Information Technologies Efficiency Models for Agile Systems Functioning

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***Abstract*—The article outlines conceptual and derivative formal models that provide means for estimation of efficiency and other operational properties of agile systems operation with regard to the use of information technologies. The estimation is fulfilled analytically through plotting the dependences of predicted values of operational properties against variables and options of solved tasks. To develop this type of models, the use of information technologies during agile systems functioning is analyzed through a technological agile system. General concepts and principles of modeling of information technology use during operation of agile systems are defined. An exemplary modeling of effects of technological informative and related technological non-informative operations of technological agile systems operation is provided. Based on concept models of operation of agile systems with regard to information technologies use, set-theoretical models followed by functional models of agile systems operation using information technologies are introduced. The examples of calculated factors of agile system operational properties and information technologies use are given.**

I. Introduction

Among the proceedings of Russian scientists in the field of "Investigation of the effectiveness of targeted processes", the work of Academician A. N. Kolmogorov [1] is the first to be described; it states a number of methods for estimating the efficiency of firing. These methods were further developed in the theory of the effectiveness of targeted processes [2, 3]. They assumed the efficiency as a probabilistic measure of compliance of the analytically calculated characteristics of the random effects of a purposeful process to the targeted values of these characteristics. This measure can be described as the probability (or other) measure of a random vector of effects hitting the target area. Models and methods of such measure construction and its analytical estimation proved to be useful, especially for optimization problem formulation.

The effectiveness of system operation and other operational properties abroad of Russia have been traditionally studied on the basis of statistical and econometrical methods and models, mainly based on "a posteriori" research, as well as through development of heuristics, for example, the “best practices”, such as PMBOK, CMMI, BABOK, and BPM, especially regarding the application of IT. It is important to note that due to the differences in models and methods applied, the Russian School of effectiveness study carries out an estimation of operational properties quantitatively, using analytical models of purposeful functioning, "a priori" research. As a result, the prediction on analytical (numerical) models and solving the optimization problems become possible.

The article introduces conceptual and formal models of agile systems functioning with regard to the use of information technologies (hereinafter referred to as “IT”). Their first distinctive feature consists in their revealing of relations between environment impact (that may lead to imperative improvement of the system and its operation) and informative and non-informative actions required for this system operation as a reaction to impact of the environment. Second, the developed concept models facilitate transition from geometric graph and set-theoretical to functional models that describe the connections revealed at concept modeling using analytic dependences between: Agile system operational properties (from here referred to as “OP”) with regard to IT application, impact of system environment, and informative and non-informative effects of agile system functioning. OP describes the main results (effects) of the application of systems.

It is better to carry out the improvement of systems and processes of their operation analytically, by solving the mathematical tasks of the OP research. Mathematical tasks of OP research shall be carried out on the base of OP indicators analytical estimation. Examples of OP are effectiveness, efficiency, capability, potentiality, productivity [1-8]. It was suggested to estimate them based on analytical possibility measure [3,9] estimation. Concept and then, mathematical models to compute OP indicators are required to solve research tasks as mathematical problems of operations research and mathematical programming. To develop such models analytic relations between informative and non-informative effects and impact of the environment are revealed in such a way that: First, the models would be based on patterns of operation conditioned by changing environment. Second, the models would register potential demand to implement processes of improvement of systems and their operation (as a reaction to changing environment). Third, they would register subsequent transient behavior of changes in the system and its functioning.

Following these models and given the use of IT, analytic dependences of OP predicted values in an agile system are plotted against variables and options in solved research tasks, namely, in estimation problems, during evaluation of agile systems OP with IT use, in design problems of agile system functioning (with the account of transition processes in operation) on the basis of OP factors of agile system functioning at IT use. To describe the relations between informative and non-informative effects at agile systems functioning (hereinafter referred to as ASF), concepts and principles (concept model) of IT application during ASF are suggested. By applying these concepts and principles, general patterns of IT application effects in the context of ASF are revealed. The suggested conceptual model provided for transition first to graph-theoretical, set-theoretical and then to functional model (to estimate probabilistic measure [9]) of IT use, in the context of ASF that is based on patterns of non-informative effects development with the use of informative effects. Based upon practical application, solution of these problems is relevant when researching: Enterprise architectures, use of IT, implementation of governmental projects and programs involving the use of IT [10-12].

General concepts and principles for IT use during agile systems functioning described at second section, for IT use modeling – at third one. Examples of schemas for operational properties indicators estimation introduced at fourth section, example of IT technologies efficiency functional models during agile systems functioning suggested at fifth section.

II. General concepts and principles of IT use

IT application in the context of ASF is exemplified with IT application in technological agile systems (hereinafter referred to as “TAS”) (including the related transition processes and IT application). Suppose, their operation is technological if defined by execution of technological operations, specifically by definition of technological operation execution in technological documentation in TAS. These include, for instance, systems that function to enforce manufacturing of unique products (e.g. in aerospace industry) and systems for implementation of governmental projects and targeted programs. General concepts required for development of models of IT application in the context of TAS include: IT, IT application, information, information use, system, system operation, purposeful changes in system operation, target, outline of changes in system operation, benefit, technological informative operation, technological non-informative operation, system operation effects, effects of transition processes during functioning. Concepts are linked together in a complex on a scheme of purposeful changes to ASF with the application of IT (figure 1). IT effects [4] are manifested at ASF conditioned by changes in operation (for example, by transition processes from reaching one target to reaching another). This change in operation becomes apparent in changes in non-informative actions (their composition, properties and sequence). The changes in non-informative actions are caused by results of the informative actions. Implementation of informative actions is governed by necessary consideration of environment impact at ASF. As a result of the series of changes, the personnel using TAS acquire the effects different from those that would appear, should there have been no changes, that is, not considering environment impact or the new ASF, conditioned by this impact.

The operation implementation with new chosen parameters is explained by technological informative operations implemented to consider environment impact. These technological informative operations provide for selection of next technological operations with better parameters (in effected conditions) depending on the changes in the states of TAS and its environment. Best operational effects are achieved through consideration of these changes at execution of technological information operations. The use of different types of technological operations (from now on referred to as “TlOp”), e.g. informative, non-informative, at ASF depending on verified TAS states and its environment is illustrated on Fig. 1.

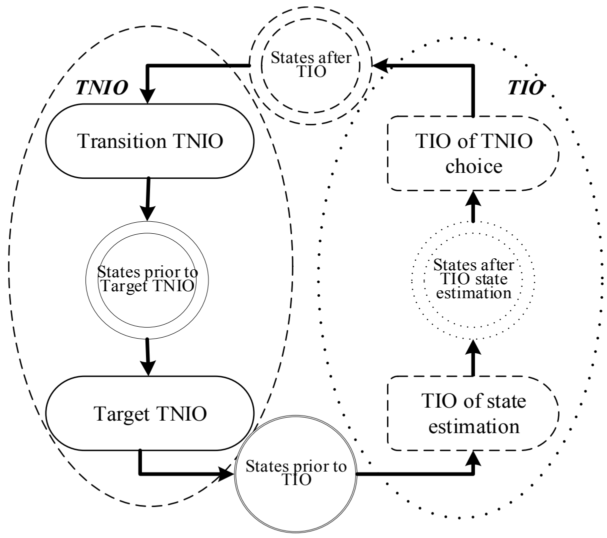

Fig. 1. Use of different types of TlOp at ASF

When TlOp sequences are implemented, first technological informative operations (hereinafter referred to as “TIO”) are executed. These operations estimate changed states of the environment and system elements with regard to environment impact. Further, TIO liable for changed TlOp are executed (if necessary). Their target result is to obtain information about the TAS state and its environment and what should be changed with this regard. Then technological non-informative operations (hereinafter referred to as “TNIO”) connected with informative operations by cause-effect relations are executed through practical implementation. The notions of information and IT, benefits of IT, benefits of information, informative and non-informative actions, TlOp, TIO, TNIO and other related notions were specified in [4]. Principles of agile system research and a number of related notions were introduced in [5]. General OP characteristics were defined in [6-8]. Let us specify the notions that are used further in the context of functional modeling of ASF.

Technological informative operation (TIO) is an informative action to be taken according to the technological documentation (e.g. manuals, descriptions). Technological non-informative operation (TNIO) is a non-informative action to be taken according to the technological documentation. Technological informative operations are executed according to a certain information technology. TIO (or, as a rule, a number of TIO) aims at obtaining (creation) and transforming the information into such a form, where it could be used by a person or technical equipment to solve a task of choosing (for instance, choosing a mode of TNIO). During implementation of TIO and TNIO sequences, depending on the occurred events and states of TAS elements and environment, which were revealed as a result, different TIO are executed. Then TIO are used for choosing various TNIO resulting in occurrence of various events and states of TAS. In this regard, the states of TAS and environment do not recur during operation in reality, and sequences of TlOp, events and states (a loop in figure 1) should be expanded into structured sequences of events and states (outcome tree). As a result, numerous possible state sequences are obtained. They are connected by branches (events) depending on states of TAS, environment and implemented sequences of TlOp (TIO and TNIO), and the events, which are revealed during TlOp execution. TAS operation outcome is a sequence of conditioned states of TAS and branches (events) between them caused by TlOp (TIO and TNIO) and actions of TAS environment. During operation, the actual TAS operation outcome is reviewed, being a sequence of implemented TAS states and branches between them caused by TlOp. During planning, the possible operation outcomes are reviewed, being a sequence of possible states and branches between them caused by TlOp (TIO and TNIO). Composition and characteristics of TlOp, which lead to possible operation outcomes, change as a result of TIO. TIO lead to various sequences of random events and states revealed as a result of changes in environment states. These events and states form possible outcomes. Each possible outcome, except for various possibility measures of its implementation (depending on states of TAS and environment, and implemented TlOp) complies with different effects (results with specified requirements) of operation and different operation efficiency.

Operational properties of TAS and IT, namely TAS potential OP (with regard to IT application), describe system parameters associated with its operational efficiency in changing conditions. This property should be estimated based on the modeling of all possible operation outcomes. TAS potential is a property that indicates if an agile system is suitable to reach changing targets (actual and possible). It would be rational to use the difference between TAS with applied “new” and “old” IT as an indicator of operational properties of the “new” IT compared with previously use one.

This indicator (measure of possibility) should be estimated on the basis of models (formalizations of concepts suggested), in particular, as a result of all TIO, TNIO characteristics and TIO, TNIO sequences probabilities modeling.

III. Concepts and principles for IT modeling use

Concepts applied during development of ASF models with regard to transition actions of TAS improvement, and principles applied during concept and formal modeling of agile systems were defined in [4-6]. Let us consider general concepts, which require interpretation due to suggested concept of IT application in the context of ASF. Simplex of TlOp (simplex) is a sequence of initial TIO (TIO required to initiate TNIO), TNIO and final TIO (TIO required to terminate TNIO). Reduced simplex (hereinafter referred to as “RS”) is a simplex containing zero TNIO. There are several types of RS depending on the type of state evaluation task they solve: If RS solves a task of general TAS state evaluation at the moment (to the moment) then it is type one RS. If RS solves a problem of state evaluation of several sites at the moment (to the moment) then it is type two RS. Depending on their specifics, different RS should be executed to evaluate the states of TAS and environment as a result of execution of simplexes. This rule is fixed by a principle of simplex linking through RS implementation. These RS are implemented differently depending on the results of execution of prior TlOp and environment states. RS target result consists in chosen composition and course of further actions. This result should be used in consequent non-reduced simplexes to achieve target results of TNIO (e.g. treated blanks). While different sequences of simplexes and RS should be executed differently (depending on various recorded states of TAS and environment), different states are implemented as a result. Afterwards these states could lead to implementation of various simplexes and TAS transition into next states, as a result. Definition of these sequences is given as a principle of functional dependency of TAS operation outcome from simplexes and states of TAS and its environment.

Nodes of an outcome tree are possible states achieved as a result of TlOp (TIO and TNIO by selected means), and tree edges stemming from the parent node are possible outcomes (transitions between states) resulting in TlOp implementation. Tree branching line at TAS operation complies with one of the (possible) functional events providing it became actual. If a TAS state during operation is calculated on the basis of the state of several sites and respective RS of type two, the subtrees complying with possible states of sites and their combinations are connected into the branch. The outcome tree corresponds with all possible TAS operation outcomes.

Composition and characteristics of outcomes and the outcome tree depend on the TlOp composition and characteristics, and, as a result, on the used IT. In particular, possibility measure of implementation of every possible outcome (possibility measure of reality of outcome) depends on the composition and characteristics of TlOp (TIO and TNIO) and state of environment at operation. Operation effects achieved as a consequence of certain outcome implementation depend on the composition and characteristics of TlOp (and the IT) and on the states of environment at operation. Knowing the possible outcome and characteristics of the effects, providing this outcome is real, one could calculate TAS potential as well as other OP indicators. The feature of the earlier introduced concepts and principles of OP estimation regarding the improvement of systems and processes of their operation implies, first of all, that such operational properties, as the potential of a system [7,8], allow for transition actions implemented with changes in system performance, the results of such transition processes, and the results of subsequent operations. Therefore, it becomes possible to estimate OP indicators, taking into account the effects of transition actions, and to solve corresponding mathematical problems. Secondly, the introduced OP allow for switching to the analytical estimation of OP, depending on the selected system characteristics, their functioning and improvement (targeted changing), and capability of purpose updating, which allows solving the tasks arising during improvement, such as mathematical problems of analysis and synthesis as well as optimization problems.

A study of OP includes an evaluation of the OP indicators, analysis of OP, and synthesis of system characteristics and its operation, according to the operational properties evaluation results. The result of the OP study is a detailed specification of the actions undertaken, i.e. solving the task (mathematical) of action selection. If IT used, a solution is obtained in the form of a (digital) action model. This model may be used in practice through the targeted changes in practice (focused improvement of activities). The accuracy of OP estimation influences the results (produced using a particular IT) of solving the problems of the selection of actions, followed by the results of the improvement of operating experience. The need to investigate the operational properties, solve the problem of choosing actions, and improve practical activities appears from time to time and the processes of its improvement are systematic and can manifest as complex tasks of experience improvement. Thus, for example, the actions planned as a result of solving the problems of OP indicators determination can be arranged in the form of a state target program (TP), defined as a set of interrelated activities aimed at addressing the systemic problems of development of the state and society.

Such actions can be used to implement changes of different types (control, transition, modernization, innovative). Their planning, preparation, and implementation can cause in their turn (in chain order) the assignment of tasks for the improvement of systems and their components, and improvement of their operation. Such tasks can appear to be newly made, and some additional actions have to be carried out for their addressing. In this regard, a number of following features are to be considered taking into account performance of OP, concepts, and methodology of OP research during improvement of systems and processes of their operation:

Estimation of OP during the improvement of systems requires the predicting of future compliance of effects to the requirements of targeted improvement of systems, their operation and other varying influences. It is necessary to investigate the compliance of the effects to the changing requirements of different possible conditions to achieve different targets.

All the possibilities of the sequence of transition actions must be kept in mind. Transition actions are purposeful changes from previous to new operation during the operation. People are forced to make decisions during the implementation of these actions in order to organize these transition activities and subsequent targeted actions under such changing conditions. For this purpose, certain IT are used (e.g. conventional and/or digital).

It should be kept in mind that the need to implement transition actions, characteristics of transition actions, and states after the transition actions that are required for further achievement of targets depends on operational conditions, possible targets, and states in which the functioning system appears before transition actions are implemented. Given the stated conditions, it is required to solve a sequence of tasks of different types about the ongoing transition and other activities, depending on the observed state and necessary targets. These types of tasks are related to the tasks of a choice and need to be solved with any (one or more) IT, irrespective of whether it automated or not. The loop of changing actions is fulfilled directly or indirectly by someone; this person forms the targets, determines the states and their conformity with targets, predicts the future, updates the tasks of changing operating experience, and then solves the tasks using some IT.

Formulation and solution of tasks of estimation, analysis, and synthesis of systems and their operation based on numeric, analytically calculated OP indicators, allows for proceeding to the formulation and solving of practical problems of improvement of systems and their operation with IT usage as mathematical tasks of OP research, application of mathematical models. A typical OP indicators estimation scheme allowing for an analytical evaluation of indicators as possibility measure, on the base of the concepts above was determined and described below.

IV. SCHEMAS FOR OPERATIONAL PROPERTIES ESTIMATION

A. Types of schemes for operational properties indicators estimation

Let us introduce the typical schemes for the estimation of OP indicators. The first scheme is aimed at the estimation of operation efficiency. According to an estimation with this scheme, it is assumed that the decision - made with IT use - on improving actions during their implementation, improving systems and processes of their operation does not affect (or not accepted for) the functioning, while the actions are aimed at achieving one target and are not interrupted.

The second scheme generalizes the first scheme to account for a plurality of possible operations in order to reach different targets under different conditions. According to this scheme, it is assumed that the possible improvements are determined in advance, with use of IT, actions may be interrupted when the target is changed, and then certain transition improvement actions determined (with IT use) before the start of operation.

Finally, the third scheme summarizes the first two schemes in order to account for both possible transition actions selected before their application to achieve different targets and targeted transition actions selected and implemented during operation, depending on the prevailing conditions.

B. Basic scheme of operational properties estimation

Let us introduce I_p as a value of measure on the set, p as a function defining this measure, Y-set of vectors of random characteristics of operational effects (characteristics of operational quality), R-set of vectors of the required component-wise relations between random values of effects of characteristics and their desired values, Y^r-set of vectors of characteristics values of the required functioning effects. Then, the estimation of I_p is set by the following scheme [7]:

$$p: Y \times R \times Y^r \rightarrow [0,1] \quad (1)$$

$$I_p = p(Y \times R \times Y^r) \quad (2)$$

I_p is the measure value of the possibility, indicating that the predicate in parentheses takes the value "true" or the value indicating that the random event corresponding to the predicate occurs. Thus, if $Y=y$ is a random variable defined on the axis of real numbers, R is the ratio "at most", y^r is the point at the real axis (the required value of the random variable y), then $p=F_y\ (x),\ I_p=F_y\ (y^r)$ is the value of the function of distribution of the random variable y in the point y^r.

C. Scheme of operational properties estimation given that the transition processes are known during target changing

Let us introduce $Y^r\ (t)$ as a random process modeling any possible accidental changes Y^r in time (which corresponds to the possible changes in targets of system operation), t_0 as the start moment of the system operation, $Y^r=Y^r\ (t_0)$, T as a target duration of the system operation. Then, the scheme of the estimation of operational properties would be of the following type:

$$p\colon Y \times R \times Y^r\ (t),\ t_0,\ T \rightarrow [0,1] \tag{3}$$

$$I_{op}=p\ (Y \times R \times Y^r\ (t)),\ t \in [t_0,\ T] \tag{4}$$

I_{op} is the measuring value of the possibility that the predicted values of system operation effects (under varying targets) comply with the desired values of effects in the corresponding way. Whereby:

$$I_{op}\ (t_0)=I_p \tag{5}$$

If the requirements are changed and corresponding changes can be determined before operation, it is necessary to plan a transition process (with the characteristics u) from one operation to another under the stated changes, which makes it possible to estimate the value of I_{op}. However, if characteristics u of transition actions cannot be determined in advance and depend upon the state of the system and the environment during operation, it is necessary to use the third estimation scheme. According to this scheme, all transition actions are a sequence of changing actions depending upon the state s (a state is the set of properties performance at a given time) during the operation of the system and the environment. Such states and actions are determined with use of IT.

D. Scheme of the estimation of operational properties given the processes of improvement depend on system states during its operation

The last OP research scheme is used when sequences of transition processes described with the characteristics u are planned and implemented during operation, depending on achieved states of the system and the environment s. Transition actions are a set of actions and relations between them, selected in accordance with different IT applied to change the "target" action and (or) necessary for the better achievement of changed or unchanged targets in view of the state that would result when the target is complete. These actions show the aimed effects because of the actions selected for the "target" process and changing its effects. At the same time, support resources are spent for their implementation. The constraint of $u\ (s)$ describes the characteristics of transition processes necessary for calculating the effects of transition actions and then targeted actions. Characteristics of the sequence $uc=u_1 \ldots\ u_n$ of such transition actions out from the plurality of possible sequences characteristics U_c depend on the characteristics of the manifested sequences of states $sc=s_1 \ldots\ s_n$ out of the plurality of possible sequences of states Sc. The scheme of estimation of operational properties in this case is as follows:

$$p\colon Y\ (Uc\ (Sc),\ t) \times R \times Y^r\ (t) \rightarrow [0,1] \tag{6}$$

$$I_{ops}=p\ (Y\ (Uc\ (Sc),\ t) \times R \times Y^r\ (t),\ t \in [t_0,\ T],\ sc \in Sc,\ uc \in Uc \tag{7}$$

I_{ops} is the measuring value of the possibility that the predicted values of operation system effects (under varying targets and transition actions) meet the required values of effects in a corresponding way, in accordance with these targets. Note that the possible sequences sc and uc depend on applied IT. At this, the previous estimation scheme complies with $Uc=u$:

$$I_{ops}\ (Uc\ (Sc),\ t)=I_{ops}\ (u,\ t)=I_{op}\ (t) \tag{8}$$

V. An example of IT efficiency functional models

The functional models to determine predicted values of system operation effects in (1-8) are developed through systematic re-expression of geometric graph and set-theoretical models. Let us set:

$m_{b.d} -\ d -$ event method a_b, of a set $M_b=\{m_{b.d}; d=\overline{1,D}\}$, of methods (described as possible implementations and predicted outcomes of events in technological documentation);

$C_i -\ \ i -$ TAS operation outcome, possible sequence of outcomes of events (outcome tree branch);

$e_{i.k}(m_{b.d})=<s_{i.k}, s_{i.k+1}(m_{b.d})>-$ event consisting in transition of elements to sites involved in the event a_b from state $s_{i.k}$ to state $s_{i.k+1}$ as a result of event execution a_b through $m_{b.d} -$ (i.e. event outcome a_b at site by method);

$C_i=<(s_{i.0}, e_{i.0}(m_{0.h})), \ldots, (s_{i.k}, e_{i.k}(m_{g.f})), \ldots, (s_{i.K}, e_{i.K}(m_{s.v}))>$:

$s_{i.k+1}(m_{g.f})=<\tilde{y}_{i.k+1.n}(m_{g.f})>-\ k+1-$ state being terminal in event outcome a_f by $m_{g.f} -$ method initiated from $s_{i.k}$, functional event element C_i. It is represented as a vector of effects as a result of $k -$ outcome of $e_{i.k}(m_{g.f})$ event a_f in operation C_i outcome;

$\{m_{0.h}, \ldots, m_{g.f}, \ldots, m_{s.v}\} -$ event methods $a_h, \ldots, a_f, \ldots a_v$ revealing an outcome of event set of TAS functioning C_i (i.e. outcomes of events $a_h, \ldots, a_f, \ldots a_v$ if implemented in such a way that the respective outcomes are included in outcome C_i);

$s_{i.K}=<\tilde{y}_n(C_i, t_\kappa)>-$ state at outcome end of TAS functioning event set C_i, namely, vector of effects of functioning, fulfilled to the moment t_K of operation end according to event set outcome C_i, where $\kappa -$ is a number of the terminal event outcome in C_i (i.e. number of end TIO outcome in C_i);

a_b may be specified by event associated with it $e_{i.k}$ at implementation a_b by methods $m_{b.d}$: $a_b = \{e_{i.k} : e_{i.k} \sim m_{b.d}\}$. $T_c\,(C_u^{\partial},h) = \{C_i, i = \overline{1,I}\}$ – c – tree of possible outcomes of TAS functioning constructed for a preset sequence C_u^{∂} of directive states formed at the boundary of TAS and its environment (environment operation outcome at TAS boundary) and for a preset IT h from a set H of possible IT.

Outcome C_u^{∂} of environment operation at TAS boundary is set by possible environment impact on TlOp elements at ASF. The outcome in the example is characterized by set, constant effects required only for C_i termination. Required informative and non-informative effects [4,5] are understood to be primary results of an action, both target and providing (resources, time). The tree is constructed at the stage of planning depending on the following: outcomes of environment operation C_u^{∂} (of which there are several, in general), possible TIO set in relation to the applied h – IT and boundary states; relations between TIO and TNIO depending on the used technology; TAS changing states as a result of environment impact.

$p_{i.k} = Poss(\tilde{E}_{i.k})$, where $Poss(\tilde{E}_{i.k})$ – is a possibility measure of a random event $\tilde{E}_{i.k}$; The possibility measure has a broad definition here [4] as one the measures (probability, indistinct measure, other types of measures and their combinations).

$\tilde{E}_{i.k}$ – a random event that involves that the k – outcome (transition $e_{i.k}$ between states) at event implementation a_b is accomplished accordingly. As a result of each environment operation outcome C_u^{∂} at TAS boundary and each TAS operation outcome C_i with application of one IT or the other, a different alignment is formed (at boundary of TAS and its environment). This alignment should be checked for the best choice of IT. Assume:

$\tilde{Y}_{j.i}$ – value j – of operation effect to the end of C_i ; $\tilde{Y}_{j.i} = f(C_i)$. For instance, labor content of service.

$\tilde{Y}^{\theta}_{j.i}$ – requirements from the environment to j – operation effect to the end of C_i ; $\tilde{Y}^{\theta}_{j.i} = g(C_i, C_u^{\partial})$.

$p_i(C_i, C_u^{\partial}) = \prod_{k: e_{i.k} \in C_i(C_u^{\partial})} p_{i.k}(C_i)$ – possibility measure of implementation of TAS functioning outcome C_i providing the outcome at boundary between environment and TAS is C_u^{∂} ;

$W_i(C_i, C_u^{\partial}) = \prod_{j=1,J} Poss(\tilde{Y}_{j.i}(C_i) \lessgtr \tilde{Y}^{\theta}_{j.i}(C_i, C_u^{\partial}))$ – possibility measure of meeting the requirements at TAS functioning outcome C_i and environment operation outcome C_u^{∂} (TAS performance measurement at preset outcomes of TAS and its environment operation). Results of TlOp package should be estimated with the account of all possible functional events at different environment impact and during different TlOp (TIO implemented according to preset IT and TNIO, which are carried out with regard to preset non-informative technology). Scalar characteristic of TAS potential meets this requirement, potential function [8] when h – IT is applied, calculated across all environment operation outcomes C_u^{∂} , with regard to possibility measures p_u of their implementation:

$$\psi(T_c, h) = \sum_{C_u \in T_c} [\sum_{C_i \in T_{c.u}(C_u^{\partial}, h)} \left(W_i(C_i, C_u^{\partial}) \cdot p_i(C_i, C_u^{\partial}) \right)] \cdot p_u \ .$$

Assume there are two IT, h (“new”) and f (“old”). For them c – (for h – IT) and p – (for f – IT) trees of outcome for TAS operation were constructed $T_{c.u}(h)$ and $T_{p.u}(f)$ for every possible outcome C_u^{∂} of environment operation at boundary with TAS from the tree of environment operation outcome T_c (at fixed outcome C_u^{∂} TAS functioning outcomes form trees $T_{c.u}(h)$, $T_{p.u}(f)$ of TAS operation outcomes when h – and f – IT are applied). Let us define the difference between TAS potential function values when old and new IT are applied. $\Delta\psi(h, f, T_c) = \psi(T_c, h) - \psi(T_c, f)$.

This difference defines OP of the “new” IT application as compared to the “old” one given the execution of the same outcomes C_u^{∂} of environment operation at the TAS boundary with the same measures of possibility p_u , according to the preset T_c . The difference defines the target effect of new IT application. The target effect reflects how suitable the IT is to reach changing targets (according to the outcomes of environment operation at boundary with TAS). The described target effect is to be compared with effects that ensure the target effect is reached (at IT application). This should be done using efficiency factors of the new IT application. Efficiency factor of the new IT application could be introduced traditionally [1-3] as a possibility measure [7] evaluating if the characteristics of the effects meet the requirements. The factor should be estimated in the context of possible outcomes of environment operation C_u^{∂} at TAS boundary with the account of value of potential $\psi(T_c, h)$ function for h IT. If it measures positively meaning the new IT should be implemented then the result should be used as a performance indicator of h – IT as compared with the previously used IT. For further calculation of efficiency factor of h – IT implementation, the agility of h – IT implementation and resource intensity of h – IT implementation should be evaluated as well.

VI. CONCLUSION

The results obtained allow evaluating predicted values of agile systems operational properties and information technologies use. They shall help to analytically estimate operational properties, in particular - the efficiency of implementation of new information technologies and other operational properties related to information technologies usage depending on variables and options in solved tasks. This should lead to a solution for the contemporary problems of the efficiency and other operational properties research using mathematical models.

ACKNOWLEDGMENT

Performed under support of the RFBR grant No. 16-08-00953

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