Aircraft life cycle management system architecture for solving cost management tasks

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Abstract. The article is devoted to cost management issue in the aircraft life cycle management system. In a theoretical analysis, the authors consider the main cost management components, the main automated systems used in the modern integrated information space and the universal scheme of using automated systems at product life cycle different stages for effective cost management problems solving. The research part of the article is based on production cost management scheme development, as well as the aircraft life cycle management system architecture formation, which allows solving cost management tasks, including during aircraft operation phase.

1. Introduction
One of the popular tools used to describe any economic system development process is the life cycle model, since effective company development management based on the life cycle model makes it possible to develop necessary transformations’ optimal directions. In most cases, practical life cycle model application is fragmented. The inability to determine various stages duration of the life cycle and the entire life cycle as a whole does not allow the unambiguous life cycle stages identification and, as evaluation criterion, the entire life cycle cost determination, and not of individual performance indicators [1]. Thus, a reliable life cycle management system is needed which will increase competitiveness and ensure the aircraft project profitability by solving the following successive cost management tasks:

- non-recurring costs management, which include the costs of:
  - new aircraft designing;
  - production preparation;
  - prototype manufacturing;
  - testing and certification;
  - mass production development and change management;
  - design, production and after-sales services (AS) (basic production facilities construction investment, production equipment, etc.) modernization and development;
  - developers’, manufacturers’, service centers’ and all enterprises’ professional training (retraining) included in the cooperation on a new aircraft creation;

- recurring costs management at all life cycle stages associated with:
  - planned cost management at the design stage;
• production costs management at the pilot and serial production stage;

• AS cost management during the operation phase;

• disposal cost management.

2. Materials and methods

2.1. Theoretical analysis

The logistic approach to industrial and transport complex managing has radically changed in recent years. Supply chain management (SCM) systems, enterprise resource planning (ERP), Product life cycle management (PLM) are widely used in aircraft and shipbuilding, production and operation of railway rolling stock transport. The aerospace and military sectors of the economy are of the highest priority. Thus, computer-aided design (CAD), ERP, product data management (PDM), SCM, customer relationship management (CRM), integrated logistic support (ILS) and other automated systems operate in the integrated information space, since their use is justified in the development process of a rather complex technical product with a long life cycle. PLM as an organizational and technical system that is designed to manage product information, as well as related processes, performs its functions throughout the entire product life cycle [2]. The product life cycle consists of many stages, each of which has its own characteristics. The ISO 9004 standard defines the product life cycle as follows: “the processes totality carried out from the moment the company’s needs are identified for a particular product to the moment these needs are met and the product is disposed of State Standard of Russian Federation GOST R ISO 9004-2010 “Managing for the sustained success of an organization. A quality management approach”. Thus, in order to ensure the development quality, support and removal from production of the product, it is necessary to take into account these stages’ features. Both product’s design and discontinuation require support. The term “product” in this context is an abstract entity, since it can mean either an aircraft or a complex computer network. This is the PLM specificity, means support for an object of any complexity, and the information used by the PLM system is a digital object’s layout [3].

2.2. Non-recurring costs management

When managing non-recurring costs, it is advisable to use project management methodology existing tools. At the stages associated with product development, plans’ hierarchical structure is formed that sets the scope of work performed at all aircraft life cycle stages to a level sufficient to ensure effective development management, taking into account the project cooperation scheme established for the program. Adequacy of the plans is achieved by standardizing the work, based on the labor costs values established by statistical methods for Research and Development (R&D) (including electronic layouts and models creation, electronic design, technological and operational documentation preparation), production preparation, testing and certification [4, 5]. The plans’ relevance is ensured by periodically comparative analysis conducting of the planned and actually achieved results to make appropriate adjustments to the current stage plan if necessary. To enable reliable accounting of non-recurring costs in the program’s financial and economic indicators calculations, the developed plans are managed within the automated project management system framework with appropriate control observance to fill in essential indicators, such as: work labor intensity, sizes and rates of performers’ remuneration, material costs volumes, overhead costs, co-executors services costs, etc. It is advisable to implement the presented tasks on Open Plan software basis in integration with Baan and SAP R/3.

An important feature of investment management in the program for creating a new aircraft is reasonable investment planning at the project’s early stages. To do this, at the preliminary project stage, a production cooperation scheme should be formed and each participant’s capabilities evaluated, as well as a scheme for AS cooperation. At the design stage, it is necessary to carry out integrated technological planning and the basic production equipment and infrastructure requirements should be determined. Based on the forecast results of possible sales volumes and the optimal production cooperation scheme,
it is possible to assess the production loading possibilities of equipment available at the implementing enterprises and the need for equipment modernization or the new production equipment acquisition and infrastructure upgrade. Based on the optimal cooperation scheme for AS, it is planned to carry out work to calculate the need for personnel with the necessary qualifications, fixed assets and working capital, spare parts distribution means, maintenance and training centers [6].

2.3. Recurring costs management
When managing recurring costs through the life cycle stages, it is important to use the design method at a given cost, where in the design process it is necessary to adhere to the following rules and sequence:

1. For the product and its components, determined taking into account certain production cooperation, several measurable and controlled indicators are established that characterize the cost, flight technical and operational requirements presented to them. Requirements are set in the form of “target” indicator values, such as aircraft performance, production costs, flight hours cost, ownership cost.

2. At each design stage, the indicators’ planned values are calculated and compared with the target values, based on which a conclusion is made on the product requirements fulfillment.

3. Planned indicators’ values are established based on existing statistics on previously completed projects, preliminary technological development of design decisions feasibility, taking into account the inherent excellence level in design and technology, as well as market needs.

4. In the design process, several alternative options for design decisions are developed, which are subsequently compared (the calculated indicators’ values are determined). From the compared options, one is selected that best meets the cost and most important flight technical and operational requirements. The choice is made by comparing the calculated values with the planned values of the indicators for each option, to determine the target values for the next program stage. The next stage transition is carried out after at the current stage the program for the product and all its components (units, functional systems) selected for control the design implementation option is installed and the possibilities of achieving the “target” indicators are substantiated.

5. Based on the established and confirmed by the program stages planned indicators’ values, planning and adjusting the program financing schemes is carried out. Thus, the target prime cost and the ownership cost should not exceed the “target” limit values, and the forecasted flight technical and operational parameters of the aircraft have to meet customers’ requirements (expectations).

To solve the problems of managing production costs, it is necessary to develop measures aimed at optimizing technological production preparation costs and the production process organization itself. Management and conduct of an operational analysis of the product cost at the production stage can be carried out as part of ERP, which is aimed at solving the following problems:

- maintaining limit "target" indicators of the product cost and its components based on data established at the end of the design phase;
- actual (production) cost establishment and control and its components based on the results of the experimental and serial product copies manufacture;
- good’s production cost comparative analysis with the established values of the “target” cost indicators;
- based on a comparative analysis and conclusion on the production conformity and “target” cost, if necessary, adjustments to the results achieved;
- ensuring, when changing or updating the data during the product development, changes or clarifications of all indicators dependent on the data that is involved in the cost control process, and, as a result, changes or clarifications of the product cost or the decision to adjust the “target” cost indicators;
- components cost control (own production parts, auxiliary materials, standard products).
The data recorded in the framework of cost management system is the source for work in the budget planning and economic analysis framework.

3. Results and discussion

3.1. Decrease in the life cycle cost during the aircraft operation phase

The current integration scale is caused by the possibility of the interaction cost reduction in the “purchasing-production-distribution” system. Time, quality, flexibility and safety have become the most critical factors in the areas of production and supply. The flexible production creation based on ILS leads to the transition from mass production to small-scale or even individual production of “custom-made” products, while ensuring high efficiency, reliability and security of supply. Creating competitive, affordable consumer high-tech products is an important issue for operators of complex equipment with a long life cycle, such as an aircraft [7].

Thus, within the proposed concept framework of the PLM system, it is planned to reduce the life cycle cost during the aircraft operation phase (maintenance and repair) with the ILS system. According to the authors of [8, 9], ILS is a set of interrelated processes carried out throughout the entire product life cycle, organized using modern management and information technologies. According to the DEF STAN 0060 standard, ILS includes logistic support analysis, planning procedures for maintenance and repair processes, integrated logistics procedures, measures to provide personnel with electronic operational and repair documentation (U.K. Ministry of Defense 2004. “Integrated Logistic Support. DEF STAN 00-60”). The information circulating in the information support system for the product life cycle is divided into three components:

- data on the product;
- data on ongoing processes;
- data on the resources required to complete the processes.

According to North Atlantic Treaty Organization (NATO) countries’ Ministries of Defense, the ILS life cycle management technology use can reduce the costs associated with AS, including the maintenance and repair process up to 30%. ILS is part of integrated logistics, which provides not only the PLM, but also a number of related tasks: reaction speed, uncertainty minimization, stocks minimization, quality assurance, and cargo transportation consolidation.

According to the Aviaport (https://www.aviaport.ru/digest/2017/10/20/490981.html?bb=), the AS system, which will be aimed at increasing the resource, reducing the aircraft operation and maintenance cost, should be based on:

- in-depth analysis of own experience and existing world practice in creating AS systems;
- development of flexible, competitive comprehensive offers for maintenance and customer service;
- goals and requirements understanding for the creation, certification (if necessary) and ensuring functioning of each AS system element;
- implementation and mandatory ISL standards use during creation and maintenance of AS system functioning;
- customer requirements and needs focus is set as one of the main;
- building clear and mutually beneficial partnership schemes for interaction between the aircraft developers, its manufacturers and maintenance and repair providers with a single product information space.

The life cycle cost reduction at the aircraft operation stage (maintenance and repair) is planned to be provided by the following implemented ILS system components:
• conducting at the development, production and operation stages a detailed logistic support analysis (LSA), which is a technology for a comprehensive study of both the aircraft itself and its operation options (maintenance and repair types and forms);
• choice and procedure for required resources use (material, labor, temporary) to ensure operation;
• planning processes for aircraft maintenance and repair carried out at the design stages and specified during the production and operation, to more quickly determine the characteristics achieved at the operational stage (monitoring) with the appropriate solutions development for maintenance and repair (bulletin revision, modernization, etc.);
• integrated planning of operation logistics procedures, aircraft maintenance and repair, carried out at the design stage and specified during the production and operation;
• providing electronic operational documentation (EOD) and electronic repair documentation (ERD), carried out at the design stage and implemented during the production process, which will eliminate difficulties in finding the necessary information regarding operation, maintenance, troubleshooting, as well as during supplier and the customer interaction.

LSA should begin at the product requirements determining stage and continue until the end of its use. The latter is necessary to assess the LSA results correctness and statistical material accumulation, which serves as the basis for the new projects’ analysis. The LSA process is cyclical in nature: at each subsequent stage, the previous stage results are specified and developed. The PLM system architecture that allows solving cost management problems is presented in the figure 1.

Figure 1. Aircraft life cycle management system architecture for solving cost management tasks.
3.2. Cost management approach

Thus, to solve cost management problems, the PLM system have to comply with the architecture, which consists of the following interconnected and interdependent components:

- Teamcenter PDM system, which will allow solving cost management tasks, providing control over the processes of initial data preparation, automated systems integration into a single information environment;
- project management system based on Open Plan, which will solving the of scope of work management tasks and non-recurring costs;
- RAM Commander system, which will allow carrying out AS technology development;
- ERP system, which will solve purchasing and production management problems, planning production equipment loading, while being an important tool for calculating the planned and production costs.

4. Conclusions

The aircraft life cycle management system study is aimed at new innovations formation based on the integration processes of various entities in the supply network and ensuring their autonomy based on effective management methods. This approach is a digital transformation in the study and understanding of a new technological structure, Industry 4.0. Methodological and practical study of the development problem and the possibility of using life cycle management systems create new effective areas for a comprehensive system assessment.

With such problem formulation, an effective material flow organization is possible only based on the applied technologies and equipment (production, logistics processes) deep knowledge, their technological unity and design methods compatibility. From this follows the urgent task of creating a new look and systems characteristics that will correspond to global changes taking place in the modern world, based on the Industry 4.0 principles, which will create the conditions for aircraft manufacturers and operators adaptation to a modern service-oriented approach using effective cost management tools at all product life cycle stages.

References

[1] Gorelov B A and Gyazova M M 2018 Performance-based incentive mechanisms in life cycle contracts Russ. Eng. Res. 38(4) 309-12
[2] Novikov S V and Sazonov A A 2019 Digital economy development in Russia: main trends’ analysis and assessment Esp. 41(5) 26
[3] Shalamov A S 2008 Integrated logistics support for high technology products Monograph (Moscow: University book)
[4] Gyazova M M 2019 Assessment of the impact of technological innovations in the design and manufacture of aircraft on the effectiveness of its use in commercial aviation Russ. Ec. Int. Journ. 4 1-7
[5] Fridlyand A A and Gyazova M M 2019 Model for assessing the impact of R&D results on the technical and operational excellence of an aircraft engine and aircraft life cycle cost Russ. Ec. Int. Journ. 1 1-11
[6] Gyazova M M 2019 Creating a model of organizational support for an innovation program at the stage of external design of the life cycle of technically complex products Russ. Ec. Int. Journ. 2 1-16
[7] Novikov S V and Sazonov A A 2019 Improving the enterprise resource planning system based on digital modules of the “industry 4.0” concept Esp. 41(5) 27
[8] Kartashev A V, Nekrasov A G and Ataev K I 2016 Life cycle management of complex high-tech products in integrated supply chains: monograph (Moscow: PrintUp)
[9] Nekrasov A G, Sokolov B V and Ataev K I 2017 Life cycle management system (transformation into a digital infrastructure): a training manual (Moscow: Techpolygraphcentre)