Optimalization of transport and logistic processes by simulation

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Abstract: Logistic centres are a necessary part of the transport and logistics processes. They are beneficial in the entire scale of their importance, ranging from the economical, ecological up to the social benefits. The costs for the construction of the logistics centres are very high. It is therefore important to set up sufficient capacity for all partial parts of the logistic centre. One possibility is to use the simulation processes to verify the expected future operations in the logistics centre. This article deals with the benefits of the simulation processes and their possible use in the design of new logistics centres.

Key words: logistic centre, simulation process, optimization.

Introduction

Transport and logistics is a part of every developing society. The amount of the transported goods increases every year. There is an increasing demand for the quality services. Besides the positive effects of goods transport is growing its negative impact on the environment. They are primarily:

- *exhaust emissions* – accruing from combustion of fuel in a gasoline and a diesel engines. It's all about carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen oxides, ketones, aldehydes, hydrocarbons and soot.
- *occupation of the arable land* – it´s represent mainly the surface consumption on the traffic construction building and parking.
- *noise* – it´s characterized as an unwanted noise, which acts to disturb a man. A traffic noise is caused by the running engine, the rolling of wheels in motion on the road, the airflow and the audible warning devices.
- *vibration* – is caused by vibrating of elastic bodies or environment which certain points mechanically vibrate. Dynamic forces are the main causes of inaccuracies in the manufacturing of parts and components. Vibrations may be cause by the technical condition of the vehicle, vehicle construction, traffic road construction, contiguous constructions, etc.
- *congestion* – is especially characterized for larger cities. They arise from the continuous increase in the number and use of cars and trucks. This trend is not enough to adjust the capacity of road and rail infrastructure, resulting in solving down traffic, increase noise and emissions in the air.
- *accidents* – characterized by the exact material claims which are caused on the vehicles or contiguous constructions. It is more difficult to calculate the injuries by hurting or man´s death. The most serious influence on the traffic accident are – psychological factors, technical factors, meteorological factors (Lábaj, J., Patsch, M., Barta, D., 2009).

It is necessary to find out a compromise between the demand for the transport and the requirement of the environment protection.

Each mode of transport has its own strengths and weaknesses. It is necessary to do the transport of goods with a combination of such modes of transport where the negative impact on the environment is as low as possible. A combination of different transport modes requires the good places for the transshipment, the storage and the beneficiation of the goods. The modern logistic centres meet these requirements.

The construction of the logistics centres is very expensive. It is very difficult to properly design the capacity and number of the handling areas and equipments.

Statement of a problem

The logistical centres are inseparable part of forward market economy. Logistical centres not only serve commodity with clients but sustain of useful reserves of products and accelerate international market. The term "logistic centre" has been used to describe centres performing a broad spectrum of logistical functions and business processes. The term combines logistics, which refers to all operations required to deliver products or services excluding produce of the goods or performing the services, which stands for a place where a particular activity is concentrated (American Heritage Dictionary of the English Language, 1992; External Costs of Transport, 2004).

The foremost tasks of logistical centres can be summarized as follows:

- the integration of the different kinds of the transport to the traffic chains,
- projection and realization complex logistical chains between suppliers and subscribers,
- practice different logistical tasks for clients,
- preparing, realization and repairs of needed infrastructure for partners,
- preparing, realization and repairs of needed informative, managing and communication system (Dolinayová, A., Čamaj, J., Průša, P., 2008).

Every logistic centre should be connected to road, rail and water infrastructure. Therefore besides the storehouse, the railway classification yard and intermodal terminal are the important parts of large modern logistic centres. Every part (storehouse, railway classification yard, intermodal terminal) can operate independently and it is possible to monitor all the processes in these partial components. It is necessary to follow the accouplements and the flows between storehouses, railway classification yard and intermodal terminal to optimize logistic processes of the entire logistic centre. Optimizing of the processes in partial parts of the logistics centre and between them can achieve the great synergies.

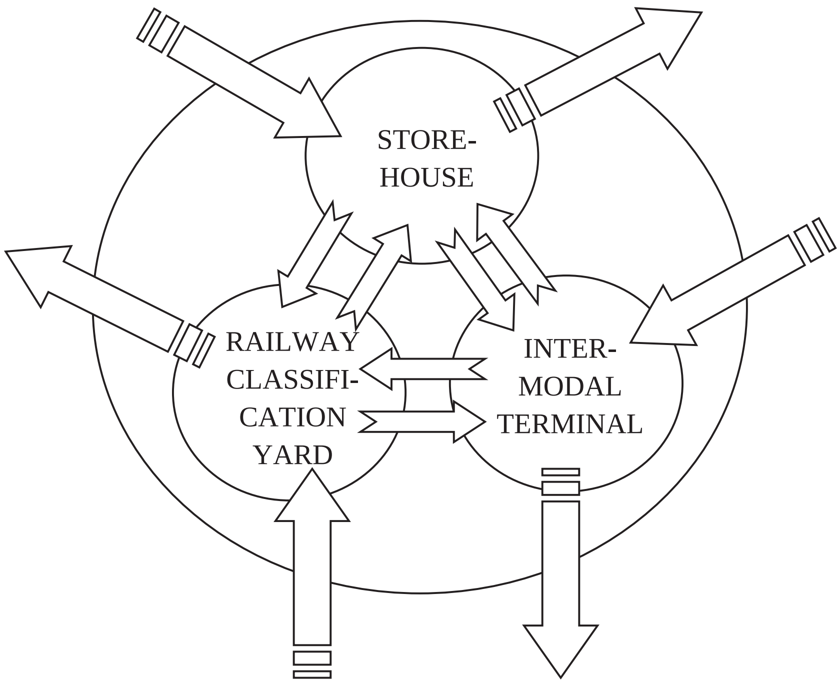

Figure 1: A simplified scheme of the logistics centre

All activities in the logistic centre are carried out gradually in the partial parts of the logistic centre. The service in the next section can be realized only after using the service in the previous section. The logistics centre can be seen as a complicated system of queuing. Every queuing system can be characterized by:

- the input current requirements,
- the queue,
- the time operation,
- the line services,
- the output current requirements.

The method of troubleshooting

A sufficiently accurate mathematical scheme (model) must be done to be able to predict the activities of the queuing system. Modelling expected build the model, which has characteristics derived from the real system. It displays all or only those facts that are important for the process. The model is thus a simplified picture of the reality.

In simple the models can be divided into:

- *mathematical models* - are formulated as a set of the equations, describing the studied system, including the restrictions and requirements on the input and output variables,
- *analytical models* - providing results in the form of the general functions for a various values of the input data,
- *simulation models* - in terms of computer they are the algorithms, by which it is possible to simulate the events and processes (Flodr, F., 1990).

Simulation method currently seems to be practically available method suitable for the examination of the complex technological problems. Its importance is increasing, especially in the design and upgrade of the technology units. The labour input and material resources necessary to implement the simulation models are now insignificant compared to the costs associated with the experimentation in the practice.

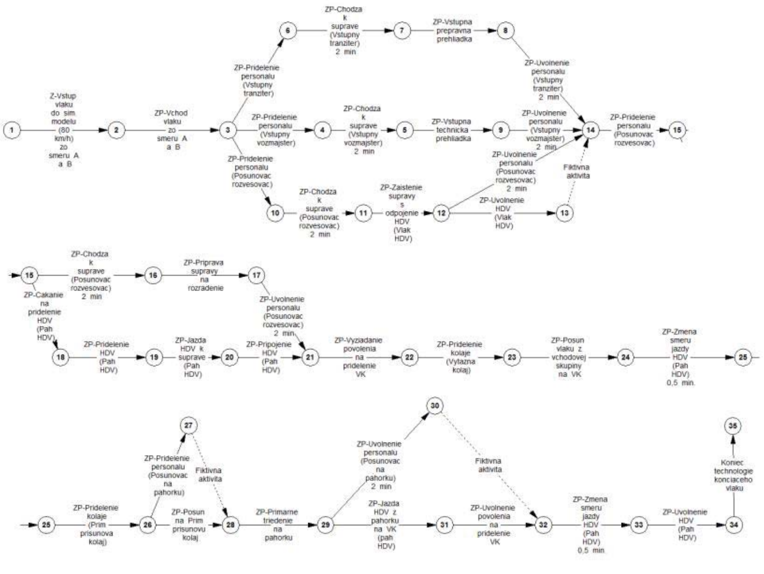

Figure 2: Example of the technological diagram – railway classification yard

The use of the simulation model can verify the plans and intentions. They can be accordingly changed before the system is placed in the realistic conditions. The simulation modelling use is convenient for the design of large and modern logistic centres, too.

Key stages of the work in the simulation modelling are:

- analyzing of the problem,
- selecting a solution method,
- modelling of the task,
- selection of the means for the model implementing,
- programming,
- experiment preparation,
- conduct of the trial,
- evaluation.

The analysis of the outcomes achieved

The processes which take place in the logistics centre are stochastic, not deterministic (Welterová, M., Lovíšek, M., Bariak, M., 2009). Therefore, the entry requirements into the system, the time of the handling and output current requirements can be described only by using of various probability distributions, for example normal, Poisson, Erlanger, exponential, gamma,... The disadvantage is that it is necessary to know the expected course of the input variables. They may be inferred from the statistical data obtained from the previous periods. It can be used for example $\chi 2$ test of good compliance to verify the input data.

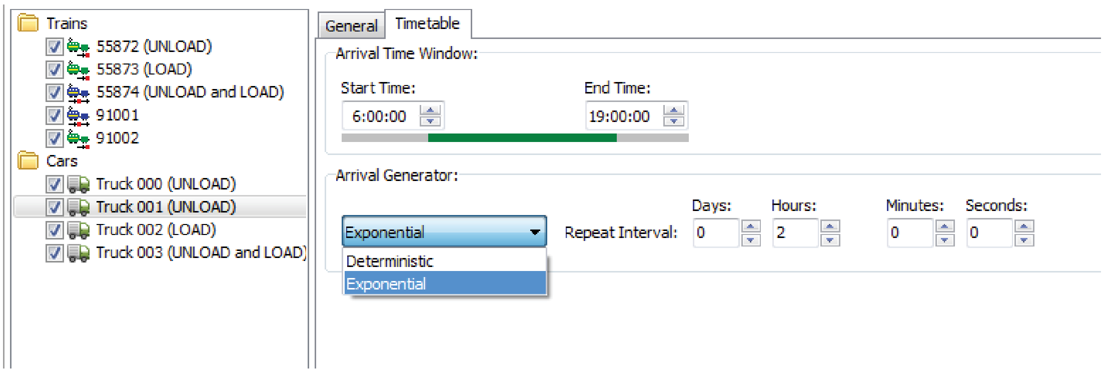

Figure 3: Example of the data entry to simulation model – store house

The basic output characteristics obtained from the simulation modelling could be:

- likelihood of the entry requirements refusal,
- average queue length of the requirements in the systems,
- maximum queue length of the requirements in the systems,
- average waiting time of the requirements in the systems,
- maximum waiting time of the requirements in the systems,
- average time which spent requirements in the systems,
- maximum time which spent requirements in the systems,

- utilization rate of the operating lines in different systems,
- limiting spaces in the systems,
- average number of the requirements contained in the systems,
- variance of the requirements contained in the systems,
- etc.

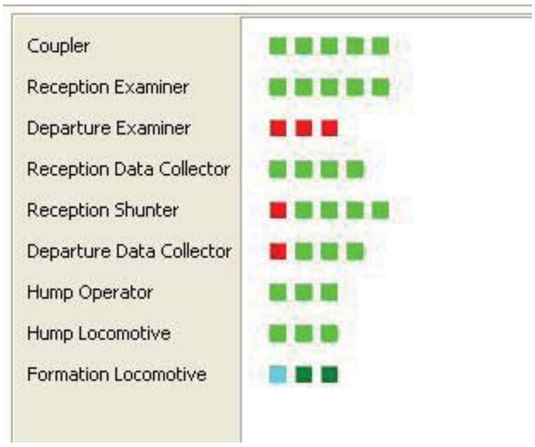

Figure 4: Example of the on-line data output – employers utilization

What can be suggested based on the results obtained during the simulation model:

- number of the operation lines,
- deployment of the operation lines,
- required capacity of the operation lines,
- technological process works,
- desired area for the entire system,
- financial budget of the implementation,
- required reserve funds,
- etc.

The practical application of the results

Simulation modelling can verify before the construction of logistic centre:

- for the storehouses:
  - number and capacity,
  - type and number of the handling equipment,
  - size of the handling areas,
  - storage technology,
  - staffing demand,
  - process times,
  - load carrying capacity,

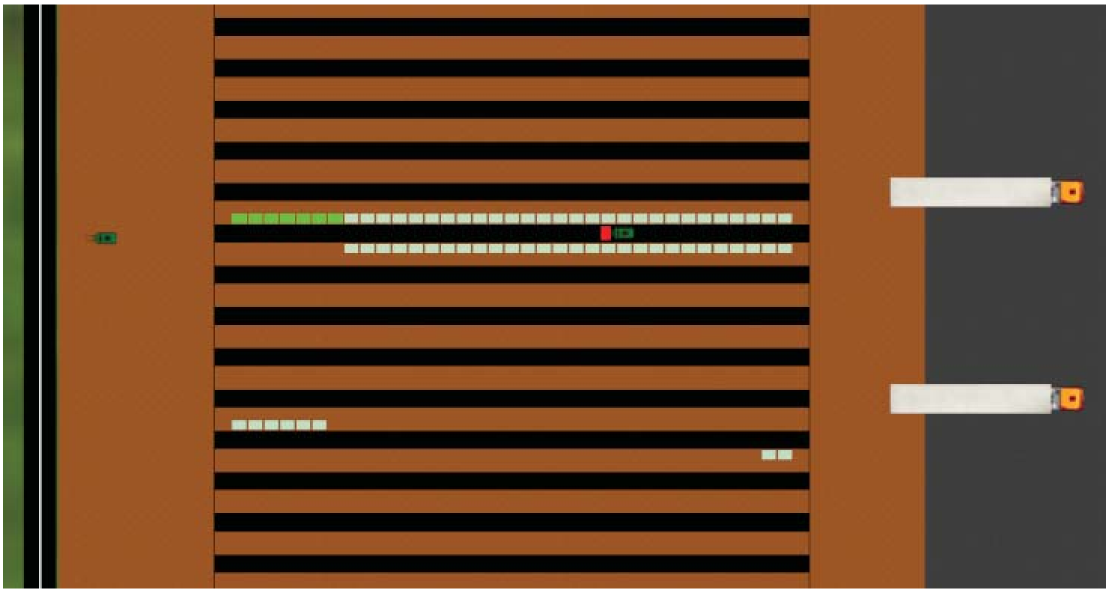

Figure 5: Example of the storehouse simulation model

- for the railway classification yard:
    - structure of the rail-yard,
    - number of the tracks in the rail-yard groups,
    - number of employees and locomotives,
    - technology of the primary and secondary splitting,
    - normative times,
    - operating efficiency,

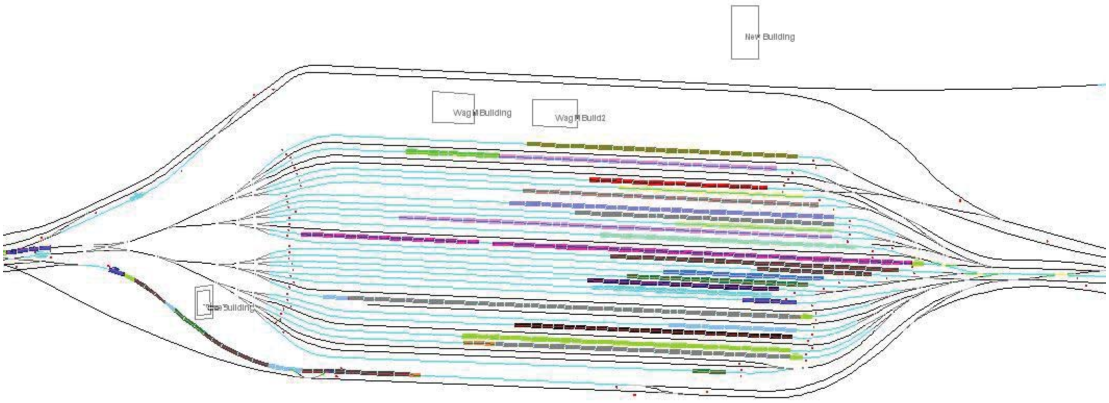

Figure 6: Example of the railway classification yard simulation model

- for the intermodal terminal:
    - type and number of handling equipment,
    - size of the handling areas,
    - technology of the trans-shipment cargo units,
    - staffing demand,
    - process times,
    - load carrying capacity.

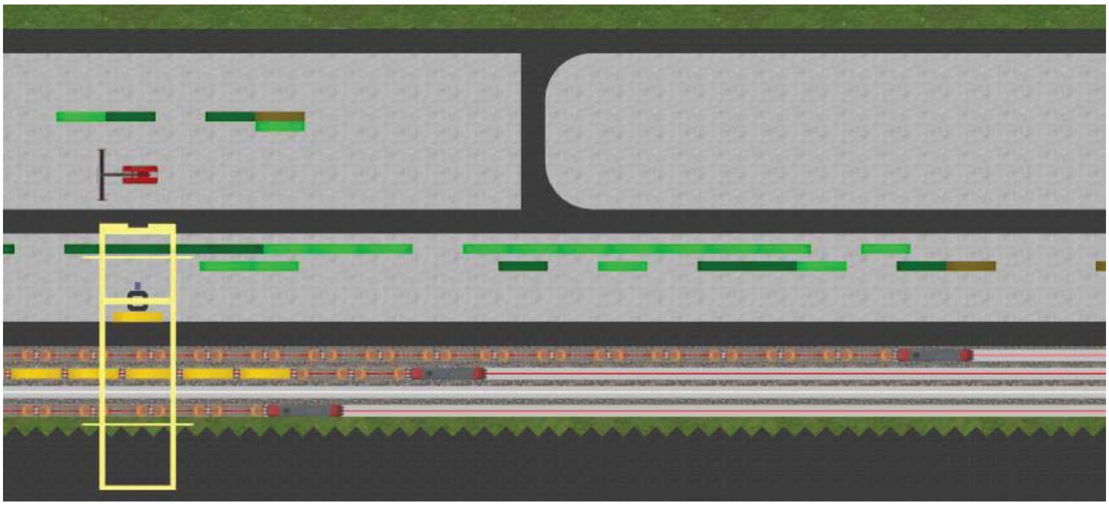

Figure 7: Example of the intermodal terminal simulation model

Conclusion

Simulation modeling provides a comprehensive and dynamic view on the whole technological process and can provide the necessary information about its behaviour. Simulation modelling is advocated as a suitable method for the verification of strategies for the construction and management of the modern logistic centres.

In second place, utilizing simulation modelling can optimize the number of handling equipment, the handling area size, the number of transport, the range of transport infrastructure. Using designated conditions eliminate any negative impact on the environment.

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