

# **APPLICATION OF THE ADVANCED ENGINEERING SYSTEMS FOR MODELING LOGISTICS PROCESSES**

**Aleksander Gwiazda, Prof.**

aleksander.gwiazda@polsl.pl

Silesian University of Technology in Gliwice, Poland

**Zbigniew Monica, PhD**

zbigniew.monica@polsl.pl

Silesian University of Technology in Gliwice, Poland

**Alex Czekanski, Prof.**

alex.czekanski@lassonde.yorku.ca

York University in Toronto, Canada

## **Abstract**

Modern informatics tools not only allow analysis of simple logistics processes but also the complex ones. They allow modeling and studying the performance of these systems in the virtual environment without creating both real models and real systems. Hence their utilization could lead to reducing the cost of their realization. The paper presents examples of such applications to problems of ecologistics and high-bay warehouses.

**Key words:** CAE systems, process modelling, production logistics.

## **Introduction**

Nowadays, one of the fundamental issues of enterprise policy is to realize operations in accordance with the legal requirements as well as with the requirements of the modern competitive environment. Currently one of the main components of the logistics system are automation sub-systems, located within the integrated supply chain. Such understood supply chain includes now all the processes and activities related to the movement of materials in any form (raw materials, semi-finished products, parts, products, packaging) from sources of their acquisition, through all the intermediate stages, to the client, as well as in the return way (secondary raw materials,

used packaging, wastes). This return logistics chain is usually defined as the reverse logistics. To ensure the smooth functioning of the logistics system it enforces implementation of the two-way flow between all participants in the logistics chain: the demand flow (from the last link of the logistics chain to the first) and the supply flow (in the opposite direction in response to demand information). In addition, at each stage of production and delivering it is necessary to make the right decisions to meet customer requirements and provide the appropriate level of logistics services at acceptable cost. Moreover, it should be noted that the global market and competition are forcing all participants of the logistics system to strive to shorten the duration of their operation.

The striving of companies to realize the previously mentioned goals, that is the fulfilment of legal requirements and, on the other hand, shortening the duration of operations, requires suitably powerful informatics tools. To effectively plan and manage production and logistics systems of an enterprise, it is needed to use appropriate computer software that supports the analysis of logistics in various aspects of its operations. As examples of such programs it could be specified the following systems: Taylor II for Windows, Enterprise Dynamics (Logistic Suite), Flexsim, Roboguide, Process Simulate or Plant Simulation. In the following sections, there are discussed the results of utilization the first of them to the analysis the selected, complex logistics processes.

## 1. Ecologistics

Ecologistics includes all activities related to the collection and disposal of waste materials, in a way that is not offensive for natural environment. The other term used for ecologistics is reverse logistics. It is based on the concept of management of waste materials as well as on disposal and recycling of materials impinging negatively on the environment (Korzeń 2001: 17). Moreover it allows making decisions according minimizing negative impact on the natural and social environment. Hence ecologistics tasks relate primarily to activities such as: waste collection, segregation, transportation, storage at selected locations, processing. Thanks to the ecologistics companies can get a lot of savings because the worn or lightly damaged things could be reused instead of utilizing them. Many wastes, being machine parts, could be processed again and used again, as it is in the case of the automotive industry. The cost of recycling is then much lower than the purchase of new materials for production. Concluding one should state that the range of ecologistics is relatively wide. It includes: public education on issues of sustainable development, organization of segregated waste

collection, regular removal of collected waste, provision of removed waste to utilization plants, placement in landfills that are not suitable for recycling, special treatment of hazardous waste (Korzeniowski 1999: 157).

Waste is goods, solids and liquids (except plants) which are the result of a business or of human existence that are, in accordance with the decision of their owners, useless in place or time in which they arise (Korzeń 2001: 18). This means that for some things that are waste, for others will be a valuable product. An example might be old newspapers and papers which have undergone appropriate treatment can be used as material for the manufacture of cartons and other packaging.

Concluding it should be stated that ecologistics and reverse logistics is a general process of flow management of waste (including damaged products) and information (related to these flows), from the places of their formation (appearance) to the place of their destination, in order to recover the value (by repairing, recycling or processing) or appropriate storage in such a way that these flows are cost effective and minimize the negative impact of waste on the environment of a man (Szołtysek 2009: 80). Hence, from strategic point of view, recycling is the key competence of reverse logistics. It is focused on several key areas including: the structure of reverse logistics network, the interdependence of many logistics activities (transportation, storage, product life cycle) and the management the logistics information systems as well as the regulations protecting the environment.

Properly designed environmental standards could stimulate innovation among the companies that have become more competitive. The way in which companies respond to environmental problems, it may be a factor in their competitiveness. In other words, in order to recognize opportunities to improve resources productivity, innovativeness and competitiveness it may be beneficial to enact stricter environmental regulations (Porter 1995: 98). There are many factors that motivate all organizations and businesses to focus on the production of environmentally friendly products and technologies.

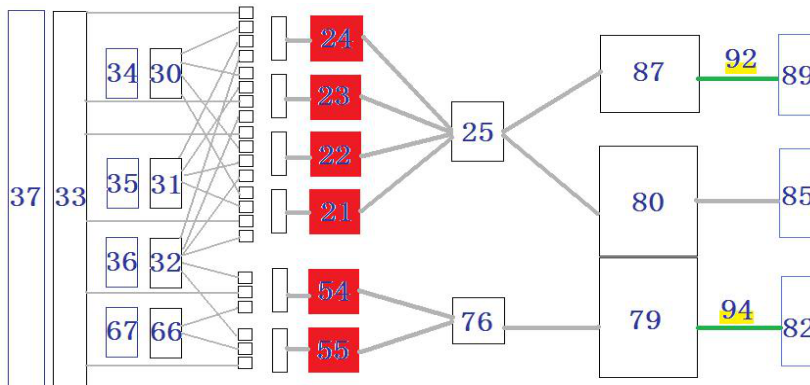
## **2. Simulation of the ecologistics process in a conventional power plant**

In the paper is presented the logistics process analysis referring to the example of a classic power plant and analysis of its logistics processes, from the point of view of the issues of ecologistics. Model of logistic processes is realized in the Taylor II program. This software is designated for modeling of queuing systems with discrete flows. It is hence appropriate to conduct simulation analysis of models of next systems: production, transpor-

tation and storage. Modeling, bases on spatial distribution of elements of an analyzed system. The layout area is used for modelling and simulating of functioning of an investigated process. In this area it is possible to define components of the analyzed system. The group of components includes next elements: In/Out, Buffer, Warehouse, Machine, Conveyor, Transporter, Path, Aid and Reservoir. Components of the model are described by their characteristic parameters (e.g. operation time, failure rate, the size of the store, production batch). They could be static or dynamic. Moreover, it is possible to determine the characteristics of the components functioning, elaborated on the basis of statistical studies. The parameters are entered in the form of discrete numbers, statistics or in the form of specifics functions of the internal programming language.

The modelled ecologistics process in the analyzed power plant is presented in Figure 1. The schematic model of power plants in relation to the activities considered with the supplying process of raw materials (coal, biomass), the production of electricity and ecologistics operations designed for the recovery of material for the production of gypsum. The particular numbers represent particular elements of the modelled system.

Figure 1. Model of logistics processes of a power plant

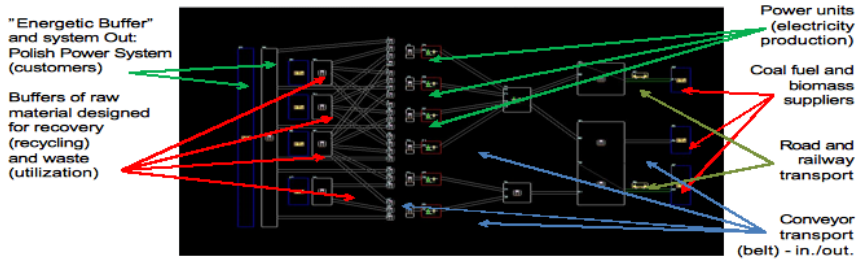


The numbers on in the figure, as it was mentioned previously, presents particular components used to model the operation process of the classical coal power plant. They are discussed below:

- 89 – system In – biomass supplier;
- 85 – system In – I-st coal supplier;
- 82 – system In – II-nd coal supplier;
- 92 – Transporter – truck ;
- 94 – transporter – PKP railway;
- 87 – Buffer – biomass storage;
- 80 – Buffer – coal yard No. 1;
- 79 – Buffer – coal yard No. 2;
- 25 – Buffer – intermediate storage  
(biomass and coal mixing);
- 76 – Buffer – intermediate storage;
- 21 – Machine – power unit No. 12;
- 22 – Machine – power unit No. 11;
- 23 – Machine – power unit No. 10;
- 24 – Machine – power unit No. 9;
- 54 – Machine – power unit No. 1;
- 55 – Machine – power unit No. 2;
- 30 – Buffer – gypsum storage – (euro-silo),
- 31 – Buffer – impounding reservoir on the  
station of Emulsifier No. 2, on fly-ash;
- 32 – Buffer – yard for storing remained waste,  
including:
  - ash - slug mix,
  - sediments from sewage-treatment plant,
  - sediments from fuel preparation
  - screenings,
  - sewage sediments,
  - sediments from water decarbonization,
  - used active carbon,
  - used ion-exchange resins;
- 33 – Buffer – virtual storage for electricity;
- 66 – Buffer – impounding reservoir on the  
station of Emulsifier No. 1, for NID;
- 34 – system Out – gypsum recipients;
- 35 – system Out – fly-ash recipients;
- 36 – system Out – firms having permission for  
waste management;
- 37 – system Out – Polish Power System (PSE  
S.A.);

The production process of a classical coal power plant could be divided into three stages (Figure 2). The first one includes the supplying operations (coal and biomass). The second include “production” of electric power in power units. This process was modelled using components considered with discrete process analysis in the form of Machine (power unit) and Buffer (energy storage). In this way it was possible to model this continuous process. Finally the third stage includes recycling of ashes and waste management.

Figure 2. Structure of the power plant



The model prepared according the presented scheme was used to analyze functioning of the investigated process of the given power plant. The input parameters for the simulation process were related with the plant supply chain. They were modelled in the system according to obtained information and reports (Figure 3). Such determined parameters were used to simulate the functioning of a power plant in the period of a year. The run of the simulation is presented in Figure 4.

Figure 3. Parameters for the simulation

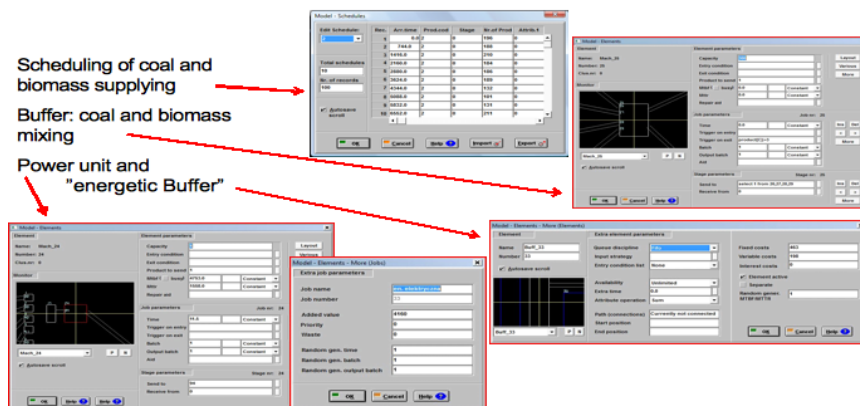
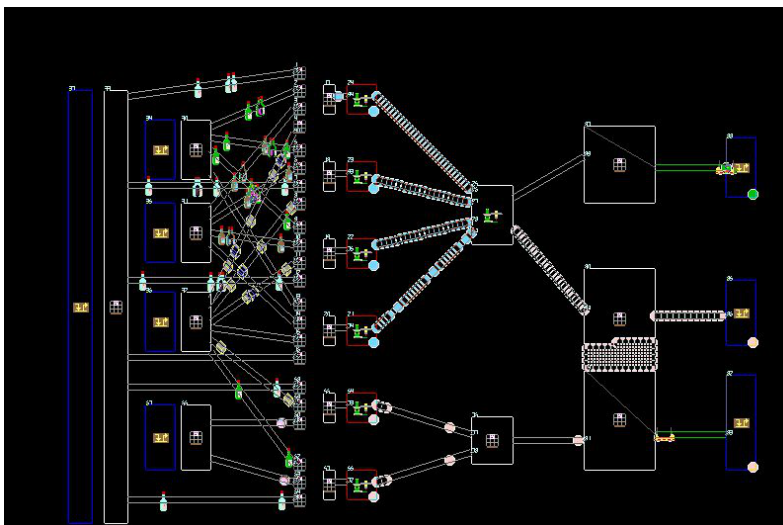
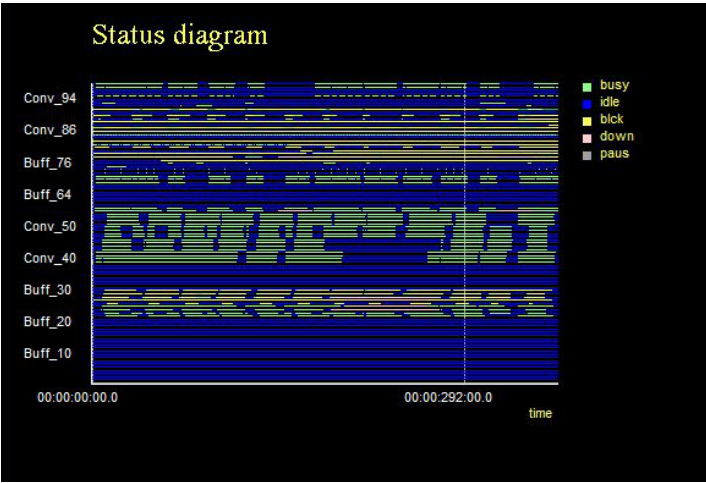


Figure 4. Simulation of the logistics process of a power plant



The conducted simulation let to investigate the operation process of a power plant and to analyze problems appearing both in short time perspective and in long time one. It facilitates searching the “bottle necks” of the system and investigating the methods of creating solutions that should help to eliminate limitations relate with these factors. The basic report prepared by the system is the Gantt chart presenting the work of all components of the simulated system. In Figure 5 is presented partial Gantt chart for chosen components of the system. It let to analyze the utilization of particular components and their cooperation.

Figure 5. Gantt chart for the analyzed power plant operations



The gypsum production considered with the fly-ashes recycling is presented in Figure 6. The increasing of production is related with the higher demand on electricity. In turn, Figure 7 presents the waste management.

Figure 6. Gypsum production

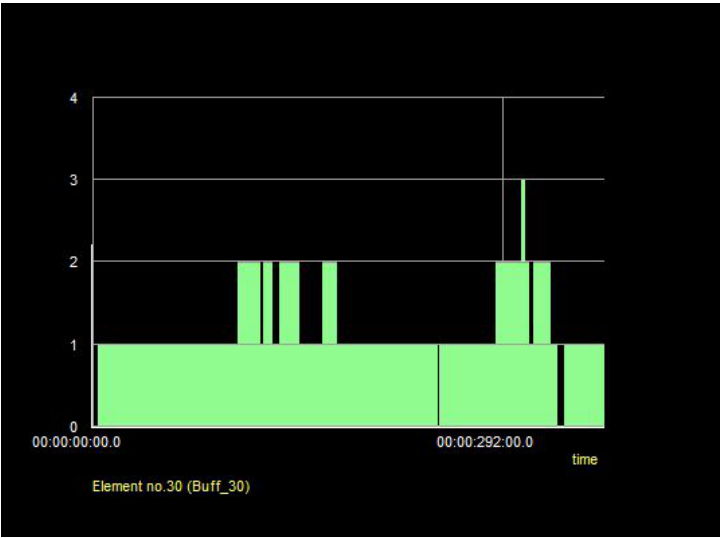
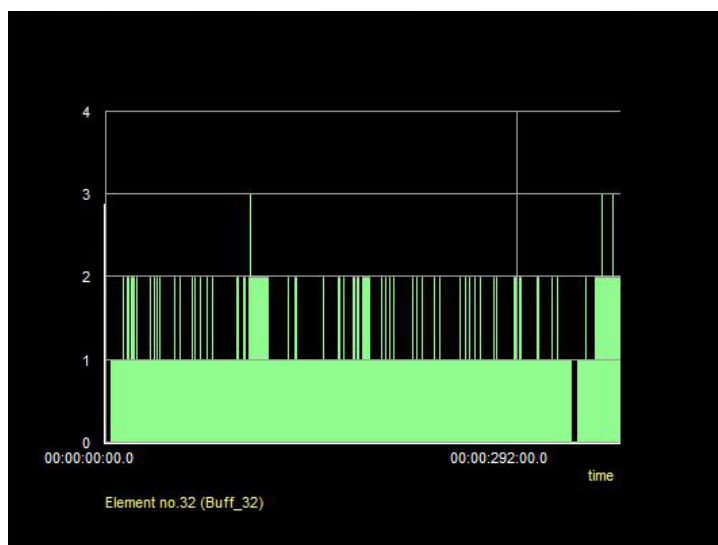


Figure 7. Waste management

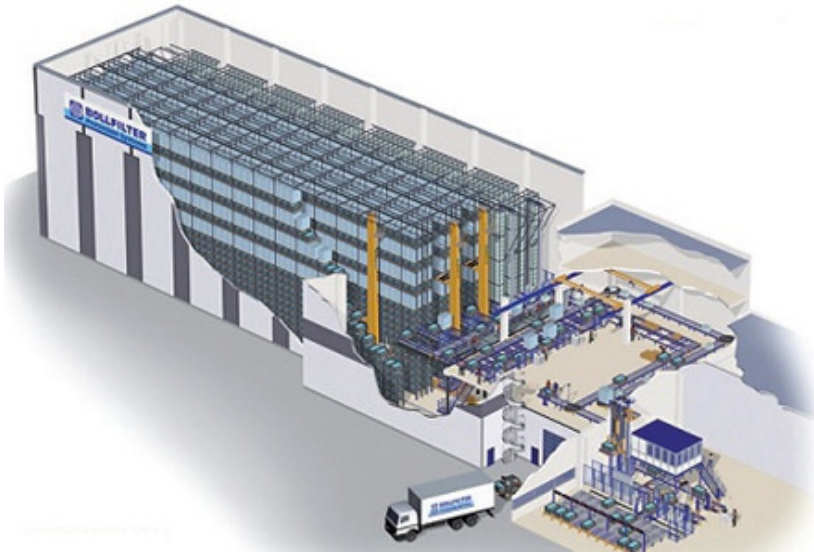


The presented analysis of the production process shows a method of controlling and supervising such processes. Utilization of simple informatics software broadens the range of possible applications. The detailed report allows analyzing functioning of particular elements of the system. From the ecological point of view the most important were reports presenting the ash recycling process (gypsum production) and the waste management. The purposes of supervising this processes is to maximize the utilization of waste material and to minimize the amount of waste. By simulating the processes of waste management it is possible not only to supervise their formation but also their utilization. These reports could be also used for the ecological audits for example according systems basing on PN-EN ISO 14001.

### 3. Problem of high-bay warehouses

The other problem, presented in the paper, is related with the logistics process of the high-bay warehouses. This group of storage systems represents their most developed group. By storing wares, pockets or pallets in high-bay storage systems, it is possible to reduce handling operations and better utilize the available floor space (Hompele 2007: 98). An average high-bay storage system can reach up to 50 m in height. It is four times more than the storage capacity of conventional systems. Moreover the efficient use of vertical storage space allows minimizing the overall warehouse foundations surface. It is particularly important in areas where land is expensive and building space is limited, that is in the urbanized areas.

Figure 8. Example of a high-bay storage system (Boll & Kirch)



High-bay storage systems also allow reducing labor costs by lowering necessary workforce requirements, increasing workplace safety by reducing warehouse movement, and removing personnel from difficult working conditions (Gudehus 2009: 527). These systems can produce major savings in inventory storage costs via improved space utilization and storage density, both vertically and horizontally. For example, for more than 20000 pallets, the place costs of an automatic high-bay storage are lower than the place costs of a block place storage. For the same amount of pallets the throughput costs of a high-bay storage are lower than for all other storage systems).

#### 4. Modeling of functioning of a high-bay warehouse

The second problem, presented in the paper, is related with the logistics of a high-bay warehouse. This logistics system was analyzed using the Enterprise Dynamics 8 program. This program includes a much larger library of components than Taylor II. Using these components it is possible to create more complex models of logistics systems. One of the additional components of the Enterprise Dynamics system is an industrial robot. It is possible to choose one of the robot types: Scara one, portal one or articulated one. It is also possible to design own robot (dimensions, range of motion axes, capacity, speed and acceleration) and program its robot trajectory at simulation level. But this is not a robots programming language dedicated

to a particular manufacturer. However it has the basic functions used for on-line or off-line programming.

Also significantly are expanded transportation and storage systems. To the components library are added conveyors, AGV trolleys, warehouse stacker cranes and others. These components are closely related with freight logistics. The other change is considered with the functionality of the Machine component. The base of technological functions has been extended by assigning specific functionalities with special types of components (Multi server, Assembler, Splitter, Unpack, Carousel server).

All this changes allow modelling more complex processes and systems. In the Figure 9 is presented a model of a high-bay storage system modelled in Enterprise Dynamics 8. The model was realized on the model layout. It includes the components like: Advanced transporter, Networks, Warehouse. These all elements are linked together to obtain the model for the simulation process. The designed system is serviced by the advanced transported. The logistics process of the high-bay storage system could be described as follows: the packages are received at the input stands and stored in the high-bay system. When they are needed they are moved to the completing stand. After completing they are moved to the output stand. As it is seen in the Figure each stand could be equipped with information concerning its utilization. It is also possible to present the functioning of the analyzed system in the form of a 3D scheme.

Figure 9. Model of a high-bay storage system

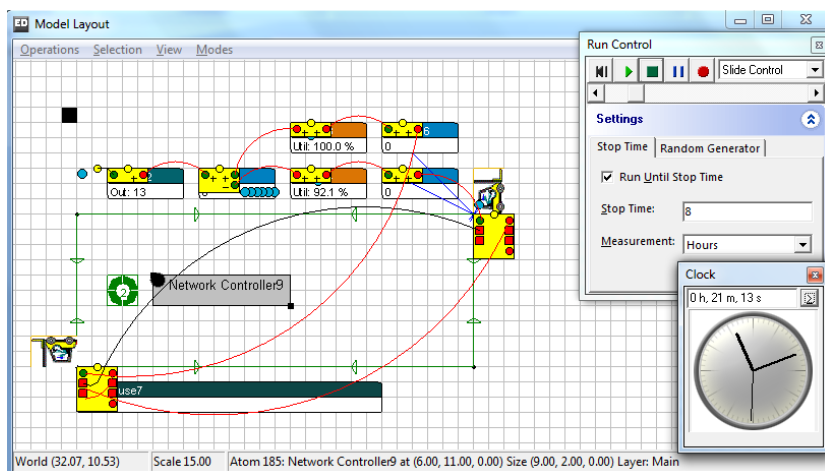
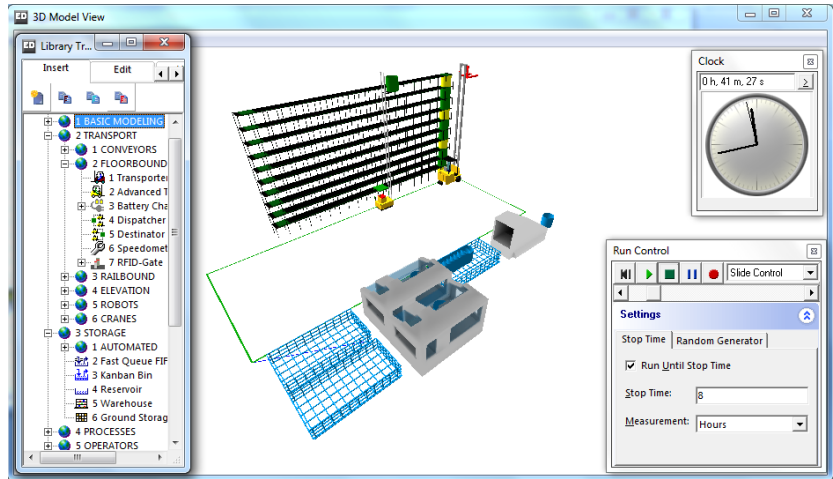


Figure 10. Model of a high-bay storage system



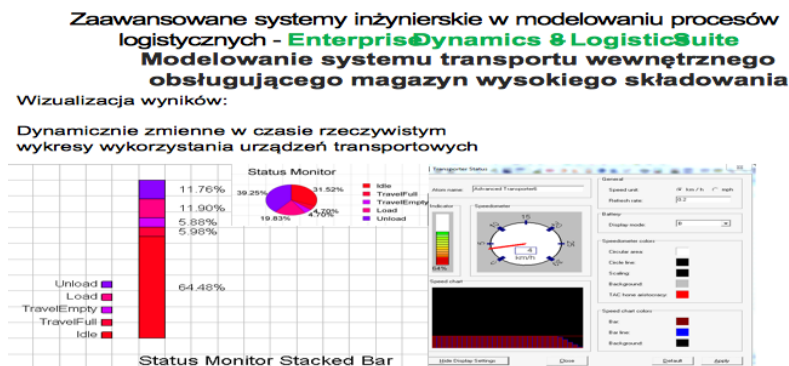
Using the program indicated there is a possibility of a comprehensive analysis of the functioning of the logistics system. The main type of report is a Gantt chart. A sample Gantt chart is presented in Figure 11. It presents the optimized sequence of transport and storing processes according the criterion of rotation. Moreover it was obtained the smooth flow of packages between particular stands.

The other solution, implemented in Enterprise Dynamics 8, is the possibility for direct monitoring of functioning of particular stands in real time. To realize this task are designated special monitors (Figure 12) that could present, in real time, the investigated variable.

Figure 11. Gantt chart for the analyzed high-bay storage system



Figure 12. Real-time monitoring of logistics processes



The presented example shows the possibility of implementation the simulation technique to analyzing and solving the problem of automated system optimization. In this case the automated logistics system is represented by the high-bay storage system. It could be served by robotized stands and by automated guided vehicles (AGV), which could be properly programmed using the internal language.

## Conclusions

The analyses of both the problems of computer simulation tools used to solve the issues of eco-logistics as well as to analyze the issues of modeling and simulation of integrated logistics systems show the capabilities of advanced informatics tools. These tools have evolved from the programs of initially narrow and limited range of application and utilization. Currently they form an integrated informatics environment, which allow for designing, analyzing and optimizing logistics systems of any type. They also enable to program functions of the components of a system, as well as modeling, basing on real data, real functioning of investigates systems. Delineated direction indicates the integrated development of virtual design environment has extended reality.

In this study are presented two specific informatics tools, and namely Taylor II and Enterprise Dynamics 8 programs. These programs allow modeling complex logistics systems basing on provided, universal components of the system. The created logistics systems are primarily discreet but it is possible to build models of logistics systems for continuous processes. This requires the use of certain auxiliary solutions. In terms of versatility, it should be specified that this generation of programs has poorly developed software preprocessors allow using the models developed in other appli-

cations. On the other hand these systems are characterized by highly developed post-processors that allow exporting and using, in other systems, developed working scheduling. Further development will be directed to develop more integrated preprocessors for this type of software.

Creation a model in these systems is carried out over the layout space by inserting the appropriate components and defining their mutual relations. A part of the creation of logistics relations refers to both the defining input characteristics and the output ones. This action also refers to defining the process characteristics of a given component of a system. Thus, the quality of the create model of a logistics process is strongly determined on the quality of partial characteristics of its components. Therefore, in the case of complex logistics models, it appears essential to carry out the experimental verification or experimental fine-tuning of the created virtual models of real systems. Similarly it was realized in the case of the presented models of the logistics process of coal power plant and of high-bay storage system. Through such actions it was managed to develop models of real logistics systems that could be used in industrial practice.

Further development of the presented solutions is moving towards a comprehensive integration of solutions of the CAx systems with the business planning systems of the ERP category. These systems should realize the optimization activities not only in terms of time and busy criteria, but also in terms of the cost criterion. However, this requires a significant increasing in the processing speed of hardware.

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