



Mathematical and Instrumental Methods for Assessing the Economic Efficiency of Science Product for Export

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Abstract

The relevance of the study is due to the needs of using standardized Russian methods of calculating the unit cost of maintenance of exported science-intensive products. The authors bring to the discussion the hypothesis that the price of the exported science-intensive products does not dominate in the market however technologies of information support of science-intensive products at the object of operation dominate. Exporting a series of products to Indonesia is described by the calculations of maintenance examples at the facility. The methods of measurement, description and modeling were used in the calculations. In the first part of the article, authors classify the activities of the integrated logistics support and the elements of the maintenance Scenario. Calculations are based on the list of the main Russian standards for exporting products. The indicators for the assessment of initial maintenance cost are defined. The article determines the effective use of science-intensive products at the site of operation possibility in the presence of trained technical personnel from the customer's country (Indonesia). The calculations determine the number of specialties of engineering staff required to perform maintenance and repair the product. Mathematical modeling service cost of the service is carried out for the products delivered for export. The purpose of the article is to reduce the cost of the service maintenance on the territory of the Customer (Indonesia), in terms of reducing the technical personnel training cost. The calculation methods recommended by Russian national standard GOST R 56130-2014 was used in the article. The research was aimed at identifying unnecessary cost, while maintaining the performance quality of the product at the facility. The calculations show how to use standardized methods effectively. The main purpose of this publication is to develop methodological provisions for the analysis of economic processes and systems based on the use of economic and mathematical methods and tools.

Keywords: Methods of Unit Cost Calculation, Efficiency, Integrated Logistics Support, Mathematical Modeling, Cooperation between Russia and Indonesia.

1 Introduction

1.1 Political Review of Indonesia

Indonesia consists of scattered Islands washed by the Pacific and Indian ocean. There are no foreign armies in

Indonesia. Indonesia doesn't have land borders with other countries. The commander-in-chief of the National army of Indonesia determines the need for the purchase of military aircrafts (message was published on Janes.com). The required aircrafts are heavy, medium and light, as well as cargo transport aircraft, helicopters. From the materials of Peter Arkhipov, the Government of Indonesia plans to cooperate with Russian Federation. The head of the Indonesian Agency R. Ryacudu (4,6,8,16) expressed interest in buying Russian

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army aircraft "SU series". The contract is estimated in \$1.1 billion. The lending deal fell under U.S. sanctions, named: CAATSA (Countering America's Adversaries Through Sanctions Act) ("ON opposition to America's opponents through sanctions»). The difficult financial situation came to Indonesia in October 2018. It was planned to hold an exhibition with the participation of leading politicians, Ministers, representatives of the Government of the countries. International Asian Exhibition Defense & Security 2019 will be held from 18 to 21 November in Bangkok. It's planning to discuss the issues of security management, the fight against terrorism, the development of defense technologies.

1.2 Economic Review of Indonesia

The ranking of countries by GDP in 2019 based on the forecast data of the International Monetary Fund. Indonesia placed on the 112 rank GDP per capital in the world 2018 (table 1).

Table 1: Gross Domestic Product on the human population in the world at 2018

	Country	Gross Domestic Product
110	Algeria	4270.98
111	Mongolia	4182.09
112	Indonesia	4178.86

The major financial institutions predict that Gross Domestic Product of Indonesia will increase on 5.4% from 2018 to 2019. The Indonesian Armed forces have considerable potential; however, it is not enough to ensure the country's defense. This is not manifested as a priority issue due to the lack of direct external threats at the moment," said Alexander Khramchikhin, Deputy Director of the Institute of political and military analysis.

2 Methodological Framework

Mathematical methods assess the science-intensive products for supplying export. They include a comprehensive analyze of the supporting processes on the science-intensive products at the facility in the customer country (Indonesia). Complex analysis includes calculations confirming the effectiveness of material, financial, labor and time resources. In the article, the selected series of products with the formal name of the exported products - SU2MKI-refers to the knowledge-intensive products supplied for export. Since the name of the SU2MKI product does not play a role in the assessing the economic efficiency of the maintenance of science-intensive products abroad, the main a priority data are: the number of exported products, the frequency of delivering the spare parts and equipment under warranty and post-warranty repairing contracts. It's also important to control the time period of service, the complexity of service, as well as the remoteness of the country of export. Different countries for the supply of science-intensive products exhibit requirements in accordance with the current requirements of international standards for the supply of knowledge-based products and their supporting directly at the facility (Indonesia).

The main purpose of this publication is to develop methodological provisions for the analysis of economical processes and systems based on the usage of economic and mathematical methods and tools. The authors discuss the

hypothesis that the price of the exported science-intensive products doesn't dominate on the market however technologies of information support of science-intensive products at the object of operation dominate. The customer must have methods for calculation and the ability to simulate the cost of providing information support for the purchased products. We will determine the requirements of domestic and international standards for the supplying exporting products. On the meeting of the technical Committee for standardization TC 482 "Support of exported military products and dual-use products" members of the technical Committee discussed issues of integrated logistics support for exporting products. In the ROE (Rosoboronexport) letter dated November 3, 2017 in the agenda included issues, the solution of which provides Russian's access to the international markets for the supply of high-tech exporting products. The main problems identified by the Technical Committee are:

- problems of normative and technical supporting of the complex science-intensive products life cycle and their solutions;
- problems of processes standardization for computer design technologies, mathematical modeling, simulation programs and modeling kits;
- problems of cataloging in the management system of after-sales service for high-tech products at the facilities;
- Problems of the methodological supporting on the basis of integrated logistics support and cataloging.

Leading experts of the Technical Committee doctor of technical Sciences E.V. Sudov, chairman Y.K. Demchenko, candidate of technical Sciences. A.N. Petrov worked out the directions of the further work for ensuring the competitiveness of high-tech products in the international market. It should be noted that the value of the product on the international market does play a key role. In the international market competitive products are those that have a long, standardized cycle of information support on the customer's territory.

The concept of a long cycle includes: warranty (2-3 years), post-warranty (3-5 years) maintenance and repair (10 years) of high-tech products in the Customer country (Indonesia).

Russian authors E.V. Sudov et al. in the training manual "Technologies of integrated logistics support in the life cycle of knowledge-intensive products of aviation equipment" consider the analyze of logistics supporting (ILP) as a one of the basic technologies (15).

The tenth issue of the electronic journal "PLM and ILP technologies" provides publications the topics about creating subsystems for solving resource management problems in the integrated logistics support system, exemplified by the reactor plants. The ninth issue of the electronic journal "PLM and ILP technologies" provides publications about "Modern technologies and standards of integrated logistics support (ILP) in product development processes" authored by the E.V. Sudov et al. (14). In the article authors analyze the current state of standards for the usage of the integrated logistics support analyze database (ALP) during the development solutions for the technical operation and development operational documentation.

Russian authors A.S. Aktymbayeva et al. the main idea E-commerce evaluation and e-business trends. Of the analysis carried out by the authors is the identification of the full-scale usage of the ASD (aerospace and defense industry of Europe - ASD) specifications (1). Compliance with the requirements for the European international specification (aerospace and defense industry of Europe - ASD) offers the usage the sets of specialized specifications. Authors V.A. Barinova et al. analysis of competitive factors of domestic high-tech companies (2). The need for IT-standardization, it was noted by the authors E.V. Blyayeva and A.V. Gavrilov (3). Authors E.A. Khitskov et al. note the need for new methods in the era of Digital economy and digital transformation of society(7).

The application of integrated logistics support standards allows to ensure the effective usage of high-tech products on the acceptable level. An acceptable cost of service at the facility will depends on the scenario of the use of high-tech products by the customer countries. The scenario for the usage of the science-intensive products includes several stages of operation with the product: run-in, run-through,

testing at the facility, the usage in the different modes of operation, run to break. The quality of ensuring operability of the product at the facility depends on the following parameters: material and labor resources; maintenance work; downtime costs; under-delivery or excessive supply of spare parts of the product, tools and accessories, the availability of high qualified technical personnel, information support for decision-making in the case of trouble-free life of the product. Integrated logistics support activities include elements of a maintenance Scenario displayed in the table 2.

Table 2 shows that the planning of Technical maintenance (MTO) for the product at the facility contains the main elements: the development of requirements for the periodicity planned MAINTENANCE; development of material and technical support (MTO); development the operational documentation (interactive, e-document), development the standards of the transportation for the product on the facility; development the resource requirements. National standards for integrated logistics supporting the exporting products are presented in Table 3.

Table 2: Activities at the integrated logistic support (ILS), and scenario technical service (STS)

Type of activity ILS /element STS	Development	Maintenance	Perfection
Planning maintenance service (MS) /Plan maintenance service (MS)	Development of requirements for the composition and frequency of scheduled maintenance	Recommendations for adaptation of the requirements to the composition and frequency of maintenance subject to the conditions of operating organizations	Recommendations for improvement of requirements to the composition and the frequency maintenance service(MS)
Planning material and technical service (MTS)/ Plan MTS	Directory development, Catalogue MTS	Recommendations for the application of the maintenance plan	Plan adjustment MTS
Development maintenance documentation (MD) /Maintenance documentation	Development and delivery maintenance documentation (MD)	Elimination of operational documentation inaccuracies at the operational stage	Changes to the maintenance documentation (MD)
Development of requirements for means of operation /Means of operation	Development of requirements for means of operation	Verification of compliance of means of operation with the developed requirements	Changes to requirements
Development of requirements for the number, specialization and qualification of personnel /Personnel	Determination of requirements to the number, specialization and qualification of personnel	Verification of personnel compliance with the specified requirements, recommendations To resolve inconsistencies	Adjustment of personnel requirements

Table 3: List of main standards of exported products

The name of the standard of the Russian Federation	Appointment
Russian national standard ГОСТ Р 55932-2013	integrated logistics support (ILS) of exported military products. Operational and repair documentation. Delivery and modification requirements
Russian national standard ГОСТ Р 56111-2014	integrated logistics support (ILS) exported military products. Nomenclature of performance and technical characteristics
Russian national standard ГОСТ Р 56113-2014	integrated logistics support (ILS) exported military products. Logistics planning
Russian national standard ГОСТ Р 56114-2014	integrated logistics support (ILS) exported military products. Requirements for the analysis of logistics support of exported military products
Russian national standard ГОСТ Р 56130-2014	integrated logistics support support (ILS) of exported military products. Estimation of technical operation costs at the development stage

Table 3 shows that the Russian national standards for integrated logistics support include: planning of logistics, requirements for the analyze for logistics supporting for exported products, cost estimation, requirements for changes.

The ROE website presents partner countries for the supplying of the high-tech products. Russian arms geographical exports include: Asia, Africa, Europe. Cooperation with Indonesia indicated by the diplomatic relations established with Russia since February 3, 1950.

Indonesia and Russia have signed an agreement on mutually beneficial cooperation in the political, economic, cultural and military fields. The Business Cooperation Council, established on 10 November 2009, is an effective mechanism. The countries signed about 20 intergovernmental agreements, which form the basis of economic cooperation between Russia and Indonesia. The countries have signed an Agreement on military-technical cooperation in 2010. In this case, emphasis should be placed on technical cooperation. Technical cooperation is possible if customer the country (Indonesia) applies the requirements of standards for providing information support for high-tech products at the facilities. GOST R 56130-2014 "Assessment of technical operation costs at the development stage" was developed by JSC "Research center "Applied logistics", approved and put into effect by the Order of the Federal Agency for regulation and Metrology of September 19, 2014 № 1150-art.

The standard provides a method of calculating the specific direct costs of, namely:

1. Specific costs of planned maintenance;
2. Unit costs for resource recovery (replacement the parts of the product due to the development of their assigned resource (service life));

3. Unit costs of unscheduled maintenance;
4. Unit costs of personnel remuneration.

The following indicators are used to estimate the initial maintenance costs:

1. The cost of creating the infrastructure of the technical operation system;
2. Acquisition costs maintenance;
3. The costs for initial training for technical personnel;
4. Acquisition costs for the spare parts to ensure the required value of the coefficient of readiness of the sample products.

A priori data for calculation.

A.2.1 Quantitative parameter:

- 5 - average number export products samples in the Park;
- 0.9 (high degree of readiness) - the required coefficient of availability.

A.2.2 Data on technical operation system infrastructure and equipment:

- $N_{\text{ИНФ}}$ - number of infrastructure facilities required to perform **technical service and repair** (TSP) of the Park of the considered product samples;
- $C_i^{\text{ИНФ}}$ - the cost of the i-th infrastructure;
- $N_{\text{СТО}}$ - number of types of **technical service system** (TSS) required to perform **technical service and repair** (TSP) of the Park of the considered product samples;
- $N_{\text{СТО}}$ - number of types of maintenance systems (SRT) required to perform **technical service and repair** (TSP) of the Park of the considered product samples
- $C_i^{\text{СТО}}$ - the unit price of one **technical service system** (TSS) of the i-th type.

A.2.3 Data on training needs:

- $N_{\text{СПЕЦ}}$ - the number of specialties of engineering staff required to perform **technical service and repair** (TSP) of the considered product samples

- $A_i^{\text{СПЕЦ}}(N_{\text{ФИ}})$ - the number of specialists of the i-th specialty - 5 required for **technical service and repair** (TSP) copies;
- $C_i^{\text{ОБУЧ}}$ - the cost of training specialist i-th specialty
- $C_i^{\text{СТО}}$ - the unit price of one **technical service system** (TSS) of the i-th type

3 Materials and Methods

The use of standards of integrated logistics support by foreign customers allows to ensure the effective use of high-tech products at an acceptable cost of its life cycle at the facility.

The state standard of the Russian Federation recommends the use of calculation methods.

The main methods of calculation are:

1. The method of calculating the cost of creating the infrastructure of the system of technical operation (A. 3.1);
2. The method of calculation of the costs of system maintenance (one **technical service system** (TSS)) (A. 3.2)
3. The method of calculating the cost of initial training of personnel for one instance of high-tech products (A. 3.3)
4. The method of calculating the cost of purchasing a set of spare parts for one instance of a high-tech product (A. 3.4)

3.1 Description of Cost Calculation Methods

A.3 - Cost calculation methods:

A.3.1 The cost of creating the infrastructure of the technical operation system for one instance of the product is calculated by the formula:

$$C_{\text{начТО}}^{\text{ИНФ}} = \frac{1}{N_{\text{ФИ}}} * \sum_{i=1}^{N_{\text{ИНФ}}} C_i^{\text{ИНФ}} \quad (\text{A.1})$$

Where $N_{\text{ИНФ}}$ - the amount of infrastructure needed to perform Maintenance and repair of the Park of the considered samples of product; $N_{\text{ФИ}}$ - average number of product samples in the Park; $C_i^{\text{ИНФ}}$ - the cost of the i-th infrastructure

A.3.2 The cost of the maintenance system for one copy of the PVN is calculated by the formula:

$$C_{\text{начТО}}^{\text{СТО}} = \frac{1}{N_{\text{ФИ}}} * (\sum_{i=1}^{N_{\text{СТО}}} n_{i=1}^{\text{СТО}}(N_{\text{ФИ}}) * C_i^{\text{СТО}}) \quad (\text{A.2})$$

where $C_i^{\text{СТО}}$ - the unit price of one hundred-th type;

$N_{\text{СТО}}$ - the number of types of **technical service system** (TSS) necessary to perform **technical service and repair** (TSP) of the Park of the considered samples $n_i^{\text{СТО}}(N_{\text{ФИ}})$ - the number of units of **technical service system** (TSS) i-th type required for maintenance of copies of product.

A.3.3 The cost of initial training of the personnel for a single instance of MPP is calculated by the formula:

$$C_{\text{начТО}}^{\text{СПЕЦ}} = \frac{1}{N_{\text{ФИ}}} * (\sum_{i=1}^{N_{\text{СПЕЦ}}} A_i^{\text{СПЕЦ}}(N_{\text{ФИ}}) * C_i^{\text{ОБУЧ}}) \quad (\text{A.3})$$

where $N_{\text{ФИ}}$ - the average number of samples of equipment in the Park (at the facility);

$N_{\text{СПЕЦ}}$ - the number of specialties of engineering and technical staff required to perform **technical service and repair** (TSP);

$A_i^{СПЕЦ}(N_{ФН})$ - number of specialists of the i-th specialty required for MRO copies;

$C_i^{ОБУЧ}$ - the cost of training specialist i-th specialty.

A.3.4 The cost of purchasing kit parts for a single instance of MPP is calculated by the formula

$$C_{начТО}^{НАЧ} = \frac{1}{N_{ФН}} * (\sum_{i=1}^{N_{КН}} C_i * N_i^{НАЧ}) \quad (A.4)$$

where $N_i^{НАЧ}$ - the quantity set of products (SP) of the i-th type in the set of spare parts; $N_i^{НАЧ}$ ($i = 1..N$)-calculate on the basis of the required value.

The effective usage of high-tech products at the site of operation is possible, in the presence of trained technical personnel. When supplying products for export, options for training technical personnel of the customer's country are considered.

The method of calculating the cost of initial training of personnel for one instance of a high-tech product is described in paragraph (A. 3.3).

4 Modeling the Situation

Let us assume that the maintenance of one high-tech product at the facility of operation of the customer's country is required: the number of specialties of engineering staff required to perform maintenance and repair; the number of specialists i-th specialty required for maintenance and repair; the cost of training i-th specialty (table 4)

Table 4: List of specialties and number of specialists for **technical service and repair** (TSP)

Profession of engineering and technical personnel	The cost of training specialist i-th specialty,(\$)	Total specialists	The cost of training, thousands (\$)
profession1	5000	5	25000
Profession2	10000	3	30000
profession3	15000	2	30000
profession4	25000	7	175000
profession5	40000	8	320000
profession6	2000	4	8000
profession7	8000	1	8000
professionN	100000	1	100000
			696000
$N_{СПЕЦ}$	31	-	
$C_{начТО}^{СПЕЦ}$	22451,61(\$)	total of all specialists	

In relation to the number of increasing specialties of engineering personnel per unit, while maintaining the cost of training and reducing the number of specialists, the total cost is reduced. Therefore, the optimal price will be determined by the lowest cost of training the necessary and sufficient number of trained personnel.

5 Results and Discussion

Mathematical modeling of product, service cost is researched in the article. The method of calculating the initial personnel training cost reveals regularity. The next steps are required in terms of reducing the personnel training cost in

order to reduce the product servicing cost on the territory of the Customer (Indonesia):

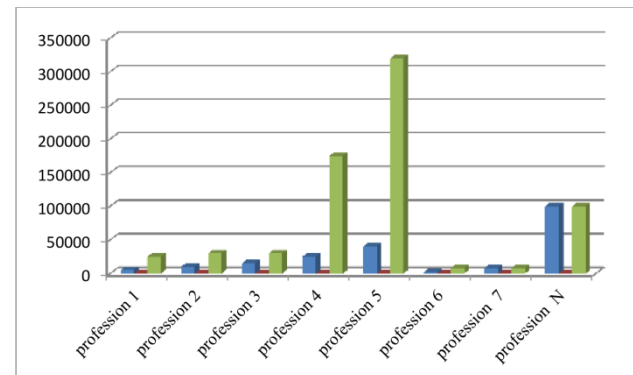


Figure 1: Result of calculation. List of specialties and number of specialists for **technical service and repair** (TSP)

Table 5: List of specialties and number of specialists for maintenance and repair

Profession engineering and technical personnel	The cost of training specialist i-th specialty	Total profession	The cost of training, thousands (\$)
profession1	5000	3	15000
profession2	10000	2	20000
profession3	15000	1	15000
profession4	25000	5	125000
profession5	40000	4	160000
profession6	2000	3	6000
profession7	8000	1	8000
profession8	3000	1	3000
professionN	100000	1	100000
			452000
$N_{СПЕЦ}$	21	- total of all specialists	
$C_{начТО}^{СПЕЦ}$		21523,81(\$)	

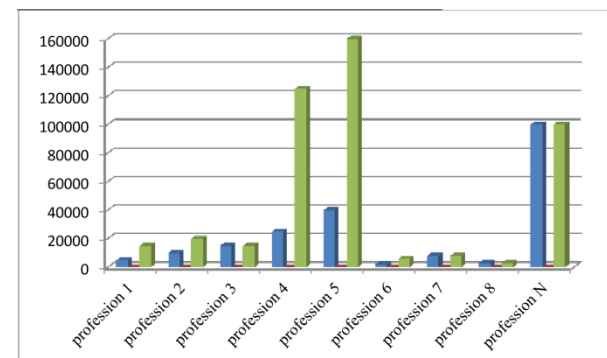


Figure 2: Result of calculation. Result of calculation. List of specialties and number of specialists for technical service and repair (TSP), the increase in per unit

- 1.Prepare more engineering and technical personnel specialties;
- 2.Minimize the number of trained specialists for maintenance and repair of specific products of one series (for example: SU series aircraft).

3. Use the calculation methods recommended by the Russian national standard GOST R 56130.

Therefore, if you apply the calculations according to the recommended methods (A. 3.1 - A. 3.4), it is possible to conduct a comprehensive cost analysis of material, financial, labor and time resources.

Information support of the product at the facility includes:

1. Number of exported products;
2. Frequency of delivery of spare parts and equipment under warranty and post-warranty repair contracts;
3. The time period of service,
4. The complexity of the service.

5.1 The Complexity of the Tinning is Calculated According to the Established Formulas

Therefore, if we take for the maximum-the necessary amount of training of technical personnel (table 4) as 100 %, respectively, we can calculate the percentage:

$$X = \frac{21523,81 * 100\%}{22451,61} = 95,87\%$$

5.2 Conclusion According to the Calculations

With an increasing number of students in engineering specialty and decreasing the technical personnel in the total number of specialists of maintenance and repair services from 31 to 21 people, the total cost is reduced by 100%-95.87%=4.13 %.

The total savings in 4.13 % of costs only in the calculation of A. The initial training cost of the personnel for one copy of the product is a significant amount. In monetary terms, it is 927, 8 thousand dollars. Studies were aimed to identify unnecessary costs with maintaining the quality of performance for the product at the facility. The calculations show the effectiveness of standardized methods usage. Application of standards of integrated logistics supported by foreign customers allow to provide cost calculations for the effective usage of high-tech products with acceptable cost for their life cycle at the facility. The main purpose of this publication is to develop methodological provisions for the economic processes analyze and systems based on the usage of the economic and mathematical methods and tools. The authors put forward for discussion the hypothesis that before buying complex science-intensive equipment, it is advisable to carry out complex calculations and simulate costs, to determine quantitative and qualitative indicators.

6 Conclusions

In conclusion, emphasis should be placed on the needs in the standardized calculation methods. Russian national standards offer improved methods of calculating unit cost. Modeling of processes allows to find the optimal amount. The Russian state social university (Moscow) has a cooperation agreement with Indonesia. RSSU qualify Indonesian students in the technological cluster of the information technologies faculty. The article approves the hypothesis that the exported high-tech product price does not dominate the market however information support technologies of knowledge-intensive products are dominant on the object of operation. Authors give practical examples of

the cost calculating for the science-intensive products support. The ways for identifying unnecessary cost with maintaining the product quality performance at the facility are examples in the article. This way may take effect to the defense products cooperation between Russia and Indonesia. Authors O.L. Mnatsakanyan, D.Y. Altimentova and D.V. Agaltsova, it is proposed to use research materials in the educational process of higher education institutions (10). Authors S.V. Veretekhina et al. conduct research to identify effective methods of calculation or economic and technical areas (18,20). Rector of Russian state social university (Moscow) of N.B. Pochinok et al. conduct a socio-economic study of approaches to the study of consumer behavior in the market (11). Development of interactive electronic documentation was carried out by the developer of the technical University by the authors S.V. Veretekhina and V.V. Veretekhin and authors S.V. Melnikov et al. (9,17). The authors of the publication Express their gratitude to the authors K.I. Erusheva, K.Yu. Kolybanov and I.R. Tishaeva, V. Redkous and A. Sergeev, E.A. Sobolev et al., E.V. Vishnevskaya, T.B. Klimova and I.V. Bogomazova, O. Zhdanovich et al. (5,12,13,21,22). The efforts of these scientists formed the basis for further research. To assess the multiplicative effect for the region (Indonesia), the authors recommend the use of evolutionary motors calculations described in the works of the authors of S.V. Veretekhina et al. (19) The collective works of the authors are of practical importance, relevant at the present stage of development of international relations between Russia and Indonesia.

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