SIMULATION AS LOGISTIC SUPPORT TO DEVELOPMENT PROCESSES (PROBLEMS IN APPLICATION)

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Abstract

If it is accepted that simulations are the most modern tools for optimization, then the application of simulations in the logistic processes is a must with daily use. The development processes also can be analyzed in the framework of logistics, since it includes rules (algorithms) which lead towards solution in analyses of complex Supply Chain system. Here is emphasized a system approach starting from the need of something in the global SC all the way to intralogistics and development of node in SC. On the case of container terminal used as the SC focal point, will be presented the application and connection of simulation within the development process from the planning up to the designing of the equipment operating there, with particular emphasis of the problems present in application of high-valued software (ex. Enterprise Dynamics and ADAMS), in the ways solved here and proposals for improvement. During analysis of power or possibilities of high valued software as tools for simulation, one must have in mind that the complexity of simulation models must be in function of the goal that one wishes to attain by simulations. The processors and memory powers of the contemporary computers encourage users towards huge models which almost ideally describe real processes, but at the same time they are permanently ascertained that in offered options there lack some new details, what is also a motivation for further modularizing of software with special features.

Keywords: Simulation, Logistic support, Optimization, Development

Presenting Author's biography

Milosav Georgijevic was born in 1949. Research for master's and doctoral dissertation, till 1989, performed at the TH Darmstadt, TH Magdeburg, TU Dresden. Afterwards he paid many visits to Germany (TU Munich, University of Dortmund). In 2000 was elected a professor, University of Novi Sad. For simulation uses, from 1986, a software ADAMS and published, in German journals, a number of papers in the field of dynamic and automation of cranes.

The lecturing by invitation:

- Nagaoka University of Technology and Tokyo Eng. University, 1998,
- Technische Universitaet Dresden, 1999,
- Universitaet Dortmund, 2000 and 2002,
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1 Problem and Aim

If by application of the high-valued software of simulation it is concluded that some segments of the reality can not be really copied into a model, the aim is to signify a problem and to give proposals how to solve it or, at least, how to improve the way of indirect copying of the reality into a model.

2 Multiple Simulation and Interface Problem

From the very beginning of the computer application also started development of the present software for simulations. Then, some thirty years ago, it was hardly portended that one user, let's say a development engineer, will have to have a system approach, i.e. a broad problem insight, from idea to realization, and simultaneously to use simulation software which each by itself describes independently segments of the processes that are related. Software is not possible to be related in concept, regardless to direct connection of the described process nature. After 1990 the industrial logistics has become issue discussed by all, the general system approach has been introduced at first in development processes, and afterwards, also, in already existing systems. In Table 1, a rough scheme of connection of production processes or services arising in the socio-economical sphere is given, where the simulation of global events with probabilities as events parameters are applicable. From all processes the idea results for industry and services, by what the technical logistics is entered. The first step is designing or reengineering of the system with simulation of materials (or goods) flows, where working places are black boxes with statistics of stay time, while transports and storages are the principal process parameters. Stochastic estimation is the key factor which influences the simulation result (events). Overall equipments participating in all processes have technical parameters as variables, what influences the result of analyses. People working in the domain of operation research, who are not familiar with technical properties of the equipment, because at that time those were separated processes in the work, designed software.

Tab. 1. Related processes and various simulation properties

By market development the equipment in production and intralogistic processes is required just according to the purpose requirement, while technical preconditions for the equipment are offered by the former simulation.

For harmonization of the mechanical properties of the equipment, and particularly control, it is needed to make simulation of the determined systems with thousands of differential equations. To make communication between the former system simulation and machines simulation, due to different conceptions, it is needed to make an interface (I). The feedbacks (FB) either confirm correctness of suppositions or return the analysis to the previous stage [3, 6, 7, 10].

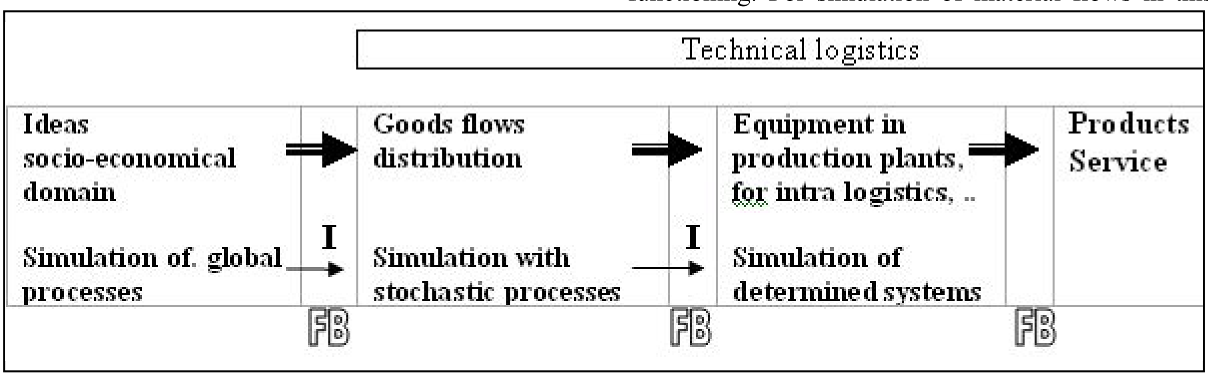
For optimization of this kind of processes the aim functions could be written. They on all levels (Figure 1) have multifold greater number of parameters than mathematical relations, so that simulations with iterative approaching to well enough solutions are the unique method for optimization of every segment respectively, which means the entirety as well. Improvements of power of simulations software make possible the quality increase of optimization processes, what actually proves the accuracy of the thesis that the simulations are the most modern method for optimizations [1, 3, 5].

3 Examples of Application

To illustrate what is said, follows the example of planning the container terminal and designing of the quayside crane adopted for the terminal's conception, with analysis of the problem in application of high-valued software as Enterprise Dynamics [7,8,9,11,12] and ADAMS [7,9,10,11,12,14].

3.1 Application of Simulation in the Phase of System Planning

The first step in modeling of materials (goods) flow should be the analysis of the real system, defining of system's limits, input and output values. This is the first abstraction and copying of the physicality of the real system into a virtual model. Thus defined system is suitable to be divided into separate elements with determination interrelations of these elements, interaction between them and system parameters of functioning. For simulation of material flows in this



phase, very outstanding is already mentioned stochastic estimation, since almost all system's operating parameters and system variables are not exact values and the problem of defining these values arises. On their proper selection the quality of the overall analysis will depend, where simulation represents a dynamical analysis of this kind of stochastic system in the real time.

In the process of modeling the output values are already defined, i.e. parameters that will be measured during the simulation and on whose analysis the goodness parameters of system functioning will reviewed. In each simulation phase there must be a feedback, which provides the verification of the previously done and potential correction. Repeating of the simulation with different input values, as well as parameters of the system itself, is a route towards optimization.

For illustration of simulation application, the flows in the container terminal are given aimed to determine the conception and basic parameters for functioning of the river container terminal and optimization. The task is to define the spatial conception of the terminal, type, number and technical parameters of the applied mechanization, based on the expected size of traffic of the containerized cargo and conditions that prevail in the concrete port. The analyses have been done in the two terminal sizes, of 100x100m and 200x100m, with application of straddle carriers or reach stackers for work in storage area. In all variants the number of stackers/carriers was a variable.

The analysis of the container flow results in obtaining of equipment time efficiency, waiting time, necessary parameters of the system operating etc. These values are base for further design of technical systems. The terminal model is presented in the Figure 1.

The used tool was software Enterprise Dynamics 6. This software is based on modular principle, i.e. the model itself is done by means of modules-atoms that exist in the software. The atoms are defined to functionally imitate behavior of a certain real element and by their linking are created a network of materials flows.

Majority of parameters used as the input values either represent system parameters of functioning adopted according to experience from the existing systems.

Hypotheses of values of these parameters directly impact the result quality as well. For illustration some parameters from the treated example are given. Operating cycle of the crane is given as:

$$t_c = \frac{\Delta x_i}{V_l} + \frac{\Delta y_i}{V_t} + t_l + t_u \qquad (1)$$

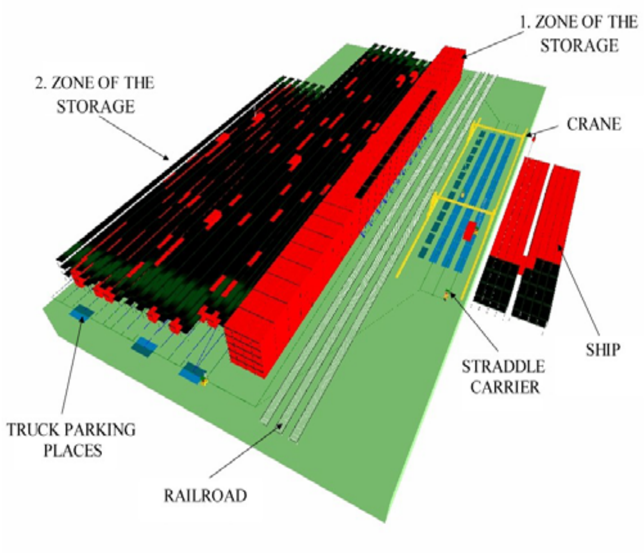


Fig.1 Model of the container terminal size of 200x100m with straddle carriers (Software ED)

$\Delta x_i, \Delta y_i$ - distance between locations of loading and unloading of a container,

V_l, V_t - speed of hoisting and trolley moving,

$t_l + t_u$ -Sum of time of load and unload of cargo (this time according to experience) corresponds to a uniform distribution.

$$f_{(t)} = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(t-\mu)^2}{2\sigma^2}} \qquad (2)$$

with median 25s and dispersion of 4 seconds).

It is also supposed that arrival of trucks and trains corresponds to the Poison's distribution.

$$f_{(t)} = \frac{\lambda(\lambda t)^{k-1}}{(k-1)!} e^{-\lambda t} \qquad (3)$$

Accordingly, the average number of arrivals is

$$\lambda = 1/\overline{t_a} \qquad (4)$$

$\overline{t_a}$ average time between arrivals is so determined that the average number of arrivals during a day is around 70 containers, while the medium number of departures is around 200 containers daily. Figure 2 shows a scheme and presentation of functioning of the observed container terminal.

Problems are to present enough accurately the real elements with existing software tools.

The first problem is with cane performing transshipment of containers from barges to the bank or directly on the trucks or railway wagons or in the first storage zone, but also vice versa from all listed locations (elements) into the barge.

The second problem relates to stackers/carriers that perform two-way connecting of the crane with other storage zones, reloading of wagons and trucks, as well as linking of the first and second storage zones, i.e. creating of one multi-functional element (ex. stacker/carrier), because canals used for linking of elements are exclusively one-way and there are not tools for sufficiently accurate description of all desired functions. Also there is a problem to define the logics of model functioning, managing the system and stochastic parameters.

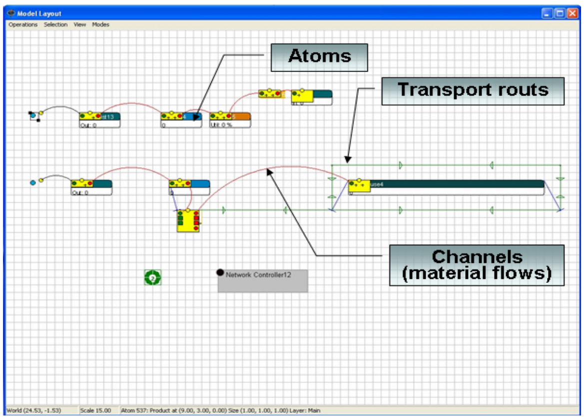


Fig. 3 Example of 2D model in software Enterprise dynamics with basic elements

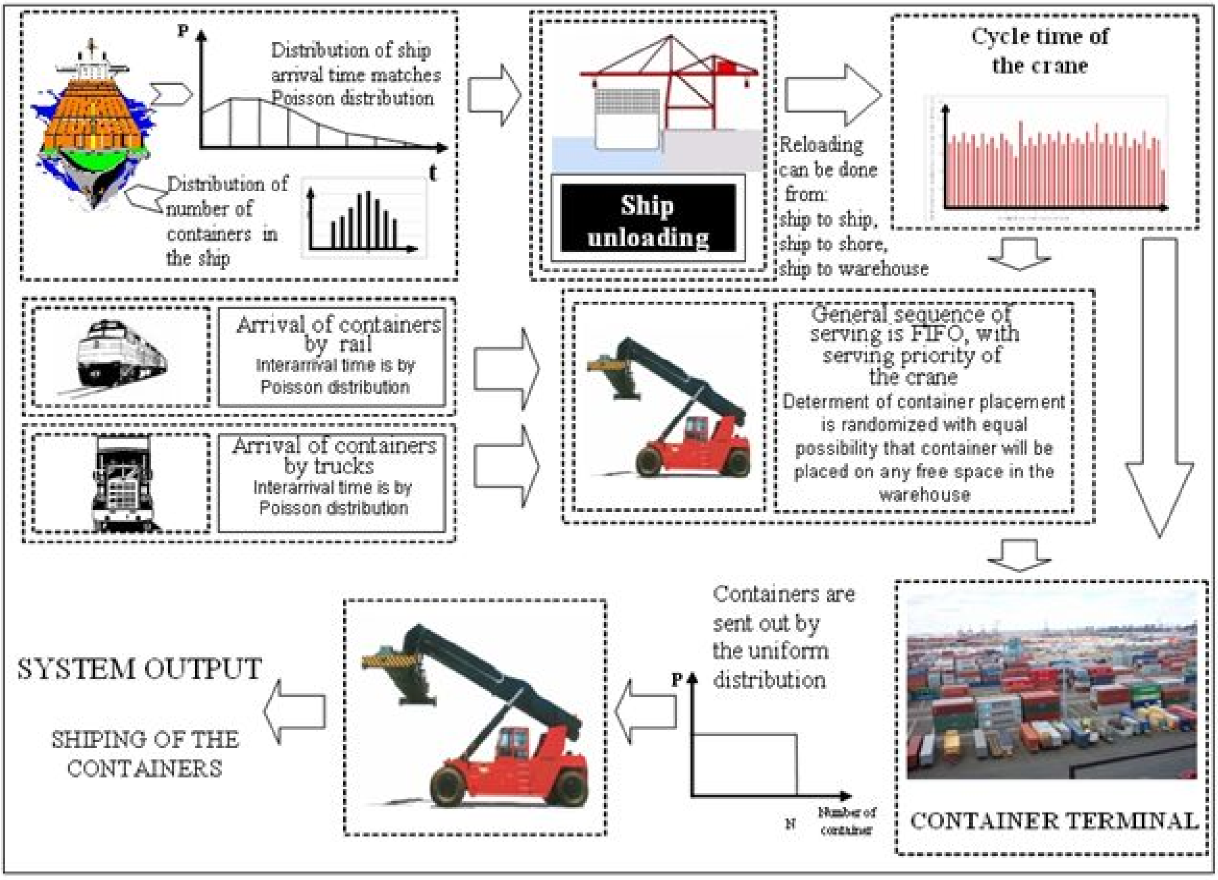


Fig. 2 Functional scheme of terminal's operation

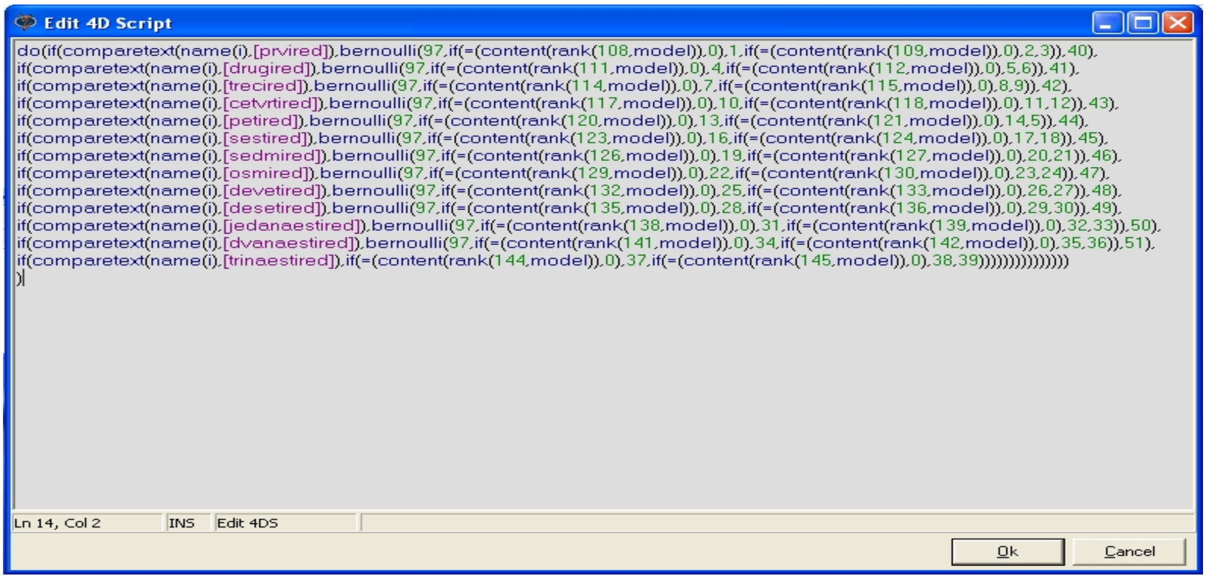


Fig. 4. Example of command (defining of logics by which the crane performs cargo unloading)

The first problem is solved by description of the real element by means of several atoms and synchronization of their work by means of set of explicit inter-dependant commands (Figure 4).

For each operating function of the carrier/stacker is used per one atom which describes this kind of means of cyclic transport, where work of one conditioned the work of all others This in much made more complex the model itself and opened a set of problems that appeared in the course of simulation, what even resulted in discovering of a minor error in software functioning (for the applied work's logics in spite of correctly given commands the model does not behave in concordance with the imposed function).

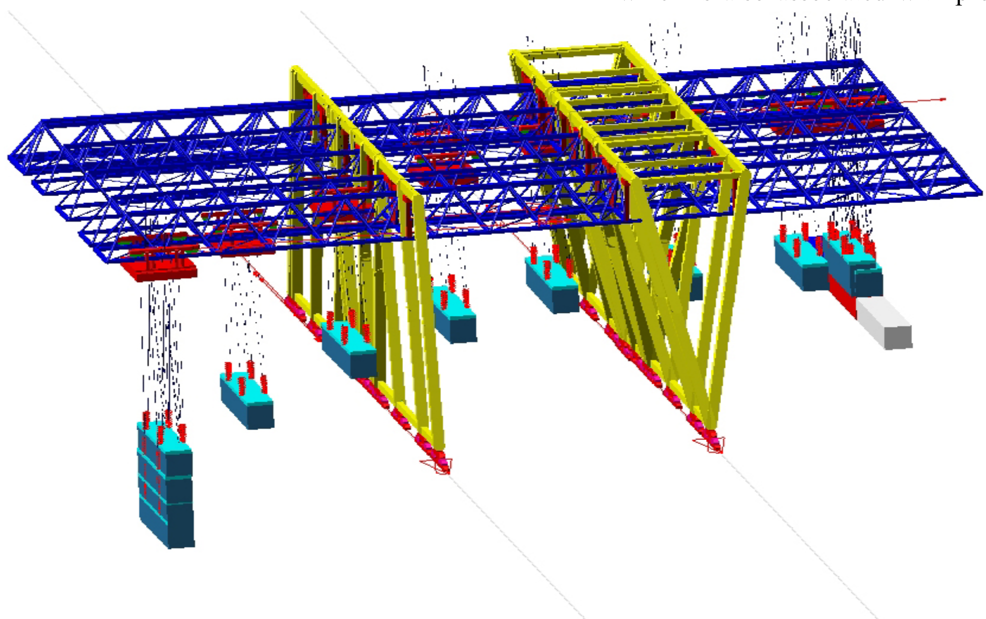


Fig. 5 Container quayside crane, model and work simulation (software ADAMS)

For purpose of easier analysis and realizing of the functioning of the complete model, the system was modeled part by part, where for each segment a small model was created and individually tested. Harmonization of work of these individual models is a complex procedure, since the change of the parameters of one sub-system inevitably influences the work function of other sub-systems, as well.

The work flexibility depends on nature of the tool itself which can be seen from the presented software, where the atoms are numerated and commands are frequently given according to the working number that atom carries. By elimination of any atom this order is disturbed so that in case of more complicated models it is hard to make changes on the model, which is also associated with probability increase of error appearance.

The great shortage of the presented software from the view-point of the user also is non-existence of undo function, what complicates work and imposes a need of continual saving of the models copies after each step.

The basic conceptual improvements that should be introduced related to the concrete example are making possible of two-way materials flows and elimination of the problem of atoms numeration. To create the two-way canals there is a need to make fundamental change of the software work itself, while the simplifying the defining of work logics of the cyclic bond meant to provide two-way materials flow (particularly outstanding problem in several kinds of atoms) implicates fewer requirements for change of software's work.

3.2 Simulation application in the equipment design phase

Further analysis includes simulation problems which refer to the adopted variant of the container quayside crane. For the adopted terminal conception the container quayside crane has been designed, which has the following technical parameters:

Distance between tracks:	25 m
Outreach on both sides:	27, 5 m
Approximate weight:	290 t
(in calculated trolley 50t)	

Dimensions and basic technical parameters of the crane have been obtained regarding location and working conditions. The crane model has 298 beam elements with structural damping, 841 part elements, 8 elements of type of spring with damping and 398 degrees of freedom.
Structure of the crane has been modeled as elastic with masses concentrated in parts. The outreach end of the beam support has been modeled as a rigid, enabling defining of trolley's running along the beam support (Figure 6).

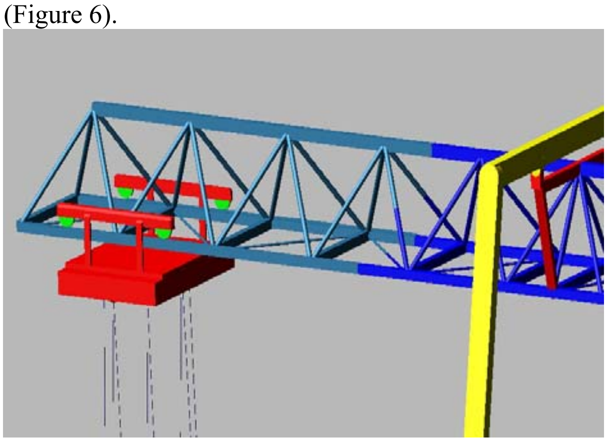


Fig. 6. End of the girder

Elements of the steel construction are modeled as a combinations of elastic elements (beams, which do not have own mass) and rigid parts of small length (part) which have own (equivalent) mass and which are most frequently on the connection points or on the place of local strengthens, thus tending toward modeling after rules of macro FEM elements. This kind of modeling produces differentiating of a model from the real physical model, which is lessening with smaller lengths of beam elements. Defining of the moving (displacement) can be done only between two rigid bodies, what is one of the basic problems accompanying work and simulation with ADAMS. External forces can be placed on the parts only. To solve the problem it is needed to know the physical phenomenon alone which is being studied as well as way the software works. The combination of these two factors as well as experience and the designer's alone creativity will all impact the success of modeling as well as the simulation as a whole. Connection of stiff and elastic parts is given in the Figure 7.
The performed simulation corresponds to work-operation of the crane with container of 40t when the trolley is placed at the outreach's end and when the lifting of the container starts from the ship.

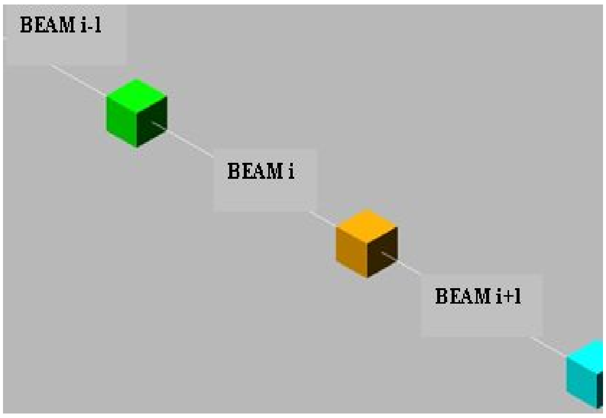


Fig. 7. Model of girder (parts and beam elements)

When the container is lifted up to height of 5m, trolley starts moving towards the terminal. Parallel to trolley's routing the crane is moving, too (Figure 6). Speed of lifting the container is 0,5m/s and speed of moving of trolley and the crane is 2m/s. Transient processes (accelerations and braking) of drive mechanisms are dependent on power of the engines to drive lifting or required control conditions for horizontal drives. By simulation the dynamic factor ϕ_2 (which considers cargo lifting from the base according EN 13001 and EN 13002) is obtained, by means of change of force in the ropes, which is a base for dimensioning of structure. Factor ϕ_2 is a relation of maximal and static (or quasi-static) force value $\phi_2 = F_{max}/F_{st}$. In the Figure 9 is presented the force change in the rope.
On the basis of load changes spectrum (forces and torques) for various operation cycles, it is possible to calculate the duration machine age.

In all cranes which have at least two moves, i.e. there is also a horizontal moving of the cargo hanging on the ropes, arises a problem of cargo swaying. Increasingly expressed tendency to enlarge the capacity of transport machinery (especially container cranes) requires increasingly greater speeds for achieving shorter period of operating cycle, but with certain accuracy in positioning, ex. ±5 cm

Beam without mass with constant cross-section (mathematical interpretation)

$$
\begin{bmatrix} S_1\\ S_2\\ S_3\\ S_4\\ S_5\\ S_6\\ S_7\\ S_8\\ S_9\\ S_{10}\\ S_{11}\\ S_{12} \end{bmatrix} =
\begin{bmatrix}
\frac{EA}{l} & & & & & & & & & & & \\
0 & \frac{12EI_z}{l^3(1+\Phi_y)} & & & & & & & & & & \\
0 & 0 & \frac{12EI_y}{l^3(1+\Phi_z)} & & & & & & & \text{symmetric} & & \\
0 & 0 & 0 & \frac{GJ}{l} & & & & & & & & \\
0 & 0 & \frac{-6EI_y}{l^2(1+\Phi_z)} & 0 & \frac{(4+\Phi_z)EI_y}{l(1+\Phi_z)} & & & & & & & \\
0 & \frac{6EI_z}{l^2(1+\Phi_y)} & 0 & 0 & 0 & \frac{(4+\Phi_y)EI_z}{l(1+\Phi_y)} & & & & & & \\
\frac{-EA}{l} & 0 & 0 & 0 & 0 & 0 & \frac{EA}{l} & & & & & \\
0 & \frac{-12EI_z}{l^3(1+\Phi_y)} & 0 & 0 & 0 & \frac{-6EI_z}{l^2(1+\Phi_y)} & 0 & \frac{12EI_z}{l^3(1+\Phi_y)} & & & & \\
0 & 0 & \frac{-12EI_y}{l^3(1+\Phi_z)} & 0 & \frac{6EI_y}{l^2(1+\Phi_z)} & 0 & 0 & 0 & \frac{12EI_y}{l^3(1+\Phi_z)} & & & \\
0 & 0 & 0 & \frac{-GJ}{l} & 0 & 0 & 0 & 0 & 0 & \frac{GJ}{l} & & \\
0 & 0 & \frac{-6EI_y}{l^2(1+\Phi_z)} & 0 & \frac{(2-\Phi_z)EI_y}{l(1+\Phi_z)} & 0 & 0 & 0 & \frac{6EI_y}{l^2(1+\Phi_z)} & 0 & \frac{(4+\Phi_z)EI_y}{l(1+\Phi_z)} & \\
0 & \frac{6EI_z}{l^2(1+\Phi_y)} & 0 & 0 & 0 & \frac{(2-\Phi_y)EI_z}{l(1+\Phi_y)} & 0 & \frac{-6EI_z}{l^2(1+\Phi_y)} & 0 & 0 & 0 & \frac{(4+\Phi_y)EI_z}{l(1+\Phi_y)}
\end{bmatrix}
\begin{bmatrix} u_1\\ u_2\\ u_3\\ u_4\\ u_5\\ u_6\\ u_7\\ u_8\\ u_9\\ u_{10}\\ u_{11}\\ u_{12} \end{bmatrix}
$$

Fig. 8. Beam matrix

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Due to cargo swaying the additional maneuvers are needed aimed to calm oscillation down, what considerably prolongs duration of the operating cycle. The crane model meant for testing of trolley moving control has the girder that is rigid, by what the accurate values of section forces in the structure are not obtained. For the simulation which gives accurate values of sectional forces, all elements of the structure must be elastic, but then the trolley moving along elastic parts is not possible.
The Figure 10 presents container swaying in direction of the trolley's moving (blue dashed line) and in direction of crane's moving (red full line).

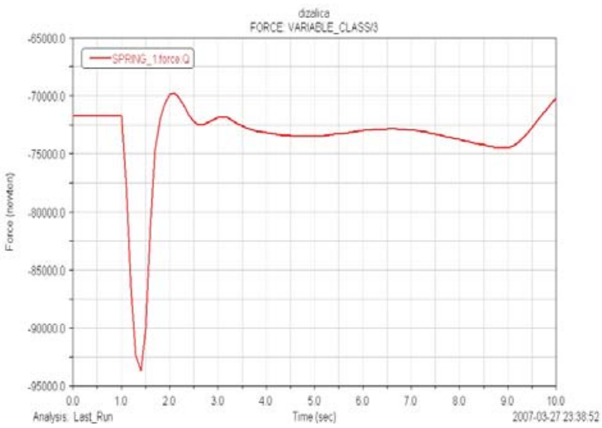

Fig. 9. Force change in the rope

From the given example it can be noticed that in this instant there is not a corresponding possibility in the ADAMS software, consequently two ideas are given as a signpost towards possible solution.

The first idea
Rigid element between two BEAM elements (along which trolleys are running) shifts along the beam and does it in the way where at each step of integration all previous parameters are copied and are being rewritten in the new step. This element would be differentially small, and after each integration step the lengths of beams which connect the given elements are modified. This idea leads towards micro FEM method; it is closer to reality but more difficult to perform. After all there is still a problem of errors that appear in transferring data from the previous simulation unto a new – modified model, which due to shifting of the rigid differentially small part has alternated structure and during the new step of simulation would appear problems in integration and higher frequencies as consequence of integration with changes on the model.

The second idea
It recognizes present possibilities of the ADAMS software. Rigid elements Pi-1, Pi and Pi+1 are connected with elastic elements (ex. BEAM1 and BEAM2). For horizontal moving of trolley the rigid elements Pi-1, Pi and Pi+1 are over-bridged by means

of corresponding rigid parts without mass (ex. Pj and Pj+1).

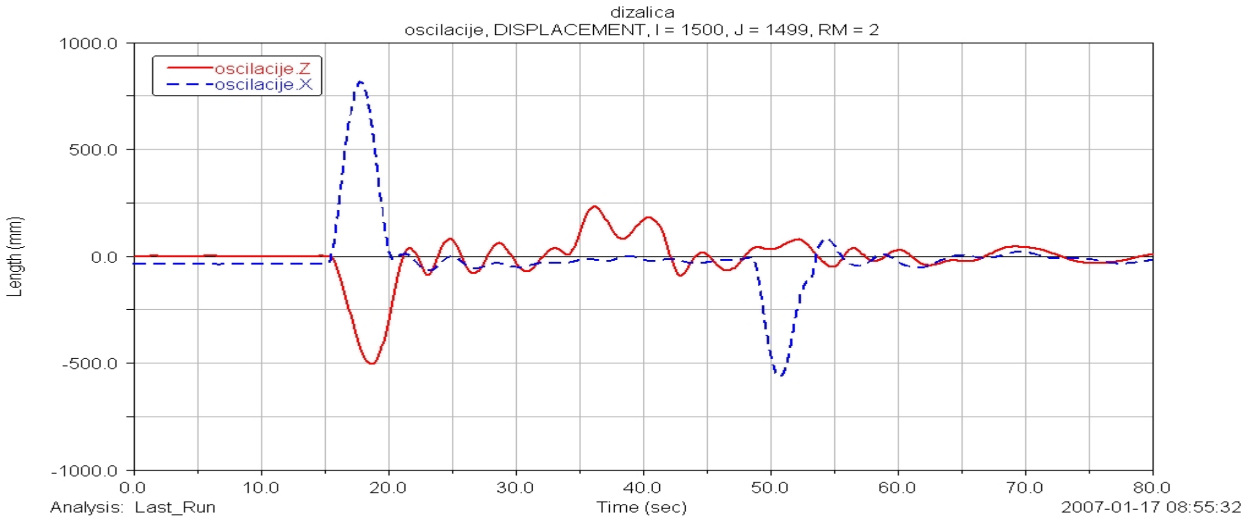

Fig. 10. Container's swaying – tests of horizontal drive control

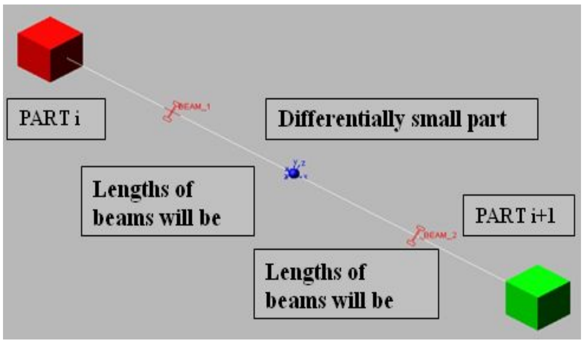

Fig. 11. Graphical display of the first idea

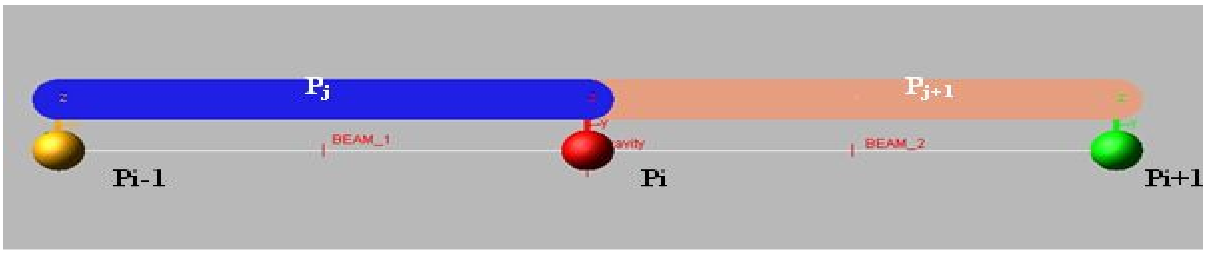

Fig. 82. Rigid and elastic elements (proposal of connecting)

Joints between rigid elements Pi and Pj allow free deforming of elastic elements just like the real structure would behave, what is possible with the existing version of ADAMS. Transition from one rigid element Pj unto another Pj+1 in the existing version is a problem, because JOINT which is between the first rigid element Pj and the trolley should be turned off and one joint between the trolley and the other rigid element Pj+1 in the same position should be established so that all parameters (results) of simulation obtained in the end of the first part (Pj) are the initial data in the next rigid part (Pj+1). This re-writing of data would be done in the moment when the trolley is on the end marker Pj which overlaps with the initial marker Pj+1. By that the position parameters (x,y,z, corresponding angles) are transferred, as well as speeds and accelerations.

For now there is no way by which the JOINT should have temporal limit (in this case up to a moment when the corresponding marker of the part j overlaps with the corresponding value of the part j+1). In this moment it is possible only MOTION and UCON to temporally regulate but by means of the suitable subroutine.

The realization of the previously described is possible by changes in the algorithm of software's operation with use of the copy option for a model.

Transition from one section of the beam element in to another one would have the same positions, but differentially small alternations in speed and acceleration vectors. These differences are dependent on the relative lengths of beam elements in relation to the supports, where from originates a demand for smaller lengths of beam elements and the correction in the algorithm which after each copy function (transient from j up to j+1 part) change directions of the local speed and acceleration vectors towards j+1 element.

4 Conclusion

Development of computers and informatics has made possible the system approach in the techniques, which starts with analysis of demands (market) and ends with recycling, where the simulation are a tool for

optimizations. In the course of simulation software development, partially (separately) have been made analyses of individual segments of this complex system, so that it has not even been thought of manners for connecting the simulation in the initial phases of the technical systems, like market analysis, goods and material flows with simulation of work and equipment, which already exists or will be design for the specific use.
The present system approach requires linking of all parts of the process, and that means need for the interface between of respective simulation software.

The explained simulation software for material flow ED is superior in relation to any classical methods, but it alone has a lot of shortages, which by means of adequate approach could be more or less successfully solved. Some of possible improvements require partial change of the mathematical tool.
ADAMS software has been for more than twenty years a superior for dynamic analyses and control of mechanical systems, but still it does not give sufficiently good possibilities for simulation of moving along elastic elements.
This paper gives suggestions for improvement of software work for this problem.
The improvements of power of software for simulations increase the quality of optimization processes, and by that is also being proved the accuracy of the thesis that the simulation are the most modern optimization method.

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