UDC 625.736 (045)

Valter Melkumyan[1]
Ivan Ostroumov[2]
Tetiana Maliutenko[3]

PROBLEM FORMALIZATION OF POLYERGATIC TRANSPORT TECHNOLOGICAL SYSTEMS DESIGN

[1,2,3]National Aviation University
Kosmonavta Komarova avenue 1, 03680, Kyiv, Ukraine
E-mails: [1]melkwh@gmail.com; [2]ostroumovv@ukr.net; [3]tm-nau@ukr.net

Abstract. *The analysis of some aspects of a terminological problem of the scientific direction of the theory of technological systems research has carried out. Determination of concepts and terms of technological systems that will allow to use results of the researches, the latest technologies, optimum control and management systems for production in different spheres of society activity, including in case of design and maintenance of transport systems are offered more expanded according to the contents*

Keywords: design; technology; technological process; technological system, transport system.

1. Introduction

Design of the transport systems (TS) within methodology of the systems concept requires application of accurate scientifically clear structure of the operation activities into different steps: beginning from introduction of the main objectives of design before development, design alternative options and a final choice of optimal structure and levels of characteristics of designed system.

One of the main objectives of synthesis and the analysis of structure and characteristics of complicate polyergatic systems is the optimal choice of methodology of research.

2. Analysis of researches and publications

Now there is developed research of technological system for different aspects of technological systems functioning.

There are conducted intensive researches in the development areas and implementations of alternative technologies, the technological processes, directed on production efficiency increase, lowering of capital investments, operational costs, ecological safety, and so on.

The standard interpretation of the term "technological process" as process of purposeful change of properties of the initial raw materials for the purpose of receiving production with necessary properties, in many respects narrows possibilities of application of researches results in the production sphere, including the newest technologies of optimum control and management systems for production in different fields of society activity.

Together that in different branch research and development operations widely uses the concepts "technology", understanding as it terms processes of formation and different provision of services to customers, such as "information technologies" "construction technologies", " medical technologies" and so on [3, 4].

3. "Aircraft-to-Satellite-to-Ground Station" link model

The term "technological process" is understudied process or set of the processes directed on achievement of the scheduled purposes.

Therefore it is expedient to extend the term "technological process" and understand like as set of interdependent technological operations within the certain technological system, directed on achievement of a main objective of its activities (creation).

4. Aeronautical satellite MIMO channels simulation

Using the expanded concept "technological process" of the term "technological system" we will understand set of certain functionally interdependent structures (subsystems), within the given (regulated) technological processes, for achievement of a main objective of system's function.

Then technological process can understand a certain set of algorithms of functioning and interaction of elements of the technological process, in total providing achievements of the intermediate or end result of formation as the term "technology" of "an output product".

In depending on the purpose of creation and functioning, technological system is possible to divide into three main groups: production (manufacturers of production), service (servicing type) and social.

Besides production and service TS can represent both systems monoergatic (one operator) and polyergatic (group of operators).

Technological systems of one and that group can differ according to technological process characteristics, features of the functioning, the purposes set before them and tasks, formations of “an output product” and at the same time to have the general principles of creation.

Thus polyergatic technological systems may contain both uniform, and different on the functional purpose technological subsystems.

It is easy to find the different functional groups as a part of technological system of servicing type (in the enterprises of transport, service services, etc.).

The main purpose of difficult systems of servicing type (which transport systems belong) is support of customers with set of certain services with necessary characteristics.

The requirements to characteristics of provided services (“the initial product” of technological system) usually are defined with requests of customers.

The research results of difficult technological systems of servicing type allows to group operation design in creation new and upgrade or radical reconstruction of exploited TS on two the generalized a design stage:

1) The first design stage considers the feasibility study on feasibility of creation of system.

2) The operations belong to the second design stage by determination of structure, characteristics and interactions of elements and algorithms of technologies of the selected system which in total provide compliance of output characteristics of designed system to the set requirements.

At the same stage carry out the feasibility study according to requirements of operating standards in the field of design of such class of systems, and also development and design of the appropriate project documentation.

Within the first design stage consider options of the allowed levels of output characteristics of the transport system which minimize levels of technical and economic expenses for creation and support of functioning of designed system and methods of their achievement.

Thus operations according to the analysis of area of functioning are directed on study of the servicing market.

The expression for the generalize description of TS it is representable in the form of such composite functionality:

$$F_{\text{TS}}(s, t) = F(R(v); C(y,t); RR(y, t); T_x(z, t); D(\xi,t)),$$

where $R(v)$ – vector of requirement’s characteristics of “output product” TS;

$C(y, t)$ – functional which to determine structure and characteristic of elements TS;

$RR(r, t)$ – functional which to determine requirement to resource characteristic (include requirement to qualification of personnel), needed for realization TS;

$T_x(z, t)$ – functional which to determine technology of function and intersection of TS elements;

$D(\xi, t)$ – functional which to determine degree of influence external conditions on stability characteristic TS elements.

Operations according to the feasibility study on feasibility of development and creation (or radical upgrade) TS are directed to support admissible, from the point of view necessary levels of output characteristics which minimize levels of technical and economic expenses for creation and support of functioning of designed system and a method of their achievement.

The values of parameters of the TS services have certain dispersion in phase space of requirements of requests, owing to stochasticity of characteristics of structural elements and destabilizing factors.

The assessment of efficiency of TS design in process and reasons for requirements to its main characteristics in many respects becomes complicated existence of prior uncertainty of conditions of its functioning, and also stochasticity of parameters of external and internal destabilizing factors.

The area of TS function in many respects is defined by admissible boundaries of phase space of change of its characteristics under the influence of external and internal destabilizing factors and elimination methods of the degradation processes influence.

Formalization of tasks of study of the market of services at a design stage TS is also connected to great difficulties because of need of the accounting of different often contradictory factors.

Often the account and requirement analysis of customers to characteristics of provided services, in case of simulation are set too simplified that finally leads to inadequate real situations of the made decisions.

With the advent of in the middle 70th theory of fuzzy sets and with development of a row of its application-oriented directions, including fuzzy mathematical programming, there were new approaches in case of the solution of similar tasks [1, 5].

Fundamental role of theories of fuzzy sets play the fuzzy relation [2, 6].

The main task TS consists of supporting conditions for satisfaction of potential customers requirements to signs of offered services with probably smallest additional expenses.

Let the set of potential customers of X, signs of offered services Y, restrictions of Z and expenditures on reduction of restrictions level C be provided in the form of such ordered sets:

$$\begin{aligned} X &= \{x_1, x_2, x_3, ..., x_n\}, \\ Y &= \{y_1, y_2, y_3, ..., y_m\}, \\ Z &= \{z_1, z_2, z_3, ..., z_k\}, \\ C &= \{c_1, c_2, c_3, ..., c_p\}. \end{aligned} \quad (1)$$

The intersection of set's element which describe in (1), we can write in view of fuzzy sets xRy, zGy and cFy with membership function $\mu_N(x, y) \to |0,1|$, $\mu_M(z,y) \to |0,1|$ and $\mu_S(c,y) \to |0,1|$.

$$R = \begin{vmatrix} \mu_R(x_1,y_1) & \mu_R(x_1,y_2) & \cdots & \mu_R(x_1,y_m) \\ \mu_R(x_2,y_1) & \mu_R(x_2,y_2) & \cdots & \mu_R(x_2,y_m) \\ \cdots & \cdots & \cdots & \cdots \\ \mu_R(x_n,y_1) & \mu_R(x_n,y_3) & \cdots & \mu_R(x_n,y_m) \end{vmatrix}. \quad (2)$$

The matrix (2) is to the generalized assessment of potential customers of the offered service to these signs and in a certain level can be interpreted as the requirement to service characteristics as it is possible to determine a level of the significance of its signs by its law for separate groups of potential customers.

$$G = \begin{vmatrix} \mu_G(z_1,y_1) & \mu_G(z_1,y_2) & \cdots & \mu_G(z_1,y_m) \\ \mu_G(z_2,y_1) & \mu_G(z_2,y_2) & \cdots & \mu_G(z_2,y_m) \\ \cdots & \cdots & \cdots & \cdots \\ \mu_G(z_k,y_1) & \mu_G(z_k,y_2) & \cdots & \mu_G(z_k,y_m) \end{vmatrix}. \quad (3)$$

Depending on a problem definition the matrix (3) can be an assessment of influence level of resources available in system on signs of the offered service or satisfaction level them process of formation of service to these signs.

Assessment levels of influence of additional expenditures on reduction of restriction or increase in opportunities of system due to new capital investments it is representable in the form of a matrix F:

$$F = \begin{vmatrix} \mu_F(c_1,y_1) & \mu_F(c_1,y_2) & \cdots & \mu_F(c_1,y_m) \\ \mu_F(c_2,y_1) & \mu_F(c_2,y_2) & \cdots & \mu_F(c_2,y_m) \\ \cdots & \cdots & \cdots & \cdots \\ \mu_F(c_p,y_1) & \mu_F(c_p,y_2) & \cdots & \mu_F(c_p,y_m) \end{vmatrix}. \quad (4)$$

The matrix (4) evaluates a level of influence of additional expenditures on reduction of restriction or increase in opportunities of system due to new capital investments.

In general it is necessary to provide a condition of domination of system opportunities concerning requirements of potential customers of services.

5. Case of full dominance of fuzzy set

The fuzzy relation of zGy dominates over xRy relation on the parameter y if in case of the equivalent to an assessment the condition is satisfied

$$Y_R \subset Y_G,$$

where Y_R and Y_G – sets of elements of matrix column correspondingly

$$\begin{aligned} Y_R &= \{y_{R1}, y_{R2}, y_{R3}, \ldots, y_{Rm}\}, \\ Y_G &= \{y_{G1}, y_{G2}, y_{G3}, \ldots, y_{Gm}\}. \end{aligned} \quad (5)$$

Let's X, Y, Z- ordered sets, xRy:$\mu_R(x,y) \to |0, 1|$ and zGy:$\mu_G(z,y) \to |0, 1|$ – fuzzy relations correspondingly.

So fuzzy relation zGy strictly dominated on relation xRy on parameter y, if for equivalent assessment satisfy the conditions:

$$\forall Y_R, Z_G : \mu_G(z_l, y_i) \geq \mu_R(x_i, y_j),$$

$$l = \overline{1,k}, \quad j = \overline{1,m}, \quad i = \overline{1,n} \text{ for } k \geq n$$

or

$$\forall Y_R, Z_G : \mu_{G^{-1}}(z_l, y_i) < \mu_{R^{-1}}(x_i, y_j), \quad (6)$$

$$l = \overline{1,k}, \quad j = \overline{1,m}, \quad i = \overline{1,n} \text{ for } k < n.$$

So, we should describe matrix columns R and G in next fuzzy sets:

$$\begin{aligned} Y_{R1} &= \{\mu_R(x_1,y_1)y_1, \mu_R(x_2,y_1)y_1, \cdots, \mu_R(x_n,y_1)y_1\} \\ Y_{R2} &= \{\mu_R(x_1,y_2)y_2, \mu_R(x_2,y_2)y_2, \cdots, \mu_R(x_n,y_2)y_2\} \\ Y_{R3} &= \{\mu_R(x_1,y_3)y_3, \mu_R(x_2,y_3)y_3, \cdots, \mu_R(x_n,y_3)y_3\} \\ \cdots & \cdots \quad \cdots \quad \cdots \quad \cdots \\ Y_{Rm} &= \{\mu_R(x_1,y_m)y_m, \mu_R(x_2,y_m)y_m, \cdots, \mu_R(x_n,y_m)y_m\}, \end{aligned} \quad (7)$$

If in sets of expression (7) the condition is satisfied:

$$\mu_G(z_l,y_i) \geq \mu_R(x_i,y_j), \; l = \overline{1,k}, j = \overline{1,m}, i = \overline{1,n},$$

for $k \geq n$, according to conditions of domination of the fuzzy sets given in operation (5), a set of

$Y_G=\{y_{G1}, y_{G2}, y_{G3}, ..., y_{Gm}\}$

dominates over the relation of a set of

$Y_R=\{y_{R1}, y_{R2}, y_{R3},..., y_{Rm}\}$,

therefore is satisfied given above a condition of domination of the fuzzy relations (6), so $Y_R \subset Y_G$, as was to be shown.

For the proof of a condition of domination of the fuzzy relations for $k < n$ in the given fuzzy sets (7) it is enough to replace functions of accessory $\mu_R(x,y)$ and $\mu_G(z, y)$ in addition:

$\mu_R^{-1} = 1 - \mu_R(x, y)$;

$\mu_G^{-1} = 1 - \mu_G(z, y)$.

Let's consider an air transport system as an example.

Let $X \in E_1$ and $Z \in E_2$ are users of airline by regions E_1, E_2:

$X=\{x_1, x_2, x_3\}$;
$Z=\{z_1, z_2, z_3\}$.

Rating of users features of service offered $Y=\{y_1, y_2, y_3\}$ by regions E_1 and E_2 have been estimated by airline experts as next matrixes:

$$R = \begin{vmatrix} 0,3 & 0,5 & 0,6 \\ 0,6 & 0,7 & 0,9 \\ 0,1 & 0,5 & 0,7 \end{vmatrix},$$

$$G = \begin{vmatrix} 0,4 & 0,6 & 0,8 \\ 0,7 & 0,8 & 0,9 \\ 0,3 & 0,7 & 0,9 \end{vmatrix}.$$

The task is to detect the optimal region for airline service direction.

Let's represent matrix as fuzzy sets:

$Y_{R1}=\{0,3y_1, 0,6y_1, 0,1y_1\}$,
$Y_{G1}=\{0,4y_1, 0,7y_1, 0,3y_1\}$;
$Y_{R2}=\{0,5y_2, 0,7y_2, 0,5y_2\}$,
$Y_{G2}=\{0,6y_2, 0,8y_2, 0,7y_2\}$;
$Y_{R3}=\{0,6y_3, 0,9y_3, 0,7y_3\}$,
$Y_{G2}=\{0,8y_1, 0,9y_2, 0,9y_3\}$.

According to (9) users rating by all marks in E_2 direction is higher than in E_2 region.

6. Case of not full dominance of fuzzy set

The fuzzy relation of zGy dominates over xRy relation by the maximum value of parameter y, in case of the equivalent estimation the second projections these relations satisfy the following conditions:

$$\mu_R^{(2)}(x,y) \subset \mu_G^{(2)}(z,y) . \quad (8)$$

By matrix (2) and (3) let's estimate the second projection of fuzzy relations:

$$\mu_G^{(2)}(z,y) = V\mu_G(z_l,y_i), l=\overline{1,k}, j=\overline{1,m}, \quad (9)$$

$$\mu_R^{(2)}(x_i,y_j) = V\mu_R(x,y), i=\overline{1,n}, j=\overline{1m} . \quad (10)$$

Let's represent (9) and (10) in appropriate sets:

$$\mu_G^{(2)}(z,y) = \begin{Bmatrix} \max\mu_G(z,y_1), \\ \max\mu_G(z,y), \\ \max\mu_G(z,y_3),..., \\ \max\mu_G(z,y_m) \end{Bmatrix}, \quad (11)$$

$$\mu_R^{(2)}(x,y) = \begin{Bmatrix} \max\mu_R(x,y_1), \\ \max\mu_R(x,y), \\ \max\mu_R(x,y_3),... \\ \max\mu_R(x,y_m) \end{Bmatrix}, \quad (12)$$

If inside of fuzzy sets (11) and (12) the next relation will be true:

$$\max\mu_G(z,y_j) \ge \mu_R(x,y_j), j=\overline{1,m},$$

then condition (8) is true.

In case xRy and zGy do not meet the conditions of strict dominance in the parameter y initial matrix will be the following:

$$R = \begin{vmatrix} 0,1 & 0,4 & 0,8 \\ 0,3 & 0,9 & 0,3 \\ 0,4 & 0,9 & 0,8 \end{vmatrix},$$

$$G = \begin{vmatrix} 0,2 & 0,4 & 0,9 \\ 0,3 & 0,9 & 0,4 \\ 0,3 & 0,8 & 0,3 \end{vmatrix}.$$

Let's define a second projection of relations according to (11) and (12) as the following sets:

$\mu_R^{(2)}(x,y)=\{0,3; 0,9; 0,3\}$;
$\mu_G^{(2)}(z,y)=\{0,3; 0,9; 0,4\}$.

Maximum rate of user services for region E_2 is higher than maximum rate of user for region E_1 or the same, according to condition (8).

Fuzzy relations cannot be satisfied none of the dominance in the general case.

7. Case of conditional dominance of fuzzy set

Let's use the concept of conditional dominance with a possibility for increasing the opportunities of TS through additional investments.

They make allow correcting the level of service quality in which conditions do not satisfy the dominance logic.

Non-dominant fuzzy relation of zGy conditionally dominates against xRy by parameter y, if equivalent estimation of these relations satisfy the following conditions:

$\exists Z(c): Y_R \subset Y_G$.

If

$X = \{x_1, x_2, \ldots, x_n\}$, $Y = \{y_1, y_2, \ldots, y_m\}$,

$Z=\{z_1, z_2, \ldots, z_k\}$, $C=\{c_1, c_2, \ldots, c_p\}$

are ordered sets and

$axRy: \mu_R(x, y) \to |0,1|$, $zGy: \mu_G(z, y) \to |0,1|$,

$cSy: \mu_S(c, y) \to |0,1|$

correspond to fuzzy relations.

Than

$\forall x, y \in E_1 x E_2, \forall z, y \in E_3 x E_2$

non-dominant fuzzy relation zGy conditionally dominates relation xRy by parameter y, if the equivalent rate $\exists\ Z\ (c)$ satisfiy the conditions:

$$\forall Y_R, Z_G: \mu_G(z_l(c), y_i) \geq \mu_R(x_i, y_j),$$

$$l = \overline{1,k},\ j = \overline{1,m},\ i = \overline{1,n},\ \text{if}\ \ k \geq n$$

or

$$\forall Y_R, Z_G: \mu_{G^{-1}}(z_l(c), y_i) < \mu_{R^{-1}}(x_i, y_j),\ \text{if}\ \ k < n\ .$$

The final step of system design is an iterative process of selection, justification of eligible areas for the existence of the output characteristics of the system, structure building strategies and technologies functioning of subsystems based on the results of the feasibility study of establishing the designed system.

During the criteria selection of technical and economic efficiency of the system at design step it is necessary to detect and understand conflicting points between users and developers.

Requirements to eliminate effects of degradation factors during operation lifecycle are important for users and will be satisfied inside technological system.

Price of technological system design and future support have to be minimized too.

In practice the developer usually tries to find a compromise solution that satisfies the conditions for obtaining the greatest effect on *En* application.

Determination of the size of the predicted total price of technological system design during external design step is an independent research problem.

To determine the amount of operating costs, you can use the value of the weighted average cost of maintaining the n output characteristics of the designed system in the feasible area in m destabilizing factors.

To determine the predicted values of total operational fees it is possible to apply specific system matrix and minimal cost C_0 to support the size of its initial performance at the required level during specific class of destabilizing factors influence:

$$E_n = \max_{y \in Y} E(y),\ \ C_0 = \min_{x \in X} C(x),$$

where Y and X are the sets of possible conditions which will be considered (y, x) to find the solution of design:

$$C_F^T = \left|\ P_j\ (t), C_{ij}^T\ \right|,\ \ j \in m\ , i \in n,$$

where $P_j\ (t), C_{ij}^T$ – probability of j destabilizing factor and elimination of the costs of its effect to the i output system parameter during the operation period T.

External operational choice of nomenclature and permissible parameter values that satisfy the conditions of domination (5) takes place during design step by variation of output parameters and strategies for constructing a rational structure of designed system.

As an example let's investigate the potential market for services of transport system.

Transport services are represented as potential users of three social groups

$X=\{x_1, x_2, x_3\}$

by attributes: y_1 – ticket price, y_2 – level of service and y_3 – movement regularity.

A resource of these TS includes:

– vehicles – z_1;

– operational and technological base – z_2;

– staff experience – z_3.

To meet the requirements of potential users of the transport system it is necessary to evaluate capabilities of the system and to determine the additional costs, aimed to improving the performance of the offered service.

Let's suppose that in the process of data analysis experts compared the system level requirements of potential users of services with capabilities of the system, reducing it to the corresponding relationship matrix

xRy: $\mu_R(x, y) \to |0,1|$ and zGy: $\mu_G(z, y) \to |0,1|$.

Initial matrix will be the following:

$$R = \begin{vmatrix} 0,6 & 0,9 & 0,8 \\ 0,7 & 0,9 & 0,8 \\ 1 & 0,3 & 0,7 \end{vmatrix},$$

$$G = \begin{vmatrix} 0,7 & 0,8 & 0,9 \\ 0,7 & 0,8 & 0,8 \\ 0,7 & 0,8 & 0,7 \end{vmatrix}.$$

The first two groups of users require high quality of service and traffic regularity.

The ticket price is the most important feature of the benefits of the transport service for users from x_3 social groups.

Represented fuzzy relation indicates that the ability of the transport system does not correspond to the full requirements of all groups of potential users to the performance of the service offered.

Let's introduce the average estimation of the designed system capabilities:

$$\mu(z,y) = \begin{vmatrix} 0, & \mu_G(z,y) < \mu_R(x,y) \\ 1 & ,\mu_G(z,y) \geq \mu_R(x,y) \end{vmatrix}$$

Then, let's create an average relation matrix of rating system capabilities:

$$G_M = \begin{vmatrix} 1 & 0 & 1 \\ 1 & 0 & 1 \\ 0 & 1 & 1 \end{vmatrix}.$$

Thus, to meet the requirements of all user groups it is necessary to improve the comfort of vehicles, expand operational and technological base of passenger service to meet the requirements of the first two social groups and reduce the price of the ticket for the third group of potential users.

Additional costs of the system set up have to satisfy the next condition:

$C = (c_1, c_2, c_3, c_4)$,

where c_1 – reduced income system by reducing the price of the ticket;

c_2 – costs by improving comfort inside of vehicle;

c_3 – costs to improve operational and technological base of the transport system;

c_4 – cost of staff training.

Results of expert evaluation of influence of additional costs for the service performance requirements are also presented in relation:

cSy :$\mu_S(c,y) \to |0,1|$.

If we have the next results

$$S = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 0,8 & 0 \\ 0 & 0,7 & 0,6 \\ 0 & 0,6 & 0,7 \end{vmatrix}.$$

Let's define a second projection of fuzzy relation S on the same grounds as services requiring corrections:

$\mu_S^{(2)}(c, y_1) = 1$,

$\mu_S^{(2)}(c, y_2) = 0{,}8$,

$\mu_S^{(2)}(c, y_3) = 0{,}7$.

From the obtained values of the projection relations list of additional expenditure required to meet the requirements of users comes form:

$C = \{1c_1, 0{,}8c_2, 0{,}7c_4\}$.

The final step of the external design is an iterative process of selection, justification of eligible areas for the existence of the output characteristics of the system, structure building strategies and technologies functioning of its subsystems based on the results of the feasibility study and the feasibility of the designed system establishment.

Collection of additional costs should not be resulted in distortions of service solutions for utility systems:

$$D_U - \left(\sum_{j=1}^{N} C_{kj} + \sum_{i=1}^{M} \Delta C_i \right) \geq \varphi(c) \qquad (13)$$

where D_U – possible total profit from services;

C_k, ΔC – investments and the additional costs of a service system, respectively;

φ(c) – the utility function (expected profit).

8. Conclusions

Conflicting requirements of user and developer have to be considered at the designing step during criteria selection of the technical and economic efficiency of the system.

It is important for users to provide the complete requirements to eliminate effects of degradation factors during operation cycle.

But operating system fees and designed price have to be minimized for developers.

In practice developers usually try to find a compromise solution that satisfies the conditions for obtaining the greatest effect on En application.

When compliance with the requirements of all potential users of the proposed transportation service does not satisfied the condition (13), we solve the problem of narrowing the provision of services or reduce the permissible level of expected profits at the expense of losing a certain amount of potential consumers of different social groups.

In this case the problem of optimizing the size of the additional costs at an acceptable level of profitability of the transport company is transformed to fuzzy mathematical programming problems.

References

[1] *Kandel, A.* Comments on the Minimization of Fuzzy Functions. IEEE Trans. on Comput. Feb. 1993. Vol. 22. P. 217.

[2] *Kaufmann, A.* Introduction to the Theory of Fuzzy Subsets. Vol. 1. Fundamental Theoretical Elements. New York, Academic Press. 1973.

[3] *Kharchenko, V.P.; Melkumyan, V.H.; Malyutenko, T.L* Applied problem of service technological systems designing. Third world Congress "Aviation in the XXIst century". 2008. P. 31.14–31.22.

[4] Zadeh, L.A. Fuzzy sets. Information and Control. 1965. Vol. 8. P. 338–353.

[5] Zadeh, L. A. Outline of a new approach to the analysis of complex systems and decision processes. IEEE Trans. Syst. Man Cybern. 1973. P. 28–44.

[6] *Zimmermann, Hans-Jürgen.* Fuzzy Set. Theory and Its Applications. Springer. 2001. 514 p.

Received 5 June 2014.

В. Г. Мелкумян[1], І. В. Остроумов[2], Т. Л. Малютенко[3]. Формалізація завдань проектування поліергатичних транспортних технологічних систем

[1,2,3]Національний авіаційний університет, просп. Космонавта Комарова 1, Київ, Україна, 03680

E-mails: [1]melkwh@gmail.com; [2]ostroumovv@ukr.net; [3]tm-nau@ukr.net

Виконано аналіз деяких аспектів термінологічної проблеми наукового напряму теорії дослідження технологічних систем. Запропоновано більш розширені за змістом визначення понять та термінів наукового напряму, що дозволить використовувати результати досліджень, новітніх технологій, оптимальних систем контролю та управління виробництвом у різних областях діяльності, у тому числі під час проектування і експлуатації транспортних систем.

Ключові слова: проектування; технологія; технологічний процес; технологічна система; транспортна система.

В. Г. Мелкумян[1], И. В. Остроумов[2], Т. Л. Малютенко[3]. Формализация задач проектирования полиэргатических транспортных технологических систем

[1,2,3]Национальний авиационный университет, просп. Космонавта Комарова 1, Киев, Украина, 03680

E-mails: [1]melkwh@gmail.com; [2]ostroumovv@ukr.net; [3]tm-nau@ukr.net

Проведен анализ некоторых аспектов терминологической проблемы научного направления теории исследования технологических систем. Предложены более расширенные по содержанию определения понятий и терминов научного направления, что позволит использовать результаты исследований, новейших технологий, оптимальных систем контроля и управления производством в различных областях деятельности, в том числе при проектировании и эксплуатации транспортных систем.

Ключевые слова: проектирование; технологическая система; технологический процесс; технология; транспортная система.

Melkumyan Valter. Doctor of engineering sciences, Professor.
Air Navigation Systems Department, Institute of Air Navigation, National Aviation University
Education: Kyiv institute of civil aviation, Kyiv, Ukraine (1961)
Research area: methodology of increase of efficiency of the aeronautical systems as a complex technological system
Publications: 48
E-mail: ans@nau.edu.ua

Ostroumov Ivan. Candidate of science, dotsent, Associate Professor.
Department of Air Navigation Systems, National Aviation University, Kyiv, Ukraine
Education: National Aviation University, Kyiv, Ukraine (2006)
Research area: technology of positioning in airspace
Publications: 71.
E-mail: ostroumovv@ukr.net

Maliutenko Tetiana. Assistant
Air navigation Systems Department, National Aviation University, Kyiv, Ukraine
Education: National Aviation University, Kyiv, Ukraine (2007)
Research area: methods of precision increase of aeronautical information, satellite navigation system
Publications: 9
E-mail: tm-nau@uk.net