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PRACTICAL EXPERIENCES OF DIGITALIZATION AND AUTOMATION IN LOGISTICS

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Abstract: *Recently, digitalization and automation have gained more and more space, which has long been felt in the field of logistics. Although we can find examples of both in almost every major company, we can state that each company uses them to a different extent and in different areas. In addition to the fact that we find many different examples, it is typical that they are specifically customized and therefore their introduction requires additional expenditures and changes at other companies. What can and to what extent is it reasonable to digitize and automate? What are the prerequisites for these to be implemented cost-effectively and in the most targeted manner.*

Keywords: *digitalization, automation, logistics, industry*

1. INTRODUCTION

Digitalization and automation in logistics are a particularly interesting task. It is best to automate cyclically repeated, standard operations. Logistics, on the other hand, is an area where unforeseen disruptions and external factors are particularly characteristic, which require quick and effective measures.

This is also why it is important to use digitalization to automate our data collection, data processing and decision-making processes. Physical automation should only be planned after this. Thus, we need to differentiate and plan process and physical automation separately. Physical automation creates a hardware and infrastructural environment, which results in constraints in the system. It requires a lot of investment and can be changed with difficulty or only at high costs, and that too only within certain limits.

In some ways, we are in an advantageous position in case of a new investment, for example, a newly built logistics centre. In such a case, logistics processes and physical activities based on them can be designed on the drawing board from scratch. In those projects, a larger investment amount is typically available, which has been set aside for the project.

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We are also in a good position in regards of restrictions, because there are no established conditions to which we have to adapt, therefore we have relatively large room to maneuver. In this case, it is easier to use plug-and-play or apply ready-to-use solutions that are available on the market and can be used after proper customization.

Design is practically limited only by the available budget. We can plan, verify with simulation and physically implement the processes we envision. We can select the software, machines, and equipment we want to use, as well as create the infrastructure surrounding them, for example, high rack systems in narrow or wide aisle arrangement, fire protection systems, or even the quality of the floor. This is an important strategic decision-making point because these will significantly determine our room for maneuver later.

We are in a much more difficult situation when we want to further develop an already functioning operation. In many cases, all these elements are already given and we either have to adapt to them or change them, which generates additional costs. In any case, our logistics processes must be designed and automated in such a way that a level of flexibility remains in the system, which still gives the possibility to eliminate the disturbances that occur, either within the system or by further develop-ing it. It must be automated to the extent and only as much as is necessary to achieve the set goals. Automation cannot be a goal in itself.

Therefore, this paper introduces the possibilities for involving digitalization and automation techniques into logistics. Following this, the 2nd chapter describes the background of this topic. Then, the third chapter details the main purpose of this paper, i.e., the possibilities of further development of existing systems. Finally, at the end of paper concluding remarks summarize the results.

2. LITERATURE REVIEW

In this section, the literature review from the topic of digitalization and automation in logistics is detailed.

Digitalization is transforming logistics processes through the integration of advanced technologies like artificial intelligence, big data analytics, and cloud computing [1]. These technologies enable real-time data collection, analysis, and decision-making, leading to improved operational efficiency and cost reduction [2]. The Internet of Things, blockchain, and machine learning are key drivers of innovation in industrial logistics [3]. Logistics 4.0 encompasses ten main directions of digitization, including big data, robotization, and 3D printing [4]. While digitalization offers numerous benefits, it also presents challenges such as business complexity and the need for robust risk management practices [1]. Successful implementation requires alignment with business strategies and organizational goals [1]. As digitalization continues to evolve, it is expected to significantly impact the economy, labor market, and competitive landscape [2].

Regarding practical insights of digitalization in logistics is gaining importance, with potential benefits including improved management quality, efficiency, and risk mitigation [5]. Practical experiences highlight the need for incremental approaches when implementing new technologies like automated guided vehicles [6]. Logistics service providers face barriers such as network complexity and resource limitations, while success factors include strong leadership and a supportive organizational culture [7]. In Russia, the integration of information systems is crucial for developing "smart logistics" and enabling synchro modal transportation [8]. Implementation strategies vary, with some companies prioritizing technologies like RFID, electronic document management, and GPS tracking [5]. Despite challenges, digitalization offers significant potential for optimizing logistics processes and improving competitiveness in the industry [7].

Automation in logistics is gaining significant attention due to its potential to enhance operational efficiency and competitiveness [9]. The implementation of advanced technologies such as artificial intelligence, machine learning, and deep learning enables autonomous task execution and reduces human labor dependency [9]. Studies have shown that automation adoption in logistics positively impacts performance, improving efficiency, accuracy, and service speed [10]. The trend towards automated and autonomous logistics systems is reshaping the industry, influencing planning and execution of future processes [11]. Automation strategies can optimize both material and information flows, leveraging technologies like cyber-physical systems, Internet of Things, and physical internet [12]. While automation in logistics shows great promise, it requires further research and development to fully realize its potential and integrate seamlessly with human expertise [9], [12].

Regarding practical of automation, other recent research also highlights the growing importance of automation. Practical automation technologies like, as listed above, artificial intelligence, machine learning, and robotics are transforming supply chains, enhancing operational efficiency, and reducing errors [13]. Mobile robots and delta-style robots are increasingly used for goods handling, packing, and order assembly in warehouses, offering faster and more accurate operations [14]. The integration of human-robot collaboration is seen as a key factor in developing social service robots that can work alongside humans, potentially revolutionizing logistics operations [9]. Educational initiatives, such as simulations with collaborative robots, are being implemented to prepare future logistics professionals for this automated landscape [15]. It can be again stated, that although automation presents numerous benefits, including improved competitiveness and adaptability, careful strategic planning is also necessary for its successful implementation in logistics systems [13].

3. Possibilities of further development of existing systems

We now turn to the possibilities of further development of existing systems through some practical examples:

1. Logistics planning, raw material ordering and follow-up (Software)
2. Inventory management (Software)
3. FMS – Fleet Management System (Software)
4. Lot management (Software)
5. Automatic pallet remover (Hardware)
6. Automatic milkrun (Software / Hardware)
7. Automatic pallet sorter (Software / Hardware)
8. Automatic high rack warehouse (Software / Hardware)

3.1. Software automation

It is also clear from these examples that digitalization and automation offer many opportunities with software, and they are in many cases a prerequisite for the introduction of Hardware. Physical automation usually saves human resources, but it requires a lot of investment and comes with significant constraints. Software automation also saves human resources, reduces human intervention and the possibility of resulting errors. It is primarily based on data analysis and processing and improves internal communication and data flow. It reduces lead times and increases the efficiency of processes. It helps or even completely takes over decision-making processes. It is therefore recommended to first concentrate on the digitalization and automation of processes before starting the automation of physical processes. If we focus our resources on this, we can achieve greater results in the short term, with lower costs. Logistics is not only moving things from A to B, but increasingly its task is to make this happen in the most cost-effective way. And this is where software and digital process support solutions come into play.

3.1.1. LOP Tool Add-in

The transition to digital platforms and automated systems can significantly improve the efficiency of raw material ordering and production planning. The integration of various planning systems with self-developed digital solutions provides optimal solutions that not only optimize planning capacities, but also enable additional cost savings in, for example, inventory management. A useful digital solution is the **LOP Tool Add-in** created in Excel. With the help of the Excel add-in, planners can immediately access the most important reports and databases, as well as the web-based applications that are often used for daily work and Power BI reports. More than 20 reports and applications are available from this interface.

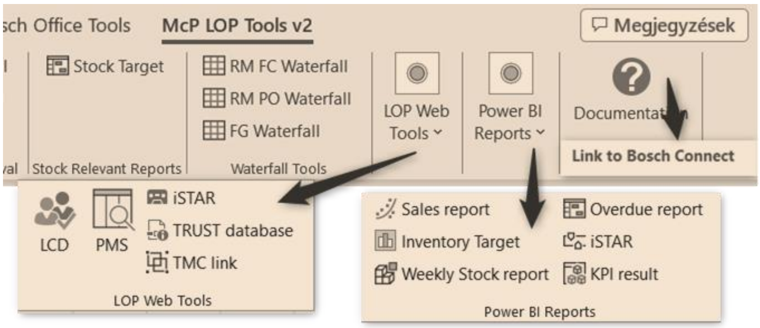

Figure 1. *Using LOP Tools [16]*

Within this, the following two reports are particularly important for logistics planners:

- One is the **report for monitoring open orders**, which shows the status of the given order, whether the partner has already confirmed and shipped the requested quantity, and whether the confirmation has been correctly transferred to the SAP system. It is also immediately visible if the given order might be late compared to the requested arrival date. All of this is visualized on a Power BI dashboard, where the raw materials can be checked using different filters. The dashboard also contains useful and important information for the management, for example, it gives an immediate picture of the value of the open order file.
- The other report to highlight is the **list of available materials**, which summarizes for the logistics planners what stocks they have available for the planned production quantities and when they are scheduled to arrive. It immediately shows the balance and gives a clear picture of when the availability of each raw material becomes critical, how long the coverage of each material lasts, from which immediate actions

can be made. It is based on an SQL database. With its help, the stock of all raw materials and finished products of the factory can be accessed and checked in seconds, and the planner can even perform various simulations in it, if it is necessary to modify the production plan. This can be useful in order to provide maximum service to flexibly changing customer needs. An example is shown in Fig. 1.

3.1.2. "Local Cross Dock"

A web-based system called **"Local Cross Dock"** (hereafter referred to as LCD), which was developed to optimize costs, specifically to reduce stock keeping costs. It is a platform that connects suppliers, logistics planners, transport management and provides input for physical logistics for the planning of revenue processes.

LCD connects high-volume partners within a 600km radius of the company and consolidates deliveries. Its biggest advantage is that raw materials can be ordered with a very short lead time, adjusted as precisely as possible to daily production plans, and due to the frequent delivery frequency, it is possible to plan with minimal stocks. Every day, LCD calculates the quantity to be ordered, considering the available and goods in transit stocks, as well as the quantity to be produced. It makes it possible to keep extremely low stocks and the daily withdrawals are much more accurate than in the case of items to be ordered with a longer lead time managed by other standard systems. In this way, significant stock keeping costs can be saved for the company. An example is shown in Fig. 2.

Figure 2. *Using "Local Cross Dock" system [16]*

3.1.3. FMS (Fleet Management System)

This system contains of the following: Time Window (TW) management, resource planning, communication tool.

Great yard management programs are available on the market, but experience shows that they do not fully serve certain complexity, resource planning and productivity measurement goals.

Therefore, a uniquely developed application was needed to apply the dynamic Time Window, to track the time of receiving of the goods and their put-away into the warehouse. In addition, it was necessary to calculate the processing time of each delivery, to determine the need for the dock, manipulation area, and technical and human resources. Target was that all participants of the process - transport organization and carriers, security and customs group, warehouse, and production planning - communicate on a single interface. The information should be available immediately, and so they can react to any changes right away. It is also important to prevent the distortion of information. It is a simple and transparent application adapted to roles, in which each colleague can only see information relevant to them. The workers receive their tasks on a tablet, the operations manager can follow the processes running in parallel on a cockpit interface, and the warehouse management receives all the data for performance evaluation. The warehouse resource planning by FMS is based on thousands of process measurements, where the processing of different types of shipments arriving in different quantities and packaging is calculated into time units. The measurements cover all the workflows of the entire warehouse process, so the throughput times, including the necessary resources, can be accurately calculated in advance. It is sufficient to enter the supplier and the incoming quantity data on the planning interface of the FMS, and the planned lead time is displayed as a result. FMS digitally manages the entire goods receipt process, saving large amounts of data for analysis and development plans. It provides daily, shift-by-shift productivity data that can be broken down into shipments, revealing the extent of possible losses and in which area they occur. An example is shown in Fig. 3.

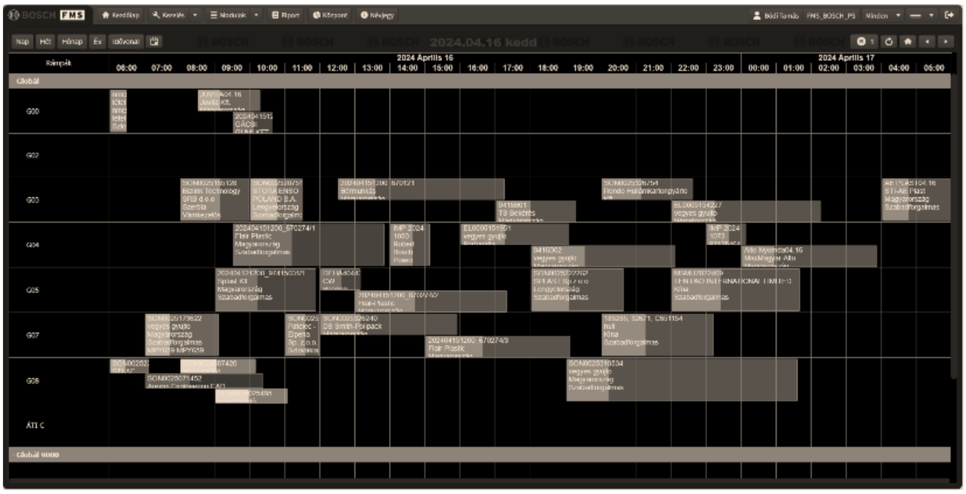

Figure 3. *Using FMS (Fleet Management System) [16]*

3.1.4. LOT management

In the production of one of the products, we implemented the internal material supply using e-Kanban and JIT based on the FIFO principle. Here, the customer requested that instead of the FIFO principle, the parts should be used in the order of the production LOTs. The SAP R/3 system used does not have an activated Batch Management module in which production dates could be tracked. Since a version update is planned for the existing system, it is not economical to introduce the Batch Management module into the old system. However, it will already be available in the version to be introduced, so a cheaper bridging solution must be found. As a solution, PMS (Production Management System), a self-developed system that manages production and other logistics processes, took over the functions that this SAP version could not handle. In the case of the affected components, the SAP-controlled, FIFO-based transport request creation in the kanban processes has been deactivated. Instead, this task was taken over by the PMS system, but already according to rules that meet customer expectations and generates transport requests in order of production LOTs. In this case, the application of a Midware was necessary to fulfill the customer's request. In the new process, the refilling of parts is realized by the joint operation of coordinated software that communicates with each other. An example is shown in Fig. 4.

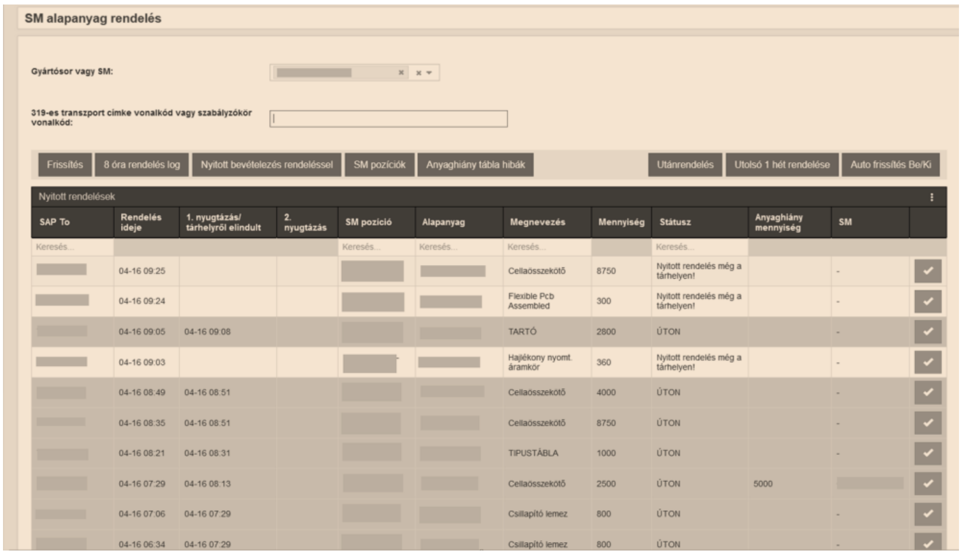

Figure 4. *Using LOT management [16]*

3.2. Automation in physical logistics areas

In the area of storage and internal material supply, it is even more true that there are no ready-to-use solutions that can be introduced anywhere and achieve the same effect. Supporting flexibility, profitability and competitiveness are key factors. Almost half of the digitalization projects do not achieve the originally expected effect, therefore, to succeed, it is important to adjust expectations to reality and to start based on smartly regulated standard processes. The well-structured construction and availability of basic and process data is inevitable.

Real, factual conclusions can be drawn from these, which show the next step. As a result of the projects described here, the total number of logistics personnel decreased by almost 10% and the return on investments was in all cases lower than 2 years.

3.2.1. Automatic pallet lifter

This is a typical example of a physical automation project, which enables the simultaneous lifting of 4 pallets of finished products arriving with tuggers onto an automatic packaging lane. The technical solution of the project has a completely unique design, it adapts to the tact time of the already established automatic packaging lane, the dimensions of the different types of tuggers and the finished product pallets with various dimensions. The developed pallet lifter is a flexible solution that can be modularly expanded in case of further demand growth. An example is shown in Fig. 5.

Figure 5. *Automatic pallet lifter [16]*

3.2.2. Automated milkrun tugger

The three automatic tugger automate tasks with long driving times, between finished product dispatch area and finished product warehouses, as well as internal raw material warehouses. Manual tuggers have been completely replaced on this route. The entire route is completed in 45 minutes by the automatic tuggers, which has 4 stops and at the stops the trolleys are manually attached and detached. A uniquely flexible solution that enables heavy manual forklift and pedestrian traffic on the same route. The internal traffic management system, which is connected to the system of the tow trucks and monitors their movements online, monitors the safety of all road users with the help of lights. An example is shown in Fig. 6.

Figure 6. *Automated milkrun tugger [16]*

3.2.3. Automatic pallet sorting equipment

The finished product pallets are sorted for each customer on a dedicated track, thereby making loading more efficient. The dedication of the tracks is carried out by the self-developed software based on up-to-date customer information extracted from the company management system. It is a unique solution specialized for the given task, which functions as the last station of an automatic packaging lane (automatic pallet lifter, automatic packaging, and strapping machine), which can be expanded in case of changing needs. An example is shown in Fig. 7.

Figure 7. *Automatic pallet sorting equipment [16]*

3.2.4. Automatic high-rack warehouse

It is by far the most complex solution of the four projects. In 40% of the raw material warehouse, automatic wide-aisle vehicles work in an area closed to manual traffic. On 5,000 m2, the warehouse, with 5 automatic forklift trucks, enables the storage of nearly 8,000 pallets every day of the year, with stable execution of continuous loading and unloading tasks. The automatic warehouse has an internal warehouse management software solution, which enables the most optimal storage, considering the turnover speed of the stock. The system is a unique solution in many ways. In addition to the standard EURO pallet size, it can also handle industrial-sized pallets (1000x1200) without pre-defined storage space allocation, dynamically planning where to store normal and where to store industrial-sized pallets on shelves of the same width. In the interest of better utilization, a low height palette storage level was also created, and in addition to the height, the weight of the pallets plays an important role in this structure. Such dimensions can only be handled well after accurate, precise measurement, therefore, and for the sake of maximum safety, all storage processes are carried out by the automatic forklifts after dimension measurement. An example is shown in Fig. 8.

Figure 8. *Automatic high-rack warehouse [16]*

4. SUMMARY

Basically, simple, well-defined, and loss-free processes can be effectively automated. At the same time, what appears to be a well-established process at first sight may not be ideal for automation from the point of view of automation.

It is therefore worthwhile to examine these processes from several angles already in the planning phase, so that we can identify the grey areas of our processes and develop them to an appropriate level even before automation. A good idea is not enough, we have to find the right solution for the task, which must be supported by analysis made from the right amount and quality of data, even with the help of simulation.

In addition to the technical problems, one of the obstacles to the success of the project can also be the resistance felt by the employees towards automation. Therefore, it is useful to involve them already during the introduction period, so that they see that their work does not stop, but that they can be given more complex, higher-level tasks in other areas, thereby improving themselves.

The soul of every automatic system is software, which will be made unique by the knowledge of the two sides, the supplier and the customer. The customer knows what challenges he faces and what results he wants to achieve, and the supplier knows the possibilities and limits inherent in the technology. It is important that they jointly create the right combination.

Finally, it is worthwhile to prepare bridging solutions already in the planning phase in order to be able to ensure uninterrupted operation during the introduction period.

Overall, it is worth automating, but it is important to find a balance between manual and automatic operation.

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