DESIGNOF SIMULATION-EMULATION LOGISTICS SYSTEM

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In modern industrial practice, innovative solutions for the improvement of processes or whole production or logistical systems are continually proposed. There are many options offered, but the problem arises in verifying the correctness of decisions and their impact on the functioning of logistic processes and the entire production system after the implementation of the changes. Forecasting or experimentation can be carried out, but there are also more appropriate verification methods because changes can have a significant economic impact on the enterprise. This paper deals with the simulation and emulation of logistics processes, because the simulation is an effective tool for detecting potential in production and logistics, as well as forthe elimination of shortcomings in the design phase of a particular solution in an enterprise. Another proposed intelligent solution is emulation, as part of the decision-making and management support systems. The resulting design of the simulation-emulation logistic system allows a significant shortening period of commissioning. The emulation of production systems is also intended for the rapid verification of the impact of guiding principles in advanced production systems for discrete production. These systems are called adaptive logistical systems that use the adaptability of new types of technologies based on reconfigurable production systems.

KEYWORDS

simulation, emulation, logistics system, innovative system

1 INTRODUCTION

Logistics is the key to success in many industries. Efficient logistics can be presented with the individualization of provided services and manufactured products towards customers. In the background of progressive globalization and the development of a comprehensive offer, current businesses are overloading logistics by increasing the flow that needs to be effectively managed at the operational level. Logistics is subject to constant change (Fig. 1). The above requirements lead to a higher complexity of the logistic system, combined with higher requirements for its flexibility. The demand for reducing stocks, increasingly high demand for quality and more chaining processes are continued, therefore logistical systems must be more robust. The current development highlights the importance of flexible logistics, which enables rapid alignment with the changed framework parameters. Completely new aspects, such as sustainability and adaptiveness, are also coming to the foreground and become part of the integration of logistic processes. Globalization is one of the reasons for the growing importance of logistics. Globalization [Seemann 2016] and logistics are dependent on each other and represent two sides of the coin. One of the consequences of globalization is a significantly increased number of interfaces throughout the process chain. These new requirements entail additional risks for planners, project implementers and logistic system operators. These risks can be reduced by simulation and emulation, making these problems more manageable and solvable.

This paper is structured in the form of four main sections, where are demonstrated the design of simulation-emulation logistics system in order to create the smart factory to predict future outcomes. In section 2 a literature survey is presented supporting the analysis of logistics process improvement using simulation and emulation. In section 3 a detailed explanation of the problem and the study is given. Finally, a short summary and an outlook are given in the conclusion (section 4).

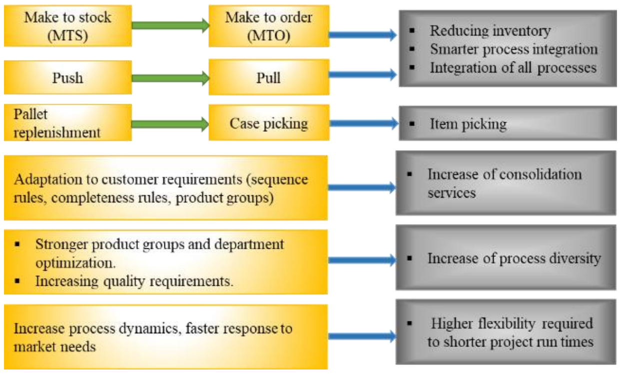

Figure 1. New requirements for the logistics systems [Dullinger 2009]

2 LOGISTICS PROCESS IMPROVEMENT USING SIMULATION AND EMULATION

Simulation models, emulation, etc. are concepts that are often present in the discussions and expert works and represent advanced solutions in all areas of logistics management.

2.1 The simulation in logistics engineering processes

Simulation eliminates the shortcomings of analytical methods, but is also time-consuming (model design, model testing, planning and execution of experiments) and the preparation of input data and therefore more expensive than other analytical modelling techniques. In complex and difficult tasks, analytical procedures have limitations that can overcome simulations. Other reasons for the use of the simulation in practice (except the implementation of the project in practice is expensive and cannot be solved by the use of analytical computational methods) can be:

- implementation of the project in practice is not possible (the system does not exist),
- the implementation of the project is too dangerous in practice [Rakyta 2016],
- the requirement for prediction of future events,
- the need to represent interrelated complex relationships that have overcome human abilities.

Manufacturing system simulation means to create certain conditions of manufacturing systems by means of models. One of the main purposes of the manufacturing system simulation is to evaluate materials flow and information flow. A simulation is executed while paying attention to particular events of interest, which occur at an instant, such as equipment start, equipment stop, etc.

Fig. 2 shows an outline of the manufacturing system simulation [Hibino 2008].

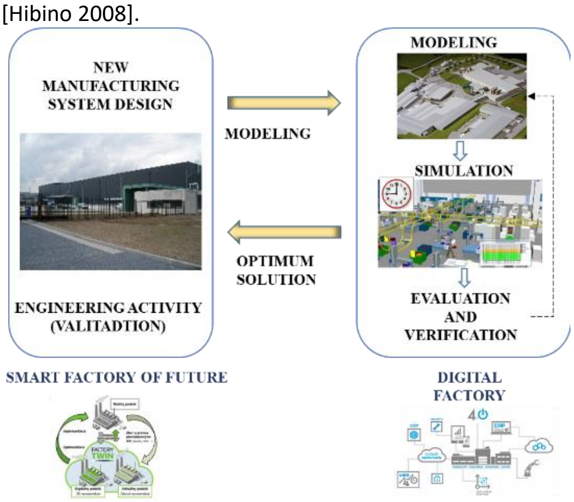

Figure 2. Manufacturing system simulation [own collaboration by Hibino 2008]

The overall behaviour of production systems depends on many factors which influence each other. One of the important factors influencing the overall performance of the production system is the proper setting of logistical flows and a suitably chosen method of supplying the lines of materials. The transport system used to provide supplies of production lines and warehouses may cause various problems in the enterprise that may lead to the production lines to stop (due to late delivery of the required material on the line). Inappropriately selected transport of transport may pose a risk in terms of job safety or bring about inefficient logistical costs. Changing the mode of transport (e.g. switching to AGV – Automated guided vehicle) can also carry unpredictable behaviour (e.g. interlocking AGV, delayed delivery of overweight material, the collapse of the entire transport system).Validation of the proposed logistics system through the simulation software Tecnomatix Plant is shown in Fig. 3.In this model, we verified available capacity logistics facilities.Statistics from the logistic simulation model can be used for example to verify the availability of system capacities, production plans, number of staff depending on the plan. Nowadays, many internal logistics companies are changing forklifts for automated logistics towing units. This change often requires a change in layout, change in the logic of picking items, an extension of transport times, changes in the method of storage components etc. [Lieskovsky 2014].

The automatic logistical system ensuring the supply of production line materials and warehouses can fully replace the human factor and the team to eliminate the potential risks associated with the error rate of the human factor. However, the planned change in the mode of transport carries the unpredictable behaviour of the planned transport system. [Skorik 2010]. Dynamic (simulated supported) planning tools provide their users with a comfortable overview of the production and logistical system in every moment. Outputs are detailed values, graphs, and diagrams that take account of changed conditions in time to prevent serious problems in production. [Dullinger 2009]

2.2 The emulation in logistics engineering processes

The current turbulent environment requires new approaches, exact and approximate, which will be robust enough, fast and usable to support the decision-making of managing staff. The emulation of production systems as one of the progressive methodis being applied in the management of modern complex systems. In the successful implementation of the above-mentioned methods, the narrow place of the pre-production phase shall shift to the implementation of the machinery and equipment system.

Since each delay at this stage is critical, the requirement of individual parts of the system, the management rules as well as the overall control system to be tested as soon as possible, irrespective of the current integrity of the resulting system. The idea of emulation is the possibility to replace the missing elements of the production system produced by the simulation model, which will subsequently be linked to the existing real elements. [Kohar 2014] The simulation model will be a full refund of the real, missing module, or elements of a complex simulation model will gradually, with the deployment of technology, replaced by real devices. [Frlicka 2011]

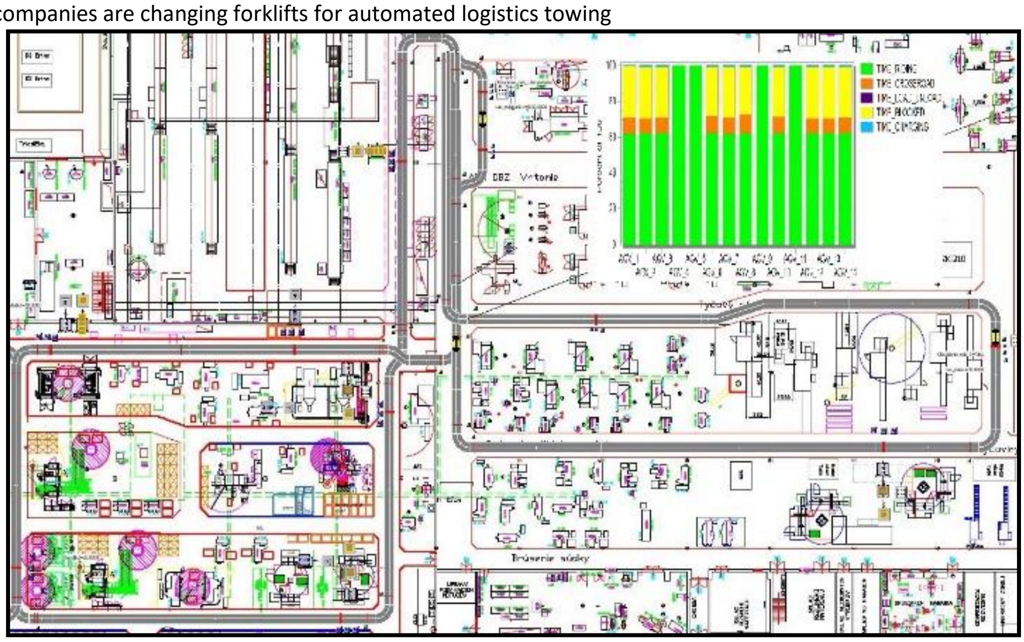

Figure 3. Simulation model of the logistics system

The synergy of the deployment and cooperation of virtual and real elements in practice will radically remove the waste caused by the necessity of changes in the design of the system because all potential errors will be localized and dealt with significantly rather than currently. Simulation techniques provide benefits for businesses from product design to the mere simulating of discrete events for logistics process planning.

The next step is emulation, which has proven to be an effective means of validating processes. Emulation is able to serve as a link between design and implementation, making the manufacturing process more efficient. Control can be done in the process before, leaving more time for program changes and troubleshooting.A manufacturing system emulator is a device or piece of software that enables a program or an item of equipment intended for one type of computer or equipment to be used with exactly the same results with another type of computer or equipment[Krajcovic 2014], [Lieskovsky 2016].Manufacturing system emulation means that under a condition where parts of equipment, control programs, and manufacturing management applications are not provided in a manufacturing system, a manufacturing system operates by mixing and synchronizing the manufacturing system emulators, real equipment, real controllers, and management applications. Fig. 4 shows an outline of the manufacturing system emulation [Hibino 2008]. Emulation is a continuation of simulation and it is the precise and functional reproduction of the logistic process with all the details. This model is so accurate that it can be linked to the PLC (Programmable Logic Controller) and controlled by it-just like the actual device later. The so-called online clutch can shorten the costly and time-consuming initial phase of the PLC programming. It reproduces the exchange of data between the control software of the actual device and the corresponding simulation model. In this way, PLC can be tested for almost realistic conditions before testing.

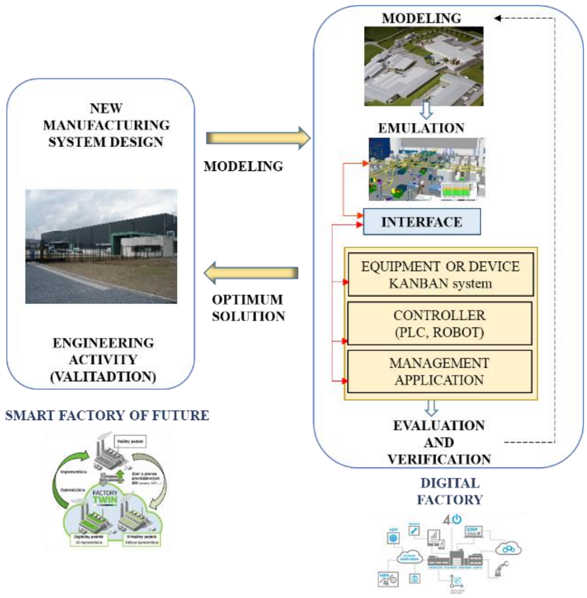

Figure 4. Manufacturing system emulation [own collaboration by Hibino 2008]

Unlike normal software tests, this process allows you to dynamically monitor the PLC throughout the period. Problem areas can be identified in advance and removed. [Durica 2015]
The advantages of emulation are:

- real-time monitoring of production systems - functional communication between the real system and the simulation model [Krajcovic 2011], [Krajcovic 2013],
- processing of real-system data to refine the simulation model,
- operational and rapid verification of control principles based on current data - initial activities in the field of the immediate actual setting of the simulation model and optimization of other procedures based on testing of different experiments.

3 DESIGN OF SIMULATION-EMULATION LOGISTICS SYSTEM

The authors have proposed the concept of simulation emulation of the logistic system. Basic connection of production system, emulation and simulation model (linking database, simulation model and real logistics device) is shown in Fig. 5. Here is a practical demonstration of such an approach created by the Department of Industrial Engineering (Faculty of Mechanical Engineering, University of Zilina). The solution is focused on the possibility of linking a real logistic system and virtual elements of a future production system represented by a simulation model.

The aim was to achieve mutual communication between the database, the model and the real element. The database served as input for the simulation model. This model, after reaching the level of the order quantity on the production plant, gives the AGV a signal that it is necessary to deliver the material in the required quantity.

Upon removal of the goods from the warehouse and its subsequent loading, the AGV device will send information about the removal of goods that is recorded in the database system. Consequently, with the new data, it is possible to check the state of inventories, after reaching the ordering level, order the material. Emulation consists in monitoring the real state of the robot (simulated AGV) and its behaviour is on-line translates into a compiled simulation model. Emulation belongs to advanced methods in managing modern complex systems. It is used to replace the entire existing production system or only parts of the simulation program. Emulation can be included among DSS systems as it helps the manager to facilitate decisions, especially in two key stages:

- **Pre-production phase.** The idea of emulation at this stage is the possibility to replace the missing elements of the production system produced by the simulation model, which will subsequently be linked to the existing real elements. The simulation model will be a full replacement of the actual, missing equipment or elements of a complex simulation model being gradually replaced by real devices.
- **Production phase.** At this stage, the emulation enables an urgent response to the deficiencies in production (machine fault, interrupted material flow and others). The individual elements of the production system are linked to the control computer, which allows the download or update of their settings. The computer will simulate a replacement production plan with the currently available devices, and the new settings are sent to the control unit of the machine. [Gregor, 2013] The main advantage of such an approach is to quickly determine the impact of changes in the control principles in production on a virtual model with a direct link to a real production system. The emulation environment can monitor production and logistics system, real-time evaluation of collected data, updating model

based on real-system data, and performing experiments on accurate, updated and verified simulation model [Furtakova, 2012].

The simulation-emulation system can be used in all production systems as in the system design phase as well as in the operation phase of this system. Its benefits are remarkable and indisputable. Businesses will appreciate the ability to know the behaviour of the system during its design. It is possible to test its reliability, accuracy and setting of control rules. In the operation phase, the system, in the event of an unexpected event, can be modified without interruption based on the link and its elements to the active network

The update is an important part of reusing the model. Its user not only changes the production plan, but also needs to constantly update the basic process data in the simulation model (machine failure, cycle times, and sorting times). Today's simulation software can communicate with different databases or spreadsheet editors. Process data shall be in Excel spreadsheets or automatically downloaded from the enterprise information system. This greatly reduces the simulation model user's expertise. Although the design of a model performed by an expert, it can also be used by a scheduler in the production, and may not be used by any programming language. Using simulation models can shorten the time and reduce the risk of decision-making not only in solving large investment projects but also in the problems we encounter each day. The Smart

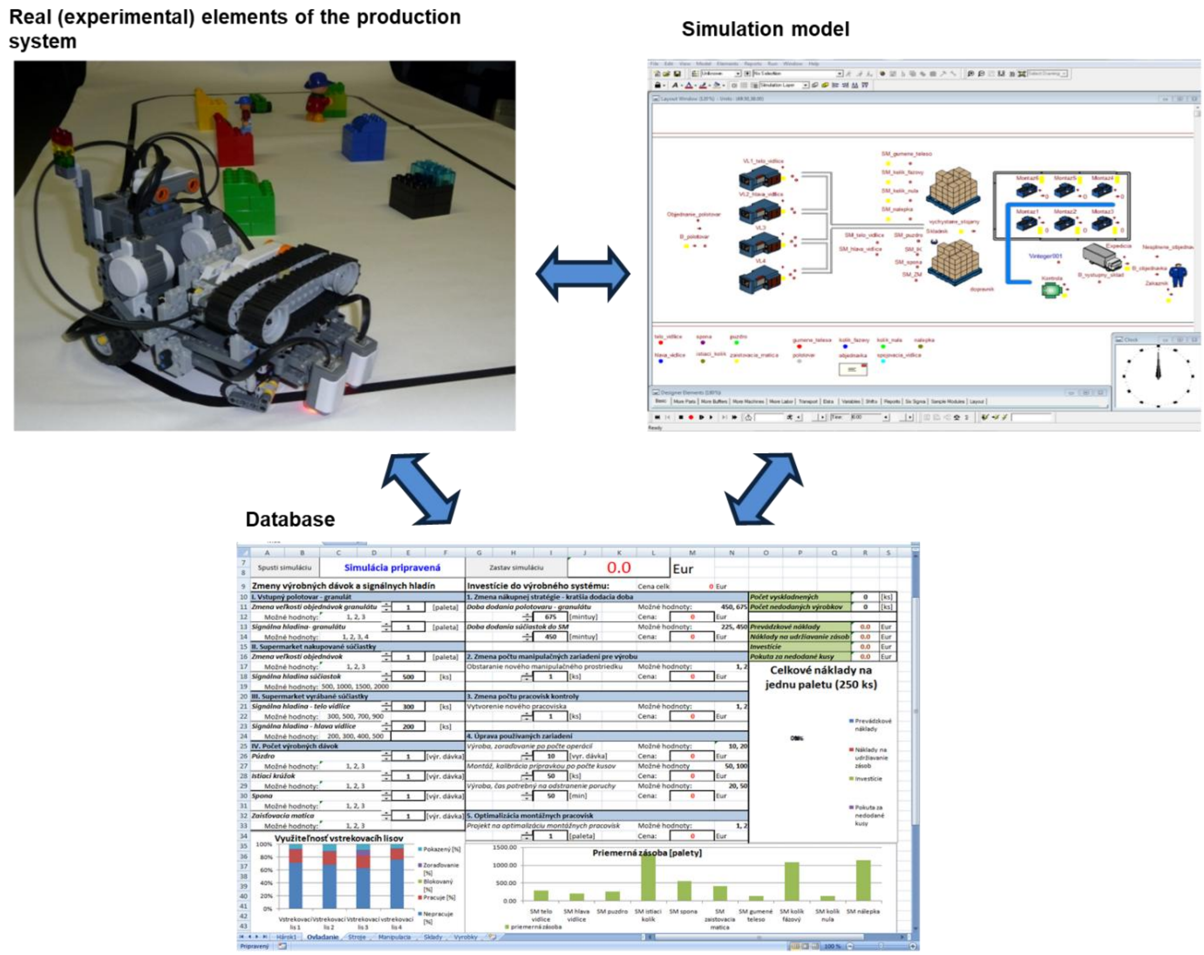

Figure 5. The interface of the simulation and emulation model

4 CONCLUSIONS

Logistic systems are systems with high inertia, long transformation cycle, t. j. their response to change and the control interventions are not immediate than by technical systems. For these systems, it is preferable to apply a forward feed-forward management system.

The concept of emulation is the gradual replacement of virtual production and logistics devices with real elements. At the same time, we have also acquired the digital twin of the production system, and in the future, we can flexibly respond to changes in the virtual environment and then implement these changes.

Enterprise is a Digital Factory extension that extends this concept of a Virtual Factory to create the digital twin in a virtual environment.

Developing integrated, scalable and semantic factory models with multi-level access, data collection with various uncertainties, real-time data capture and capture capabilities from all enterprise resources (e.g., enterprise assets, machines, workers, and objects) processes, activity planning and business management, and will facilitate faster growth by shortening delivery times to the market. Enterprises that are designed in such a holistic and structured way will be more energy efficient and provide a safer working environment. Design standardization and managerial approaches make it easy to deploy and reduce their operations. The availability and reliability of such factories and the use of advanced maintenance methods, which in turn will be reflected in more efficient production.

Further research will be needed to develop dynamic, object-oriented models that will represent examples of real-world resources as well as semantic representation for modelling of intangible assets at the operating level. In the future, the goal is to create a link between logistics devices and a model that interact with each other and work with data in real time. This will allow you to track the movement of the equipment, stock inventory status and plan production based on these data.

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REFERENCES

[Dullinger 2009] Dullinger, K. H. Simulation in Logistics – New application fields. Vol. 5, No. 7, 2009. In German, Available from <http://docplayer.org/42534526-Electronic-scientific-journal-of-logistics-simulation-in-der-logistik-neue-anwendungsfelder.html>.

[Durica 2015] Durica,, L., Micieta, B., Bubenik, P., Binasova, V. Manufacturing multi-agent system with bio-inspired techniques: CODESA-Prime. “MM Science Journal”. Volume 2015, December 2015, pp. 829–837. DOI: 10.17973/MMSJ.2015_12_201543

[Frlicka 2011] Frlicka, M. Concept of simulation-emulation environment. Diploma thesis. Department of Industrial Engineering. Faculty of Mechanical Engineering, University of Zilina. Žilina, 2011.

[Furtakova 2012] Furtakova, S. Simulation metamodelling of manufacturing systems. Dissertation thesis. University of Zilina, Department of Industrial Engineering. 2012.

[Gregor 2013] Gregor, M., Stefanik, A., Hromada, J. Lean Manufacturing Systems Optimisation Supported by Metamodelling. IFIP International Federation for Information Processing, 2008, Vol. 257.

[Hibino 2008] Hibino, H., Yoshiro, F. Emulation in manufacturing engineering processes. Proceedings of the 40th Conference on Winter Simulation. Winter Simulation Conference, 2008.

[Kohar 2014] Kohar, R. and Hrcek, S. Dynamic analysis of a rolling bearing cage with respect to the elastic properties of the cage for the axial and radial load cases. Communications: scientific letters of the University of Zilina, 2014, Vol. 16, No. 3A, pp 74–81. ISSN 1335-4205

[Krajcovic 2011] Krajcovic, M., Furmann, R. Modern Approach of 3D Layout Design. Transcom 2011: 9-the European conference of young research and scientific workers, EDIS: University of Zilina, Zilina 2011, pp. 43–46.

[Krajcovic 2013] Krajcovic, M. et al. Intelligent manufacturing systems in concept of digital factory. Communications: scientific letters of the University of Zilina, 2013, Vol. 15, pp 77–87. ISSN 1335-4205. Available from <http://www.uniza.sk/komunikacie/archiv/2013/2/2_2013en.p d f>.

[Krajcovic 2014] Krajcovic, M., Gabajova, G., Micieta, B., Order picking using augmented reality.Communications – Scientific letters of the University of Zilina 2014, Vol. 16, no. 3A, pp. 106–111.

[Kuric 2018] Kuric, I., Cisar, M., Zajacko, I. Diagnostics of the wire coating production line by implementation of computation methods et al. conference: 5th international conference on industrial engineering and applications (iciea) location: natl univ singapore, shaw fdn alumni house, Singapore, singapore date: apr 26-28, IEEE 2018 5th international conference on industrial engineering and applications, pp. 463-467

[Lieskovsky 2014] Lieskovsky, R. Differences between manufacturing strategies. In: International Journal of Science Commerce and Humanities. 2014, Vol. 2, No. 4, pp 192-195.ISSN 2052-6164

[Lieskovsky 2016] Lieskovsky, R. Photos of Segmentation of product line in Emerson. Emerson Network Power, 2016.

[Plinta 2016] Plinta, D., Krajcovic, M. Production system designing with the use of digital factory and augmented reality technologies. “Advances in Intelligent Systems and Computing” 2016, Vol. 350, pp. 187–196.

[Rakyta 2016] Rakyta, M., Fusko, M., Haluska, M., Grznar, P. Maintenance support system for reconfigurable manufacturing systems, [w:] Annals of DAAAM Proceedings of the 26-th DAAAM International symposium on intelligent manufacturing and automation. DAAAM International Vienna, Vienna 2016, pp. 1102–1108.

[Seemann 2016] Seemann, P. Upcoming global method of team coaching in increasing employee motivation. In: Globalization and its socio-economic consequences. Rajecke Teplice, Slovakia, University of Zilina, 2016, pp. 1964-1971.Available from <http://ke.uniza.sk/sites/default/files/content_files/proceedings_part_iv.pdf>.

[Skorik 2010] Skorik, P., Stefanik, A. Emulation environment - A robust approach to designing and testing management principles in production based on simulation, optimization and metamodelling, InvEnt 2010: 7.6.-9.6.2010, Terchova. Zilina: GEORG. ISBN 978-80-89401-12-3. pp. 374-377., in Slovak

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