Procedures improvement of forming the execution labor intensity of R&D

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Abstract. The study purpose is to increase the validity of the evaluating labor costs process on the performing research and development work (R&D). The official methods in force in the Russian Federation have applied as a methodological basis for improving the procedure as well as domestic and foreign methods for assessing the labor intensity of R&D. The proposed principles for assessing labor intensity are based on unit labor costs, applied for three types of R&D (typical basic research, changes in the main functional systems, and new development), and take into account three complex correction and labor deflation factors. The scientific novelty of the study is the formation of new principles for calculating the complexity of R&D.

1. Introduction
The R&D in the aerospace industry is associated with significant costs. The estimated cost of the work performed is the most important indicator for deciding on the financing type. The basis for adequate R&D pricing is assessing the labor intensity of research.

The main factors affecting the probability of forecasting results are as follows: presence of only a development concept; data lack to predict the labor intensity of R&D; high uncertainty of the research process [1, 2].

The practice analysis shows that at aircraft manufacturing enterprises the actual R&D performance data do not correspond to the planned parameters, which is also due to an unreasonable calculation of labor intensity.

The principles for assessing the labor intensity are considered as a study object, study subject is the method and the model for assessing the labor intensity of R&D performance [3, 4].

2. Theoretical basis
There are 10 methods for calculating the cost and labor intensity of R&D in Russia, three of them give some approaches to determining labor costs.

The application preparation guidelines for the formation of topics and financing volumes as a part of activities of the Federal Target Program “Research and Development in Priority Directions for the Development of the Russian Science and Technology Complex” for 2014–2020 determine the basis for organizing labor standards during R&D, concepts of the time rate (labor intensity), labor intensity standard, labor rationing methods [5, 6].

The methodology for substantiating the initial (maximum) contract price (lot price) to perform research, development and technological work within the framework of the implementation of Federal
Target Programs and extracurricular activities in the science field coordinated by the Ministry of Education and Science of the Russian Federation gives the rules for justifying the labor intensity and the work timing under the costly method.

The methodology for calculating the projects’ cost and the initial (maximum) contracts’ price proposed for implementation within the framework of the Federal Target Program for the Development of Education for 2011–2015 establishes labor standards for calculating the cost of developing, finalizing and developing automated systems and software products. The coefficients are used as correction factors: complexity, novelty, value of results, scale, quality, performer qualification [7, 8].

3. Methodology
The definition of the R&D labor intensity is the first most complex probabilistic process of forming a contract price. The following main methods for determining the R&D labor intensity in domestic practice are distinguished:

- direct counting method according to the nomenclature of work, which is based on the actual and forecast planning information collected from the design and production units about labor intensity of each operation proposed by R&D. If there is reasonable information, this method provides high accuracy and reliability of estimates for scientific research that is close in complexity and content. The labor intensity is formed from the existing list of standard works. An increase in the complexity for certain types of work is caused by the required increase in the number and qualification of performers;
- empirical method for calculating the R&D labor intensity, which is based on the principle of a certain relationship between technical characteristics and the complexity of model development, is stable for each equipment class. The calculation of the labor intensity for performing R&D by the empirical method is based on the use of special normative-reference tables and functional dependencies developed by industry research institutes dealing with issues of economics and labor organization. The method does not fully consider the specifics of works and performers;
- analog-comparative method, which is based on the proposition that similar R&D has a similar labor intensity. From 3 to 5 analogs of R&D (equipment of the same class) with similar technical characteristics and technological process are selected for evaluation. Each analogue is compared with the evaluation object, the labor intensity of the analogue is adjusted for the novelty coefficient [9]. The obtained estimates of the labor intensity of analogues are averaged. The method is not applicable if R&D has a high innovation degree. The method weaknesses is a lack of a sufficient analogues number for the aviation industry. The method is used for certain similar types of work;
- expert method, which is based on the use of the experts experience or highly qualified specialists. The method is used in conditions of information certainty. The disadvantages include the subjectivity factor in the preparation of expertise, as well as expert assessments, even with a high degree of multicollinearity and autocorrelation of the expert group [10, 11].

Now we consider the foreign methods for calculating the R&D labor intensity:
- predicting method of the labor intensity of development in DARPA (Defense Advanced Research Projects Agency), which involves an interval assessment based on the stage of the R&D life cycle. The method uses various tools, including detailed engineering calculations, regression equations linking the labor intensity of previous projects with technical and economic characteristics, technical coefficients complexity and readiness, detail and aggregation coefficients, probabilistic parameters of the work structure on the product and its elements, introduce amendments to the technical complexity and maturity R & D [12]. The method does not require a large amount of information. However, the method is designed for the subjective assessment of experts at introducing correction factors and probabilities.
- PERT (Program (Project) Evaluation and Review Technique) technique that uses the beta distribution of the relevant parameters, which is based on a pessimistic, most likely and
optimistic forecast. The total labor intensity of the system is determined on the basis of a random sample of the estimated cost for each subsystem [13, 14]. The process is repeated many times, while it is desirable to obtain the several thousand cost estimates. The results obtained serve as the basis for a statistical assessment of the total labor intensity. The method considers the uncertainty of the labor intensity of R&D performance associated with the accepted parameters and value distributions. The method does not consider probability error in interval estimates.

- method for predicting labor intensity in NASA is based on an analysis of a wide range of related areas of R&D performed through various funding sources. The developed and constantly updated regulation describes the forecasting methods and models used by NASA, and also contains practical information (predictive and actual according to the R&D performed) regarding their application. A study of the R&D results in related fields allows us to consider the technical equipment factor of labor for future performers.

- method for assessing the labor intensity of the entire project cycle (LCCE), which includes the entire labor intensity of the design, manufacture, testing and operation of products. The method makes it possible to evaluate the project in a consolidated manner, based on elaborated regulatory and legislative acts that implement a common goal - improving the efficiency of project activities. There is an access to permanently updated information on completed and planned R&D. The controllability degree in the distribution of work among collaborators is reduced [15].

The considered domestic and foreign methodology allows us to formulate the principles of labor intensity assessment, which will allow damping the identified shortcomings.

The proposed approach to assessing the labor intensity includes several principles that are based on the best current techniques, and also contains new technologies:

1) Technical and technological characteristics determination of R&D. The possibility of a R&D typology is revealed at the stage of the technical task formation, and a search is made for similar studies.

2) Differentiation of works into standard and innovative ones. After forming the list of necessary for the performance of work with varying aggregation degrees, they should be differentiated according to the presence of established standards and novelty. The labor intensity is taken on the basis of reference books for work without any complication, for which standards have not been developed.

3) Adjustment factors application. It is necessary to apply corrections for innovative types of work, based on data on analogues, the number of which should be from 3 to 5 in accordance with the requirements of the legislation on valuation activities.

It is necessary to apply coefficient of novelty, scale for research, the novelty degree of which is in the range of 0% -10%.

It is necessary to apply the coefficient of novelty, scale, complexity for research, the novelty degree of which is in the range of 11% -40%.

It is necessary to apply the coefficient of novelty, scale, complexity, qualifications of performers, R&D quality for research, the novelty degree of which is in the range of 41% -80%.

It is necessary to apply the coefficient of novelty, scale, complexity, qualifications of performers, R&D quality, results value for research, the novelty degree of which is in the range of 81% -100%. The labor intensity is determined, including by expert means for fundamentally new works. The results are compared with the calculation of the labor intensity using coefficients.

4) Matrix adjustment factors application. It is proposed to use the table of coefficients of given intervals for innovative types of work. Each recommended value of the table is formed as an influence result of three groups of factors: the novelty type of the work \((j)\) (typical basic research, changes in the basic functional systems, new development); work uniformity coefficients (change coefficient in the standards of basic labor intensity \((T^B_j)\), by reference on types of work \((1 \leq L_j \leq 1.2)\)); adjustment coefficient of labor intensity \((T^A_j)\), for the performers number and their qualifications by types of work.
that differ significantly from reference \((1 \leq P_j \leq 2.5)\); adjustment coefficients on research results (factor complicating the design documentation \((1 \leq K^f_j \leq 1.1\)), value coefficient of the results \((1 \leq K^v_j \leq 1.4)\)).

5) Application of infrastructure adjustment coefficients. When R&D executives are selected, their infrastructural production features are often not considered, which can increase or decrease the complexity of the work. The coefficient is recommended to adjust the entire complexity or part of it, considering the differentiation of the co-executors. The change in labor intensity under the influence of the infrastructure coefficient should not be more than 10%.

6) Labor intensity deflation. The adjustment type of labor intensity for R&D to be carried out associated with a change in the technical equipment of performers, capital productivity and growth in labor productivity in research and development. The aviation industry development program for sub-sectors until 2030 sets the limit values for the growth of labor productivity, which can become targets for deflators by years \((i)\) of the innovative project implementation \(\left( \frac{1}{(1+\alpha_{ij})} \right)\). Thus, the predictive R&D labor intensity \((j)\) of innovation type is calculated by the formula:

\[
T_j = \sum \left( (T^{b}_{ji} - L_{ji} + T^{n}_{ji} P_{ji}) K^{k}_{j} K^{r}_{ji} K^{ss}_{ji} \left( \frac{1}{(1+\alpha_{ij})} \right) \right)
\]

7) Application of specific labor intensity indicators. It is proposed to use specific indicators as criteria for assessing the accuracy and reliability of assessing the predicted R&D labor intensity. The main technical and technological characteristics of R&D can be applied in the denominator. The predictive labor intensity is calculated in the numerator. Comparison of specific labor intensity is carried out with previously performed scientific studies, which were aimed at achieving similar technical and technological parameters of R&D. The specific labor intensity can be used as a criterion in the competitive selection of R&D performers. The decrease in the specific labor intensity indicators indicates a high degree of the forecast reliability of the R&D labor intensity [16].

4. Results and conclusions
The analysis of the official Methods for assessing the R&D cost has shown that the labor intensity of them is not adequately systematic. The analysis of the methods for assessing labor intensity used in domestic and foreign practice allowed us to identify factors that make it possible to improve the forecast accuracy, as well as to formulate shortcomings. The proposed methodology for assessing labor costs is based on the following principles: considering the technical and technological characteristics of R&D, differentiating work into typical and innovative, applying complex interval adjustment factors (including matrix type), applying an infrastructure adjustment coefficient, and intensity. It is necessary to use the specific labor intensity indicators as criteria for assessing the accuracy and reliability of the forecast labor costs. The proposed approach allows damping the shortcomings of existing methods and techniques for determining the labor intensity of innovative R&D.

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