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Streamlining Project Management in the Production Sector: A Case Study of Industrial Engineering

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Abstract
The objective of the research is to pinpoint issues in project management, as this is crucial for the development of a successful project. There is a need to expand the existing knowledge in project management, as it contributes to enhancing a company's project management system. Additionally, the study presents effective remedies for project management challenges. Initially, we introduce the specific project, followed by an examination of the current state of production processes. In this context, we endeavour to propose solutions. The concluding section focuses on evaluating these solutions, summarizing the study, and achieving the study's objective. These outcomes contribute to cost savings and ensure maximum customer satisfaction.

Keywords
Industrial Engineering, Project Management, MCT map, Gantt chart, Project.

Introduction

Project management has become an essential method for both identifying and solving challenges encountered within contemporary business operations. In the face of evolving challenges and heightened customer expectations, businesses are increasingly turning to case studies as a strategic tool. Addressing these challenges necessitates a commitment to streamlined processes, ensuring simplicity at every stage from receiving customer requests to delivering the final outputs. As highlighted by (Grznar et al., 2023; Saukko et al., 2020) the effective course of a project and the overall proficiency of project management within an organization play pivotal roles in ensuring the smooth flow of these processes (Junior Pacagnella & Da Silva, 2023; Pekarcikova et al., 2023; Mitalova et al., 2022).

Therefore, project management is a tool for managing changes and approaching complex tasks in large companies (Krajcovic & Plinta, 2014; Szabo et al., 2023; Rakyta et al., 2022). However, this trend is gradually developing not only in big businesses but also, in medium and small-sized companies (Krajcovic & Plinta, 2012; Trojanowska & Dostatni, 2017; Plura et al., 2023).

Regardless of company size or industry, the pervasive challenge confronting every business today lies in the imperative to enhance resource management and the need to reduce costs. As a result, the need to introduce professional project management or at least its elements will grow in small companies (Bestvinova et al, 2022; Pekarcikova et al., 2021).

Project management emerges as a powerful tool for companies seeking to optimize their resource utilization across various dimensions, including finance, time, human capital, know-how, and technology. This specificity is particularly pronounced in the context of production and manufacturing enterprises. In these settings, unforeseen events and challenges are commonly addressed through project-based approaches. The primary goal is to systematically identify and resolve problems, ensuring an efficient and targeted solution (Micieta et al., 2023, Micieta et al., 2021).

Literature review

The scope of interest that must be taken into account in the context of project management may be seen in the literature study that follows. The purpose of

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the paper is highlighted in the above analysis, which is project management in the context of industrial engineering in production processes.

The study of the author (Plattfaut, 2022) shows that project management is a key success in business process management. The study suggests that professionals in practice should take project management knowledge to optimize business processes and introduce and improve digitization.

The case study (Xiong et al., 2021) connected with the Research and Development (R&D) case study outlines a detailed process that how an R&D project applies the effective visual communication method to support information transparency in project management to solve problems effectively. This article proposes a visual management method coupled with project management to deliver a seamless project output.

In the study (Hansen et al., 2021) the authors focus on investigating the research gap that exists for project organizations within the field of complexity management. Two key conclusions emerge from the study. Initially, it is determined that three primary factors contribute to complexity in project organizations: project risks, individual preferences and talents, and project management. Second, seven guidelines are produced for project organizations that are involved in complexity management projects, based on the case study. The findings enhance existing complexity management frameworks by offering fresh insights into complexity management in project organizations.

The authors (Marin-Martinez et al, 2021) deal with suggest a simulation model that takes into account system dynamics and the components of the Quick Response Manufacturing (QRM) approach. The created model is a highly helpful tool for decision-making since it makes it easier to determine lot sizes and process flow durations in manufacturing settings where the competitive strategy is centred on markets that require high levels of product customization and unpredictability. The effects of variability and machine resource use are assessed by running four distinct scenarios. The findings demonstrate that even a small variation in the way machine resources are used has a significant effect on process flow times and, in turn, on Manufacturing Critical-Path Time (MCT), another crucial QRM variable.

According to (Nelfiyanti et al, (2020) in their study, many methods can be used in manufacturing industries to minimize wastage. There are numerous ways to reduce waste in the industrial sector. Quick Response Manufacturing is one of the techniques that can be applied (QRM). As a result, this article uses analysis, from published studies to determine and assess how QRM is applied in the manufacturing sector. The method can help create an appropriate model for assessing QRM strategies and their implementation in industrial industries.

The company-wide QRM approach is designed for businesses whose clientele's needs change frequently. Standardization and sound planning are costly, ineffective, and counterproductive in manufacturing facilities with fluctuating demand or a broad range of products. For this reason, the QRM technique was developed, resulting in shorter lead times for administration and production. Because internal procedures are effectively adjusted to meet client needs, it helps businesses expand. By cutting expenses, boosting delivery efficiency, and enhancing quality, QRM further boosts profitability. This strategy has several useful tools, of which Manufacturing Critical path time is used in this case study (Vavrik et al., 2020; Plinta & Radwan, 2023; Wiecek et al., 2019).

The research goal of the case study

A case study was defined as part of the project assignment, to assemble a proposal for enhancing the company's project management system. The case study was carried out in the Production Automation section of an unidentified company X. This business is committed to innovation in the fields of robotization, automation, and digitization.

In addition to dealing with automation directly, the Production Automation branch also provides engineering services. Automation and robotization in business are critical to improving worker productivity, technology, and overall business system efficiency. Company X guarantees that machinery and equipment with a single function are developed and built precisely in compliance with customer specifications. This is especially true of the Production Automation division. They are designed to automate repetitive tasks in production, drastically cutting down on time, decreasing error rates, and lowering workplace hazards. They also aid in enhancing operator comfort and quality as well as workplace ergonomics. The design of automated work environments or complete production processes and systems is another area of focus for this division.

This section collaborates with:

- Production lines using automation.
- Managing specialized machinery and equipment.
- Special arrangements for assembly.

Therefore, we examined a specific project that Company X was working on for an unidentified Company Y to enhance the division's project management system. The pertinent procedures were examined and enhanced as part of this project. Company Y is a business that manufactures automotive ceiling panels. In this project, Company X was responsible for overseeing the building of an assembly line that is used to assemble the ceiling panel for the interior element of cars, namely the KIA Sportage NQ5. The assembly of this line happened at company X's location, which is in Slovakia, close to Zilina. In the following Fig. 1, you can see a 3D image of a sample part of the ceiling panel assembly line.

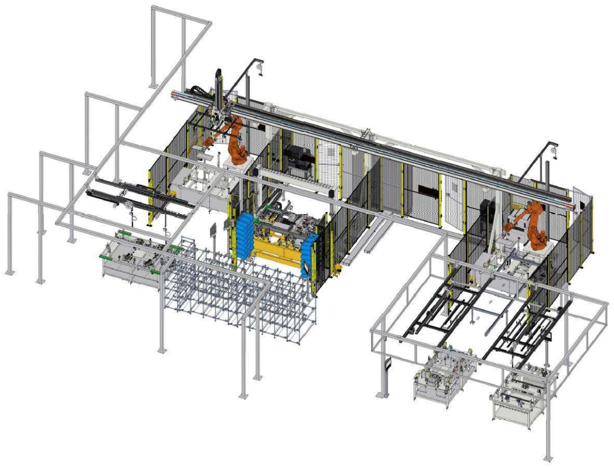

Fig. 1. An assembly line for ceiling panels shown in 3D demonstration [Source: Authors]

Figure 2 provides illustrations of the assembly line, representing the anticipated outcome of the entire project. Nevertheless, for the successful completion of the project and the proper functioning of all its processes, it is imperative to address the analysis of the project's current state, focusing specifically on:

- Project management cycle.
- Current status of the material and inventory procurement process.
- Current state of the product production and assembly process (assembly line).
- Project activity analysis.
- Key performance indicators of the project (current status).

In general, Company X has countless projects that it undertakes for companies. There were more projects that it was analysed for this company. These were closed projects. However, in this article, we have selected one. The goal of the case study is to improve the project management system in Company X.

Fig. 2. Visualization of the assembly line workplace directly in the production process [Source: Authors]

Analysis of the current state of the project

In the next part of the article, it is possible to see a description of the individual activities of the project, their duration, their share within the entire project, key indicators of the project, and work on the project.

Company X goes through the following processes in project management and projects:

- Dealing with customer inquiries.
- Creating an offer.
- Project order or services of Company X.
- Creation of Computer-aided Design (CAD) and documentation.
- The process of procurement of materials and supplies.
- The process of production and assembly of products.
- Installation and start-up at the premises of Company X (close to Zilina).
- Programming and activation of the product at the customer.
- Complete takeover or completion certificate.

The first step is that the customer approaches Company X with their requirements and Company X deals with the demand of their potential customer. Company X creates an offer for its customers to provide. If the customer agrees to the offer, then the customer orders the project or, in other words, the service of Company X. Subsequently, the project continues with the purchase process, which is related to the process of procurement of materials and supplies. Next, the project continues with the production process, which is related to the processes of production and assembly of products. This is usually followed by installation and start-up at the premises of Company X. This is followed by programming and activation of the product at the customer's location. The project ends with activities that are related to the complete takeover of the product and services, which are associated with the handover protocol that is handed over by Company X to the customer.

In the following Fig. 3 it is possible to see the Gantt diagram for the current state of the project. Fig. 3 results from the activities that take place within the project, while the project begins with the activity of accepting the demand from the customer on 01/07/2020 and ends with the activity of complete takeover or by delivering the transfer protocol on 21/07/2021.

Figure 3 also shows that the entire project lasts 276 days. The process of receiving an inquiry from a customer takes 23 days. The offer creation process takes 89 days. The order process takes 2 days. The process of creating CAD construction and documentation takes 75 days. The process of acquiring materials and supplies takes 50 days. The process of manufacturing and assembling the product takes 51 days. Installation and start-up at the premises of Company X lasts 48 days. Programming and activation at Company Y lasts 55 days. And complete takeover or the handover protocol takes 3 days. It is also possible to see that some activities such as processes in purchasing and processes in production and assembly can run concurrently. The construction of the Gantt chart is used to generate the Manufacturing Critical-path Time map (MCT map), which will provide information about the productive time within the entire project.

Manufacturing Critical-path Time map is a Quick Response Manufacturing (QRM) innovative strategy tool that serves to identify productive activities within a project. It is a tool that is used to optimize the processes involved. As part of this project, it is determined what is the ratio of the productive time of individual activities within the Lead Time of the respective activity.

The MCT map for the current state of the project can be seen in the Fig. 4. In the individual columns, you can see processes, description of processes, productive time in days, the share of productive time within lead time in %, the start of the activity, end of the activity, lead time of activity and classification from activity in terms of lead time. These properties describe individual activities that can be seen in individual lines. At the end of the selected columns, you can see their summary.

The data within the MCT map are calculated for one-shift operation, while the duration of working time is 8.5 hours. The data are then converted to man-days.

The following facts were discovered by developing the MCT map:

- For the "demand" activity, the ratio of productive time is 0.4% within the Lead Time activity.
- In the "offer" activity, the ratio of productive time is 4.7% within the Lead Time activity.
- For the "order" activity, the ratio of productive time is 2.1% within the Lead Time activity.
- In the activity "CAD design and documentation" the ratio of productive time is 80.0% within the Lead Time activity.
- In the activity "purchase of mechanical parts" the ratio of productive time is 5.8% within the Lead Time activity.
- In the activity "purchase of electrical parts" the ratio of productive time is 6.9% within the Lead Time activity.
- In the "mechanical assembly" activity, the ratio of productive time is 49.0% within the Lead Time activity.

ID	Name	Start date	End date	Duration
1	KIA NQ5 LINE	Jul 01, 2020	Jul 21, 2021	276 days
2	Demand	Jul 01, 2020	Jul 31, 2020	23 days
3	Offer	Jul 30, 2020	Dec 01, 2020	89 days
4	Order	Dec 02, 2020	Dec 03, 2020	2 days
5	CAD design and documentation	Nov 30, 2020	Mar 12, 2021	75 days
6	Purchase	Feb 22, 2021	Apr 30, 2021	50 days
7	Mechanical part	Feb 22, 2021	Apr 30, 2021	50 days
8	Electrical part	Feb 22, 2021	Apr 30, 2021	50 days
9	Production and assembly	Feb 01, 2021	Apr 12, 2021	51 days
10	Mechanical part	Feb 01, 2021	Apr 12, 2021	51 days
11	Electrical part	Feb 01, 2021	Apr 02, 2021	45 days
12	Company X installation	Mar 15, 2021	May 19, 2021	48 days
13	Programming at the customer	Apr 05, 2021	Jun 18, 2021	55 days
14	Completion certificate	Jul 19, 2021	Jul 21, 2021	3 days

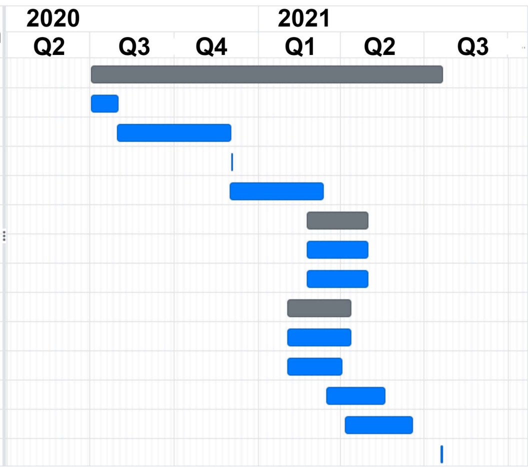

Fig. 3. Gantt chart of the current status of the project [Source: Authors]

PROCESS	PRODUCTIVE TIME (days)	LEAD TIME (days)	PRODUCTIVE TIME/LEAD TIME (%)	PROCESS STARTS	PROCESS ENDS	LEAD TIME (h.:min.)	LEAD TIME CLASIFICATION
COMPLETION CERTIFICATE	0.4	3.0	11.8%	19.7.2021 8:00	21.7.2021 17:00	72: 00	ADMINISTRATION
PROGRAMMING AT THE CUSTOMER	15.0	55.0	27.3%	5.4.2021 8:00	18.6.2021 17:00	1320: 00	MANUFACTURING
COMPANY X INSTALLATION	15.0	48.0	31.3%	15.3.2021 8:00	19.5.2021 17:00	1152: 00	MANUFACTURING
ELECTRICAL ASSEMBLY	15.0	45.0	33.3%	1.2.2021 8:00	2.4.2021 17:00	1080: 00	MANUFACTURING
MECHANICAL ASSEMBLY	25.0	51.0	49.0%	1.2.2021 8:00	12.4.2021 17:00	1224: 00	MANUFACTURING
PURCHASE ELECTRICAL PART	3.5	50.0	6.9%	22.2.2021 8:00	30.4.2021 17:00	1200: 00	LOGISTICS
PURCHASE MECHANICAL PART	2.9	50.0	5.8%	22.2.2021 8:00	30.4.2021 17:00	1200: 00	LOGISTICS
CAD DESIGN AND DOCUMENTATION	60.0	75.0	80.0%	30.11.2020 8:00	12.3.2021 17:00	1800: 00	ENGINEERING
ORDER	0.0	2.0	2.1%	2.12.2020 8:00	3.12.2020 17:00	48: 00	ADMINISTRATION
OFFER	4.2	89.0	4.7%	30.7.2020 8:00	1.12.2020 17:00	2136: 00	ADMINISTRATION
DEMAND	0.1	23.0	0.4%	1.7.2020 8:00	31.7.2020 17:00	552: 00	ADMINISTRATION
Total	141.0	276.0	51.1%		21.7.2021 17:00		

Fig. 4. Part of the Manufacturing Critical-path Time forthe current state of the project [Source: Authors]

- In the "electrical assembly" activity, the ratio of productive time is 33.3% within the Lead Time activity.
- For the "Company X installation" activity, the ratio of productive time is 31.3% within the Lead Time of the activity.
- In the activity "programming at the customer" the ratio of productive time is 27.3% within the Lead Time activity.
- In the "handover protocol" activity, the ratio of productive time is 11.8% within the Lead Time activity.

Within the MCT map of the current state, it was found that the total number of productive days is 141 man-days within the entire duration of the project, which lasts 276 man-days. This means that the entire project has a productive time ratio of 51.1% within the entire Lead Time project.

Various key performance indicators of the project can also be identified within the second part of the MCT map. In the graphic representation, the main item is the labour in hours for the entire project. As part of the entire project, the hours worked by individual weeks were determined, which were subsequently calculated for the entire project. Labour for the entire project is 3,384 hours.

In Fig. 5, it is possible to see a graph of the dependence of the progress of work within the project for the current state. It shows the labour force values in time from the beginning of the project on 01/07/2020 to the end of the project on 21/07/2020 during the individual weeks of the project. From Fig. 5, the labour for the project started to rise at the beginning of December 2020 and kept its value until the end of January 2021. Subsequently, labour began to rise steadily from the beginning of February 2021 until March 2021 because more activities were performed at the same time. This can be seen from the Gantt chart and the MCT map. From this date, the labour decreased.

Results of the analysis of the current state

In the succeeding section of the article, it is possible to see the results of the analysis of the current state, which are related to the identification of problems. They are shown using an Ishikawa diagram. The most critical areas in the project were the purchase and production processes, which will therefore be analysed in more detail. Subsequently, it is possible to see suggestions for improving or solving these problems.

The identification of problems within a project is generally described through an Ishikawa diagram, which can be seen in Fig. 6. The identification of individual problems was determined based on an interview with the buyer, the storekeeper, and the head of the

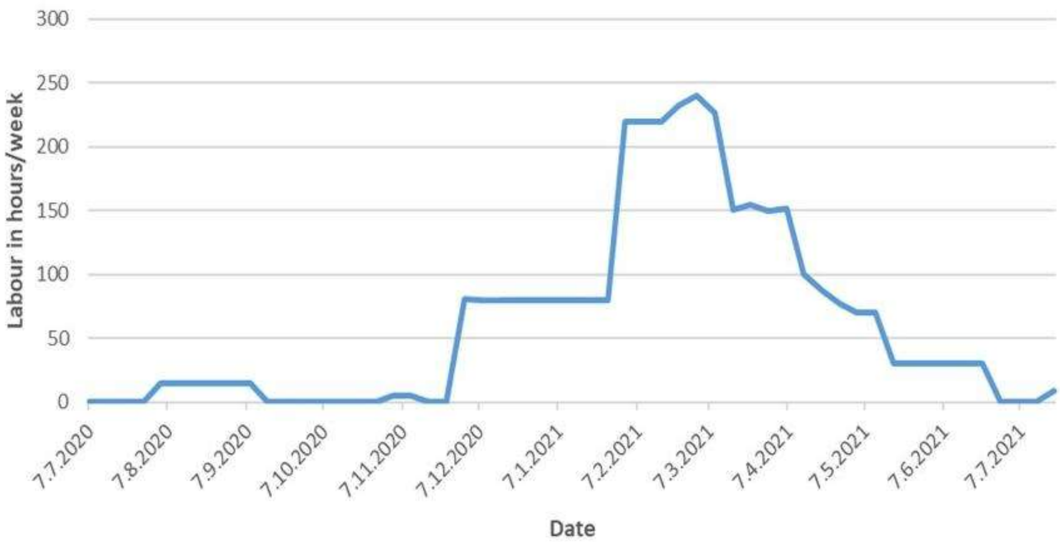

Fig. 5. Figure of the dependence of the progress of labour overtime for the current state of the project [Source: Authors]

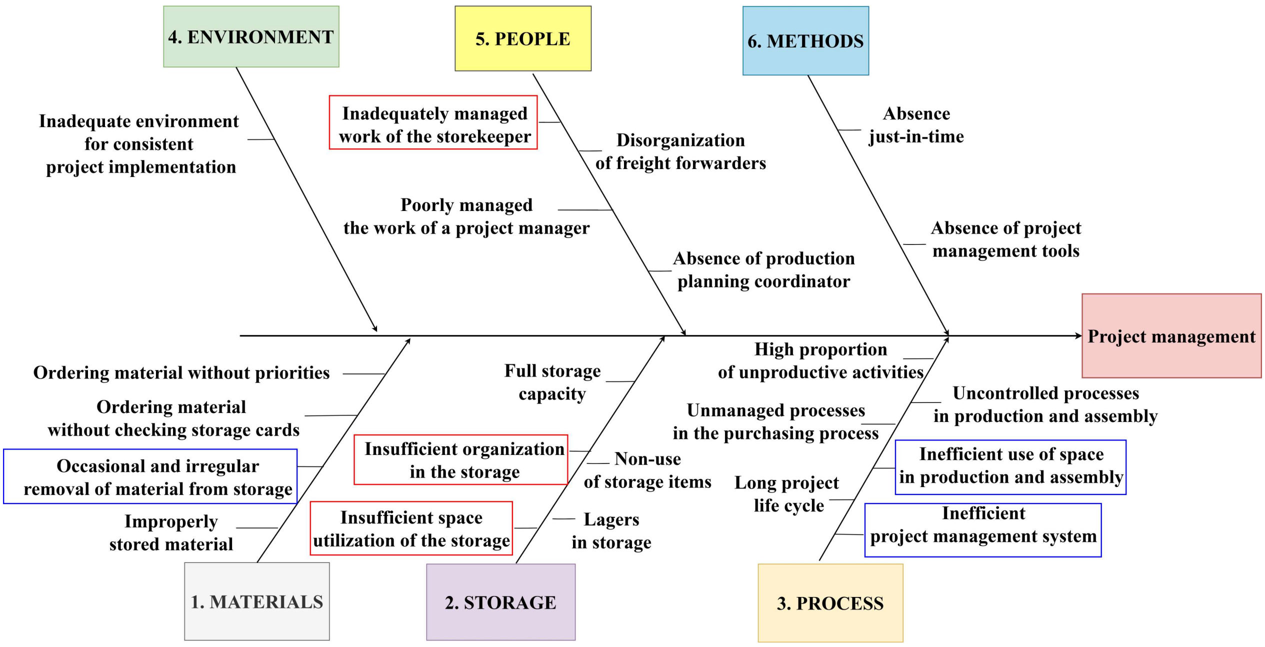

Fig. 6. Ishikawa diagram of the current stateof project management [Source: Authors]

Production Automation division.

From Fig. 6, it is possible to see various causes that result in a problem in project management. Problems arise mainly in the process of procurement of materials and supplies and production and assembly.

Based on the above-mentioned interview with the buyer, storekeeper, and head of the Production Automation division, a brainstorming session was conducted, in which various potential causes of the problem in project management were identified. Subsequently, an Ishikawa diagram was drawn up, in which the potential causes of the problem were assessed with the multidisciplinary team. It was rated using a scale of 3, 6, and 9, where 3 is the least probable cause, 9 is the most probable cause, and 6 is probable cause. The causes with the most points can be considered as root causes. Root causes in the material and inventory procurement process are marked with a red box. The root causes within the manufacturing and assembly process are marked with a blue box.

Root causes of the consequence in the process of procurement of materials and supplies:

- Unmanaged work of the storekeeper.
- A problem in the warehouse or insufficient organization in the warehouse.
- Unstocked and unused material within the warehouse or insufficient space utilization of the warehouse.

The highest number of points went to a problem in the warehouse or insufficient organization in the warehouse.

Root causes of the consequence within the manufacturing and assembly process:

- Sudden removal of material for production and assembly.
- Problematic implementation of several projects simultaneously in production and assembly or an ineffective project management system.
- Inefficient use of space in production and assembly.

The highest number of points was awarded to the cause of problematic implementation of several projects simultaneously in production and assembly, or ineffective project management system.

The processes within the procurement of material and supplies and production and assembly are unmanaged and it is necessary to work on their improvement or to provide proposals for modification and improvement. These improvements are necessary for the modification of project management and the improvement of processes within projects and project management. These processes are addressed because, within the current state, they have shown bottlenecks in project management and have an impact on the project itself and the length of the project.

Description of root causes and suggestions for improvement

In the process of procurement of materials and supplies, the cause of the problem in the warehouse or insufficient organization in the warehouse received the highest number of points.

There are other issues related to this main issue:

- The warehouse worker's incomplete idea of what components and items are in the warehouse.
- The project manager issues a requisition for the material/service, regardless of whether the items are physically present in the warehouse.
- The material is ordered without prior visual inspection of the warehouse or stock cards.
- Material and components are ordered without priority, that is, material and components are ordered all at once, regardless of whether or not the material is currently needed.
- The warehouse is overcrowded.
- The organization in the warehouse is unmanaged.
- The warehouse is not used up to the height.
- The material is not stored according to the relevant projects.

In the following Fig. 7 it is possible to see the warehouse and the real situation in the respective warehouse. This is the aforementioned space Company X, which is used for processing another assembly line of ceiling panels for Company Y.

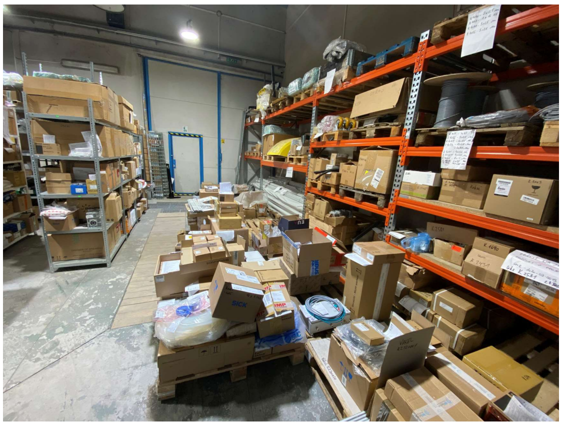

Fig. 7. Material warehouse at Company X [Source: Authors]

Suggestions for improvement in the process of procurement of materials and supplies:

- Procure components that will be ordered and removed from storage using the just-in-time principle, that is, not ordering all components and material at once, but according to priority, which saves space in the relevant warehouse.
- Do not stockpile the entire material for the respective project all at once, but gradually according to the priorities and needs of production and assembly, which saves the time of workers in production and assembly, who usually waste 2 or 3 days searching for individual components.
- Establish production phases, that means, for example, one specific project in which the assembly of the line has 4 phases, namely: mechanical, pneumatic, hydraulic, and electrical, while the assembly of each of these phases will take place on a different date, and concerning these phases, order the relevant material and take them out of storage.
- After the arrival of the material in the newly created material receiving zone, it is necessary to mark in the internal system of company X which project it is, and based on the specific project and the established production phases, this material should be stored in a precisely specified place.

- Use the warehouse to the height and procure pallet racks, which saves space in the warehouse.
- Use high storage and procure shelf-level warehouses.
- Use a carousel filer (paternoster) – material-to-person system.

Advantages of carousel stackers:

- Ensure saving of warehouse space.
- Represent a system of efficient picking.
- Eliminate errors when removing individual components – Pick-by-Light systems.
- Represent a simple power supply for various management of the warehouse itself.

In the process of production and assembly, the cause of the problem that received the highest number of points, is the problematic implementation of several projects simultaneously in production and assembly, while it is an inefficient project management system.

There are other issues related to this main issue:

- During the production and assembly of several projects at the same time, there is not enough space for the production and assembly itself.
- Storage in the production hall in production and assembly is not efficient.
- The material taken out of storage takes up space for the subsequent production and assembly of the relevant project.

In the following Fig. 8 it is possible to see the production and assembly areas. These are premises that are located next to warehouses within Company X.

Fig. 8. Production and assembly area of Company X [Source: Authors]

From Fig. 8, it can be seen that the space of the production hall of Company X, which is used for production and assembly, is large, but with several projects in the production and assembly phase, it is impossible to fully use this space. It regularly happens that if it is necessary to work on several projects, the production and assembly process becomes very uncontrolled and almost non-functional, which mainly results in an extension of the total project time.

Suggestions for improvement in the process of production and assembly:

- Remove unused material to free up space.
- Unload the material for production and assembly only when it will be used, thus freeing up space for more projects running at the same time.
- Division of production and assembly into relevant assembly sections or phases or workplaces (workplace 1, workplace 2, workplace 3, etc.) which ensures efficient storage and saving of space, it is about differentiating production from the point of view of phases: mechanical, pneumatic, hydraulic and electrical, while the assembly of each phase will take place at a different time and due to this, the material will be taken out of storage.
- Introduce a pre-assembly zone in production and assembly.
- Division of production into technological units.
- Secure the job position of production planning coordinator, who is currently absent.

Competences and duties of the production planning coordinator:

- Ensure the coordination of individual projects,
- Ensure production scheduling.
- Ensure communication with suppliers.
- Find out which material will be needed in individual phases.
- Ensure the management of individual projects itself.
- Ensure the planning of materials needed for predefined inputs.

The gross monthly salary of a production planning coordinator is estimated at approximately €2,050 per month. Therefore, the procurement costs for the employer and their estimate within this proposal is approximately €2,771.59 per month.

Project indicators after incorporating proposals

In this chapter, it is possible to see the evaluation of the project after the implementation of individual proposals. You can also see the Gantt chart, MCT map, and labour for the design status of the project that was carried out for Company Y for an interior element for cars, specifically the KIA SPORTAGE NQ5.

From Fig. 9, it follows that the project starts on 01/07/2020 and ends on 28/06/2021. By introducing

Fig. 9. Gantt diagram after incorporating proposals [Source: Authors]

individual changes that can be seen in previous chapters, the overall duration of the project was shortened to 259 days.

Tasks with which the given project begins, demand, supply, and order are external, as they depend on the customer, and therefore it is very difficult to influence them. Therefore, these activities are immutable. The activity of creating CAD construction and documentation is also constant.

The process, which includes the purchase of mechanical and electrical parts, is expected to be shortened by a total of 13 days on average. Based on the suggestions from the previous chapter, it is estimated and assumed that if the accounting status of the warehouse corresponds to the actual status, a regular check of the warehouse cards will take place and the material will be used from the warehouse, then the time of this entire process will be shortened by an average of 10 days. Another aspect of the mechanical and electrical purchasing process is that the material will be ordered sequentially, and this process can run parallel to the manufacturing and assembly process, which is expected to reduce the time of the entire process by an average of another 2 days.

The last aspect is that if a material receiving zone is introduced, which is currently absent, it is estimated that an additional 1 day will be saved on average. Therefore, it is assumed that the process of procurement of material and supplies will be shortened by the above-mentioned 13 working days on average. Based on the above estimates and facts, it is assumed that the process could start on 22/02/2021 and end on 13/04/2021.

The manufacturing and assembly process, whether electrical or mechanical, began in its current state almost 3 weeks earlier than the purchase process itself. The activity went smoothly, but nothing was produced, as the necessary material from the purchase was not secured. Therefore, assuming that the individual activities are to take place simultaneously, the production and assembly process must begin approximately at the same time as the purchase process itself. In the case of this project, it is recommended that the manufacturing and assembly process begin one week after the material and inventory procurement process itself. A further reduction in time is made possible by the introduction of a production planning coordinator position, which will effectively schedule the entire production and assembly process, which is expected to save time by another 3 days. Another aspect that will enable the reduction of working time is that the warehouse will be managed, and the material will not be removed suddenly, but gradually according to the above suggestions. It is assumed that production and assembly workers will subsequently save 2 days, which were previously lost by redundantly searching for material in the impact stockpiled material for the given project. Therefore, it is assumed that the process of production and assembly of the product will be shortened by an average of 25 working days in total. Based on the above estimates and facts, it is assumed that the process could start on 01/03/2021 and end on 07/04/2021.

The duration of the "Company X installation" activity does not change, but this activity can be performed if the installation is at least 80% complete, and therefore its deadline has been shifted and adapted.

It is assumed that the process could start on 10/03/2021 and ends on 14/05/2021, with the same duration as the current state of 48 days. The activity of programming at the customer is unchanged, but its term has also been shifted and adjusted so that there is no needlessly unused time. It is assumed that the process could start on 29/03/2021 and end on 11/06/2021. The last activity is the handover protocol. This activity was shortened, as the activity lasted 3 days, but only 8.5 hours were worked on it for the whole 3 days.

Therefore, this activity can be shortened to one 8.5-hour work shift. It is assumed that the process could start on 28/06/2021 at 8:00 a.m. and end at 5:00 p.m. on the same day. So, it is shortened by 2 days.

In the following Fig. 10 it is possible to see the basic part of the MCT map of the proposed state. MCT map for design status is compiled after in-depth analysis with the buyer, project manager, and warehouse from Company X.

Data from Fig. 10 are based on the Gantt diagram of the design status and are transferred to the corresponding table of input data, which serves to generate data for the given project.

The data in the MCT map for the design state is calculated as in the current state for one-shift operation, while the duration of the working time is 8.5 hours. The data are then converted to man-days.

After incorporating the individual proposals and developing the MCT map, the following facts are proposed:

- The activities "demand", "offer" and "order" remain unchanged because their activity is difficult to influence, as they depend on the customer.
- In the activity "CAD design and documentation", it emerged from the current situation that the number of hours worked per week within the scope of this activity was less than in recent weeks during the initial dates. The first 9 weeks were worked on average 80 hours, while in the remaining 6 weeks, the number of hours worked was up to 120. It means that for the first 9 weeks, this activity was not given enough attention and for the next 6 weeks it was necessary to speed up the pace. Therefore, the proposal is to average every week devote an average of 103 hours to this activity, which represents a constant penetration between 80 hours and 120 hours. If he devotes 103 hours to this activity every week, it is assumed that the ratio of productive time will be 85.6% within Lead Time.
- The activities "purchase of mechanical parts" and "purchase of electrical parts", the duration of these activities were shortened by an average of 13 days. Following the suggestions in the previous chapters, after reducing the total time within this activity, it is necessary to increase the number of hours worked per week. The recommendation is to in-

PROCESS	PRODUCTIVE TIME (DAYS)	LEAD TIME (DAYS)	PRODUCTIVE TIME/LEAD TIME (%)	PROCESS STARTS	PROCESS ENDS	LEAD TIME (h.:min.)	LEAD TIME CLASIFICATION
COMPLETION CERTIFICATE	0.4	1.0	35.4%	28.6.2021 8:00	28.6.2021 17:00	24:00	ADMINISTRATION
PROGRAMMING AT THE CUSTOMER	15.0	55.0	27.3%	29.3.2021 8:00	11.6.2021 17:00	1320:00	MANUFACTURING
COMPANY X INSTALLATION	15.0	48.0	31.3%	10.3.2021 8:00	14.5.2021 17:00	1152:00	MANUFACTURING
ELECTRICAL ASSEMBLY	20.8	28.0	74.1%	1.3.2021 8:00	7.4.2021 17:00	672:00	MANUFACTURING
MECHANICAL ASSEMBLY	17.2	20.0	85.8%	1.3.2021 8:00	26.3.2021 17:00	480:00	MANUFACTURING
PURCHASE ELECTRICAL PART	14.3	37.0	38.7%	22.2.2021 8:00	13.4.2021 17:00	888:00	LOGISTICS
PURCHASE MECHANICAL PART	14.3	37.0	38.7%	22.2.2021 8:00	13.4.2021 17:00	888:00	LOGISTICS
CAD DESIGN AND DOCUMENTATION	64.2	75.0	85.6%	30.11.2020 8:00	12.3.2021 17:00	1800:00	ENGINEERING
ORDER	0.0	2.0	2.1%	2.12.2020 8:00	3.12.2020 17:00	48:00	ADMINISTRATION
OFFER	4.2	89.0	4.7%	30.7.2020 8:00	1.12.2020 17:00	2136:00	ADMINISTRATION
DEMAND	0.1	23.0	0.4%	1.7.2020 8:00	31.7.2020 17:00	552:00	ADMINISTRATION
Total	165.4	259.0	63.9%		28.6.2021 17:00		

Fig. 10. Part of the Manufacturing Critical-path Time for the design state of the project [Source: Authors]

crease the number of hours worked to 43 hours per week within the entire activity of this project. This is because the buyer will devote 8.5 hours a day to this activity, as the process runs parallel to the production and assembly process. If he devotes 43 hours to this activity every week, it is assumed that the ratio of productive time will be 38.7% within Lead Time.

- In the case of "mechanical assembly" and "electrical assembly" activities, the duration of these activities was shortened by an average of 25 days. As following the suggestions in the previous subsections, after reducing the total time within this activity, it is necessary to increase the number of hours worked per week. The recommendation is to increase the number of hours worked per week by an average of 43 hours. This is due to the assumption that the introduction of the production planning coordinator position will increase the number of hours worked to the base hours. It will also not be necessary to wait for the material, because under the mentioned conditions it should be available "just-in-time" and it is possible to work on this activity constantly. The recommendation is that the recommended number of hours worked for mechanical assembly should be 103 hours per week and for electrical assembly 83 hours. Assuming that 103 hours (mechanical assembly) and 83 hours (electrical assembly) will be devoted to these activities, it is estimated that for mechanical assembly the ratio of productive time will be 85.8% within Lead Time, and for electrical assembly, the ratio of productive time will be 74.1% within Lead Time.
- The activities "Company X installation" and "programming at the customer" are unchanged, only the dates within the entire project are shifted.
- During the "handover protocol" activity, the total time was shortened, as the activity lasted 3 days, but only 8.5 hours were worked on it for the whole 3 days. Therefore, this activity can be shortened to one day. Assuming that the activity will last one day, and 8.5 hours will be devoted to it, it is estimated that the ratio of productive time will be 35.4% within the Lead Time.

To sum up, within the MCT map of the design state, it was found that the total number of productive days is 165.4 man-days within the entire duration of the project, which lasts 259 man-days. This means that the entire project has a productive time ratio of 63.9% within the entire Lead Time project.

The second part of the MCT map serves to determine the number of hours worked within individual activities. It is a graphic part of the map, in which it is shown in which week how many hours will be completed within the required task.

The second part of the MCT map serves to determine the number of hours worked within individual activities. It is a graphic part of the map, in which it is shown in which week how many hours will be completed within the required task. From Fig. 11 after incorporating the individual proposals, the labour for the entire project is assumed to be 3,970 hours. As part of the shortening of the total project time, the efficiency increases. In the following Fig. 11 it is possible to see a graph of the dependence of the course of

Fig. 11. The dependence of the progress of labour over time for the design status of the project [Source: Authors]

work within the project for design status. It shows the proposed labour values in the time from the beginning of the project – 01/07/2020 to the end of the project – 28/06/2021 during the individual weeks of the project.

Evaluation of the project and project management

In this section, you can see the evaluation of the project and project management. It is also possible to see a comparison of the current and proposed state of the project.

Relevant evidence for the success of this case study is the fact that shortening the project management saved funds and shortened the project time. Within the scope of the product value and the length of the project, it was determined by Company X after a thorough internal review that reducing the Lead Time duration of the project by one day represents a reduction in the commitment of finances by the amount of approximately €1,000.

In the following Tab. 1 it is possible to see the evaluation of the total duration of the project for Company Y from the initial demand activity to the handover of the product to the customer for the current and design state.

Table 1 shows that the current state of the project is 276 man-days, but the design state is 259 man-days. Which represents a reduction of Lead Time by 17 man-days. The reduction in the commitment of finances is approximately €17,000.

Table 1
Evaluation of the Lead Time of the Project
[Source: Authors]

Project duration: current status	Project duration: design status	Difference	Cost reduction
276 man-days	259 man-days	18 man-days	€17,000

In Table 1, only the finances saved from shortening the project time are evaluated. Additional funds would be saved by incorporating the designs within the warehouse space. However, in this case study, closer attention was not paid to the calculations within the warehouse space.

Another evaluation element is labour. Labour's evaluation can be seen in the following Table 2.

Table 2
Evaluation of the labour of the project [Source: Authors]

Labour: current status	Labour: design status	Difference
3,384 hour/project	3,970 hour/project	586 hour/project

Table 2 shows that after incorporating the individual proposals, the labour time increased by 586 hours using the MCT map. As part of the shortening of the total project time, the efficiency increases. The graphic representation of this indicator can be seen in Fig. 12. From Fig. 12. it is also possible to see

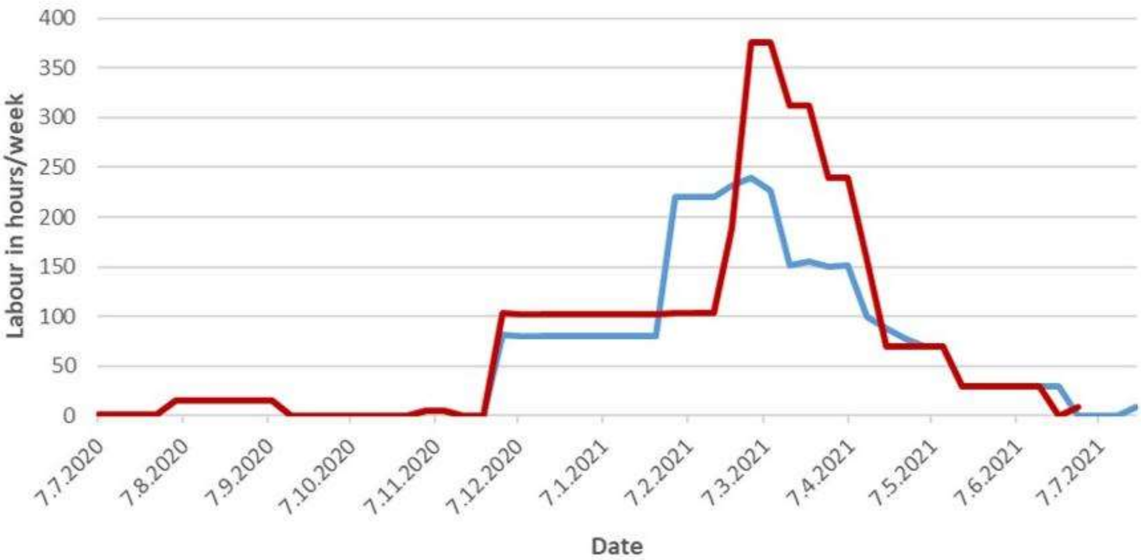

Fig. 12. Evaluation of the labour of the project, current state (blue), design state (red) [Source: Authors]

that after incorporating the individual proposals and shortening the time, the increase in labour is rapid.

Conclusions

The utilization of project management has become a vital approach in recognizing and addressing challenges that arise in modern business operations. Therefore, this study uses project management and its methods to improve the project management system itself in the company.

To manage customer requirements and project processes, it is necessary for the company to have an adequate project team and for project management within the company to be at an adequate level. Therefore, this study aimed to compile a proposal for the improvement of the project management system in Company X in the Production Automation division.

As part of the improvement of project management in the company, the project management cycle, material and inventory procurement processes, and product production and assembly were analysed. Subsequently, the identification of problems in these processes and the proposal of individual solutions to eliminate these problems were determined. Furthermore, the area of the production hall of Company X near Zilina was analysed. Part of the work was an in-depth analysis of the activities of a specific project using tools such as the Gantt chart and the MCT map. These tools were used to analyse the share of productive time and the share of productive activities within the entire project. The recommendations for Company X, specifically the Manufacturing Automation division, are for the company to focus on a project management system using the suggestions presented in the design section of the case study. These proposals consist of the modification of processes within individual projects and the modification of workplaces, which are significant milestones in project management. It is also necessary to add fundamental importance to key indicators of project performance, productive time, and productive activities within the project, which can be easily analysed through the MCT map for each subsequent project. The recommendation is to use more and more principles and tools of the innovative QRM methodology and the tools of methodology, which is currently not commonly used in the Slovak industry and is only beginning to develop. An additional recommendation involves the gradual incorporation of artificial intelligence into future project management endeavors, alongside a concerted focus on advancing information and communication technologies.

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