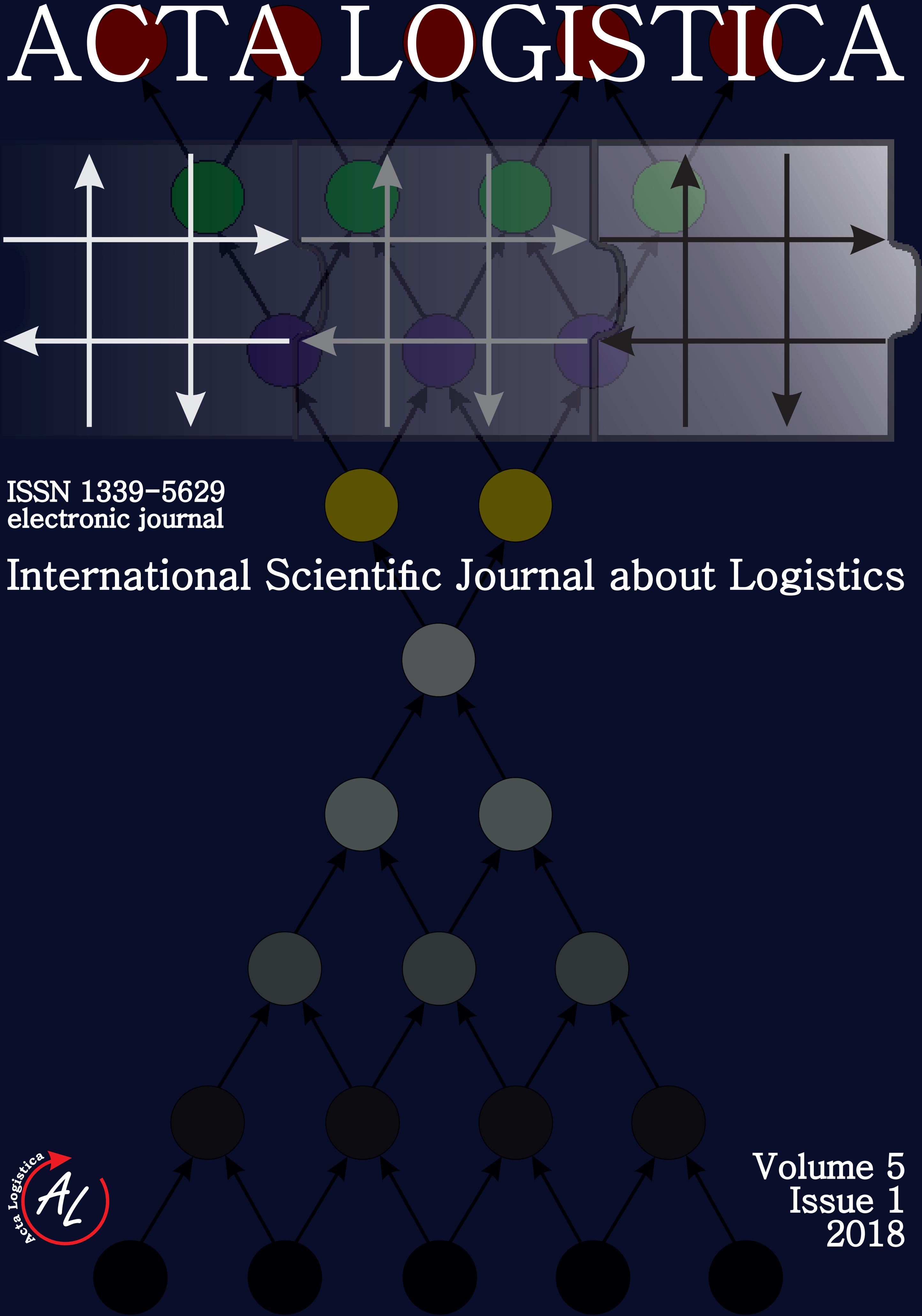
ACTA LOGISTICA



ISSN 1339-5629
electronic journal

International Scientific Journal about Logistics

Volume 5
Issue 1
2018

CONTENTS

(MARCH 2018)

Acta logistica - International Scientific Journal about Logistics
Volume: 5 2018 Issue: 1 Pages: 1-6 ISSN 1339-5629

doi:10.22306/al.v5i1.83
Received: 16 Mar. 2018
Accepted: 26 Mar. 2018

A LOGISTIC APPROACH TO ESTABLISHING BALANCED SCORECARD OF RUSSIAN OIL-PRODUCING SERVICE ORGANIZATIONS

Olga Mihailovna Perminova
Kalashnikov Izhevsk State Technical University, 7 Studencheskaya St., Izhevsk, 426069, Udmurt republic, Russian Federation, olgaa@istu.ru (corresponding author)
Galina Anatolievna Lobanova
Kalashnikov Izhevsk State Technical University, 7 Studencheskaya St., Izhevsk, 426069, Udmurt republic, Russian Federation, gallobanova@mail.ru

Keywords: balanced scorecard, key performance indicators, logistical principles, oil-producing service organizations, strategy
Abstract: The aim of the study is to develop methodological recommendations for balanced scorecard practical implementation into activities of Russian oil-producing service organizations in present-day conditions on the basis of logistical principles. The perspectives for balanced scorecard development based on logistics principles and strategic management peculiarities of the oil-producing service organizations are proposed in the article. The indicators and their characteristic values, allowing to coordinate operational and strategic management and to obtain synergistic effect are suggested. As a result of the study, the authorial methodology of balanced scorecard using for oil-producing service organizations was developed in order to improve effective cooperation between service organizations of vertically integrated oil companies.

1 Introduction

Currently in a fast-changing business environment there is a growing need for logistic management approach implementation and revision of existing methods for the estimation of activities. The application of modern stream-oriented processes management methods is a key source of competitive advantage. For a long time, the development and performance of a company had been measured only on the basis of economic and financial indicators. Besides that, many companies cannot analyse the ways of achieving company's strategy. These and many other factors, to our opinion, require changes. The balanced scorecard (BSC), developed on the basis of logistic principles, can provide the manager with the most complete view of the enterprise activity on the market.

2 The experience of BSC implementation

The experience of BSC implementation by Russian companies shows, that in most companies this implementation takes place on the top-management level. That is the implementation in order to motivate employees, or implementation on certain areas. The restricted BSC implementation by domestic enterprises is presented in Table 1 [1].

Table 1 Features of BSC implementation by Russian companies

Implementation restrictions	
1. Activity features in Russian companies	
Factor	Meaning
4 perspectives of BSC	In BSC all indicators are divided into four perspectives (segmentation of market, intellectual capital, return on capital etc.). In Russian practice indicators of business income are mainly used, excluding other perspectives.
Marketing policy	Many managers do not monitor the market, do not create customer database, do not conduct monthly surveys for the increase of the short-term profit. Therefore, marketing policy is restricted by the "introduction" products to the market.
Motivation system	There is no particular motivation system in the Russian experience. The system is usually based not on workforce productivity, but on gross income. There are problems – the lack of responsibility zone, incomplete regulations and job descriptions.
Implementation stage of BSC	The BSC implementation involves step-by-step designing "from the bottom to top", which gives the opportunity to train people and progressively align implementation at all management levels. In Russian practice, there is "from top to the bottom" variant, which leads to internal processes in coordination. The BSC implementation must begin with evaluation of company's resources and its market position. In Russian practice, the first stage is holding of the seminars with foreign experience analysis for companies' top-

	managers, without considering strengths and weaknesses and market position. Besides, often there is a lack of clear strategy, management and all resources are directed to addressing short-term objectives.
2. Features of BSC implementation by domestic enterprises	
Market and company	Implementation of the system should be in price-quality relationship because it is not always profitably to use the standard BSC variant in the fast-changing domestic market. It should be noted that initially BSC was designed for western companies, operating in saturated segments of the market, where it is possible to evaluate competitive advantages of all companies.
BSC as a means of preventing the bankruptcy	In Russian practice, BSC implementation is possible by companies facing crisis situation. BSC implementation will reveal all problem areas. At the same time, it is necessary to remember that BSC implementation – is a resource-consuming process. There is an increase of all costs if this tool is inappropriately used.
Mind-set	Russian companies can face insufficient levels of company culture and intellectual capital when implementing western technologies. (For example, lack of experience in dealing with problems of mid-level and top-level managers when implementing BSC).
Risks	In Russian practice, it is a quite common phenomenon to execute a job at any cost, which completely denies working upon risks (external and internal).As a result, resource intensity and costs for elimination of errors after implementation of projects are increased.

Such tendency also emerges when BSC is implementing by oil-producing service organization, since certain mechanisms and directions of formation BSC are not identified, that leads to ineffective managerial decision-making.

Balanced scorecard includes the key performance indicator system (KPI). That is a group of financial and non-financial indicators affecting on quantity or quality change of the results in relation to the strategic aim.

Currently the majority of vertically-integrated oil-companies (VIOC) in Russia use the following performance indicators (Table 2) [2].

Table 2Themainindicatorsofvertically-integratedoil-companies performance

№	Main indicators of performance	PAO ANK «Bashneft»	PAO NK «Rosneft»	PAO «Lukojl»	PAO «Gazprom-neft»	PAO «Tatneft»	PAO «TNK-VR»	PAO «Surgutneftegaz»
1	Oil extraction, million tons	+	+	+	+	+	+	+
2	Estimated reserves, million barrels	+	+	+	+	+	+	+
3	Prospective reserves, million barrels			+	+	+		+
4	Possible reserves, million barrels			+	+	+		+
5	Headway in production drilling, thousand meters	+	+	+		+	+	
6	Headway in exploration drilling, thousand meters	+	+	+		+	+	
7	New development well	+	+	+				
8	Number of wells in use	+	+	+	+	+	+	+
9	Number of running well	+	+	+				
10	Number of inactive well	+	+	+				
11	Average daily production rate, tons per day		+	+	+	+	+	+
12	Average watercut, %		+	+	+			
13	Gas output, billion cubic meters					+		
14	Share of green-fields in total carbon production, %				+	+	+	+
15	Number of oil fields, pcs	+	+	+	+	+	+	+
16	Average well depth, thousand meters			+	+	+	+	

Table 2 presents a range of indicators across the entire structure of existing Russian VIOC, which allows to control work effectively. The main indicators are: oil extraction, headway in production drilling, number of wells in use, average daily production rate etc.

The usage of logistic principles (rationality, consistency, hierarchy, integration) allows to improve the methodology of indicators selection.

The main indicators of vertically-integrated oil-companies performance by projections are offered in the result of studied material [2-6].

The "Finance" projection includes different indicators: 1) financial sustainability (absolute and current liquidity ratio, financial leverage); 2) growth in profits (return on capital employed, return on sales and return on assets).

The "Industry specialization" projection includes indicators: downtimes of service organization gang for different reasons, a number of high rate well, a number of performed plan targets, production loss during emergency work, well-timed equipment provision.

The "Business processes" projection includes: quality control system, development of applied researches, a constant process improvement and an existence of the best supplier.

The "Training and growth" projection includes: reduction of labour turnover, personnel development, better employee motivation.

It is necessary to consider the aim of managing stream-oriented processes – providing the output of adjustable indicators, corresponding to logistics regulations [4]. The "Business processes" projection transforms into the "Stakeholders" projection and involves following directions: customer, service organizations and suppliers. Besides, the "Business processes" projection changes to the "Success factors" projection, which reflects both the results of the work with the environment and usage of company's internal resources.

The algorithm of producing BSC indicators with considering logistical principles consists of the following stages: 1) overview of company's strategic objectives on the basis of logistic approach; 2) monitoring an interconnection of company's strategy and its structural divisions' aims; 3) key figure block development for assessment of strategy implementation with considering logistical principles; 4) calculating KPI in all directions of the company 5) BSC calculation for the selected KPI indicators from projections; 6) creating strategic chart of the company with considering indicator's influence on strategic objectives; 7) BSC implementation and monitoring of existing indicators' deviations, elaboration of negative trend reduction measures.

OOO "Mekhanik" organization was chosen for the BSC test. This organization is involved in uninterrupted oil production for PAO "Udmurtneft". Company's performance analysis showed that the following factors have a negative effect on the profit: a) downtimes (51% - downtimes of major work over gangs), b) equipment (31% - non-provision of standard set of equipment), c) debts (9% - debts which are not settled for various reasons), c) delayed delivery (9% - long deliveries from the factories).

With consideration of influence factors and logistical principles there has been developed the BSC system, regulation values (under the terms of the legislation), recommended values (by market trends) and indicative values (by industry specification) for OOO "Mekhanik" service organization (Table 3) [1-3].

Table 3 The balanced scorecard for OOO "Mekhanik" service organization

<table>
<tr><th>Indicators</th><th>2014г.</th><th>2015г.</th><th>2016г.</th><th>Note</th></tr>
<tr><td colspan="5">Projection:Finance</td></tr>
<tr><td rowspan="2">1.Absolute liquidity ratio</td><td>0,002</td><td>0,002</td><td>0,67</td><td rowspan="2">Monitoring dynamic patterns during the reporting period</td></tr>
<tr><td colspan="3">Recommended values
0,2 - 0,7</td></tr>
<tr><td rowspan="2">2.Current liquidity ratio</td><td>1,23</td><td>1,34</td><td>1,28</td><td rowspan="2">Monitoring dynamic patterns during the reporting period</td></tr>
<tr><td colspan="3">Recommended value - 2
(minimum value 1,5)</td></tr>
<tr><td rowspan="2">3. Financial leverage</td><td>1,15</td><td>0,94</td><td>0,98</td><td rowspan="2">Monitoring dynamic patterns during the reporting period</td></tr>
<tr><td colspan="3">Recommended values
0,4 - 0,8</td></tr>
<tr><td rowspan="2">4. Return on Capital Employed (ROCE), %</td><td>82,80</td><td>115,50</td><td>14,11</td><td rowspan="2">Monitoring dynamic patterns during the reporting period</td></tr>
<tr><td colspan="3">Recommended value, %
in foreign practice - 10- 12,
in Russian practice - 20.</td></tr>
<tr><td rowspan="2">5.Return on sales (ROS), %</td><td>48</td><td>57</td><td>49</td><td rowspan="2">Regulation values are found in appendix №4 to Russian Federal Tax Service order on 30.05.2007 № ММ-3-06/333@.</td></tr>
<tr><td colspan="3">Regulation value, %
23,8</td></tr>
</table>

6. Return on assets (ROA), %		38,50	45,50	7,13	Regulation values are found in appendix №4 to Russian Federal Tax Service order on 30.05.2007 № ММ-3-06/333@.
		Regulation value, % 8,1			
Projection: Stakeholders					
Customers - oil and gas production unit					
7. Production loss during emergency work, tons per year	Oil production loss during emergency work for the annual report	278	289	262,8	Monitoring dynamic patterns during the reporting period by indicative method. Losses are shown in 3 zones
		Indicative values, tons per year			
		120-300	300-420	420-540	
Service organizations					
Major workover (WO)					
8. Downtimes of major workover gang waiting for dismantlement or assembling	Actual number of major workover gangs' downtimes for the annual report	765	1886	1620	It is necessary to control downtimes and monitor its reasons. The protocol for downtimes longer than 2 hours must be implemented. The indicator shows increasing or decreasing of gang downtimes through the fault of service organization. The main aim is to prevent the transition of indicators in the red zone
		Indicative values, hours per year*			
		600-1500	1500-2000	2000-2500	
Technological transport					
9.Standard set of equipment provision	Number of equipment/number of equipment according to the business plan	0,96	0,97	0,95	In this line the most important daily-needed equipment is recorded. There is a high chance of work disruption if this equipment is not present
		Recommended values 0,9-1			
Suppliers					
10. Delay in delivery	The amount of delayed deliveries / the amount of all deliveries	0,2	0,23	0,1	The indicator is needed to control a work with customers. The results of this work are directly reflected in the debts receivable
		Recommended value is not above 0,3			
11. The effectiveness of supplier's performance	Expert survey	0,40	0,42	0,48	The advantage of expert survey is in engaging respondents from all levels of organization
		Indicative values*			
		0-0,3	0,3-0,75	0,75-1	
Projection: Success factors					
12.Agility in responding to orders, tons per year	Oil production loss for annual report	620	754	895	The indicator is used for monitoring of reasons for the transition to the critical zone. For the correct report it is necessary to keep a daily and monthly record of emergency works that is to make summary table on all types of work, deadlines and the reasons for deviations
		Indicative values, tons per year*			
		800-1300	1300-1700	1700-2500	
13.Orders completion rate		0,25	0,16	0,2	The report with debt indication is to be implemented, there should be

Acta logistica - International Scientific Journal about Logistics
Volume: 5 2018 Issue: 1 Pages: 1-6 ISSN 1339-5629

	The amount of debt orders/ the total amount of orders	Indicative values*			noted the reasons of inability to fulfill an order
		0-0,4	0,4-0,6	0,6-1,0	
14.Quality control system	The amount of performed works/the total amount of works (mechanical assembly and disassembly)	1,06	1,02	1,08	The indicator allows to estimate effectiveness of using resources (according to the business plan)
		Recommended values 0,8-1			
15.Development of applied scientific researches	The amount of carried out researches/the total amount of researches	0,5	1	0,25	Coefficient demonstrates the amount of practically applied researches
		Recommended values – 0,7- 1			
Projection: Training and growth					
17.Personnel development	The amount of people completed advanced training courses/the total amount of employees	0,78	0,78	0,84	The coefficient reflects the effectiveness of human resources department
		Indicative values*			
		0-0,4	0,4-0,8	0,8-1	
18. Better motivation of employees	Expert survey	0,71	0,73	0,70	Respondents from all levels of organization should be engaged
		Indicative values*			
		0-0,3	0,3-0,75	0,75-1	
*Green zone – recommended values; Yellow zone – acceptable values; Red zone – critical values.					

In general, the proposed BSC system has specific features, which are not inherent in individual projections. The synergetic effect is possible to be achieved by BSC implementation. This system also allows assessing company's potential in all directions, reducing time between the development and implementation of the strategy, coordinating operative and strategic management, monitoring implementation of the strategy in different ways, motivating employees to follow strategic aims, creating a feedback for making the decisions in the shortest time and applying tools taking into account industry specificity.

3 Conclusion

The result of this study is the developed balanced scorecard system, which reflects the specificity of oil industry and represents a flexible mechanism of management. In the addition to finding relationship between financial and non-financial parameters, this study identified possible ways of achieving interaction with the stakeholders, building partnership with the customers, decreasing transport costs and optimizing data base for making immediate and balanced decisions.

References

[1] GERASIMOV, E.U., RUSOV, A.N.: *Balanced scorecards as a strategy implementation tool*, [Online], Available: http://www.cfin.ru/management/controlling/bsc/bsc%26srategy.shtml [27. Oct 2017].

[2] VARAKINA, V.V.: *Common system of performance indicators in vertically-integrated companies*, p. 23, 2007.

[3] KAPLAN, R.S., NORTON, D.P.: *Balanced system of indicators, From the strategy to the actions*, M: ZAO "Olymp-Business", p. 320, 2008.

[4] DRUCKER, P.F.: *The preface of management*, M: Williams, p. 400, 2007.

[5] POLECKAYA, K.O., MANGARAKOVA, N.A.: *The problems and application prospects of KPI system in Russian practice*, Siberian Federal University, p. 4, 2016.

[6] TASMUHANOVA, A.E, KULEMBETOVA, A.R.: Strategic management of oil and gas companies with the help of BSC, Kazan, *Izdatel'stvo molodoi uchonyi,* No. 22, pp. 489-494, 2015.

[7] REVENKO, N.F., LOBANOVA, G.A, MARATANOVA, O.E.: *Logistics of production*

processes: a tutorial, Izhevsk, Izdatel'stvo Izhevskogo gosudarstvennogo universiteta imeni M.T. Kalashnikova, p. 280, 2015.

Review process
Single-blind peer review process.

doi:10.22306/al.v5i1.84 *Received: 19 Mar. 2018*
Accepted: 26 Mar. 2018

TRENDS IN AUTOMATIC LOGISTIC SYSTEMS AND LOGISTIC MARKET IN SLOVAKIA

Augustín Stareček
Institute of Industrial Engineering and Management, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava, Jána Bottu 25, 917 24 Trnava, Slovak republic, augustin.starecek@stuba.sk
Milan Bachár
Institute of Industrial Engineering and Management, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava, Jána Bottu 25, 917 24 Trnava, Slovak republic, milan.bachar@stuba.sk
Natália Horňáková
Institute of Industrial Engineering and Management, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava, Jána Bottu 25, 917 24 Trnava, Slovak republic, natalia.hornakova@stuba.sk (corresponding author)
Dagmar Cagáňová
Institute of Industrial Engineering and Management, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava, Jána Bottu 25, 917 24 Trnava, Slovak republic, dagmar.caganova@stuba.sk
Helena Makyšová
Institute of Industrial Engineering and Management, Faculty of Materials Science and Technology in Trnava, Slovak University of Technology in Bratislava, Jána Bottu 25, 917 24 Trnava, Slovak republic, helena.makysova@stuba.sk

Keywords: logistics, automatic systems, workforce, logistics market
Abstract: The paper focuses on innovation in the field of automated logistics systems oriented on increasing the efficiency, safety and performance of industrial enterprises in Slovakia. Majority of new trends in logistics are based on the Industry 4.0 concept, which is focused on increasing the competitiveness of industrial enterprises. The development of the industry in Slovak republic resulted to the increased demand for warehouse space. Dynamic development of the industrial sphere in Slovakia also leads to the increased demand for qualified labour. The authors of the paper analysed new trends in automated logistics systems such as autonomous vehicles, AGV systems and hybrid modules for AHV vehicle. Mentioned facts are also evident by the analysis of logistics warehousing development and the need for the logistics workforce in Slovak republic.

1 Introduction

Logistics belongs to the basic every day and most important activities of each industrial enterprise. The main role of logistics is to move material or different products from point A to point B with the aim to make relocation the most efficient [1]. If enterprises want the individual relocation activities to be as effective as possible, the enterprises must ensure that selected activities will have the shortest possible time, right quality and, last but not least, the lowest cost [2]. The effort to implement advanced, stockless production systems, such as Just in Time, place increased demands on logistics. Based on the mentioned reasons, the importance of shortening the time of shipment, keeping the schedule of loading and unloading is increasing. It means higher demands on the volume of goods transport between Slovakia and abroad [3].

The warehouse logistics is characterized by the fact that its implementation is connected to considerable financial resources of the enterprise. At present, it is necessary to innovate the production process and one of the possibilities of the innovation is the concept Industry 4.0. This concept Industry 4.0 can be considered as an instrument of competitiveness. The biggest issue in the maintaining of the production process is the skilled labour. According the mentioned reasons, it is necessary to address the implementation of innovative methods into the business's practice with the regard to the personnel assurance of the production process [4].

2 Analysis of the current state of labour force and logistic market in Slovakia

Due to major demographic changes, longer average life and lower birth rates, the European labour force will be with higher age average in the next years. Older labour force presents up to 35 % of the working-age population in many European countries. In the next decade, the European Union will increase the share of older labour force in industry by up to 15 % [5]. Industry in Slovakia constantly develops with constant demand for a qualified labour force. In the next three years, the Slovak industry will need more than 45,000 employees [6].

The Slovak secondary schools and universities provide a number of graduates, as much as labour market needs, but the structure of graduates does not correspond to the requirements of the enterprises. In the automotive industry, there is currently lack of 14,000 employees with the

Acta logistica - International Scientific Journal about Logistics
Volume: 5 2018 Issue: 1 Pages: 7-14 ISSN 1339-5629

required qualification. That is the reason why the automation and the support for intelligent/smart technologies in enterprises in Slovakia is more than necessary to keep enterprises competitive [6].

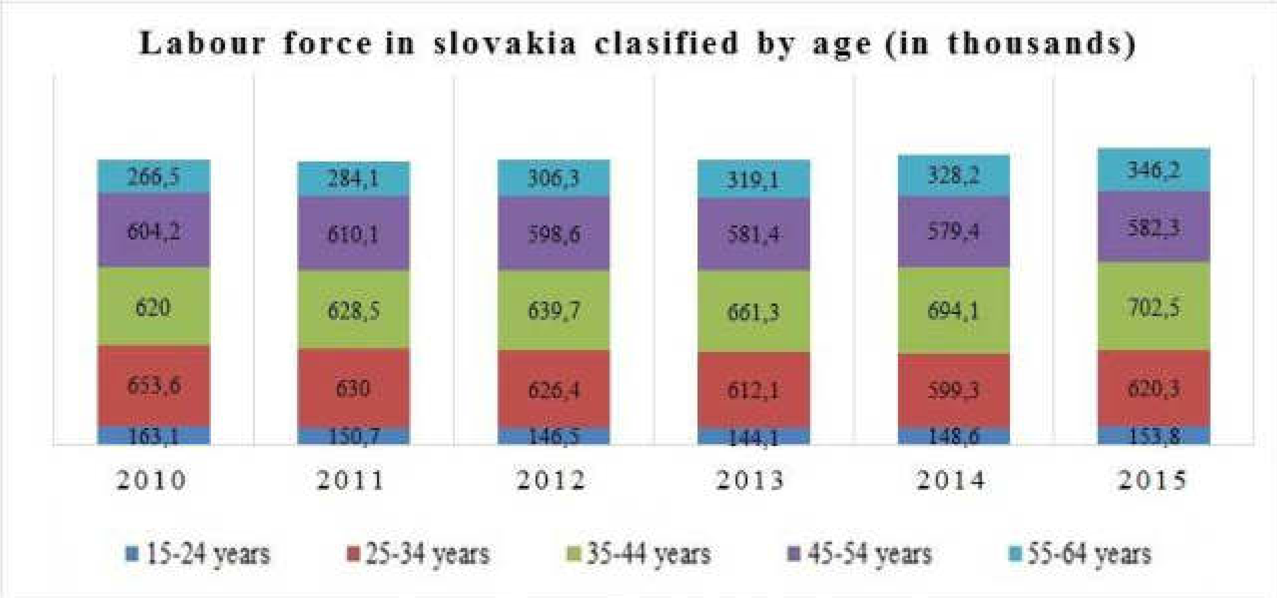


Figure 1 Labour force in Slovakia classified by age [7]

Figure 1 shows an increase in the number of men and women employed in Slovakia. To compare the year 2010 and 2015, in 2015 more than 79,000 women and men aged 55 to 64 were employed. The group of employees (aged 55 to 64) will be in retirement age over the next ten years. Within the European Union, as a result of the aging of the population, 15 % of the labour force will be in the age of 55 to 64. It will be up to 21 % in Slovakia. According the above mentioned, the employers should already think about the creating the right conditions for the work of an aging population [7]. The implementation of concept Industry 4.0 into industrial practice will not reduce the need for skilled labour force. Enterprises also have to start to analyse the age structure of their employees. The awareness of the Slovak industrial enterprises about active aging of the population is low and is often misinterpreted [8].

2.1 The analysis of the logistics market in Slovakia

According to CBRE (advisory group), the development of warehouse space in 2016 helped to provide another 147,685 m^2 of logistics and warehouse space in the total Slovak stock at 1.67 million m^2. In the last quarter of 2016, four warehouses with space of over 52,000 m^2 were built in the market, the largest one was built for Volkswagen Slovakia, a.s.. The Figure 2 shows the offer versus demand in the logistics market in Slovakia over the reference period [1].

From the Figure 2 results it is evident that there is an increased demand for warehouse spaces in Slovakia in recent years. The mentioned fact was caused primarily by the development of industry in the industrial areas of Western Slovakia. In addition to a compacted network of industrial enterprises, it can be stated that demand is also affected by a good road network connected to Austria, Hungary and the Czech republic. The drop in demand and offer of warehouse space was recorded mainly during the economic crisis (year 2009). Nowadays the demand for warehouse spaces is almost two times higher than the offer [10].

Automotive manufacturing company Volkswagen Slovakia, a.s. with developers Prologis and CTP are the largest warehouse companies in the Slovak market. The mentioned trio owns almost half of all Slovak warehouses, especially in the surrounding areas as Lozorno, Senica, Nitra, Trnava and Devínska Nová Ves, where it is currently the largest potential in development not only in the industrial area, but also in the field of warehouse logistics. Almost 400,000 m^2 of land contracted by the tenants, up to 2/3 of the area was formed by the new enterprises. The largest transaction according to CBRE was the rent of the land to Faurecia in Lozorno. The entry of Jaguar Land Rover to Nitra, with a planned start of production in 2018, caused that it is necessarily needed to build a large number of logistics warehouses for subcontractors of Jaguar Land Rover. In addition to the development of industrial areas around the Volkswagen Slovakia, a.s. in Bratislava and Jaguar in Nitra, the new industrial properties will be added to Dubnica nad Váhom, where the developer wants to build 70,000 m^2 of warehouse space. Across the Slovak Republic, the number of projects with a total volume of 130,000 m^2 is expected, of which most of them are already contracted. The estimates of warehouse occupancy from the years 2016 and 2017 are that the newly built warehouse areas will be fully occupied and the demand for new warehouse areas will be still high. The implementation of new trends in logistics made the warehouse management more efficient (examples: reduction of the extensive travel time or increased picking productivity) [9].

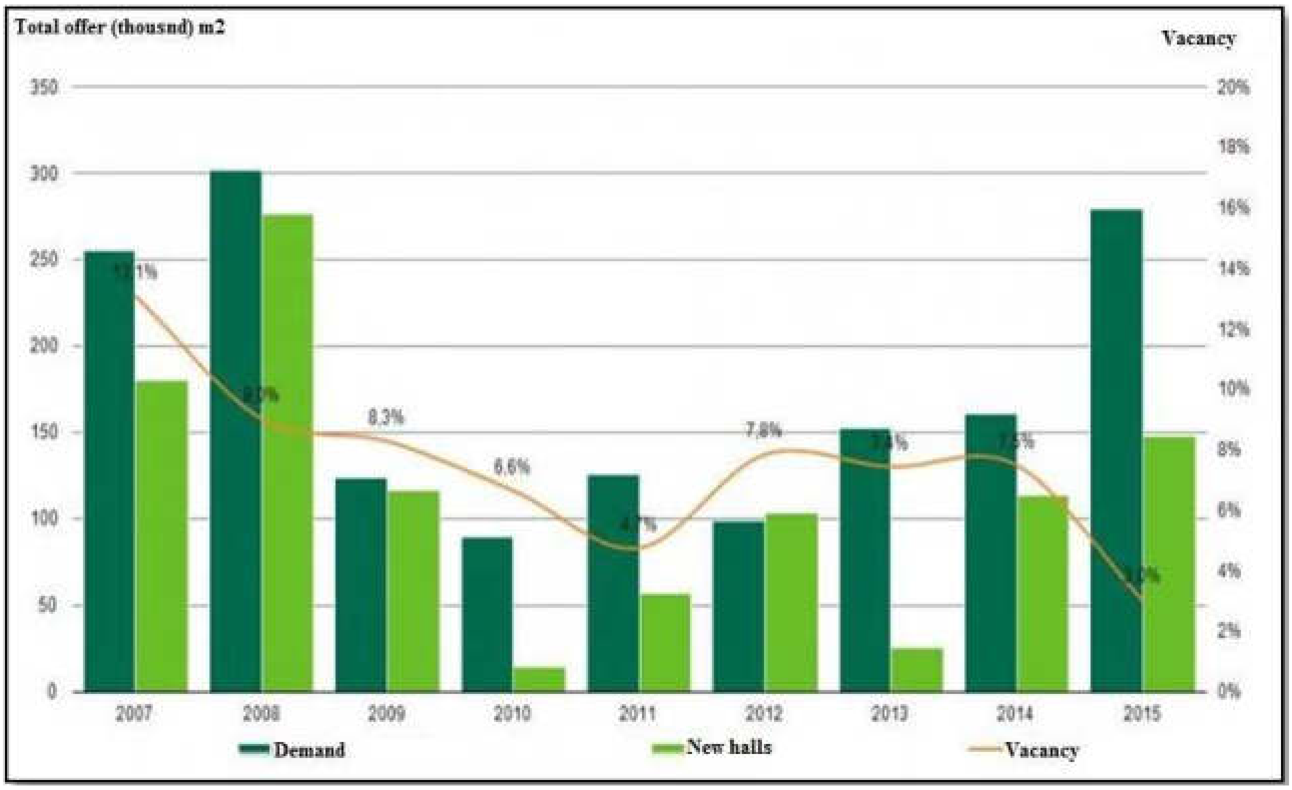


Figure 2 Offer versus demand in logistics market [9]

3 Trends of automatic logistic systems

Great competition on the global market, including Slovak republic, pushes the enterprises to constantly increase the performance and achieve the best competitive position against the rivals. International cooperation in industrial sectors is conditioned by the quality of logistics and the ability to import components and distribute the products from the production and warehouses. Currently, the trend of rapid reduction of input costs, i.e. increase of the profit plays a key role in the Slovak and Czech enterprises [11]. Supply logistics management is unsystematic, inefficient, ordering of material is intuitive in many Slovak and Czech enterprises.

The mentioned current characteristics of the supply logistics is linked with other issues in production. The main issue of supply logistics is to set the level of the inventory in order to meet the two opposing requirements - prompt fulfilment of customer requirements and associated increase in inventories and costs and the minimizing the value of input warehouses. The implementation of right management system will allow to achieve cost reductions, increase utilization of machines and employees, improve production planning and management system, increase productivity, and thus to have better economic indicators of the enterprise [12].

3.1 Automatic logistics system in the context of Industry 4.0

In the literature, there are several definitions that describe the term Industry 4.0. The concept can be also described as a revolution, whose main task is the informatisation of production and logistics technologies within the machine-machine data exchange. The result of the 4th industrial revolution are smart factories that will be flexible, reconfigurable, efficient, ergonomic and directly linked to the customer, including subcontractors. In general, the 4th industrial revolution is characterized by the following six creative principles [11]:

- Interoperability: the ability of cyber-physical systems to interact with each other and the possibilities for mutual communication of people and intelligent factories through the Internet of Things and the Internet of Services,
- Virtualization: the building of a virtual form of intelligent factory by collecting and connecting data from sensors,
- Decentralization: the ability of cybernetic-physical systems to decide about the own proceeding within the intelligent factory,
- Real-Time: ability to aggregate and evaluate information in real time and provide immediate outputs / solutions,

Acta logistica - International Scientific Journal about Logistics
Volume: 5 2018 Issue: 1 Pages: 7-14 ISSN 1339-5629

- Service orientation: the providing services via Internet of Services,
- Modularity: the flexibility of intelligent factories to changing requirements by replacing or expanding the individual parts/modules.

All above mentioned six principles of concept Industry 4.0 were considered in designing Automated Guided Vehicles (AGVs).The role of an automated logistics system is to deliver the required material in the correct quantity and quality to a predetermined location at a given time. The logistics process puts the emphasis on management of logistics processes and limitation of human factor faultiness [11].

There are complex solutions consisting of multiple modules for automatic supply of workplaces and production lines. The AGV automatic logistics system consists of a vehicle and various types of peripherals, such as automatic roller conveyors, e-frames, gravity wagons and a control system. Thanks to the wide modularity of AGV vehicles and their peripherals, the AGV system offers several levels of automation [11].

(1) The first level of automation means simple replacement of manually driven vehicles for the AGV vehicles with accessory (Figure 3).

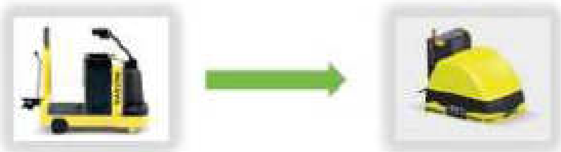


Figure 3: The first level of automation [11]

(2) The second level of automation means replacement of the manually driven vehicles for the AGV vehicles + peripherals (Figure 4).

Figure 4: The second level of automation [11]

(3) The third level of automation represents replacement of manually driven vehicles for AGV vehicles + peripherals + control system (Figure 5).

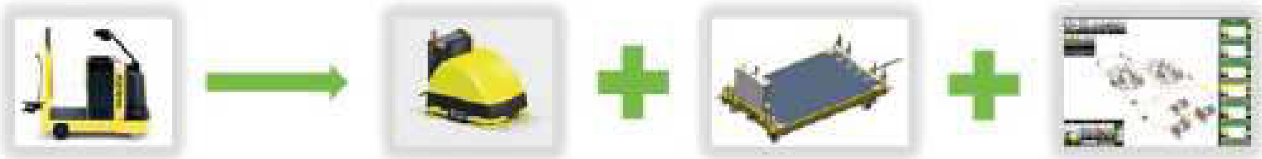


Figure 5: The third level of automation [11]

The market offers a wide range of complex modular solutions for automated supply of production lines. As a basis for automated supply of production lines with material, enterprises can apply the AGV logistics system, which consists as mentioned above of an autonomous logistic vehicles and various additional peripherals such as a hydraulic module, automatic roller conveyors, gravity wagons and etc.. By using the technical devices automation in logistics does not end. For greater complexity, the industrial enterprises can also use other automated devices such as a lifting - rotation device or a handling device (example: devices for handling the pallets) [12].

The combination of the above mentioned technical solutions and devices allows to create an efficient and efficient automated logistics system that reflects the trends of an already existing the 4th industrial revolution. These types of innovations in logistics, as well as in the manufacturing area, bring time and cost savings but also the ergonomic solutions for handling the loads [13]. The advantage of autonomous technical and technological solutions is the modularity which increases the flexibility in the implementation of logistics systems to the conditions of industrial enterprises.

Acta logistica - International Scientific Journal about Logistics
Volume: 5 2018 Issue: 1 Pages: 7-14 ISSN 1339-5629

3.2 Innovation of AGV system for automation of industry logistics

In order to consider technical system as competitive, it must meet several basic parameters such as [15]: meet customer requirements, be affordable and reliable. The AGV Automatic Logistics System offers a comprehensive solution for the automation of logistics processes in industrial enterprises by using the automated drawing of the wagon with material on pre-defined route by autonomous logistic vehicles in industrial halls. The mentioned system results in increased automation and productivity while lowering the logistics costs and ensuring increased security provided by sensors and cameras. In order to supply robotic and automated workplaces by automated supply system, it is necessary to create a modular system with easier adaptation to manufacturing, robotic workplaces or assembly line [14].

A comprehensive modular solution is capable to provide various levels of automation, according to customer needs [13]. CEIT Company offers a wide range of different modules that are able to adapt to demanding customer requirements at a high level of robotization of workplaces. The individual solutions and modularity options of offered technical solutions are shown in Figure 6.

Figure 6 Addition modules for AGV vehicles [13]

One of the main advantages of the AGV system is its modularity, which constantly develops and transcends its entire structure. Elements of a modular system such as a vehicle, a peripheral and a control system are just basics. In developing each of the three basic building blocks, it is important to keep the idea of modularity as much as possible. To keep the main idea of modularity, AGV can be used in any industry sector. The AGV are limited only by meeting the company's operational parameters. The vehicle as a basic part of the modular system has several additional modules and modifications serving for various ways of connecting the cargo within the logistics flow during the production process [13].

3.3 *Importance of AGV vehicles in logistics*

An autonomous logistic vehicle is a device that meets the function of transport motor vehicle without operating personnel to transport the material by wagons or various transport modules. Vehicles are driven by electrical energy and most often driven by a magnetic tape located on the floor. Based on RFID (Radio Frequency Identification) tags, the vehicle can determine the route, speed, stop, or communicate with the control system to manage the autonomous system. The role of the system is to manage complex situations, junctions, preference in driving and etc. [14].

The automatic plug-in and disconnect module with the reverse module (Figure 8) extends the operational capabilities of each compatible logistics trailer. The combination of these two features allows the trailer to change the direction of move by retrieving data from the RFID tag and automatically connect load located outside the direct route and consequent automatic disconnecting. Reversing in the designated areas can be used not only to connect the load, clear the route, but also to automatically connect the logistics trailer to the docking station. The automatic connection and disconnection module has the following features [15]:

- Automatic connection and disconnection of wagons based on RFID tag information,
- Module providing reverse mode at the designed areas to maintain the highest possible level of the health protection of the employees and material,
- Connections which are proceed outside the direct route. It is needed to reverse to the place which is allowed by the additional reverse module,
- Safety during the reverse process is provided by crash strips,
- Maximum reverse speed is limited to 0.25 m / s.

Figure 7 Automatic plug-in and disconnecting module with reverse module [13]

Another option to extend the automation of logistics trailers is a hydraulic module that enables the trailer to control various types of peripherals with a hydraulic system. The logistics trailer equipped with the hydraulic module (Figure 8) fulfils the function of an autonomous trailer capable to pull the wagons and mobile conveyors equipped with a hydraulic system. To ensure the mentioned operations, the trailer must be equipped with a hydraulic unit, the relevant software and connections for interconnecting the hydraulic system with peripherals. Peripheral control is performed automatically by data retrieved from the RFID tag on the trailer track. It is also possible to manually operate the peripheral directly from the display on the trailer [13].

Figure 8 Hydraulic module of logistics trailer [13]

The hydraulic module has the following features [13]:

- The possibility of connecting the peripherals that require connection of hydraulic circuits,
- Control of connection or disconnection commands using the RFID tags or manually one,
- Possibility to connect single-acting or double-acting hydraulic systems,
- Hydraulic system connection using a quick joints,
- Possibility to connect up to 4 peripherals.

The modular system of autonomous logistics trailers allows customers to use the logistics system exactly with regard to their needs and to the degree of required automation. Autonomous logistic trailers and their modules, such as automatic connection and disconnection with the reverse module or hydraulic module are successfully implemented in several enterprises where the automation and efficiency of logistics processes is successfully increased [15].

4 Conclusion

The interest of warehouses and logistics halls increases in Central Europe. Ten years ago, investors could choose only from 4.6 m2 of warehouses and logistics halls in Central Europe, today it is almost 18 million. In 2014, more than 1.4 million m2 of logistics areas were built in the region, which is slightly above the average of the decade and slightly more than the total amount of industrial area in Slovakia at the present. The Figure 9 shows vacancy rate of warehouse spaces in middle Europe. It is clear that demand grows and the vacancy of warehouse spaces decline significantly [16].

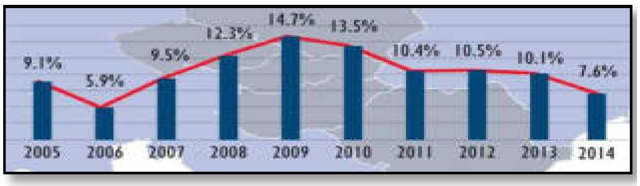


Figure 9 Vacancy rate of warehouse spaces (average of middle Europe) [7]

It can be stated that in Slovakia the vacancy rate is up to 4 %, the average of Central Europe is twice as high. The level of vacancies has decreased compared to previous periods [17].

Intelligent/smart technology in industry and logistics in context of the concept Industry 4.0 is a relatively new concept that entered the market in the last few years. The options, as well as the possibilities of using the technologies, are still partially limited. The lack of skilled labour force and the financial difficulty of implementation into corporate practice are the main limitations [7]. The impact of new trends on the logistics market in Slovakia is evident. In the last two decades many industrial enterprises and warehouse spaces were developed. Despite the fact that industrial enterprises try to eliminate stocks of materials and finished products, production without stock is still not possible. The implementation of new technologies into the warehouse management along with the development of the economy allows the construction and efficient use of warehouse areas. Automated logistics technologies in the field of storage result in the elimination of human element in storage processes.

One of the negatives in implementing the concept Industry 4.0 is the fact that there is lack of qualified labour force. Another negative factor is the aging population and the issue of resolving the aging labour force when it is necessary to involve the personnel assurance of the production systems to solve the situation [18]. The analysis shows that the demand for warehouse areas still increases. The mentioned fact is caused by efficient use of warehouses not only for their primary storage function but also for the consolidation activities. Production and crossdocking warehouses create the main space for implementation of automated logistics systems.

Acknowledgement
The paper is a part of KEGA project No. 030STU-4/2018 “E-platform for Improving Collaboration among Universities and Industrial Enterprises in the Area of Education" and VEGA project No. 1/0235/17 „System identification of complex preconditions for supporting innovation and employment in the less developed regions of Slovakia“.

References

[1] BEELIN, A.: *How will smart technology transform warehouses?*, [Online], Available: <http://www.jllrealviews.com/industries/what-does-the-future-look-like-forwarehouses/> [01 Nov 2016], 2015.

[2] CHARBULOVÁ, M., MATÚŠOVÁ, M., CAGÁŇOVÁ, D.: *Intelligent production systems and clamping systems for intelligent production systems.* In MMA 2009. Flexible Technologies : Proceedings. 10th international scientific conference. - Novi Sad, 9.-10.10. 2009. Novi Sad : Faculty of Technical Sciences, p. 194-197, 2009.

[3] VÁCLAVÍK, I.: *Súčasný stav logistiky na Slovensku z viacerých aspektov*, [Online], Available: <http://style.hnonline.sk/autosalon/189414-sucasny-stav-logistiky-naslovensku-z-viacerych-aspektov> , [01 Nov 2017], 2005. (Original in Slovak)

[4] FIDLEROVÁ, H., JURÍK, L., SAKÁL, P.: Application of AHP in the process of sustainable packaging in company, *Production Management and Engineering Sciences*, No 1. London, UK: CRC Press. Taylor & Francis Group, p. 585-591, 2016.

[5] ILMARINEN, J.: *The support of active aging at the workplace*, Bratislava: Európska agentúra pre bezpečnosť a ochranu zdravia pri práci, p. 8, 2012. (Original in Slovak)

[6] KVAŠŇÁK, L.: [Online], Available: <https://www.etrend.sk/firmy/volkswagen-prijal-za-tri-roky-viac-ludi-ako-chce-celkovo-zamestnavat-jaguar.html>, 2016. (Original in Slovak)

[7] SPIŠÁKOVÁ, A., VRAŇAKOVÁ, N., KOLTNEROVÁ, K., CHLPEKOVÁ, A.: Design of the implementation of concept of age management in industrial companies, *Fórum manažéra*, Vol. 12, No. 2, p. 52-56, 2016.

[8] MPSVR SR. *National programme for active aging (2014-2020)*, Ministerstvo práce, sociálnych vecí a rodiny Slovenskej republiky, p. 84, 2014. (Original in Slovak)

[9] MISTRÍK, L.:[Online], Available:<https://reality.etrend.sk/realitny-biznis/slovenskom-rajom-skladovych-hal-alogistiky.html)>, 2016.

[10] MISTRÍK, L.: *Central Europe is growing – The great interest in warehouses and halls,* In: Trend.sk., [Online],Available: <http://reality.etrend.sk/realitny-biznis/strednaeuropa-rastie-o-sklady-a-haly-je-velky-zaujem.html>, [09 Mar 2017], 2015. (Original in Slovak)

[11] ČAČO, M. et al.: The new trailer type extends the automation capabilities of the industry, *ProIN*, Vol. 17, No. 3 p. 17-19., 2016. (Original in Slovak)

[12] UHROVÁ, M.: *Trend in business logistics optimization*, [Online], Available:<http://www.ipaslovakia.sk/sk/tlac-a-media/napisali-sme/trendyoptimalizaciepodnikovej-logistiky>, [01 Nov 2016], 2005. (Original in Slovak)

[13] ČAČO, M. et al.: Devices to increase the internal delivery efficiency, *ProIN*., Vol. 18, No. 2, p. 22-24., 2017. (Original in Slovak)

[14] KERNER, S.: SafeAutonomousLogistics and TransportationVehicles in OutdoorAreas, [Online],Available:<https://www.iml.fraunhoferde/en/fields_of_activity/automationembedded_systems/research/SaLsA.html> [07 Nov 2017], 2016.

[15] ČAČO, M. et al.: Innovations of the AGV System for Automation of Industrial Logistics, *ProIN*., Vol. 18, No. 2, p. 18-21., 2017. (Original in Slovak)

[16] BALYO: *Intralogisticsisturning to automation - Linde presents automationas a focal point At WoMH,* [Online], Available: <http://www.balyo.com/en/NEWS/Intralogisticsis-turning-to-automation-Linde-presents-automation-as-a-focal-point-at-WoMH>, [01 Nov 2016], 2013.

[17] SOTNÍK, A.: Central Europe advanced significantly. *Transport a logistika,* 17 (3), p. 68 – 69, Výkonnosť podniku – Vol. VII, No. 3, 2017, 2015b (Original in Slovak)

[18] SOTNÍK, A.: New Opportunities for Central and Eastern Europe, *Transport a logistika*, Vol. 17, No. 4, 68, 2015c.

[19] VRAŇAKOVÁ, N., CHLPEKOVÁ, A., KOLTNEROVÁ, K., PRAČKOVÁ, P.: Die steuerung von den multigenerationteams in den industriebetrieben, *Vedecké práce MtF STU v Bratislave so sídlom v Trnave, Research papers Faculty of Materials Science and Technology Slovak University of Technology in Trnava,* Vol.25, No. 41, p. 35-42, INSPEC, 2017.

[20] SOURCE, L.: *Intra logistics is turning to automation - Linde presents automation as a focal point,* [Online]. Available: <http://www.forkliftnet.com/news/html/newshtml/news_7987.html> [06 Nov 2016], 2016.

Review process

Single-blind peer review process.

doi:10.22306/al.v5i1.85
Received: 22 Mar. 2018
Accepted: 27 Mar. 2018

FORMATION OF SUPPORT FOR SMALL ENTERPRISES IN THE PROCESS OF BUSINESS INCUBATION WITH THE APPLICATION OF LOGISTIC CHAINS

Inna Matveeva
Kalashnikov Izhevsk State Technical University, 7 Studencheskaya St., Izhevsk, 426069, Udmurt Republic, Russian Federation, inna.matweewa@gmail.com (corresponding author)
Ekaterina Khomenko
Kalashnikov Izhevsk State Technical University, 7 Studencheskaya St., Izhevsk, 426069, Udmurt Republic, Russian Federation, ekaterina_izh@mail.ru

Keywords: support of small enterprises, information and analytic instruments, logistic chains, business incubation
Abstract: In this article the content of information and analytic support for small businesses is disclosed, the specifics of using information and analytic instruments such as consulting, training, expert support, event-monitoring are described, and improvement of the provision of information and analytic services through remote and complex rendering of these instruments in the form of online support. The purpose of this article is to develop practical recommendations for improving the support for small business in the business incubation process taking into account the trends in the formation of the information economy. One of the most effective institutions for supporting small business is the formation of a network of business incubators. The problem of absence or the complexity of obtaining information and analytic services due to weak interaction between a small enterprises and a business incubators was investigated. We propose to develop an IT complex, which includes a database of existing business incubators and relevant information and analytic instruments for support small enterprises. This complex is based on the remote interaction of small enterprises and business incubators. Getting a remote information analytic service can be considered as a logistical process of delivering a service to the small enterprise. Remote application of a complex of information and analytic instruments will contribute to the following results: improving the quality of providing infrastructure support; expanding the cooperation of the business incubator with scientific organizations; development of a positive image of the business incubator; improving the interaction of small enterprises and business incubators.

1 Introduction

In the economy of a new type informatization of entrepreneurial activity is the dominant trend. The process of formation of the information economy proposes the organization of an appropriate support for entrepreneurship. The development of support for entrepreneurial activity in turn demands improvement of the structure, functions, methods and instruments of support for small business [1-3]. Implementation of the process for improvement of infrastructure support can be performed through the use of information logistic chains.

The purpose of this article is to develop practical recommendations for improvement the support for small business in the process of business incubation taking into account the trends in the formation of the information economy.

One of the most effective institutions for support of small business is the formation of a network of business incubators. In particular the business incubator makes the opportunities, first, to lay the basis for a new generation of small business entities, secondly, to support already working entrepreneurs and, thirdly, to solve many social and economic problems at the regional level.

The relevance of the development of the system of business incubators is provided for the use of effective instruments to support of small business. Having become wide spread in the West, business incubators today become one of the most effective institutions in the support system for small business in Russia [4]. In the framework of implementation of the organization, information and analytical functions of the business incubator, it is possible to define the structure of information and analytic instruments with which the business incubator is able to give a certain type of support to small businesses (Figure 1). An information and analytic instrument is understood as a set of implemented information and analytic services provided by business incubators in the framework of support for small businesses and grouped according to their functional purpose.

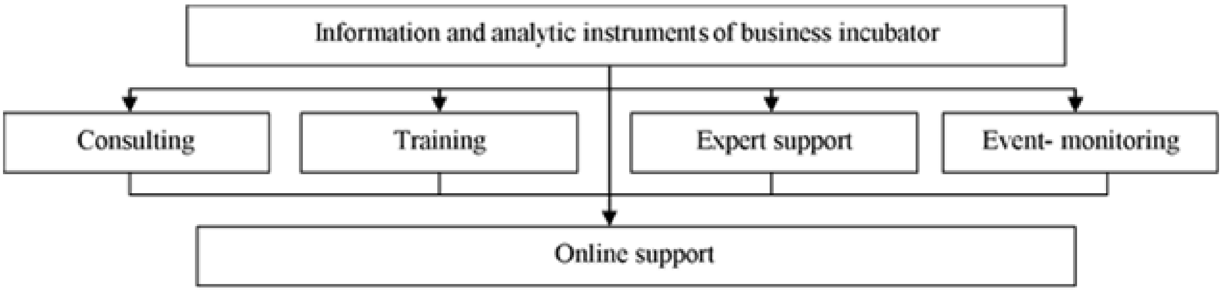


Figure 1 Information and analytic instruments of support for small enterprises given by business incubators

Mutual problems in the use of information and analytic instruments are:

- lack of qualified personnel in the business incubator; there are specialists in different branches of knowledge, and by implication, a narrow range of topics in the framework of consulting and training of small enterprises named residents of business incubator [7];
- a low level of information and technical support for business incubators, that leads to the inability to use qualitative these information and analytic instruments;
- lack of work on forming the image of a business incubator as a key institution of small business support. First, it is the lack of one's own website and publicity of business incubators; secondly, the lack of a quality monitoring system of support to small enterprises;
- the lack of remote cooperation between small enterprises and business incubators, that put the onus on a small enterprise to be a physical resident of a business incubator (that is to rent an office / room / equipment within the walls of a business incubator).

In the framework of development of information and analytic support for small enterprises it should formulate the next basic tasks aimed at the integrated use of the afore-named instruments:

- expanding the cooperation of the business incubators with research institutes, universities, industrial enterprises and other support institutions (technology parks, investment centres, etc.) to receive methodological and scientific support, access to research results and specialized equipment, as well as attract expert (employees of research institutes, teachers of universities, employees of state institutions and organizations, experts of financial and credit organizations);
- development of a positive image of business incubators by promoting their services (publicity, inviting potential exhibitors, organization thematic conferences, seminars and webinars, master classes and creating a firm style);
- development of new thematic ways of consulting, training and expert support for small enterprises;
- creation of remote collaboration, incl. establishment of feedback between residents and business incubators by applying information and analytic instruments in a complex, for example, as a single IT complex.

That way, the central and perspective task of improvement information and analytic support of small business is the use of information and analytic instruments remotely and in its entirety. By means of it the business incubator will be able to increase the number of incubated small enterprises, thereby to contribute to their successful development in the early stages of their entrepreneurial activities.

2 Methodology

The research of the interaction of business incubators and their residents made it possible to identify a set of problems of providing information and analytic support to small enterprises. One of the key problems is the lack (for most business incubators) or the difficulty of obtaining information and analytic services due to the weak interaction between the small enterprises and the business incubators.

We propose to develop an IT-complex that includes a database on working business incubators and their corresponding information and analytic instruments for supporting small enterprises. This complex is based on the information-remote interaction of small enterprises and business incubators, by means of it the efficiency and complexity of the provision of services is achieved [5,6].

Getting a remote information analytic service can be considered as a logistical process of delivering a service to the end user - a small enterprise. It is important to build a logistics chain of the process of obtaining information and analytic services by a small enterprise in the process of business incubation. Figure 2 shows the logistics chain for obtaining information and analytic support for a small enterprise.

At the first stage, a small enterprise formulates an actual problem and searches for an information and analytic service that contributes to its solution. At the second stage, a small enterprise analyses the existing list of working business incubators and, based on the rating of the support institute, chooses the best business incubator for it. In the third stage, the selected business incubator assesses its existing potential for information and analytic infrastructure support instruments and identifies a specific specialist who will be responsible for providing information and analytic services at the fourth stage. In the absence of the necessary expert, an outside specialist (the fifth stage) can be recruited in the state of the business incubator, ready to provide the information analytic service of proper quality (the sixth stage).

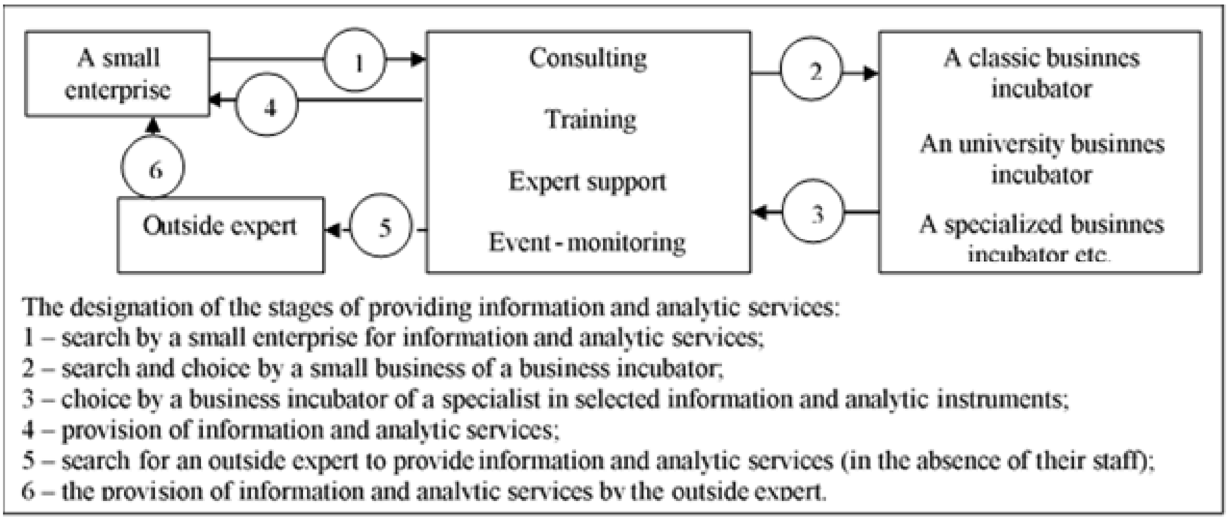


Figure 2 A logistic chain of provision of information and analytic services in the process of business incubation

The logistics chain of the information and analytic service presented in Figure 2 is of a simplified nature. In addition to assessing the needs of a small enterprise in a certain service and the available information and analytic potential of a business incubator, it is necessary to determine the quality of the service provided for the further improvement of information and analytic support.

3 Result and discussion

The introduction of information-distance interaction in the business incubation process will yield the following basic results:

a) for a small enterprise:

- simplification and acceleration of the procedure for obtaining information and analytic services through informatiszation of the business incubation process;
- the possibility of obtaining services online without a territorial link to the business incubator;
- improvement of current indicators of the development of the enterprise;
- transaction costs cut;

b) for a business incubator:

- improving the quality and speed of providing information and analytic support through the development of competition between business incubators and rating the provision of support to small businesses;
- popularization of the business incubator as one of the key institutions of support for small business;
- increased incubation of small enterprises;

c) for the region and country:

- growth of entrepreneurial activity among the population;
- increasing the number of small enterprises as a result of improving their support quality.

The proposed recommendations for improving the support of small business in the process of business incubation will allow complex and remote use of information and analytic instruments in the form of a supply chain presented in Figure 2.

4 Conclusions

The formation of the information economy and the processes of informatization of entrepreneurial activity directly affect the organization of support for small businesses. Increasing the role of the information and analytic component determines the need for remote and complex use of information and analytic instruments through online support of small enterprises. Such support is possible if there is an IT complex of information and analytic instruments functioning in the country's territory. This complex is a list of information and analytic services provided by working business incubators.

The remote application of a complex of information and analytic instruments (consulting, training, expert support and event-monitoring) will be able to reveal following results:

- improving the quality and speed of providing support for small enterprises;
- expanding the cooperation of the business incubator with scientific organizations in order to attract outside experts;
- development of a positive image of the business incubator as one of the key support institutions;
- improving the interaction of small enterprises and business incubators, incl. establishment of feedback.

That way, the formation and development of the information economy in Russia requires the improvement of institutions regulating economic relations in the information sphere, in the support of business processes [1,2], which determine the transformation processes in all subsystems of the business infrastructure.

Acknowledgement
This article was supported as a part of the Ph.D. thesis on «Mechanism of integration of information and analytic instruments for the infrastructure support of small enterprises in the process of business incubation». R&D have been performed in Kalashnikov Izhevsk State Technical University.

References

[1] KHOMENKO, E.B., ZLOBINA, E.YU., GLAVATSKIH, O.B., MATVEEVA, I.V.: *Strategy development infrastructure of small and medium-sized enterprises in the transition to an infor-mation economy: monografiya*, Izhevsk, Izdatel'stvo Izhevskogo gosudarstvennogo tekhnicheskogo universiteta imeni M.T. Kalashnikova, p. 316, 2015.

[2] MATVEEVA, I.V., KHOMENKO, E.B.: Forming the concept of the theory of information economy: methodological and practical aspects, *Vestnik Permskogo nazionalnogo issledovatelskogo politehnicheskogo universiteta. Social and economic sciences*, No. 1, pp. 136-146, 2017. doi: 10.15593/2224-9354/2017.1.11

[3] PRAJOVA, V., PERMINOVA, O., FAIZULLIN, R.: Principles of Organizations' Interaction while Forming Mechatronics Specialists' Professional Competences in a Regional Industry Cluster, *Procedia Engineering*, Vol. 96, pp. 370-373, 2014.

[4] MATVEEVA, I.V., KHOMENKO, E.B.: Business Incubator as the Institute of Information Support of Small Enterprises, *Vestnik IzhGTU im. M.T. Kalashnikova,* Vol. 20, No. 2, pp. 131-134, 2017. doi: 10.22213/2413-1172-2017-2-131-134.

[5] MATVEEVA, I.V.: Projecting the Information-analytical Portal «Virtual Business Incubator», *Intelligent systems in manufacturing,* Vol. 15, No. 1, pp. 78-81, 2017. doi: 10.22213/2410-9304-2017-1-78-81.

[6] SHCHENYATSKY, A.V., CHUKHLANTSEV, E.S., SHCHEKOTUROV, I.M.: Analysis of the possibility to develop the computer-aided design system for local-area networks, *Intelligent systems in manufacturing,* Vol. 21, No. 1, pp. 195-197, 2013.

[7] PERMINOVA, O.M.: Modern educational tendencies in Russia, Review of social and economic sciences, *University Review*, Vol. 3, No. 1, pp .21-29, 2009.

Review process
Single-blind peer review process.

doi:10.22306/al.v5i1.86 Received: 26 Mar. 2018
Accepted: 28 Mar. 2018

AUTOMATIC WAREHOUSES WITH TRANSPORT ROBOTS OF INCREASED RELIABILITY

Sergey Trefilov
7 Studencheskaya St., Izhevsk, 426069, Udmurt republic, Russian Federation, Kalashnikov Izhevsk State Technical University, trefilov376908@gmail.com
Yury Nikitin
7 Studencheskaya St., Izhevsk, 426069, Udmurt republic, Russian Federation, Kalashnikov Izhevsk State Technical University, nikitin@istu.ru (corresponding author)

Keywords: warehouses, robots, control, diagnostics
Abstract: The algorithm of optimal control of transport robots for automatic warehouses is considered in the paper. The minimum criterion for a quadratic form was chosen as the criterion of optimality. A quadratic functional of quality that determines the energy of control and displacement is considered. A solution is proposed for a quality criterion that minimizes the energy of control and displacement. The robots control based on a mathematical model is proposed with the calculation of the state matrices and the control matrix at each step. The properties of transport robots system are considered: controllability and identifiability. For a linear stationary system, the criteria for controllability, identifiability and observability as the rank of the extended matrix are chosen. It is proposed to perform diagnostics of drives, electronic control devices and software in a complex manner based on the parametric model and calculation of the identifiability criterion. A large inaccuracy in the measurement results in a larger control error and a loss of controllability. Moreover, with the loss of identifiability, the measurement problem becomes poorly conditioned. This approach will allow to perform complex diagnostics of transport robots system and in time to identify potentially faulty components and exclude them from the system.

1 Introduction

There are many papers on automatic warehouses and transportation equipment [1-7]. The development of wheeled vehicles of general and special purpose is considered in papers [8-11]. In papers [12-18] problems of diagnostics of transport robots and their drives are considered.

At present, much attention is paid to the reliability and safety of the use of complex systems, which include multi-agent automatic warehouse systems. As a rule, the model of technical systems reliability is represented in the form of a connection between the failure rate parameter and the probability of failure. All models of system diagnostics are defined either as diagnostics of individual elements of the system in order to confirm their probabilistic model, or as a complex analysis of probabilistic models for the entire system, taking into account the connection between the elements.

The main attention is paid to the accuracy of measurements for verification of the probabilistic reliability model. The solution of diagnostic problems in practical tasks is confronted with measuring poorly-defined tasks. Moreover, the probabilistic model based on the failure rate is oriented to sudden failures, although for complex systems it is characteristic to remain operational even if some or all of the elements of this system fail. This approach implies an increase in the number of information measuring diagnostic subsystems at the element level with very complex algorithms for processing primary data and decision algorithms for reliability system.

In this paper, we propose a systematic approach to the solution of the problem of diagnostics of complex systems, based on the construction of a matrix mathematical model that assumes the possibility of computing the properties of complex systems such as controllability, observability, and identifiability. These properties are used to diagnose a complex system in the sense of its ability to perform an a priori specified objective function. The model of a complex system is represented as:

$$\dot{x} = A(t)x(t) + B(t)u(t)$$
$$z(t) = C(t)x(t) \quad (1)$$

where:
A(t) is a functional matrix of size n x n, called the state matrix of the system (object);
B(t) is a functional matrix of size n x r, called the control matrix (input);
C(t) is a functional matrix of size m x n, called the exit state matrix.

Controllability, observability and identifiability are determined by the rank of the matrix sequence

$$\mathrm{rank}[B_k \vdots A_kB_k \vdots (A_k)^2B_k \vdots \cdots \vdots (A_k)^{n-1}B_k] = n,$$
$$\mathrm{rank}\left[C_k^T \vdots A_k^TC_k^T \vdots (A_k^T)^2C_k^T \vdots \cdots \vdots (A_k^T)^{n-1}C_k^T\right] = n.$$

2 Methodology

Let the automatic warehouse be serviced by *n* highly manoeuvrable robots, each of which has three degrees of freedom, that is, the state of the robot is determined by the speed of linear displacement with respect to the coordinates x, y and rotation around the z coordinate. Then the state vector can be written as

$$x^T = [v_x(t), v_y(t), \omega(t)]^T$$

In general, when all vectors and matrices are time-dependent, the problem is non-linear and has only particular solutions. To find the equation of state, we represent (1) in a discrete form, with the sampling time Δt tending to zero, and the trajectory on each discrete part is linear. We write (1) in the form

$$\frac{x_{k+1}-x_k}{\Delta t} = A_kx_k + B_ku_k$$
$$z_k = C_kx_k \qquad (2)$$

This approach involves the calculation of the state matrices A(t), the control B(t), and the measurement of C(t) in the solution of the measurement task.

Multiplying the left and right sides of the first equation by Δt, we obtain

$$x_{k+1} = \tilde{A}_kx_k + \tilde{B}_ku_k,$$
$$z_k = C_kx_k \qquad (3)$$

where $\tilde{A} = \Delta t \cdot A + E$,
$\tilde{B} = \Delta t \cdot B$.

This equation relates the transition of the system from the state x_k to the state x_{k+1}. In the interval Δt we take the values of the matrices to be constant. Then for a group of highly manoeuvrable transport robots [11] having a state vector

$$x^T = [v_x(t), v_y(t), \omega(t)]^T$$

and driven by two drives, we can to record for the whole ensemble of n robots is similar to (3).

$$\begin{bmatrix} v_{k+1\,x}(1) \\ v_{k+1\,y}(1) \\ \omega_{k+1}(1) \\ \vdots \\ v_{k+1\,x}(n) \\ v_{k+1\,y}(n) \\ \omega_{k+1}(n) \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1(2n-1)} & a_{1(3n)} \\ a_{21} & a_{22} & \dots & a_{2(2n-1)} & a_{2(3n)} \\ & & \dots & & \\ a_{(3n-1)1} & a_{(3n-1)2} & \dots & a_{(3n-1)(2n-1)} & a_{(3n-1)(3n)} \\ a_{(3n)1} & a_{(3n)2} & \dots & a_{(3n)(2n-1)} & a_{(3n)(3n)} \end{bmatrix} \cdot \begin{bmatrix} v_{k\,x}(1) \\ v_{k\,y}(1) \\ \omega_k(1) \\ \vdots \\ v_{k\,x}(n) \\ v_{k\,y}(n) \\ \omega_k(n) \end{bmatrix} +$$
$$+ \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1(2n-1)} & b_{1(2n)} \\ b_{21} & b_{22} & \dots & b_{2(2n-1)} & b_{2(2n)} \\ & & \dots & & \\ b_{(3n-1)1} & b_{(3n-1)2} & \dots & b_{(3n-1)(2n-1)} & b_{(3n-1)(2n)} \\ b_{(3n)1} & b_{(3n)2} & \dots & b_{(3n)(2n-1)} & b_{(3n)(2n)} \end{bmatrix} \begin{bmatrix} u_{11} \\ u_{12} \\ u_{21} \\ u_{22} \\ \vdots \\ \vdots \\ u_{n1} \\ u_{n2} \end{bmatrix}$$
$$\begin{bmatrix} z_{k\,x}(1) \\ z_{k\,y}(1) \\ z_{k\omega}(1) \\ \vdots \\ z_{k\,x}(n) \\ z_{k\,y}(n) \\ z_{k\omega}(n) \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1(2n-1)} & c_{1(3n)} \\ c_{21} & c_{22} & \dots & c_{2(2n-1)} & c_{2(3n)} \\ & & \dots & & \\ c_{(3n-1)1} & c_{(3n-1)2} & \dots & c_{(3n-1)(2n-1)} & c_{(3n-1)(3n)} \\ c_{(3n)1} & c_{(3n)2} & \dots & c_{(3n)(2n-1)} & c_{(3n)(3n)} \end{bmatrix} \cdot \begin{bmatrix} v_{k\,x}(1) \\ v_{k\,y}(1) \\ \omega_k(1) \\ \vdots \\ v_{k\,x}(n) \\ v_{k\,y}(n) \\ \omega_k(n) \end{bmatrix} \qquad (4)$$

In (4) for convenience of writing, the "wavy line" icon above the matrix elements is omitted. Further, the matrices A, B, C and their elements will be denoted without a wavy line. Let us find the solution (1) without the second equation, which is the measuring part of the system.

The quadratic functional of quality, which determines the energy of control and displacement, is expressed as follows

$$I = \frac{1}{2}\int_{t_0}^{t_f}(x^T Q x + u^T G u)dt, Q \geq 0, G > 0, \quad (5)$$

where Q and G are positive arbitrarily defined matrices. The matrices Q and G are chosen arbitrarily.

It is not always possible to obtain a solution of the equation for finding u. It is proposed to select these matrices by selection or simulation modelling [19], [20].

The solution (1) for the quality criterion (5), minimizing the control and displacement energy, is determined by the following expression [19], [20].

$$u = -G^{-1}B^T K x \quad (6)$$

where K is the Cauchy matrix, $K = K^T$, which can be found by solving the Riccati equation [19]

$$-\dot{K} = Q + A^T K + K^T A - K^T B G^{-1} B^T K, \quad K(t_f) = 0$$

Cauchy Matrix

$$K = \begin{bmatrix} k_{11} & k_{12} & \cdots & k_{1(n-1)} & k_{1n} \\ k_{21} & k_{22} & \cdots & k_{2(n-1)} & k_{2n} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ k_{(n-1)1} & k_{(n-1)2} & \cdots & k_{(n-1)(n-1)} & k_{(n-1)n} \\ k_{n1} & k_{n2} & \cdots & k_{n(n-1)} & k_n \end{bmatrix}, k_{ij} = k_{ji} \quad (7)$$

must be positive definite, since positive definite matrices Q and G are used in the quadratic functional of quality (5), which is also positive.

Thus, the robot group is controlled by the solution (6) according to the model (4) with calculation of the matrices of state A_k and the control matrix B_k at each step k. The matrix $C = C_k$ at each step k remains unchanged, determined by the information-measuring system, can be represented as

$$C = \begin{bmatrix} 1+\varsigma_1 & 0 & \ldots. & 0 \\ 0 & 1+\varsigma_2 & \ldots & 0 \\ & & \ldots & \\ 0 & 0 & & 1+\varsigma_n \end{bmatrix}, \quad (8)$$

where $\boldsymbol{\varsigma_n} = [\varsigma_1, \varsigma_2, \ldots, \varsigma_n]^T$

is a random vector that maps the random character of measurements to an information measuring system.

3 Result and discussion

Important properties of a complex system are its manageability and identifiability. Manageability allows in principle to implement the target function of the system. Identifiability in its parametric form will be used to diagnose the state of the system in terms of its potential functionality.

Controllability. For a linear stationary system, at each step of linearization, the criterion of controllability is the rank of the extended matrix:

$$rank[B_k \vdots A_k B_k \vdots (A_k)^2 B_k \vdots \cdots \vdots (A_k)^{n-1} B_k] = n. \quad (9)$$

If condition (9) is satisfied, then the system is controllable.

Identifiability. In abstract-theoretical analysis, identifiability is a particular case of observability. Identity is understood as the receipt or refinement of the model of a real object from experimental data. For a linear stationary system at each step of linearization, the criterion of identifiability and observability is the rank of the expanded matrix:

$$rank[C_k^T \vdots A_k^T C_k^T \vdots (A_k^T)^2 C_k^T \vdots \cdots \vdots (A_k^T)^{n-1} C_k^T] = n. \quad (10)$$

If condition (9) and (10) are satisfied, then the system is observable, manageable and identifiable.

The model of a complex system consisting of a group of robots includes models of mechatronic devices. In the mechatronic device model, parameters such as inductance, coercive force of magnetic components, leakage currents, etc., which are changed during operation due to aging and interaction with other components of the system, are directly or indirectly connected. It is proposed to carry out diagnostics of drives, electronic control devices and software in a complex way based on the parametric model (4) and calculating the criterion of identifiability (10), taking into account the degree of proximity to zero of the main determinants in calculating the rank of the expanded matrices (9) and (10).

We write down the solution of the information-measuring problem of the model (4).

$$\begin{bmatrix} v_{k\,x}(1) \\ v_{k\,y}(1) \\ \omega_k(1) \\ \vdots \\ v_{k\,x}(n) \\ v_{k\,y}(n) \\ \omega_k(n) \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} & \cdots c_{1(2n-1)} & \cdots & c_{1(3n)} \\ c_{21} & c_{22} & \cdots c_{2(2n-1)} & \cdots & c_{2(3n)} \\ & & \cdots & & \\ c_{(3n-1)1} & c_{(3n-1)2} & \cdots c_{(3n-1)(2n-1)} & \cdots & c_{(3n-1)(3n)} \\ c_{(3n)1} & c_{(3n)2} & \cdots c_{(3n)(2n-1)} & \cdots & c_{(3n)(3n)} \end{bmatrix}^{-1} \cdot \begin{bmatrix} z_{k\,x}(1) \\ z_{k\,y}(1) \\ z_{k\omega}(1) \\ \vdots \\ z_{k\,x}(n) \\ z_{k\,y}(n) \\ z_{k\omega}(n) \end{bmatrix} \tag{11}$$

The vector of the right-hand side of (11) is substituted in (6) as an estimate of the state. A large inaccuracy in the measurement leads to a larger control error and, in the end, leads to a loss of controllability. Moreover, with the loss of identifiability, the determinant of the inverse matrix in (11) is close to zero and the measurement problem becomes poorly conditioned. Such approach will allow to perform complex diagnostics of the system and in time to detect potentially faulty components and to exclude them from the system.

4 Conclusions

In this paper we present:

Mathematical model of diagnostics of a complex system, based on the matrix model of control in the time domain.

Optimal discrete algorithm for computing the control vector for a group of mobile robots.

Algorithm for monitoring the system based on the potential for performing the objective function by determining the properties of the system-controllability, observability and identifiability, by calculating the rank of the matrix sequences composed of the matrices of state, control, and measurement.

Thus, for a complex system, from the measurements of the current state, the correspondence of its behaviour to the a priori model of this complex system is determined, which allows us to speak of the fulfilment of the objective function.

Acknowledgement
The reported study was funded by RFBR according to the research project № 18-08-00772 A.

References

[1] HRICOVÁ, R.: Situation on intermodal terminals in the slovak republic, *Acta logistica*, Vol. 4, No. 3, pp. 19-23, 2017. doi:10.22306/al.v4i3.51
[2] FERENCOVÁ, J., HURNÁ, S.: Logistics technologies in aviation, *Acta logistica*, Vol. 4, No. 2, pp. 11-17, 2017. doi:10.22306/al.v4i2.3
[3] STRAKA, M.: The position of distribution logistics in the logistic system of an enterprise, *Acta logistica*, Vol. 4, No. 2, pp. 23-26, 2017. doi:10.22306/al.v4i2.5
[4] KOVÁCS, G.: Logistics and production processes today and tomorrow, *Acta logistica*, Vol. 3, No. 4, pp. 1-5, 2016. doi:10.22306/al.v3i4.71
[5] WITKOWSKI, K., HUK, K., PERZYŃSKA, A.: Selected it solutions in logistics strategies of supply chains, *Acta logistica*, Vol. 3, No. 4, pp. 31-37, 2016. doi:10.22306/al.v3i4.75
[6] BALLOVÁ, L.: Options of transport for kosice's surrounding in nonstandard times, *Acta logistica*, Vol. 3, No. 1, pp. 19-22, 2016. doi:10.22306/al.v3i1.55
[7] IGNÁCZOVÁ, K.: FMEA (failure mode and effects analysis) and proposal of risk minimizing in storage processes for automotive client, *Acta logistica*, Vol. 3, No. 1, pp. 15-18, 2016. doi:10.22306/al.v3i1.54
[8] FILKIN, N.M., ZYKOV, S.N., KORSHUNOV, A.I., ZAVIALOV, P.M., BOŽEK, P.: A unified machine for technological electric transport ladder-backbone load-bearing system, *Acta logistica*, Vol. 4, No. 3, pp. 5-8, 2017. doi:10.22306/al.v4i3.7
[9] RICHTARČÍK, F.: Usage of rfid technology for the needs of logistics of services, *Acta logistica*, Vol. 3, No. 1, pp. 5-8, 2016. doi:10.22306/al.v3i1.57
[10] BOŽEK P., FILKIN, N.M., ZYKOV, S.N., KORSHUNOV, A.I., ZAVIALOV, P.M.: A unified machine for technological electric transport load-bearing system, *Acta logistica*, Vol. 4, No. 2, pp. 1-5, 2017. doi:10.22306/al.v4i2.1
[11] TREFILOV, S.A., KALINKIN, A.A., NIKITIN, Y.R.: High-maneuverable transport robot, *University Review*, Vol. 1, No 2. Trencin, Alexander Dubcek University of Trencin, Slovakia, Izhevsk State Technical University, Russia. pp. 34-39, 2007.
[13] ABRAMOV, I.V., NIKITIN, YU.R., ABRAMOV, A.I., SOSNOVICH, E.V., BOŽEK, P.: Control and diagnostic model of brushless DC motor, *Journal of Electrical Engineering*, Vol. 65, No. 5, pp. 277- 282, 2014.

[14] ABRAMOV, I., BOŽEK, P., NIKITIN, Yu., ABRAMOV, A., SOSNOVICH, E., STOLLMANN, V.: *Diagnostics of electrical drives*, Proceedings of International Conference on Electrical Drivers and Power Electronics EDPE 2015. 21-23.09.2015, Tatranska Lomnica, The High Tatras, Slovak Republic, pp. 364-367, 2015. Publisher IEEE, 345 E 47TH ST, NEW YORK, NY 10017 USA. Accession Number: WOS:000380458300062.

[15] NIKITIN, Yu., TURYGIN, Yu., SOSNOVICH, E., BOZEK, P.: Trends in Control of NC Machines, *Procedia Engineering*, Vol. 149, pp.352-358, 2016. doi: 10.1016/j.proeng.2016.06.678

[16] HRUBOŠ, M., SVETLÍK, J., NIKITIN, Yu., PIRNÍK, R., NEMEC, D., ŠIMÁK, V., JANOTA, A., HRBČEK, J., GREGOR, M.: Searching for collisions between mobile robot and environment, *International Journal of Advanced Robotic Systems,* September-Octob., pp. 1-11, 2016. doi: 10.1177/1729881416667500.

[17] TURYGIN, Yu., BOŽEK, P., NIKITIN, Yu., SOSNOVICH, E., ABRAMOV, A.: Enhancing the reliability of mobile robots control process via reverse validation, *International Journal of Advanced Robotic Systems,* November-December, pp. 1-8, 2016. doi: 10.1177/1729881416680521.

[18] ABRAMOV, I., NIKITIN, Y., ZORINA, O., BOŽEK, P., STEPANOV, P., STOLLMANN, V.: Monitoring of technical condition of motors and bearings of woodworking equipment, *Acta Facultatis Xylologiae,* Vol. 56, No. 2, pp. 97–104, 2014.

[19] SAGE, E.P., WHITE, C.S.: *Optimum control of systems*: Trans. from the English / B.R. Levina. - M .: Radio and Communication,pp. 392, 1982. (Second ed.: USA, 1977) (Original in Russian)

[20] Krasovskogo, A.A.: *A handbook on the theory of automatic control* / A.A.Krasovskogo, M.: Science. Gl.red.phys.-math. lit., p. 712, 1987. (Original in Russian)

Review process

Single-blind peer review process.

Acta logistica - International Scientific Journal about Logistics
Volume: 5 2018 Issue: 1 Pages: 25-29 ISSN 1339-5629

doi:10.22306/al.v5i1.88

Received: 28 Mar. 2018
Accepted: 31 Mar. 2018

PLANNING AND ECONOMIC PERSPECTIVE OF MATERIAL FLOW

Michal Buša
Technical University of Košice, Institute of Logistics, Park Komenského 14, Košice, Slovakia,
e-mail: michal.busa@tuke.sk (corresponding author)
Ivana Kazimírová
Virgin Australia Group, Brisbane Domestic Airport, Eagle Farm, Brisbane, Australia,
e-mail: ivana.kazimirova@virginaustralia.com
Martin Paška
Technical University of Košice, Institute of Logistics, Park Komenského 14, Košice, Slovakia,
e-mail: martin.paska111@gmail.com
Eduard Puškáš
Technical University of Košice, Institute of Logistics, Park Komenského 14, Košice, Slovakia,
e-mail: eduard.puskas@gmail.com
Csaba Farkas
Technical University of Košice, Institute of Logistics, Park Komenského 14, Košice, Slovakia,
e-mail: csbfrks92@gmail.com

Keywords: material flow, planning, costs, economic perspective

Abstract: The production is usually divided into quite a number of handling, control and technological operations in the production enterprise, and these are realized at different workplaces. Parts, semi-finished goods, raw materials and products need to be relocated. For this reason, material flow is created. The material flow is an organized movement of material in the production process or circulation of products. It is characterized by the intensity, frequency, direction, performance, structure, character of the transported material and used technique (transport and handling).

1 Introduction

The term "material flow" represents an organised movement of material in the manufacturing process or product circulation. It is characterised by the direction, intensity, frequency, length and performance, structure, character of transported material and transporting and handling equipment used [1].

As arises from the definition, the material flow includes:

- Material unloading in the plant premises;
- Material movement through production stock warehouses, production shops, production operations, intermediate warehouses and finished product warehouses;
- Dispatch of finished products or waste from plants;

It includes the entire material movement starting with its supply to the plant through all the phases of storage, production and transportation process and ending with their dispatch or with warehouses of business organisations [8].

1.1 The intensity of material flows

The intensity of material flows in the circulation is influenced by factors, of which we can mainly state [4]:

- Diversification process as a process extending diversity of elements of the manufacturing process and with it corresponding tendencies, which, apart from the intensity, have also an impact on material consumption;
- Raw material base of the national economy and its regional distribution;
- Irregularity of the rhythm of production;
- Long-term fluctuation of material flow demands;
- Level of information flow management;
- Level of supplier-customer relations, especially selection of suppliers and their determination for selected materials, and integrity and promptness of deliveries;
- Level of organisation management and provision of materials and technologies;

The material flow consists of two basic groups of elements:

- Passive elements of the material flow i.e. materials, raw materials, semi-finished products and finished products;
- Active elements of the material flow, i.e. transport, handling and storage operations [4].

In enterprises, the material flow is formed by the flow of all kinds of working objects (passive elements) such as:

- Raw materials and basic materials;
- Work in progress;
- Finished products;
- Waste;
- Purchased products and semi-finished products;
- Auxiliary material (lubricants, cleaning agents);
- Spare parts;
- Packages;
- Small items and non-durable goods [2].

The most significant group, which, at the same time, forms the most relevant part of the material flow are raw and other materials and corporate work in progress and finished products. All the types of working objects are used throughout enterprises in certain amounts, internal structure, and direction with certain frequency [3].

2 A standard material flow planning process

A) Activity: Planning of raw materials - verification of disposition of raw materials, creation of appeals (call-off) and orders (activities 010,020,030,040) (Figure 1).

Description of the activity:

1. After actualization of the production plan in the system SAP and data transferring to *MAP xr*, the raw material scheduler checks the requirements of all needed raw materials (for suppliers outside the EDA). The production plan is updated weekly on Tuesday. Requirements for materials are checked on a daily basis.

2. In parallel to the point 1, the raw material scheduler checks the state of raw materials supply in the raw material store (including the consignment store) for the next 4 weeks. This time period may be extended depending on the agreed delivery times.

3. In the case of need (negative stock supply, level of supplies under the safe limit, supplies exceeded maximal available level), the scheduler of raw materials realizes modifications in the *MAP xr* system.

a. Modify the amount of the current call-off,
b. Create a new call-off,
c. Cancel the actual call-off,
d. Modify the date of the actual call-off,
e. Create a new order (only in the case of suppliers who deliver fixed quantities),
f. Generate a list of call-off and send to suppliers.

Output: Updated schedule of raw material delivery in the *MAP xr*, list of call-off, orders (created in SAP).

B) Activity: Assurance of raw materials supply (activities 050,060,070,080) (Figure 1).

Description of the activity:

1. After receipt of positive feedback from suppliers, the raw material scheduler assures the material transport according to the confirmed date of loading. Transport is realized by the forwarding company, contractors of the enterprise. This applies to EXW supplies.

2. The scheduler of raw materials monitors the deliveries (quantity and time) and determines the priorities for unloading if it is necessary. Two automatically generated daily reports sending by e-mail present a tool: critical deliveries and warning list.

Output: Delivery, call-off, confirmation of the order by suppliers, plan of transport.

C) Activity: Actualization of the planning system (*MAP xr*) in the case of suppliers who have EDA (activities 100,110,120,130) (Figure 1).

Description of the activity:

1. After the production plan actualization in the SAP and data transferring to *MAP xr*, the responsible person by supplier checks the requirements for each material. By agreement, this is done once a week, after receipt of a suggestion from the raw materials planner.

2. In parallel with the point 1, the responsible person by supplier checks the availability of raw materials in the local store (including the consignment store) for the determined period which may vary according to the agreed delivery times.

3. In the case of need (deficiency of supplies, supplier under the level of safe limit, supplies exceeded maximal available level), the supplier realizes modifications in the system *MAP xr*:

a. Modify the amount of the current call-off (reference),
b. Create a new call-off,
c. Cancel the actual call-off,
d. Modify the date of the actual call-off.

Output: Updated delivery plan of the material in the *MAP xr* (date of reference = ETA).

D) Activity: Control of raw material delivery by the supplier (activity 150) (Figure 1).

Description of the activity:

1. The supplier organizes the transport in accordance with agreed rules (minimal and maximal supplies) by the state of supplies.

2. The supplier sends to customer and delivery enterprise (if the material is stored in external store) notification of details of transport at least one day before the delivery.

E) Activity: Control of risks of material supply (activity 160,170,180,200) (Figure 1).

Description of the activity:

1. The scheduler of raw materials is in contact with the supplier about the actual state of the critical delivery (quantity, time).

2. The scheduler of raw materials is also in contact with scheduler of production about possible modifications in the production plan, alternative solutions are prepared. If it is necessary, the scheduler of raw materials will contact other suppliers to provide a replacement solution.

3. The scheduler of raw materials negotiates with the supplier, transporter about data and information about the quantity and time, who takes responsibility for losses, demands remedial actions as to the future.

4. The scheduler of production modifies the production plan according to the latest information.

Output: Updated production plan. Invoice for the production failure. Recording with corrective actions.

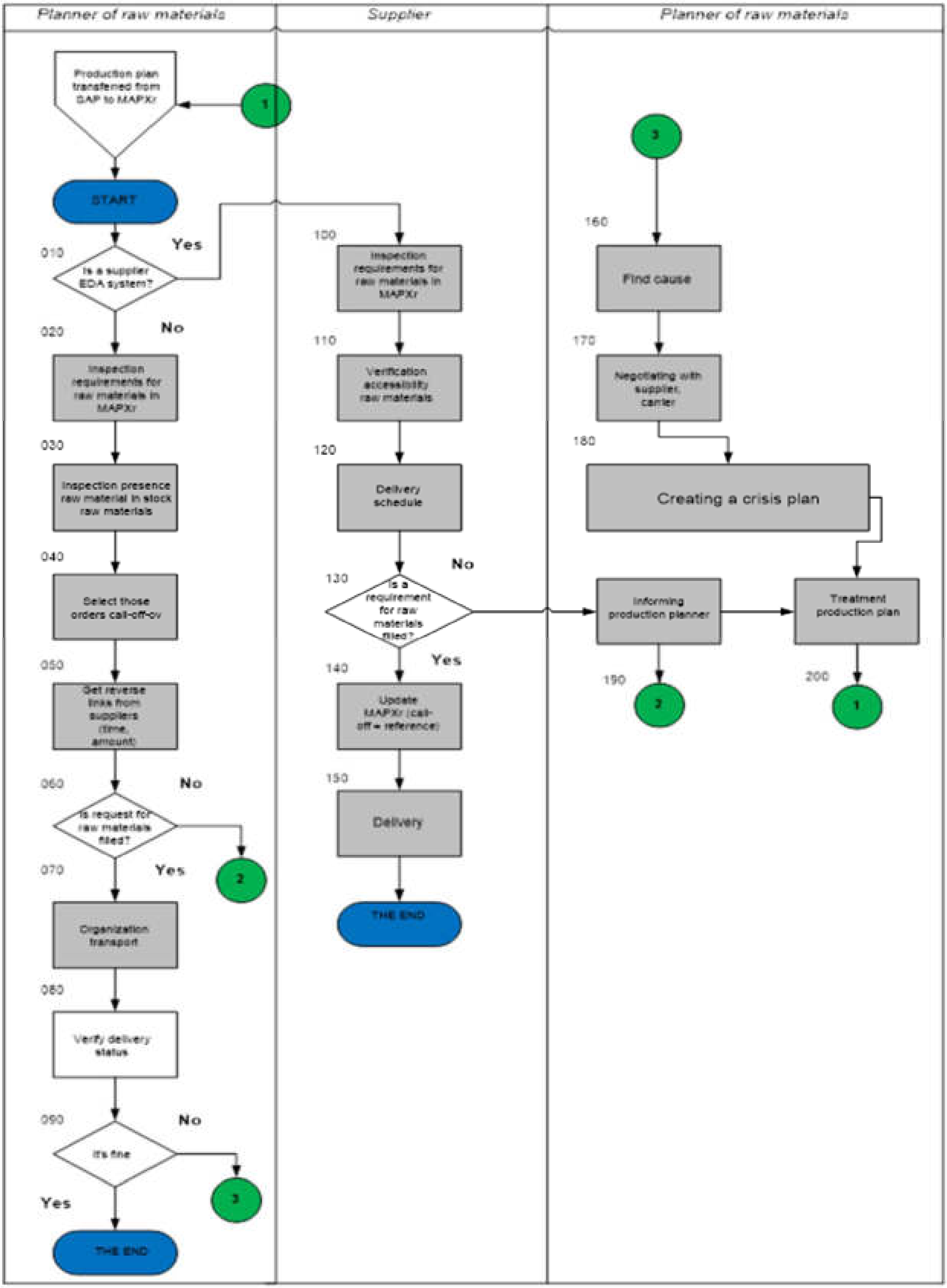


Figure 1 Process flowchart: A standard material flow planning process

3 Economic perspective of material flow

From the economic perspective costs connected with material flow execution cover [6]:

1. Payroll expenses related to wages and salaries of handling performing employees working in the field of in-house transportation, warehouse management or management of packaging and a part of salaries of individual and other workers, who deal with material handling in their working time;
2. Fuel and power expenses;
3. Package costs and costs of long-time consumer goods used up for handling;
4. Maintenance costs and repairs of machinery designed for material handling;
5. Depreciations of sites, buildings and equipment designed for material handling;
6. Other costs such as administrative costs, lighting and heating costs etc. [5].

The amount of the above costs directly relates to the level of material flow, its length and the volume of material under transport.

The level of material flow and with that connected costs are both influenced by a large group of space, production, organisation and personnel-related factors, of which the most important are:

1. Enterprise territorial location in relation to its suppliers, customers, governing bodies, transport networks (railway, roads, water courses), power and water supply etc.;
2. Layout of buildings in enterprises' premises;
3. Network of horizontal and vertical character between and inside buildings;
4. Power and utilities, including water, steam and power supply etc.;
5. Buildings and their properties such as shape, area they take up, layout of doors, beams etc.
6. Produced amount and product mix – amount and mix of produced parts, purchased parts and batch sizes;
7. Type of production – piece, batch or mass production;
8. Character of machinery – number, character and use of machines, degree of mechanising and automation;
9. Arrangement of workplaces – object, technological, site production etc.
10. Handling equipment – number, character, use and degree of mechanising and automation;
11. Technological procedure specifying the progress of certain product manufacturing;
12. Ergonomic, hygienic, safety and other requirements [7].

4 Results and discussion

All these factors influence the spatial structure of manufacturing process and level of material flow, whether in a positive or negative way [9]. An element, which is important or even inevitable for the execution of material analysis module is the need to have available or to prepare operational production records [10].

1. Recording the actual progress of manufacturing process;
2. Provided data:
   - Actual issued product amounts;
   - Periods of individual operations and products implementation;
   - Labour and material consumption;
   - Deviations, failures and their causes;
3. Activities connected with the provision of production records:
   - List of production documents;
   - Corporate own recording and processing of data on the actual progress of manufacturing process;
4. System of production documents:
   - Technical documents (drawing, bill of materials, technological procedures...);
   - Documents for work progress management (work sheets, identification sheets, deadline sheets..),
   - Issue documents (issue slips);
   - Handover documents (handover sheet);
5. System of initial documents:
   - Identification sheet;
   - Work sheet;
   - Handover sheet;
   - Material issue slip;

The production program must take into consideration the size of production capacity and the chain of consecutive, branching and parallel processes from the perspective of IPO (input-process-output) schemes that make it possible to specify inputs required (basic raw and other materials, semi-finished products and components, auxiliary materials, power and utilities etc.) stated both in material volumes and monetary values [11].

Examples of fundamental factors that have to be considered for the purposes of material analysis of the manufacturing process [5]:

- Availability of given basic materials;
- Possibility to substitute given materials should those be not available;
- Quality of raw and other materials is examined using a set of physical and chemical properties;
- Distance of material (raw material) sources that influences the amount of transportation costs;
- Level of the risk connected with the provision of given raw and other materials;
- Price level of raw and other materials that is directly shown in production costs;

The price cannot be considered separately but in its relation to quality – the higher the quality of raw materials the lower the specific consumption. This might lead to reduced production costs compared to the use of raw materials of lower quality [8].

5 Conclusions

Great attention needs to be paid to power and utilities demands. Demands related to material and power and utilities inputs make it possible to determine some cost parameters (or parameters, on which these costs depend) that form part of input data for the purpose of economic efficiency assessment. A well-arranged summary of cost quantities related to material inputs and power and utilities should contain:

- Names of material inputs or power and utilities and their units of measure;
- Standard of consumption per unit of manufactured products;
- Expected purchase prices per unit of material inputs or powers or utilities;
- Expected costs per unit of production;
- Expected costs per assumed (scheduled) production volume;

Calculations of material input and power and utilities demands make it possible to specify the level of material inventory with its impact on the economic side of the model (not only do material inventories hold funds in a long run but they also require storage, for which storage capacities need to be established) [11].

References

[1] BIGOŠ, P., KISS, I., RITÓK, J., KASTELOVIČ, E.: *Materiálové toky a logistika II*, Košice: Elfa, 2008. (Original in Slovak)

[2] DAŇKOVÁ, A. et al.: *Podnikanie malých a stredných podnikov*, p. 198, Prešov, 2007. (Original in Slovak)

[3] GREGOR, M., KOŠTURIAK, J.: *Just in time,* ELITE Bratislava, 1994.

[4] KRAJCOVIČ, M. et al.: *Priemyselná logistika*, EDIS, Žilina, 2004. (Original in Slovak)

[5] MALINDŽÁK, D. et al.: *Teória logistiky*, Karnat, 2007. (Original in Slovak)

[6] ROSOVÁ, A.: *Logistika a náklady podniku,* Košice, Dekanát - Edičné stredisko, 2011. (Original in Slovak)

[7] SANIUK, S., SANIUK, A.: *Production orders planning in a network of small and medium sized enterprises,* 31-38, Contemporary problems in managing production and services supporting manufacturing processes, Series of monographs, Łódź, 2009.

[8] SPIŠÁK, J.: *Logistika obslužných procesov*, Košice, Elfa, 2005. (Original in Slovak)

[9] SPIŠÁK, J.: *Logistika obslužných procesov II.*, ES AMS FBERG, 2006. (Original in Slovak)

[10] VIESTOVÁ, K. et al: *Lexikón logistiky,* Bratislava: Iura Edition, 2007. (Original in Slovak)

[11] WITKOWSKI, K.: Quality of Service in Logistics, *Nové trendy v manažérstve kvality*, Vol. 4, pp. 285-289, 2011.

Review process
Single-blind peer review process.

JOURNAL STATEMENT

Journal name:	**Acta logistica**
Abbreviated key title:	Acta logist
Journal title initials:	AL
Journal doi:	10.22306/al
ISSN:	1339-5629
Start year:	2014
The first publishing:	March 2014
Issue publishing:	Quarterly
Publishing form:	On-line electronic publishing
Availability of articles:	Open Access Journal
Journal license:	CC BY-NC
Publication ethics:	COPE, ELSEVIER Publishing Ethics
Plagiarism check:	Worldwide originality control system
Peer review process:	Single-blind review at least two reviewers
Language:	English
Journal e-mail:	**info@actalogistica.eu**

The journal focuses mainly for the original and new, interesting, high-quality, theoretical, practical and application-oriented contributions to the field of science and research as well as to pedagogy and education in the field of logistics and transport.

Publisher:	**4S go, s.r.o.**
Address:	Semsa 24, 044 21 Semsa, Slovak Republic, EU
Phone:	+421 948 366 110
Publisher e-mail:	**info@4sgo.eu**

Responsibility for the content of a manuscript rests upon the authors and not upon the editors or the publisher.