Algorithm for the Development and Delivery of a Multi-Item Set of Spare Parts and Maintenance Supplies for Geographically Dispersed Consumers

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Abstract. The algorithm for the best development and delivery of a multi-item set of spare parts (SP) and/or maintenance supplies (MS) from the warehouse of the manufacturer or the central warehouse of the dealer to remote/ geographically dispersed consumers that use a certain type of equipment. The solution to this problem is very important in order to improve the efficiency of the technical operation of machines and equipment used in any business. Market economy conditions require a strong need in spare parts and a new level of monitoring and management of the spare part provision system for machines and equipment. The article concerns the automation of the management decision making process and practical implementation of the algorithm based in the method that takes the form of a set of math models that take into account the sufficient number of factors and establish the right connections between the controlled and non-controlled variables. The controlled and non-controlled parameters have been established, the structure of the algorithm for the implementation of math models allows to form a set of spare parts and choose a proper vehicle for the delivery of the set to the consumer. The multi-item set of spare parts must be flexible, both in terms of its composition and of the number of items on the list, the names of the parts that depend on the specific conditions of the delivery, including the operation conditions and the reliability of the serviced equipment. The establishment of the economically justified parameters for the delivery and stock set of spare parts for geographically distributed consumers should be conducted by the minimization of expenditures on the delivery and development of this analytical expression of the target function and the algorithm for its implementation when it comes to any equipment, including construction, agricultural or forest equipment.

1. Introduction

Due to the imperfect system for provision of spare parts, the expenditures on the technical maintenance of machines, while their share can account for up to one third of the prime cost of the product [1]. The role of deliveries and an emergency fund of spare parts in the organization of technical maintenance and reduction of down time due to the lack of spare parts is considered in the publication [1] and in [2, 3]. The scientific and technical experts are actively studying the issues of developing and functioning of an emergency fund of spare parts accounting for the logistics and the life cycle [4-6]. The organization of rational procurement of spare parts aimed at reducing down time and losses connected to technical maintenance of machines and associated issues are covered in these
publications [7-13] in sufficient detail. Despite the fact that many Russian and foreign authors [14-21] have studied economically justified deliveries of spare parts, the organization of best possible and timely delivery of spare part sets with various contents and quality for remote machines and equipment have not been researched enough. Such deliveries for maintenance materials (MM) have not been studied at all. In terms of economically justified fast deliveries, the automation of managerial decision-making processes plays the central role through the development of mathematical models that describe the real-life cases and relevant algorithms. This will allow to assemble and deliver flexible and not strictly regulated sets of spare parts and maintenance materials, that would be both justified in their contents and the number of elements; they also should be made for an established operation period using economically justified means of delivery.

Solutions to these issues are pertinent in particular in terms of expensive machines manufactured abroad and the corresponding costs of their SP and MS [3].

The goal of the present paper is to develop and test the algorithm for the identification of the best parameters of the fast delivery of flexible lists of spare parts in terms of their number and contents to remote clients under the system of the best possible multiple delivery periods for the purposes of determined and fully met fixed demand.

The research studies the authors’ own ideas as well as scientific publication on technical operation, marketing and management of technical service and provision of spare parts for transport, technological, forestry, agricultural and construction machines.

2. The goal setting and methodological basis for the solution of the issue

The solution to the problem of the best possible deliveries of spare parts (SP) of maintenance supplies (MS) depends on many factors, the main ones are the following: per time unit consumption for every type of SP and MS, their weight (mass), size, cost, and the type of the vehicle by the type of delivery and distance from the consumer that have different number of operated machines and equipment.

Delivery of SP and MS from the central warehouse of the dealer or the manufacturer can be made in two ways:

1. Every shipment of $i$-th materials and elements with specific consumption per unit of time (ten days, a month, a quarter, a year), with specific mass (weight), and size is delivered for a certain period of time as a set by a certain type of transport to operate the specific machine and equipment fleet.

2. The deliveries are made in batches that vary in their contents, mass, size and the price of spare parts, but which have multiple resources (need), and it calls for the availability of transport options; the delivery periods should be adjusted to the contents and number of elements (with different grouping coefficients), any size of machine fleet and any distance to the location of the client. For example, the need for four types of spare parts in a ten-day period is 2; 1; 05; 025 parts per 100 units of equipment. The delivery can made monthly with 8, 4, 2, 1 of every type of elements (e.g. when the grouping coefficient equals four) to operate the machine fleet with 100 machines by an economically justified type of transport.

There is a need for a technical and economical comparison of delivery options and cost efficiency justification for the delivery of SP and MS and sets that are flexible both in terms of their contents and the number of elements different in their technical characteristics.

Let us consider the solution to the problem of the identification of best parameters for the delivery of a multi-component sets of SP and MS for remote machines and equipment through justification and approbation of the algorithm that allows to calculate the best system of multiple delivery periods of SP and MS with a view to fully meet the determined and fixed demand that is partially studied in the following publications [1, 6, 7, 9].

When deliveries are made independently under the Wilson's formula [1], the total expenditures per unit of time ($L$) will equal:
\[
L = \sum_{i=1}^{N} \sqrt{2 \cdot q \cdot (1 + \gamma) \cdot \mu_i \cdot S_i} = \sqrt{2 \cdot q \cdot (1 + \gamma)} \cdot \sum_{i=1}^{N} \sqrt{\mu_i \cdot S_i},
\]

where \(\mu_i\) is the average demand per months for \(i\) - th parts, pcs/month;
\(S_i\) - cost of storage per month, rubles/month
\(N\) - number of SP and MS elements;
\(q\) - delivery cost of SP and MS, rubles;
\(\gamma\) - the coefficient of delivery price growth for SP and MS depending on the number of their delivery.

The delivery cost for a \((q_n)\) shipment "n" of SP and MS from one supplier can be presented with a linear function [5]:

\[
q_n = q \cdot (1 + \gamma \cdot n),
\]

where \(n\) is the number of simultaneously delivered MS and SP, pcs/\(n = \frac{1}{1 \cdots N}\).

Individual SP and MS with similar cost demand are put into groups to be ordered together, and that allows to minimise the gaps between the individual and group best delivery periods. As the delivery periods by groups are multiple, it is possible to ensure the best possible overlapping of the deliveries from the economical point of view [5, 9].

Let there be given: \(K_i\) - the coefficient of dividing SP and \(i\) - th MS into groups in a shipment (number of groups \(K = 1, 2 \cdots\)); \(n_k\) is the number of elements (SP and MS) in the \(K\) - th group.

The company's expenditures on the delivery of spare parts or \(i\) - th MS \((K_i \geq 2)\) per unit of time will amount to:

\[
L_i = \frac{1}{2} \mu_i \cdot S_i \cdot K_i \cdot T \cdot \gamma \cdot \frac{\beta_i \cdot g}{K_i \cdot T},
\]

where \(T\) is the frequency of deliveries per month.
\(\beta_i\) - share of additional expenditures on the delivery of SP and MS depending on the \(j\) - th transport vehicle \((j = 1, j)\).

It is necessary to identify the best possible delivery period \(T\) and distribute all the SP and \(i\) - th MS by groups, so that the expenditures on the parts were minimal.

\[
L = \frac{1}{2} \cdot T \cdot \sum_{i=1}^{N} \mu_i \cdot S_i \cdot K_i + \frac{q \cdot \beta_i}{T} \left( \gamma \cdot \sum_{i=1}^{N} \frac{1}{K_i} + 1 \right) \rightarrow \min. \tag{1}
\]

In order to identify the minimal target function, take two derivatives \(L\) by \(T\) in the grouping constance intervals, e.g. the constance \(K_i\):

\[
\begin{align*}
\frac{dL}{dT} &= \frac{1}{2} \sum_{i=1}^{N} \mu_i \cdot S_i \cdot K_i - \frac{q \cdot \beta_i}{T^2} \left( \gamma \cdot \sum_{i=1}^{N} \frac{1}{K_i} + 1 \right), \\
\frac{d^2L}{dT^2} &= -2 \cdot \frac{q \cdot \beta_i}{T^3} \left( \gamma \cdot \sum_{i=1}^{N} \frac{1}{K_i} + 1 \right). \tag{2}
\end{align*}
\]

Let us find the limits of the groups' stability. When \(T\) is increased, coefficients \(T\) and \(\frac{1}{T}\) in the formula (1) change, when the contents are adjusted as \(i\) - th SP with value \(K_i\) makes a transition to value \(K_i - 1\). The moment of transition is determined in the following way [1]:

\[
T_{R,i} = \frac{2 \cdot q \cdot \beta_i \cdot \gamma}{\mu_i \cdot S_i \cdot K_i (K_i - 1)}, \tag{3}
\]

where \(R\) is the index in the description of the delivery frequency that marks the right limit of the interval.

Function (1) is continuous piecewise convex and has negative spikes of the derivative on the right boundaries of the grouping constance intervals [7].
The best delivery period $T^*$ with constant grouping can be identified by equalling zero to the first derivative $\frac{dL}{dT}$ from the correlation (2).

This period equals:

$$T^* = \frac{2 \cdot q \cdot \beta_i \cdot \left( y \cdot \sum_{i=1}^{N} \frac{1}{K_i} + 1 \right)}{\sum_{i=1}^{N} \mu_i \cdot S_i \cdot K_i}. \quad (4)$$

The best delivery period corresponds to the minimal expenditures per unit of time $L^*$:

$$L^* = 2 \cdot q \cdot \beta_i \left( y \cdot \sum_{i=1}^{N} \frac{1}{K_i} + 1 \right) \cdot \sum_{i=1}^{N} \mu_i \cdot S_i \cdot K_i.$$

To ensure the further transformations, let us identify the numerator and denominator of the subradical expression (4) through $G$ and $H$. Find their increments in the course of the transition of $r$-th SP from $K_r$ to value $(K_r - 1)$, e.g. beyond the first boundary of the interval:

$$\Delta G_r = \frac{2 \cdot \beta_i \cdot y \cdot q}{K_r (K_r - 1)}, \quad \Delta H_r = -\mu_r \cdot S_r,$$

where $R$ is the index in the description of the delivery frequency that marks the right limit of the interval.

Whereby

$$T^* = \sqrt{\frac{G}{H}}; \quad L^* = \sqrt{G \cdot H}. \quad (6, 7)$$

Reduction of total expenditures after such a transition can only be possible under the following condition: $\frac{\Delta G}{G} < \frac{\Delta H}{H}$ or $\frac{\Delta G}{|\Delta H|} < \frac{G}{H}$, that is equivalent to the condition:

$$T_{R,r} < T^*.$$  

Formula (4) shows that value $T_{R,r}$ increases fast, when $K_r$ decreases, whereas $T^*$ grows very slowly. Thus, the fulfillment of condition $T_{R,r} \geq T^*$ for all $i$-th SP and MS means that further growth of $T$ and decreasing $i$-th SP $K_r$ and grouping coefficient, associated with it, is not expedient, as minimum $L^*$ is going to increase.

Similar arguments can also be made for the increasing coefficients $K_r$ when moving along axis $T$ by decreasing the delivery period for SP and MS. The estimated ratio for the left limit of the grouping constancy interval is the following:

$$T_{L,i} = \frac{2 \cdot q \cdot \beta_i \cdot y}{\mu_i \cdot S_i \cdot K_i \cdot (K_i + 1)} \quad (8)$$

where $L$ is the index in the description of the delivery frequency that marks the left limit of the interval.

The general list of controlled and uncontrolled variables of the target function for the best possible spare parts delivery is shown in Table 1.

Control-flow chart for the calculation of delivery periods of multi-product shipment of SP and MS providing for the delivery transport is shown in Figure 1 and 2. Figure 1 shows the control flow chart for the adjustment and control of the delivery vehicle in terms of the size and weight of the SP and MS shipment. Figure 2 shows the control flow chart for the calculation of the delivery of multi-product SP and MS shipments that provides for the calculations starting from the left limits as usually the best value is $T^* < T^0$.  

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Table 1. The general list of controlled and uncontrolled variables of the target function.

| № item number | Variables of the target function | Designation | Dimension |
|----------------|----------------------------------|-------------|-----------|
| 1              | Delivery period for multi-product set of SP and MS | $T^*$ | months |
| 2              | Number of $i$-th SP and MS in the shipment | $n_i$ | pcs. |
| 3              | - share of additional expenditures on the delivery of SP and MS depending on the $j$-th transport vehicle | $\beta_i$ |        |
| 4              | Grouping coefficient for $i$-th SP and MS in the shipment ($K = 1,2$) | $K_i$ |        |

**Controlled variables of the target function**

1. Number of simultaneously delivered SP and MS ($n = \bar{1}, \bar{N}$) | $N$ | pcs. |
2. Delivery cost of SP and MS | $q$ | rubles |
3. The coefficient of delivery price growth for SP and MS depending on the number of their delivery | $\gamma$ | pcs$^{-1}$ |
4. Average demand (need) for $i$-th SP and MS | $\mu_i$ | pcs/month |
5. Storage cost of $i$-th SP and MS | $S_i$ | rubles/mont h |
6. Mass of $i$-th SP or MS | $m_i$ | kg |
7. Physical size of the $i$-th SP or MS (or the package) | $V_i$ | m$^3$ |
8. Capacity limits $j$-th vehicle used for delivery | $M_i$ | kg |
9. Capacity limits of $j$-th vehicle used for delivery | $V_j$ | m$^3$ |

Numerals from 1 to 3 demonstrate the connection between the two algorithms. Dashed lines mark the main calculation control flow charts (in Figure 2) that are numbered and indicate the following:

1. Preparatory and reflecting calculation and ordering $\mu_i \cdot S_i$ and also the identification of the transformation range $K_i$ with the initial grouping and calculation $R_K(T_0)$.
2. Initial grouping of products.
3. Cost minimization associated with the reduction of delivery time $T$.
4. Cost minimization associated with an increase in delivery time $T$.
5. Output element.

The algorithm allows to implement the mathematical model to establish the frequency and size of a multi-product shipments of spare parts and maintenance supplies and to minimize the financial losses associated with the delivery of SP and MS to distant clients, when the consumption and types of various maintenance parts are different in a given period of time.
Figure 1. The selection algorithm for vehicles that deliver multi-product shipments of SP and MS.
Figure 2. Calculation algorithm for the delivery period for multi-product shipment of SP and MS.
It is essential to follow this calculation order in order to implement the algorithm for the establishment of the delivery parameters of a SP and MS multi-product shipment [3].

1. Calculate the initial delivery period with the minimal $\beta_i$ and maximal value $\mu_i \cdot S_l$ $T_0$:

$$T_0 = \sqrt{\frac{2 \cdot q \cdot \beta_i \cdot (1 + \gamma)}{\mu_i \cdot \beta_i}}$$

2. Order the SP and MS items (products) in descending order $\mu_i \cdot S_i$ and renumber them. For the first SP and MS with maximal value $\mu_i \cdot S_i$, $K_1 = K_i = 1$. When values $\mu_i \cdot S_i$ decrease, value $K_i$ will grow by $i$. It is expedient to increase $K_i$ if:

$$\mu_i \cdot S_i \leq 2\beta_i \cdot \gamma \cdot q / T^2 \cdot K \cdot (K + 1) = R(K)$$

Using $T_0$, we get the limit value of cost demand for every integral value $K$:

$$R_K(T_0) = \frac{\gamma \cdot \mu_1 \cdot S_1}{K \cdot (K + 1) \cdot (1 + \gamma)}$$

3. Identify for $i$-th SP item the least $k_i$, that is the best one and that does not violate condition (9).

4. Calculate the initial value $T^*$ and total cost $L^*$ with the help of the following expressions:

$$G = 2 \cdot q \cdot \beta_i \left(\gamma \cdot \sum_{i=1}^{N} \frac{1}{k_i} + 1\right), \quad H = \sum_{i=1}^{N} \mu_i \cdot S_i \cdot k_i,$$

Values $T^*$ and $L^*$ are calculated using the formulas (6, 7).

5. Calculate the right limits of the grouping constancy groupings $T_{R,i}$ using the formula (3).

6. Under condition $T_{R, i} < T^*$, proceed to item 7, otherwise, to item 11.

7. Calculate values $\Delta G_R$ and $\Delta H_R$ using the formulas (5) for all $i$-th SP and MS that do not violate the condition $T_{R, i} < T^*$.

8. Change value $k_i$ to value $k_i - 1$ for all $i$-th products that have $T_{R, i} < T^*$, and calculate the new value $T_{R, i}$ using the formula (3).

9. Calculate the new values of adjustments $G$ and $H$ using the formulas:

$$G_{\text{hob}} = G + \Delta G_R, \quad H_{\text{hob}} = H + \Delta H_R.$$

Calculate $T^*$ and $L^*$ using the formulas (6, 7).

10. Let us consider Item 6.

11. Calculate the right limits for $i$-th SP $T_{L, i}$ grouping constancy interval using the formula (8).

12. If at least one $i$-th SP product meets the condition $T_{L, i} < T^*$, proceed to item 13; otherwise, proceed to item 17.

13. Calculate adjustments $\Delta G_L$ and $\Delta H_L$ for all $i$-th SP products that have $T_{R, i} < T^*$:

$$\Delta G_L = \sum_i \left(- \frac{2 \cdot \beta_i \cdot \gamma \cdot q}{k_i \cdot (k_i + 1)}\right), \quad \Delta H_L = \sum_i \mu_i \cdot S_i.$$ 

14. Change value $k_i$ to value $k_i + 1$ for all $i$-th SP products that have $T_{L, i} < T^*$, and calculate the new value $T_{L, i}$ using the formula (8).

15. Calculate the new values $G$ and $H$:

$$G_{\text{hob}} = G + \Delta G_L, \quad H_{\text{hob}} = H + \Delta H_L.$$ 

Calculate $T^*$ and $L^*$ using the formulas (6, 7).

16. Let us consider Item 12.

17. Establish the size of a shipment of the $i$-th SP and MS product using the expression:

$$n_i = \mu_i \cdot k_i \cdot T^*.$$ 

Approximate $n_i$ upward to an integral value.

18. Check the initially selected $i$-th transport vehicle for its cargo capacity and holding capacity.

$$\sum_{i=1}^{N} m_i \cdot n_i \leq M_j, \quad \sum_{i=1}^{N} V_j \cdot n_i \leq V_j,$$

where $m_i$ is the mass of the $i$-th SP or MS, kg.
**$M_j$** Load bearing Capacity limits of $j$-st vehicle used for delivery, kg.

$V_i$ — physical volume of the $i$st Sp or MS product, m$^3$.

$V_j$ — Capacity limits of $j$-th vehicle used for delivery, m$^3$

19. If at least one of the conditions (10) or (11) is not met, go back to item 1 and select the next value $\beta_j$ in ascending order; otherwise, go to item 20.

20. The result is the latest calculated value $T^*, L^*, \beta_j, k_i, n_i$, that are the final parameters of the delivery.

3. **The algorithm testing and the results of solving the established problems**

We test the algorithm and the mathematical model for the delivery of a multi-product shipment of spare parts and maintenance supplies under the conditions of three extreme situations with the initial data and exploring the influence of the following:

- changing delivery cost (delivery distance);
- changing demand for SP and MS (changing cost of SP and MS);
- changing size and weight of SP and MS.

The bigger the distance between the consumer and the source of SP and MS, the higher the cost of delivery. This is why, in order to reduce financial losses, the delivery interval should increase as well as the size of the shipment for every SP and MS. When the distance is shorter, you will get the reverse result.

Another extreme situation is associated with the changing demand for SP and MS. If the demand significantly increases, the delivery cost for SP and MS grows accordingly. Another case of changing SP and MS delivery costs is connected to the adjusted size and weight of SP and MS being delivered. If the weight and the size of SP and MS being delivered increase, the shipment might not fit into the intended vehicle, or the vehicle might not be able to transport the SP and MS shipment of the given weight. This will result in a need for a bigger vehicle with more load bearing capacity, e.g. in growing costs of delivery of SP and MS.

Let us consider the aforementioned situations in the case of delivering a 10-product shipment of SP and MS to a consumer. Three vehicles can be used for the shipment. The first one has a load bearing capacity of 400 kg and volume capacity of 1.5 m$^3$, while the second one bears 1500 kg with 6 m$^3$ volume capacity, and the third one carries 8000 kg and has the capacity of 25 m$^3$. The delivery cost increase coefficients depending on the selected vehicle equal: the first vehicle - 1.00; the second vehicle 0.85; the third one - 3.5. The cost of the delivery by the first vehicle is $g$=500 rubles. The cost of storing SP and MS at the consumer's is 2.5% of its cost per month. The initial data on every SP and MS product being delivered are shown in Table 2. The results of the calculation of the parameters are shown in Table 3.

### Table 2. The initial data on every SP and MS product being delivered.

| Index of SP and MS | Cost, rubles | Demand pcs/months | Mass, kg | Volume, m$^3$ |
|--------------------|-------------|-------------------|---------|--------------|
| 1                  | 2           | 3                 | 4       | 5            |
| 1                  | 8000        | 0.39              | 1.0     | 0.01         |
| 2                  | 1200        | 4.58              | 2.0     | 0.05         |
| 3                  | 19000       | 10.50             | 6.9     | 0.03         |
| 4                  | 230         | 4.37              | 0.2     | 0.01         |
| 5                  | 11000       | 0.41              | 1.0     | 0.05         |
| 6                  | 900         | 7.55              | 0.8     | 0.09         |
| 7                  | 2400        | 12.50             | 2.0     | 0.012        |
| 8                  | 3500        | 2.00              | 1.0     | 0.02         |
| 9                  | 980         | 2.10              | 3.3     | 0.01         |
| 10                 | 1100        | 2.66              | 1.2     | 0.07         |
Table 3. The results of the calculation of the best delivery parameters for SP and MS to a company depending on changing delivery costs.

| Index of SP and MS | Delivery period, days | Delivery size, pcs | Delivery period, days | Delivery size, pcs | Delivery period, days | Delivery size, pcs |
|--------------------|-----------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|
| 1                  | 2                     | 3                  | 4                     | 5                  | 6                     | 7                  |
| 1                  | 14                    | 1                  | 26                    | 1                  | 37                    | 1                  |
| 2                  | 14                    | 3                  | 26                    | 5                  | 37                    | 6                  |
| 3                  | 7                     | 3                  | 13                    | 5                  | 18                    | 7                  |
| 4                  | 22                    | 4                  | 40                    | 6                  | 56                    | 9                  |
| 5                  | 14                    | 1                  | 26                    | 1                  | 37                    | 1                  |
| 6                  | 14                    | 4                  | 26                    | 7                  | 37                    | 10                 |
| 7                  | 7                     | 3                  | 13                    | 6                  | 18                    | 8                  |
| 8                  | 7                     | 1                  | 13                    | 1                  | 18                    | 2                  |
| 9                  | 14                    | 1                  | 26                    | 2                  | 37                    | 3                  |
| 10                 | 7                     | 1                  | 13                    | 2                  | 18                    | 2                  |
| Costs L∗, rubles per month | 1564.81 | 2814.18 | 4040.34 |

The results of the calculation of the best delivery parameters for SP and MS to a company depending on the demand and changing weight of SP and MS are shown in Table 4.

Table 4. The results of the calculation of the best delivery parameters for SP and MS to a company depending on the demand and changing weight of SP and MS.

| Index of SP and MS | When demand changes | When weight changes |
|--------------------|---------------------|---------------------|
|                    | Demand pcs/months   | Delivery period, days | Delivery size, pcs | Weight kg | Delivery period, days | Delivery size, pcs |
| 1                  | 0.39                | 22                  | 1                    | 1.0       | 39                    | 1                  |
| 2                  | 4.58                | 22                  | 4                    | 2.0       | 19                    | 3                  |
| 3                  | 10.50               | 11                  | 4                    | 6.9       | 19                    | 7                  |
| 4                  | 4.37                | 44                  | 7                    | 0.2       | 58                    | 9                  |
| 5                  | 12.3                | 11                  | 5                    | 1.0       | 39                    | 1                  |
| 6                  | 7.55                | 22                  | 6                    | 0.8       | 19                    | 5                  |
| 7                  | 12.50               | 11                  | 5                    | 90        | 19                    | 9                  |
| 8                  | 2.00                | 22                  | 2                    | 1.0       | 19                    | 2                  |
| 9                  | 2.11                | 33                  | 3                    | 3.3       | 39                    | 3                  |
| 10                 | 2.66                | 11                  | 1                    | 1.2       | 39                    | 4                  |
| Expenditures L∗, rubles per month | 2974.25 | 3827.70 |
| Number of the vehicle | First vehicle | Second vehicle |

4. Conclusions
1. The contents of the controlled and uncontrolled parameters are established, the structure of the mathematical model is developed for the delivery of a multi-product SP and MS shipment, flexible in terms of its contents and number, as compared to "inflexible" joint shipments.
2. On the basis of the justified mathematical model, an algorithm is developed and tested to find the best possible frequency, size and means of delivery of a multi-product SP and MS shipment that is determined by the designated conditions.

3. The presented model and algorithm for its implementation are universal and can be used to organize deliveries of SP and MS to any machines in any industry, for example, for distant clients in forestry or construction industries.

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