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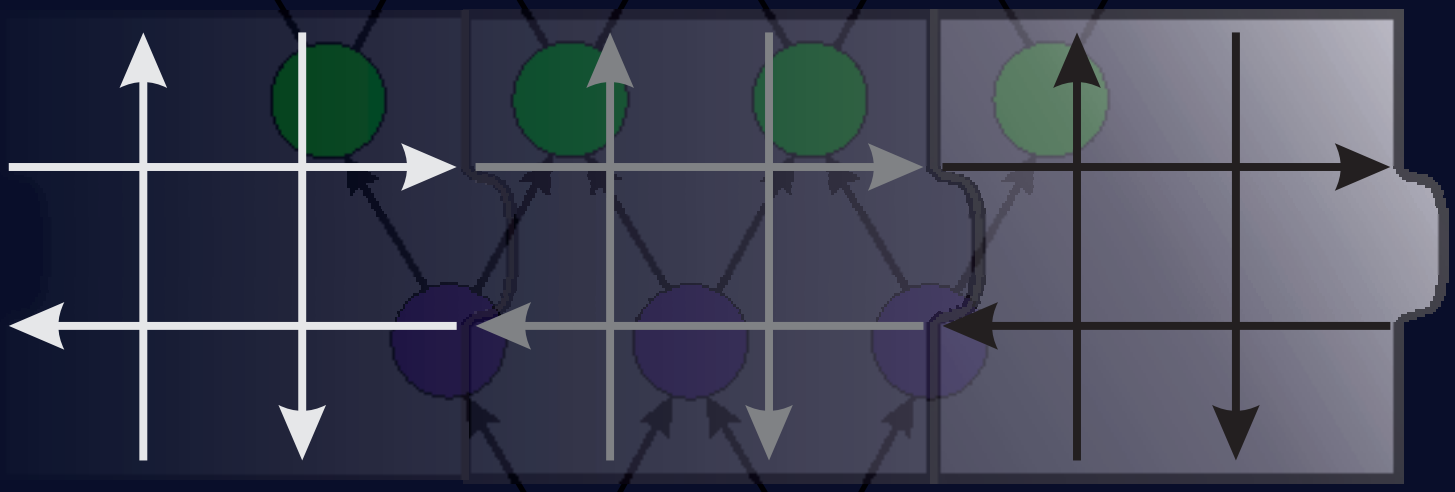

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CONCEPTION AN INTELLIGENT NODE ARCHITECTURE FOR INTRALOGISTICS

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Keywords: logistics, Cyber Physical System - CPS, Industry 4.0
Abstract: Intralogistics makes up an important part of the supply chains some call it the 'heart of the logistics'. Lately the appearance of cyber-physical systems has been caused significant changes in this area, enabling not only a set of interconnected devices, but let new concepts to be implemented. This paper presents a novel control structure between the centralized and decentralized concepts – the so called intelligent node – which opens new possibilities for local control of intralogistics processes. The paper surveys possible connection of the intelligent node to the simulation based digital twin.

1 Introduction

Industrial companies witness in the recent years a large number of new concepts and solutions spreading across the world of production and logistics. Some call the effect of these changes fundamental, some say these are revolutionary. The most relevant issue here is the launch of Industry 4.0, which is a relevant project [1] from Germany on the application of Cyber-physical systems in the industry. It describes principles of production processes based on the tight integration and interconnection of physical and digital components. Networking is a decisive feature of this approach, the system components autonomously communicating with each other making decentral decisions along the value chain. Industry 4.0 takes also account of the increased computerization of the manufacturing industries where physical objects are seamlessly integrated into the information network.

Industry 4.0 supply however not only solutions but raises question and poses challenges as well. In [2] the author characterizes CPPS systems (cyber-physical production systems) as a composition of autonomous and cooperative elements and sub-systems that are getting into connection with each other in situation dependent ways, at various levels. Having such a complex structure the research focuses on the modelling, forecasting snd control of the systems operation. There are several important question in this context, like the level of autonomy, the cooperation, and tho possibilities for an optimization.

Complex systems' control of Industry 4.0 requires facing and handling of the Big Data problem. Generally this is a term for large and complex data sets, for which conventional data processing techniques are not adequate. The Big Data problem addresses capture, analysis, searching, sharing, storage, transfer, visualization of data from various sources in different forms. Additionally the speed of the information flow is also challenging. In order to cope with this problem a common solution to decentralize the intelligent, decision-making functions. Internet of things (IOT) devices are necessary enablers for this. A typical application for the above is presented in [3], where development of a method for self-aware and self-maintenance machines is described.

Factory logistic systems of large production facilities also pose a big data problem. Production and logistic data come from different sources, such as the production planning, manufacturing machines, and human participants of various roles in the system. Size of the facility multiply the amount of data by the number of production and logistic segments.

These complex systems must be controlled in an adequate way. There are many different possibilities for an optimal control structure, the most common and relevant variants are described in Chapter 2. Our approach presents the so called „intelligent material flow" node and details its advantages and applicability in general and through an example. This paper is part of our research project „EPIC" that has received funding from the European Union's Horizon 2020 research and innovation programme.

2 Control architectures of factory logistics

This chapter describes the most common characteristics of factory logistic control. Most common and traditional system structures are built up using the centralized hierarchical concept shown in Figure 1. Here the materials handling system and warehouse management are integrated under the production control. This way all the logistic operations originate directly from the production, therefore separate optimization issues in the logistics are limited.

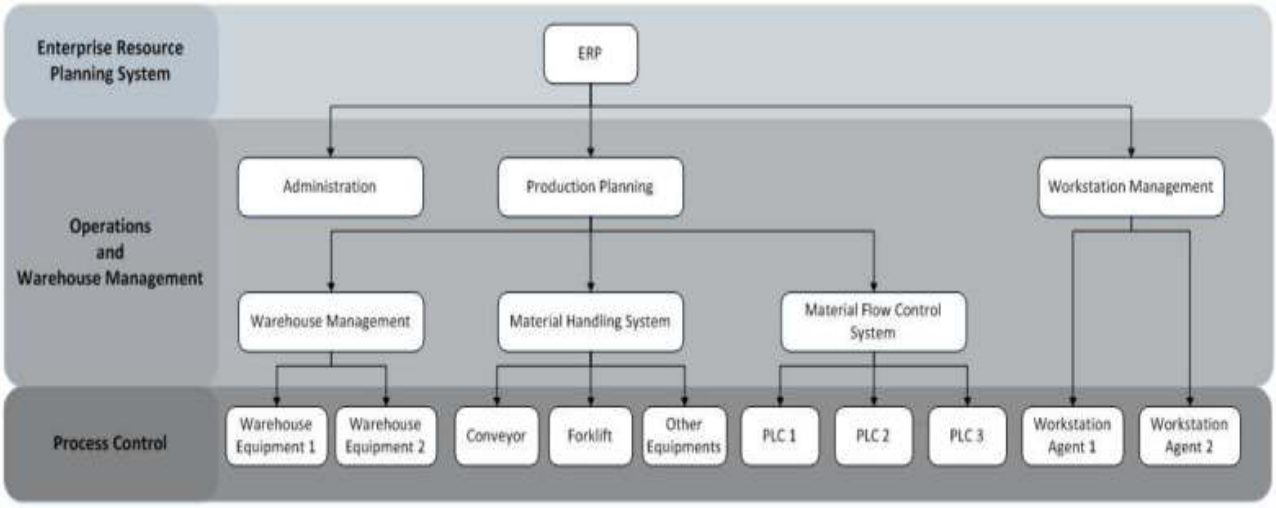

Figure 1 Centralized control

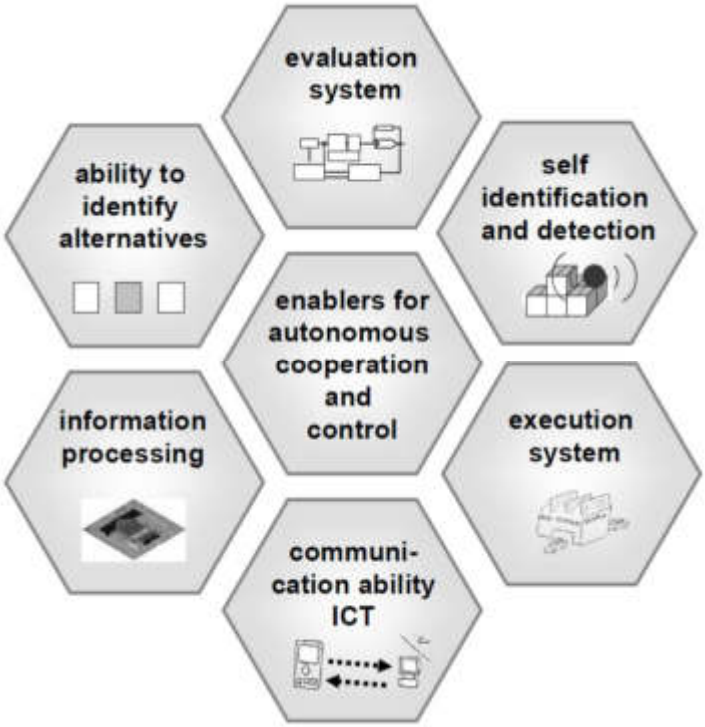

Figure 2 Enablers of autonomous cooperation and control [4]

Though using centralized systems there are possibilities for a broad, overall optimization, lately the need arose for more decentralized systems. This change of paradigm was caused by is increasing complexity in combination with a high incidence of potentially disruptive factors [4]. Further, the increasing number of product variants leads to a great number of possible combinations. This complexity cannot be managed by means of conventional, centralized control systems. In order to match to the above changed environment integration of new technologies and control methods has become inevitable.

The new requirements led to the appearance of highly decentralized, autonomously cooperating control system in the production and logistics. To create such a decentralized structure, several enablers from the system side must be met, like depicted in Figure 2.

Schumacher and Hummel in der publication [5] proposed a decentral event-based control structure. It consists of "system-"and "scenario-specific nodes" which provide agent-like decision-making. The connected modules are very versatile, starting from the conventional (Manufacturing Execution Systems - MES) system approaches for the modelling of special resources like collaborative robots.

Decentralized systems build up a strongly interconnected network of nodes, where intelligence, functionality, type and location of these nodes are diverse.

Between the central and decentral concepts partially distributed architectures also exist (see [6]), where an intelligent logistic object with appropriate micro- and macro view architecture is also depicted (see Figure 3).

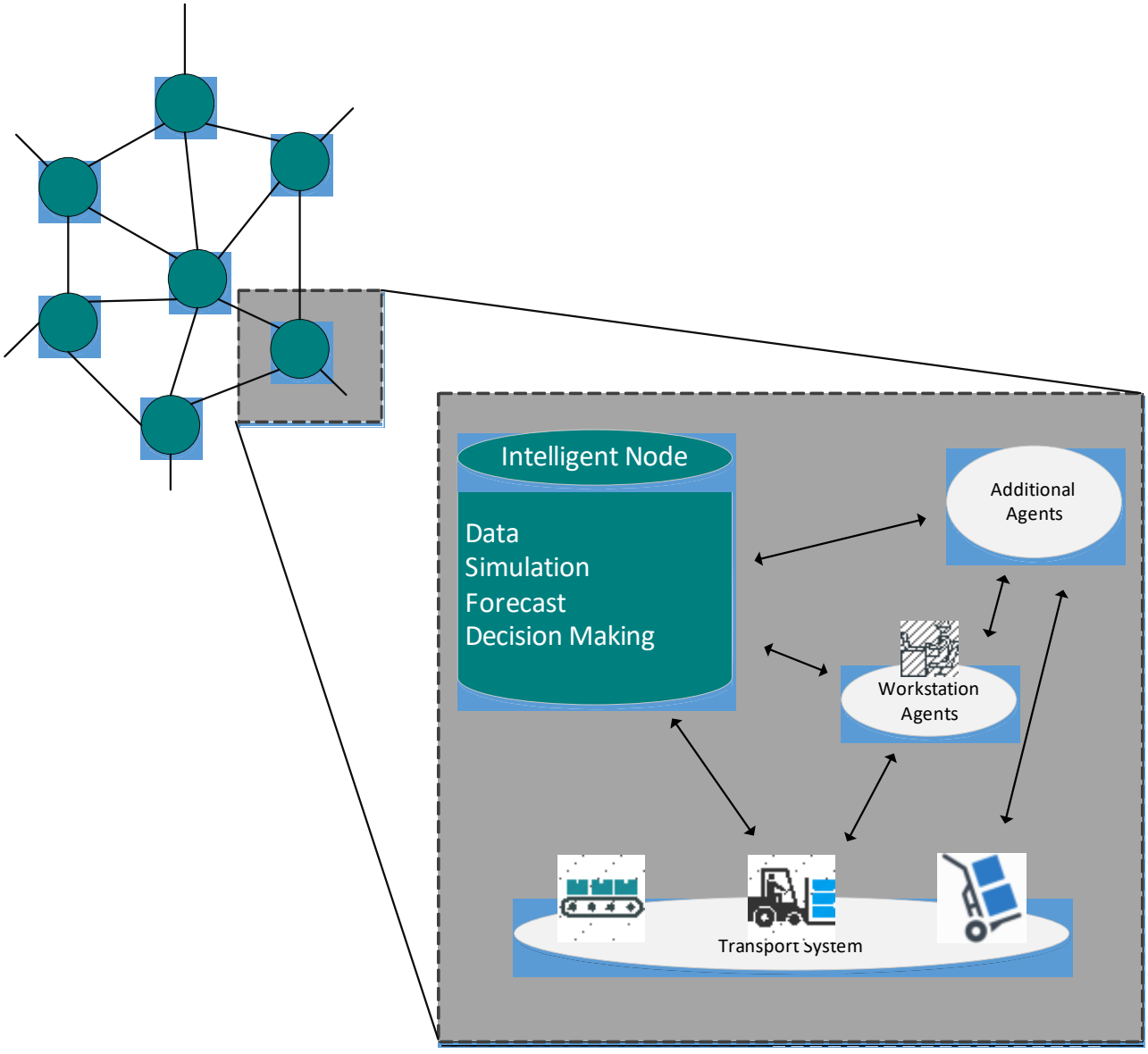

Figure 3 Concept of an intelligent logistic object wide a wide range of control functions [6]

The above paper describes that autonomous controlled logistic systems have several architectures which differ in the extent of ability transfer, the distribution of abilities and the representation of system elements. The higher the level of the first two aspects are, the bigger is the autonomy and complexity in the control system. The representation of a system is real, if logistic objects include control functionalities, otherwise it is virtual. The three main classes of architecture are Classical (Centralised) Production Planning and Control (PPC) Systems, Fully

Distributed Architectures with all the elements being intelligent logistic objects, and Partial Distributed Architectures where only a few clients have decision-making abilities. The concept of the intelligent node meets the requirements of a partial distributed control system architecture, as it is based on some complex information objects that collect information from other system elements, make decisions and transmit them back to the clients.

In production logistic systems continuous changes raise difficulties for the creation of the necessary control architecture. To match the structure to the continuously changing environment, manual tuning of the elements would require to excessive work. Therefore, self-adaptive features of the elements gain more and more importance. This is also related to the Big Data problems solution: this way a large amount of information can be transferred into knowledge via the adaptation process. In conventional systems central optimization was carried out. It should be remarked however that this is not feasible any more in large systems where the Big Data problem comes forward. Therefore, trends of decentralized adaptation come also forward.

Fully decentralized adaptation has however a backlash: the information remains decentral, there is no way to use it for other purposes. To cope with this problem (namely how to use the information generally) ontologies come into application. This is a good methodology to abstract and concentrate information. Originating from the computer and information technology, its excellent thinking pattern gets more and more applications in other areas as well.

The term "ontology" is originally a term from philosophy and indicates the discipline that deals with existence and the things that exist. In terms of informatics, "exist" means all the subjects which can be represented by data (see [7], [8]).

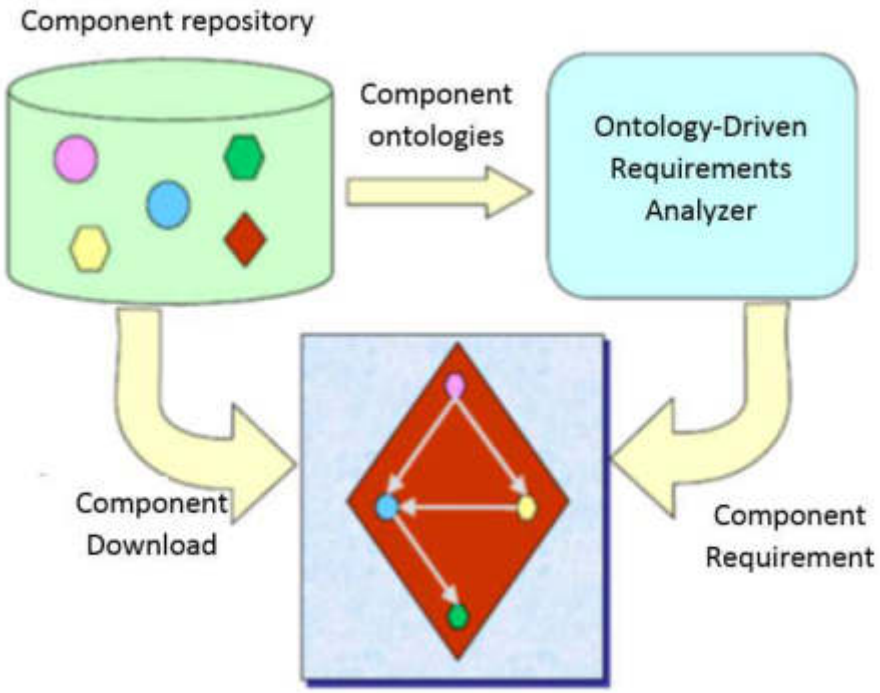

Figure 4 Concept of an intelligent logistic object with a wide range of control functions [9]

By translating the information into ontologies, adaptation of the systems can be carried out easier. Knowledge from earlier time periods can also be stored into repositories, from where these can be „taken" on demand, in the case of modelling altered processes. A good example for that can be found in the paper on Benjamin et al. [9]. Here the ontologies are stored in a virtual repository of components. Using this modelling and simulation, experts can easier identify the necessary elements, thus creating a more homogenous simulation model. The process itself is depicted in Figure 4.

Simulation aspects are very important in the control of logistic systems. The primary application area of them is to forecast the system's features. A general discussion of adaptability in logistic simulation modelling can be found in our previous work [10]. Therefore, we suggest an emphasized role for the simulation models.

Next, based upon the above considerations, definition of the proposed intelligent node architecture follows.

3 Structure of the proposed intelligent node for factory logistics

From the previous section we concluded that partially decentralized decision-making units can be advantageously applied for complex factory logistic systems. The necessary adaptive functionality can be

achieved if the node is connected to the necessary sensors and other information sources and human supervisors as well.

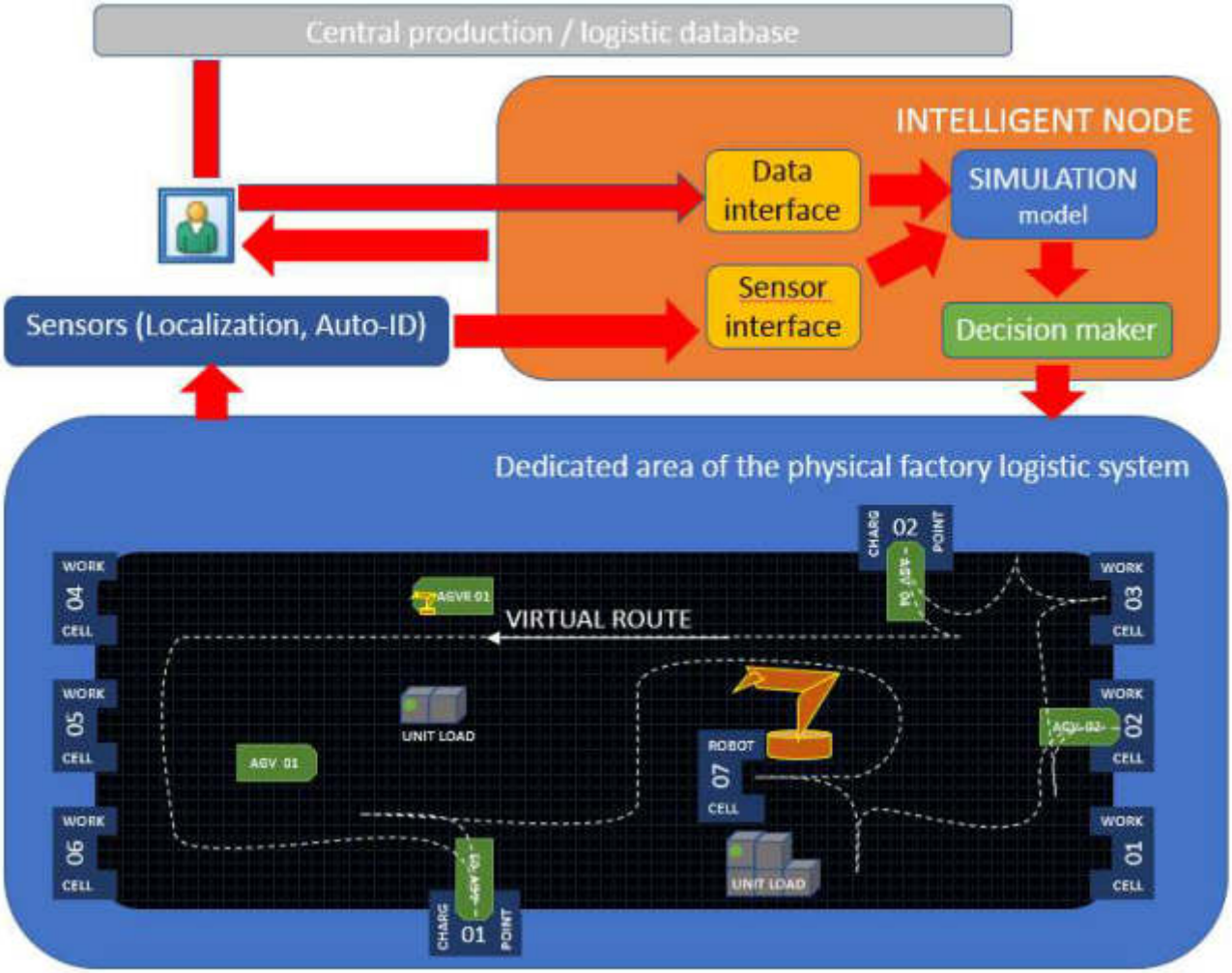

Figure 5 Concept of an intelligent node and its environment

Partially decomposition is done upon the spatial concept which means the nodes are distributed over the material flow area. This way local acting humans, sensors information sources are connected to this node. This approach differs from the functional one which would help decision-making in a certain problem over the whole system.

We preferred the spatial concept because it enables not only system adaptability but eases teaching of humans for the control's specialities, resulting in a bidirectional learning and adaptability between men and machines.

The proposed intelligent node's structure is explained via an example (see also Fig. 5.). Below the area of effect has been depicted (physical factory logistic system). It consists of in the example work cells from which some of them robotized. Among them the unit loads are transported using automatic guided vehicles (AGVs). The system is equipped with various sensors which are categorized into two categories. First a general localization system is necessary for the localization of material handling machines. Second, auto-ID sensors are installed as well, enabling measuring position and timestamp for various logistic objects (unit loads, tools etc.). It is expected that auto-ID information is automatically used for the determination of travel times in the simulation model. The intelligent node disposes of a data interface as well. Its functionality is detailed in the next section. Actually it enables transfer of the necessary information from the central production / logistic database into the simulation model. The information is filtered by human interaction. The simulation model is a digital twin which gives the necessary information for the decision maker module.

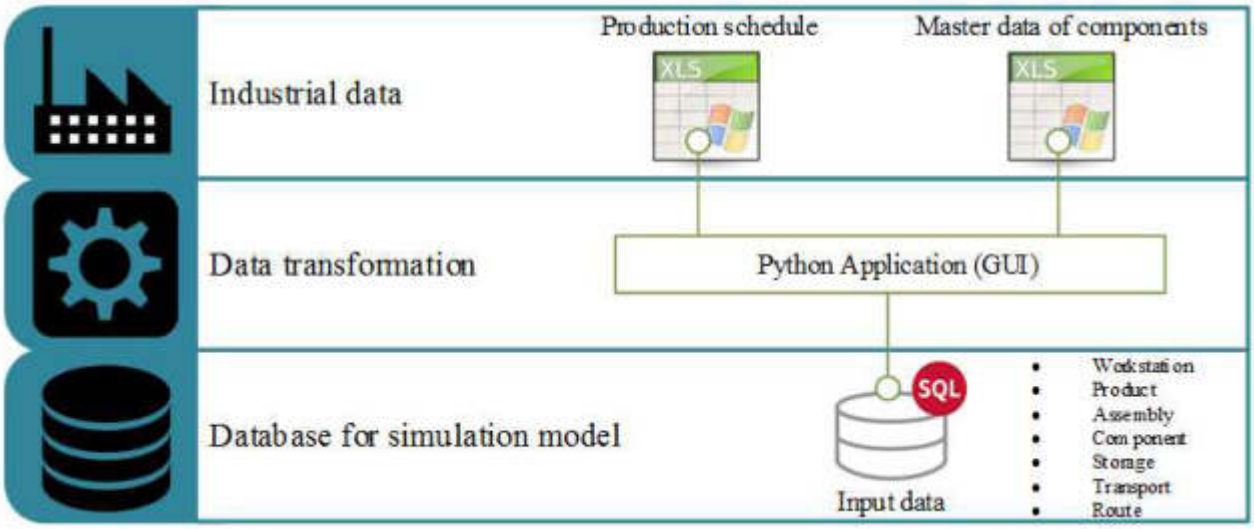

Figure 6 Data transfer into the simulation model

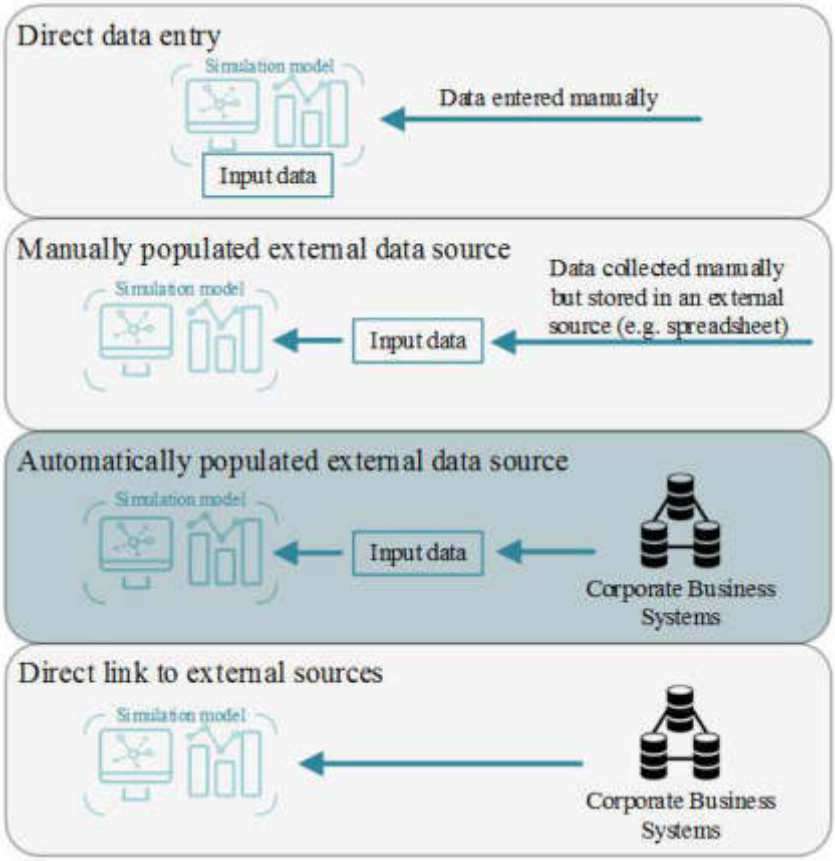

Figure 7 Data transfer into the simulation model

The intelligent node's functionality is to override the central control's decisions. For example, it is enough for the central control to send an AGV to a certain node the exact path and traffic control comes from the intelligent node. Its advantage comparing to the conventional AGV controls come from the flexibility as it can directly use various information sources. An important feature is the user interaction, so it can be easily adapted to unexpected changes as required by the concept of Industry 4.0.

4 Specialities of the data interface

The data interface module is a key component in the system. This is indispensable if continuous adaptivity is required, because there is no general solution for data

conversion for the above specific task. Therefore we propose an interactive software, through which important material flow related data is transferred from central databases into the simulation model. It is indeed a two-steps process: first the necessary data is extracted from the central database, using a semi interactive method. Afterwards, the simulation model can be set up using automatic algorithms. The process flow is presented in Fig. 6. This semi-automatic methodology is not unknown for the generation of simulation data. Skoogh et al. in their paper [11] summarize methods for input data management in simulations and defined for the above four groups.

In the listing of Figure 7. we found that our methodology and automatically populated external data source are the most connected as in our intelligent node an automatic model generation is carried out

5 Conclusions

Above results belong to the foundational phase of our research work on the intelligent nodes. The overall goal of this topic is to verify that creating multifunctional intelligent nodes with defined circle of effect is a viable alternative against the fully decentral concept which increases intelligence at every available component. Next step of the research focuses on the transfer of these early results into industrial applications which increases acceptance.

References

[1] Bundesministerium für Bildung und Forschung: Zukunftsbild „Industrie 4.0“ [Online], Available: http:// https://www.bmbf.de, 2017.
[2] MONOSTORI, L.: Cyber-physical Production Systems: Roots, Expectations and R&D Challenges, *Procedia CIRP*, Vol. 17, p. 9–13. doi:10.1016/j.procir. 2014.03.115, 2014.
[3] LEE, J., KAO, H.A., YANG, S: Service Innovation and Smart Analytics for Industry 4.0 and Big Data Environment, *Procedia CIRP*, Vol. 16, p. 3-8. doi:10.1016/j.procir.2014.02.001, 2014.
[4] WINDT, K., HÜLSMANN, M.: Changing Paradigms in Logistics — Understanding the Shift from Conventional Control to Autonomous Cooperation and Control, *Understanding Autonomous Cooperation and Control in Logistics*, p. 1-16. doi:10.1007/978-3-540-47450-0_1, 2007.
[5] SCHUHMACHER, J., HUMMEL, V.: Decentralized Control of Logistic Processes in Cyber-physical Production Systems at the Example of ESB Logistics Learning Factory, *Procedia CIRP,* Vol. 54, p. 19-24. doi:10.1016/j.procir.2016.04.095, 2016.
[6] SOWADE, S., RIPPEL, D., & SCHOLZ-REITER, B.: Modeling concept for the infrastructure of autonomous logistic processes, *CIRP Journal of Manufacturing Science and Technology*, Vol. 5, No. 4, p. 254-266. doi:10.1016/j.cirpj.2012.09.011, 2012.
[7] AY, F.: *Context Modeling and Reasoning using Ontologies*, University of Technology Berlin, 2007.
[8] FRANCONI. E.: *Revised Ontology Task Handbook*, Deliverable TONES-D07, 2006.
[9] BENJAMIN, P., PATKI, M., MAYER, R.: *Using Ontologies for Simulation Modeling*, Proceedings of the 2006 Winter Simulation Conference, Dec. 2006.
[10] BOHÁCS G, RINKÁCS A.: Development of a novel material flow simulation model for the integration of spatial and process relevant information, *Logistics Journal*, Not Reviewed, (urn:nbn:de:0009-14-43422), 2016.
[11] SKOOGH, A., PERERA, T., JOHANSSON, B.,: Input data management in simulation – Industrial practices and future trends, *Simulation Modelling Practice and Theory*, Vol. 29, p.181-192. doi:10.1016/j.simpat.2012.07.009, 2012.

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DETERMINATION OF IMPORTANCE OF ORE RAW MATERIALS EVALUATION CRITERIA

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Keywords: costs, production, ore, price
Abstract: Industrial enterprises are now obliged to solve complicated and comprehensive problems. As a rule, they have a multi-criteria character, whereas separate criteria have fundamentally different properties. Logistics mathematics-based tools enabling the evaluation of these complicated problems are being more and more applied at present. A common problem can be the evaluation of a series of supplier's offers for commodities, which are typical by a wide spectrum of properties. It could be, for example, input production raw materials. A possibility of the use of mathematic tools in evaluating the quality of the ore raw materials was analysed within the performed investigation. The paper deals with an analysis of the results in determining a relevant importance of separate criteria.

1 Introduction

The tasks of multi-criteria decision-making in our understanding is such decision-making tasks, in which the consequences of particular decisions are evaluated by several criteria. The settling of a task of multi-criteria decision-making is, then, a procedure, by application of which we are able to find out an optimal state of the system, and that is with regards to more than one considered criterion [1].

Decision-making problems and processes can be divided by many aspects. At basic classification of decision-making problems and processes, we can use a division to sufficiently and insufficiently structured decision-making problems, when the basic classification aspect is the division of the problems by aspect of their complexity and ability of algorithmization; decision-making processes under conditions of certainty, risk or uncertainty, whereas the classification aspect is information on the states and consequences of the versions with regard to separate evaluation criteria; dependent and independent decision-making processes [1,2].

As a rule, the sufficiently structured decision-making problems are repeatedly solved on the operative level of management and there are routine procedures of the solution for them. What is typical for these problems is that variables, which occur in them, can be quantified and, as a rule, have the only quantitative criterion of evaluation [3]. The insufficiently structured decision-making problems are typical by such characteristics as a solution of higher levels of management, their novelty and often non-repeatability, a necessity of application of a creative approach, the usage of knowledge, experience and intuition, existence of a higher number of criteria for the evaluation of the solution versions or complicated interpretation of information used for decision-making [4,5].

Another aspect is range and character of criteria, which characterize this decision-making problem. We often meet with problems in the sphere of logistics, which are typical by a wide spectrum of criteria, which additionally have absolutely different properties [6]. We have to synthesize fully different properties for the evaluation. A possibility of the use of tools of multi-criteria decision-making in the evaluation of ore raw materials was analysed within the performed investigation. The fundamental aspect is the determination of importance of the evaluated criteria in a form of weights. Accordingly, their value determines the result of evaluation. A method of paired comparison was used within the investigation. This tool enables simplification of the decision-making process because the evaluation is based on a preference of one of two versions.

2 Importance of the evaluation criteria

While using most of methods of multi-criteria decision-making, it is firstly required to determine a weight of separate criteria of evaluation. The preferences of particular criteria are expressed by criteria weights, respectively their values, and information on relative importance of separate criteria is thus specified [7]. This importance can be expressed by a vector of the weights of the criteria. The more significant the criterion is, the higher weight it has, and conversely, less significant criteria have lower weights. That's why the weights of the criteria are occasionally called as importance factors [8]. In practice, it is very difficult to obtain precise values of the weights from a user; that's why there was developed a series of methods, by means of which estimations of the weights are designed on the basis of simple subjective information from the user. The methods of the weights determination can be divided

to two classes. As far as the determination of the weights is independent of the knowledge of impacts of the versions, methods of direct determination of the weights can be used, such as a point scale, allocation of 100 points (also referred to as the point method) and a method of weights determination by comparison of the criteria by means of their preferential order. Methods based on the paired comparison includes a paired comparison method, which uses so called the Fuller's triangle, and Saaty's method. In case that the results of the methods have to be known, a compensation method is used to determine the weights of criteria. The method of gradual weights allocation, which can be combined with other methods, is used in case when a great number of criteria is available.

3 Criteria of evaluation of an ore raw material

The evaluation of quality of the ore batch can be realized from different points of view. In principle, three basic possibilities can be identified:

- evaluation of the behavior of ore while its lowering through the well of the high furnace,
- single-purpose proving tests serving for the determination of a selected metallurgical indicator,
- complex approaches for the evaluation of ores.

The problem of evaluation of the ore raw materials is complicated with regard to the wide spectrum of the relevant criteria, which evaluate fully different characteristics and have different dimensional indicators. It very complicates comparing particular types of ore. One of the opportunities is the use of the multi-criteria mathematic methods for the evaluation of ores. Firstly, however, it is necessary to determine the importance (the weight) of particular criteria. The following seven criteria were selected for the evaluation of the ore raw materials:

1. Ore price (dollar / ton)
2. Iron content (%)
3. Ore strength after testing in a drum, according to ISO (%)
4. Homogeneity of lumpiness (Vx, %)
5. Quantity P (%)
6. Reducibility (%)
7. Humidity (%)

Criterion 1 (hereunder referred as K1) - Price

The ore price in the present economic conditions belong to the key parameters. Strong competition makes metallurgical enterprises continually search for potential savings. Therefore, the ore ingredient as a basic input raw material for the high-furnace process is a dominant component from the costs point of view. Lately, the price of ore strongly fluctuates, which naturally influences the cost level of the entire process. Metallurgical enterprises often struggle to look for cheaper sources of ore raw materials, which, however, can mean a significantly worse quality, which will be expressed itself by worsening the technological parameters of the high-furnace process. It is necessary to realize in this regard that the energy intensity of the production of raw iron directly depends on the properties of the used ore, and - thus - the ore type directly determines the production costs.

K2 - Iron content

The content of iron belongs to the basic characteristics of the demanded raw materials influencing the effectiveness of the entire process. The content of iron in the ore raw materials shouldn't be long-term under the limit of 50 %. Raw materials containing iron in an amount higher than 65 % may be considered as excellent. The content of iron is naturally given by a type of ore (oxide, carbonate, silicate).

K3 - Ore strength after testing in a drum

The ore strength belongs to the physical properties influencing the high-furnace process. The strength is expressed by a share of class under 0.5 mm and above 6.3 mm; and after testing in an ISO drum should be generally: the share under 0.5 % should be lower than 5 % for ores and pellets, the share of class under 6.3 mm should be higher than 75 % for ores and higher than 90 % for pellets.

K4 - Homogeneity of lumpiness

Homogeneity of lumpiness, which was evaluated on the basis of a coefficient of variation, was selected as the fourth evaluating criterion. The coefficient evaluates variability in a form of percentage, and its growing value means a higher rate of fragmentariness. The ore lumpiness belongs to the frequently used international classification scales of ores, which set up raw materials to several groups.

K5 - Phosphorus content

The content of negative elements in the high-furnace process is very crucial. The negative elements can be a cause of violation of the course of the high-furnace process and invoke a quite a few of typical causes. The most frequent of them are sudden changes of the speed of gas flowing, a swift decrease of the batch, an excessive warming-up of the well of the furnace. Also, viscosity of slag or raw iron is often changed, which means problems with their withdrawal from a high furnace. Other effects can be related to the influence of the service life of the lining and its integrity. A series of these causes can be caused by pollutants, such as alkaline carbonates, zinc, phosphorus, lead and other negative elements.

K6 - Reducibility

The sixth evaluating criteria is reducibility, which belongs to the important properties of the metallic batch. The reduction of iron oxide belongs to the elementary processes ongoing in a high furnace. The reducing processes proceed practically in the entire high furnace with the exception of relatively small oxidizing spaces in

the well. Reducibility of ore fundamentally influences the effectiveness of the entire high-furnace process.

K7 - Humidity

The last evaluating criterion is humidity, i.e. a quantity of H20 concentrated in the ore raw material. The content of free or bound water can also essentially influence the costs of both agglomerative and entire high-furnace processes.

4 The results of the performed investigation

For the estimation of the weights, the method of paired comparison only uses information about which of the two compared criteria is more important. The resolver gradually compares each two criteria among each other. The comparison can be carried out in the Fuller's triangle. Firstly, we firmly number the criteria by sequential numbers: *1,2,…k*. Afterwards, a triangle scheme is presented to the resolver. Its double-rows contain pairs of the sequential numbers configured so that each pair is unique here. The resolver is required to mark such a criterion for each pair which he/she considers to be the most important.

Considering the above, the base for the paired comparison method is the comparison of all criteria in the pairs with the aim to determine how many times each criterion is considered to be the most significant in comparison with all other criteria. The most significant criterion is thus a criterion with the biggest number of preferences. The preferences are considered as non-normed weights, which have to be consequently recalculated to the normed ones. Sometime, however, a certain criterion obtains a zero preference, which should mean that is has zero importance. But, based on the principle of the selection of the criterion for decision-making, it is unequivocally clear that each selected criterion has a certain importance. In this case, an additional consideration of the obtained preferences is being performed. The procedure of the determination of the weights with help of the paired comparison method can be divided into the following steps:

1. Determination of the number of preferences for each criterion (P_{pi}) (how many times each criterion is more significant than all others)
2. Calculation of the weights of particular criteria (v_i) according to the formula (1)

$$v_i = \frac{n+1-p_i}{n(n+1)/2} \qquad (1)$$

where
n – total number of criteria
p_i – order of each of the criteria depending on the number of the obtained preferences,

1. Evaluation of the determined weights
2. Determination of the order of particular criteria

The paired comparison method was applied within the performed investigation for the evaluation of the criteria importance for the evaluation of iron ore. The respondents in the company, dealing with the metallurgical production, carried out evaluation of the followed criteria with help of the binomial comparison system. The record of evaluation is part of Table 1. The left part of the table contains a record of the performed decisions. The votes assigned to each criterion (*Ppi*) were also summarized. Based on the assigned votes, an order of particular criteria was compiled. A criterion which obtained the highest number of votes is put on the first place. The last step was the calculation of the normed weights with help of the formula (1). An example of weights calculation:

$$V_{i1} = \frac{7+1-3}{7(7+1)/2} = \underline{\underline{0{,}1785}}$$

$$V_{i2} = \frac{7+1-2}{7(7+1)/2} = \underline{\underline{0{,}2142}}$$

$$V_{i3} = \frac{7+1-1}{7(7+1)/2} = \underline{\underline{0{,}2500}}$$

$$V_{i4} = \frac{7+1-7}{7(7+1)/2} = \underline{\underline{0{,}0357}}$$

$$V_{i5} = \frac{7+1-6}{7(7+1)/2} = \underline{\underline{0{,}0714}}$$

$$V_{i6} = \frac{7+1-5}{7(7+1)/2} = \underline{\underline{0{,}1071}}$$

$$V_{i7} = \frac{7+1-4}{7(7+1)/2} = \underline{\underline{0{,}1428}}$$

All steps of the paired comparison method are shown in Table 1. The calculated weights (*Vi*) are an evaluation criterion, according to which all criteria are compared. The higher the criterion weight is, the higher importance it has.

Table 1 Record of the paired comparison method

K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_i	P_{pi}	P_i	V_i
	2	3	1	5	1	1	K_1	3	3.	0,1785
		3	2	2	2	7	K_2	4	2.	0,2142
			3	3	3	3	K_3	6	1.	0,2500
				5	6	4	K_4	1	7.	0,0357
					6	7	K_5	2	6.	0,0714
						7	K_6	2	5.	0,1071
							K_7	3	4.	0,1428

The final order of the followed criteria for the evaluation of ores is shown in Table 2, and in a form of a diagram in Figure 1. The criterion No. 3 is on the first place; and - on the contrary - the worst evaluation is for the criterion No. 4, which was evaluated by the lowest weight.

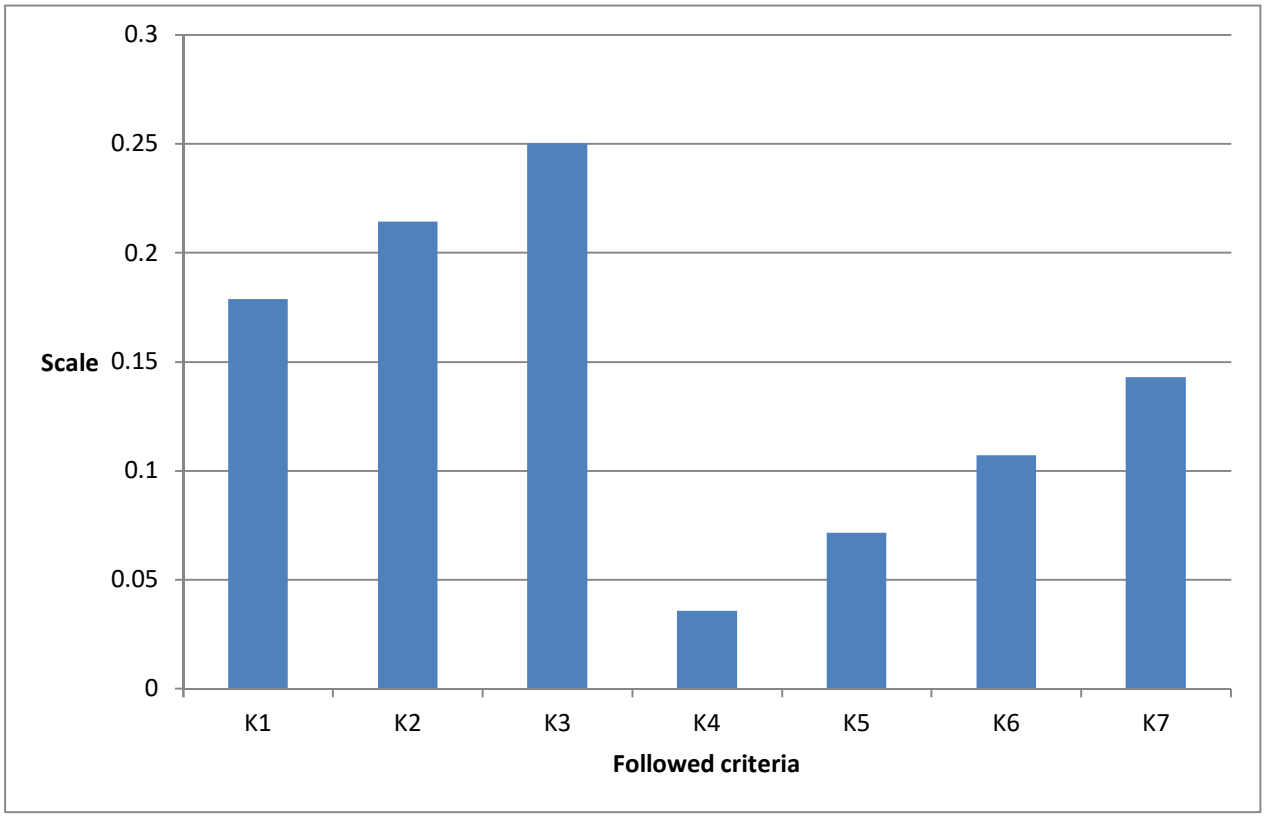

Figure 1 Values of the weights determined by the paired comparison method

Table 2 Total evaluation of the paired comparison method

Criterion	K1	K2	K3	K4	K5	K6	K7	∑
Weight	0.1785	0.2142	0.2500	0.0357	0.0714	0.1070	0.1428	1

The weights determined for the specified criteria can be used in evaluating particular ore raw materials. The weights finally represent an importance of separate criteria.

5 Conclusion

The tools on the basis of the paired comparison offer an interesting occasion how to easily determine the importance of particular criteria. Their usability is mainly suitable where a wide spectrum of criteria must be evaluated. In this case, it will be always complicated for a respondent to divide weights between a bigger numbers of criteria in case of the paired comparison, on the opposite, the respondent has to make a decision just between two alternatives. This aspect fundamentally simplifies the entire decision-making process. The paired comparison method was applied within the realized investigation of the evaluation of the ore raw materials. Its simplicity, universality and algorithmic unpretentiousness enable the use in a wide spectrum of industrial spheres. Its usage can be high-effective in the sphere of the industrial logistics, where there are problems having a similar multi-criteria character.

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References

[1] JABLONSKÝ, J.: *Operační výzkum*, Praha, Professional Publishing, a.s., 2002. (Original in Czech)
[2] FIALA, P.: *Modely a metody rozhodování*, Praha, Oeconomica, 2008. (Original in Czech)
[3] FOTR, J., ŠVECOVÁ, L. et al.: *Manažerské rozhodování*, Praha: Ekopress, s r.o., 2010. (Original in Czech)
[4] KOŠTURIAK, J.: *Inovace – Vaše konkureční výhoda,* Praha, Computer Press, s.r.o., 2008. (Original in Czech)
[5] ALHURAISH, I., ROBLEDO, C., KOBI, A.: A comparative exploration of lean manufacturing and six sigma in terms of their critical success factors, *Journal of cleaner production*, Vol. 164, No. 15, pp. 325-337, 2017.
[6] PERNICA, P.: *Logistika pro 21. Století*, 2. díl. Praha, Radix, s.r.o., 2005. (Original in Czech)
[7] CHANDRA, CH., GRABIS, J.: *Supply chain configuration: concepts, solutions and applications*, London, Springer, 2007.
[8] MONCZKA, R, M., HANDFIELD, R., B., GIUNIPERO, L.: *Purchasing and Supply Chain Management*, New York, Cengage Learning, 2008.

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APPLICATION OF THE PRINCIPLES FOR LOGISTICS PRODUCTION COMPANY EFFECTIVITY

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Keywords: testing, system, simulation, automation, modernization
Abstract: The thesis focuses on the effectiveness of product testing. A system analysis is used in diploma thesis in the detailed analysis of the individual subsystems and their characteristics, Which later improve the project proposal and emphasize the efficiency and the demands or requirements of the company for the final solution of the problem. The solution utilizes Tecnomatix 13 simulation of individual product testing, and its results are later taken into account in the economic evaluation of the proposed testing system. At the same time, the current situation is compared with the proposed project.

1 Introduction

The thesis is focused on the effectiveness of product testing. The problem is related to the constant search for back-logs and more efficient business activities to ensure competitiveness on the market. The main goal of the thesis is to design an efficient system testing in a particular company, so as to manage with the quantity of assembled products. The system analysis is used in diploma thesis to solve current problem. It is also used the simulation in software Tecnomatix 13, which is used in the current state of product testing as well as the new, suggested system of testing products. The results of the simulations are aimed primarily at occupancy of machines and amounts of tested products. These results are then reflected in the economic evaluation and comparison of the quantities of the products tested, the cost of the test product, staff costs in the current state of the with new system for product testing. An important part of the thesis is the pricing of the suggested new system of testing and payback period of the new system.

1.1 Analysis of current situation

The project is carried out in a company engaged in the manufacture of low-voltage devices. In the usage of system analysis, specific department was analysed, as department of assembly of products, where deficiencies were identified as outputs of analysis and they needed to be solved [1].

Product assembly department consists of seven parts:

1) Part for the assemblage of the necessary components - in this section necessary components are folded into one, which is important for the actual assemblage of the products. This work is performed by human personal on special devices. Example of the components shown in Figure 1 - on the left are the necessary components, and on the right is a composite component.

Figure 1 Components necessary for the product assembly

2) Part of the storage components- in this section the necessary components are stored, which are made directly in our company or bought from external suppliers. Also in this section are also stored parts, which were used in previous operation. Mentioned parts are very important for product assemblage. They are stored in plastic containers. The warehouse system is the type of market.

3) Mounting part – There are 2 parts folded in this section, and it is PFI_I and PF_II. Components from the market are stored into plastic case, which will be closed, stored and used for next part of testing (Figure 2).

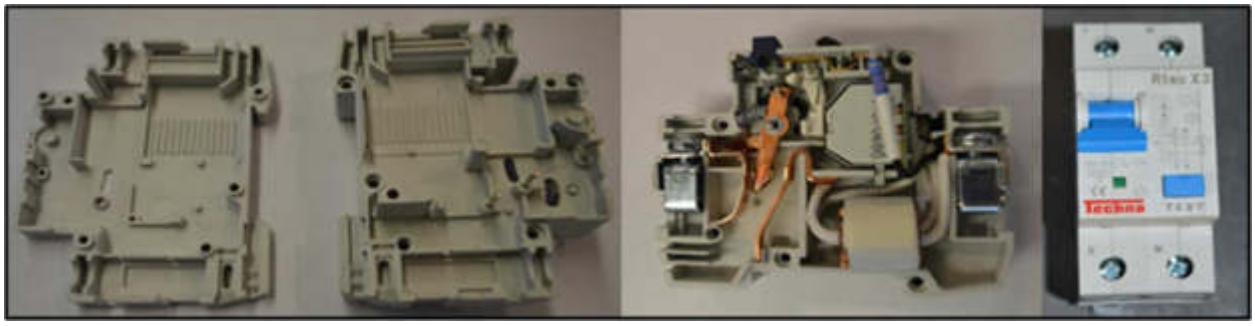

Figure 2 Components necessary for the product PFI_I assembly

4) Testing part of products – The testing is carried out on 5 testing devices, and the output can be with positive result or negative result. The products are inserted into test machines by using handmade. In this section is used high percentage of human work, which is not optimal. The simulation of testing products was created in the simulation software Tecnomatix 13 (student version), and the results were focused on number of tested parts and on the percentage of occupancy of machines.
5) Part of products setting - After testing the products, products with a positive result moving in the melting department, where the parameters of products were set.
6) Part for logo etching – The logo of company, or for company that is product made, is etched (Figure 3).

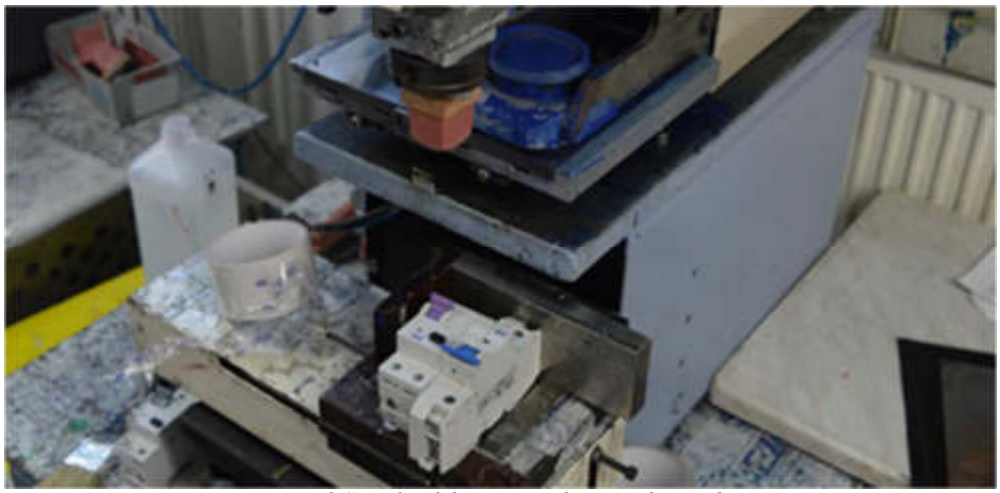

Figure 3 Sample of designation logo on the product

7) Part of the logo etching, packaging and shipping- Thanks to laser, the required descriptions are etched on the case of products (Figure 4). Later, the products are packaged and shipped [2].

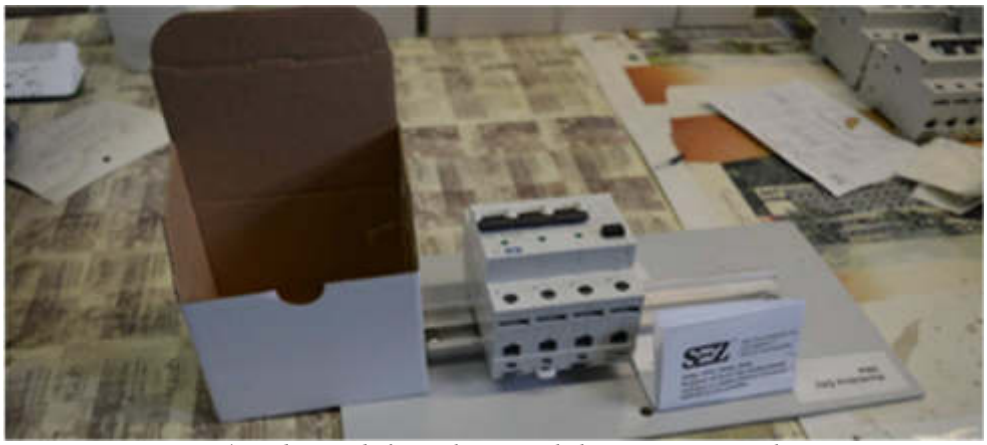

Figure 4 Product ready for packaging with the necessary manual paper

1.2 Identified deficiencies

Identified deficiencies mainly point on the system of current product testing, where happen the situations, that products made in the current date is not tested, because of the time, and need to be tested during overtime shifts. Mentioned deficiencies are mostly connected with testing machines, which belong to old ones, what means that it requires more time to test one part.

The solution of this problem may be solved by simulation, which was used during analysis and was suitable for the synthesis purposes. Possibility to eliminate the mentioned deficiencies is to do more variants of testing, but mainly the solution depends on automatization and robotization of testing system. The role of simulation is to experiment and to suggest more efficient system of testing, which eliminate the mentioned deficiencies and after that, the company will obtain the reserves, which will have important role to secure competitiveness on the market [3].

2 The project of testing department of the new production line

For the long time, company thinks about change in process testing, because current way of product testing is not efficient. It is necessary to design new system of testing, which is going to be fully modernized, automatized and robotized.

This new system, may be mainly used to increase the number of tested products and reduced the number of operations, which are performed by operators [4].

All operations in the current situation will be included in a new project with new parameters.

2.1 The requirements of the company

The company got some idea, how testing line should looks like, requires and what should it performs. After the consultation about issues with my consultant for diploma thesis, the requirements were collected as required by company management, by the automatized line, and these are:

- distribution of products by type into two separate testing processes,
- that the product is shipped to the necessary equipment without the need for relocation of staff,
- increase the number of assembled products in one shift,
- that the product contains identifying information about the production, about the results of testing,
- to test line separated the products tested according to the test results (positive, negative).

2.2 Machines and equipment needed for a new testing line

Now, new testing machines have better performance. The most important is time in which they can test the product without the passing the same test twice because of negative result of the test.

New machines have a few seconds shorter testing time but as mentioned, these machines will test the product only once without the need for repetition. Modernization of machine (purchased new ones) indicates the different times of testing and riveting, which are listed in table 1, together with a comparison of current machines and new machines. New machines are offering new functions, and this fact is very important for greater efficiency of product testing compared to the current testing process [5].

Table 1 Comparison of new machines with the current

Machine / equipment	Time operation of the new machine	The original time operation
Tester No. 1, reading the data by RFID chip	24 seconds	27 seconds
Tester No. 2, reading the data by RFID chip	21 seconds	27 seconds
Tester No. 3, reading the data by RFID chip	17 seconds	25 seconds
Tester No. 4, reading the data by RFID chip	23 seconds	23 seconds
Tester No. 5, reading the data by RFID chip	15 seconds	22 seconds
Machine for the definitive closure of the product	5 seconds	7 seconds

The new test line must require the mentioned requirements of the company management and therefore it is necessary to design and to use devices that require these requirements and ensure greater efficiency of product testing. These machines are also designed to incorporate into an automatized testing process. Times necessary to testing line are bellowed in the Table 2.

2.3 Simulation of the new testing line in the simulation software Tecnomatix 13

After the finding of necessary data, parameters and management requirements on the new testing line, which are shown in Table 1, Table 2 and the above mentioned requirements of the company, were suggested several options for system of product testing. However, the efficient is the simulation model, bellowed in Figure 5 [6,7].

Other functions and parameters of machines already mentioned in the tables, can be seen in simulation model, were suggested, so that the testing process was efficient and worked without any operator intervention (person) [8].

Table 2 Other new equipment needed to test the line

Machine	Feature	Time / single action
RFID data recorder	It is used for recording basic information about the product.	3 seconds
Robot	Its functions are to pick up, set up, unload and lay the product.	2 seconds
RFID reader with divider according to the following operations	It is necessary to read the RFID chip and to divide the products according to selected categories.	4 seconds
RFID reader	It is necessary to read the data accoridng to it pushes out the stopper for concrete worker of the departmer during the product assemblage.	2 seconds

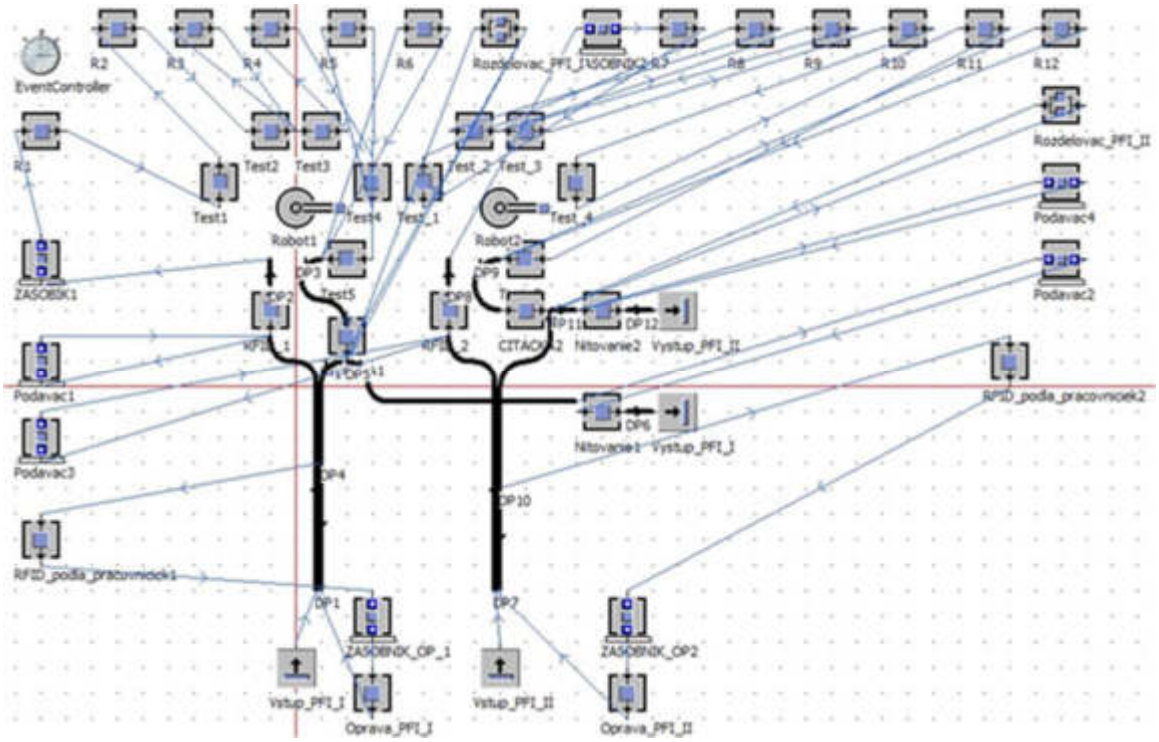

Figure 5 The simulation model of the new testing line in software Tecnomatix 13P

2.3.1 Simulation time

Simulation time was determined only at the inputs, since the workers have a working time 7 hours 20 minutes (8 hour shift - 30 minute lunch break - 10 minutes break for a snack). The whole simulation end up, until the all product entered the testing line, are not finished in tests.

2.3.2 Conveyor needed for the automatized testing line

For the product transportation, from A point to B point should be used conveyor that require the requirements for automatized testing regarding to the transport of products to the necessary places. Example of a conveyor together with the parameters:

- length - 11.1 m,
- width - 0.1 m,
- height - 1 m,
- conveyor speed - 0.5 m/sec,
- automatic stop (when the conveyor does not contain any product) [9].

2.3.3 Identification data on the product during the testing process

In order to product contains the identification data is used technology of RFID chip to read datas about product itself, but also about the whole production process and about the results of the testing process. RFID is glued on the product to save data needed for correct management of process of new testing line [10].

2.4 Location for the new testing line into Test department

Conveyor must be located, so that the simulation results were not distorted, because conveyor length has important role in transporting products from A point to B point. This length is mainly associated with the indicator of transit time. Location of the new suggested testing line can be seen in Figure 6 and Figure 7. The new testing line requires the demands of company in terms of its dimensions because the current machines are predominantly small in comparison to places they are located. When the whole line was designed, it was mostly taken regard on conveyor, which has important role according to location in the designed hall.

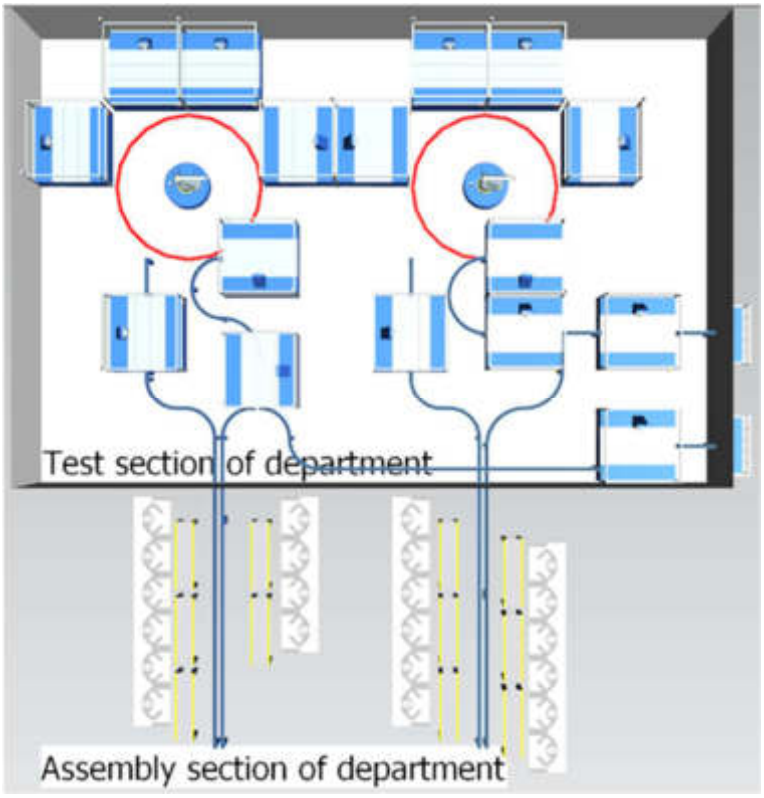

Figure 6 Location of new testing line into Testing department (top view)

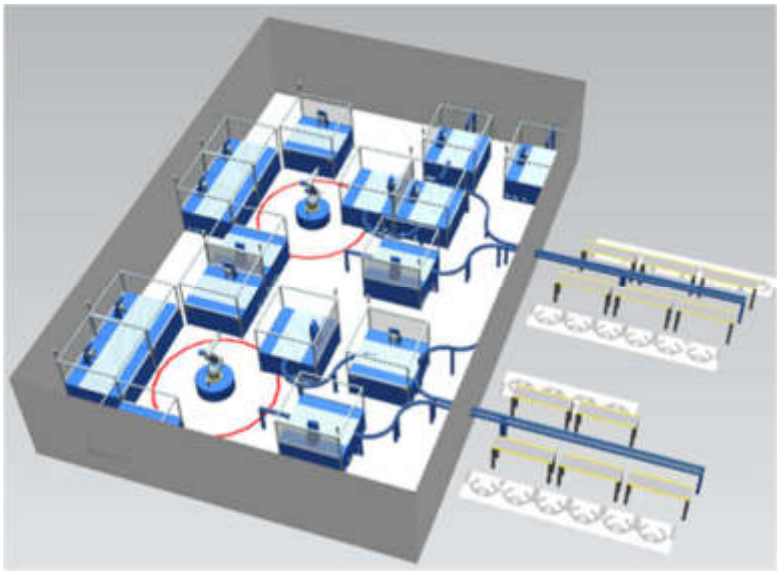

Figure 7 Location of the new testing line into Testing department (3D view)

2.5 *Simulation results of the new testing line*

The results are mainly focused on capacity of the machines, the number of tested units, the number of repaired units and the time for a new production line is able to test all assembled products within one working shift. These values are the most important from the perspective of the company.

The number of tested products in the testing line, can be seen in Figure 8 and percentage increase of tested products in Table 3.

Table 3 The percentage increase in the products tested

Type of product	The current number of tested products	Number of products tested on the new testing line	The increase in the product testing %
Number of products PFI_I	548	813	**32.60%**
Number of products PFI_II	430	586	**26.62%**

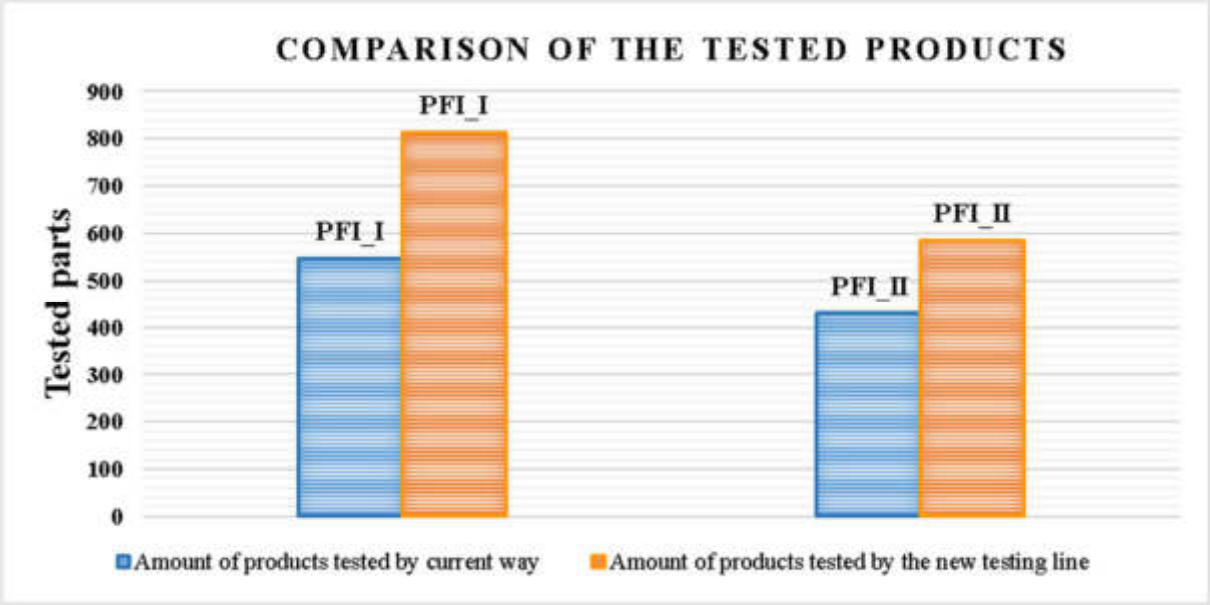

Figure 8 Graphical representation of comparison tested products by current testing way and by the new testing line

3 Results

The current method of product testing, requires more money, because it needs to be consider: wage costs, operating costs of testing, costs of protective equipment or clothing. The suggested testing line has lower costs, because in the new testing line, there isn´t need of any human help, so the cost of wages and the cost of protective equipment are excluded. Operating costs are lower than the current cost of testing. In the new design has been added cost of RFID chips, but in such quantities tested RCDs price is acceptable, and it is valid that price is going to be lower, with greater quantity of products it is going to be bought. In the future the company plans to increase the production, so quantities of RFID chips are going to be higher.

After result evaluation, it got comparison of the current state with suggested new testing line with 0 staff costs, savings 19% for activity expenses and costs associated with one testing product with savings up to 87.5%. Investment return is assumed for 8.56 years. This investment return is going to decrease because of increasing of production of products, so investment return should pay back sooner that it was expected.

4 Conclusion

The article topic is focused on efficient testing of products in a particular company and therefore in its analysis of the current state with the emphasis on the Assembly department, which is currently testing of the product performed. Application of systems analysis, whose task was to analyse and to find deficiencies and which are not effective for this system. The thesis points out the deficiencies and ways to eliminate them. As an ideal way of dealing with the deficiencies is simulation used in simulation software Tecnomatix 13. In this software it was experimented with multiple ways, how to deal with the requirements of the company management, function of new testing line, and also cost of the testing line. It was suggested fully automatized testing line, which allows company to keep capacities during increasing of amount of production assemblage. More important is fact that new

testing line is going to be more efficient than the current system of product testing.

In this thesis are presented compared amounts of tested products in current and new testing method, an increase of 32.6% for the type of product PFI_I and an increase of 26.62% for the type of product PFI_II. In addition to increase of amount of tested products, costs indicators highlight the differences between those 2 systems. The cost are mainly focused on employees and costs associated with the operation but also important are overall costs on one tested product. These results were then compared and it was found that the new test line is less expensive and more beneficial for the company in the long term because the current way of testing is more expensive. The new test line is the pricing of an unnamed company, and the price was taken into consideration along with other costs in return for that investment. The investment return was calculated for 8.56years, what is acceptable period of the time. The results of this project are very positive, which can bring a lot of assets for the company.

References

[1] MALINDŽÁK, D.: *Výrobná logistika I.*, Štroffek, Košice 1996. (Original in Slovak)

[2] BANIK, A.: *Analýza a posúdenie materiálových tokov vo väzbe na dizajn nového výrobku*, Technical University of Košice, 68, Košice, 2016. (Original in Slovak)

[3] KOŠTURIAK, J., GREGOR, M.: Jak zvyšovať produktivitu firmy, Žilina, InForm, 2002. (Original in Slovak)

[4] HAMMER, M., Agenda 21: *Co musí každý podnik udělat pro úspěch v 21. Století,* 2nd ed. Praha, Management Press, 2012. Knihovna světového managementu; zv. 32. (Original in Czech)

[5] MALINDŽÁK, D.: Modely a simulácia v logistike, *Acta Montanistica Slovaca*, Vol.15, Special Issue 1, pp. 1-3, 2010. (Original in Slovak)

[6] Kliment, M., Trebuňa, P.: Simulation as an appropriate way of verifying the efficiency of production variants in the design of production and non-production systems, *Acta logistica*, Vol. 1, No. 4, pp. 17-21, 2014.

[7] Trebuňa, p., Kliment, M., Halčinová, J., Markovič, J., Fiľo, M.*: Tecnomatix Plant Simulation, a describtion of the work environment and basic controls*, The 16th International Conference, Trends and Innovative Approaches in Business Processes 2013, 2013.

[8] VELÍŠEK, K., KOŠŤÁL, P.: *Mechanizácia a automatizácia*, STU in Bratislava, Bratislava, 2007. (Original in Slovak)

[9] FEDORKO, G., MOLNÁR, V., MICHALIK, P.: *Hadicové dopravníky*, Technická univerzita v Košiciach, Košice, 2013. (Original in Slovak)

[10] RFID and NFC, [online], [2018.3.19], Available: https://learn.sparkfun.com/tutorials/connectivity-of-the-internet-of-things/rfid-and-nfc, 2018.

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IMPROVEMENT OF EFFECTIVENESS OF PRODUCTS PLACING AND DISPATCH IN THE DISPATCH WAREHOUSE OF THE ROUGH ROLLING PLANT

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Keywords: logistics, management, warehouse, Pareto analysis
Abstract: The paper describes a metallurgical enterprise and its production plants, including assortment of the manufactured products. The paper continues by the system of placing these products into a dispatch warehouse of the rough rolling plant, describes its benefits and disadvantages in connection with another processes. It also contains several alternatives of products disposition in warehouse with regards to certain criteria, as well as reasons why the enterprise should place emphasis on a correct lay-out of the products, which will lead to the grow of the effectiveness of placing and dispatch of the products and - by this - to the decrease of the total costs of the enterprise.

1 Introduction

As far as the company wants to be successful and competitive, it must approach systematically to the logistics management and to control particular activities as comprehensive processes. The main aim of the logistics management is the maximal satisfaction of all customer's requirements with the required quality, in agreed time and with the minimal costs.

The first part of the paper presents a metallurgical enterprise and contains a description of its production plants and all manufactured assortment of the rough rolling plant and the dispatch warehouse where these items are stored and also processed.

The second part of the paper deals with the system of placing the products in the dispatch warehouse of the rough rolling plant. Proposals of placing with the use of professional literature are here also discussed.

Consequently, a Pareto analysis is worked out, also known as an 80/20 rule, which identifies the most significant products manufactured and placed in the dispatch warehouse of the rough rolling plant. These products are afterwards divided into groups and sub-groups and consequently - based on the, "ABC" and „XYZ" analyses – the most suitable placement of these products in the warehouse is selected with respect to the optimization of the dispatch process.

The last part is engaged in evaluation of the proposal of the disposition of the products, which will cause the growth of the processes effectiveness, mainly by means of decreasing the manipulation times of the cranes and the searching time of particular products.

2 Metallurgical enterprise

The manufacturing activity of the enterprise is mainly focused on the production of machine parts, steel structures, engineering investment complexes and production lines, operating cylinders, castings, wheel sets and axles. A part of the enterprise is also a heat processing shop and an electric motors repair shop. Enterprise

is preferably focused on the metallurgical industry, but it also can satisfy needs of the customers dealing in the petrochemical, mining, machine engineering, building, automotive, etc. industries. The annual manufacturing capacity exceeds 3 mil. tons of steel. The enterprise exports its products to more than 60 countries across the world.

The entire enterprise consists of several production plants. Particular plants produce a wide spectrum of products and also provide all sorts of services. These are Cocking Plant, High Furnaces, Steel Plant and Rolling Plant. The Rolling Plant consists of Rough Rolling Plant, Continuous Wire Rolling Mill, Band Mill P1500 and Medium and Fine Rolling Plant. This plant manufactures long flat products which are being used for constructions and structures, for example, structures of high-voltage columns.

The Rough Rolling Plant this paper is focused to, called also the HCC Rolling Plant, manufactures rough sectional steel, starting from separate circular rods, through shaped steel (profiles of L, V, I, U etc. types) and also special steel profiles. Profiles of steel armatures and flat steel are also manufactured here. The profiles are placed in the dispatch warehouse of the Rough Rolling Plant, where other modifying operations are also performed [1-3].

3 Products placing system

Random organization of the warehouse is one of the easiest types of storing we know of. Very simplistically, it is a system of random storing, when different stored items are placed to the nearest free places which are currently available [4, 5].

The procedure of proposing a lay-out of the storage area is not easy, because it is necessary to estimate how many products and of which type will be stored by the enterprise. Especially difficult is to sketch out the warehouse area in regard to big companies with a wide assortment of products. After that it is necessary to lay-out the warehouse area and propose alternative possibilities of solution, from which only one solution best meeting conditions of effectiveness will be selected [6].

As far as the stored products are concerned, the warehouse can be organized with respect of several following criteria [7]:

- products with high turnover rate are situated as close as possible to the main dispatch place,
- products with slow turnover rate are situated in the most distant places in the warehouse,
- other area is determined for such products which come into the warehouse regularly, or for such products which requires performing other operations (modifications or processing) prior to the dispatch.
- storage premises should be configured with regards to the speed of selling as well as to the difference of sizes and types of the stored products.

Provided the enterprise observes a correct lay-out of the warehouse, of its areas and stored products, the total costs will be, thus, decreased. There are five main reasons for the correct lay-out of the warehouse, and that is the growth of the outputs, improvement of the flow of products, the decrease of the costs, improvement of customer's service, and the provision of better conditions for employees [8].

4 Pareto analysis

The Pareto principle (also known as the 80/20 rule) should be used by each organization which wishes to increase its effectiveness and satisfaction. It can multiply company's profitability and improve quality of the total services, while decreasing the costs. The 80/20 rule asserts that a minority of causes, inputs or endeavours usually leads to a majority of results, outputs or successfulness. For example, 80 percent of outputs is the result of 20 percent of inputs, or 20 percent of products brings 80 percent of the turnover [9].

The 80/20 rule can be also applied to the assortment of the manufactured products - see Figure 1, where you can see products manufactured by the metallurgical enterprise in one of its production plants in 2017. The most manufactured item is so called V-Profiles (the V-Profiles are most frequently used for the construction of high-voltage columns), which have more than a 60 % share in the all manufactured assortment placed in the dispatch warehouse of the Rough Rolling Plant. A smaller quantity of P-Profiles (flat shapes) and U-Profiles is manufactured. These 3 types together (V, P, U Profiles) create 80 % of all items placed in the dispatch warehouse. The output of the Pareto diagram is, thus, the identification of the most significant items (items with the highest turnover rate) of the dispatch warehouse.

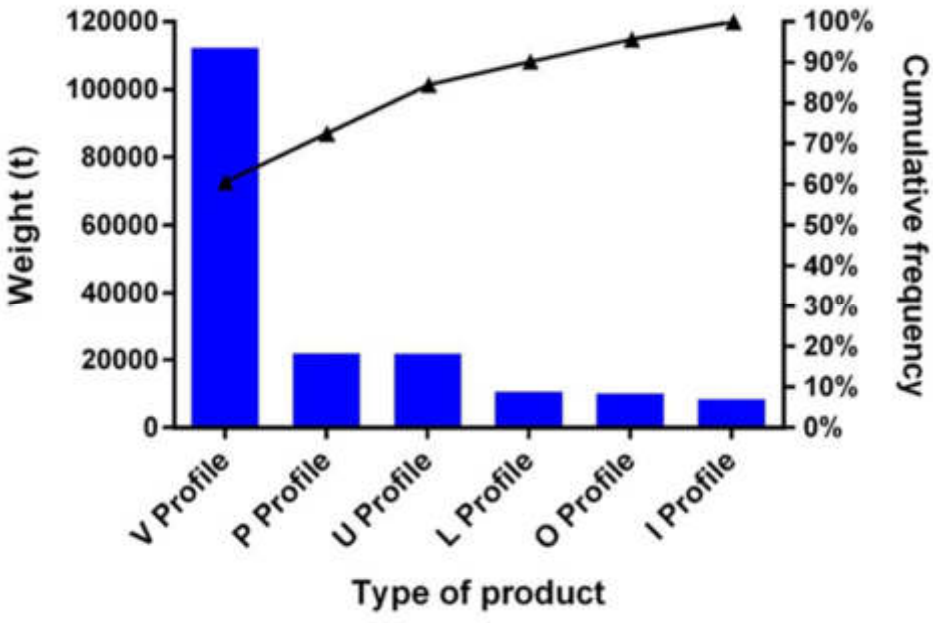

Figure 1 Overall share of particular products in 2017 – Pareto analysis

5 Division of products into groups

5.1 ABC analysis

Based on the data obtained from the statement of balances of the dispatch warehouse, a quantity of the manufactured products was determined (see Table 1), and these products were consequently divided into groups depending on the frequency of production. The "Group A" contains products with the highest frequency of production (V-profile), which create more than 60 % of the total quantity of the products placed in the dispatch warehouse in 2017. The "Group B" consists of P and U Profiles. These products, however, create just more than 23.5 %. The products included in the "Group C" has the lowest frequency of production. This Group consists of three types of profiles (I, O, L) and takes almost 16 % of the total quantity of the stored products in the given year.

Table 1 Division of the products into groups depending on the frequency of their production

Group	Product type	Quantity (t)	Frequency (%)	Cumulated (%)
C	I-Profiles	8,352.4	4.5	4.5
	O-Profiles	10,139.0	5.5	10.0
	L-Profiles	10,528.7	5.7	15.7
B	U-Profiles	21,876.4	11.8	27.5
	P-Profiles	21,942.6	11.9	39.4
A	V-Profiles	112,297.5	60.7	100.0
		185,136.6	100.0	

5.2 Division of the warehouse into zones on the basis of the "ABC analysis"

Group A

The main principle is that the products of the "Group A", which are the most significant for the company from the point of view of the frequency of production, are situated in the place, which is the nearest to the loading platform - see Figure 2. This place is strategically important because bunches of products weighing few tons will be loaded (dispatched) quicker if they are situated in this area. Due to shorter distances which must be traveled by cranes with the products in the premises of the warehouse, the manipulation times will be shortened. The cranes, consequently, will be freer for another possible operation in the warehouse.

Group B

The products of the Group B have an ordinary meaning for the company from the point of view of their frequency, that's why they are situated in the warehouse in a place, which is neither in the nearest nor in the farthest distance to the loading platform. The dispatch of these products is not so frequent as the dispatch of the products of the Group A.

Group C

On the contrary, the least important products for the enterprise from the point of view of frequency are the products of "Group C", which are placed in the most distant part of the warehouse from the loading platform. The cranes have to travel the biggest distances for the products from this group. With regards to the lowest number of stored products of this group, the time loss is, thus, the lowest.

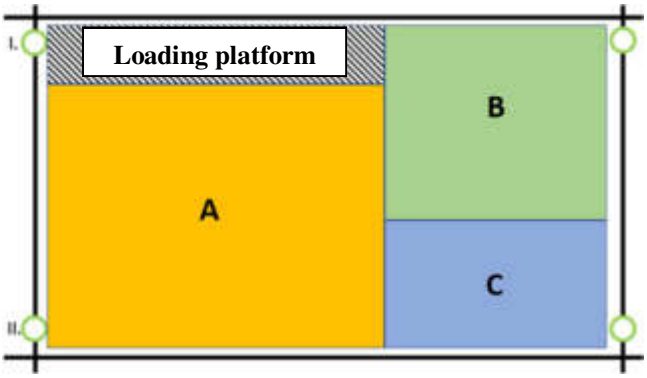

Figure 2 Distribution of products in the warehouse according to the ABC Analysis

5.3 XYZ Analysis of the products of Group A

This analysis deals with the distribution of the products of Group A (the most significant products for the enterprise from the point of view of frequency) into sub-groups of X, Y, Z depending on their turnover rate. The XYZ Analysis is applied with a sample of the products in the I. quarter of 2017. The used data were obtained from the statements of balances of the dispatch warehouse of the metallurgical enterprise. The Group X contains products with the lowest turnover rate, the Group Y - products with the average turnover rate, and Group Z - products with the highest turnover rate. Table 2 shows distribution of particular types of V-Profiles depending on their sizes and quantity.

Table 2 Distribution of the products into groups depending on their turnover rate

Group	Size (mm)	Quantity (t)
X	80x80	732.4
	140x140	716.3
	90x90	572.8
		2021.5
Y	130x130	1072.5
	110x110	1610.4
		2682.9
Z	150x150	2902.3
	120x120	3434.8
	100x100	4837.1
		11174.2

The division of the products of Group A into sub-groups in dependence on their turnover rate makes it possible to determine more detailed distribution of these products for even bigger acceleration of the dispatch time. Whereas, the product with the highest turnover rate fall into Group Z will be situated as close as possible to the loading platform - see Figure 3, products of Group Y directly behind them, and, in the end, the products with the lowest turnover rate of Group X - farthest from the loading platform.

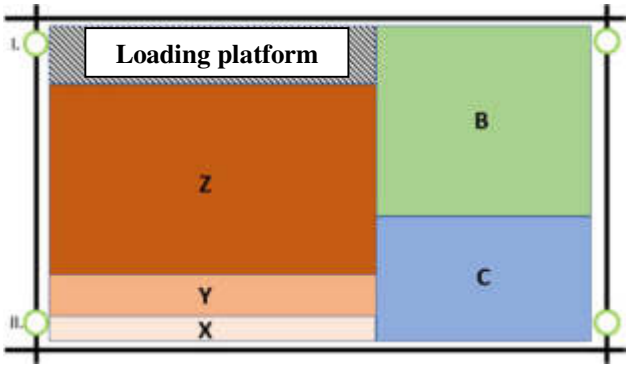

Figure 3 Distribution of products of Group A in the warehouse according to the XYZ Analysis

6 Final recommendations, evaluation and conclusion

According to the internal interviews with employees of the enterprise and the results of the Pareto Analysis, it is necessary to pay attention especially to the disposition of the V-type profiles. This type of profiles takes the biggest share of the manufactured products, namely more than 60 %.

The ABC Analysis was consequently performed and became a base for the decision about dividing the products into groups from the point of view of the frequency of production, and further proposition of the lay-out of the warehouse according to separate groups of the productions. The proposition of the warehouse was performed so that separate groups of the products were placed on strategically the most beneficial positions of the warehouse with regards to the decrease of the manipulation times of the cranes.

The lay-out of the warehouse area in dependence on the turnover rates for the products of Group A.

One of the possible form of the rules for the optimization of the operation of the warehouse and acceleration of dispatching is the determination of storing places in accordance with the turnover rates of the products. This proposal comes from data of the manufactured profiles in 2017 and the XYZ Analysis, which was carried out with the products of Group A. The products of this group were divided into three groups in dependence on the turnover rate and a position in the warehouse was consequently assigned. The products of Group Z with the highest turnover rate are placed as close as possible to the loading platform so that the orders consisted of these products can be dispatched as quickly as possible and so that loading times were shortened and process as a whole was optimized.

This proposal however has one difficulty. The enterprise manufactures a wide portfolio of products of all sorts of sizes. Neither the enterprise itself know what will be produced in the next month. This disadvantage however can be solved, for example, by implementation of more detailed visualization of the warehouse, where it will be possible to effectively propose a lay-out of the profiles in accordance with particular sizes with help of a sufficient software.

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References

[1] ArcelorMittal, www.arcelormittal.cz: Production plants of the enterprise, [Online], Available: http://ostrava.arcelormittal.com/o-spolecnosti/zavody.aspx [12 Apr 2018].
[2] ArcelorMittal, www.arcelormittal.cz: Enterprise profile, [Online], Available: http://ostrava.arcelormittal.com/o-spolecnosti/o-spolecnosti.aspx [24 Apr 2018].
[3] ArcelorMittal, www.arcelormittal.cz: Enterprise history, [Online], Available: http://ostrava.arcelormittal.com/o-spolecnosti/historie-spolecnosti.aspx [11 May 2018].
[4] MACUROVÁ, P., KLABUSAYOVÁ, N., TVRDOŇ, L.: *Logistics,* Ostrava, VŠB-TU Ostrava, 2014.

[5] SIXTA, J., MAČÁT, V.: *Logistics: theory and practice,* Brno, CP Books, Business books (CP Books), 2005.
[6] SATISH, K. K., PURVA, K.: *Basics of distribution management: a logistical approach*, Eastern economy ed. New Delhi, Prentice-Hall of India, 2003.
[7] LAMBERT, D. M., STOCK, J. R., ELLRAM L. M.: *Logistika: příkladové studie, řízení zásob, přeprava a skladování, balení zboží*, 2nd ed., Brno, CP Books, Business books (CP Books), 2005. (Original in Czech)
[8] OWENS, G., MANN, R.: *Materials Handling System Design*, The Distribution Handbook, ed. James F. Robeson; William C. Copacino (New York: Free Press, 1994). Převzato z LAMBERT, Douglas M.; STOCK, James R.; ELLRAM, Lisa M. Logistika. 2nd ed., Brno: CP Books, 2005.
[9] KOCH, R.: Pravidlo 80/20: umění dosáhnout co nejlepších výsledků s co nejmenším úsilím. 3. aktualiz. vyd. Praha, Management Press, 2015. (Original in Czech)

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COULD ACCELERATORS AND EQUITY CROWDFUNDING COMBINE TO IMPROVE ACCESS TO FINANCE FOR EARLY STAGE STARTUPS?

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Keywords: financing, venture capital, startups, entrepreneurship, technological companies
Abstract: The main goal of this article is to explore possible concepts of combining the acceleration program and equity crowdfunding. Both are venture capital instruments that finance businesses at the very early stages of their life cycle. The equity crowdfunding and the acceleration programs can be used to raise capital for business creation, first production and product distribution. In addition to the capital, they provide start-ups with additional benefits such as mentoring, networking, feedback from the crowd and a pool of experts. The authors of the paper believe that a combination of these two tools can even increase their positive impacts. In this article the authors of the paper search the first providers combining accelerator programs and equity crowdfunding. Afterwards based on those examples and their common features there are classified different concepts of how to combine acceleration programs and equity crowdfunding. Moreover, short characteristics are added for each concept and brief description of the process of each identified concept.

1 Introduction

Two venture capital instruments are discussed within this paper, namely acceleration programs and equity crowdfunding. These are two innovative, fast-growing tools that focus on financing innovative projects. The authors of the paper explore the possibilities for their interconnection in order to maximize their contribution to the financing of the technological startups as access to capital is often a serious barrier for their development. The authors also believe there are several similarities between these tools and their interconnection can increase their current contribution in this field.

De Buysere et al. [1] define crowdfunding as "the collective effort of multiple individuals who are joining and collecting their resources to support efforts initiated by other people or organizations. This is mostly done through or with the help of the Internet. Individual projects and businesses are funded by smaller contributions from a large number of individuals, allowing innovators and entrepreneurs to use their social networks to raise financial resources."

Marom and Sade [2] define crowdfunding similarly. They describe it as an innovative funding mechanism that uses the Internet and social networks to raise funds from a large number of investors, usually a smaller sum from each investor than the amounts commonly invested by venture capital investors. Crowdfunding can be used to obtain seed capital for company creation, initial production and distribution of the product, but also for other purposes as the realization of an art project, medical treatment and many other forms of projects and initiatives.

Bradford [3] understands equity based crowdfunding as a type of crowdfunding that offers investors a share in the business they help to finance. Equity based crowdfunding is a form of funding through which the enterprise can obtain financial resources not only from large professional investors but also from a large number of smaller investors via the Internet, while the option of getting only few but bigger investors remains. Investors, in exchange for the provided capital, acquire a stake in the company's ownership.

The second risk capital instrument examined within this paper are accelerators. Miller and Bound [4] define the basic features of accelerators as follows:

- Time-limited support in the form of intensive mentoring and group meetings in the accelerator.
- A freely accessible and highly competitive selection process.
- Focus on small teams, not individuals.
- Provision of pre-seed capital, usually in exchange for equity.
- Accepting companies in a batch or cohort into the program.

During the period of the acceleration program, businesses are dedicated to prototype research and development, testing, designing upcoming product versions, technology issues related to production, logistics etc. When businesses develop a product that fits the needs of the market and can be implemented with a sustainable

business model, businesses go into the next phase and focus on planning the growth of the company. They work on a marketing strategy, deciding which markets they should enter, selecting the channels they should use, budgeting. The plans for the production and logistics of their product during the period of fast growth are also developed within such programs at this stage.

Baird, Bowles, and Lall [5] list the four main functions of the acceleration programs:

• To support business development of the startups (eg, by mentoring).

• To provide infrastructure (eg. office space, joint back office services).

• To establish new contacts (with customers, investors, mentors).

• To provide financial resources.

2 Methodology

For the purpose of identifying and classifying the possible concepts of combining acceleration programs and equity crowdfunding is crucial to know today's providers who, in any way provide their services in a form that combines these two venture capital instruments. Knowing them will also be helpful to characterize these different possibilities of combining accelerator programs and equity crowdfunding. The search of such providers was by:

1. Internet research,
2. Searching in specialized databases,
3. Consultations with experts.

The search was done mostly by an internet research. The authors of the paper searched for the providers primarily using the search engine and the search was based on selected keywords associated with terms such as accelerator, crowdfunding, equity based crowdfunding, business, startups, and so on. Providers of such services communicate their offer most often through their websites, so this form of search was considered to be the most appropriate. This research was complemented by search in specialized databases such as f6s, angelist, gust, and crunchbase, where both technology companies and service providers such as accelerators can be searched for. In addition, authors of the paper also approached the experts from the industry to get tips for such providers and published articles dealing with this topic were reviewed.

The identified providers were segmented into several groups based on recurring features and the characteristic features and process were described per each group.

3 Result and discussion

The first identified provider was the Crowdcube crowdfunding accelerator. In 2012, the crowdfunding platform Crowdcube begun to provide a training course for those who are interested in their services to help them to increase their chances of being able to raise capital through their platform. What presents also increase of sales for the platform which are based on the amount of transactions made through their platform? It was a training that lasted three weeks, calling it the accelerator, but its intensity was distinct from the usual accelerators. Net time lasted only 10 hours [6].

After two years, a similar service was launched by CoPhilly's crowdfunding accelerator. In this case authors of the paper already agree with calling this service an accelerator as the duration has been increased to ten weeks and participants attended the accelerator at least three times each week to meet mentors, investors, attend lectures, and so on. An interesting fact is that university students have been involved in this program to help participating businesses and to gain new insights and skills themselves. Unlike conventional accelerators, preparing for a crowdfunding campaign was the only goal of this program [7].

In 2015 Zoomaal [8] came up with a new form of combining crowdfunding and acceleration program. It was an acceleration program that used crowdfunding in its selection process. Applicants for a place in the acceleration program had to get a pre-agreed amount through the crowdfunding campaign. If they succeeded, the accelerator accepted them into their program, where they provided them with additional capital from their sources. Therefore, the candidates had to show through crowdfunding that there are people who are interested in their product. A similar example occurred afterwards only once, a year later, when The Valley Labs Accelerator used the same concept of using crowdfunding in the acceleration program selection process, but it is not active any more.

In 2016, several accelerators including Collider [9], Startup Wise Guys [10], Ignite and Webstart Bristol [11], announced a new way to use equity based crowdfunding by accelerators. These accelerators used equity based crowdfunding to raise financial resources for their own activities. They did this through an equity based crowdfunding campaign to get the resources they used to cover their own expenses of running an accelerator but also to finance the companies they chose for their program. Investors who supported the accelerators obtained small, predefined share in all the businesses selected for the acceleration program.

In the same year the Crowdfunding accelerator came up with a new innovation in the field of combining acceleration programs and equity crowdfunding. Its purpose is to prepare crowdfunders for their campaign through training and consultations similarly to Crowdcube and CoPhilly. The difference is that the whole program is online. Therefore, participants do not have to travel anywhere and all meetings can be accessed via conference calls and webinars [12].

In 2017 was established for the first time the fourth identified way of interaction between equity based crowdfunding and the acceleration program in the form of collaboration between their providers. The platform Crowdcube created three partnerships with three accelerators in 2017 and 2018. Participants in these

classical accelerators, focusing on areas such as product design and acquisition, have the opportunity to raise capital through equity based crowdfunding during the program. Crowdcube experts are available to help them to prepare their Crowdcube campaign. In 2018, Crowdcube is also launching co-operation with Virgin Startups Crowdboost, the program of the famous billionaire Richard Branson, which is as some of the other programs mentioned above designed to help participants to raise capital through equity based crowdfunding [13].

Overall, 18 service providers that combined at least some elements of the acceleration program with equity based crowdfunding or vice versa were identified within this paper. As could be seen, some examples were very similar. Therefore, the authors of the paper grouped the individual cases into four different groups, categories where providers in each group are connected by some similarities in the form of realizing the combination of crowdfunding and the acceleration program. All the providers and the categories of four identified concepts can be seen in Table 1.

Table 1 Overview of service providers combining elements of the acceleration program and crowdfunding by category

	Company	Country	Year
C1	Crowdcube crowdfunding accelerator	UK	2012
	CoPhilly	USA	2014
	Cleantech crowdfunding accelerator	UK	2015
	Crowdfunding accelerator	UK	2016
	CF Academy	UK	2016
	Blue fund rewards	USA	2017
	Global giving accelerator	Singapúr	2017
	Chuffed	UK	2018
C2	Zoomaal	Bejrút	2015
	The Valley labs accelerator	Izrael	2016
C3	Collider	UK	2016
	Startup Wise Guys	Estónsko	2016
	Ignite	UK	2016
	Webstart Bristol	UK	2016
C4	TAN & Crowdcube partnerstvo	UK	2017
	LMarks & Crowdcube partnerstvo	UK	2017
	L39 & Crowdcube partnerstvo	UK	2018
	Virgin Startups & Crowdcube - Crowdboost	UK	2018

Based on these examples, specifically the main features of the interconnection of the acceleration program and the equity crowdfunding that have been observed in these examples, the authors of the paper suggest a classification of four basic concepts how accelerators and equity crowdfunding could be combined.

1. Hyper-accelerator specialized on equity crowdfunding.

a. Hyper-accelerator (owned by equity crowdfunding platform provider) linked with the campaign.
b. Independent hyperaccelerator not linked to the campaign.

2. Equity crowdfunding as a validation within the acceleration program selection process.

3. Equity crowdfunding as a source of funding for the acceleration program.

a. With the campaign done on the external provider's site.
b. With the campaign implemented on own website.

4. Equity crowdfunding integrated into the acceleration program.

Hyper-accelerator specialized on equity crowdfunding.

Suitable also for reward crowdfunding: Yes

Suggested Monetization: Combination of fixed fee and commission fee. Commission as a percentage of the collected amount motivates the program operator to provide the best possible support for its participants. At the same time a fixed fee should be paid at the start of the program in case a participant decides during the preparation that the campaign will not be executed or for the case that the participant does not cooperate with the organizer properly.

The process:

1. The startups send an application and the accelerator selects participants.
2. The selected startups participate in the acceleration program. Like in typical accelerators, they meet with mentors, other participants of the program, attend lectures, workshops, etc. But unlike conventional accelerators, this type is focused on just one topic (target) - to prepare a project for a crowdfunding campaign. The program can be very intense (7-10 days) or stretched within a few months (similar to conventional accelerator programs).
3. In the case of a hyperaccelerator linked to the campaign, the campaign starts after the program.

Equity crowdfunding as validation within the acceleration program selection process.

Suitable also for reward crowdfunding: Yes

Suggested Monetization: A commission fee paid to the crowdfunding platform as a percentage of the amount raised. A small equity in the start-up transferred to the accelerator in exchange for additional investment and participation in the program.

The process:

1. The startups submit applications and the accelerator prepares a shortlist of pre-selected projects, which continue within the selection process.
2. These projects run a crowdfunding campaign.
3. Projects that have successfully completed the campaign are accepted for the acceleration program.
4. Program participants will receive additional capital from the accelerator.
5. Accepted projects participate in the acceleration program.

Equity crowdfunding as a source of funding for the acceleration program.

Suitable also for reward crowdfunding: No

Suggested Monetization: A commission fee paid to the crowdfunding platform as a percentage of the amount raised.

The process:

1. Accelerator raises funds for its upcoming program through a crowdfunding campaign before the program. Investors get a small stake in all companies that are accepted for this upcoming program.
2. The accelerator divides the acquired capital. One part is devoted to an accepted business as an investment from an accelerator. The second part covers the spendings of the accelerator related to organizing and running the program.
3. Accelerator selects participants, startups which subsequently take place in the acceleration program of the accelerator.

Equity crowdfunding integrated into the acceleration program.

Suitable also for reward crowdfunding: Partly yes, however, it is suggested to use it mainly in the synthesis with equity crowdfunding as it is more suitable for a wider range of companies.

Suggested Monetization: Business share transferred to the accelerator in exchange for investment, participation in the program, and mediation of the crowdfunding campaign through a dedicated equity crowdfunding platform.

The process:

1. The startups submit applications and the accelerator selects program participants.
2. The selected startups participate in the acceleration program. In the period of few months they meet mentors, other participants, attend lectures, workshops, etc. (as usually in a typical acceleration program).
3. In addition, they use this support to prepare an equity crowdfunding campaign.
4. Startups at the end of the structured acceleration program present their projects to investors at a demo day.
5. Startups run their campaigns on the crowdfunding platform to raise capital to fund the next life cycle (ideally right after the demo when businesses also normally in a common acceleration program start to communicate with investors who have got interested in their projects at the demo day).

4 Conclusions

It is important to address the issue of financing technological companies and the development of their new products in the initial phase of their life cycle. It is usually for them difficult to find sources of capital and funding in classical ways. This is why the authors of the paper have explored in this article the possibility of combining two venture capital instruments to increase their contribution in this area. Specifically, these two instruments were acceleration programs and equity based crowdfunding. Four concepts of how equity crowdfunding and accelerator programs could be combined are classified and briefly characterized within the paper. The authors of the paper anticipate that their application to practice can bring even bigger positive impact on the financing of startups than these two instruments create separately. These examples have emerged in the countries with developed venture capital markets, most of them in the UK. However, the authors of the paper believe these concepts could be applied worldwide.

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References

[1] DE BUYSERE, C et al.: *A framework for European crowdfunding,* 1st ed., European Crowdfunding Network, 2012.

[2] GAFNI, H., MAROM, D., SADE, O.: Are the life and death of an early stage venture indeed in the power of the tongue? lessons from online crowdfunding pitches, *Strategic Entrepreneurship Journal*, 2018. doi:10.1002/sej.1293

[3] BRADFORD, C.S.: Crowdfunding and the Federal Securities Laws, *Columbia Business Law Review*, Vol. 2012, No. 1, pp. 150, 2012. Available at SSRN: https://ssrn.com/abstract=1916184

[4] MILLER, P., BOUND, K.: *The startup factories, The rise of accelerator programmes to support new technology ventures*, London, Nesta, 2011.

[5] BAIRD, R., BOWLES, L., LALL, S.: *Bridging the "Pioneer Gap": The Role of Accelerators in Launching High-Impact Enterprises*, [Online], Available: http://www.aspeninstitute.org/sites/default/files/content/docs/ande/Bridging%20the%20Pioneer%20Gap%20The%20Role%20of%20Accelerators%20in%20Launching%20High%20Impact%20Enterprises%20.pdf [02 June 2018], 2013.

[6] ALOIS, J.D..: *Crowdcube to co-host Crowdfunding Accelerator course to fast track entrepreneurs seeking investment*, [Online], Available: https://www.crowdfundinsider.com/2012/10/2639-crowdcube-to-co-host-crowdfunding-accelerator-course-to-fast-track-entrepreneurs-seeking-investment/ [02 June 2018], 2012.

[7] coPhilly,www.cophilly.com: CoPhilly Innovation Accelerator program, [Online], Available: http://cophilly.com/accelerator-program/ [02 June 2018], 2014.

[8] Zoomaal, www.zoomaal.com: Zoomaal Crowdfunding Accelerator program, [Online], Available: http://zoomaal.com/accelerator#partners [02 June 2018], 2014.

[9] Seedrs, www.seedrs.com: Collider 2016, [Online], Available: https://www.seedrs.com/collider3 [02 June 2018], 2016.

[10] OHR, T.: *Startup Wise Guys is Europe's first accelerator to sucessfully raise funding via equity crowdfunding*, [Online], Available: http://www.eu-startups.com/2016/12/startup-wise-guys-is-europes-first-accelerator-to-sucessfully-raise-funding-via-equity-crowdfunding/ [02 June 2018], 2016.

[11] WALLS-HESTER, L..: *Incubators and accelerators – an accessible route into tech equity investment*, [Online], Available: http://www.altfi.com/article/2260_incubators_and_accelerators_an_accessible_route_into_tech_equity_i nvestment, [02 June 2018], 2016.

[12] Focused for business, www.focusedforbusiness.com: Crowdfunding Accelerator: Making successful crowdfunding quicker and easier, [Online], Available: https://www.seedrs.com/collider3 [02 June 2018], 2016.

[13] DONNELY, S..: *Virgin StartUp launches equity crowdfunding accelerator*, [Online], Available: https://startups.co.uk/virgin-startup-launches-equity-crowdfunding-accelerator/ [02 June 2018], 2018.

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