigation parameters; algorithms for complex processing of information from measurements of GNSS and inertial systems.

9. Development of algorithms for integrated processing of information from inertial systems and satellite navigation systems (SRNS) GLONASS / GPS / Galileo

Conclusion

Thus, from the above, it can be seen that solving the problems of further development of UAV navigation systems using specific hardware and software, for example, automatic correction of current coordinates obtained from inertial navigation systems, based on methods of correlation-extreme navigation in the absence of information from satellite navigation system, will allow the use of unmanned and manned UAVs in a mixed aviation group, which leads to the emergence of an aviation complex with qualitatively new properties and characteristics.

Literature

1. Modern information technology in the problems of navigation and guidance of unmanned maneuverable aircraft / Ed. M.N. Krasilshchikova and G.G. Serebryakova. - M .: FIZMATLIT, 2009 .-- 556 p.
2. Unmanned aerial vehicles: Methods of approximate calculations of the main parameters and characteristics / V.M. Ilyushko, M.M. Mitrahovich, A.V. Samkov et al .; under the general. ed. V.I.Silkova. - K .: Central Research Institute of Armed Forces of the Armed Forces of Ukraine, 2009 - 302 p.
3. The global market for drones [Electronic resource]. - Access mode: http://vpk-news.ru/print/articles/18914.

4. Unmanned Aircraft Systems for Logistics Applications. (By John E. Peters, Somi Seong, Aimee Bower, Harun Dogo, Aaron L. Martin, Christopher G. Pernin.) [Electronic resource]. - Access mode to the resource: http://www.rand.org/content/dam/rand/pubs/monographs/201 1 / RAND_MG978.pdf.
5. Raspopov V. Ya. Microsystem avionics: textbook. pos. / V. Ya. Raspopov. - Tula: “Vulture and K”, 2010. - 248 p.
6. Lerner R, Rivlin E. Direct Method for Video Based Navigation Using a Digital Terrain Map IEEE Trans Pattern Anal Mach Intell. 2010 Aug 31 [Electronic resource]. - access mode to the resource: http://www.ncbi.nlm.nih.gov/pubmed/2082007.

Литература

1. Современные информационные технологии в задачах навигации и наведения беспилотных маневренных летательных аппаратов / Под ред. М.Н. Красильщикова и Г.Г. Серебрякова. – М.: ФИЗМАТЛИТ, 2009. – 556 с.
2. Беспилотные летательные аппараты: Методики приближенных расчетов основных параметров и характеристик / В.М. Ильюшко, М.М. Митрахович, А.В. Самков и др.; под общ. ред. В. И. Силкова. – К.: ЦНИИ ВВТ ВС Украины, 2009 – 302 с.
3. Мировой рынок беспилотников [Електронний ресурс]. – Режим доступа: http://vpk-news.ru/print/articles/18914.
4. Unmanned Aircraft Systems for Logistics Applications. (By John E. Peters, Somi Seong, Aimee Bower, Harun Dogo, Aaron L. Martin, Christopher G. Pernin.) [Електронний ресурс]. – Режим доступу к ресурсу: http://www.rand.org/content/dam/rand/pubs/monographs/2011/RAND_MG978.pdf.
5. Распопов В. Я. Микросистемная авионика: учеб. пос. / В. Я. Распопов. – Тула : «Гриф и К», 2010. – 248 с.

6. Lerner R, Rivlin E. Direct Method for Video Based Navigation Using a Digital Terrain Map IEEE Trans Pattern Anal Mach Intell. 2010 Aug 31 [Електронний ресурс]. – режим доступу к ресурсу: http://www.ncbi.nlm.nih.gov/pubmed/2082007.