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Models and Methods of Optimal Information Operations Use for System Functioning

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***Abstract*—The article outlines models of system functioning and methods to use these models for solving problems of optimal information operations use for systems functioning. Models provide means for estimation of information operation effects and as a result, the operational properties of systems and their functioning with regard to information operations fulfilled. Such systems' functioning is changed due to information operations. Examples of operational properties are efficiency, the effectiveness of system functioning, system capabilities and system potential. Operational properties are estimated based on functioning effects. Such effects of information operations are manifested through a system functioning under the conditions of a changing environment. An estimation of effects and operational properties is fulfilled analytically. This makes it possible to solve appropriate practical problems of optimal information operations usage as mathematical problems. It is made through plotting the dependences of the predicted values of effects and operational properties of information operations and corresponding IT usage against the variables and options of problems solved. To develop this type of model, the use of information operations during system functioning is analyzed through an example of a technological system. An exemplary modeling of the effects of technological information and the related technological non-information operations of technological systems operation is provided. Based on concept models of information operations of technological systems, functioning set-theoretical models followed by functional models are introduced. An example of operational properties indicators estimation is considered. It is based on Architecture of Integrated Information Systems (ARIS) diagramming tools' usage. Use cases of such indicators include choosing optimal information operations characteristics.**

Keywords— ***information operation, information technologies, optimization, modeling, efficiency, indicators, models, methods***

I. Introduction

As shown in [1], chains of information operations are required to create dynamic capabilities or potential in systems under conditions of environment changes. Dynamic capabilities are usually defined in known literature [2] as the ability of a firm to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. A more detailed definition of dynamic capabilities as a firm's "behavioral orientation to continuously integrate, reconfigure, renew, and recreate its resources and capabilities, focusing on upgrading and reconstructing its core capabilities in line with dynamic, changing environment to obtain and sustain competitive advantage" was given in [3]. A role of dynamic capabilities consists in "changing internal components of the firm and creating new changes" [4].

As we can see, these definitions describe the ability of a firm or an organization to change, adapt, compete, and perform in a changing environment. We define system dynamic capability as a systemological property. System dynamic capability is a system's ability to perceive its changing goals in its changing environment. This definition is similar to our previous definition of a system's potential and other operational properties of systems and operational properties of information technology usage [5–9]. Other examples of models and methods for the definition and estimation of such properties can be found in [10–28]. This ability to perceive a system's changing goals in its changing environment requires a system to check system and environment states which could be done with sensors or humans, to learn, to produce information about actions needed for further execution and then to perform such actions in order to change the system and its actions, and to adapt and perceive changing goals in a changing environment. This ability manifests on a changing border of the system and its environment which can be checked with the use of sensors or humans. For such ability, the system must be able to perform information operations to check the characteristics of a system and its environment (further—sensing type information operations) and then to perform information operations of other types to process obtained information, to learn, and to produce information about actions required. Environment changes generate this need for information operations of different types, which are performed as causal for non-information (material) actions followed by chain of information actions. Such material actions can be executed by human or device (for example, by an actuator). Thus, an environment change makes Information Technology (IT) usage necessary, which, in turn, causes sensing type information operations effects, and subsequently other information operation effects to produce dynamic capability effects on the changing border of a system and an environment. This kind of information operations and IT corresponding to such operations is always required for the dynamic capability or system potential effects to be realized and environment change is required to generate a need for

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such IT usage. Therefore, when one talks about the operational properties of IT usage or dynamic capabilities, one estimates the role of all types of information operations in the creation of system dynamic capability effects in response to a changing environment.

To describe the relations between information and non-information actions of different types and dynamic capability effects during system functioning, concepts and principles (concept model) of IT application for dynamic capabilities effects-realization are suggested. Through applying these concepts and principles, the authors reveal general patterns of IT application. The suggested conceptual model is provided for transition first to graph-theoretical, set-theoretical, and then to a functional model (to estimate probabilistic measure [9]) of IT usage for dynamic capabilities effects. It is based on patterns of non-information effects development with the use of information obtained by sensing type information operations and other types of information operations—till actuator type operations.

General concepts and principles of information operations and the corresponding IT usage for dynamic capabilities for effects creation, or IT-enabled dynamic capabilities [29], are described in section two; modeling concepts, principles, and patterns of such capabilities' creation are described in section three. Examples of schemas for indicator's estimation of operational properties including indicators of dynamic capabilities are introduced in section four. In section five, prototypes of software package for estimation of IT enabled dynamic capabilities indicators are described.

II. INFORMATION TECHNOLOGY USE FOR SYSTEMS FUNCTIONING: BASIC CONCEPTS, PRINCIPLES, ASSUMPTIONS AND CONCEPTUAL MODELS

The use of IT is illustrated on the example of such complex systems that the operation of these systems (and hence the use of IT) is technological. We will say that the operation is technological if it is specified by technological operations modes – technological operations descriptions in the technological documentation for a complex technological system (hereinafter – CTS). In connection with this assumption about the technological form of functioning, not any actions in the systems are considered further, but only technological operations. This assumption allows us further to assert that the states of the beginning of CTS operations, the modes of technological operations implementation and the possible resulting states of such operations are described in technological documentation.

The essence of changes in non-information operations as a result of the information operations use is that – as a result of the changing environment different states of the system and the environment can be implemented as well as different requirements can show. These states and requirements can lead to different information operations and their results, i.e. lead to changes in information operations and next to changes in other operations. It is assumed that the number of such changes of operations is finite and can be described by modes of operations. Such modes on the basis of the initial states allow specifying the possible transitions and the corresponding possible final states of operations.

Modes of technological operations are specified in technological documentation on CTS, so this feature can be represented as a feature of the technological documentation, consisting in an exhaustive description of the possible initial states, transitions and final states and in the finiteness of such states and transitions. Accordingly, knowing the possible changes in the environment and its impacts on CTS, it is possible to build a model of the possible CTS states as a result of chains of environment impacts and information operations.

These chains, in turn, can lead to different states of the beginning of non-information operations and then, as a result, to different modes of non – information (or material) operations implementation. And various modes of such material operations can lead to effects that will meet the effect requirements of changing environment differently.

Information operations in CTS, thereby, can allow carrying out material actions in the changing environment conditions with modes of operations which are better adapted to these changing environment conditions.

Assumption accepted about the technological nature of CTS operations (of all types) and assumption about limited number of possible environment states allows us to assert further that the possible chains of ways of implementation of information and dependent on them modes of implementation of non-information operations can be modeled.

To model the use of information operations and so, the use of IT describing these operations, it is necessary to perform conceptual modeling of possible sequences of environment states, information and non-information operations. In these sequences states and operations are in causal relationships, and relationships and states can be alternative. It is assumed further that such alternatives are known and the measure of possibility of such alternatives can be constructed.

The basic concepts and their relations necessary to describe the chains of information and non-information operations are given in [29]. Concepts were linked together with IT use schema. Concepts have been formalized using the Mind Maps format of knowledge representation. Such representation allows to process concept model using knowledge processing applications. Then, based on conceptual models obtained it is necessary to pass to mathematical models of possible sequences of environment and CTS states. Next it is necessary to obtain models of CTS functioning effects, assuming that one of the possible sequences of states and transitions realized. It is assumed that transitions are described in technological documentation with use of functioning laws and regularities of nature. To model such possible sequences of relations between states, information and non-information actions and their subsequent formalization, a method of modeling research problems based on possible sequences of states and operations is proposed.

III. EXAMPLES OF MODELS FOR INFORMATION OPERATIONS EFFECTS AND OPERATIONAL PROPERTIES ESTIMATION

An algebraic structural model for operational properties indicators of the complex technological system (CTS) describes the elements and structure of the workplaces (WP).

$e_{jk} - k -$ th element on $j -$ th WP, according to the technological documentation; $e_{jk} \in E_j$, where $E_j -$ workplace $j = \overline{1,J}$; Realizations of states and WP in appropriate sets were fulfilled according to the concept model created. At a given moment t, part or all of the WP are functioning – those ones WP where TlOp are implemented. TlOp, implemented on the WP according one of possible modes can begin only if specified state of the WP reached. Such TlOp can lead to different states as a result of TlOp implementation, depending on the environment conditions. The set of states of $E_j -$ th WP at each moment forms a state of CTS.

$$Q(t) = \bigcup_{j=\overline{1,J}} Q_{E_j}(t) \quad (1)$$

System states $Q(t)$ at moment t are manifested and checked at the boundary of the system and its environment.

The mathematical models of states at the CTS boundary are built in the form of an algebraic model of sequences of CTS states on the boundary of CTS and transitions of such states. It is assumed that the number of states checked on the boundary is limited. The algebraic model can be shown as geometric graph. Then, from the algebraic model constructed, a functional model of correspondence between the states of the CTS and its environment on their boundary is generated. The peculiarity of this model is that it unites the model of CTS, the model of states at the boundary of CTS, the model of states on the boundary of CTS environment, and the model of the environment, and it is that model which needed to obtain the functional relations for the calculation of CTS potential indicators. We assume that both the number of states at the boundary of CTS and its environment and the possible number of transitions between such states are finite. States at the boundary are checked with special information operations. This information operations result is a measure of CTS and environment states' correspondence. Thus, the sequence of such information operations on the border is finite and this sequence shall be used to determine CTS's potential indicators, according its definition. As a result of the research, the main types of relations between states were identified. These types of relations model are arc (hyper arc, nested graph) at the tree of states. Transitions are a particular case of relations which are associated with operations mode in this tree. Namely, relations belong to two main classes—relations of possible joint realization of states (simultaneity relation) and relations of possible transitions between states. The first are caused by the possible implementation of TlOp on several WP at the same time. The second class relations are caused by the completion of TlOp and as a result of it, transition to the state of TlOp termination. Let us introduce relations classes. They correspond to arcs of tree classes.

O_1 – States jointly implemented through the execution of technological prescriptions during non-information (material) operations (TNIO) on various WP. As a result, relation characterizes the composition of WP states during TNIO execution (composition, combinations of states in the implementation of complex TIO on complex RM);

O_2 – The transition from one (initial) state to another (final) state due to the execution of prescriptions by TNIO at WP. It is transition from the initial WP material state which shall include TNIO prescriptions (information) to final material state of executed prescriptions. This transition can be realized by the person or device (for example, actuator).

O_3 - The transition between non-information and information states. It consists in the measurement and checking of the (material) state. This transition can be realized by a person, by device (for example, by sensor, by computer).

O_4 – The transition between states, consisting in the transfer of information (for example, prescriptions transfer). This transition can be implemented by a person, by a technical device (communicating device, networking device).

O_5 - The transition between states, consisting in the obtaining of prescriptions according results of the state checking. This transition can be realized by a person, by a technical device (computer).

O_1 , in turn, can be divided into types: O_{11} – States may be observed together at some time at some circumstances. O_{12} – There is a non-zero measure of the possibility for states to be observed together at a given time.

These relationships can be further divided into types depending on the types of states that can be implemented together. Relations O_2, O_3 require input (initial) and output (final) states of different types (information, non-information) during the transition. Thus they shall form sequences with relations of information types. We assume that other relations can form chains of information relations. Each of the possible finite sequences of states and relations (transitions) checked on the boundary of the CTS and the environment is part of a particular branch of the tree. It is assumed that the number of such sequences (tree branches) can be , that is, the set of possible sequences of CTS states has L power. C^{CTC} : $|C^{CTC}| = L$.

The sequence of states assumed as such that for different initial states before testing states on the boundary different modes of implementing technological non information operations (TIO) corresponds. The mode of TIO execution functionally depends on the state before the start of the TIO, on the IT used and depends on the plan of operations. If the state before the start of the TIO, information technology and the plan of operations are known, than the mode of TIO known as well. The mode to execute TIO of state check on the border of the environment, in turn, may correspond to the one mode of environment states change, if environment states changes are modeled accordingly. It is assumed that environment operations modes are not known for sure, but resulting states sequences, their relations (transitions) and the measure of the possibility of transitions implementation is known. Therefore as a result of one environment states transition sequence and one sequence of modes of implementation of the CTS operations we can get pair of states on the border which correspondence can be measured and which possibility to actualize can be measured as well. In the sequences of C^{CTC} states each pair of states on the boundary correspond to different branches of trees of environment states and tree of CTS states.

Let us fix the sequence of environment states and transitions. To do this, assume that the actions and states of the environment do not depend on the operations modes and states in the CTS, but CTS states, of course, depends on sequence of environment states. Then the specified sequences of the environment states can be presented without taking into account their connections with CTS functioning and as a result, sequences of environment states can be presented in the form of a tree of possible sequences of environment states before a tree of CTS states can be constructed.

In this tree, the edges correspond to the environment states transitions which happen due to modes of actions in the environment (possibly unknown). States corresponds to states of environment on the border of environment with CTS. Let's denote the number of states sequences of the environment as a result of some modes of action of the environment as M . Let's denote a set of possible sequences of environment states as a result of some modes of environment actions as C^{Cp} . Respectively, $|C^{Cp}| = M$ and the elements $c_m^{Cp} \in C^{Cp}$ are associated with the branches of the tree of environment states, $m = \overline{1, M}$.

The functional model of the environment constructed first by parameterization of the sequences $c_m^{Cp} \in C^{Cp}$, associated with branches. It means parameterization of states, transitions their dependencies and then parameterization of sequences of states, including parameterization with probabilities of states and transitions actualization.

Then, functional relations are assigned that connect the parameters, measure the probability of the states and transitions in the branches of the tree, as well as creating the dependent characteristics of the states of the environment. A mathematical model of the environment under assumption of independence of the activities of the environment from CTS operations is connected with a mathematical model of the CTS states compliance to states of its environment on their boundary by relating states to an appropriate TIO of state checking on the boundary. These relations are specified between the nodes of the CTS states tree as a result of the CTS functioning and the nodes of the environment state tree. Since the state of CTS during its functioning depends on the states of the environment, and such dependence in the study of the potential cannot be neglected, each method of implementation of checking the TIO on the boundary of the CTS is related to the branch of the tree of possible states of the environment. Complex model of CTS and environment states compliance can be constructed as a result. It allows measuring CTS potential.

In this regard, the set of branches of the CTS state tree is constructed under the condition that the branch $c_m^{Cp} \in C^{Cp}$ is given, that is $|C^{CTC}(c_m^{Cp})| = L_m$. Example of environment and system functioning models elements relations illustrated at Fig. 1.

Further, speaking of the branch $c_l^{CTC} \in C^{CTC}(c_m^{Cp})$, $l \in \overline{1, L}$ we will assume that it is built for $c_m^{Cp} \in C^{Cp}$, i.e. $l_m \in \overline{1, L_m}$. This means that a relationship is defined between each branch $c_m^{Cp} \in C^{Cp}$ and the corresponding $C^{CTC}(c_m^{Cp})$. As a result, a new tree can be constructed, that includes a branch $c_m^{Cp} \in C^{Cp}$ before the root of $C^{CTC}(c_m^{Cp})$ tree. Relations of environment states and CTS states shall be hidden on such tree but shown by separate model. This tree has the property that traverse can be set on this tree, extending the bypass of the $C^{CTC}(c_m^{Cp})$ tree. The extension is understood in the sense that one traverse include set of other traverses with use of tree structure.

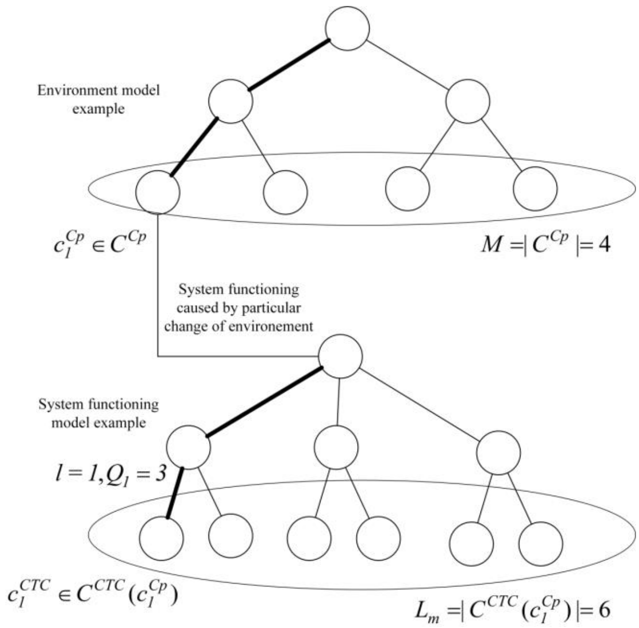

Fig. 1. Example of environment and system functioning models elements relations

The resulting model, corresponding to all branches $c_m^{Cp} \in C^{Cp}$, $m = \overline{1, M}$ and corresponding to each branch $C^{CTC}(c_m^{Cp})$ used to create functional model and then to create terminal model to calculate CTS potential.

The number of states in the state tree branch $l \in \overline{1, L}$ is assumed to be variable due to the fact that the number of operations that caused transitions and, accordingly, the number of resulting states could be different because of environment impact.

As well, due to same environment impact, the durations of the states transitions and the duration of the sets of actions on different WP is different as well. As a result, the number of required state checks at the system and environment boundaries may vary.

Let the number of such states is Q_l for a given branch $l \in \overline{1,L}$ of the tree. Each state check number on the CTS border $q_l \in \overline{1,Q_l}$ corresponds to the implementation of the checking TIO in the specified mode and the only state corresponding to this mode $q_l \in \overline{1,Q_l}$. Each of the states:

$$\hat{S}_{l.q} =< \hat{y}_{1.l.q}....\hat{y}_{k.l.q}...\hat{y}_{K.l.q} > ; \quad (2)$$

Checked at the boundary of the CTS and its environment is fully described by the effects of functioning by the time the state check starts. State (1) is compared with environment state which specifies requirements values:

$$S^{\partial}_{l.q} =< y^{\partial}_{1.l.q}....y^{\partial}_{k.l.q}...y^{\partial}_{K.l.q} > . \quad (3)$$

They may be random but for simplicity are considered non-random. Then, a probability measure $P_{l.q}$ of states $\hat{S}_{l.q}$ compliance to requirements of the environment $S^{\partial}_{l.q}$ can be defined as:

$$\begin{aligned} P_{l.q} &= P(\hat{A}_{l.q}) = \\ &= P(< \hat{y}_{1.l.q} r_1 y^{\partial}_{1.l.q} ... \hat{y}_{k.l.q} r_k y^{\partial}_{k.l.q} ... \hat{y}_{K.l.q} r_K y^{\partial}_{K.l.q} >) \end{aligned} \quad (4)$$

where r_k - k – th required relationship between predicted values of effect characteristics and their required values (e.g.<,>)). The probability measure is calculated using a functional model for calculating the correspondence at the boundary of the CTS and the environment.

$P(\hat{A}_{l.q})$ – the probability of an event consisting in the fact that when checking the state $\hat{S}_{l.q}$ for one of the possible branches of the tree, when performing a single checking TIO by defined mode, required by environment characteristics of the effects will be achieved.

This event means that the result of the checking TIO is good to achieve the required intermediate goal of the CTS functioning given the states of environment changes fixed (the intermediate goal of CTS is achieved in current environment circumstances). Since such checking TIO of states $\hat{S}_{l.q}$ corresponding to the modes of checking TIO in one branch of $C^{CTC}(c^{Cp}_m)$ number is less or equal to L , and all of them are expressed in the model, the measure of compliance for the implementation of the entire sequence of checking TIO for one branch $c^{Cp}_m \in C^{Cp}$, correspondence measure for whole (but one) branch of $C^{CTC}(c^{Cp}_m)$ can be calculated as the probability of a complex event $\hat{A}_l$ which means all intermediate goals achieved in a given environment circumstances.

Event $\hat{A}_l$ probability is:

$$P(\hat{A}_l) = P(\bigcup_{q \in \overline{1,Q_l}} \hat{A}_{l.q}) \quad (5)$$

If the probabilities of compliance for each of the checking TIO are conditionally independent in their sequence, than:

$$P(\hat{A}_l) = \prod_{q \in \overline{1,Q_l}} \hat{A}_{l.q} \quad (6)$$

Let the probability of an event $\hat{B}_{q,p}$, consisting in the fact that the transition $a_{q,p}$ will be executed $\hat{B}_{q,p} = (\hat{S}_{l.q}, \hat{S}_{l.p}) : \exists a_{q,p} : q, p \in \overline{1,Q_l}$ is equal to $P_{q,p} = P(\hat{B}_{q,p}) \sim a_{q,p}$, i.e. the probability $P(\hat{B}_{q,p})$ is associated with the transition $a_{q,p}$.

Then the probability of implementing a branch $v_l : l \in \overline{1,L}$ of the tree $C^{CTC}(c^{Cp}_m)$:

$$P_l = P(\bigcap_{a_{q,p} \in v_l} \hat{B}_{q,p}) \quad (7)$$

$$P_l = \prod_{a_{q,p} \in v_l} P(\hat{B}_{q,p}) \quad (8)$$

Then, as a scalar indicator of the CTS potential ψ as well as its dynamic capability, we can take the expected probability of the event that whatever branch $c^{Cp}_m \in C^{Cp}$ and corresponding branches of $C^{CTC}(c^{Cp}_m)$ implemented, there will be right correspondence between expected and required states measured by checking TIO. It means, whatever changes of environment happens, and whatever operations conducted to fulfill changing goals, changing goals of the CTS will be achieved:

$$\bar{\psi} = P(\hat{C}) \approx \sum_{l \in \overline{1,L}} (P_l \cdot P(\hat{A}_l)) \quad (9)$$

In general, the probability $P(\hat{C})$ of event specified can be represented as a random variable ψ , not its expected value $\bar{\psi}$. ψ discrete distribution $f_{\hat{\psi}}(l)$ is described by the vector of pairs:

$$f_{\hat{\psi}}(l) = (P_l, P(\hat{A}_l)) \quad (10)$$

This vector of pairs can be used as a vector function of CTS potential:

$$\Psi = < f_{\hat{\psi}}(l), l = \overline{1,L} > \quad (11)$$

These indicators describe different characteristics of the CTS potential given functioning of CTS terminated. Indicators alike can be constructed for any moment during functioning. Variants of CTS potential indicators can be used, for example, obtained by using the criteria of optimism and pessimism.

These indicators make sense of different characteristics of the complex probabilistic measure of compliance of the predicted effects with the requirements to them. This compliance is measured at the boundary of the CTS and its environment at different times and taking into account possible changes in the environment and then, as a result of that change, appropriate changes in CTS. The mathematical model of such correspondence on the boundary is the basis of the mathematical model of the CTS potential estimation task. To obtain a mathematical model of the tasks of potential estimation based on model specified it is necessary to construct models which reveal the values $< \hat{y}_{1.l.q} ... \hat{y}_{k.l.q} ... \hat{y}_{K.l.q} >$ and $< y^{\partial}_{1.l.q} ... y^{\partial}_{k.l.q} ... y^{\partial}_{K.l.q} >$ with the use of labeled (parametric and then functional) graph-theoretic models. In fact, such a task can be interpreted as a special kind of graph extension—its disclosure, which describes the calculation of the functioning effects. Under the disclosure of marked graph-theoretic (initial) models it is understood that a sequence of operations with such models, such that as a result of operation the element of the model, which is associated with the disclosed value (parameter, variable) is calculated based on the composite traverse of the disclosed model and initial model. With the use of the proposed graph-theoretic models in the form of hierarchical trees and graphs, and associated with their elements, such properties of the models are achieved by replacing the node of the original tree with a composite tree. In this regard, the model of effects manifestation $< \hat{y}_{1.l.q} ... \hat{y}_{k.l.q} ... \hat{y}_{K.l.q} >$ under requirements $< y^{\partial}_{1.l.q} ... y^{\partial}_{k.l.q} ... y^{\partial}_{K.l.q} >$ changes should be created as trees parameterized with operations and states characteristics. Functional dependencies on trees must be specified in such a way that by traversing the models and by functional dependencies computation it will be possible to calculate the required values.

IV. SOFTWARE PROTOTYPES FOR ESTIMATION OF OPERATIONAL PROPERTY INDICATORS

Modeling of operational properties of IT usage requires creation of multiple system functioning models under multiple scenarios of environment functioning. Multiple models creation may be quite complex. Therefore, I propose to use diagrammatic means. Graph theoretic, diagrammatic models transformed into parametric through adding parameters and variables to graph theoretic models are built. Database of parameters and variables restrictions is used for this purpose. In the example considered, diagrammatic models were created with ARIS (Architecture of Integrated Information Systems) toolset modernized so as to use nested parameterized diagrams with functional expressions embedded to reflect graph theoretic models of different type built. Next, parameterized models are transformed into functional through adding formulas to ARIS models elements. Then, nested diagrammatic models are transformed into Microsoft Excel spreadsheets shown below. Resulting spreadsheets constitute a program model of IT enabled system dynamic capability estimation.

Examples of diagrammatic models are shown below. They are based on some common sub-process models (Fig. 2). Simplest models available were used. For example, only four scenarios of environment functioning are possible and there are four changing goals as a result. Diagrammatic model of functioning could be built for each goal. The use of an IT is modeled with relevant IT operations, resulting in a change of the course of functioning. Such operations require additional resources and time when a functioning goal is altered due to a change of environment. Next, an indicator of IT enabled dynamic capability is estimated as a probabilistic mix of system functioning efficiency with IT used for functioning changes according to four different scenarios of functioning change.

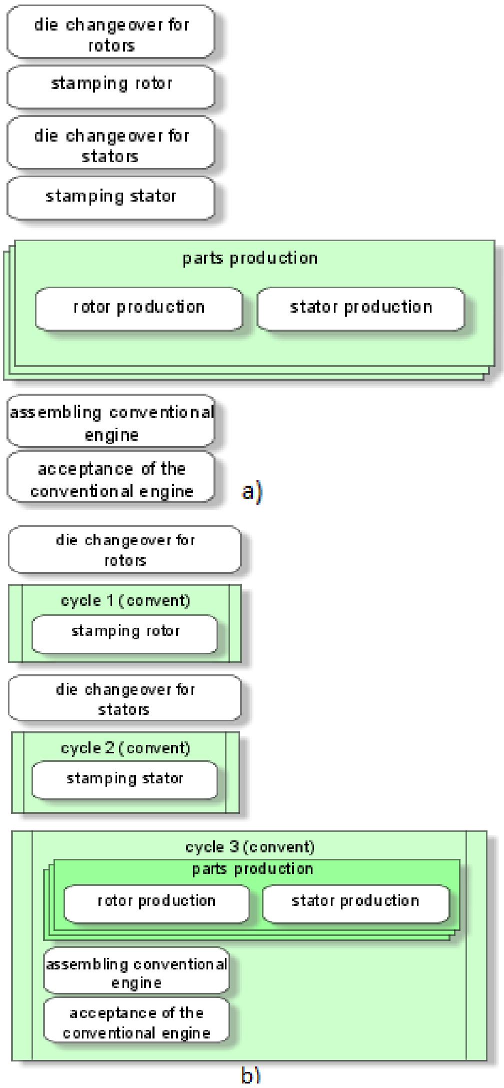

Fig. 2. Diagrammatic ARIS models to estimate operational properties indicators for unique (a) and serial (b) production

Example of Microsoft Excel table received as a result of modeling shown below (Fig. 3).

Element name	Moment of the beginning	Proba bility	Required time	Required cost	Prompt ness	Savings	Produc tivity	Potentiality	First start time	Finish time	mot
(ser) electric engines production	0:00:00						1,000	0,210	6:48:00	6:48:00	6:48:00
goal selection (A/B)	0:00:00						1,000		6:48:00	6:48:00	6:48:00
probable functioning (A,B)	6:48:00						1,000		6:48:00	6:48:00	0:00:00
conventional engines output (A)	6:48:00						1,000		213:36:00	213:36:00	206:48:00
Goal A	6:48:00	0,6	200:00:00	7 200,00 ₽	1,000	1,000	1,000	0,600	106:00:00	106:00:00	99:12:00
preparation of the output accordi	6:48:00						1,000		11:36:00	11:36:00	4:48:00
ser producing of conventional eng	11:36:00						1,000		106:00:00	106:00:00	94:24:00
second stage	6:48:00						1,000		213:36:00	213:36:00	206:48:00
goal selection (C/D)	6:48:00						1,000		13:36:00	13:36:00	6:48:00
delay T1	13:36:00						1,000		213:36:00	213:36:00	200:00:00
probable functioning (AC,AD)	213:36:00						1,000		213:36:00	213:36:00	0:00:00
AC	213:36:00	0,3	400:00:00	7 200,00 ₽	1,000	1,000	1,000	0,300	312:48:00	312:48:00	99:12:00
preparation of the output accordi	213:36:00						1,000		218:24:00	218:24:00	4:48:00
ser producing of conventional eng	218:24:00						1,000		312:48:00	312:48:00	94:24:00
AD	213:36:00	0,7	400:00:00	6 000,00 ₽	1,000		1,000		312:36:00	312:36:00	99:00:00
preparation of the output accordi	213:36:00						1,000		218:12:00	218:12:00	4:36:00
ser producing of special engine 3p	218:12:00						1,000		312:36:00	312:36:00	94:24:00
special engines output (B)	6:48:00						1,000		213:36:00	213:36:00	206:48:00
Goal B	6:48:00	0,4	200:00:00	6 000,00 ₽	1,000		1,000		105:48:00	105:48:00	99:00:00
preparation of the output accordi	6:48:00						1,000		11:24:00	11:24:00	4:36:00
ser producing of special engine 4p	11:24:00						1,000		105:48:00	105:48:00	94:24:00
second stage	6:48:00						1,000		213:36:00	213:36:00	206:48:00
goal selection (E/F)	6:48:00						1,000		13:36:00	13:36:00	6:48:00
delay T1	13:36:00						1,000		213:36:00	213:36:00	200:00:00
probable functioning (BE,BF)	213:36:00						1,000		213:36:00	213:36:00	0:00:00
BE	213:36:00	0,2	400:00:00	7 200,00 ₽	1,000	1,000	1,000	0,200	312:48:00	312:48:00	99:12:00
preparation of the output accordi	213:36:00						1,000		218:24:00	218:24:00	4:48:00
ser producing of conventional eng	218:24:00						1,000		312:48:00	312:48:00	94:24:00
BF	213:36:00	0,8	400:00:00	6 000,00 ₽	1,000		1,000		312:36:00	312:36:00	99:00:00
preparation of the output accordi	213:36:00						1,000		218:12:00	218:12:00	4:36:00
ser producing of special engine 6p	218:12:00						1,000		312:36:00	312:36:00	94:24:00

Fig. 3. Program Model to Estimate Operational Properties Indicators

It constitutes a program model for estimation of operational properties of IT usage and corresponding dynamic capability indicators. It was obtained automatically, using model-driven meta-modeling [30-35] and ARIS possibilities to generate a program code.

V. CONCLUSIONS

The results obtained allow for evaluation of predicted values of systems operational properties regarding information operations use. Corresponding IT usage indicators, dynamic capabilities or system potential indicators can be estimated as a result. Analytical estimation of such indicators becomes possible depending on variables and options in mathematical problems solved. This could lead to a solution of contemporary problems of a research using predictive analytical mathematical models and mathematical methods. Among research problems are ones dedicated to the IT productivity, IT efficiency, system dynamic capabilities estimation, analysis and synthesis. Problems possible to decide include choosing best information operations, choosing IT and TIO characteristics for optimal implementation of new IT. It makes it possible, as a result, to overcome the existing gap between the need to solve operational properties research problems (especially with regard of information operations), based on mathematical models and methods and the lack of the necessary concept and methodology for solving such problems. Example of such problem is optimal usage of distributed ledger technologies for business processes, robotic technological process optimization and cyber-physical systems characteristics choosing.

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