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MATLAB PACKAGE USAGE FOR BUILDING SIMULATION MODEL

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Abstract. One of the main objectives of information systems usage is simulation of past / future events with the highest probability value of their occurrence and predicting outcomes. The practical significance of simulation models is not only in the quantitative evaluation, but also it is in illustrative representation of different situations of system behaviour and the possibility of rapid changes of input parameters. Dynamic system software simulation has been known for a long time, but high-speed powerful devices that do not use MATLAB are required for the effective application of the system. Integrating of one of the fastest matrix mathematical systems - MATLAB package Simulink opens up new possibilities of using advanced mathematical methods for solving dynamic and situational modeling of complex systems and devices. The article is devoted to reveal the possibilities of using the MATLAB package Simulink and generalized signal graphs for constructing simulation models as an example of economic processes.
Keywords: MATLAB, Sirnulink, simulation model,3D- graphics, economic processes.

Introduction. One of the main objectives of information systems usage is simulation of past / future events with the highest certainty value of their occurrence and outcomes predicting. As it is clear crisis of growth and fall occasionally stag the global economy, the economy of certain countries, including ours. Unfortunately, there are no general scientifically based tools of assessment of these phenomena and their prevention in time. This is quite natural, because even beyond the power of mathematics to formalize the multifaceted system of economic relations in their infinite set. Therefore, there is a need to create opportunities to reproduce a particular phenomenon with a view to predict, and thus prevent the most disastrous consequences.

A number of scientific works, including the works of S.I. Parinov, A.A. Emelyanov, N.B. Kobelev, A.I. Kustov [1-13], which substantiate the general techniques of economic situations modeling on the basis of the standard package of logistics and technical possibilities of their usage for simulation of various states of the economy at both local level and global one. The practical significance of simulation model is not only in the quantitative evaluation, but also in representation of different situations to illustrate system behavior and the possibility of rapid changes in the input parameters in order to find answers to the question: "What if ...?". One of the most interesting applications, which are represented at the domestic simulation software market, is Matlab, including its package Simulink. This program has a well- developed algorithm for constructing simulation models using distributed libraries. However, due to the fact that a large consumer does not have enough information on its application so the package is not popular in Ukraine although it is widely used by economists in Russia and Europe.

Taking everything into account, the goal of practical realization of the simulation models of a certain number of economic problems on the basis of the package Matlab Simulink is set.

Materials and methods. A package of dynamic system simulation - Simulink 5.1 joined MATLAB 6.5 package system for the first time in 2003. Version 7.8 has already been developed and successfully used today. This is a comparatively new and substantially modified version of the popular package that has long been considered one of the best simulation packages of block defined dynamical systems. The software simulation of dynamical systems has been known for a long time. They include, for example, programs Tutsim and LABVIEW for Industrial Automation. However, the effective application of the features requires high-powerful devices that do not need MATLAB. Integrating one of the fastest matrix mathematical systems - MATLAB Service Sirnulink opens up new possibilities of using advanced mathematical methods to solve dynamic and situational modeling of complex systems and devices.

Simulink package is the core set of interactive software designed for mathematical modeling of linear and nonlinear dynamic systems and devices which are presented in its functional schematic block diagram, called S- model or model. Thus there are different versions of the simulation: the time domain, frequency domain, along with

effective management, based on spectral Fourier transformations, using Monte Carlo method and so on.

To build a functional block diagram of the simulated devices Simulink block has an extensive library of components and user-friendly flowchart editor. It is based on a graphical user interface and is essentially a typical means of visually -oriented programming. Using a palette of components (sets), the user moves the necessary blocks from the palette to the desktop package Simulink and connects the inputs and outputs of the blocks. Thus, a block diagram of a system or device is created, which is a model itself.

When building a package, Simulink models uses elements of graph-analytic methods of analysis, thus synergetic effects of the work are clearly distinguished.

Synergetics, is borrowed from Greek "syn" – "common" and "ergos" – "action") - a theory of self-organization in systems of different nature. It deals with phenomena and processes which results in appearing of the properties that none of the subsystems posses. As the patterns are generally identified and used in different areas, so this approach involves inter-discipline.

Integrated with the aim to study the properties of complex systems analysis modeling techniques (graph theory), on the one hand, and numerical methods incorporated in the package Simulink, on the other hand, provides a significant simplification and acceleration of procedures for building and debugging S- models. In graph theory it can expand its scope for the analysis of nonlinear systems and systems with variable parameters. According to the package Simulink the usage of graph theory simplifies patterns and structure design of the program of sustainable algorithm of calculations.

When choosing the type of graph to be used, it is necessary to be guided by the characteristics of the system, which will be played in the model. It is this feature of the graph theory which makes it possible to reflect the specifics of the economic system, because the economic system is a versatile system, all elements of which are in organic relationship with each other and do not exist outside of this unity. Functional similarities of a living organism provide the elements of the economic system with organic integrity. This is a specific feature of a system which differs from other so-called summative systems that consist of objects, each of which is more or less self-contained and can not exist outside of this integrity. Every economic system is singled out from other systems for the specifics of basic characteristic: leading type of ownership of resources, the main groups of working objects of social production and the relations between them, economic form of production results, principles of organization of production, distribution, exchange and consumption, the system of economic laws. The existence of an economic system is only possible if the connection between these characteristics and flows of product exchange. However, these flows are not chaotic, and they are made according to certain algorithms that can be represented in the form of mathematical models. So, to build a model using Simulink package, graphs for determining the direction of flow should be used, on the one hand and on the other hand, it is reasonable to minimize the number of parameter values to obtain a structural model. These graphs are graphs signal.

The signal is called a directed graph that reflects the system of linear algebraic equations that describe the objective function. Depending on the form of a system of linear equations the following types of signal graphs: signal graphs of Myezona, signal graphs of Coates, summed signal graphs (signal graphs of Anisimov) and others, are defined [14].

Generalized signal graphs represent a system of linear algebraic equations, which are presented in a generalized in a cause- effect form where in each equation of the unknown variables with their weighting coefficients is expressed in terms of the unknown and other parametric variables. Generalized signal graph has: nonweighted vertices, which are the sources of corresponding parametric variables, weighted vertices which correspond the desired variable and have a weight given by weights coefficient, arc directed from vertices corresponding to the variables in the right-hand side of equations to

vertices corresponding to the variables in the left sides of equations and are characterized by weights (transfers) that are equal to the corresponding variables. Generalized signal graphs are widely used in building models of electric circuits, which take into account, firstly, the direction of movement, and secondly, the possibility of constructing various types of motion (parallel, sequential, mixed), and thirdly, the simulation both linear and nonlinear processes. Synergism of Simulink becomes apparent when the generalized graphs of signal detected are used. In point of fact, it is possible to simulate (analyze) business processes by simple means, to investigate transient processes, to complicate the model elements, to build complex models of subsystems, i.e. The analysis of experience in building S - model enables identification of an algorithm of generalized modeling process :

Step 1. Problem definition and problem description. Production of the symbolic form model with the definition of the main elements.

The symbolic form model should bind the input variables with output dependent variables and economic strategy, that is, the way of the economic system management.

Depending on the specific changes in the function, which is being modeled, the following types of mathematical models are distinguished: continuously - deterministic (D - scheme), discrete deterministic (F - circuit), discrete stochastic (P - scheme), continuous - stochastic (Q- scheme).

Continuously deterministic models include the models described by ordinary differential equations or differential equations in partial derivatives. There is usually some time for a function, which is being defined as an independent variable (argument). A symbolic form model of this type reflects the dynamics of the system and therefore is called D- scheme.

So-called finite state machines are discrete deterministic models. Automatic machine may be represented as a unit, which takes the input signals and gives out output signals and may have some internal state. A set of input signals and internal states is a finite set in finite automaton. The name F-scheme is derived from English.

Discrete stochastic models include automatic or probabilistic automat. That is why it is called R- scheme. In general terms, this machine can be defined as a discrete transducer of information from memory, the operation of which in each cycle depends on the state of memory and it can be described stochastically.

An example of a typical circuit continuously stochastic diagram can be queuing systems (QS). That is why it is called Q- scheme.

Step 2. A selected model type with generalized signal graphs is constructed. In this case, certain rules should be followed:

- vertices-sources are assigned by blocks from the library “Sources” according to the research objectives. The specified library includes components that simulate the input parameters of the symbol form model and the components of reading data from a file;

- for the transformation of information the next blocks are selected: Integrator blocks from the libraries “Continuous”, “Discrete”, and blocks with capacity of data manipulating function from the library “User-Defined Functions”;

- arc of generalized signal graphs with unit weights show links in S- model. Signs of individual arcs are defined by parameters of block “Sum”. The connection of blocks arc with a weight different from the unit is carried out with the help of block F-Gain, which allows to set the appropriate ratios increase / decrease flow.

Step 3. Setting parameters of S- model.

Step 4. The necessary components from the library «Sink» are connected to S- model for measuring relevant parameters.

Step 5. The test of S- model is carried out for construction of output graphs and charts.

Results. Let us consider the implementation of building simulation models of economic systems with capabilities of Simulink library [15 –1 8].

Task 1. Investigate the dependence of pumping up the budget on the size of fiscal revenue tax rate and justify the tax percentage rate.

Continuously - deterministic model (D-scheme) is used to solve this problem.

We build mathematical model. The tax revenues of the company for the modeled period, is

built on the budgetary accounts and can be represented with the formula

$$BD(t)=\int_{t_1=tb}^{t_2=tf} PRF(t)*TXRT*dt\ ,$$

where *BD(t)* - is the amount of funds accumulated in the budget from the beginning of the simulation until the t, hrn.; *PRF(t)* - is the company income before taxation at the time t, hrn./year ; *TXRT* – is the tax rate; *t* – is the current time ; $t_1 = tb$ - initial time simulation; $t_2 = tf$ – is the final time of the simulation. Profits are capitalized during the simulation, calculated as

$$CP(t) =.$$

Profit at the time *t*

$$PRF(t) = CP(t)*RN,$$

where *RN* – is the return on equity of the company.

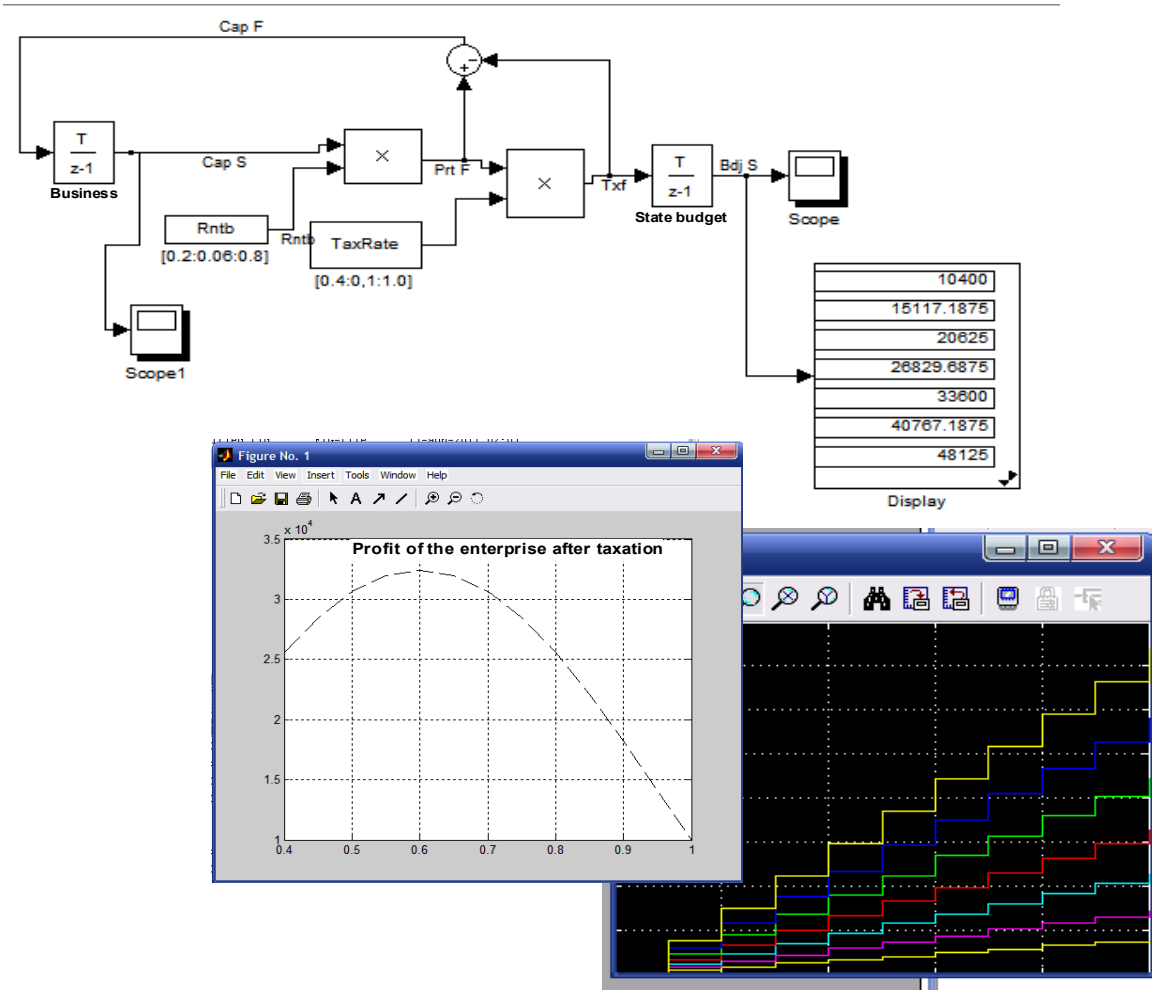

Figure 1. Model of budget filling in terms of improved tax rate

We set the source data to build the model: profitability of an enterprise (Rntb) and tax rate (TaxRate), using the Constant block from the library "Sources" (initial value: step change: final value). The function of storage for business and budget is determined by the discrete integrator block Discrete-Time Integrator from the library "Discrete". Concurrently, block Forward Euler - Euler direct method is used in the settings: approximation of *T/(z-1)* transfer function *1/s*. Output power is calculated by the formula

$$y_{(k)}=y_{(k-1)}+T*u_{(k-1)},$$

where $y_{(k)}$ - is the output signal integrator simulation step number *k*, $u_{(k-1)}$ - is an input signal integrator *k-1* step simulation (initial value profit user input), *T* - is the sampling step. Scope and Display blocks allow visualizing the model calculations and giving the screen accordingly graphics and digital data (Fig. 1), which show that we are continuing to accumulate funds and increase the tax burden.

Built simulation model shows that this path does not lead to the desired result, i.e. budget

revenues, but reducing the amount of profit that is capitalized, does not allow businesses to create a sufficient basis for development. This causes the reduction of the tax base and thereby leads to revenues reduction. Most progressive rate on the profits of the enterprise is its initial value, which provides constant stable payments to the budget and enables capitalization of the profit of the companies for their further development.

As the above model shows, blocks are connected by generalized signal graphs-arc with unit weight. Block Sum is used to determine the amount of company profits after taxation. In this block the characters of arcs change according to the formula, and then we obtain the corresponding direction of the flow: the calculation of the profit of the company after taxation with a given profitability of production.

Task 2. Using simulation modeling cause-effect mechanism to investigate appearance of cycles and crises of overproduction: machinery.

Discrete deterministic model (F - diagram) is used to solve this problem.

A mathematical model is constructed and the output data blocks and accumulation are defined [20]. In this case, the storage units must be able to self-regulation: production delays and stimulate demand. A block from the library Saturatio "Continuous" is used, which allows you to simulate the delay in production in comparison to demand (Fig. 2).

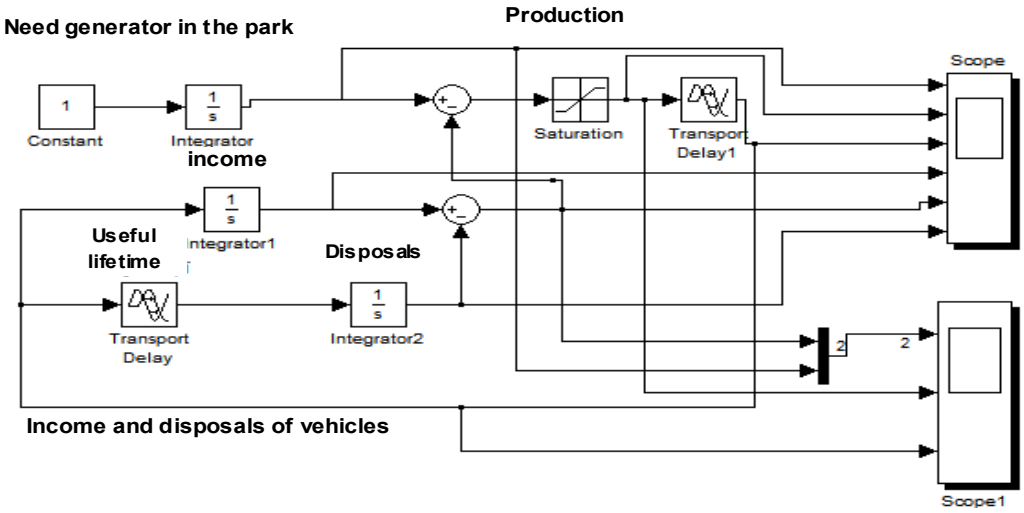

Figure 2. Block diagram of the simulation crisis mode

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To compare the necessity and the actual number of machinery a block multiplexing Mux Library "Signal Routing" is used. Blocks are interconnected by arcs with unit weight of generalized signal graphs, which allow not only to direct the flow of information to determine its sign and direction, but also to get visible results in the output in graphs (Fig. 3).

Analysis of the results shows that the demand for machines is growing steadily, and their actual number is reduced due to aging equipment to the park. This should stimulate production. However, the production does not only keep pace with demand, but also has some disruptions associated with the national policy to invest public funds in business development.

Task 3. To study the conditions of price stability for a product based on prices analysis of the previous periods.

Cobweb model which is a special type of discrete stochastic model (P-diagram) is used to solve this problem.

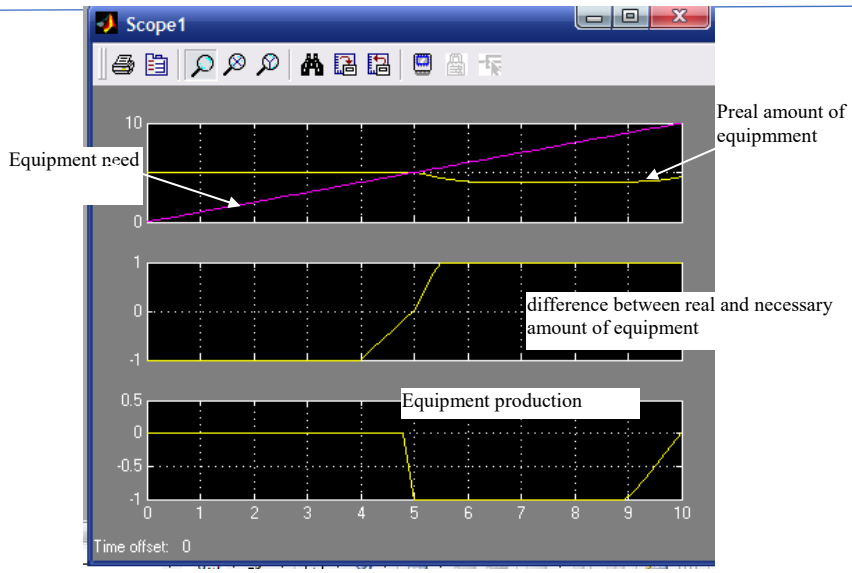

Figure 3. Simulation results - task 2

This model, in its simplified form is built for small businesses. This is due to a restriction that is used in its construction: reserves accumulated in previous periods are not included (i.e., zero start). This is the most typical for small businesses that can not create large commodity stocks, firstly, the reasons for the additional costs of storage, and the second is for the withdrawal of a certain amount of money from circulation, so the model can be taken as the beginning of zero count.

In constructing the model assumes that demand for *T*- that period of time has a linear dependence on the current price and demand is subject to random variation. The next formula is used to describe the demand

$$D_{md}=D_0-K_d*P_{rc}+U,$$

where D_{md} - is the demand for the current time interval (*T*); D_0 - is the demand at a price equal to 0; K_d - is curvature line demand; P_{rc} - is the price, which will be determined on *T*- is the time period; *U* - is the random variable set by statistical law. The price is supposed to depend on a linear combination of the prices of the two previous periods of time. The next dependency is used

$$S_{pl}=S_0-K_s*P_{rc}+V,$$

where S_{pl} - is the proposal for the current time interval (*T*); S_0 - is the offer at a price equal to 0; K_s - is curvature lines offer; P_{rc} - is the price, which will be determined on T-that time interval; *V* - is random variable with a set by statistical law.

Having local equilibrium market $S_{pl} = D_{md} + W$, where W is the random variable with a given distribution, we define

$$P_{rc} =(D_0 - S_{pl} + U + W)/K_d.$$

According to the mathematical model we build a simulation model (Fig. 4), in which blocks of generalized signal graphs of Gain, power functions with appropriate formulas FCN, key blocks of Manual Switch are used.

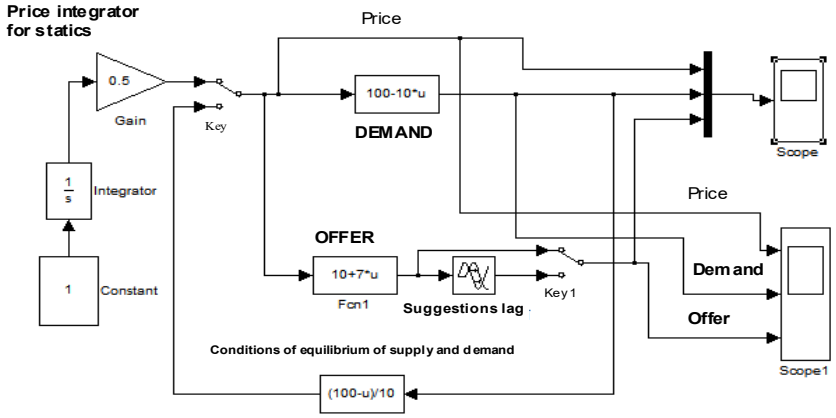

Figure 4. Cobweb model of a firm (the equilibrium price)

The result obtained by simulation model in Fig. 5 allows proving the effect of system parameters D_0, K_d on type of dependence of the time to price

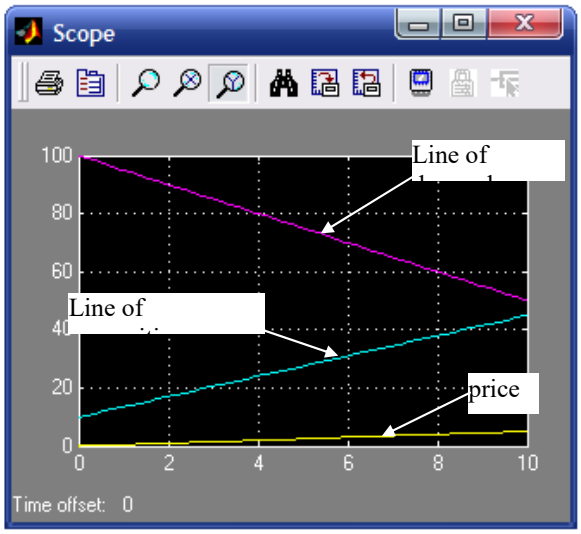

Figure 5. Simulation results - Task 3

The value of Simulink is obviously extensive and open to be studied and modified for the library components (blocks). It includes the source of signals from virtually any temporal dependencies scaled, linear and nonlinear processes with various forms of performance, quantizing, integrating and differentiating power system. An important advantage of the package is the ability to set the task in blocks of undefined mathematical expressions that can solve common tasks, using examples of Simulink package or simply asking the new expressions that describe the work modeled by systems and devices. An important feature of the package is also the possiblity to specify system functions (S- functions) to include them in the library of Simulink. The possibility of devices and systems modeling in real time should be also noted.

Conclusions. Consequently, the implementation of building of simulation models on the example of three tasks using generalized signal graphs confirmed the reality and feasibility of using the Matlab package Simulink. As a software tool, Simulink is a typical representative of visually - oriented programming language. At all stages, especially in the preparation of model systems, the user has virtually no case with conventional programming. Program in the codes generated automatically during the input units selected components and their connections and set the parameters of components.

The means of visualization of Simulink simulation package is so clear that sometimes a feeling of the real system appears. Moreover, Simulink almost instantly changes the mathematical description of the model as the introduction of new units, even in the case where the process is accompanied by changes in the order of the equations and leads to significant qualitative change in system behavior.

As it can be seen from the above examples, simulation modeling, which uses the above package, allows to present information about the system being modeled for fast analysis and decision making in a compact and visual way. Since the system can be decomposed into components presented in the form of blocks and connections between them, the analysis of different scenarios of behavior provides the ability to change parameters in each block. This makes it possible to investigate the impact of each parameter on the capacity of the system. Thus even a non-specialist can change the behavior of scripts, which set clear visual pattern in the software field, quickly configure and play different variants of scenarios. Comparability of the real system and created a model based on Simulink package enables identification of the causes disruption of normal functioning both standard and a model. This enables the user to make predictions of events and take appropriate measures to avoid \ reach the results of modeled actions. As the technology of computer equipment is extremely dynamic both in time and possibilities, then the practitioners could promptly respond to the need of analyzing the results of their activities with regard to the future. It is necessary to educate specialists in the spirit of the needs to imitate production processes in the system cohesion. In its turn, everything leads to designing a system to teach analytical methods activities with the help of information systems to students who major in different courses.

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