MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY

Air Transportation Management Department

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MASTER THESIS
(EXPLANATORY NOTES)

Theme: Method of the forwarding company inventory management automation

Done by: Oleksandra O. Solonska

Supervisor: Dmytro O. Shevchuk, PhD Technical Sciences, Associate professor

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Kyiv 2020

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Кафедра організації авіаційних перевезень

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
_______________________Шевчук Д.О.
«______»____________________2020 р.

ДИПЛОМНА РОБОТА
(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ «МАГІСТР»

Тема: «Метод автоматизації управління матеріальними запасами транспортно-експедиційного підприємства»

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Київ 2020

NATIONAL AVIATION UNIVERSITY

Faculty of Management, Transport and Logistics

Air Transportation Management Department

Major (specialty): 275“Air Transportation Technology”

APPROVED BY
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“______”____________________2020

TASK

of completion the master thesis

Oleksandra O. Solonska

1. Theme of the master thesis entitled “Method of automatization material stocks management of a transport expeditionary company” was approved by a decree of the Rector order № 2026/ст.. from 16.10.2020

2. Term performance of thesis: from 05.10.2020 to 19.12.2020.

3. Initial data required for writing the master thesis: the generalized indicator of advantage is calculated and the method of receiving its values is considered. Thus, the task of finding the optimal reserves of MR is reduced to finding the maximum of this indicator.

4. Content of the explanatory notes: the synthesis of mathematical (analytical) and simulation models of MR inventory management in multilevel FFC - methods of probability theory, inventory management theory and simulation systems; to determine the individual parameters of the model and develop the calculation of the optimal size of stocks - methods of theory of expert estimates; for software implementation of mathematical model of inventory management and calculation of optimal inventory sizes - numerical methods; for analysis and interpretation of modeling results, as well as methods of mathematical statistics; for development of

information model of management of stocks and its program realization - methods of modeling and programming.

5. List of mandatory graphic matters: schemes of preparation, decision-making and implementation in MR inventory management, calculation of the expected economic effect from the introduction of ASM stocks MR typical transport enterprise.

6. Planning calendar

№	Assignment	Deadline for completion	Mark on completion
1.	Collection and processing of statistical data	05.10.2020	done
2.	Writing of the theoretical part	16.10.2020	Done
3.	Writing of the analytical part	26.10.2020	Done
4.	Writing of the design part	16.11.2020	Done
5.	Writing of the introduction and summary	26.11.2020	Done
6.	Execution of the explanatory note, graphic matters and the presentation	02.12.2020	Done

7. Given date of the task: October 05, 2020.

Supervisor of the master thesis: Dmytro O. Shevchuk

Task was accepted for completion: Oleksandra O. Solonska

ABSTRACT

Explanatory note of the thesis: 85 pages; 20 drawings; 3 tables; 29 sources used.

MATERIAL RESOURCES, TRANSPORT AND FORWARDING ENTERPRISE, AUTOMATED WORKPLACE, AUTOMATED MANAGEMENT SYSTEM, INFORMATION

The object of study - the process of functioning of the AMS stocks MR typical transport and forwarding company.

The subject of research is the method of synthesis of AMS by MR stocks of a typical freight forwarding enterprise.

The purpose of the thesis is to reduce the total costs that arise in the operation of multilevel systems, through the creation and use of automated management systems (AMS) of material resources.

Research methods in solving research problems were used: for the synthesis of mathematical (analytical) and simulation models of MR inventory management in multilevel FFC - methods of probability theory, inventory management theory and simulation systems; to determine the individual parameters of the model and develop the calculation of the optimal size of stocks - methods of theory of expert estimates; for software implementation of mathematical model of inventory management and calculation of optimal inventory sizes - numerical methods; for analysis and interpretation of modeling results, as well as methods of mathematical statistics; for development of the information model of management of stocks and its program realization - methods of modeling and programming.

Practical value. The proposed system of AMS MR takes into account the following principles of construction: interactivity, integration, accessibility, flexibility, reliability, manageability, which allows to develop highly effective systems to support management decisions with MR inventories of typical FFC and ensure their optimal value.

Thesis materials are recommended for use in research, in the educational process and in the practical activities of specialists in the organization of transportation and transport management.

CONTENT

LIST OF ABBREVIATION

Workstation - automated workplace;

AMS - automated management system;

FFC - freight forwarding company;

LOSEC - logistics operating system in emergency conditions;

MR - material resources;

ZVI KK - a means of displaying information for collective use;

TG - type group;

VM - actuators;

CC - computer center;

MB - the governing body.

INTRODUCTION

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Head of the Department:	Shevchuk D. O.								

Actuality of theme. Inventories are the most expensive elements of logistics systems (LS), because they are not only "frozen" means, but also require significant costs for their maintenance and replenishment. Therefore, the constant development of logistics systems of a typical transport enterprise, in particular, systems of automated management of material resources (MR), is an urgent task.

Consumer demand is random and non-stationary, because it is not known in advance when and in what typical transport company will need this or that taxation or equipment.

Effective inventory management in real conditions involves the logistics of a large set of various factors, often uncertain in nature. Prompt solution of these complex problems is not always possible, primarily due to the limited psychophysiological capabilities of logistics and the need for real-time decision-making. The way out of this situation is the use of automation in the process of drug inventory management, ie the use of automated inventory management systems of material resources. The development and implementation of automated control systems in the process of inventory management of a typical transport enterprise is an urgent task.

The object of study is the process of functioning of the automated management system (AMS) of MR stocks of a typical freight forwarding enterprise

The subject of research is a method of synthesis of AMS by MR reserves a typical freight forwarding company.

The purpose of the study there is a reduction of the total expenses arising in the course of functioning of multilevel systems, due to creation and use of the automated control systems (AMS) of stocks of material resources.

Research methods. In solving the research problems used: for the synthesis of mathematical (analytical) and simulation models of MR inventory management in multilevel FFC - methods of probability theory, inventory management theory and simulation systems; to determine the individual parameters of the model and develop the calculation of the optimal size of stocks - methods of theory of expert estimates; for software implementation of mathematical model of inventory management and calculation of optimal inventory sizes - numerical methods; for analysis and interpretation of modeling results, as well as methods of mathematical statistics; for development of information model of management of stocks and its program realization - methods of modeling and programming.

Scientific novelty of the obtained results. The method of automation of management of material resources at the transport enterprise that will provide effective management of stocks in the real conditions having casual and nonstationary character is offered.

A mathematical model of logistic decision support systems (DSS) was synthesized, which differs from the existing ones by the following components (user interface subsystem; database management subsystem and model database management subsystem), which will allow to make optimal management decisions on inventory size in real time.

The practical significance of the results. The generalized indicator of advantage is calculated and the method of receiving its values is considered. Thus, the task of finding the optimal reserves of MR is reduced to finding the maximum of this indicator.

The requirements to the AMS to support decision-making at the strategic level of MR inventory management of a typical freight forwarding company are determined and its functional and structural scheme of the system is developed.

1. THEORETICAL PART

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ANALYSIS OF METHODS OF SYNTHESIS OF AUTOMATED MANAGEMENT SYSTEMS OF MATERIAL RESOURCES

1.1. Analysis of existing methods of theory and practice of inventory management of material resources of FFC

Freight forwarding company (FFC) is one of the most important sectors of the country, the efficient and reliable operation of which ensures the constant and reliable operation of the national economy, creates conditions for its growth, increases the level of competitiveness and efficiency of other industries and spheres of production, is the key to improving living standards. [1, 2]. An important component of the transport FFC is air transport, the efficiency of which is closely linked to the general state of the world economy, international trade, its industries, incomes, etc. [5].

The process of providing freight forwarding services by the company is technologically complex and consists of a large number of different inventory operations, which include a certain type of inventory, which depends on which services they are aimed at. In accordance with the type of services are allocated and accounted for specific to each type of operations and processes stocks (Fig. 1.1). Modern concepts of inventory management of FFC are based on the assumption that it is necessary to minimize both individual components of inventories and reduce losses that occur due to inconsistencies in production processes and economic transactions in space and time.[5, 6].

With information on the structure, volume and dynamics of inventories, the management of a typical FFC is able to control and track inventories for services, respectively, will be more efficient use of resources [5, 6].

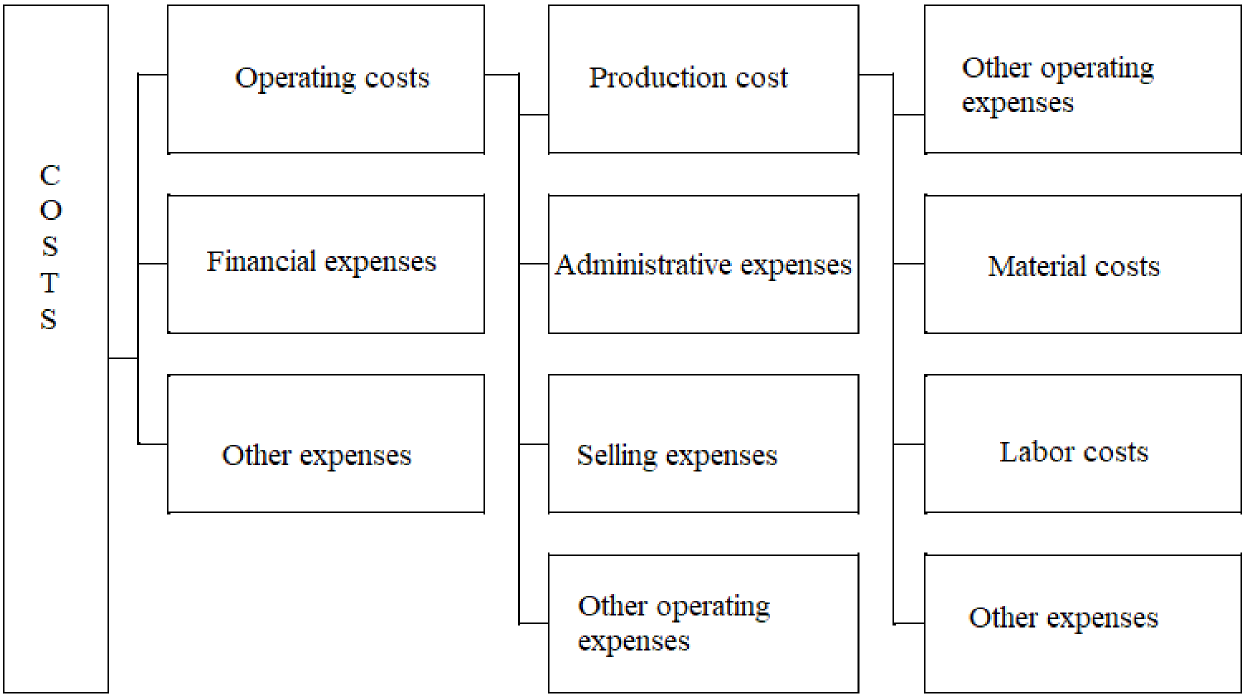

Fig. 1.1. The structure of inventories of FFC [5]

The level of compliance of these factors with the requirements of the market, both legislation and consumers of airport services, depends on the level of funding for the work, ie the level of inventories to ensure the organization and provision of services [5, 7].

Thus, in modern conditions of operation of transport enterprises, stocks are an important aspect of their competitiveness, efficiency of the service delivery process, economic stability and profitability. The main condition for the survival of domestic transport enterprises, especially regional ones, and the possibility of future development, is the way to reduce inventories and maintain them at the optimal level.[2, 5, 6].

That is, the main tool for improving FFC quality of its activities, increase profitability and achieve high economic results is the effective management of logistics inventories FFC [5].

The inventory management system of FFC is a target, multilevel system, where the object of management are the inventories of the enterprise, and the subject of inventory management of FFC - the control system that must be automated [5].

For a typical FFC inventory management is to provide the necessary resources for its current activities and maintain the continuity of its implementation [5, 8].

In terms of the peculiarities of transport companies, inventory management FFC can be represented as a process of accounting, planning, analysis and control of inventories by place of origin, types and carriers, in order to make management decisions to optimize their level and composition, increase efficiency resources and capital, increase profitability [5, 8].

The main parameters of inventory management FFC are [5, 8]:

1) Object of management - a set of inventories as a key element of a typical FFC, which reflects its effectiveness and efficiency for a certain period.

2) The subject of management - an individual (manager, logistician) or collective (specialists of the unit) entity that performs a certain function in the process of managing inventories of FFC and has specific features for its implementation.

3) The basic principle of management - inclusion in the system of typical FFC. This means that the management of inventories of FFC will be in the full sense, provided that it, on the one hand, will have the characteristics of any activity of a typical FFC, on the other hand, is a mandatory element of FFC activities and automated FFC management organizational structure , in the absence of which this structure will not be able to fulfill its purpose.

4) The main criterion is the focus on achieving efficiency and taking into account the factors of this efficiency, as a consequence, the transition from traditional approaches (accounting, marketing, design, etc.), the main purpose of which is minimization of inventories, to new approaches (process, responsibility centers). etc.), aimed at optimizing inventories and to the greatest extent corresponding to the main characteristics of the typical FFC.

FFC inventory management includes [1, 2, 5, 8]:

- awareness of the fact of where, when and to what extent the resources of a typical FFC are spent;

- understanding the patterns of behavior of different types of inventories; forecasting the exact location, time and required amount of additional resources;

- the ability to provide a constant maximum level of return on resources involved in the activities of a typical FFC;

-search and use of reserves to reduce inventories and costs in general;

- creation of conditions for successful functioning of the automated FFC of management of activity of the transport and forwarding enterprise which should have orientation on constant control of material stocks and search of ways of their effective decrease;

- emphasis on the prevention of inventories, rather than their accounting; inclusion in the advanced automated FFC inventory management.

The main purpose of FFC inventory management is to solve the following specific tasks [5, 9]:

- determining the role of FFC inventory management in the process of improving economic performance; identification of inventories for basic management functions;

- calculation and analysis of inventories for individual units that are directly involved in the process of providing services and the standard FFC as a whole; calculation of mandatory inventories per unit of services of a standard FFC, which in itself will lead to a holistic calculation of the cost of services;

- creation of an information base that allows you to choose the most effective business decision, and assess the degree of need for inventories in making these decisions;

- finding technical methods of measuring and controlling inventories; identification of reserves for the reduction of inventories at each stage of the service process and in all structural units of the standard FFC;

- the choice of methods of rationing of inventories; selection of automated FFC inventory management, which best suits the conditions of its operation.

Thus, transport companies play an important role in the functioning of the aviation industry and contribute to the needs of the population and industries in air transport. In turn, the cost of services of transport companies directly depends on the size of their inventories. Thus, the volume of traffic is directly dependent on their cost, which is affected by the stocks of transport companies[5, 10].

In this regard, priority is given to transport enterprises measures aimed at effective management of inventories of FFC in order to reduce the cost of airport services, which will reduce the cost of air transportation, revive demand for industry services, increase profitability and profitability of domestic transport enterprises [5, 9].

The peculiarity of inventory management FFC is the need for an integrated approach to it, which should consist of: interconnected implementation of all functions of inventory management of the enterprise (planning, accounting, control, analysis and management decisions), implementation of inventory management at all stages of life cycle of services, the creation of a single information base for the implementation of an integrated approach to inventory management of the enterprise [5, 9].

Let's analyze the characteristics of FFC. In the process of FFC operation, the input material flow from suppliers of material resources (MR) enters its input, then distributed between its structural levels, forms an internal material flow, which then turns into an output material flow coming to consumers. Thus, the material flow in the FFC is the material resources moved between its various elements. The material flow of material resources is characterized, as a rule, by intensity, rhythmicity, determinism [1 - 3].

Within the FFC, in addition to material, there are also circulating information flows that arise in the process of managing the processes of providing consumers with MR. The main target function of FFC is to provide consumers with MR. Its implementation also implies the implementation of such logistical functions as the maintenance of stocks and delivery of MR [4, 5]. The main characteristic of FFC is the quality of its operation. To assess the quality of FFC operation, it is necessary to determine the criteria for the effectiveness of its operation as a complex system [5].

The criterion of the effectiveness of a complex system is usually understood as its characteristic that reflects the degree of its adaptation to the solution of its tasks or the degree of achievement of their, in this case logistical, goals.

The completeness and clarity of the description of the purpose of functioning of the difficult system, the list of the tasks solved by it is rather essential. If the goals of the system are defined, you can ask questions about assessing the quality of its operation [5]. Based on the fact that the purpose of the FFC is the timely and complete provision of consumers of MR, it is possible to formulate efficiency criteria (with known restrictions on the cost of the system itself). A common, and perhaps the only requirement for the provision process, in accordance with existing guidelines and regulations, is the requirement to comply with its timeliness and completeness. At the same time, a number of well-known scientists in the field of research of material support processes at one time noted the need to take into account economic and other factors in the process of material management [6].

According to the established order of functioning of FFC the principle of creation of the maintenance of stocks of MR is put in a basis of its organization [3]. In other words, MR stocks must fully meet the need that arises during the planning period. In turn, the delivery of MR - as another function of FFC, is carried out precisely in order to create stocks, filling their costs for the next planning period to the previous result. Thus, the process of providing MR consists in constant, with the established periodicity (month, quarter), creation (filling of their expense) of MR stocks for what function of delivery is carried out, that is for what material streams in FFC circulate. This conclusion emphasizes the central role of stocks in this process in relation to logistics systems.

The efficiency of a particular FFC depends on the choice of one or another size of MR stocks. Accordingly, in order for the efficiency of FFC operation to be constantly maximum, it is necessary that the MR reserves have a constant optimal size [7 - 9]. To confirm this opinion, it is necessary to cite the statement of

Glushko IM: “It is necessary that the stocks of material resources were optimal in size. Thus under optimum stocks of material means we will understand such their sizes (volume) which provide material needs of all consumers in the established term according to the developed plan at the minimum cost of their creation, storage and transportation "[6].

As mentioned above, the size of MR stocks is not the only factor that affects the timeliness and completeness of MR provision and total costs [6]. However, stocks are the mechanism by which the authorities can regulate (maximize) the efficiency of the FFC, given the parameters of the external and internal environment, including the need for MR. In fact, they are created for this purpose. The impact on the efficiency of the inventory supply process in the modern economy (logistics) is called inventory management. Study of inventory management processes, optimization of their size, etc. is the subject of inventory management theory [3 - 6].

The issue of practical application of inventory management theory in logistics processes today is a subject area of logistics and is sometimes called inventory logistics [10] or warehousing logistics [11]. Inventory management and automation are important cyber and economic issues. According to some experts, the use of logistics methods makes it possible to reduce the level of stocks by 30 - 50% and reduce the duration of delivery of material resources by 25 - 40% [11].

The logistical approach to inventory management (inventory logistics) is to optimize their level, increase availability and maximum readiness for consumption. Inventory management involves the following actions:

- determination of the optimal structure and size of stocks;
- determination of optimal terms and sizes of replenishment of stocks;
- determination of optimal stocks of stocks;
- determination of optimal routes of replenishment of stocks;

The set of rules by which these decisions are made is called a system or strategy of inventory management (warehousing logistics system). Thus, the inventory management system is a central link in the inventory management process, because according to it, the main stage of any management process - decision making [9].

The inventory management system is designed to continuously provide consumers with material resources. For the situation when there are no deviations from the planned indicators and stocks are consumed evenly, in the theory of stock management developed two main systems - periodic with critical levels [12].

Issues of decision support at all stages of the inventory management process (targeting, development and decision-making, organization of implementation and control) are becoming increasingly important (Fig. 1.1).

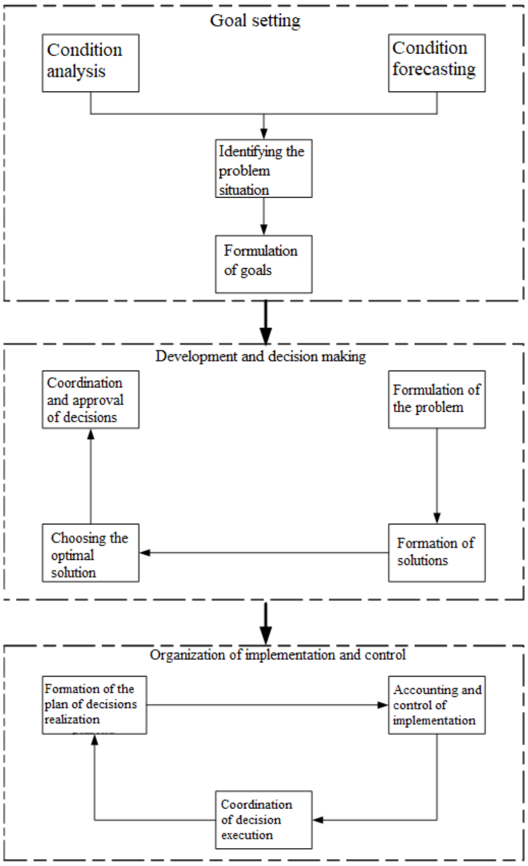

Fig. 1.1. Scheme of preparation, decision-making and implementation in MR inventory management

In fact, the problem is to automate the creative part of the work of the responsible group of employees of the organizational management of the freight forwarding company - managers of all ranks and decision makers, under the real conditions of their activities (logisticians).

Problems of decision-making in the management of material resources of FFC are mostly unique and non-standard, but they have the following general features in their situational basis: uniqueness of the situation of choice; difficult to assess the nature of the alternatives under consideration; insufficient certainty of the consequences of actions (uncertainty of aftereffects); the presence of a set of heterogeneous factors that must be taken into account when making decisions; the presence of a person or group of persons responsible for decision-making.

Logisticians act in the interests of the organization (FFC) and its co-owners (airlines). They allocate resources and negotiate agreements. They analyze the level of productivity and the corresponding deviations from the plans for the supply of material resources of FFC. The work of logisticians is assessed by their ability to make effective decisions. The effectiveness of business decisions is appreciated by many co-owners, but especially by logisticians within the management hierarchy and shareholders.

In order to create an effective ACS MR, it is necessary to refine the general understanding of the business decision-making process, in particular, to have unambiguous answers to the following questions:

- What sFFCs do logisticians take when developing and making specific decisions?

- when does the process of creating and making a decision begin and end?

- how to identify those who are involved in creating a specific solution (decision makers, responsible executors, problem owners)?

Designers of ACS MR also need to ask themselves these questions and answer them. The design of ACS MR should begin with an understanding of the existing process of development and decision-making in organizational management, ie with the clarification of the essence of management decisions.

In periodic systems, the order is made in each period T, and in systems with critical levels - when the current stock is reduced to the order threshold $\hat{y}$ or below. The simplest inventory management systems differ in the method of determining the volume of the order: the order either has a constant volume q, or brings to the maximum level $\hat{Y}$. Thus, each of the four simplest systems is characterized by two parameters: (T, q), (T, $\hat{Y}$), ($\hat{y}$, q), ($\hat{y}$,$\hat{Y}$) [12].

For more complex situations, only some data on the structure of optimal systems are known, and algorithms for calculating the parameters of the latter are usually absent. In such cases, the cost of developing and implementing algorithms for strictly optimal inventory management may be in comparison with the savings achieved in fines and storage costs and even exceed it. For this reason, suboptimal systems of the simplest class are widely used in inventory management in complex logistics systems [12].

Qualitative features of the operation of the above inventory management systems are obvious. The system with periodic replenishment and q = const does not contain a feedback element, and the process is uncontrollable. Such a system - type (T, q) - meets the regulatory supply and can be used in conditions of stable, determined demand. It is natural to assume that the occurrence of any random disturbances in logistics systems, where a similar inventory management system is implemented, will negatively affect the efficiency of the entire system [13].

Periodic table with upper boundary level (T, $\hat{Y}$) is more flexible and responds very quickly to changes in demand. Its disadvantage is a slight increase in the average level of stock and excessive sensitivity to demand [13].

Systems with periodic replenishment have a common drawback - unregulated frequency of orders. This causes unnecessary transport and organizational costs after periods of low demand and increases the average failure at high demand. On the other hand, their advantage is the coincidence of moments of control of the level of current stocks and orders. In addition, systems of periodic type with the possibility of combining orders for several nomenclatures allow you to organize deliveries on a system of multiple periods and thus achieve a reduction in the cost of orders for all nomenclatures together. The usual scope of these inventory management systems is logistics systems with random, non-stationary demand with a high cost of fines at relatively low inventory storage costs.

Critical level system ($\hat{y}$, q) responds to demand more slowly than the system (T, $\hat{Y}$), because the demand from the moment of the last delivery to reach a critical level accumulates without causing a reaction of the system. This reaction itself is not subtle enough and with the temporary stabilization of demand at a normally high level leads to frequent shortcomings. Systems of this class are usually used in FFC with random, stationary demand and high cost of fines at relatively higher costs of storage.

"Two levels" system ($\hat{y}$,$\hat{Y}$) is the most flexible in terms of demand and allows you to maintain the relative stability of the stock near the critical level with a fairly liquid supply. In practical use, it is more difficult than ($\hat{y}$, q). The combined particle combines systems ($\hat{y}$,$\hat{Y}$) is a model from $\hat{Y} - \hat{y} = 1$ (at discrete demand). Here the order is made upon receipt of each next request. The advantage of this system is the low probability of both the accumulation of excess stocks and the emergence of deficits. The disadvantage is the management process, which is difficult to implement in practice, the need for constant control of the level of current stocks and the calculation of the moments and sizes of the order [14]. As a rule, this version of the system is typical of logistics systems for the supply of expensive material resources with random, non-stationary demand with a high cost of fines and high storage costs. However, the recent widespread use of automation tools and the emergence of computer logistics based on them, significantly reduces these shortcomings of this system, and make it possible to implement it in any logistics system. So,

From the preliminary analysis it became clear that the main characteristics of the logistics system that determine the choice of a particular inventory management system are the nature of the need, the nature of delivery, as well as the cost of delivery, storage, and deficit (penalties). These characteristics are not primary in nature, but depend on a group of external factors that, acting together or separately, determine the state of these parameters.

1.2. Analysis of external factors that show the impact on the quality of operation of the freight forwarding company

Logistics [5, 9]- is the management of enterprise flows in the process of its operation, namely: production, raw materials, distribution of products, works and services, both within the enterprise and with the external environment (suppliers, consumers, intermediaries). The functions of logistics include the formation of flows and their flow, production, assembly, packaging, transportation, warehousing, provision, marketing and consumption of manufactured products, works and services. It is traditionally believed that logistics is the production infrastructure of the economy and aims to ensure the promotion of a particular product, work or service. The logistics system of the enterprise consists of a number of elements that can be divided into such sub-FFC as the supply process, production process, warehousing process, transportation process and sales process[2, 4, 5, 9].

He proposes to consider logistics as a set of processes that ensure the functioning of the enterprise. Therefore, it is inherent in the consideration of logistics as the sum of inventories for the implementation of logistics processes within specific limits of the movement of material flows[5, 9].

It focuses on processes such as transportation, warehousing and inventory management and does not specify the boundaries of movement. These processes are accompanied by stocks, which are really significant and make up most of the total logistics stocks and in the absence of their clear classification and sources, the calculation results are inaccurate, which leads to a negative impact on the rational management decisions.[5, 10, 11].

So in the works [5, 6, 11], offers to divide logistical stocks into the following categories, namely:

- productive stocks

- stocks related to the financing of works aimed at the formation of consumer value, in order to obtain which the consumer is willing to pay (general inventories, stocks for the organization of sales, stocks for wages, financial stocks);

- stocks to support the logistics business - related stocks, which can not be avoided in the course of economic activity of the enterprise, but which themselves do not create added value (transport stocks, stocks of an organizational nature, stocks to perform control functions);

- stocks for supervision - stocks are aimed at carrying out activities aimed at preventing the occurrence of negative results in the process of customer service (stocks to study the quality of work of contractors and representatives of the enterprise);

- unprofitable stocks - stocks for the performance of functions and works that are not effective (production downtime, elimination of accidents, etc.).

In general, in the works [5, 10, 11], in two large groups can be divided into stocks in the transport system:

1) Inventories associated with the organization of flows within the enterprise - arise as a result of the acquisition of necessary resources, operations in the production process, warehousing, transportation, loading and unloading, etc.

2) Inventories carried out in the process of selling products - arise in the process of delivery of products to the consumer, carrying out loading and unloading operations, insurance of cargo for the period of transportation, formation of necessary stocks, stocks related to freight forwarding functions, administrative stocks, freight fees and other types of inventories [5, 12].

According to the functions of the logistics sector of the enterprise, logistics stocks are classified according to the following areas [5, 10, 12]:

- purchase - the cost of items of purchase, the price of which may depend on discounts; stocks for placing an order for the purchase of material resources; transport stocks and stocks during acceptance of cargoes; stocks for storage of production stocks;

- production - stocks caused by the lack of stocks of work in progress; stocks for ordering the production of missing parts; stocks for storage of parts of work in progress;

- sales - stocks caused by lack of stocks of finished products; stocks for storage of finished products; stocks for ordering.

In addition, the types of logistics inventories can also be determined by such classification features as: the level of value added; according to the system of assignment to the carrier; in connection with the volume of production; by place and forms of origin; by logistics functions; by areas of material flow movement; by source of movement.[5, 13].

It was found that today the main problems of identification of logistics stocks in transport enterprises include [4, 5, 13]:

- traditional FFC accounting do not allocate logistics stocks in separate groups;

- traditional tax accounting does not separate logistics stocks from the general group of inventories;

- the existence of significant differences in the principles of classification of logistics stocks;

- finding logistics inventories outside the control of company management in the management accounting system;

- lack of software with integrated logistics management functions FFC.

In relation to FFC, these external factors reflect the current state of the economic situation. Among the most important are the following:

1. The nature of the tasks performed by consumers determines the activity of secured consumers, which affects the degree of wear of MR, ie the amount of its costs, as well as the cost of delivery, creation and storage (movement) of MR stocks, depreciation of vehicles, etc.

2. Similarly, the nature of the tasks to be solved affects the assessment of the importance of the tasks to be solved by consumers in these conditions, which, in turn, in terms of logistics, affects the cost of the deficit. Of course, in relation to

this FFC, "deficit costs" should be understood not only as direct material or financial costs, but also to reduce the efficiency of consumers.

3. The influence of external factors affects mainly the magnitude of all types of losses in MR in all parts of the logistics chain FFC, ie at all stages of the material flow of MR. Along with the previous one, this factor also affects the cost intensity of MR, ie directly on its deficit.

4. The nature of geoinformation conditions, first of all, affects the timeliness and completeness of the supply of MR consumers, ie the nature of the supply of MR, as well as the cost of creating and storing MR stocks, including depreciation of vehicles.

5. Weather conditions (time of year) determine the nomenclature and weight of the MR unit, which, along with the previous factors, affects the size of the MR demand, as well as the condition of the supply routes and all types of costs.

6. Possibilities of means of storage of stocks of MR (warehouse base) are expressed in quantity, capacity and technical characteristics of rolling stock. This factor affects the amount of storage costs, including the cost of setting up vehicles allocated for the delivery of MR stocks, and also acts as a kind of limitation in calculating the parameters of the stock management system.

7. Capabilities of means of delivery of MR (transport base) are expressed in quantity, capacity and technical characteristics of the vehicles allocated for delivery of MR.

8. The capabilities of MR suppliers are the most important factor that determines the nature of MR supplies, which means the level of security or insecurity (deficit) of MR consumers. The main sources of replenishment of the needs of MR are, first of all, centralized supplies from enterprises that produce items of MR, as well as the resources of the local material (economic) base in the locations of secured consumers.

9. Current prices for MR, JSC, fuel and lubricants are a necessary parameter in determining all types of costs that arise in the process of providing consumers with MR.

10. The established sizes of payment of transport services are necessary at approximate calculation of cost of work of drivers and loading and unloading works which are used at delivery and storage of MR. This factor must also be taken into account when calculating the cost of delivery of MR.

Thus, this group of factors primarily causes the stochastic nature of the needs of MR, which varies significantly depending on the specific conditions of the consumer and economic situation, as well as the high level of all types of costs that arise in the process of providing consumers of MR. In other words, external factors that reflect the conditions of consumption and the economic situation determine the state of the characteristics of FFC. Along with the process of MR inventory management, these factors and characteristics of FFC affect the efficiency of its operation.

1.3. Analysis of research methods for automated inventory management systems

Analysis of existing research methods shows that the main and most promising area of research of complex, including logistics, systems is the method of mathematical modeling [13].

In the modern practice of logistics in the construction of FFC the most widespread methods of computer simulation. The advantages of simulation are well known, it is, first of all - the ability to build an adequate model of the object under study.

An important point in determining the elements of the developing ACS of the inventory management process is the construction of a mathematical model of inventory management. The mathematical formulation of the problem of synthesis of the optimal inventory management system significantly depends on the studied real situation [15]. The system analysis of various FFC allows to carry out decomposition of process of management of stocks and to allocate the following elements of a task of optimum management of stocks:

- structure of the logistics system;

- demand for collateral;

- replenishment of stocks;

- cost functions (prices);

- restrictions;

- adopted inventory management system;

Consider some generalized mathematical models of inventory management in a single-nomenclature logistics system with one warehouse and one consumer [16].

The simplest and most common variant of the deterministic model of inventory management is the case with a constant intensity of demand and supply, as well as a fixed delay in supply, which is described in detail in [17]. The diagram of stock level change is shown in fig. 1.2.

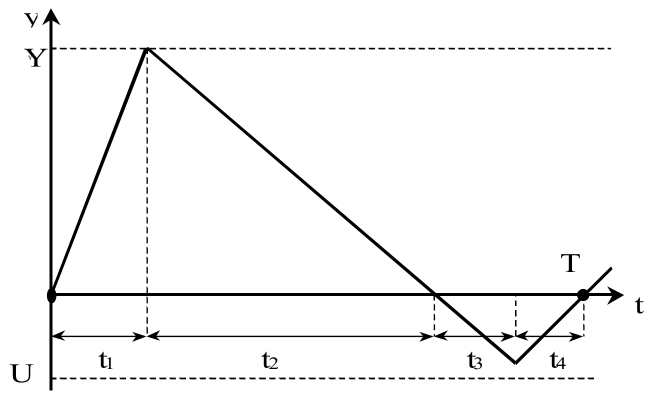

Fig. 1.2. Diagram of changes in the level of stock at deterministic demand

The period of operation of the system has a duration of T. Denote by $\hat{Y}$ marginal stock in the warehouse, and through U the maximum deficit. Assuming storage costs (and penalties) proportional to the average stock (deficit) and the time of their existence, respectively, we obtain for the function of costs for the period:

$$L_T = g + s \int_{0}^{t_1+t_2} y(t)dt + p \int_{t_1+t_2}^{T} y(t)dt,$$

where g is the fixed costs associated with the start of production,

s - the cost of storing a unit of stock,

p - costs from the shortage of a unit of material.

$$\hat{Y}^* = \sqrt{\frac{2\mu g(1-\frac{\mu}{\lambda})}{s(1+\frac{s}{p})}} \quad ; \tag{1.1}$$

$$T^* = \sqrt{\frac{2g(1+\frac{s}{p})}{\mu s(1-\frac{\mu}{\lambda})}} \quad . \tag{1.2}$$

In the case of relatively high fines ($\frac{s}{p} \approx 0$) and high intensity of stock filling ($\frac{\mu}{\lambda} \approx 0$), for optimal $\hat{Y}$ and T, we obtain the known formulas of Wilson (WiFFCon):

$$\hat{Y}^* = \sqrt{\frac{2\mu g}{s}} \; ; \tag{1.3}$$

$$T^* = \sqrt{\frac{2g}{\mu s}} \; ; \tag{1.4}$$

Formulas (1.3), (1.4) in one way or another are given in almost all sources relating in one way or another to the issues of inventory management or inventory logistics (warehouse logistics). The main advantage of inventory management, implemented on the basis of this technique, is the simplicity of parameter calculation $\hat{Y}$ and T. However, it should be noted that the case with such ideal parameters as stationary demand and supply is not typical of the real conditions in which the logistics system operates.

Consider a stochastic model of inventory management [16]. The simplest stochastic, continuous inventory management model is a one-time inventory decision model. In practice, such systems are found in logistics systems with a relatively small need for material resources, as well as in providing consumers in hard-to-reach and remote areas. Since these systems do not take into account the dynamics of demand over time, the model of this type is static [16].

The mathematical expectation of total costs in such a system will be:

$$L_T = s\int_0^{\hat{Y}}(\hat{Y} - x)f(x)dx + p\int_{\hat{Y}}^{\infty}(x - \hat{Y})f(x)dx + c(\hat{Y} - z), \tag{1.5}$$

where x is the random demand for the period T, with the distribution function f (x),

z - stock in the system before the operation (transitional stock),

$\hat{Y}$ - stock after replenishment (current stock),

s - the cost of storing a unit of stock,

p - costs from the shortage of a unit of material,

c - the cost of creating a unit of stock.

From the condition

$$\frac{dL_T}{d\hat{Y}} = s\int_0^{\hat{Y}} f(x)dx + p\int_{\hat{Y}}^{\infty} f(x)dx + c = sF(\hat{Y}) - p\left[1 - F(\hat{Y})\right] + c = 0; \tag{1.6}$$

to find the optimal (minimum cost Lt) $\hat{Y}$ we obtain the equation

$$F(\hat{Y}^*) = \frac{p - c}{p + s}, \tag{1.7}$$

where $F(u)$ - integral function of demand distribution for time T.

The model of the form (1.6) is the most common stochastic model of inventory management and is given in many sources, where this problem is considered [13]. Model (1.7) is well suited for describing inventory management processes in this type of logistics systems. However, it does not take into account the following important points:

- the presence of several levels of warehouses;

- priority of providing consumers;

- losses in material resources during the movement of material flow in the system and during storage of stocks;

- the impossibility of an objective monetary assessment of the costs of the shortage of material resources.

Consider the inventory management model for the case of unsteady demand, described in [61]. This model is not static, because it, in contrast to model (1.6), takes into account the nature of changes in demand during the period T = 1.

The stock level in this model is described by the function:

$$y(t) = x - s(t) + \varepsilon(t), \tag{1.8}$$

where x is the initial stock,

s (t) - demand change function,

$\varepsilon(t)$ is an arbitrary differential function under the conditions:

$$\varepsilon(0) = 0,\ \varepsilon(1) = 0, \tag{1.9}$$

$$\varepsilon'(t) \le s_{\min},\ 0 \le t \le 1. \tag{1.10}$$

Condition (1.9) means that the stock level y (t) varies from x at t = 0 to x – s at t = 1. Condition (1.10) means that the level of stocks in the range from $0 \le t \le 1$ there is a non-increasing function.

Only the following two cases are possible:

1. $s \le x$. In this case, the initial stock x is sufficient to meet the demand of S.

2. $s > x$.. In this case, the initial stock x is not enough and at the end of period T there is a deficit.

Let's mark the moment of occurrence of deficit. Obviously, there is a root equation

$$x - s(\theta) + \varepsilon(\theta) = 0. \tag{1.11}$$

The mathematical expectation of total costs for discrete demand will be

$$\varphi(x) = c_1\left[\sum_{s=s_{\min}}^{x} z_{0,1}(x,s)p(s) + \sum_{s=x+1}^{\infty} z_{0,\theta}(x,s)p(s)\right] - c_2 \sum_{s=x+1}^{\infty} z_{\theta,1}(x,s)p(s),$$

(1.12)

where c_1 - the cost of storing a unit of stock;

c_2 - costs from the deficit of a unit of stock.

$$z_{a,b}(x,s)=\int_a^b [x-s(t)+\varepsilon(t)]dt\,,\ 0\le a,b\le 1\,, \tag{1.13}$$

$$z_{a,b}(x,s)=x(b-a)-s\frac{b^2-a^2}{2}+E_{a,b}\,, \tag{1.14}$$

$$E_{a,b}=\int_a^b \varepsilon(t)dt\,. \tag{1.15}$$

Given (1.11), for the case of uniform consumption of stocks ($\varepsilon(t)\equiv 0$), as well as using formula (1.13), expression (1.12) can be further converted to the following form

$$\varphi(x)=c_1\sum_{s=s_{\min}}^{x}(x-\frac{s}{2})p(s)+\frac{1}{2}\sum_{s=x+1}^{\infty}\frac{1}{s}\left[c_1x^2+c_2(s-x)^2\right]p(s)\,. \tag{1.16}$$

The considered mathematical constructions (1.5), (1.8) - (1.16) are models of stock management with periodic replenishment of stocks (periodic system, T, $\hat{Y}$)). Due to the uncertainty of the moment of stock creation, the use of these systems is unprofitable [17]. Critical level systems are more acceptable in this situation ($\hat{y}$, $\hat{Y}$).

To accurately solve such problems, their analogy with the problems of queuing theory can be useful. In particular, we can consider the maximum stock as the total number of service channels flowing stock - as the number of free channels, the time of delivery of a new batch as the duration of service, the amount of deficit as the length of the queue [18].

If the deficit accumulates and the fine is paid due to the delay in its coverage, the corresponding queuing model will be a system with expectations. When covering the deficit due to urgent supplies, we have to consider the model with failures [18].

This approach is studied in detail in [19,20]. The price of the universality of these models is their cumbersomeness and often the lack of possibility of their analytical study in the modeling of more or less real inventory management processes, due to the loss of visibility.

1.4. Analysis of methods for calculating optimal inventories

In [13] the following method of calculation of optimal stocks of material resources in relation to FFC is given.

Normative stocks of the k-th type of material assets are proposed to be determined by the formula

$Q_{зk} = Q_{пk} + q_{хk} + q_{тk}$,

where Q_{nk} - component of inventories to ensure the consumption of material resources and the creation of non-reducible inventories by the end of the planned period;

q_{xk} ,, q_{mk} - accordingly, additional stocks to replenish losses incurred during transportation and storage.

Growth of values q_{xk} and q_{mk} depends on the probabilities of storage of stocks, respectively, in storage - P_{xk} and in the process of transportation (creation) - P_{mk} . This relationship is described by the following formulas:

$$q_{xk} = \frac{1 - P_{xk}}{P_{xk}} Q_{nk}$$

$$q_{mk} = \frac{1 - P_{mk}}{P_{mk}} Q_{nk}$$

In order for regulatory stocks to have a really optimal size, when calculating them, except q_{xk} ,, q_{mk} and Q_{nk} , the account of expenses for their creation and storage is also necessary. Thus, this problem is a problem of multicriteria (vector) optimization [21]. A clear analytical solution of this class of problems is known to be quite difficult, so to solve it it is possible to use the Pareto optimization method, various modifications of the method of concessions, the method of weighing coefficients [22]. Although this method does not allow to obtain any specific values, however, it is possible to identify the area of optimal solutions, which in turn can provide significant assistance to the researcher.

In [23], the application of relations (1.1), (1.2) is proposed to solve in principle the same problem. The main disadvantage of this technique is that it is designed to study simple, deterministic systems, which obviously can not be attributed to FFC.

The American economist K. Davis made an attempt to organize multi-item support by creating a rational system of inventory management in a large, supplier organization [24].

Thus, the total costs in the system

$$L = \sum_{i=1}^{N} l_i ,$$

where N is the number of nomenclature species in the system,

l_i - the average value of all types of costs per unit time on the i-th nomenclature.

In turn l_i determined by the formula:

$$l_i = g_i \frac{\mu_i}{q_i} + s_i c_i (\hat{y}_i + \bar{y}_i + \frac{1}{2} q_i) + p_i \frac{\bar{y}_i}{\tau_i} ,$$

where g_i - ordering costs,

μ_i - need,

q_i - order size,

s_i - storage costs,

c_i - unit cost of tangible assets,

$\hat{y}_i$ - initial stock,

$\bar{y}_i$ - the average amount of i-th material received on overdue applications,

p_i - the cost of the deficit,

τ_i - harvesting time.

The analysis showed that the existing MR inventory management system, with a constant frequency of deliveries to the maximum level, does not meet the operating conditions of FFC. Its main drawback is the lack of adequate response to random and non-stationary fluctuations in consumer demand for MR. This shortcoming is a consequence of unregulated size of inventories, which in turn reduces the efficiency of FFC (high probability of deficit in the MR), or increase in total costs. At the same time, the emergence in modern logistics of more stringent requirements for efficiency and flexibility of inventory management MR, the complexity of the inventory management process and requirements for its efficiency impose enormous burdens on LPR and for him, due to limited psychophysiological capabilities, the task is difficult to solve. yawning. So,

1.5. Conclusions

1. From the analysis it became clear that the main characteristics of the logistics system that determine the choice of a particular inventory management system are the nature of the need, the nature of delivery, as well as the cost of delivery, storage, and deficit (penalties).

2. The system with periodic replenishment does not contain a feedback element, and the process is uncontrollable. Such a system - meets regulatory supply and can be used in conditions of stable, determined demand. The periodic table is more flexible and responds very quickly to changes in demand. Its disadvantage is a slight increase in the average level of stock and excessive sensitivity to demand.

3. The quality of the logistics system depends on the influence of external factors that have a stochastic nature, which varies significantly depending on the specific conditions of the consumer and economic situation, as well as the level of all costs incurred in providing consumers MR.

4. Effective management of MR stocks in modern conditions is impossible without the widespread introduction of computer technology in this process, ie causes the need to develop ACS stocks of material resources.

2. THEORETICAL PART

Air Transportation Management Department				NAU.20.11.97 002EN					
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DEVELOPMENT OF METHOD OF AUTOMATION OF MANAGEMENT OF MATERIAL RESOURCES AT THE TRANSPORT AND FORWARDING ENTERPRISE

2.1. Distribution of functions in the automated MR inventory management system between the computer system and the dispatcher

The responsibility for the organization of timely and complete material support of MR consumers lies with the logistics department. Any logistics unit organizationally consists of a management body (MB), warehouses with MR stocks and means of delivery.

As a result of functioning of MB of department of logistics of all links of FFC between them there are bilateral information streams - streams of control commands and streams of data on states of the managed object. As a controlled object can act on the one hand a warehouse with reserves of MR, and on the other subordinate MB lower level FFC. Thus, we can distinguish two types of information flows: vertical - between the MB subcontracting levels and horizontal between the MB and warehouses with stocks MR. The set of all MB FFC interdependent with these data flows form, thus, a single subsystem control FFC.

In fig. 2.1 shows a diagram of the organization of the control subsystem in the logistics system. The above description of the functions of conversion of information flows performed by the OP in the process of inventory management MR can be divided into two groups - functions, the implementation of which relies on the logistician (ASM operator) and functions performed by the machine part of the computer system. This distribution of functions is a necessary FFC in the preliminary further development of subsystems that provide ASM stocks MR.

Thus, to solve this set of tasks, the machine part of the ASM stocks MR must contain the following main elements (subsystems):

- automated accounting system of material resources on the basis of a centralized database;
- system of automated workplaces for logistics department staff;

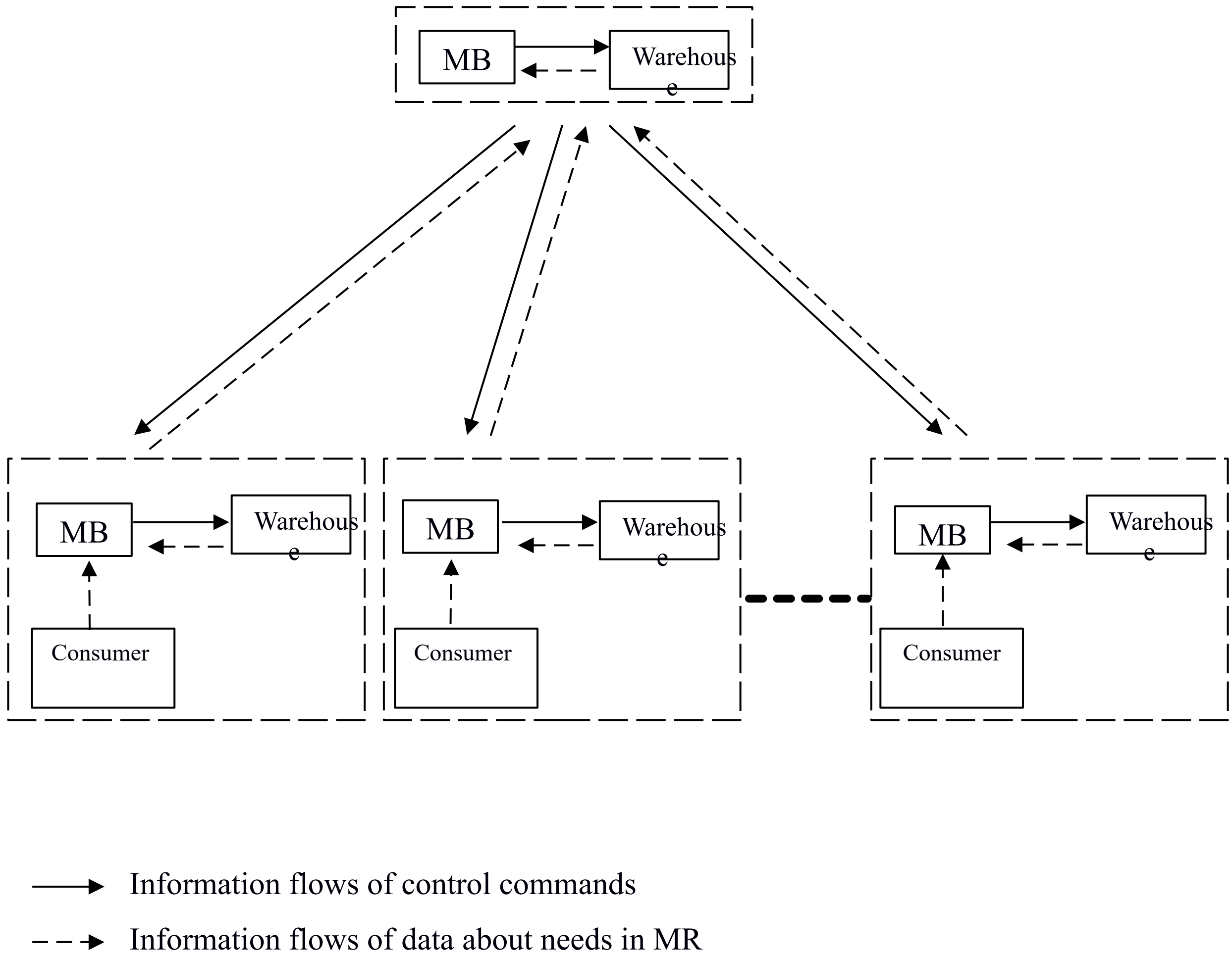

Fig. 2.1. Block Scheme of preparation, decision-making and implementation in MR inventory management

– software based on a set of mathematical (simulation, analytical) models of MR inventory management, demand forecasting and supply, as well as means of their optimization;

– automated information system;

– hardware and software.

Table 2.1

Distribution of functions in ASM by MR stocks in FFC (transport enterprise)

Elements of the inventory management process	Functions performed by the machine part of the system	Functions performed by a person (LPR, logistician)
Multifactorial forecasting of consumer needs and supplier capabilities	Use of a set of prognostic models, formation of the recommendations adapted for the person concerning tendencies of change of needs at consumers and possibilities of suppliers	Collection and input of initial data necessary for forecasting on the computer, analysis of results
Collection and analysis of data on the state of the parameters of the logistics system and the environment of its operation, flowing in the needs of consumers, the state of stocks of MR, their size and location	Estimation of efficiency of functioning of logistic system, at the given parameters proceeding from results of mathematical modeling, formation of recommendations on its increase	Collection and input of initial data necessary for modeling on the computer, the analysis of results
Calculation of optimal stocks, decision-making on the choice of one or another size of the order for replenishment of stocks, terms of submission of applications to suppliers, placement (warehousing) of stocks, etc.	Optimization of a complex of mathematical models, calculation of the optimum sizes of MR stocks and their placement on points of storage (warehouses), formation of applications to suppliers	Analysis of the results and decision-making on the choice of a particular size of the order to replenish stocks based on the personal preferences of the LPR and the results of optimization.
Formation of teams to create stocks of the established sizes or their expense, transfer of orders to executive bodies, submission of applications to suppliers	Preparation of primary accounting documents in electronic form	Execution of the necessary primary accounting documents, transfer of orders to executive bodies, submission of applications to suppliers
Control over the results of execution of the transferred orders	-	Control over the quality of work of executive bodies, exchange of information with suppliers and consumers.

In fig. 2.2 shows a variant of the organization of hardware and software ASM stocks MR.

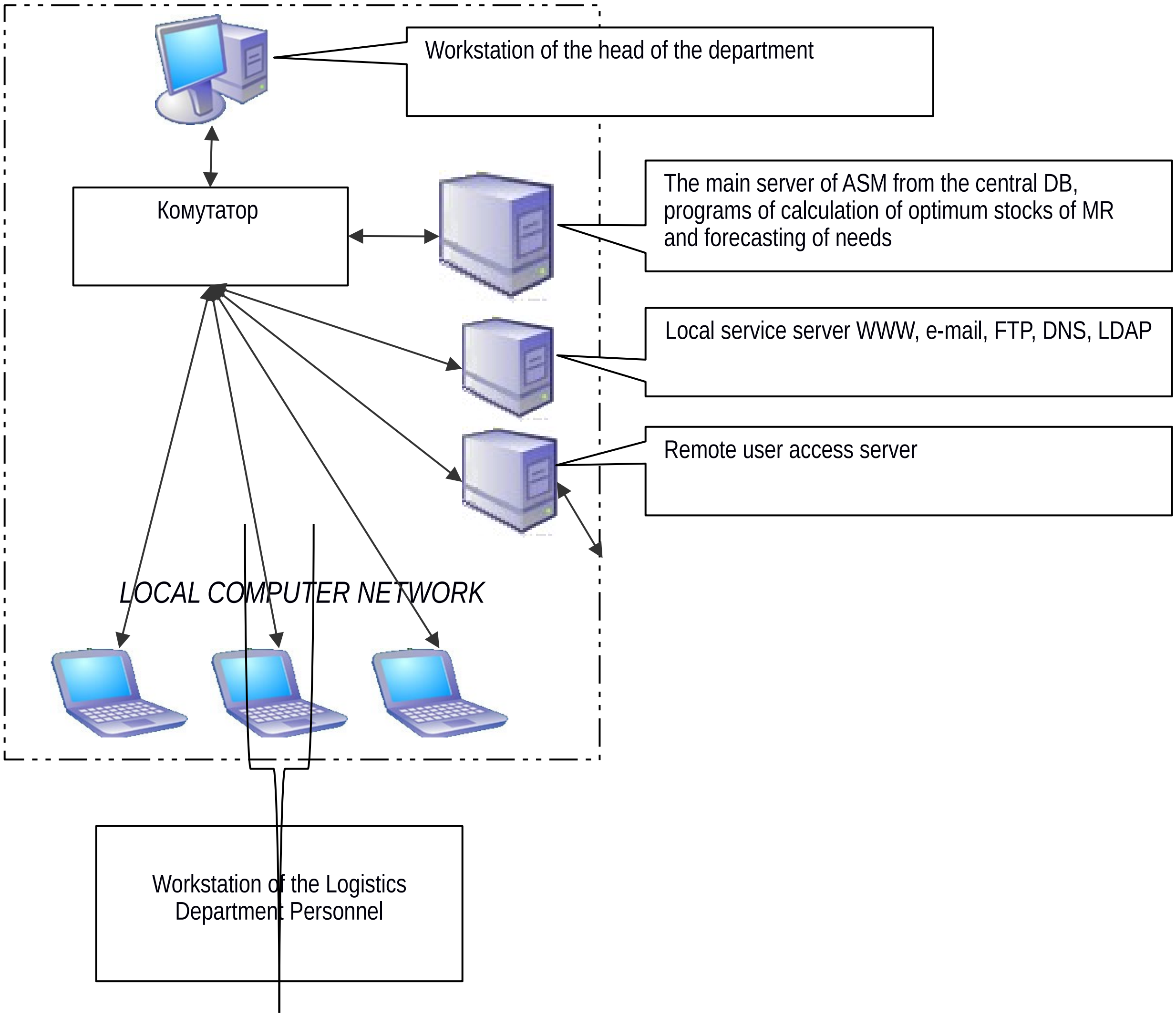

Fig. 2.2. Block diagram of the organization of hardware and software ASM stocks MR

2.2 Development of an information model of an automated MR inventory management system at a transport enterprise

One of the key points in the development of ASM by MR stocks in multilevel FFC is the creation of an information model of the system. [25, 26] At this time, there is no single definition of the concept of information model due to the large range of types of simulated objects and systems. However, based on the analysis of literature sources, the most complete is the following: Information model - a symbolic model that describes the information processes (origin, transmission, transformation and use of information) in systems of various natures. Sign information models are built using different languages (sign systems). The symbolic information model can be presented in the form of the text, the table, the diagram and so on.

However, the most complete tool for information modeling of complex systems of all kinds at this time is the Unified Modeling Language (UML). UML is a graphical language for visualizing, specifying, designing, and documenting systems in which software plays a major role. Undoubtedly, ASM belongs to the class of such systems. As a means of designing software systems, the UML language is designed mainly for the technology of object-oriented modeling. However, the methods used in it to describe the systems are quite universal and as a means of graphical representation of models can be used quite widely.

Let's briefly consider the main components of UML. The UML dictionary consists of three basic concepts: entities, relationships, and diagrams. Entities are abstract, which are the main elements of the model. Relationships connect different entities; diagrams group sets of entities related to a particular subject area.

UML defines four types of entities: structural, behavioral, grouping, and anatomical.

Graphical representations of system models in UML are called diagrams. In terms of the UML language, the following types are defined:

- diagram of use cases or precedents (use case diagram);
- class diagram;
- behavior diagrams;
- statechart diagram;
- activity diagram;
- interaction diagrams;
- sequence diagram;
- collaboration diagram;
- implementation diagrams;
- component diagram;

– deployment diagram.

Each of these diagrams specifies different ideas about system models. In this case, the diagram of use cases represents a conceptual model of the system, which is the source for the construction of all other diagrams. The class diagram is a logical model that reflects the static aspects of the structural construction of the system, and the behavior diagrams, which are also varieties of the logical model, reflect the dynamic aspects of its operation. Implementation diagrams are used to represent the components of the system and relate to its physical model.

Of the above diagrams, some are used to denote two or more subspecies. The following diagrams are used as independent representations: use cases, classes, states, activities, sequences, cooperation, components and deployment.

Central to object-oriented modeling is the development of a logical model of the system in the form of a class diagram. The class diagram is used to represent the static structure of the system model in the terminology of object-oriented programming classes. The class diagram can reflect, in particular, the different relationships between the individual entities of the subject area, such as objects and subsystems, as well as describe their internal structure and types of relationships.

Using UML, consider a class diagram of a logistics system. Taking into account the characteristics of system elements and ASM components, the following class diagram was constructed in UML terms (Fig. 2.3).

The diagram shows the following classes of objects:

– vehicles with subclasses of means of delivery and means of storage;
– logistics flow including classes of material and information flow;
– control commands and data on the state of the information flow;
– governing body, which includes the class of logistics (LPR) and ASM;
– ASM stocks MR including classes of workstations, AIS and databases on the presence of MR in warehouses;
– composition, including classes of storage and stocks of MR;
– consumers;
– operating conditions;

– subordinate authorities in this regard;

– the highest governing body in respect of which it is the object of management.

The analysis of the diagram shows that the following classes of control objects can be distinguished in the system: warehouse with MR stocks, means of delivery and controls of lower levels of FFC. Other relations reflect hereditary and associative ties between FFC classes.

The class diagram reflects the static structure of the system. For the analysis of behavioral characteristics of objects of the considered classes the diagram of variants of use is intended. Use diagrams describe the functional purpose of the system or what the system should do. Chart development has the following goals:

– determine the general boundaries and context of the modeled subject area;

– formulate general requirements for the functional behavior of the designed system;

– develop an initial model of the system for its subsequent detailing in the form of logical and physical models;

– prepare source documentation for the interaction of system developers with its customers and users.

The usage diagram is also called the precedent diagram. The precedent describes a set of sequences, each of which represents the interaction of entities outside the system with the system as such and its key abstractions. Such interactions are in fact system-level functions that are used to visualize, specify, design, and document its desired behavior at the requirements collection and analysis stages. The precedent represents the functional requirements for the system as a whole.

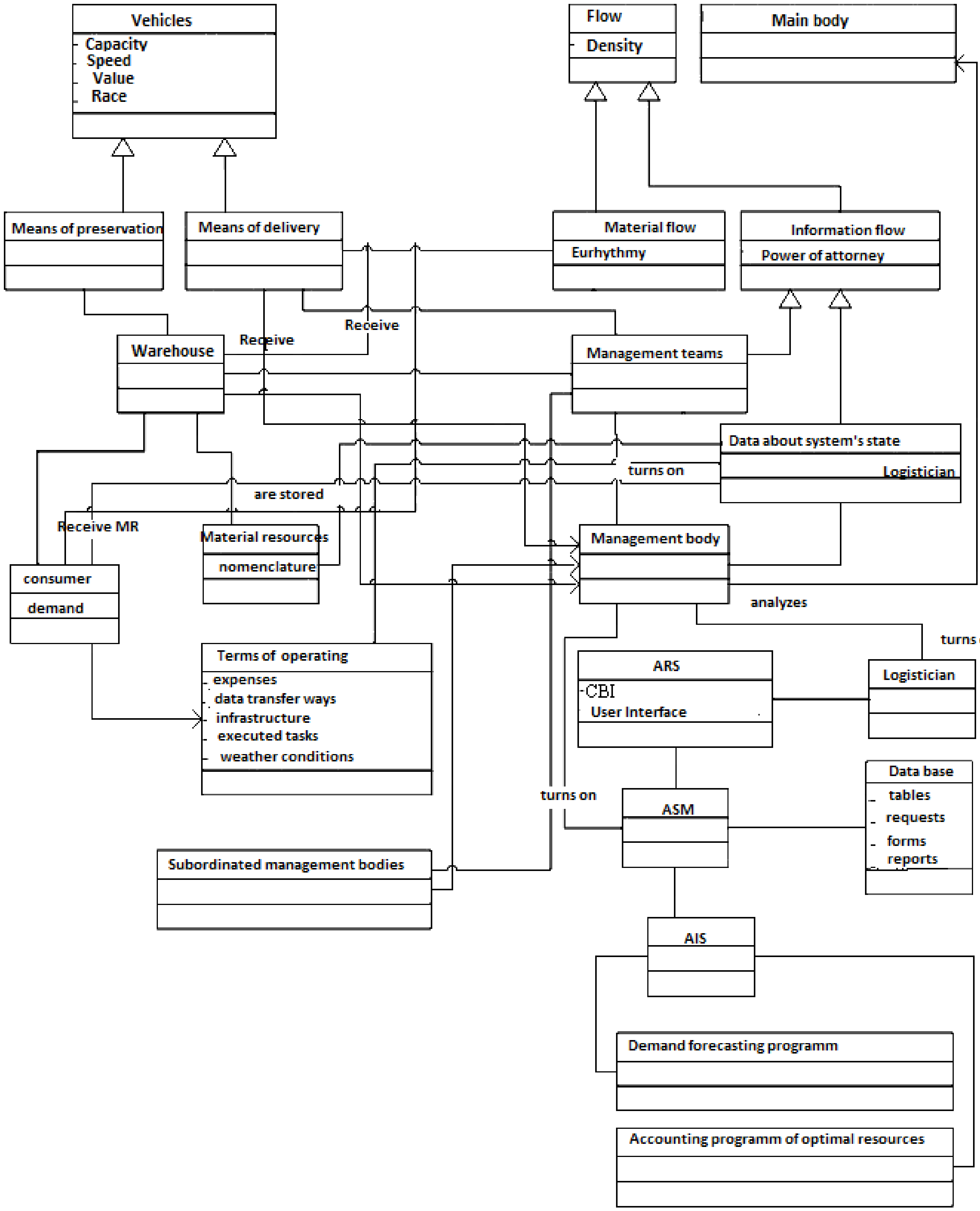

Fig. 2.3. Class diagram of the logistics system, which uses ASM stocks MR

Consider the behavioral properties of the elements of the ASM stocks of MR in the process of managing stocks of MR using a diagram of the use of objects of the previously considered classes on the example (Fig. 2.4).

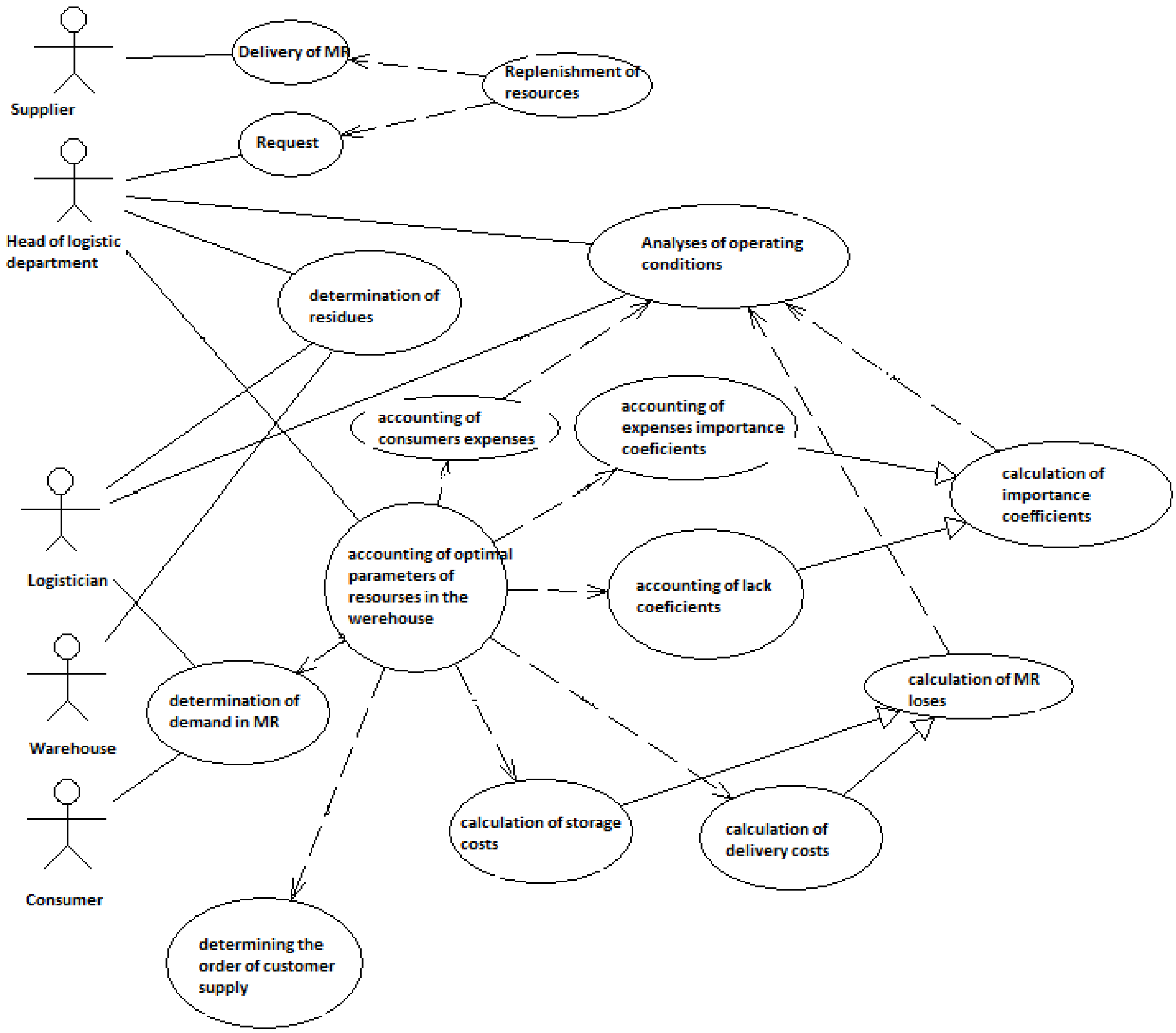

Fig. 2.4. The diagram of possible variants of use of ASM by MR stocks is developed

The diagram clearly shows the variety of functions of the ASM elements by MR stocks and methods of their interaction.

The analysis of the diagram shows that the most responsible function in the process of MR inventory management is to determine their optimal size in all FFC warehouses. It is also seen that the greatest management burden lies on the management of the transport company. From this analysis it is necessary that for effective management of MR stocks in FFC introduction of ASM at the department level is necessary. In turn, the software of such ASM should be based on the program for calculating the optimal reserves of MR.

The diagrams discussed above reflect the static and behavioral aspects of ASM stocks in FFC. The dynamic properties of systems in UML are described using activity diagrams.

Activity diagrams can also be used to simulate the behavior of an object as it moves from one state to another at different points in the control flow. Activity diagrams can be used independently for visualization, specification, design and documentation of dynamics of set of objects, but they are suitable also

The following activity diagram (Fig. 2.5) shows the sequence of operations of the control object in the management of MR stocks. Analysis of this chart allows you to select groups of operations that should be performed in parallel. The diagram also clearly shows the actions performed by the machine part of the system and logistics, as well as their logical relationship.

Thus, the considered models reflect the static structure of classes of objects of TPP and ASM by MR stocks, their functional purpose, and also dynamics of activity of control bodies of TPP taking into account the requirements shown earlier to system.

The study of the process of information exchange in the ASM involves the use of the method of decomposition as part of a systems approach.

The method of decomposition allows to decompose the initial investigated system (in this case ASM stocks of MR) into simpler objects - typical groups of consumers (TG) of the information, as a rule, the same nature (structure), as well as initial system, and, set of these more simple typical consumer groups (objects or systems) should be equivalent to the structure of the initial system.

Although in the general case, the methodology of dividing the initial complex information system into simpler typical groups is based on its graphical representation, the definition of a typical user group, which can later build a model of information exchange in ASM, can be carried out usually only on physical considerations [14].

A typical group (TG) of system consumers is a structure designed to solve certain (in some cases - specific) tasks, built in functional and organizational terms in the form of a multilevel (multilevel) scheme, where management functions are distributed between subcontracting levels. In this case it is

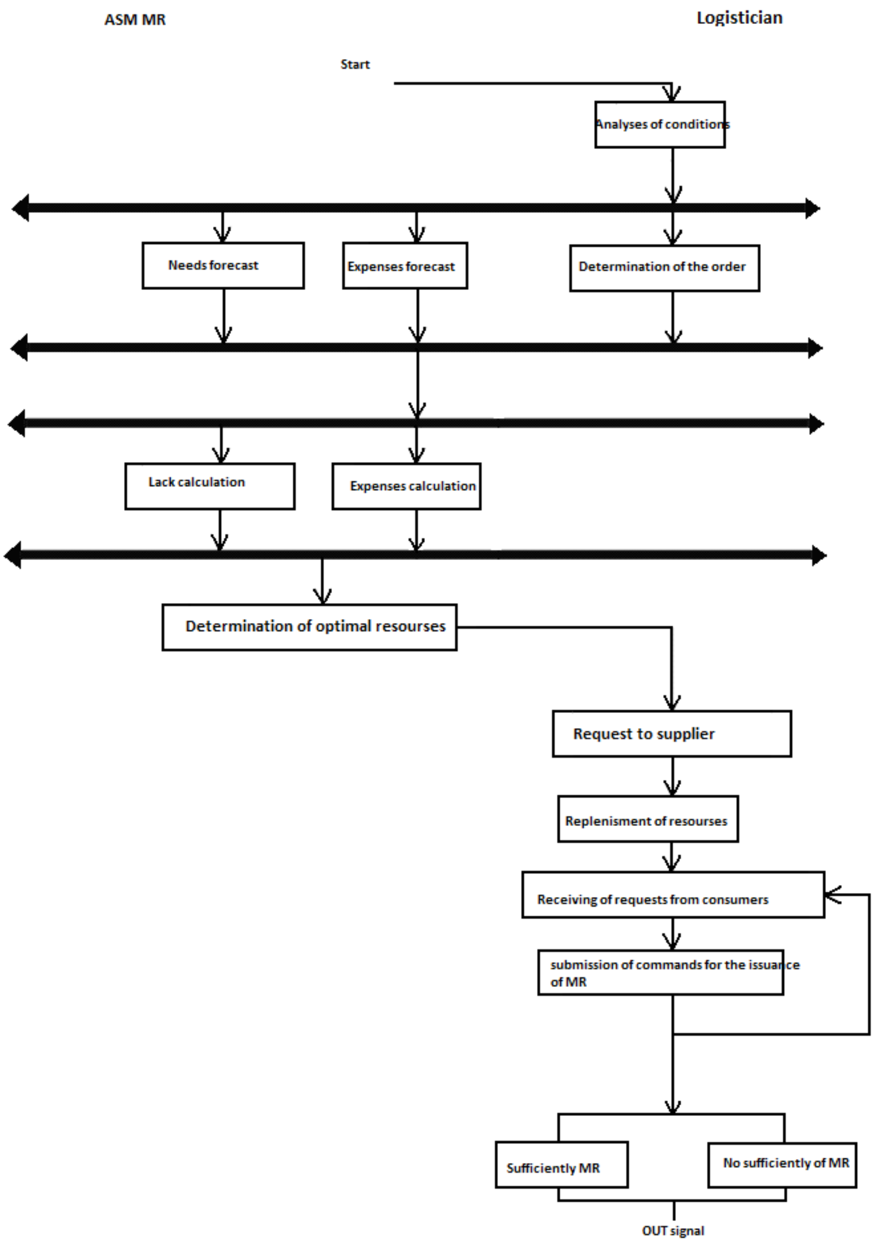

Fig. 2.5. Algorithm for inventory management of MR forwarding company

There may be any group of persons (logisticians) that solves the problem of providing a locally located group of consumers of material resources.

2.3. Model of information exchange in a local typical group of information consumers

The original conceptto build models of information exchange processes in the ASM, there is the concept of a local typical group of consumers, defined in theoretical and plural terms. At this level, a typical group of consumers, as a system with a specific architecture, is determined by the language of set theory: any system S can be represented as the product of components (objects) Ui:

$$S \subset \prod_{i \in N} U_i ,$$

where N is the set of indices (objects) of the studied system;

Ui - components of the product, which are the objects of the studied system S.

Atconstruction of a model of information exchange in a typical group of consumers of main interest are such objects Ui system S as input U1 = Yin and output U2 = Yin information flows. In this case, a typical user group, being an information system S, can be defined by the following relationship [4]:

$$S \subset (Y_{вх} \times Y_{вих}) ; \tag{2.1}$$

here is the plural

$$Y_{вх} = \prod_{i \in N_{вх}} Y_{вх}(i) \, ; \, Y_{вих} = \prod_{i \in N_{вих}} Y_{вих}(i) \tag{2.2}$$

denote information flows, respectively, at the input and output of the system S (typical consumer group), and $N_{вх} \subset N$ and $N_{вих} \subset N$ form a breakdown of the set of indices N, ie $N_{вх} \cap N_{вих} = \varnothing$. Such a system is an input-output system.

As part of the input information flows, it is advisable to provide: information on the state of the external system that provides replenishment of material resources, the state of MR stocks in the middle of the system, information on MR requests from consumers, the state of transport and transport network at the present time, and the state of the climatic and geographical environment, as well as information about the measures taken on current consumer requests.

Output information flows are information about the state of operation of FFC. Representation of a typical group of consumers as a system S, in the form of relation (2.1) is extremely general and fully consistent with the nature of system research aimed at clarifying the organization and information connection of elements (units) of the system, rather than studying any specific mechanisms within this limited reality. Even in conditions of uncertainty, if the system under study can be described only verbally, all verbal statements redefine the relationship of the form (2.1).

To analyze the processes of information exchange in a local typical group of consumers, it is advisable to consider the issues of information interaction of its units (subsystems), the organizational connection of which forms a typical group as a system in general. In this case, it is necessary to introduce the concept of a class of subsystems that are connected (in the information sense), and then on it to define different models of information interaction.

Based on the relationship (2.1), any i-th subsystem Si (subdivision of a typical consumer group) with objects $Y_{вх}(i)$ *i* $Y_{вих}(i)$, which is part of an arbitrary level of TG, is defined as

$$S_i \subset (Y_{вх}(i) \times Y_{вих}(i)), \qquad (2.3)$$

where the objects of the system are the set

$$Y_{вх}(i) = \prod_{j \in N_{вх}(i)} y_{вх}(i,j)\, ;\, Y_{вих}(i) = \prod_{j \in N_{вих}(i)} y_{вих}(i,j) \qquad (2.4)$$

In the general case, some, but not all components of the sets $U_{вх}(i)$, $U_{вих}(i)$, can be used to implement information connections.

If in the set $Y_{вх}(i)$ to allocate subsets $X_{вх}(i)$, the elements of which can serve for the department, the condition

$$y_{вх}(i,j) \in x_{вх}(i) \qquad (2.5)$$

will mean that $x_{вх}(i, j)$ is a component of the Cartesian product $Y_{вх}(i)$, which participates in the information connection with other elements of the system. Then the family of component sets $Y_{вх}(i)$, which do not participate in the compounds, can be determined by the ratio

$$Y^*_{‰›}(i) = \left\{ y^*_{‰›}(i,j) : y^*_{‰›}(i,j) \in \bar{X}_{‰›}(i) \right\} \qquad (2.6)$$

Now the input object of the Si system can be represented as a Cartesian product of two composite components

$$Y_{вих}(i) = Y^*_{вих}(i) \times X_{вих}(i) \qquad (2.7)$$

Similarly, the Cartesian product of the source components that can participate in the connection, determine through $X_{вих}(i)$. Then from this subsystem S_i

$$S_i \subset (Y_{вх}(i) \times Y_{вих}(i)) \qquad (2.8)$$

it is possible to form, generally speaking, many information-interacting systems of a kind

$$S_i(x) \subset (Y^*_{вх}(i) \times X_{вих}(i)) \times (Y^*_{вих}(i) \times X_{вих}(i), \qquad (2.9)$$

which differ from each other in the choice of auxiliary sets $X_{вх}(i)$ й $X_{вих}(i)$ involved in the connection.

In this regard, the class of systems that are connected can be determined by the ratio

$$S(x) \subset \left\{ S_i(x) : S_i(x) \subset (Y^*_{вх}(i) \times X_{вх}(i)) \times (Y^*_{вих}(i) \times X_{вих}(i)) \right\} \qquad (2.10)$$

This ratio allows us to determine the information links between units of the local two-tier logistics system in the ASM. Thus, based on the relationship (2.10), the model of information exchange between the units of S_i and S_{i+1}, which are part of the n-th level of TG users, has the form

$$S_i \subset (Y_{вх}(i) \times X(i)) \times (Y_{вих}(i) \times X(i+1));$$

$$(2.11)$$

$$S_{i+1} \subset (Y_{вх}(i+1) \times X(i+1)) \times (Y_{вих}(i+1) \times X(i)),$$

According to the corresponding relation (2.11) the scheme of information interaction between divisions of arbitrary level n of local TG of consumers is given in fig. 2.7. Here it is necessary to understand that information communication horizontally is "through". Based on the analysis of the relationship (2.11) and the structure in Fig. 2.6, it is possible to present a generalized model of the information exchange process for the category of users united in a local type group. This model has the form shown in Fig. 2.7.

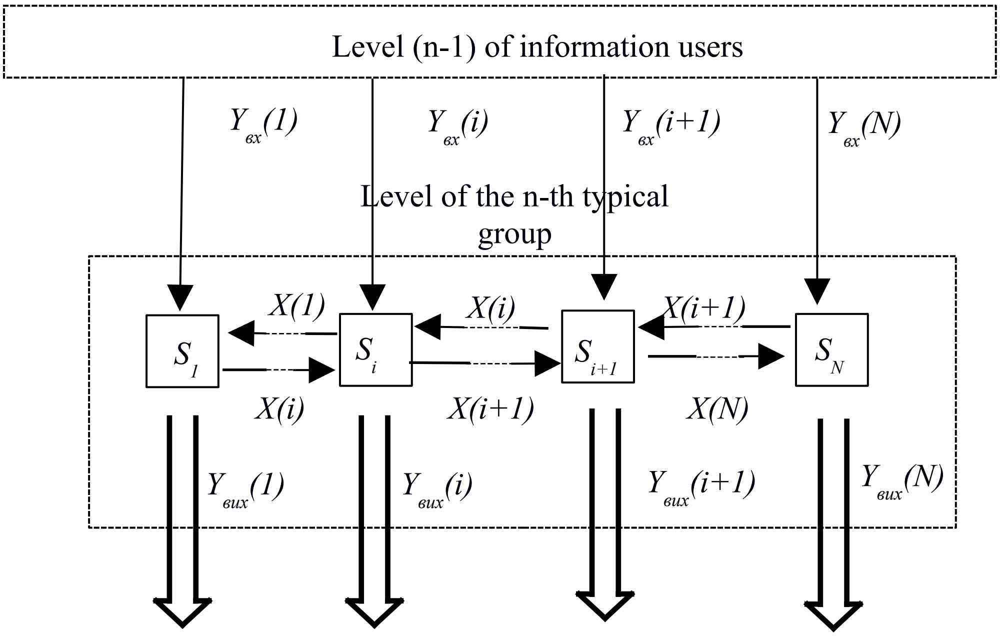

Fig. 2.6. Model of information exchange in TEP

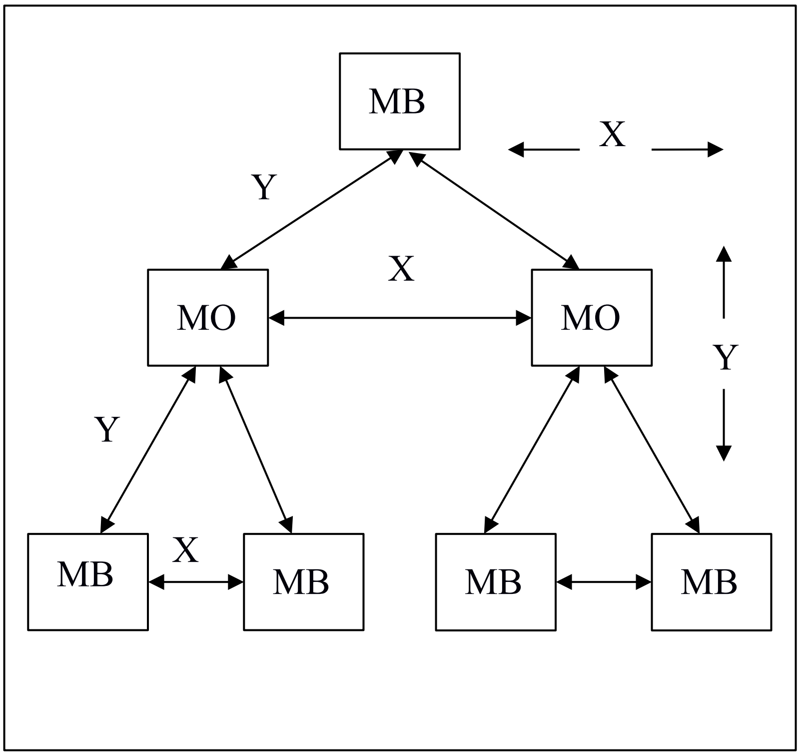

Fig. 2.7. Model of information exchange in a local typical group of information consumers

Here, the symbols X and Y mean information exchange, respectively, horizontally and vertically within the boundaries of a dedicated local two-tier logistics system.

Speakingabout the information exchange horizontally (X) and vertically (Y) between the divisions of the two-level logistics system, the model of which is shown in Fig. 2.7, it is necessary, first of all, to determine the sequence of information transformations in the process of local information interaction between subdivision B and its subordinate subdivision A.

The generalized model of local information interaction between subdivisions A and B along the vertical (Y) in the hierarchy of the two-level logistics system is shown in Fig. 2.8, includes:

- managed object A (final distribution, bodies, warehouses with stocks of material resources);

- control body B, which produces control information (logistics department);

- data sources about the managed object and channels of transmission of this information to the control body;

- communication channels and various technical devices designed to bring control commands to the controlled object.

Let IA be the information about object A that object B needs to make a decision.

Given the technical capabilities of the sources of information used, and the capabilities of data channels (define these capabilities by some function $\overline{\varphi}$,, which determines the ability of these devices with some degree of completeness and probability to transmit I_A in B), the input of the control body will receive information I^*_B, not fully adequate (corresponding) to the value of I_A, ie

$$I^*_{\hat{A}} = \overline{\varphi}(I_{\hat{A}}) \qquad (2.12)$$

After some processing, the information I^*_Y will be issued on the display device at the workplaces of officials of the governing body.

The quality of the display system can be conditionally determined by some display function φ, which describes the conversion of information I^*_Y in I_B, ie:

$$I_{\hat{A}} = \varphi\left(I^*_{\hat{A}}\right) \qquad (2.13)$$

Thus, I_B is a reflection of the information state of the managed object in the control body. Full adequacy of I_A and I_B values is impossible.

The analysis of I_B information leads to the formation of a decision in the governing body on the further behavior of the object A.

The adopted decision with the help of communication channels and other technical devices should translate the controlled object into a new information state $I^{**}_{A.}$. Call the control function F actions on the information of the I_B in the control body, which lead to the receipt of $I^{**}_{A.}$

$$I^{**}_{\hat{A}} = F\left(I_{\hat{A}}\right) \qquad (2.14)$$

Communication channels and technical control devices of object A can transmit (implement) control commands to object A only with a certain degree of completeness and probability (we will define it by function $\overline{F}$). Then the transition to a new information state I^*_A

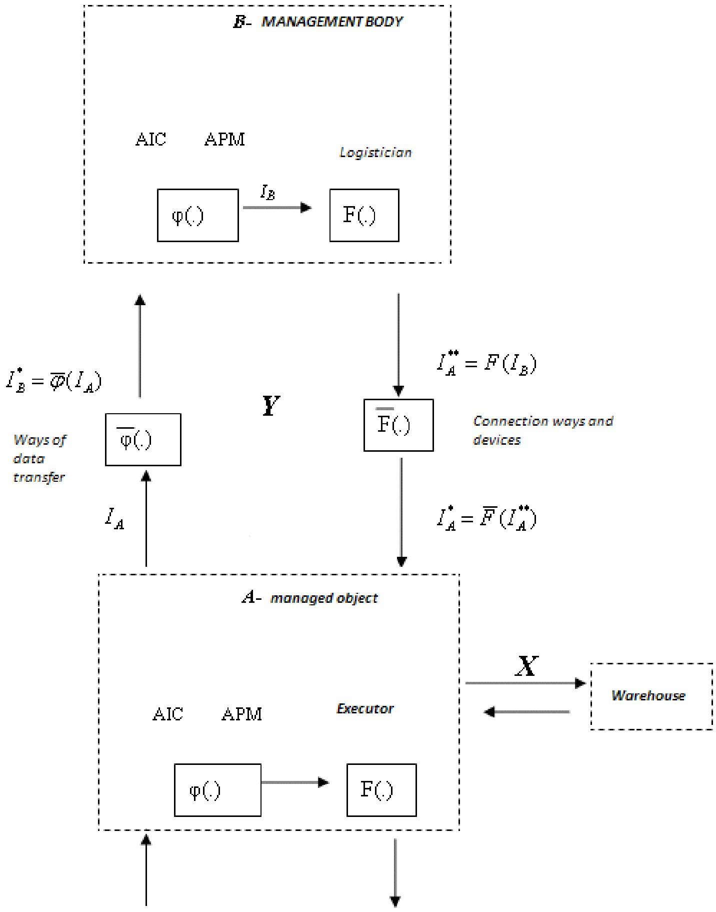

Fig. 2.8. Model of local information interaction of the managed object

$$I^*_A = \overline{F}\left(I^{**}_A\right) \quad (2.15)$$

Expressions (2.12) - (2.15) show that the efficiency of the control system, which can be assessed as the parameters I^*_A approach their optimal values for the accepted conditions of the situation, depends on the perfection of the functions $\overline{\phi}, \phi, \mathrm{F}\ i\ \overline{F}$,, that is, from the perfection of the subsystems of collection and transmission of the situation data, from their reflection in the control body, from the quality of the decision-making process and bringing the control commands to the controlled object. In the local module of information interaction the initial information for work of the subsequent subsystems is formed.

All these subsystems must be considered as complex, because their constituent objects in the general case are complexes of interacting elements of different nature (people, technical means, support processes). This leads to the manufacture and implementation of functions $\bar{\phi}, \phi$, F $i \bar{F}$ carried out by performing a large number of private target functions.

Since the absolute adequacy of I_A and I_B cannot be ensured, they strive to have it at a level sufficient for the needs of practice. This level is considered reached if the completeness of the total I_B information and the time of its display allow to obtain a quantitative justification of the decision, ie to determine the extreme value of $F(I_B)$, not exceeding some time allowed to perform these works in specific conditions. All other things being equal, this is achieved through the use of appropriate methods and means of display, as well as the capabilities of technical and mathematical components of the system involved in the information process.

Automation of even the simplest decision-making processes significantly changes the content of the software and mathematical part of the control system. On the basis of the received information in the computer should be carried out:

- analysis and assessment of the situation;
- modeling (forecasting) of possible directions of development of events;
- selection of the best or appropriate solution;
- coordination of parameters of command information with tasks of all process of planning and management as a whole.

Similarly, using the relations (2.1) - (2.11), it is possible to formalize the processes of interaction of typical user groups with different measures of information integration.

This model reflects the generalized information interaction of several local typical groups of consumers of information, which belong within the specific structure of the transport enterprise.

It should be noted that, if necessary, information exchange can take place, in addition to the upper, and between other levels of each of the typical consumer groups. Information exchange between users in the integration of typical groups of individual FFC is illustrated by a generalized model. Here the coordination of information exchange is carried out at the level of multilevel FFC provides the needs of the freight forwarding company.

2.4 Development of the architecture of the automated system of management of material resources in the transport and forwarding enterprise system for typical groups of consumers of information

The models of information exchange considered above between typical groups of information consumers allow to determine the general architecture of the ASM with MR stocks in logistics systems of higher levels of integration.

Based on the degree of integration of the process of information exchange between consumers of information, we can distinguish the following architecture of ASM FFC and its subsystems:

- ASM stocks MR FFC department;
- ASM stocks MR FFC unit;
- ASM stocks MR FFC transport enterprise.

The elements of the structure are:

- two-level logistics system (department);
- three-level logistics system (subdivision);
- information center;
- node of interaction (higher management body) with other typical groups of consumers of information and networks.

The exchange of information between consumers of information of the typical group takes place horizontally and vertically in accordance with the specific scheme of information exchange, and from any level of the typical group, if necessary, access to the center of exchange of operational information. The operational information exchange center provides access for logisticians of different levels of the typical group to such networks as, for example, public networks, common channel signaling networks, as well as broadband networks for high-speed information transmission and database access. Moreover, access to a network from any level of a typical group, organized in advance, is determined by the specifics of the tasks to be solved by units of this level. In addition, the center can also provide access to networks based on leased lines.

Each of the networks has its own topology and its own connection identification scheme, as a result of which consumers of information connected to each of them must have addresses, access procedures and signaling protocols specific to this network. It is clear that the ASM stocks of material resources in a two-tier logistics system, requires the use of effective means of information exchange between all consumers. For these purposes, there is a network in which the routing of messages, signals, etc. within a typical user group.

The network exchanges service information simultaneously between all consumers of information of a typical group. This information is transmitted in the form of messages, defined in accordance with the structure of the two-tier logistics system, where the procedures and management functions are uniquely defined for any level. The database access network satisfies services for obtaining reference and operational information. This network is organized in such a way that the data stored in it can be accessed in advance by certain levels of consumers of information of the typical group.

The broadband data transmission network provides the staff of the two-tier logistics system with high-speed channels for the exchange of text data, graphics and video information.

The access of users of a typical group to the public network allows to expand the functional, operational and information capabilities of the ASM.

2.5. Conclusions

Based on the analysis, the functions to be performed by the machine part of the automated control system and the operator (logistics) are distributed. Having defined the list of the first it is possible to present the general information model of the automated system of management of stocks of MR.

The analysis showed that at this time the most complete means of describing information systems for various purposes is UML. Using this language of object-oriented modeling of the past diagrams are developed and constructed:

– static structure of classes of elements of ASM and methods of their interaction;

– the variety of functions of the ASM and the operator, as well as their logical relationship;

– dynamics of interaction of ASM with MR stocks and logistics in the process of their joint activity.

On the basis of the analysis of the given diagrams the directions necessary for development of the mathematical and software of ASM by stocks of MR were developed.

The development of the information model also includes the study of existing and projected information flows of the automated control system and the definition of their main characteristics. To this end, first of all, it is necessary to analyze the structure of the managed and control systems and build models of information exchange in the ASM.

3. DESIGN PART

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DEVELOPMENT OF SOFTWARE IMPLEMENTED TOOLS FOR SUPPLY OF STOCKS OF MATERIAL RESOURCES TO THE TRANSPORT AND FORWARDING ENTERPRISE

3.1. Development of a mathematical model of MR inventory management of a typical freight forwarding company

The solution of the task of this study, which consists in the synthesis and justification of adequate mathematical and information support of the developing ASM inventory MR, involves the development of a set of mathematical models of inventory management based on analysis and synthesis of models of information exchange in the automated inventory management system. The initial information in the construction of mathematical models of the functioning of systems are data on the purpose and operating conditions of the studied system, obtained as a result of the effective operation of the automated information system ASM FFC [25].

Each specific system is characterized by a set of properties, which means the values that reflect the behavior of the simulated object (real system) and taking into account the conditions of its operation in interaction with the external environment [25].

The system model can be represented as a set of quantities that describe the process of functioning of a real system and form in the general case the following groups of parameters [26]:

- the set of environmental influences;
- a set of own parameters of the system (parameters of the internal environment);
- set of initial characteristics.

When modeling the system, the parameters of the external environment and the system's own parameters are independent or input variables, and the output characteristics are dependent or output variables of the model. As a rule, the main, initial, characteristic of the system, which reflects the quality of its operation, is the efficiency indicator. Under the efficiency of a complex system is understood as a numerical characteristic of the system that assesses the degree of adaptability of the system to the solution of its tasks. In order for the efficiency indicator to fully characterize the quality of the system, it must take into account all the main features and properties of the system, as well as the conditions of its operation and interaction with the external environment. There are several requirements and conditions that should be followed when choosing an performance indicator:

- the efficiency indicator should characterize not some part of the system, but the system as a whole;

- the efficiency indicator and its dependence on the established factors must provide the possibility of obtaining a quantitative assessment with the required accuracy;

- the area of change of the efficiency indicator should have clearly delineated boundaries [25].

In the study of complex FFC, in order to optimize their parameters, often have to consider not only the value of efficiency, but the cost of the system, which may have different dimensions and physical content, but together characterize the quality of the system.

In relation to logistics systems, as an indicator of the efficiency of the system, taking into account the results of the analysis conducted in the previous section, which combines the largest number of initial characteristics of FFC and reflects the purpose of FFC, you can choose the deficit of MR D_T, which arises in the process of functioning of FFC during the planning period T, and thus reflecting the completeness of the MR. That is, when assessing the integrated characteristics of FFC, which reflects how rational the size of the created stocks, it is not enough to take into account only the efficiency indicator without taking into account the costs incurred in the operation of the system. Therefore, based on the fact that FFC has optimal stocks, if they provide maximum efficiency at minimum cost, an additional initial parameter of the model will be the total cost Q_T on the process of FFC operation during the planning period T.

The size of the deficit that occurs during the planning period T depends, firstly, on the magnitude of the need for MR and, secondly, on the size of the created reserves of MR, designed to meet this need. Because the size of the need value is random, then the size is random and the deficit. Both the demand and the size of stocks in the development model are traditionally measured as a percentage of the number of supplied consumers and therefore are represented by continuous, dimensionless quantities. Important factors influencing the size of the deficit are all sorts of losses that occur during the operation of the system. The losses that affect the operation of the FFC include the following:

11. losses in the process of storage of MR stocks;
12. losses in the process of material flows MR.

Based on the analysis of the features of information interaction in the process of providing with a typical group of consumers (TGC), conducted in paragraph 2.3, determine the optimization criteria and a set of models for managing stocks of material resources in the logistics system.

For the case of one warehouse and one consumer, the mathematical expectation of a deficit is determined by the formula:

$$D_T = \int_{\alpha\beta z}^{\infty} (r - \alpha\beta z) f(r) dr \quad , \tag{3.1}$$

where r is the need for MR during the period T;

$f(r)$ - density distribution of demand during the period T;

z - MR stocks are created to meet the needs of r;

α - the ratio of losses arising in the process of storage of stocks;

β - the coefficient of losses that occur when transporting MR from the warehouse to consumers.

In general, according to FFC, the size of the deficit that occurs in the system consists of the size of deficits that occur in each individual consumer.

Total costs Q_T , arising in the process of operation of FFC, consist of the cost of creating, storing stocks of MR and the cost of moving MR between the elements of the system, the movement of material flows. They, as well as the deficit, depend on the magnitude of the need for MR, on the size of the created reserves of MR and on these types of losses. In addition, the total cost also depends on the cost of creating, storing inventory and transporting the unit of MR.

Thus, for FFC, consisting of n consumers, m warehouses and k unit material flows (material flow is a flow that occurs between two structural elements of the system), the simulated parameters are:

13. system needs - $R_1, R_2, \ldots R_n$ from the density of distribution - $f_1(r_1), f_2(r_2), \ldots f_n(r_n)$;;

14. MR stocks - $z_1, z_2, \ldots z_m$;

15. the cost of the cost of creating a unit of MR - $c_1^{(c)}, c_2^{(c)}, \ldots c_m^{(c)}$;

16. cost of storage costs MR - $c_1^{(x)}, c_2^{(x)}, \ldots c_m^{(x)}$;

17. the cost of transportation of the unit MR - $c_1^{(мп)}, c_2^{(мп)}, \ldots c_k^{(мп)}$;

18. coefficients of losses during storage of stocks in warehouses - $\alpha_1, \alpha_2, \ldots \alpha_m$;

19. coefficients of losses at delivery of MR between levels of system - $\beta_1, \beta_2, \ldots \beta_k$.

Given that the studied FFC has a hierarchical structure, as well as the fact that each structural element of the system has one input material flow, the number of material flows arising in the system during its operation is associated with the number of its structural elements (compositions and consumers) resulting from the ratio

$$k = n + m . \qquad (3.2)$$

Thus, the model of MR inventory management in FFC represents the dependence of deficit indicators and total costs (output parameters of FFC) on the internal parameters of the system and the parameters of the external environment (input parameters).

Next, we construct and consider the properties of MR inventory management models in FFC with the simplest linear and hierarchical structure. In the future, using the studied properties inherent in simple systems, it will be possible to begin to develop models of more complex structures.

Under the linear FFC means a chain of warehouses, each of which subsequently satisfies the requirements of the previous one, and each supplier has one consumer. The rationalization of the linear FFC, to which it is possible to reduce the FFC with a hierarchical structure, can, in particular, give the optimal separation of the total reserves of the sublevel system.

As a linear FFC can also be represented as a logistics chain - a chain of warehouses, including the highest level warehouse, between which the material flows of MR to a single consumer of the system [25]. This fact is all the more important because any FFC of arbitrary structure can be represented as a set of logistics chains, ie linear FFC (subsystems). Examining each subsystem in this way, we examine, in the end, the whole system. This conclusion emphasizes the importance of building a FFC model with a linear structure.

Consider a two-level FFC with a linear structure. The block diagram of the system is presented in Figure 3.1.

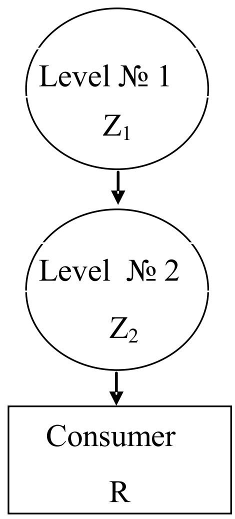

Fig. 3.1. FFC scheme with a linear structure

The consumer will have a deficit in MR when he consumes all the stocks of the system, ie when the demand exceeds the total amount of stocks. Thus, the mathematical expectation of a deficit in the system provided by the consumer is determined by the expression

$$D_T = \int_{\alpha_1\beta_1\beta_2 z_1 + \alpha_2\beta_2 z_2}^{\infty} (r - \alpha_1\beta_1\beta_2 z_1 - \alpha_2\beta_2 z_2) f(r) dr \; . \tag{3.3}$$

where r is the need for the period T;

$f(r)$ - demand density distribution;

z_1, z_2 - MR stocks at system levels, created to meet the needs of r;

α_1, α_2 - coefficients of losses that occur during the storage of stocks at the appropriate levels of the system;

β_1, β_2 - coefficients of losses arising in the process of supply of MR between a given level and a lower (level or consumer).

In determining the costs at each level, the costs of creating and storing stocks, as well as the cost of transporting MR to the lower level of the system were taken into account.

By analogy with the three-level FFC, we can write expressions for the mathematical expectation of deficit and expenditure in the K-level FFC with a linear structure.

Again, enter the notation

$$\mu_i = \alpha_i \prod_{j=i}^{K} \beta_j \; . \tag{3.4}$$

The mathematical expectation of the deficit is determined by the expression:

$$D_T = \int_{\sum_{i=1}^{K} \mu_i z_i}^{\infty} \left(r - \sum_{i=1}^{K} \mu_i z_i \right) f(r) dr. \tag{3.5}$$

The costs at the k-th level of the system are equal to:

$$Q_{Tk} = (c_k^{(c)} + c_k^{(x)}) z_k +$$
$$+ \frac{c_k^{(мn)}}{\prod_{i=k}^{K} \beta_i} \left[\int_{\sum_{i=k+1}^{K} \mu_i z_i}^{\sum_{i=1}^{K} \mu_i z_i} \left(r - \sum_{i=k+1}^{K} \mu_i z_i \right) f(r) dr + \sum_{i=1}^{k} \mu_i z_i \int_{\sum_{i=1}^{K} \mu_i z_i}^{\infty} f(r) dr \right], \tag{3.6}$$

then the costs throughout the system as a whole naturally look like

$$Q_T = \sum_{k=1}^{K} Q_{T_k} , \tag{3.7}$$

where z_k - stocks of MR at the k-th level of the system, created to meet the needs of r;

α_k - coefficients of losses arising in the process of stock storage at the k-th level of the system;

β_k - coefficients of losses arising in the process of delivery between the k-th and k + 1 level.

Model (3.4) - (3.7) reflects the dependence of efficiency and total costs on the separation of stocks. As mentioned earlier, this model can be used to study the logistics chains of real FFC or FFC having one consumer. Peculiarities of FFC with a hierarchical structure are the influence of stocks of higher levels on the ability to meet demand at a lower level, as well as the dependence of deficit and total costs not only on total stock but also on its distribution by system elements.

Analytical research of systems of the given structure with casual demand meets considerable difficulties which reason consists in complexity of calculation of parameters of distribution of demand for the higher links of system and optimization of stocks on them. However, the presence of the order of supply, as established in the studied FFC, simplifies the solution of this problem.

Consider the simplest, single-level FFC with a hierarchical structure that provides two consumers and has one warehouse [25]. Its block diagram is presented in Fig. 3.2. The warehouse where the stock is stored z_0, denote accordingly C_0. The indices specified in R, reflect the order of supply of the relevant consumers, and, consequently, the order of their consumption of the stock z_0 .

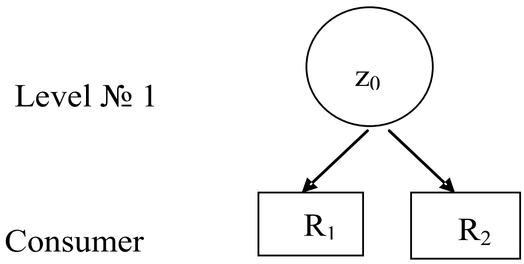

Figure 3.2. FFC scheme with a hierarchical structure

The deficit that occurs in the system is equal to the sum of the deficits that occur in each individual consumer, ie

$$D_T = D_{T1} + D_{T2} \ , \qquad (3.8)$$

where D_T - deficit that occurs in the system in the MR during the period T;

D_{T1} - deficit that occurs in the first consumer;

D_{T2} - deficit that occurs in the second consumer.

Consider the deficit of the first and second consumers. Because the first consumer is satisfied in the first place, the mathematical expectation of a deficit for him for the period T is equal to

$$D_{T1} = \int_{\alpha_0 \beta_{01} z_0}^{\infty} (r_1 - \alpha_0 \beta_{01} z_0) f_1(r_1) dr_1 \ . \qquad (3.9)$$

where r_1 - the need for MR in the first consumer arising during the period T;

$f_1(r_1)$ - its distribution density;

α_0 - coefficients of losses arising in the process of storing stocks in the warehouse C_0

β_{01} - the coefficient of losses arising from the delivery of MR from the warehouse C_0 to the first consumer.

After meeting the needs of the first consumer in the warehouse C_0 the balance remains

$$Z_{02} = \begin{cases} \alpha_0 z_0 - \dfrac{R_1}{\beta_{01}} & \text{при} \quad R_1 \le \alpha_0 \beta_{01} z_0, \\ 0 \quad \text{при} \quad R_1 > \alpha_0 \beta_{01} z_0 \end{cases} \tag{3.10}$$

where Z_{02} - balance in the warehouse C_0 for another consumer;

Consider the calculation of total costs incurred in the operation of FFC

$$Q_T = Q_{T1} + Q_{T2} + (c_0^{(c)} + c_0^{(x)}) z_0. \tag{3.11}$$

where Q_T - costs incurred in the system in the MR during the period T;

Q_{T1} - costs incurred in providing the first consumer;

Q_{T2} - costs incurred in providing the second consumer;

$c_0^{(c)}$ - the cost of creating a unit of MR in the warehouse C_0;

$c_0^{(x)}$ - the cost of storing a unit of MR in the warehouse C_0.

Consider the calculation of the components Q_{T1} and Q_{T2} more details. As previously noted, the amount of costs incurred in the operation of the system includes the cost of transportation of MR, which depends on the volume of material flows, as well as the cost of storage and stockpiling. As in previous models, we are dealing with two cases - the first, when the value of the demand of any consumer does not exceed the size of the created stocks, and the second, when the value of the need exceeds the size of the created stocks.

Ultimately, the stock z_0 and the first consumer is nothing more than a single-tier logistics chain. Then, using formula (3.9) for the mathematical expectation of costs for the first consumer, we can write:

$$Q_{T1} = \frac{c_{01}^{(мп)}}{\beta_{01}} \left[\int_0^{\alpha_0 \beta_{01} z_0} r_1 f_1(r_1) dr_1 + \alpha_0 \beta_{01} z_0 \int_{\alpha_0 \beta_{01} z_0}^{\infty} f_1(r_1) dr_1 \right]. \tag{3.12}$$

where $c_{01}^{(мn)}$ - the cost of transportation of a unit of MR from the warehouse C_0 to the first consumer.

In a similar way, only taking into account the randomness of the balance, you can write for the costs of providing a second consumer, ie in the operation of the logistics chain " Z_{02} →the second consumer ". As in the case of deficits, we will find a mathematical expectation of costs in relation to needs R_2 , and in relation to the balance Z_{02}

$$Q_{T2} = \frac{c_{02}^{(мn)}}{\beta_{02}} \int_0^{\alpha_0 z_0} \left[\int_0^{\beta_{02} z_{02}} r_2 f_2(r_2) dr_2 + \beta_{02} z_{02} \int_{\beta_{02} z_{02}}^{\infty} f_2(r_2) dr_2 \right] \varphi_2(z_{02}) dz_{02}. \quad , (3.13)$$

where $c_{02}^{(мn)}$ - the cost of transportation of a unit of MR from the warehouse C_0 , to another consumer.

Thus, the deficit and total costs that arise when providing a second consumer, depend not only on his needs R_2, but also out of need R_1 the first consumer, expressed in terms of balance Z_{02} and the density of its distribution $\varphi_2(z_{02})$.

Similar considerations can be applied and in calculation of indicators of deficit and the total expenses arising at functioning of one-level FFC with hierarchical structure providing N consumers. Namely, the deficit in the n-th consumer at $n = 1,\ldots,N$, stock

$$D_{Tn} = \int_0^{\alpha_0 z_0} \int_{\beta_{0n} z_{0n}}^{\infty} (r_n - \beta_{0n} z_{0n}) f_n(r_n) \varphi_n(z_{0n}) dr_n dz_{0n} \quad (3.14)$$

and costs will add up

$$Q_{Tn} = \frac{c_{0n}^{(ïї\ )}}{\beta_{0n}} \int_0^{\alpha_0 z_0} \left[\int_0^{\beta_{0n} z_{0n}} r_n f_n(r_n) dr_n + \beta_{0n} z_{0n} \int_{\beta_{0n} z_{0n}}^{\infty} f_n(r_n) dr_n \right] \varphi_n(z_{0n}) dz_{0n} \quad (3.15)$$

Here is the distribution density of the residue $\varphi_n(z_{0n})$ is determined taking into account the following expression:

$$Z_{0n} = \begin{cases} Z_{0n-1} - \dfrac{R_{n-1}}{\beta_{0n-1}} \quad \text{ïðè} \quad , R_{n-1} \le \beta_{0n-1} Z_{0n-1} \\ 0 \quad \text{ïðè} \quad R_{n-1} > \beta_{0n-1} Z_{0n-1} \end{cases} ; \quad n = 2, \ldots, N , \quad (3.16)$$

where Z_{0n-1} - balance in the warehouse C_0 in the interests of the previous consumer in relation to the nth. If n = 2 then $Z_{0n-1} = Z_{01} = \alpha_0 z_0$.

When considering the properties and features of the above models, the dependence of deficit and total costs on the separation of stocks in a system with an arbitrary number of levels and the distribution of stocks in a system with an arbitrary number of consumers was clarified.

Using the developed approaches to the construction of the above models, it is possible to synthesize a general model of inventory management in FFC, ie a model of inventory management in a hierarchical system with an arbitrary number of levels and an arbitrary number of consumers. In the future, knowing the structure of a particular FFC, based on the general model, you can build a private model of inventory management in relation to this FFC.

At the end of this section it is important to note that the models developed by us, in accordance with the previously considered classification, belong to the class of stochastic, static, analytical models. The choice of this modeling method allows to make a parametric synthesis of FFC, which extends to the entire area of the factor space, taking into account that it consists in calculating with a given accuracy the optimal reserves of MR in relation to certain conditions.

3.2. Development of a method for processing the original data and calculating the parameters of the model of inventory management MR typical transport and forwarding company

The main input parameter of the considered models of inventory management is the need for MR. In relation to the typical FFC, it becomes clear that the need for MR includes, first of all, the natural consumption of MR, as well as all kinds of its losses. Losses of MR during storage in the form of stocks, as well as during delivery in the process of its consumption, are taken into account in the developed models in the form of independent parameters, so when determining the need - R remains to take into account the natural consumption of MR.

So

$$R = \eta X \, , \tag{3.17}$$

where X is the natural flow rate of MR;

η - the number of insured persons.

From this expression it is seen that the need - R is a linear function of one random argument, in this case the cost of MR on natural wear - X. Using formulas for the density of the distribution of the linear function of one random argument, we obtain:

$$f(r) = g\left(\frac{r}{\eta}\right) \cdot \frac{1}{\eta}, \tag{3.18}$$

where $f(r)$ - density of distribution of needs of MR;

$g(x)$ - the density distribution of the natural flow of MR.

Takes into account the change in demand throughout the interval of the numerical axis, is

$$\int_{-\infty}^{\infty} f_0(r)dr = 1,$$

whereas the need for the case considered in the paper takes only positive values.

That means

$$\int_{0}^{\infty} f_0(r)dr < 1,$$

which does not correspond to the properties of the density distribution of a random variable.

We introduce the probability P_r that during the period T there will be a need for MR, including zero

$$P_r = \int_0^{\infty} f_0(r)dr .$$

In order to determine the parameters of the law of distribution of the cost of MR on natural wear - a mathematical expectation m_x and standard deviation σ_x, as a rule, the study (estimation of parameters) of statistical material is carried out.

If the statistical material is a few dozen observations, then estimate the parameters m_x and σ_x can be carried out according to the following formulas [25]:

$$m_x = \frac{1}{N}\sum_{i=1}^{N} X_i \quad (3.19)$$

$$\sigma_x = \sqrt{D_x} = \sqrt{\frac{\sum_{i=1}^{N}(X_i - m_i)^2}{N-1}}, \quad (3.20)$$

where N is the number of observations of the consumption of MR on natural wear;

D_x - its dispersion;

X_i - the result of the i-th observation.

When studying the cost of MR, the expert survey should be built in such a way as to obtain if not absolute, then at least relative quantitative estimates of the cost of MR in these conditions. When estimating the cost of MR, experts need to give some basic information - a kind of support, based on which the expert can equalize, and then quantify the cost of MR. This may be some evaluation continuum, within which the quantitative (score scale) varies for the expert. Then the maximum expense of MR, at its estimation for example on a 100-point scale, would be estimated in 100 points, and the minimum in 0 points. Thus, the expert would compare the estimated cost of MR in these conditions, in comparison with its maximum or minimum value, and would give an equivalent scale estimate. For the most adequate optimal assessment of MR, it is necessary to offer experts to compare the cost of this consumer of MR in different non-standard operating conditions, with the cost of MR in any real situation that takes place in life. Thus, the key question asked by the experts after outlining the situation and providing them with supporting information could be as follows: considering it equal to 10 points.

When processing expert data, the survey results are summarized in table. 3.1. Further statistical processing of the survey results is aimed at obtaining group estimates of MR indicators in different conditions of FFC operation, as well as assessing the degree of reliability of the examination and can be carried out according to the method described in [27].

Table 3.1

The results of a survey of experts on the method of scale estimates of the cost of MR in different operating conditions of FFC

Expert	Variants of FFC operating conditions			
	A	B	C	D
№	1	2	3	4
1	x_{11}	x_{21}	x_{31}	x_{41}
2	x_{12}	x_{22}	x_{32}	x_{42}
3	x_{13}	x_{23}	x_{33}	x_{43}
...	...	...	...	...
M	x_{1M}	x_{2M}	x_{3M}	x_{4M}

In order for experts to be able to approach the most differentiated approach to assessing the degree of impact of the deficit and total costs on the value of the indicator Π , it is offered to break them into group of more elementary factors connected with each of the characteristics and in set of functioning reflecting quality, FFC. This group should consist of two subgroups.

The first refers to the deficit, the second - to the total costs. As a result of such decomposition it is planned to obtain a group of six factors - three for each indicator. This amount is most acceptable for the expert as for the LPR.

Thus, as a result of processing of results of expert interrogation on each variant of conditions of functioning of FFC we need to receive relative weights of importance not of two, but six factors.

$$\mathbf{A}^{\mathrm{T}} = (a_1 \quad a_2 \quad a_3 \quad a_4 \quad a_5 \quad a_6), \tag{3.21}$$

where A^T - vector of weights.

In the questionnaires offered to the experts at the first stage of the examination, the subgroups of factors for ranking are presented in a general list, arranging them in a mixed order. The interrogative part contains the task, for example:

"Please number the importance of the following factors used in determining the optimal (rational) stocks of MR in the considered operating conditions."

After the task there is a table with the specified list of factors opposite to each of which the expert should put a rank corresponding to the given factor.

Let a group of 3 experts be involved in the survey. The answers of experts together represent a matrix of advantages:

$$\mathbf{F} = \begin{pmatrix} f_5 & f_2 & f_1 & f_3 & f_6 & f_4 \\ f_2 & f_3 & f_1 & f_6 & f_4 & f_5 \\ f_3 & f_5 & f_4 & f_1 & f_6 & f_2 \end{pmatrix}; \qquad (3.22)$$

each row of this matrix will represent a number of advantages of the corresponding expert.

3.3. Principles of determining the rational composition of the elements of the interface of the ASM interaction with MR stocks and means of their software implementation

In the previous sections, a set of mathematical models of MR inventory management in FFC was considered, as well as some methods for determining the values of input parameters, finding the optimal size of inventories, which is the implementation of mathematical software for MR inventory management in FFC. In relation to the problem solved in this work, the mathematical support of ASM is its central element, however, in the study of the stages of automation of inventory management MR in FFC no less important is the ability to implement adequate information and software that allows maximum use of human capabilities. and the machine part of the system. Obviously, the human operator (logistics) is the closing link of the inventory management system, ie the subject of management, ASM is a hybrid system in which the operational (managerial) staff and agro-industrial complex ASM are equal partners in solving complex management problems. Rational organization of work of ASM operators with stocks of material resources is one of the most important factors that determine the effective functioning of the logistics system as a whole. In the vast majority of cases, management work is an indirect human activity, because in the conditions of ASM he manages, "not seeing" the real object, which, in particular, fully applies to inventory management. Between the real control object and the human operator is the so-called information model of the object, implemented on the means of displaying information. The interface of human interaction with the technical means of ASM consists of agro-industrial complex and interaction protocols.

- conversion of data circulating in the APC, into information models displayed on monitors;
- regeneration of information models;
- ensuring human dialogue with the technical means of ASM;
- conversion of influences coming from the human operator into the data used by the control system;
- physical implementation of interaction protocols (coordination of data formats, error control, etc.).

When creating ASM stocks of material resources in FFC great importance of software development, because it is the software that creates computer intelligence, which solves complex scientific problems, which implements the composition of inventory management processes. At this time, the creation of such systems significantly increases the role of the human factor, and hence the ergonomic support of the system. The main task of ergonomic support is to optimize the interaction between man and machine not only during operation, but also in the manufacture of technical components. Thus, when systematizing the approach to the design of the interaction interface, it is advisable to use the principles of creating an architecture of information models:

- the principle of minimum labor, which has two aspects:

- minimization of resource costs by the software developer, which is achieved by creating a certain methodology and technology of creation, inherent in conventional production processes;

- minimization of resource costs by the user, ie the human operator must perform only the work that is necessary and can not be performed by the system, there should be no repetition of work already done.

3.4. Analysis of the research results obtained using the mathematical support of the ASM with MR stocks of a typical freight forwarding company

Let's analyze the influence of the values of different parameters of the inventory management model on the value of the advantage indicator, and in the practice of using ASM, on the decision made by the LPR. In the course of this analysis the degree of influence of values is considered

- losses during storage and transportation of MR;
- costs of expenses for creation, storage and transportation of the MR unit;
- the size of MR stocks in different elements of the logistics system when they (stock sizes) jointly consider the value of the advantage indicator. The solution of this problem is necessary in order to find out the general properties of the system, as well as what factors, to what extent and in what sequence they should be taken into account, in order to most effectively operate the operator with ASM inventory management MR.

To assess the influence of the values of different input parameters of the model on the value of the advantage indicator, it is proposed to use the method of correlation analysis of the relationship between two random variables.

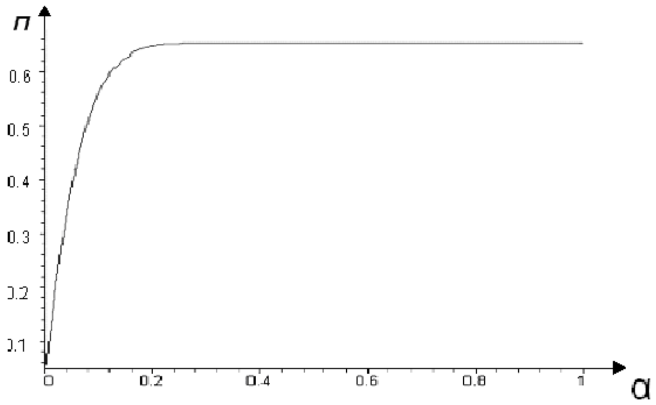

Fig. 3.3. Dependence of the advantage indicator on the losses during storage of MR

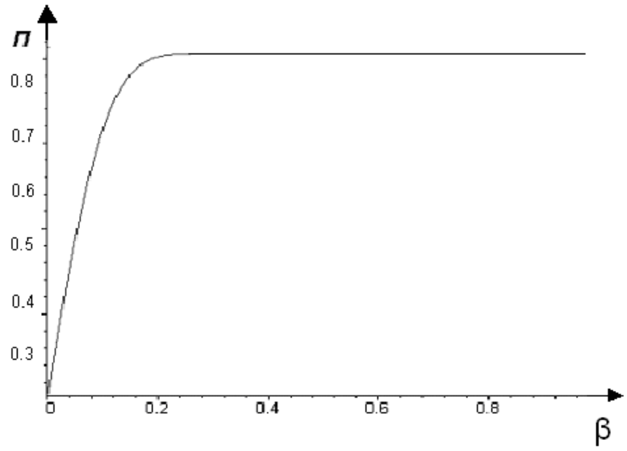

Fig. 3.4. Dependence of the indicator of advantage on losses at delivery of MR

Consider the impact of cost indicators. The dependence of the advantage indicator on different cost indicators of the model is presented in Fig.3.3 - 3.7.

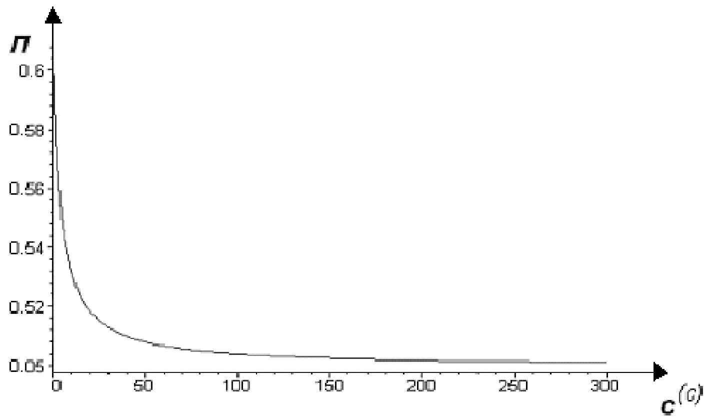

Fig. 3.5. Dependence of the advantage indicator on the cost of creating a unit of MR (in US dollars)

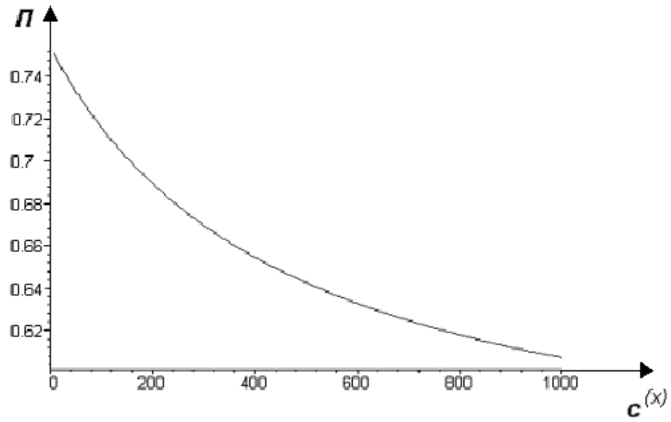

Fig. 3.6. Dependence of the advantage indicator on the cost of storage of a unit of MR (in US dollars)

The simulation results were processed using the built-in tools of Microsoft Excel, in particular using the function of calculating the correlation coefficient "CORREL". As a result, the following data were obtained for the correlation coefficients of the studied parameters of the model and the advantage indicator, namely for:

– the coefficient of losses during storage of MR $k_{\alpha P}$ = 0.52564;

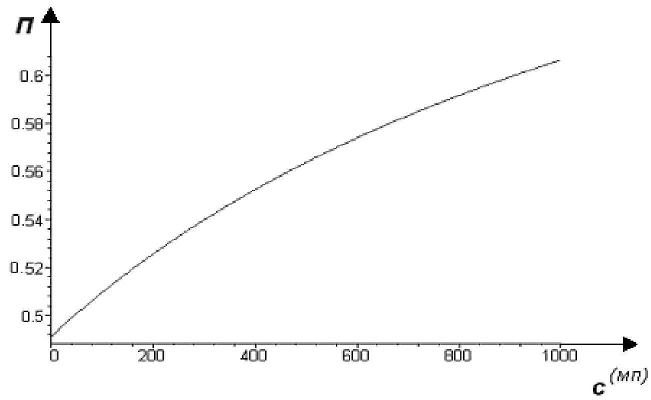

Fig. 3.7. Dependence of the advantage indicator on the cost of transportation of a unit of MR (in US dollars)

– the coefficient of losses during the delivery of MR $k_{\beta P}$ = 0.47;
– the cost of creating one unit of MR $k_{c^{(c)}\Pi}$ = 0.84;
– the cost of storage of one unit of MR $k_{c^{(c)}\Pi}$ = 0.90;
– the cost of transportation of one unit of MR $k_{c^{(c)}\Pi}$ = 0.98.

Based on the obtained data, we can conclude that the change in the values of cost indicators has a more significant effect on the value of the advantage indicator P in comparison with the change in the values of loss coefficients. This conclusion determines the order of determination and input of initial data by the ASM operator with MR stocks for more efficient operation of the system, namely the order of data input is recommended as follows:

- the cost of transportation of one unit of MR;
- the cost of storage of one unit of MR;
- the cost of creating one unit of MR (the cost of a unit of MR);
- coefficients of losses during storage of MR;
- coefficients of losses at delivery of MR.

Determining the values of these input parameters of the model and their subsequent introduction into the machine should be carried out, of course, for each element of the logistics system (warehouse or consumer). The received distribution of sequence of definition and input of values of input parameters of model is important not only for the operator of the considered ASM, but also for the developer, in particular, at designing and creation of the interface of interaction.

To determine the general properties of the logistics system of this type with their subsequent interpretation, consider the change in the indicator of preference depending on the separation and distribution of MR stocks in the FFC. The dependence of the advantage indicator on the size of stocks created at different levels of the system is presented in the following graphs (Fig. 3.8 - 3.9)

Figure 3.8 shows the case when the advantage index takes some maximum value at optimal, non-zero stocks of MR in the warehouse of the first and one of the warehouses (third) of the second level. Stocks in the warehouses of the first and second consumers are deliberately fixed. This property of the system indicates that under these conditions, if for some reason it is impractical to create stocks in the warehouses of the second level, the provision of consumer data (in our case, the first and second) is carried out at the expense of stocks of the first level. Less better consumers Created in the warehouse of the consumer provided in the second turn and the consumer provided in the third turn satisfy the needs at the expense of own stocks of the second level.

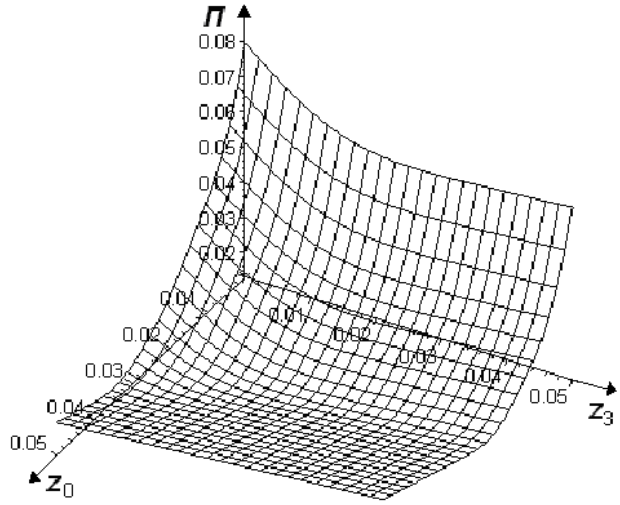

Fig. 3.8. Dependence of the advantage indicator on the sizes of the stocks of the MR created in a warehouse of the first level and in a warehouse of the second level of FFC of the consumer provided in the third turn

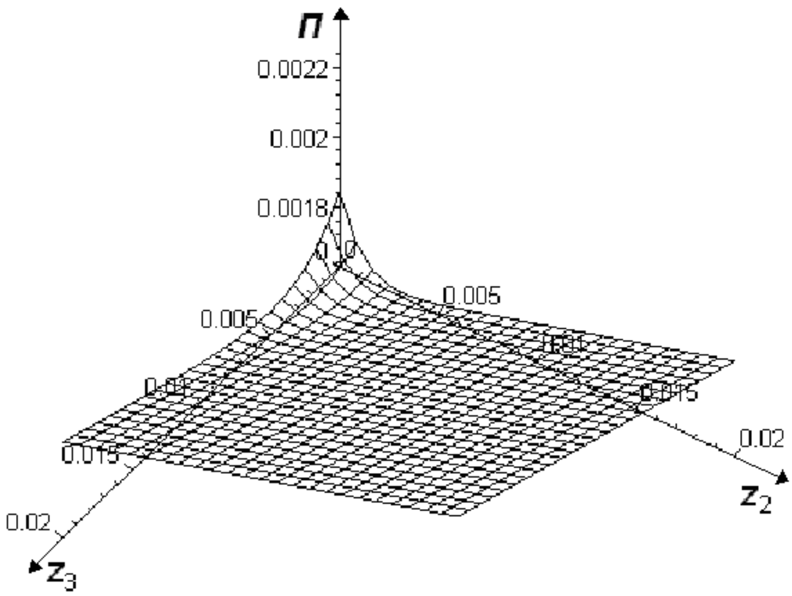

Fig. 3.9. Dependence of the advantage indicator on the size of MR stocks

Thus, it is important to note a property common to logistics systems of this class. From the analysis of the model of management of MR stocks in FFC it is necessary that in these systems, according to the existing classification of stocks, stocks of the lower level on the functions, it is necessary to carry to current stocks. Stocks of the upper levels of the system can perform the functions of both current stocks - for consumers who do not have their stocks rationally, and insurance - for consumers who have their own stocks.

The model behaves slightly differently when considering the dependence of the advantage indicator on the system of inventories of the second level of any two consumers, as shown in Figure 3.9. In this case, the optimal size of one of the stocks always tends to zero (the size of the stocks of other consumers are fixed). Figure 3.9 is the stock of the consumer, provided in the third place. This feature of the inventory management model means that, under certain conditions, a group of consumers will be better able to meet their needs mainly through their own stocks, and other consumers will be best suited to meet their needs in MR at the expense of tier one stocks.

The choice of one or another option of creating stocks for a given consumer, due to the established order of supply, depends on the established option of creating stocks and their optimal size for higher priority consumers in relation to this. Thus, it is most difficult to determine the optimal size of MR stocks in the warehouse of the consumer, provided last and in the warehouse of the first level, because to determine these values it is necessary to take into account the state of input parameters in all elements of the system. At the same time, the studied properties of the inventory management model indicate the existence of a complex, uncertain relationship between the parameters of the inventory management model and, consequently, between the states of the logistics system, which affects, in particular, the distribution of optimal MR inventories.

As a rule, the logistics system considered in this example can be in one of four standard variants (states), conditionally designated "A", "B", "C", "D", each of which has a corresponding set of values of parameters of the inventory management model. .

3.5. Assessment of the economic effect expected from the introduction of ASM stocks of material resources in the practice of managing stocks of a typical freight forwarding company

The economic effect in general should be represented by the sum

$$E = \Delta P + \Delta S,$$

where ΔP - profit growth expected as a result of the implementation of research results in the practice of MR inventory management;

ΔS - savings expected as a result of implementation of research results in the practice of MR inventory management.

Consider the logistics system of providing details of the transport enterprise to assess the economic effect expected from the introduction of ASM stocks MR. Since the analysis of the results of optimization of MR stocks in this logistics system shows a clear tendency to reduce the average stocks that must be created for the most efficient operation of the system in the planned period, the economic effect is a positive result from the implementation of research results. Logistics systems of this type by their nature do not bring any monetary profit, so to solve this problem we need to determine the amount of cost reduction expected from the introduction of ASM stocks MR. This value is defined as the difference between the total costs incurred in the operation of the system, in which the MR stocks are created according to the existing norms, and the total costs for the stocks created by the ASM by the MR stocks. Total costs consist of costs incurred in the creation and storage of stocks, as well as costs incurred in the delivery of MR.

To calculate the total costs, we can use the program to calculate the optimal stocks. Recall that this program is designed to calculate the values selected by us in section 3.1. indicator of efficiency of functioning of logistic system and size of total expenses for the given set of input parameters, and also for search of optimum stocks on the maximum value of an indicator of advantage. The results of the calculations are listed in table. 3.2.

Thus, the solution of this problem is reduced to the alternate substitution in the program of the values of stocks established by the existing norms and calculated by means of the program, and also to calculation of a difference of values of total expenses. The results of the calculations are presented in the following table.

Table 3.2

The results of the calculation of the expected economic effect from the introduction of ASM stocks MR typical transport enterprise

Typical options for the operation of the logistics transport system	Costs incurred in the operation of the logistics system		Cost reduction (savings), UAH
	using the developed ASM stocks MR	using the traditional MR inventory management system	
Situation "A"	18000	45000	27000
Situation "B"	190000	690000	500000
Situation "B"	82000	202000	120000

3.6. Comparative analysis of the principles of construction of the existing and the proposed automated management system of material resources of a typical freight forwarding company

Automated management system of material resources of the logistics transport enterprise "TradeMaster" is an interactive system that provides the manager with easy access to models and data in order to support the decision-making process regarding poorly structured and unstructured tasks of optimal management of material resources.

Virtually all existing types of computer systems for decision support (DSS) of the logistician are characterized by a clear structure, which contains three main components: the subsystem of the user interface; database management subsystem and model database management subsystem (Fig. 3.10).

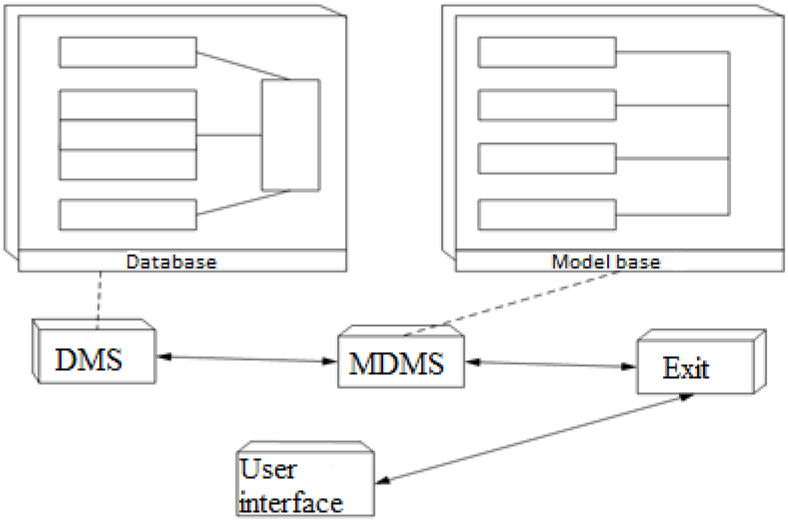

Fig. 3.10. Classical structure of ASM MR: DMS - database management system, MDMS - model database management system

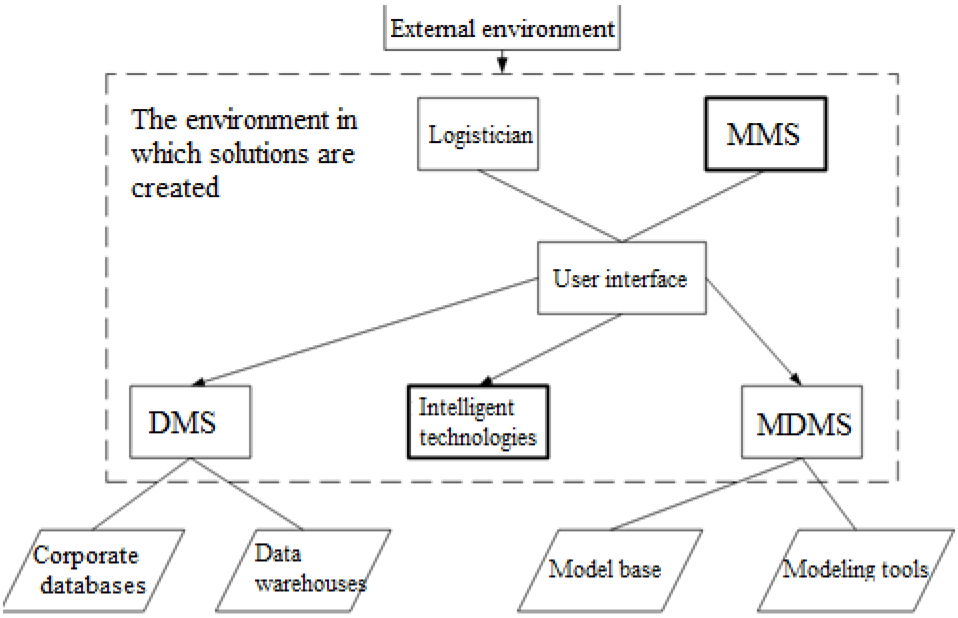

Fig. 3.11. The proposed structure of the ASM MR: DMS - database management system, MDMS - model database management system

These three subsystems form the basis of the classical structure of the ASM MR, due to which the latter differ from other types of information systems.

Recently, with the development of the global Internet, corporate and inter-organizational networks, it is proposed to add new subsystems to the existing system: message management system (communications or communication) - MMS, as well as the subsystem of intelligent DSS logistics transport company (Fig. 3.11). Model components include: model management, optimization models, simulation models, quantitative and qualitative models. Communication components: ASM MR architecture, networks, Web-server, protocols. User interface components: dialog, menus, diagrASM, graphics.

A feature of the developed ASM MR is interactivity, integration, accessibility, flexibility, reliability, robustness, controllability.

Interactivity ASM MR means that the system responds to various actions by which the operator intends to influence the computational process, in particular, in the dialog mode. The operator and the ASM MR exchange information at a rate comparable to the speed of information processing by the operator.

Integration ASM MR is the compatibility of the components of the system for data management and means of communication with users in the decision support process.

Accessibility ASM MR is the ability to provide responses to user requests in the right form and at the right time.

Flexibility ASM MR characterizes the ability of the system to adapt to changing needs and situations.

Reliability ASM MR means the ability of the system to perform the desired functions for a given long period.

Robustness (robustness) ASM MR is the ability of the system to recover in the event of erroneous situations of both external and internal origin. For example, in a robust system, errors in input information or hardware failures are allowed. Although there is a connection between reliability and robustness, these two characteristics of the system are different: a system that will never be renewed in the event of erroneous situations can be reliable without being robust; a system with a high level of robustness, which can be restored and continue to work in many erroneous situations, can be considered unreliable at the same time, as it may be unable to perform the necessary service procedures before the damage.

Controllability ASM MR means that the user can control the actions of the system, interfering in the solution of the problem.

Developed ASM MR has the following features and properties:

1. ASM MR provides assistance to the head in the decision-making process. The human mind and computer-generated information are one for decision making.

– ASM MR supports and strengthens (but does not replace or cancel) the reasoning and evaluation of the head. The control remains with the operator. The user "feels comfortable" using the system, thanks to a user-friendly interface, and is not afraid to work with it.

– ASM MR increases the efficiency of decisions (not just the productivity of the operator). In contrast to administrative information systems, in which the emphasis is on the maximum productivity of the analytical process, in the ASM MR is much more important the efficiency of the decision-making process and the decisions themselves.

– ASM MR integrates models and analytical methods with standard data access and data sampling. One or more models (mathematical, statistical, simulation, quantitative, qualitative or combined) are activated to assist in decision-making. The contents of databases and data warehouses cover the history of current and previous operations, as well as internal information and information about the environment.

– ASM MR is easy to use even for people who have not gained significant experience in communicating with computers. The systems are "user-friendly", require virtually no in-depth computer knowledge, and provide easy system navigation, dialog documentation, built-in learning tools, and other attributes of software interface systems.

– ASM MR is built on the principle of interactive problem solving. The user has the opportunity to maintain a dialogue with the ASM MR in a continuous mode, rather than limited to entering individual commands and then waiting for the results.

– ASM MR is focused on flexibility and adaptability to adapt to changes in the environment or in approaches to solving problems chosen by the user. The manager must adapt to changing conditions himself and prepare the system accordingly. The evolution and adaptation of a system must be combined with its life cycle.

It is proposed to supplement this characteristic of the ASM MR with new opportunities due to "intellectualization", in particular:

1. ASM MR includes a knowledge module that describes some aspects of the worldview of decision makers, describes how to complete different tasks, indicates which conclusions are valid in different circumstances.

3. ASM MR has the ability to acquire and maintain descriptive knowledge (record keeping, registration) and other types of knowledge (storage of procedures, rules).

4. ASM MR has the ability to present knowledge in this case in different ways, as well as in standardized reports.

5. ASM MR is able to select any desired part of the stored knowledge for the presentation or acquisition of new knowledge by means of recognition and / or problem solving.

3.7. Conclusions

1. Developed software implemented tools of the ASM operator with MR stocks in the logistics system. They contain a mathematical model of inventory management in this system, the basis of mathematical software, which is an ASM inventory MR.

2. The generalized indicator of advantage is calculated and the method of receiving its values is considered. Thus, the task of finding the optimal reserves of

MR is reduced to finding the maximum of this indicator. The method of calculating this indicator is based on expert assessments.

3. The results of the economic efficiency assessment showed that, as a result of the introduction of the ASM in the FFC, MR savings were obtained in the amount of: Situation "A" UAH 27,000; Situation "B" UAH 50,000; Situation "B" UAH 120,000.

4. The proposed system of ASM MR takes into account the following principles of construction: interactivity, integration, accessibility, flexibility, reliability, manageability, which allows to develop highly effective systems to support management decisions with inventory MR logistics transport company "TradeMaster".

SUMMARY

Air Transportation Management Department				NAU.20.11.97 004EN					
Done by:	Solonska O.O.			SUMMARY	Letter			Sheet	Sheets
Supervisior:	Shevchuk D. O.						D	100	2
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1. The quality of the logistics system depends on the influence of external factors that have a stochastic nature, which significantly vary depending on the specific conditions of the consumer and economic situation, as well as the level of all costs arising in the process of providing consumers MR.

2. The method of automation of management of material resources at the transport enterprise which will provide effective management of stocks in real conditions having casual and nonstationary character is offered.

3. Synthesized a mathematical model of decision support systems (PPR) of the logistician, which differs from the existing following components (user interface subsystem; database management subsystem and model management subsystem), which will make optimal management decisions about the size of inventories in real time

4. Effective management of MR stocks in modern conditions is impossible without the widespread introduction of computer technology in this process, ie causes the need to develop ACS stocks of material resources.

5. Requirements to the computer-interned complex of decision support at the strategic level:

- to provide timely and effective analysis and processing of a large object of information (quantitative, qualitative, graphic, inaccurate, etc.);
- introduce modeling of knowledge and decision-making processes based on human knowledge and experience;
- to provide an opportunity to experiment with practical situations and the necessary response to them;
- take into account the dynamics and instability of changes, both the internal conditions of the production system and the environment;
- have the ability to learn from experience and adapt to changes in current situations.

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