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ИССЛЕДОВАНИЕ ПРИНЦИПОВ ИНТЕГРАЦИИ СИСТЕМ В КБО ИМА

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В данной статье рассматривается разработка комплексов бортового оборудования (КБО) по концепции интегральной модульной авионики (ИМА). Рассмотрена система как составная часть КБО ИМА. Выделены способы интеграции систем в зависимости от степени их интеграции. Определен перечень систем трудноинтегрируемых с высокой степенью интеграции. Предложены условия классификации систем по степени сложности их интеграции. Определены принципы частичной и полной интеграции. Описаны главные проблемы проектирования современных, интегрированных в комплекс, систем. Выявлены основные этапы интеграции систем. Представлены существующие средства автоматизированного проектирования интегрированных комплексов. Сделаны выводы по описанным принципам интеграции.

Ключевые слова: интегрированная модульная авионика, вычислительные системы, иерархия систем, верхний уровень проектирования, системы автоматизированного проектирования.

RESEARCH OF THE PRINCIPLES OF SYSTEM INTEGRATION IN THE OEC IMA

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This article discusses the development of onboard equipment complex (OEC) on the concept of integrated modular avionics (IMA). The system is considered as an integral part of the OEC IMA. The ways of integrating systems are highlighted depending on the degree of their integration. The list of systems difficult to integrate with a high degree of integration has been determined. The conditions for classification of systems according to the degree of complexity of their integration are proposed. The principles of partial and complete integration are defined. The main problems of designing modern systems integrated into the complex are described. Identified the main stages of system integration. Existing computer-aided design tools for integrated systems are presented. Conclusions on the described principles of integration.

Keyword: integrated modular avionics, computing systems, system hierarchy, top level design, computer aided design systems.

1. Introduction

A distinctive feature of modern on-Board aircraft systems is the desire to implement the transition to centralized hardware resources. The main example of this transition is the concept of integrated modular avionics (IMA) [1,2]. The essence of this concept is to reduce the mass-dimensional characteristics of avionics (avionics), improve reliability, reduce the cost of maintenance (MS), improve the functionality of the airborne equipment for a minimum period and cost.

The existing principle of differentiation of systems does not allow to operate fully freely with the functionality of the complex. This is due to the rigid assignment of functions and tasks to individual systems, subsystems and nodes. Currently, the organization of the development process is to create the so-called end-to-end elements/systems of the complex. That is, the design focuses on the independence and isolation of certain nodes. On the one hand, a clear advantage was previously considered to increase reliability and fault tolerance due to this method of separating elements from each other. But with the increase in requirements for aircraft (AC) had to face the problem of redundancy of similar components, components and subsystems. Therefore, it was necessary to abandon the consideration of each system as a separate independent component. Despite the work of the systems with each other, they were considered and designed independently. The new concept assumes establishment and control of interrelations between systems and subsystems from the highest level of design, for control of redundancy or insufficiency of reservation of any equipment for functions and tasks of various level of criticality.

2. Ways of systems integration

To integrate systems, it is necessary to determine their level of integration. This will determine the further localization of the integrated subsystems, which are similar in purpose and functionality, as well as have the same type of hardware. For example, device I/O, interfaces with other components of the device primary or secondary processing data/information, etc. let us denote several methods of integration of systems and subsystems.

Method of integration by functional purpose. Ability to transfer functions or parts of them to other systems. This is possible in the presence of devices that perform individual tasks, but locally concentrated in one part of the aircraft. At the same time, the tasks performed by these devices should be of the same type, for example, the task of concentrating data from the sensors of measuring primary information. Therefore, the integration of the measurement and calculation problem at the functional level would be absurd.

Method of integration by hardware resources. This method involves the constructive combination of individual units, modules and blocks in a single Cabinet or rack. The advantage of such integration is the reduction of weight-dimensional parameters of several systems to the size of a single device, whose weight and dimensions are obviously less than the sum of these parameters of the systems separately. For relatively complex systems, the limitation is the production base of electronic components, namely differences in temperature ranges, energy consumption and design.

Method of integration by software resources. The essence is the integration of subprograms into higher programs, to reduce the total number of software applications (SA) and the possibility of their clear separation and isolation from each other. As a result, we get the opportunity to use common computing resources to perform SA.

In addition to the proposed methods of system integration, there is a high-level integration (HLA). The described principles of integration [3] allow us to consider the complex of avionics as a centralized or distributed computing system (CS) and information processing system (IPS). Based on one of the main principles of the IMA on a single hardware platform, we can talk about a single computer on Board. But with the development of information processing technology, the concept of distributed information processing in complex and multi-level computing systems has appeared [4,5]. The application of integration methods at the top level simplifies the process of integration of complex systems with a high degree of integration. List of existing aircraft systems with a high degree of integration:

- inertial navigation system (INS);
- radio communication system;
- airborne display systems, etc

Despite the diversity of avionics systems, the following types of information processing stand out:

- data processing;
- processing of signals;
- signal transformation;
- signal conditioning;

– data/signal input / output.

As can be seen from the above classification by type of processed information can be identified 5 types of computing systems airborne.

3. System hierarchy

Hierarchical models of multilevel systems are used to determine the computing power of each aircraft. Let us use the methods of the theory of hierarchical multilevel systems (HMS) [6]. The main features that indicate the presence and need for a hierarchical structure are:

- vertical decomposition of systems / complexes into subsystems;
- influence the output of the subsystems to work upstream systems;
- the right of intervention of the upper systems in the functioning of the lower systems.

Then the functional complexity of the complex can be represented as a set of input and output signals that are in a hierarchical relationship with each other. The emergence of such complex aircraft due to the fact that a multi-level system allows to simplify the process of solving a large problem. In addition, the multilevel hierarchical structure of the aircraft provides the following advantages:

- resistance to low-level internal changes (i.e. changes in subsystem input signals can be adjusted at a higher level without changing subsystems of the same level);
- simplification of the system expansion (adjustment is made only at the level and in the system in which the new element is introduced);
- in a hierarchical system, higher fault tolerance than in a single-level centralized system (there is a possibility of failure localization in a subsystem of the same level).

A broader view defining the classification of hierarchical systems is shown in [6]:

- strata (levels of description);
- layer (the difficulty level of the task solution);
- echelon (organizational level).

In the design of modern systems integration of systems is divided into partial and complete integration.

Partial integration implies only functional integration or only hardware integration [7].

Full integration involves merging the functionality of several systems into a single hardware platform without degrading these parameters.

Currently, the developers of avionics faced a number of problems caused by the increase in the functionality of the complex as a whole:

– avionics is a set of systems operating in real time-pipelining (so when using hardware integration, we can talk about conditionally simultaneous execution of functions by the system, when the intervals of execution of one function are less than the time of the whole system);

– difficulty in adding avionics functions while maintaining the overall structure;

– time-consuming reservation process (in fact, it is necessary to create a similar aircraft);

– low reliability of the pipeline;

– reducing the effectiveness of the use of the avionics due to the change of priorities in the system at different stages of the flight.

These tasks are solved by the use of distributed aircraft and integrated systems of on-Board equipment. System integration has two main stages:

1) Functional integration Stage.
2) Technical integration Phase [8]

Since these two stages are very complex and voluminous, computer-aided design (CAD) systems are widely used for their implementation. The most famous of them are given in [9].

4. Conclusion

Based on the described methods of integration and existing methods, we can conclude about the high complexity of the process of developing integrated avionics systems. To simplify the development process is possible with the help of CAD, which allows to evaluate the functionality of avionics at the top level of design. The purpose of this CAD is to generate a hierarchical structure of the complex with a certain functionality of each system. The input data for such CAD are the functions of the AEC described in the technical specification for the complex, and the result is the functional models of the systems and the complex as a whole, with the main parameters described for their development.

List of references

1 В.И. Бабуров, Б.В. Понамаренко, Принципы интегрированной бортовой авионики - Спб, Изд. «Агенство «РДК-Принт», 2005, С.75
2 I. Moir, A. Seabridge, M. Jukes, Civil avionic systems - New Delhi, 2013, pp.172
3 В.И. Бабуров, Б.В. Понамаренко, Принципы интегрированной бортовой авионики - Спб, Изд. «Агенство «РДК-Принт», 2005, С.202
4 Ф.Г. Энслоу, Мультипроцессорные системы и параллельные вычисления, 1976
5 Farber D.J., Larson K.C. The System Architecture of the Distributed Computer System – Communication System, Pilytechnics Institute of Brooklyn, April 4-6, 1972
6 Месарович М., Мако Д., Теория иерархических многоуровневых систем – М.:Мир, 1973. – 344с.
7 А.С. Шаламов, В.Н. Буков, Научные проблемы комплексных исследований в области создания и эксплуатации бортового оборудования ЛА на информационно вычислительных сетей – Науч.вестник МГТУ ГА, 1998, №3, С.59-74
8 В.И. Бабуров, Б.В. Понамаренко, Принципы интегрированной бортовой авионики - Спб, Изд. «Агенство «РДК-Принт», 2005, С.225
9 Khakimov A.V., Nechaev V.A., Kostishin M.O. Investigation of the automation level of designing the software and hardware structure of the on-board equipment integrated modular avionics - (MIST: Aerospace -2018) in October 20, 2018 in Krasnoyarsk, Russia.