***Визначено клас динамічних моделей цільових операцій. Моделі визначеного класу забезпечують відображення процесів цільової операції в кожну мить часу в рамках часового інтервалу досліджуваної операції. Відносний показник, що створений з використанням динамічної моделі цільової операції, поширює можливості ідентифікації досліджуваних операцій. Можливості, пов'язані з використанням розробленого показника, ілюстровані у роботі на прикладі дослідження простої цільової операції***

***Ключові слова: класифікація операцій, облікова модель цільової операції, динамічна модель цільової операції, ефективність операції***

***Определен класс динамических моделей целевых операций. Модели определенного класса обеспечивают отображение процессов целевой операции в каждый момент времени в рамках временного интервала исследуемой операции. Относительный показатель, созданный с использованием динамической модели целевой операции, расширяет возможности идентификации исследуемых операций. Возможности, связанные с использованием разработанного показателя, проиллюстрированы в работе на примере исследования простой целевой операции***

***Ключевые слова: классификация операций, учетная модель целевой операции, динамическая модель целевой операции, эффективность операции***

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# DETERMINATION OF THE CLASS OF DYNAMIC MODELS OF TARGET OPERATIONS

**I. Lutsenko**
Doctor of Technical Sciences,
Associate Professor*
**E. Fomovskaya**
PhD, Associate Professor, Head of Department*
E-mail: fill.fo@mail.ru
**O. Serdiuk**
Postgraduate student
Department of Computer Systems and Networks
SIHE «Kryvyi Rih National University»,
XXII Partz'yizdu str., 11,
Kryvyi Rih, Ukraine, 50027
E-mail: olgajs28@gmail.com
*Department of Electronic Devices
Kremenchuk Mykhailo Ostrohradskyi
National University
Pervomaiskaya str., 20,
Kremenchuk, Ukraine, 39600

## 1. Introduction

Today, the cybernetics as the management science faces numerous theoretical problems «and the practical efficiency of the solution of these problems depends on how the theoretical bases are correct» [1].

Since the fundamental developments of applied cybernetics should be based on a solid theoretical foundation, the importance of developing basic object of research is beyond any doubt. Such basic object of cybernetics is the processes of the system operation.

However, the only and widely used model of the operation is the model based on recording the data about the products of the operation on the input and output of the research object. We define such a model of the operation as «the accounting model of the operation».

Those models, in which quantitative parameters of the input and output products are reduced to comparable measures, generally to expert estimates, we define as «the accounting target model of the operation». As shown by the history of cybernetics and economics, reliance on the accounting model of the target operation does not allow to lay a solid foundation for the theoretical bases of management. One of the facts confirming this thesis is the lack of efficiency index developed in the study of the accounting model of the operation in cybernetics, and, respectively, in economics.

A characteristic feature of the accounting model of the operation is a minimum of information. That is, information about the quantitative parameters of the products of the operation is available only in the points of recording of these products at the input and output of the system.

To have an opportunity to develop indexes that provide unambiguous identification of the operation, for example, with respect to resource efficiency, it is necessary to use information regarding the movement of products on the entire time interval of the studied operation. This opportunity can be provided by a fundamentally different class – the class of dynamic models of target operations.

Thus, determination of the class of dynamic models of target operations is an important scientific task.

## 2. Analysis of literature data and problem statement

Currently, the solution of cybernetic tasks in achieving the objectives in most cases is based on the economic indicators, obtained empirically. These are costs, income and profitability. Numerous attempts to create an interdisciplinary efficiency criterion on the basis of these indicators have not been successful.

Therefore, in managed systems there is no possibility of optimization associated with the maximum efficiency. It is possible only to roughly estimate the efficiency of a set of processes within a certain time interval.

Obviously, the development of a fundamentally new class of indicators for the identification of the target operations will be successful in the event of a fundamental change in the approach to the construction of a new class of models of the research object.

However, there are very few works related to the study of models of target operations. It seems that the issue of development and research of the models of target operations tends to be avoided.

The well-known monograph devoted to management [2] notes that today there is no answer to the question what is «operation» in principle: «What is a transaction? Above all, how does one decide which of the many transactions within a business is the transaction that is representative of the actual cost structure? There is no set answer».

If, for example, the title of the work tells about the computations related to the research of the operation or project, it does not mean that in the work there will be the model of operation [3] or the operating model of the project [4].

Of course, you can always use indirect methods.

Relying on logic and common sense, it can be assumed that the basic methodology associated with the construction of models and operations research is concentrated within the knowledge base of such same-name discipline as «operations research». Moreover, according to the authors [5], the operational efficiency should be the ultimate goal of research.

However, in literature dealing with solving the problems related to operations research there is no explanation of what the efficiency is [6], there is no definition of «technological operation» and «purpose of operation» [7], there is no classification of operations in principle [8], the abstract concept of «operation», with very few exceptions, is used only in the title [9].

The monograph [10], widely known in the scientific community, aimed at solving the issues related to the operations research only in the CIS countries ran to seven editions.

Nevertheless, it is obvious that a serious breakthrough in the operations research requires the expansion of the theoretical foundation. And since the achievement of any operational objective requires conducting the target operation, obtaining new theoretical results in the field of research of target operations can be based only on the in-depth study of the developed mathematical model.

Therefore, the development of the class of the model of the system operation, the use of which provides a more accurate identification of target operations, is an important scientific task.

## 3. Purpose and objectives of research

The purpose of the research is to determine the class of dynamic models of target operations.

Achieving this goal leads to solving a number of tasks such as:

– development of conceptual definitions of the class of accounting and dynamic models of target operations;

– study of models of simple accounting operations and determination of restriction for the «profitability» indicator, identifying the efficiency of operations;

– determination of the class of dynamic models of target operations and demonstration of the new features of this class in solving the problems related to the efficiency identification.

## 4. Selection of research object

In this paper, the object of research is the processes of cybernetic managed systems.

### 4. 1. Research plan

The research involves the following steps:

1. Creation of the simple accounting model of the target operation.

2. Study of models of operations when changing one accounting parameter while holding all others constant.

3. Identification of restrictions of the accounting model when solving problems of efficiency identification of the compared operations.

4. Comparison of the results of the identification of the examined operations using the index resulting from the study of the processes of the dynamic model of the target operation.

Despite the fact that the accounting model of the operation is not explicitly presented in the theory of cybernetics, such a model exists and is widely used in practice as well as in research.

Let RE denote the value equal to the sum of expert estimates of input products of the target operation, and PE denote the value equal to the sum of expert estimates of output products of the target operation. Let $T_{op}$ denote the accounting time of the operation. Let us assume that the sum of expert estimates of input products of the operation is reduced to the start time of the operation and the sum of expert estimates of output products of the operation is reduced to the completion time.

Definition. Let us define the model of the operation, in which the expert estimate of input products is reduced to its start, and the expert estimate of output products is reduced to the completion time, as «the simple accounting model of the target operation».

This model can be presented as a vector (Fig. 1), chart (Fig. 2), tuple (target signature), etc.

Let us define indicators RE, PE and $T_{op}$ as the basic indicators of the model of the simple accounting operation.

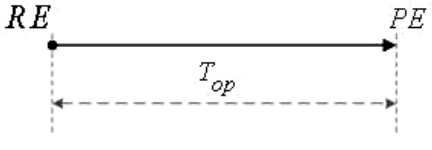


Fig. 1. The simple vector accounting model of the reduced operation

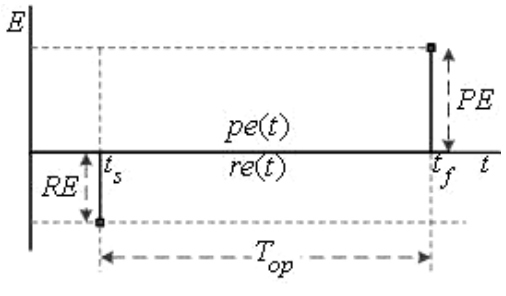


Fig. 2. The accounting model of the simple reduced operation in the form of a time chart

Mathematically, the signal of recording of expert estimates of input products in the model of the simple operation is the function re(t) that has a non-zero value with the amplitude RE at the time $t_s$. Accordingly the signal of recording of expert estimates of output products in the model of the simple operation is the function pe(t) that has a non-zero value with the amplitude PE at the time $t_f$.

Expert estimates of input products (Fig. 2) are shown in the negative range, because they are bound by the operation processes.

Using the model of the simple accounting operation as a vector, it is possible to demonstrate the concept for the approach to the construction of the model, which today is used as the research object.

The principle of construction of such a model is that all accounting expert estimates of input products are at the start time of the studied period, and accounting expert estimates of output products – at the completion time (Fig. 3).

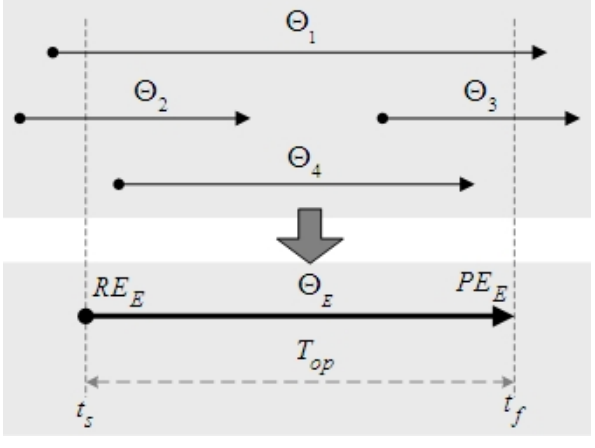


Fig. 3. The principle of construction of the accounting model of the operation

At that, $\Theta_1$ type operations, the start and completion times of which are beyond the analyzed period, do not participate in the formation of the research object in principle. In $\Theta_2$ type operations, expert estimates of output products ($PE_2$) get in the formed model of the research object, in $\Theta_3$ type operations – expert estimates of input products ($RE_3$), and in $\Theta_4$ type operations, expert estimates of input products ($RE_3$) and expert estimates of output products ($PE_2$) get in the model of the research object.

Thus, expert estimates of input products and expert estimates of output products of the studied model (Fig. 3) are determined as follows: $RE_E=RE_3+RE_4$; $RE_E=RE_2+RE_4$. The accounting time of the research object is reduced to the time interval of the studied period.

Surely, with this approach, the research object is not a natural operation, but some of its synthetic models.

Since data of individual operations may either be completely ignored or not fully taken into account, this technology can be used only in problems of strategic analysis and structural optimization. It is necessary to clearly realize the degree of approximation of the research results and all the consequences that accompany such a research.

However, the initial accounting model of the individual operation (Fig. 1, 2) contains all necessary information to identify its efficiency.

For this, we use the axiomatic approach, having formulated three axioms.

Axiom 1. In case of equal time of simple target operations and values of expert estimates of their output products, more efficient operation is the one that has the lowest value of expert estimate of input products of the operation.

Axiom 2. In the case of equal values of expert estimates of input products of the studied simple target operations and their time, more efficient operation is the one that has a maximum value of expert estimate of output products of the operation.

Axiom 3. In the case of equal values of expert estimates of input products of simple target operations and values of expert estimates of their output products, more efficient operation is the one that has a minimum duration of the target operation.

For example, of the two operations (Fig. 4), the first operation (Fig. 4, *a*) is a priori more efficient than the second one (Fig. 4, *b*), because, other things being equal, it has a lower expert estimate of input products of the operation.

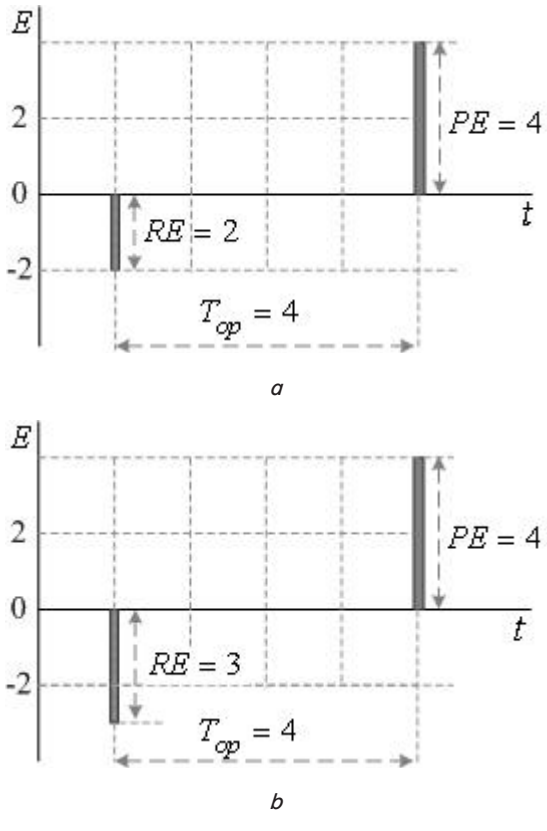


Fig. 4. Models of simple accounting operations with the value of the expert estimate of output products and time of operations: *a* – RE=2, PE=4, $T_{op}$=4; *b* – RE=3, PE=4, $T_{op}$=4

Of the two operations (Fig. 5), the first operation (Fig. 5, *a*) is a priori more efficient than the second one (Fig. 5, *b*), because it has a higher expert estimate of output products, other things being equal.

Of the operations (Fig. 6), the first operation (Fig. 6, *a*) is a priori more efficient than the second one (Fig. 6, *b*), because for the time of the first-type operation, the second-type operation can be performed twice and a double value of the difference (PE–RE) can be obtained.

Thus, key accounting indicators RE, PE and $T_{op}$ initially carry complete information based on which conclusions can be drawn regarding such indicator as the «resource efficiency». But the fact that the efficiency indicator has not so far been derived on the basis of the accounting model of the operation shows that for the solution of this problem requires the development of the accounting model of the operation that displays the process dynamics.

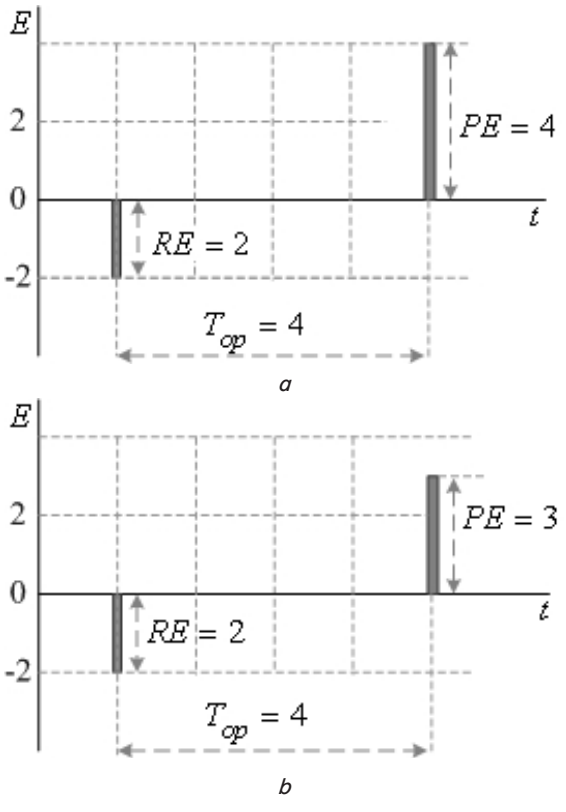


Fig. 5. Models of simple accounting operations with equal expert estimates of input products and time of operations: *a* – RE=2, PE=4, $T_{op}$=4; *b* – RE=2, PE=3, $T_{op}$=4

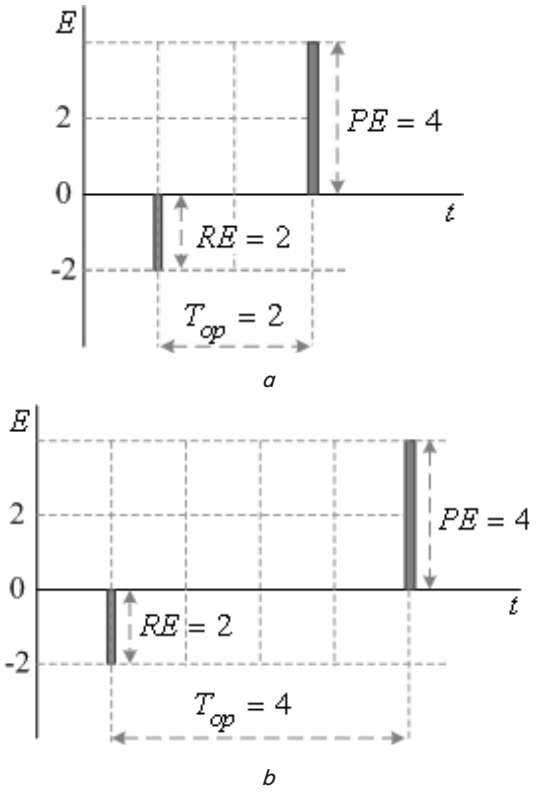


Fig. 6. Models of simple accounting operations with equal expert estimates of input products and time of operations: *a* – RE=2, PE=4, $T_{op}$=2; *b* – RE=2, PE=4, $T_{op}$=4

It is necessary to clarify the concept of «efficiency». The fact is that the difference between the output and input (value added or economic profit) is not the purpose of the operation. The value added can be called a target product of the accounting operation. The aim of the operation is the most efficient use of resources and maximum efficiency of the operation. The maximum efficiency of the operation provides the maximum return from the value added obtained in the process.

Therefore, the developed model of the operation should reflect not only the facts relating to recording the accounting parameters of the operation, but something greater connected with the dynamics of the processes occurring in the cybernetic system.

Theoretically, to obtain complete and accurate information about quantitative parameters of products during the manufacturing process, they should be continuously monitored. However, in some cases it is not possible, since during the operation the products may interact with each other and change the size, shape, composition, state, etc.

Furthermore, the amount of information that can be obtained in those cases where it is possible is extremely large and unsuitable for storage in databases for later use. But this is not really necessary, as the data on the process dynamics can be obtained in full by the «deployment» of data of the accounting model of the operation. For this, the «black box» (BB) method should be used.

According to the concept that underlies this method, everything that gets on the BB input disappears because nothing is known about the internal structure of BB. The history of this object is associated with only those parameters that this object had at the BB input.

The object that appears at the BB output is considered to be not directly related to the object input and has its «own history» only with the appearance at the output.

Let us consider how the BB method can be used to convert the data of the accounting model of the target operation into the dynamic target model. To be specific, let us consider this process on a concrete example (Fig. 7).

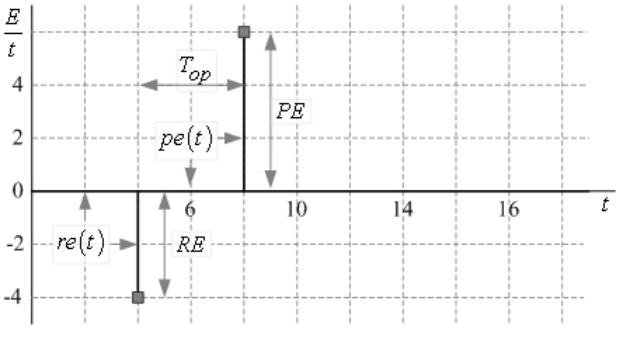


Fig. 7. The studied accounting model of the target operation

Based on the concept of BB, the input product of the value RE gets on the input of the operation, and after some time the output product of the operation of the value PE gets on the output of the operation.

The process of recording the input product of the operation by the sensor at the BB input can be described by the function $re(t)$, and the process of recording the output product of the operation at the BB output – by the function $pe(t)$. Then the dynamics of the process, associated with the

product of the value RE, inside the BB, can be characterized by the function

$$\mathrm{ire}(t)=\int_0^t \mathrm{re}(t)dt,$$

and the dynamics of the process, associated with the product of the value PE at the BB output – by the function

$$\mathrm{ipe}(t)=\int_0^t \mathrm{pe}(t)dt \quad \text{(Fig. 8).}$$

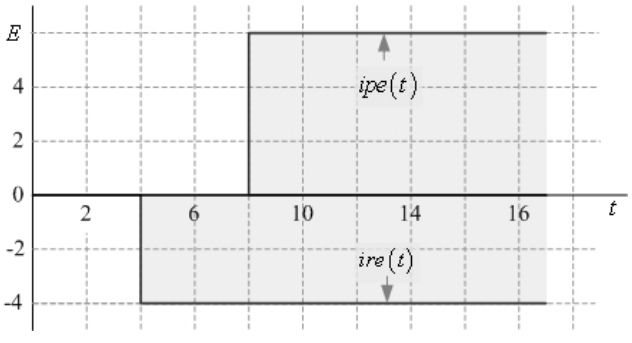


Fig. 8. The dynamic model of the operation in the form of two functions of resource consumption ire(t) and resource productivity ipe(t)

If we add up the functions $\mathrm{ire}(t)$ and $\mathrm{ipe}(t)$, we obtain the dynamic model of the target operation in the form of a single function $\mathrm{ice}(t)$ (Fig. 9).

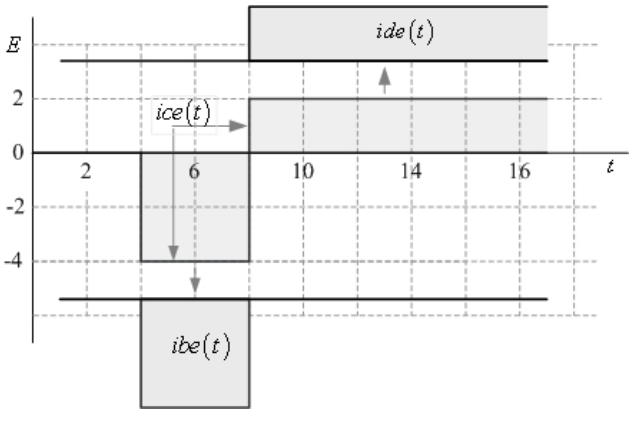


Fig. 9. The dynamic model of the target operation in the form of the function ice(t)

The function $\mathrm{ice}(t)$ (Fig. 10), in general, can always be constructed on the basis of the functions $\mathrm{ire}(t)$ and $\mathrm{ipe}(t)$ (Fig. 12) commonly representing the accounting model of the target operation in the form of the functions $\mathrm{re}(t)$ and $\mathrm{pe}(t)$ (Fig. 11).

The analysis of the functions ibe(t) and ide(t) (Fig. 9) shows that the expert estimate of input products of the simple operation cannot be determined by the accounting value RE, as these resources are bound by the operation for a definite time, equal to the parameter of the operation $T_{op}$.

Let us introduce the concept of «integrated assessment of resources bound by the target operation», which is determined by the product $\mathrm{RET}=\mathrm{RE}\cdot T_{op}$.

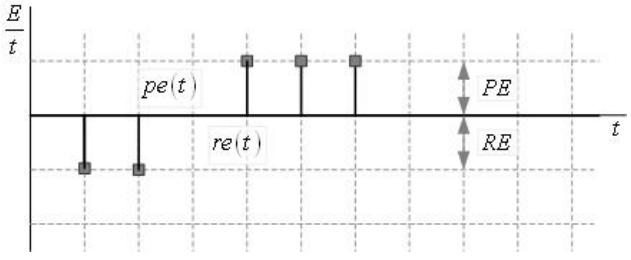


Fig. 10. Example of the accounting model of the target operation in the form of two functions re(t) and pe(t)

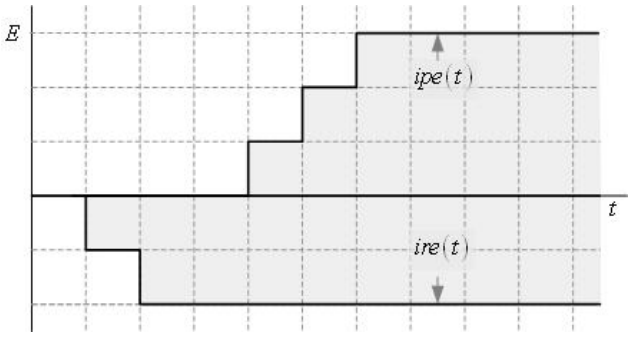


Fig. 11. Example of the dynamic model of the target operation in the form of two functions ire(t) and ipe(t)

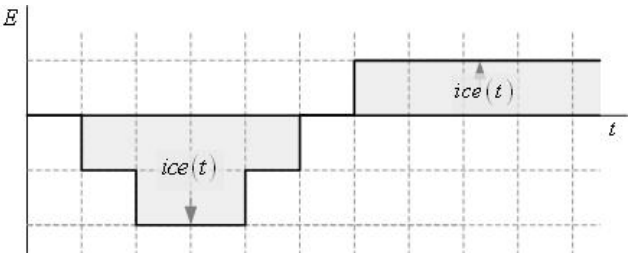


Fig. 12. Example of the dynamic model of the target operation in the form of the function ice(t)

To compensate for the bound resources of the target operation, the value added $(\mathrm{PROF}=\mathrm{PE}-\mathrm{RE})$ should «work» for a definite time.

If we integrate the functions $\mathrm{ibe}(t)$ and $\mathrm{ide}(t)$, the intersection point of integrals of the functions $\mathrm{vbe}(t)$ and $\mathrm{vde}(t)$ (Fig. 12) will make it possible to determine the time of the studied operation $T_c$ at the end of which the value added of the operation actually starts giving the return. Let us define this return as «potential effect» (A). The potential effect $(\Delta T)$ is determined on the unit time interval from the time $t_a$ (Fig. 12).

The potential effect is logical to determine on the unit time interval from the time $t_a$ from the expression $A=(\mathrm{PE}-\mathrm{RE})\Delta T$.

In this case, it is possible to determine the indicator of comprehensive profitability (RC) using the expression

$$\mathrm{RC}=\frac{A}{\mathrm{RET}}=\frac{(\mathrm{PE}-\mathrm{RE})\Delta T}{\mathrm{RE}\cdot T_{op}}.$$

Let us define the models on Fig. 8, 9 and Fig. 11–13 as «dynamic models of simple target operations».

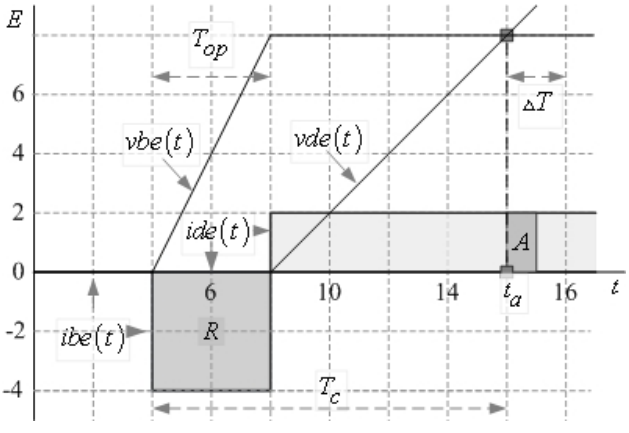


Fig. 13. The principle of determination of the estimated completion time of the operation ($t_a$)

*Definition*. We define the class of models of system operations, in which the input and output products of the operation are reduced to comparable measures, and the dynamics of the bound state of the products of the operation is determined in the whole range of research as the class of dynamic models of the target operation.

## 5. The results of the study of pairs of models of simple target operations using the axiomatic approach

Operations research (Fig. 4–6) was carried out with the help of three different methods.

The first method involves the use of the axiomatic approach. For one of the two operations, which is more efficient according to one of the axioms (№1–№3), a one level was set for the indicator E, for less efficient operation – zero level.

Also, to evaluate the pairs of operations, the indicators of «profitability» (R) and «comprehensive profitability» (RC) were used. The results of identification are shown in Table 1.

Table 1

The results of identification of target models of the dynamic class using the axiomatic approach (E), the indicators of «profitability» (R) and «comprehensive profitability» (RC)

| Task | | RE | PE | T | E | R | RC |
|---|---|---|---|---|---|---|---|
| Fig. 4 | a | 2 | 4 | 4 | 1 | 1 | 4 |
| Fig. 4 | b | 3 | 4 | 4 | 0 | 0.33 | 1.33 |
| Fig. 5 | a | 2 | 4 | 4 | 1 | 1 | 4 |
| Fig. 5 | b | 2 | 3 | 4 | 0 | 0.5 | 2 |
| Fig. 6 | a | 2 | 4 | 2 | 1 | 1 | 2 |
| Fig. 6 | b | 2 | 4 | 4 | 0 | 1 | 4 |

Column E shows the result of rating assessment of efficiency for each pair of compared operations (Fig. 4–6) using the symbols «1» and «0». As can be seen, the profitability indicator, which is determined by the expression $R=(PE-RE)/RE$, does not adequately evaluate operations (Fig. 6). They are defined as equivalent, which contradicts the axiom 3. This is due to the fact that the evaluation expression does not include the time of the operation.

At the same time, comprehensive profitability coped with this task. The operation (Fig. 6, *a*) is defined as more efficient.

## 6. Analysis of the research results

In the paper, three pairs of simple accounting models of target operations were studied for rated efficiency within each pair. This possibility is determined by the axioms 1–3.

It is shown that the use of the standard economic indicator of «profitability» does not provide the opportunity of credible identification of the third pair of simple target operations for a selection of more efficient operation of a pair.

Using the BB method, the dynamic model of the simple target operation was developed. The expansion of the model ice(t) into two functions ibe(t) and ide(t) allowed to create a cybernetic indicator of comprehensive profitability on their basis. The approach to the construction of the dynamic model can be generalized for the whole class of dynamic models of target operations while the indicator of comprehensive profitability identifies only the type of simple target operations.

The class of dynamic models of target operations can be used to develop a new class of identification indicators of target operations.

This work is an extension of earlier studies [11].

Further developments in this area can be associated with the elaboration of the type of reference and reduced models as a subclass of dynamic models of target operations.

It is obvious that the indicator of comprehensive profitability has successfully identified all pairs of operations, which cannot be said about economic profitability. Operations in Fig. 6, *a, b*, a priori with different efficiency, have identified profitability inadequately.

The comprehensive profitability indicator coped with the task successfully.

Studies have shown that the class of dynamic models of target operations has more capabilities as compared to the class of accounting models.

The fact that the comprehensive profitability indicator has provided an adequate evaluation in the process of comparative identification of operations, shown in Fig. 4–6 does not mean that it is the criterion of efficiency. This indicator was used solely to demonstrate the distinctive features that favorably distinguish the class of dynamic models of the operation in comparison with the class of accounting models.

## 7. Conclusions

Determination of the class of dynamic models of target operations allows extending the research methods related to the development of such discipline as operations research.

The paper defines the concepts of « the accounting model of the operation», «the accounting model of the simple target operation» and «the dynamic model of the simple target operation». The concepts of the baseline indicators of the accounting model of the simple target operation were defined. Three axioms that determine the classes of accounting models of simple target operations, the maximum efficiency of which is determined by comparing the values of one of the basic indicators were formulated.

Investigation of models of simple accounting operations using the indicator of «profitability», built with the use of basic indicators characterizing this class of operations,

showed the area of restricted use. This area is determined by the opportunity of rating assessment of the class of models of simple target operations with the same time.

The class of models of system operations, in which the input and output products of the operation are reduced to comparable measures, and the dynamics of the bound state of products of the operation is determined on the whole range of research is defined in the paper as the class of dynamic models of target operations.

The study of the process dynamics of the class of dynamic operations provides opportunities to improve the «sensitivity» of identification methods of operations and to develop a new class of indicators, enabling the optimization of system processes in terms of resource efficiency [12].

The study of the model of the target dynamic operation has allowed to develop the comprehensive indicator of profitability, which provides the rating assessment of the efficiency for the class of the simple target operations.

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