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METHODOLOGY FOR EFFICIENCY IMPROVEMENT IN WAREHOUSES: A CASE STUDY FROM THE WINTER SPORTS EQUIPMENT INDUSTRY

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Abstract: *The paper considers a methodology for efficiency improvement in warehouses. The methodology is developed for the needs of the winter sports equipment division of Amer Sports Corporation. Key aspects of the methodology are the concept development of balanced scorecard for the distribution logistics and the application of lean methods in the warehouse. The main criteria for evaluation of the warehouse processes are examined. The paper presents the implementation of balanced scorecard as a tool for logistics processes and costs monitoring and management decisions in the Amer Sports distribution center for winter sports equipment. The application of the lean methods in the warehouse are also discussed. The paper presents also the improvements achieved by applying the methodology in the warehouse.*

Key words*: warehouse efficiency improvement, balanced scorecard, logistics controlling, lean manufacturing, warehouse management, process optimization, warehouse automation, winter sports equipment products.*

1. INTRODUCTION

Nowadays, factors like globalization, competition, rapid market changes, short product life cycles, high productivity and reduction of time-to-market make the impact of logistics on production by far wider than in the past. Such a complex scenario has led to a considerable interest in the design, planning and control of warehousing systems as new research topics [11].

Warehouses may be defined as material handling stations dedicated to receiving, storage, order-picking, accumulation, sorting and shipping of goods [21]. A significant part of the efforts to reduce production costs and increase the efficiency of industrial enterprises are the rationalization and the modernization of the warehousing systems. Modern industrial production cannot function successfully without proper handling and warehousing processes that ensure its organization in terms of time requests and space restrictions as well as the complexity and the formation of the produced assortment.

The main directions, on which the warehousing activities influence the increase of the overall efficiency of the public production, are [7]:

- reduction of inventories and accelerated turnover of material values;
- increasing regularity and efficiency of technological processes and transport;
- increasing and maintaining the quality of products and raw materials;
- a reduction of total labor consumption and the cost of product;
- improvement of working conditions;
- increase the usability of the production area;
- reduce downtime of vehicles for highway and factory transport;
- exemption of the employees from unproductive handling and storage activities for use in the core production or services.

The literature on warehouse design and performance optimization can be divided into three mainstreams [13, 15]:

1. contributions addressing warehouse design decisions, typically concentrating on order picking routing or product location strategies;
2. papers proposing analytic or simulation models;
3. publications on benchmarking and performance evaluation.

Despite the importance of warehouse design and their management, the literature on warehouse performance assessment is meager, with two mainstreams [11]:

(1) contributions proposing frameworks for designing or analyzing warehouses;
(2) those which directly address performance assessment.

On other hand, many authors agree on the lack of systematic approaches on warehouse analysis and optimization [9, 12]. Aim of this papers is to fill this gap by proposing an integrated approach for warehouse analysis and optimization. This employs several tools borrowed from lean manufacturing additionally to the well-known methods for efficiency improvement.

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Furthermore, for the purpose of monitoring and performance analyses a balance scorecard is developed considering the specific logistics needs.

The methodology is implemented in the central distribution center for winter sports equipment of Amer Spots Corp. Some of the applied improvements as well as the improvement of certain key performance indicators (KPI) will be discussed.

2. THE CASE COMPANY AND SPECIFICITY OF THE WINTER SPORTS EQUIPMENT BUSINESS

The case company Amer Sports Corp., established in 1950, has a long history of commodity products. In the end of the 1980s a decision was made to transform the company entirely into a sporting goods one. The first sporting goods brand was acquired in 1989 followed by further acquisitions over the next 19 years. At the time of the study, the company owned seven global business units providing customers with sports equipment for a range of summer and winter sports, indoor and outdoor sports, sports instruments as well as fitness equipment. At the center of the study is the specialized warehouse for winter sports equipment (WSE) located in Altenmarkt, Austira. The WSE division includes the following brands:

- Atomic: alpine skiing and cross-country skiing products;
- Salomon: alpine skiing and cross-country skiing and snowboarding products
- Armada: alpine skiing products.

The winter sports business is characterized by high seasonality with a strong dependence on weather conditions and snow cover that determine consumer demand [8]. The demand development for winter sports goods can be defined as a stagnating market. For example, the alpine ski market worldwide ranged between 5 and a little over 7 million pairs between 1980 and 2000 and then fell to 4.1 million in 2004. One of the main reasons for this was the drop in sales on the Japanese market, which from 2.5 million pairs in 1992 shrank to 0.5 million pairs. The main reasons for this decline are the demographic structure of the population (aging population) and the greater interest of young people in electronic and video games. This decline was also observed in other markets, such as imported ski shoes in the US, from 1.2 million in 1988 to 700,000 pairs [3]. The statistical portal "Statista" also gives insight into the development of worldwide sales of winter sports goods, although product grouping is made on different criteria. The group of winter sports equipment includes skis, ski bindings, poles and snowboards and ice skates, but helmets and ski goggles are excluded. However, the provided data gives a good idea of sales levels and future expectations. On Fig. 1 are shown the sales values of winter sports equipment in North America and the expectations for the next years.

Although the winter sports business is not a growing market, the business and the products are highly complex. The sales planning of new collections is a substantial and relatively long and sophisticated process.

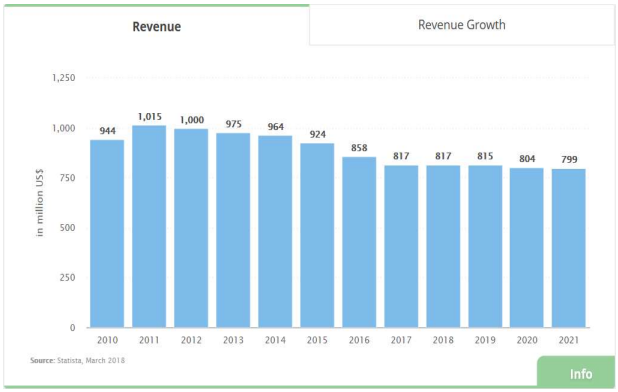

Fig. 1. Sales value of winter sports goods in North America [22].

For example, the development of collection 2016/2017 begins in the fourth quarter of 2014, the production starts a year later in the fourth quarter of 2015 and the order intake starts in February 2016 after the trade fair for sport business in Munich – ISPO.

There are two main types of orders in the sports business: pre-orders and re-orders. The pre-orders are done during the spring (Feb-May) for deliveries starting from August. The re-orders are done during the season and are considered as immediate orders.

The pre-orders are approx. 30% of the total number of orders representing 80% of the total units. The delivery on time is essential part of the customer expectations, especially for the re-orders, for which the customers are expecting 48–72 h delivery time (from order intake to order receipt). The re-order service requirement increased in the last years as the retailers are also trying to reduce the risk on their side.

Due to the above-mentioned specific features of the winter sports business, 95% of the company's production is produced in Europe. This is typical not only for Amer Sports Corp. but also for all European producers of winter sports goods [10]. Thus seeks to compensate the high uncertainty caused by dependency on the weather conditions and the high deviations between forecasted and actual sales by increasing the flexibility in the manufacturing process and the delivery time.

The high customer requirements increased not only the importance of the logistics but meant also a significant change for the warehouse – the delivery execution time (pick & pack) for re-orders needed to be reduced from 48h to same day delivery without increase of the warehouse operational costs. In order to fulfill the requirements it was necessary:

- to set a control and monitoring tool that allows a complex overview of the warehouse processes and cost drivers;
- to define the areas of improvement;
- to improve without high capital investments.

3. DEVELOPMENT OF WAREHOUSE BALANCED SCORECARD

3.1. The balanced scorecard concept

In the late 1980s, many scientists have expressed concern about traditional performance measures that

focus only on financial performance. Researchers criticize these measures because they believe they encourage managers to focus on short-term financial results while ignoring long-term prospects [14]. Performance measurement (PM) in the context of supply chain becomes more important. The reason is obvious: companies are starting to look for ways to improve operational efficiency through better integration of the operations of successive echelons and separate functions in the value chain [19]. In the yearly 1990s, Kaplan and Norton developed a balanced system of financial and non-financial indicators, structuring the outcomes in four perspectives. This balanced system of indicators preserves financial indicators as key performance indicators for the company, but complements them with indicators of three additional perspectives (customer, internal business processes and learning and growth) (Fig. 2). The purpose of these additional perspectives is to create a long-term shareholder value [16].

By its nature the Balanced Scorecard (BSC) is a comprehensive change program that makes it possible to modify virtually every aspect of the organization. The name itself (score) emphasizes the need for arrangement in order to ensure a balance between key parameters of the organization in the process of managing change in it. One of the first applications of the balanced scorecard are aimed at enriching the means of reporting quality of management "panels indicators"(dashboard) [18].

Widespread is the perception of evaluation of results as a tool for control and assessment of the performed activities. The evaluation of results through a balanced scorecard should be used in a different way - to express the strategy of the organization, to disseminate the strategy and to support the linking of individual, company and inter-agency initiatives and activities in order to achieve common goals. Used in this way, the balanced scorecard should be seen as a tool for communication, information and development and not as a controlling system. The four perspectives of the balanced scorecard allow a balance between short- and long-term goals of the organization, between objective and subjective outcomes as well as between the desired results and the factors affecting them. Although the multiplicity and variety of indicators might seem confusing, a well-constructed map of indicators constitutes a unity in its purpose, as all indicators aim to achieve an integrated strategy [17].

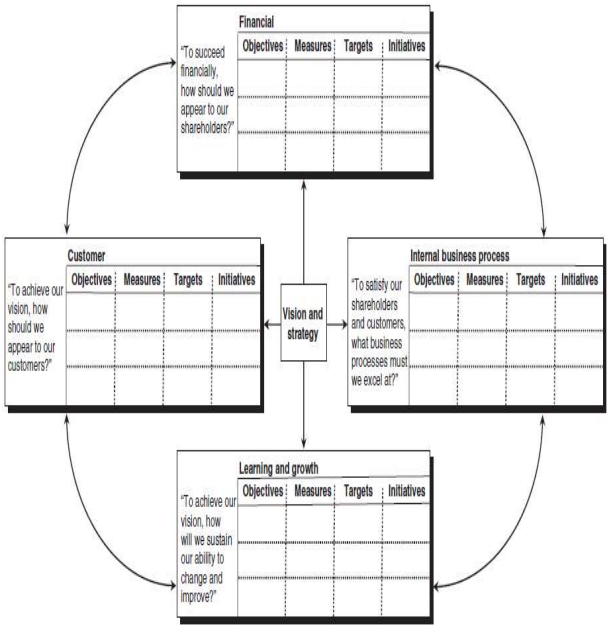

Fig. 2. Translating vision and strategy: four perspectives [16].

3.2. Logistics controlling and balanced scorecard adaptation

The high complexity of the logistics systems and the increased performance requirements for them are increasing the necessity for targeted planning, management, control and coordination of the different logistics fields. These tasks are treated by the logistics controlling with the following purposes [5]:

- permanent control of economic efficiency (costs, productivity, etc.) by comparing planned and actual indicators;
- collecting, processing and providing information for taking management decisions.

By developing a comprehensive cost and performance reporting system and a system of performance indicators, it is aimed to achieve the most accurate and up-to-date evaluation of the logistics activities. The implementation of a logistics system of indicators aims the solving of the following problems [5]:

- optimal solution of conflicting objectives;
- clearly defined targets for the logistics;
- early detection of deviations, opportunities and risks;
- systematic search for problems and their causes;
- developing the improvement potential;
- accurately defined evaluation of the results;
- employees evaluation according to the results;
- continuous support in performing routine logistics tasks.

It is recommended that the management through indicators to be done with a balanced scorecard tailored to the logistics needs and requirements. Table 1 shows the adapted balanced scorecard to the logistics needs.

For the needs of the warehouse it is proposed that the four perspectives of the balanced scorecard to be supported with the logistic controlling method. As a result, a warehouse balanced scorecard should contain the following four perspectives: structure, cost, productivity and quality [1]. The indicators in the four perspectives should provide the following information [5]:

- perspective structure: production capacity and order/delivery structure, number of employees and technical means, as well as the costs for the considered period;
- perspective costs: identification of logistics activities and related costs;
- perspective productivity - productivity of employees and technical means;
- perspective quality – evaluating the level of achievement of the set goals.

Table 1

Derivation of logistics indicators based on the balanced scorecard [2]

Balanced Scorecard	Strategic Task	Indicators
Finance	Cost reduction	- Preparation costs per unit - Administrative processing costs per order - Delivery costs per unit - Logistics costs to revenue
	Reduction of capital tied up in current assets	- Value of the current assets per product at the end of the period - Inventory range - Turnover
Customer	Improvement of the customer satisfaction	- Satisfaction index - Complaint rate
	Increase market share in a particular market segment	- Market share in the market segment
	Increase customer profitability	- Logistics costs per customer
	Improvement of delivery flexibility	- Duration of fixation horizon for customer orders
Internal business processes	Reduction of deviations from the agreed delivery capacity	- Delivery punctuality - Percentage of stored non-demand products - Complaint rate
	Increase in delivery reliability	- Delivery reliability
	Cycle time reduction	- Average duration of order processing - Average processing time of complaints
	Increase cost transparency	- Proportion of logistics processes with reported cost parameters compared to the total number of logistics processes in the company
	Increase performance transparency	- Proportion of logistics processes with regular performance recording compared to the total number of logistics processes in the company
	Increasing the ability to provide information to customers	- Proportion of the ability to provide information on the first customer contact
Learning and growth	Develop innovative services for customers	- Proportion of logistics services implemented in the last 2 years
	Encourage process thinking of employees	- Proportion of employees with experience in the different logistics fields
	Increase employee satisfaction	- Satisfaction index - Absenteeism - Staff fluctuation rate

3.3. Implementation of warehouse balanced scorecard

In order to improve the monitoring of warehouse processes and the identification of potential problems and opportunities for improvement, it was decided to implement the balanced scorecard as a management and communication tool at the distribution center for winter sports equipment products of Amer Sports Corporation. Table 2 presents the structural framework of the implemented balanced scorecard with some of the used indicators.

The developed balanced scorecard contains not only the four logistics-adapted perspectives but also the strategic tasks outlined in section 3.2. In addition, the perspectives and the strategic tasks are applied not to the warehouse as a whole but to each of its units (departments). The operations in the distribution center concerned are divided into the following departments: inbound (goods receipt), product storage, picking, service (ski mounting and service), packing, loading and transportation. Applying the approach of the balanced scorecard at the lowest structural level, aims to provide comprehensive information about the processes and the related activities.

The implementation of this concept was accomplished through the development of a database and the development of dashboards. In this way, the following tasks are intended to be fulfilled:

- providing logistics data for detailed analyses;
- providing a management tool for activities, costs, and deviations tracking;
- providing a communication tool for the logistics and the company employees.

In Fig. 3 the implemented balanced scorecard is shown where the following information is provided:

Table 2

Structural framework of the warehouse balanced scorecard

	Structure	Performance	Costs	Quality
Inbound	• deliveries/ truck • average order lines/truck	• unloading time per truck • direct working h/working h	• costs/loading unit • costs/truck	• failures during inbound • inbound forecast accuracy
Storing	• fill rate per LU • stock turnover rate	• Working h scrapping • units per product group	• costs/Loading unit • maintenance costs	• # inventory diff. € • disposability of forklifts
Picking	• average lines/delivery • average quantity/line	• inbound working h/working h • units picked/hour	• costs/delivery • costs/unit	• outbound forecast accuracy • # picking failures
Service	• number assembled Units/ product group • number assembling/delivery	• assembled units/hour • operating hours/machine	• assembling costs/unit • costs of incorrected assembling	• # customer claims/assembled units • # incorrect assembling/total assembling
Packing	•average lines/delivery • average quantity/line • number SKU/parcel	• direct working hours • indirect working hours • units/hour	• costs/delivery • costs/line • costs/Unit	• outbound forecast accuracy • # packing failures • # incidences
Outbound	• fill rate/container • number storing positions	• turnover rate/day (Pallet, parcel) • loaded pallets/day	• costs/loaded pallet • costs of not exchanged pallets	• # of loading errors • # overspent loading times
Transportation	• number deliveries /country • number trucks/country	• deliveries On time/total deliveries • scheduled trucks, FCL	• freight costs • costs/carrier, parcel service	• # damage in transit • # lost deliveries

Fig. 3. Snapshot of the developed warehouse balanced scorecard.

- Workload and Complexity is monitored for each of the departments in the warehouse;
- Working Hour Structure – information about the productive, non-productive and absenteeism hours for each department;
- Productivity – productivity performance for each department;
- Cost Structure – fix and variable costs per department and in total;
- Safety – special focus on the working accidences and their severity;
- Logistics Service – information about the transportation quality and customers complaint.

The dashboard provides detailed information on a monthly basis and offers a comparison option between different calendar years. In this way it provides not only a compact information but also an easy comparative analysis of the changes. Due to the high seasonality of the winter sports goods in just one season of the year, the provision of data on a monthly and annual basis is sufficient for the practical needs and the abovementioned management objectives.

With the balanced scorecard implementation the following results were achieved:

- increased transparency of changes in the warehouse processes due to company decisions or customer requirements;
- high productivity transparency;
- increased costs transparency for each unit (department) of the warehouse; improved internal communication;
- increased focus on customer satisfaction;
- improved analysis for employees training and development;
- improving information for decision making.

4. LEAN WAREHOUSING

The research community has only recently started the application of lean principles to the warehouse, because only the integration of lean tools allows to analyze the overall warehouse management problem from different point of view solving it in a more logical approach. However, the related literature is meager and the lean tools are rarely integrated into a streamlined, high quality system [11].

Koether and Meier propose an application classification of the lean tools in the warehouse. According to their classification the following lean tools can be easily applied in the warehouse: 5S, process standardization, waste elimination, 5 W's, 8D problem solving, Ishikawa diagram, Six Sigma, Self-inspection, Low Cost Automation, idea management, PDCA, Audit, Total Productivity Maintenance, Just in Time, Value Steam Mapping, Kanban, Milk run, Supermarket [4].

Although the proposed tools can be used in the warehouse and can increase the productivity, it is still missing an integrated approach of the application of the lean tools in the warehouse – when to use it, what should be their role and how can they supplement the existing logistics optimization methods.

5. MAIN STEPS OF THE METHODOLOGY TO INCREASE THE WINTER SPORTS EQUIPMENT WAREHOUSE EFFICIENCY

Based on the analyses done in the previous sections it was shown that the optimization of warehouse processes should not only be accurate and clearly systematized but also the effect of their application should be controlled. Moreover, due to the fact that the warehouse is the last unit in the supply chain, a very good coordination with the other units of the company is also necessary.

The optimization according to the proposed methodology is done in the following order (Fig. 4):

Step 1: Assignment – specification of optimization requirements.

The formulation of the problem is one of the most responsible steps in the optimization of the warehouse

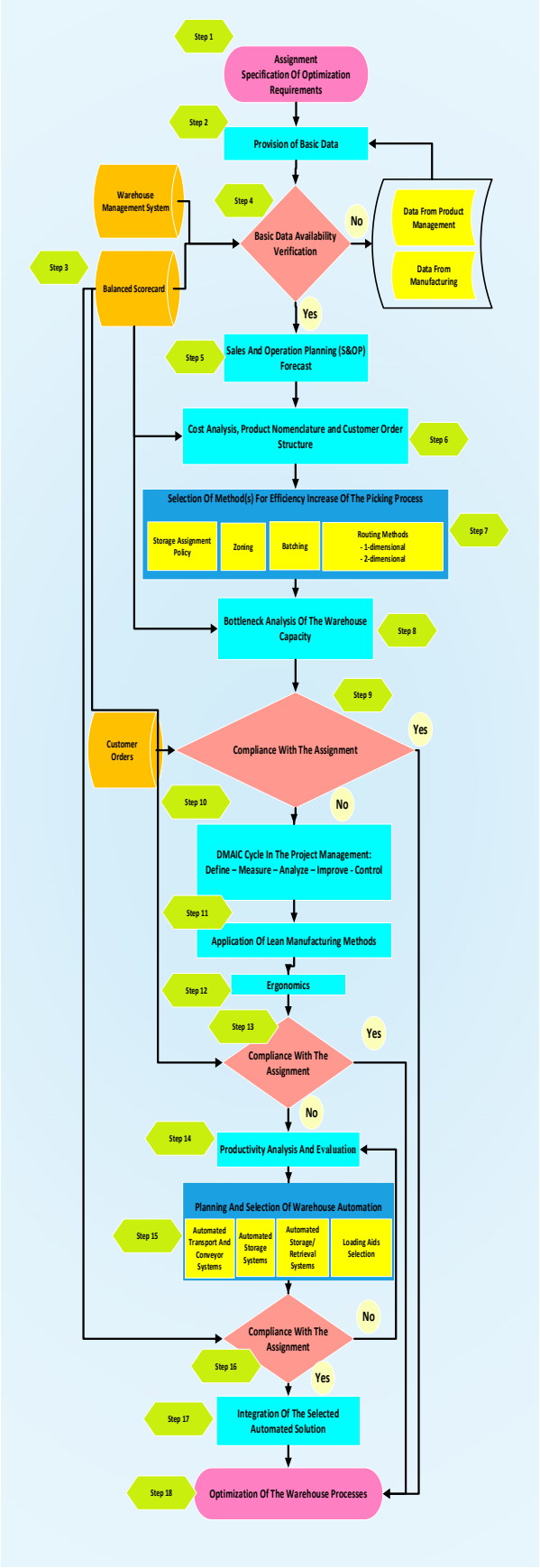

Fig. 4. Methodology for WSE warehouse efficiency increase.

processes. Therein must be clearly defined what is the ultimate goal, namely: reduce costs, reduce cycle time, improve the quality of performance (reduce errors) or increased occupational safety.

Step 2: Provision of basic data for the warehouse management system.

The master data is the basis for the efficient operation of the warehouse. They must be responsibly maintained as is the case with the winter sports goods and expanded with specific information such as technical restrictions – e.g. there are skis and bindings which cannot be sold together, correlated products – e.g. certain helmets and goggles are designed to be sold together.

Step 3: Warehouse balanced scorecard.

The balanced scorecard is an essential tool for monitoring and controlling the processes, their quality, product complexity (number of stock keeping units) and the customer orders complexity.

Step 4: Verification of the basic data availability.

The responsibility for the scope and reliability of the basic data is not only logistics responsibility but mainly product management and manufacturing responsibility. In case of non-compliance or lack of necessary basic data, it is important to have good coordination and communication between the departments within the company so that they can be timely corrected or complemented. The basic data includes the master data, inventory data, movement data and unit load and packing master data.

Step 5: Providing sales and operation planning (S&OP) forecast.

The information about the planned sales is significant for the design of warehouse processes for winter sports products. Due to the high seasonality and long planning processes the forecasted sales of winter sports goods are not reliable regarding the volumes. However, this information has a great value for the warehouse management. As it is stated by [20], even if the forecast is inaccurate, the distribution of the items in the product group does not change. A statement that has been confirmed for the winter sports products. This allows ABC classification of the products, which, depending on the storage policy applied, can lead to increased efficiency.

Step 6: Cost analysis, product nomenclature and customer order structure.

The information available from the balanced scorecard provides a detailed cost analysis of the logistics departments, the structure (complexity) of the orders and the quality of performance. The information analyzed in this step serves as a basis for comparison with data obtained after optimization. The data analyzed in this step also serves to determine the methods for efficiency increase.

Step 7: Selection of method(s) for efficiency increase of the picking process

Based on the data analyzed by the balanced scorecard and taking into account the peculiarities of the warehouse the most appropriate methods or combination of them are chosen in order to increase the efficiency of the picking process. The following decisions needs to be taken at this step: storage assignment policy, implementation of zoning; implementation of batching; routing methods.

Step 8: Bottleneck analysis of the warehouse capacity

In this step an analysis of the required and the available capacity of each of the departments in the warehouse is carried out. This analysis is carried out at the beginning of June, after completion of the order intake of the main client orders (pre-orders), which represent about 80% of the total quantity ordered for the year.

Step 9: Check for compliance with the assignment

In case the methods for efficiency increase of the picking process fulfill the requirements of the assignment and the departments in the warehouse have the necessary delivery capacity the optimization task can be considered as successfully accomplished. If this is not the case, then it will be proceeded with the next step.

Step 10: Implementation of the DMAIC cycle in the project management.

In the implementation of the lean philosophy in the distribution logistics processes is not only important to have a responsible project manager for the management and execution, but also to ensure transparently through and sustainability of implemented methods and processes. The methodology of the DMAIC cycle meets these requirements [1].

Step 11: Application of Lean Manufacturing Methods.

Application and implementation of Lean Manufacturing methods appropriate to the activities and characteristics of the warehouse.

Step 12: Implementation of ergonomics

Due to the specificities of the processes in the warehouse, under ergonomics meant [6]:

- stress due to the organization of work (interaction between man and company resources, as well as working conditions – light, temperature, humidity, etc.);
- energetic stress – this is a stress in consequence of which the musculature, the cardiovascular system and the metabolism are affected;
- information stress – this is a stress that leads to mental exhaustion as a result of receiving, processing and transmitting information;
- psychological stress – the following factors influence the human psyche:
  - working tasks – short deadlines for execution, decision-making without the necessary information;
  - working environment – noise, light, etc.;
  - organizational structure in the enterprise – structural changes, vaguely defined responsibility and others;
  - social aspect - poor working atmosphere, lack of communication and so on.

Step 13: Check for compliance with the assignment

In case the methods of steps 10, 11 and 12 fulfill the requirements of the assignment, the optimization task can be considered as successfully accomplished. If this is not the case, then it will be proceeded with the next step.

Step 14: Productivity analysis and evaluation.

In this step, a detailed performance analysis is carried out. On its basis the processes that have reached their maximum optimization with the existing technology and at the same time are obstacles for the execution of the assigned task are identified.

Step 15: Planning and selection of warehouse automation.

On the basis of the analysis done in step 14 the process and the means by which the automation will performed are selected. Depending on the needs automated transport and conveyor systems, automated storage systems and automated storage/retrieval systems can be selected. Additionally, a specialized loading aids can be selected in order to eliminate some constrains for automation caused by the product dimensions of the winter sports products.

Step 16: Check for compliance with the assignment

In case of fulfillment of the assignment it will be continued to step 17 and in the event of non-compliance it returns to step 14 for a new productivity analysis and evaluation.

Step 17: Integration of the selected automated solution

In this step the chosen automation is integrated into the warehouse and becomes part of the new warehouse processes.

Step 18: Optimization of the warehouse processes according to the assignment.

This step is the end of the optimization process and is reached when the assignment requirements are fulfilled.

6. RESULTS

The integration of methodology in the winter sports equipment warehouse led to the following results:

- Improvement of the basic data availability;
- Development and implementation of warehouse balanced scorecard as tool for data analysis and process monitoring;
- Classed based storage based on S&OP forecast. The other optimization methods – zoning, batching and routing had been already implemented;
- Implementation of the lean philosophy in all logistics levels – shop floor, project management and warehouse management;
- The ergonomics is set as impartible part of the lean management;
- The future automation of the warehouse can be executed faster and cheaper due to elimination of the waste activities.

The following operational improvements have been achieved:

1. Increase of the warehouse delivery reliability from 75% to 99.97%.
2. Reduction of the cycle time (execution time) for the re-orders (immediate orders) (Fig. 5).
3. Occupational Accidents.

The number of the accidents remain the same, however the days off work due to the accidents reduced from 80 to 18 days.

4. Operational Efficiency.

The operational efficiency is measured with the total working hours compared to the shipped units. In this way also the working effort for implementing the lean culture

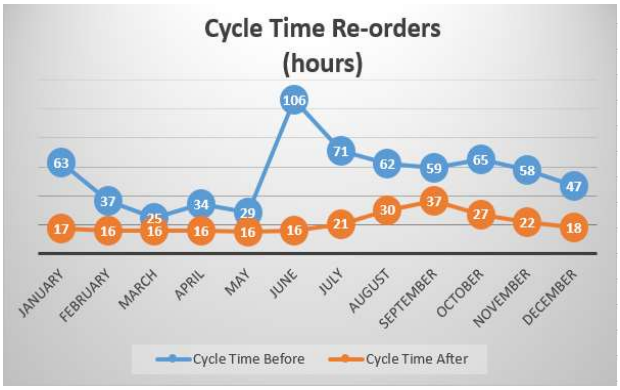

Fig. 5. Cycle time for re-orders Before and After.

and projects is also considered. The operational efficiency measured in this way increased with 13.5% from 20.3 units per hour to 23.1 units per hour.

7. CONCLUSION

The paper proposes a methodology which is designed for the needs of the Amer Sports winter sports equipment warehouse but basically it can be applied to any warehouse. The methodology includes the well-known methods for warehouse operations optimization as well as two additional key aspects - development of balanced scorecard for the warehouse needs and the lean manufacturing tools as intermediate step between the manual and automated processes. The main criteria for evaluation of the warehouse processes are examined. The paper presents the implementation of balanced scorecard as a tool for logistics processes and costs monitoring and management decisions giving a bright overview over the warehouse processes.

The efficiency benefits of the methodology are also presented. By applying this methodology the warehouse was able to fulfill the increased customer requirements by increasing the productivity without high capital investments (e.g. automation).

However, as in the modern warehouse the processes and the operations are IT controlled the further studies should consider the implementation of the lean principles in the warehouse management systems. Furthermore, the lean efficiency improvement boundaries in the warehousing needs to be researched which would encourage the wider enhancement of the lean management.

REFERENCES

[1] H. Augustin, *Lean Warehousing*, HUSS-Verlag, München, 2010.

[2] M. Engelke, A. Rausch, A., *Supply Chain Management mit Hilfe von Key Performance Indikatoren*, Integrative Management- und Logistikkonzepte, (pp. 183-204), Gabler Verlag, Wiesbaden, 2002.

[3] J. Fry, *The Story of Modern Skiing*, University Press of New England, 2010.

[4] R. Koether, K. Meier, *Lean Production für die variantenreiche Einzelfertigung*, Springer Fachmedien Wiesbaden GmbH 2017.

[5] C. Schulte, *Logistik, Wege zur Optimierung der Supply Chain*, Verlag Franz Vahlen München, 2013.

[6] M. Ten Hompel, V. Sadowsky, M. Beck, *Kommissionierung*, Springer-Verlag, Berlin, Heidelberg, 2011.

[7] V. Spassov, *Logistics Engineering*, Press "Technika", 2012.

[8] P. Appelqvist, F. Babongo, V. Chavez-Demoulin, A.P. Hameri, T. Niem, *Weather and supply chain performance in sport goods distribution*, International Journal of Retail & Distribution Management, Vol. 44, Iss. 2 pp. 178 – 202.

[9] P. Baker, M. Canessa, *Warehouse design: a structured approach*, European Journal of Operational Research, Vol. 193, No. 2, 2009, pp. 425–436.

[10] K. Caskey, *Locating medium volume and complexity manufacturing: cases from the ski industry*, Competitiveness Review, Vol. 24, Iss. 2, 2014, pp. 75–94.

[11] M. Dotoli, N. Epicoco, M. Falagario, N. Costantino, B. Turchiano, *An integrated approach for warehouse analysis and optimization*: *A case study*, Computers in Industry, Vol. 70, 2015, pp. 56–69.

[12] J.P. Gagliardi, J. Renaud, A. Ruiz, *A simulation model to improve warehouse operations,* in: Proc. Winter Simulation Conference, 9–12 December 2007, Univ. Laval, Quebec, Canada, 2007, pp. 2012–2018.

[13] J.X. Gu, M. Goetschalckx, L.F. McGinnis, *Research on warehouse design and performance evaluation: a comprehensive review*, European Journal of Operational Research, Vol. 203, No. 3, 2010, pp. 539–549.

[14] Z. Hoque, *20 years of studies on the balanced scorecard: Trends, accomplishments*, gaps and opportunities for future research, The British Accounting Review, Vol. 46, 2014, pp. 33–59.

[15] A. Johnson, L. McGinnis, *Performance measurement in the warehousing industry*, IIE Transactions, Vol. 43, No. 3, 2011, pp. 220–230.

[16] R.S. Kaplan, *Conceptual Foundations of the Balanced Scorecard*, Handbooks of Management Accounting Research, Vol. 3, 2009, pp. 1253–1269.

[17] R.S. Kaplan and D.P. Norton, *The balanced scorecard: Translating strategy into action*. Boston, MA: Harvard Business Press, 1996.

[18] M. Kuzmanova, *Balanced Scorecard – Flexible Tool for Stimulating Changes in Organization*, Economic Alternatives, Issue 6, 2007.

[19] C. Lohman, L. Fortuin, M. Wouters, *Designing a performance measurement system: A case study*, European Journal of Operational Research, Vol. 156, 2004, pp. 267–286.

[20] T. Mostard, R. Teunter, R. de Koster, *Forecasting demand for single-period products: A case study in the apparel industry*, European Journal of Operational Research, Vol. 211, 2011, pp. 139–147.

[21] J.P. van den Berg, *A literature survey on planning and control of warehousing systems*, IIE Transactions, Vol. 31, 1999, pp. 751–762.

[22] www.statista.com – accessed on 2018-03-30.