TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY

Department of Mechanical Industrial Engineering

MANUFACTURING CAPACITY DEVELOPMENT RESEARCH BASED ON BUSINESS PROCESS ANALYSIS

TOOTMISVÕIMEKUSE ARENDUSUURING ÄRIPROTSESSIDE ANALÜÜSI BAASIL

MASTER THESIS

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Tallinn 2019

AUTHOR'S DECLARATION

Hereby I declare, that I have written this thesis independently.
No academic degree has been applied for based on this material. All works, major viewpoints and data of the other authors used in this thesis have been referenced.

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Thesis is in accordance with terms and requirements

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THESIS TASK

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Study programme,

main speciality: MATM02/11 - Product Development and Production Engineering

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Thesis topic:

(in English) *Manufacturing capacity development research based on business process analysis*

(in Estonian) *Tootmisvõimekuse arendusuuring äriprotsesside analüüsi baasil*

Thesis main objectives:

1. Selection of suitable methodology and business process management tools for implementation of the tasks set by the NTM Baltic enterprise.

2. Analysis of production and management processes at the enterprise; detection of weak points that cause the reduction of the efficiency.

3. Drafting suggestions for improving the processes to increase the efficiency

Thesis tasks and time schedule:

No	Task description	Deadline
1.	Drafting the main subject of the thesis; determination of the main tasks.	21.02.2019
2.	Compilation of theoretical basis and discussion of the case.	21.03.2019
3.	Analysis of the current situation at the enterprise; identification of weak points.	18.04.2019
4.	Drafting suggestions for improvement; solving questions on the thesis formalization.	16.05.2019

Language: English **Deadline for submission of thesis:** “.......”....................201….a

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PREFACE

This thesis was written with the purpose to investigate the productional and management problems at the NTM Baltic Ltd. The basic activity of the company is manufacture of metal structures – the elements of refuse collection vehicles.

The need for analysis and subsequent improvements was announced at the general meeting, in the presence the board member Arno Aasma, the production manager Viljar Hollo as well as the author of this work, who holds the position of the production foreman. All the main actors of the enterprise – the shop workers, procurement and sales assistants, the management – were involved in the process of the analysis.

The NTM Baltic is a subsidiary of the international NTM Group. Changes in the structure of the production, which may proceed from the results of the study, should be agreed with the parent company, in this regard, the research work is written in English language.

INTRODUCTION

This research paper was written at the NTM Baltic Ltd. (NTMB), the subsidiary of the Finnish NTM Ltd. Company.

Over the last 3 years, the volume of the trade turnover in the company has increased significantly, which has led to a number of new issues to be solved. At this stage of development, the situation is not critical, however, now it is already possible to identify a large number of weaknesses that in the future, in the case of further development of the company, can become a serious impediment, therefore, it should be identified and delved into right now.

The methods of corporate management as well as the production capabilities developed in this company gradually, with the growth of orders and the corresponding growth of the company. From 2005 to 2015, the number of employees increased from 20 to 35 people, of which 28 shop workers and 7 in the office. In relation to this rather slow growth of the company, the solution of new problems did not require radical changes and was made step by step, by layering new conditions and solutions to the existing basis.

Over the recent 4 years, the volume of trade increased by 3511629 units (from 2782456 euro to 6294085 euro), which is 126% of the figures in 2015. During this time, the staff grew by 15 people, and production filled almost all available space, but the change of the production building is not planned for at least the next 5 years. The variety of manufactured products expanded significantly, thereby notably complicating the work with documentation, planning and management of the production.

Today, the company requires changes that will increase the efficiency of the enterprise at all levels of the activity.

In the course of the work, the analysis of the current situation in the production will be carried out, the main “weaknesses” in the planning and management department as well as directly in the production area will be identified. The most obvious practical issues that materially affect the efficiency of the production process will be identified and analysed. In search for the best solutions to the existing problems, various philosophies will be considered from which the most suitable for a particular case will be chosen, and a preliminary analysis of the possible benefits of the enterprise will be carried out.

As the object of the study a group of products called Kärllyft (bin lift) will be chosen, which has been the most problematic for several years due to the large number of subtypes, models (more than 60 units), and components in these models as well as their technological features. The production of this group affects all processes of the enterprise – such as pricing and change, communication with the client, planning and optimization, production of blanks, assembly and welding processes, surface treatment, etc. Working with this object makes it possible to analyse most of the operations of the NTMB enterprise.

Objectives and tasks

The main goal of this work is to detect problematic areas in the processes of the enterprise, which directly affect the efficiency of both the management and shop workers. In addition, it is necessary to formulate a proposal of various options for reconsidering and rectifying the problems found, and then analyse the possible benefits derived from the introduction of the proposed solutions.

To achieve the goal mentioned above, following tasks must be completed:

- Make a brief overview of the enterprise
- Choose business process management tools that will be appropriate for the assigned task
- Identify and model the existing business processes
- Identify problematic areas inside the processes
- Specify the mistakes that directly affect the efficiency
- Suggest possible solutions of the existing problems
- Make an analysis of presumable impact of the changes
- Give suggestions for further improvements

1 INFORMATION ABOUT THE ENTERPRISE

1.1 Overview of the parent enterprise

The company NTM (Närpes Trä & Metall - swed.) was founded in 1950 by Lennart Nordin. Initially, NTM had a metals department and a timber product manufacturing department. The company produced a range of items, including furniture, wheelbarrows, farm vehicles and repaired agricultural equipment.
Today it is an engineering company that develops, manufactures, sells and maintains transport equipment for heavy goods vehicles and refuse and recycling material collection vehicles. One of NTM’s most important products have always been truck bodies, but nowadays the fastest growing element of NTM’s production constitute refuse collectors. After several phases of development, they represent more than half of the company’s turnover.
NTM’s exports now constitute more than 75% of the company’s total volume and go to Sweden, Norway, Denmark, Iceland, the UK, Russia, Poland, the Netherlands, Austria and the Baltic States. NTM currently has over 400 employees in Finland and subsidiaries in Sweden, the UK, Estonia, Germany, Russia and Poland. [1]

1.2 Overview of the enterprise under study

As mentioned above, the NTM Baltic (NTMB) is a subsidiary of the international NTM company. The NTMB was founded in 1996 and was engaged in repairing of special-equipment vehicles. In 2005 the main profile of the company was reorganised and the production of a metalwork and mechanical engineering became the main business direction.
Currently, the NTMB is an average (by Estonian standards) company, 99% of whose products are exported. Finland (70%), Germany (15%), England (10%) and aftersales market to the neighbouring countries (Latvia, Lithuania, Poland) occupy a large niche of the total number of export products.
Besides, the NTMB is the official representative of the parent company in Estonia. One of the NTMB departments provides the pre-sale preparation, warranty repair and maintenance of garbage trucks, sold to Estonia. At the moment, none of the competing companies offers such services, which was one of the fundamental factors that ensured the first place among competitors. Today, the NTM works closely with all major waste removal companies in Estonia and Tallinn in particular – RagnSells, Keskkonnateenused and Ecovir. In 2018, 17 cars with different functional capabilities were sold to these companies. Another 21 vehicles are planned for 2019.
At present, the company has 50 employees, 42 of whom work in the shop, and 8 belong to the management. The annual turnover for 2018 amounted to 6294084.86 euro, which was 23.5% more than in 2017. The planned turnover for 2019 should grow by 15% compared to the previous one.

1.2.1 Technological capabilities and the corporate structure

The industrial building is divided into 4 departments:

- Machining shop – it has milling, turning, drilling machines
- Paint shop – it has a chamber for sandblasting and a “hall” for parts priming
- The main workshop – there are welding tables, racks with material and blanks, saws, bending machines, guillotine, rollers
- Assembly area and area for repair/maintenance of customer machines.

The company does not have laser/plasma cutting or CNC machines. All work related to this equipment is ordered from subcontractors.

All products are divided into groups and split between 3 foremen. Each foreman is a project manager for specific items/orders and controls their production process from beginning to end.

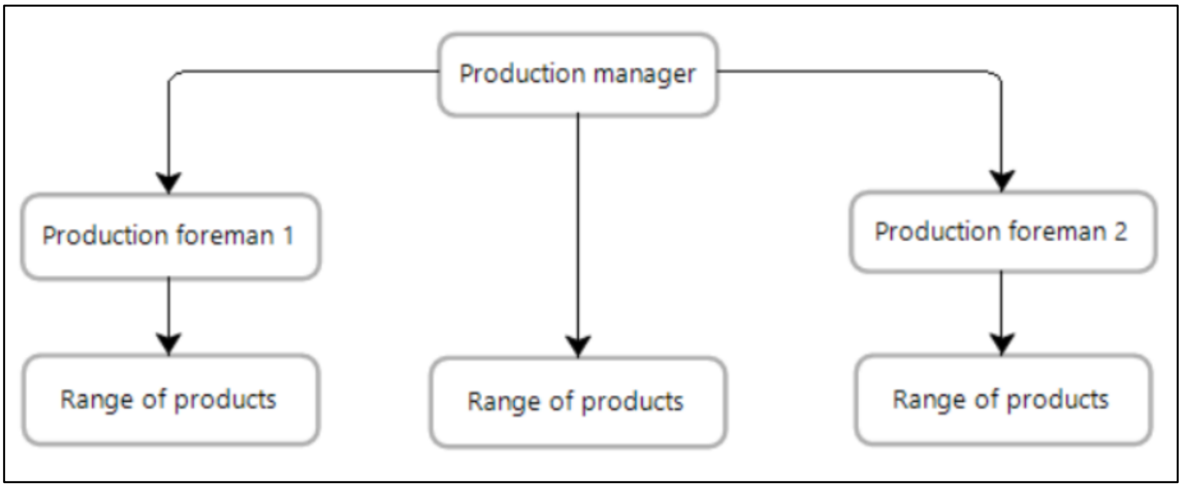


Figure 1.1 Distribution of responsibilities among production supervisors

Each foreman controls his own team of welders, the rest of the workers are in general subordination. The company also employs two assistants who deal with paperwork, purchasing supplies, communicating with suppliers and subcontractors.

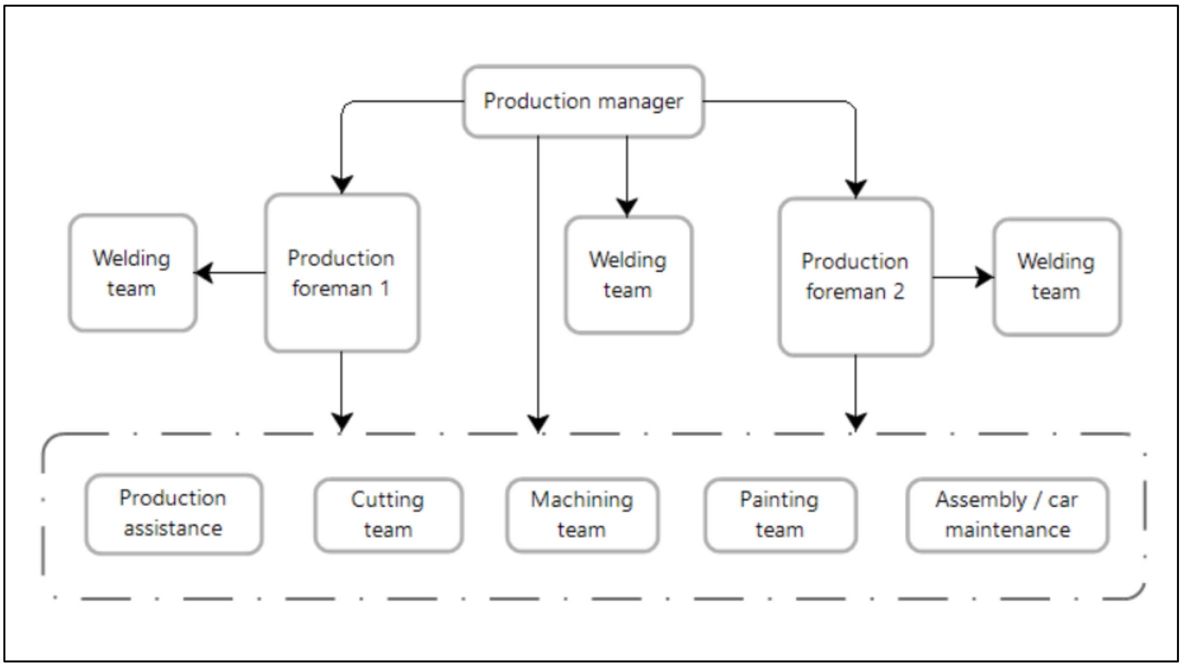


Figure 1.2 Corporate structure of the production department

1.3 Analysis of the current state of the enterprise

Table 1.1 Statistical indicators of the company's development in the period from 2005 to 2018

	2005	2010	2015	2016	2017	2018
Staff quantity (people)	20	30	35	40	47	50
Production staff quantity (people)	16	24	28	33	39	42
Management staff quantity (people)	4	6	7	7	8	8
Annual revenue (eur)	972989,13	1534551,24	2782456,42	3712445,34	5096128,99	6294084,86
Working space (m^2)	2724	2724	2724	2724	2724	2724
Storage space (m^2)	1490	1490	1490	1490	1490	1490
Product type variety (pcs)	14	20	30	34	39	43

Based on the table it can be concluded that the company has steadily grown over the past 13 years. At the same time, no major changes were carried out in the sphere of management or in the production sphere.

At this stage of existence of the enterprise the certain “top points were reached”:

- The production areas are overloaded. All the space in the shop is occupied. There is no possibility to create additional jobs (welding).
- Expansion/change of the production area is not expected. Decisions of this kind must be agreed with the management of the parent company. For the next 5 years, during the construction works on the expansion of the main production building (NTM FINNLAND, Närpio), the purchase/lease of new buildings for subsidiaries is not subject to approval.
- The control system has continuously changed and fine-tuned in line with the growth of production volumes but has not changed dramatically. To date, this system has a lot of errors/flaws that interfere with the correct work of management.

Since the expansion of the production area is not expected, solutions should be sought to improve the productivity by optimising the existing problems. Due to the constant employment associated with the ever-growing volume of work and processing of new information, the company’s management was not able to “take a step aside” and make a qualitative analysis of the position of the company. In this regard, it was decided to create this project on the basis of the thesis for the analysis and preparation of proposals to improve the production performance.

Since it is not completely clear what the main “bottle necks” of production are, it was decided to use the tools of the Business process management (BPM) as it is an effective discipline that uses various methods to discover, model, analyze, measure, improve, and optimize business processes. [2]

1.4 Main product groups

Today 90% of the NTMB production consist of parts for garbage trucks. Large-sized and technically complex components are assembled, welded and prepared for painting (primed) in Tallinn. Further, their assembly and installation on the chassis is carried out at the main plant in Närpio, Finland.

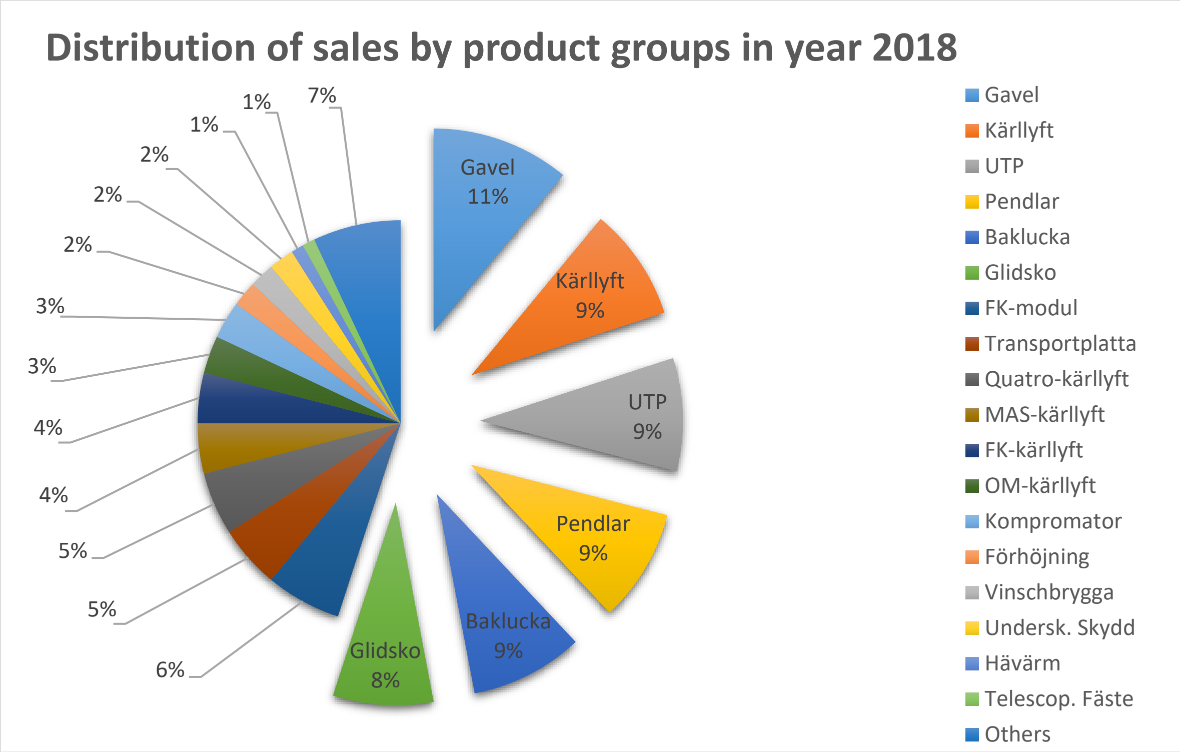


Figure 1.3 Distribution of sales by product groups in year 2018

1.5 Brief description of the main products

Gavel – this is a rear part of the lateral side of garbage trucks. The part is reinforced by a set of stiffeners, as it is not a plain wall, but has several important functions:

- Hydraulic levers are fixed on the Gavel, to which the bin lift is attached.
- Gavel has special guides in which elements of the garbage pressing mechanism move.
- Hydraulic cylinders are fixed to the interior of the Gavel, which cause the garbage pressing mechanism move.

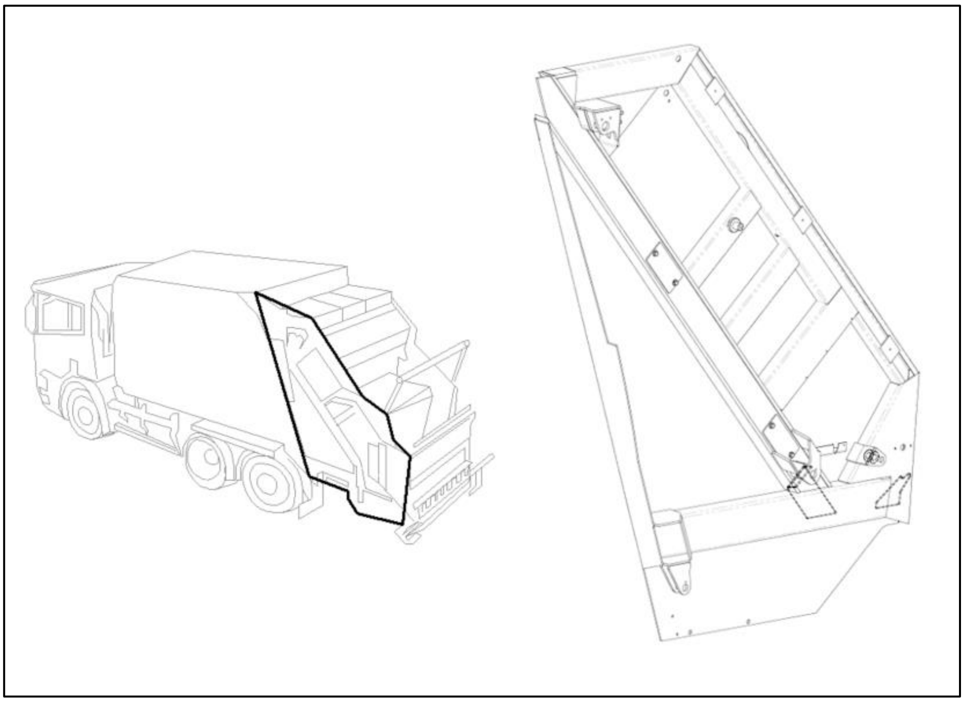


Figure 1.4 Visual identification of the product called “Gavel”

UTP (Uttryckar platta) – ejector plate. It moves from the rear part of the container to the front as the container fills with garbage. Then, it serves as the main thrust element for unloading of the garbage at the landfill.

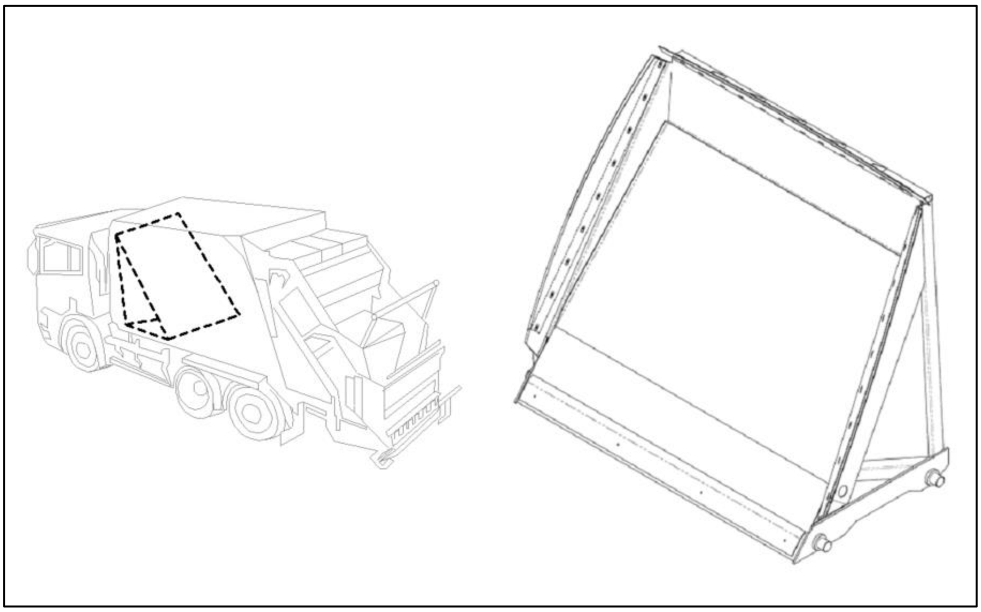


Figure 1.5 Visual identification of the product called “UTP”

Pendlar – the pressing element in machines with side loading.

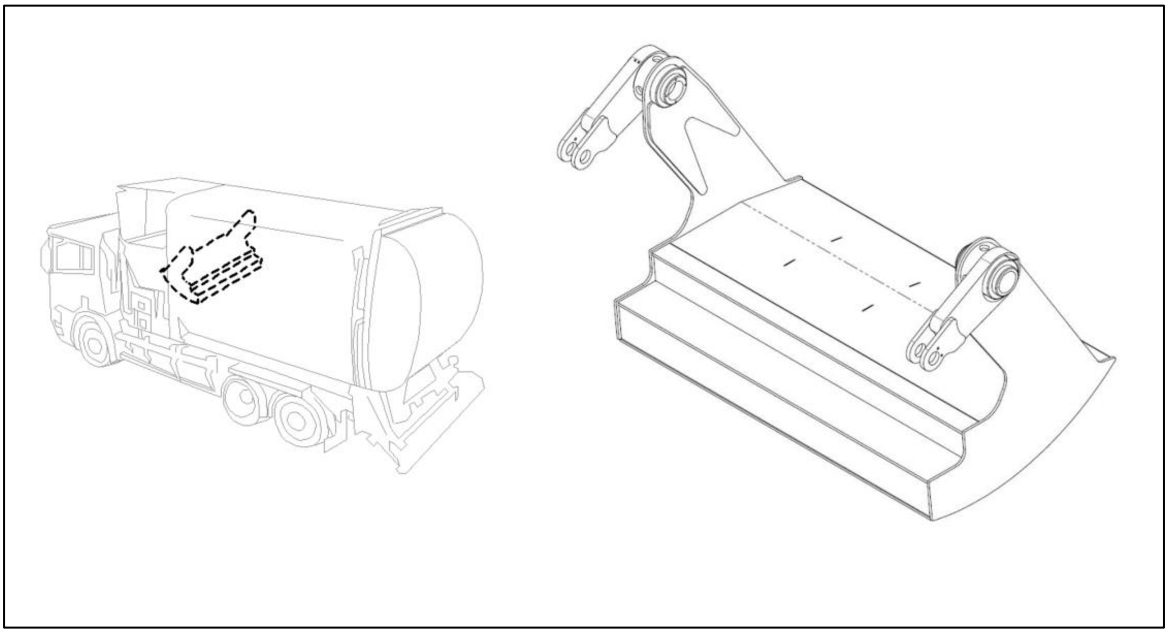


Figure 1.6 Visual identification of the product called “Pendlar”

Baklucka – the rear cover of the container on the side loading machines, provides a tight closure, as machines of this type are usually used for the disposal of semi-liquid biological waste.

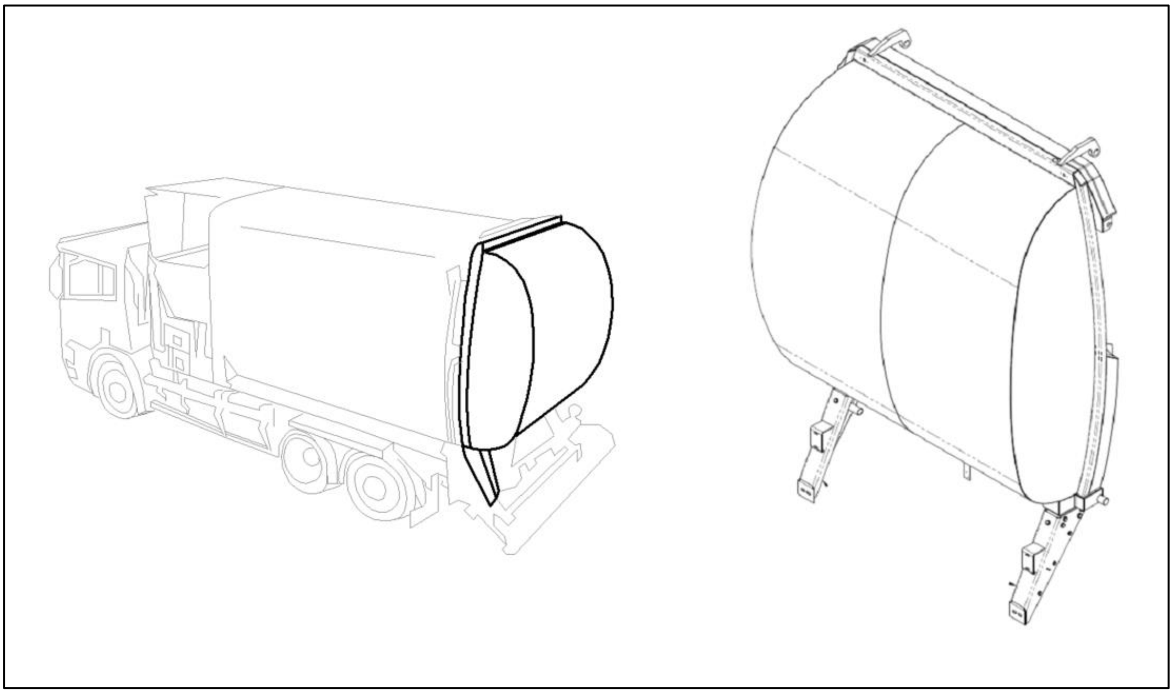


Figure 1.7 Visual identification of the product called “Baklucka”

Glidsko – the movable element of the garbage-pressing mechanism. It moves inside the guide channels of the Gavel. It has special plastic inserts that significantly reduce friction during movement and can be easily replaced when worn out.

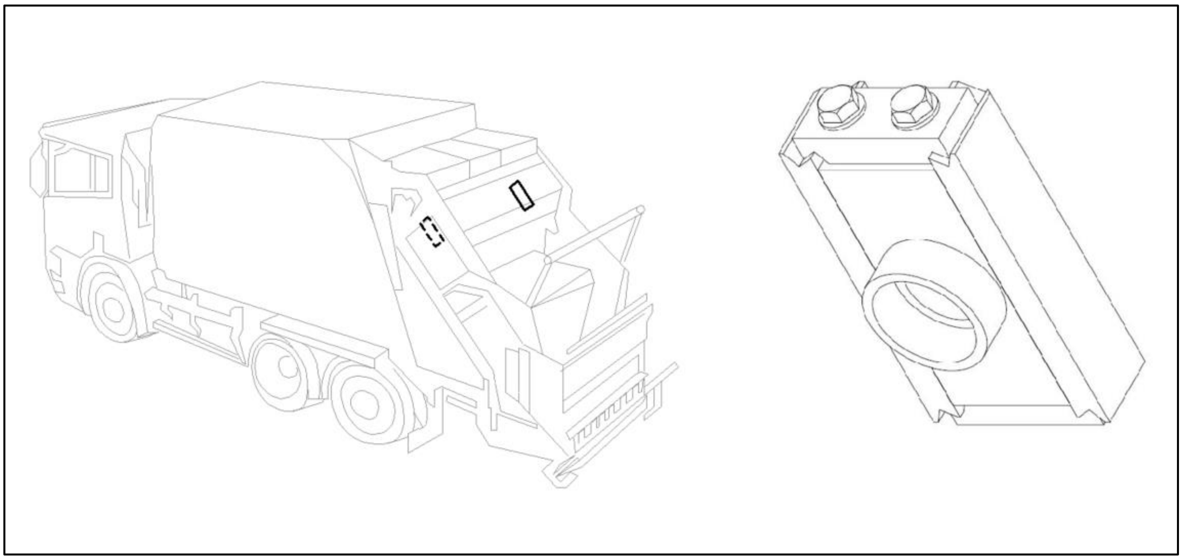


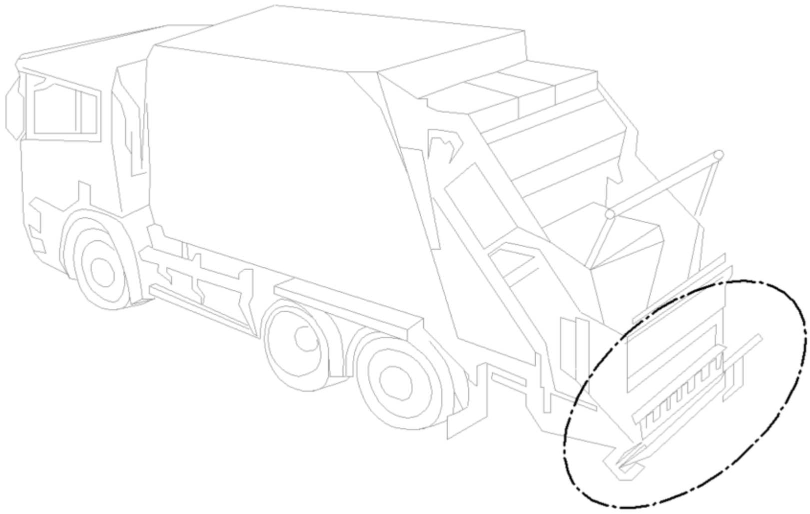
Figure 1.8 Visual identification of the product called “Glidsko”

1.5.1 The Object of study

The so-called bin lift (Swedish – Kärllyft) – a mechanism for lifting garbage containers and unloading garbage into the garbage truck compartment – was chosen as the object of the study. The reason for this choice is that the product bin lift is one of the three most frequently-produced products, for several years is has been the most complex and problematic in the production, therefore, it can most accurately reflect all the existing problems. The rear loading lifts division includes more than 60 different models, variable in size and function, the most important of which include:

- Lifting capacity
- Ability to load garbage into separate compartments (sorting)
- Ability to weigh collected garbage at the time of loading
- Ability to grab and lift pressed paper blocks

In the course of this work, for the analysis and detection of errors in production processes, the simplest model of the rear loading lift Kärllyft Standard 1000276053 is suitable.



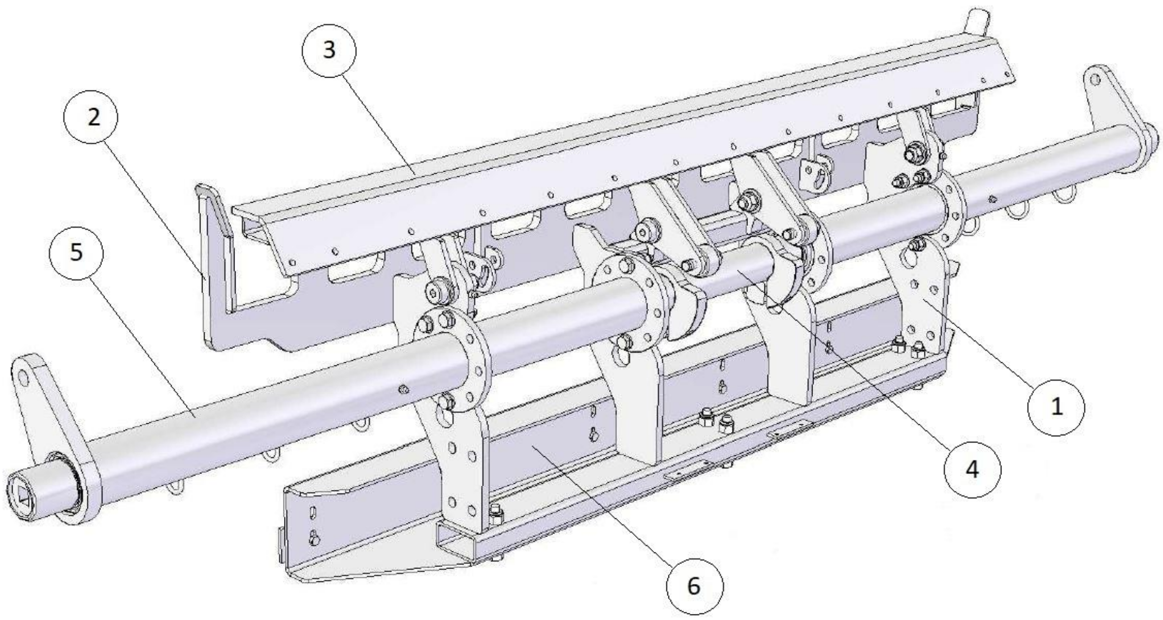


Figure 1.9 Visual identification and numerical designation of the product called “Kärllyft”

Main elements:

1 – Frame. It serves as the main frame of the product where all other parts are mounted, this certain frame is designed for 5 different models of the lifts. This frame contains some power thrust parts, that are also used on the other frames of similar type but different size.

2 – Toothed gripping plate (Comb). Picks up the container from the lower side a special reinforced edge and raises it above the ground, while turning. There are more than 40 combs of different shapes and sizes. Some elements such as gripping tooth are used on each of them.

3 – Clamping plate. Presses the garbage bin to the top of the comb so that it does not fall into the container of the garbage truck. This plate is installed on 7 different models of bin lifts but contains elements used on 34 different models.

4 – Internal frame tube. It is the main axis of rotation of the lift as well as the element connecting the lift with hydraulic levers that are lifting it. The axis of such length and shape is mounted on 5 other similar models.

5 – External frame tube. It is installed on the inner tube through sliding bearings. By rotating on the inner tube, it transfers rotation to the main frame. Contains elements installed on another 26 models of lifts.

6 – Support bar. Rests against the garbage bin at the bottom and takes the load when the bin is rotated. The certain bar is installed on 6 other lift models, similar in type and size.

2 METHODOLOGY

2.1 Business Process Management

What is Business Process management?

This is the question that needs to be asked at the very beginning to ensure that there is a common understanding. There are many answers to that question. BPM has been misinterpreted frequently - some providers call the BPM to be another name of process improvement or process reengineering, others see it just as process modeling of performance management, the thirds are trying to sell the "Lean" message to executives. Many of the industry commentators provide definitions that specify technology as the most essential component of BPM.

John Jeston claims that BPM is more than just one of these definitions but is a discipline that includes all of them.

Business process management (BPM) - is a management discipline focused on using business processes as a significant contibutor to achieving an organization's objectives through the improvement, ongoing performance management and governance of essential business processes. [3]

2.1.1 Business Process Modeling

Business process modeling (BPMo) - is a way of visual representation of business processes of the enterprise in the form of diagrams and tables, convenient for their further use with the aim of the analysis, improvement and automation of the studied processes. Modelling is performed by a team of analysts, some of whom have expert knowledge in the field of modelling while others have professional knowledge about the simulated processes. The latter, as a rule, are employees of the enterprise under research. [4]

Business Process Models are the representation of current (”as is”) and proposed (”to be”) enterprise processes, so that they may be compared and contrasted. By comparing and contrasting current and proposed enterprise processes business analysts and managers can identify specific process transformations that can result in quantifiable improvements to their businesses. [5]

2.1.2 Business Process Reengineering (BPR)

Business process reengineering is one approach for redesigning the way work is done to better support the organization'sneeds. Within the framework of this basic assessment of mission and goals, reengineering focuses on the organization's business process that can be decomposed into specific activities, measured, modeled, and improved or even eliminated, if needed. Reengineering identifies,

analyzes, and redesigns an organization's core business processes with the aim of achieving dramatic improvements in critical performance measures, such as cost, quality, service, and speed.
Unfortunately BPR is not a panacea and there is wide range of cases where the method was absolutely inefficient. Many organizational experiments with reengineering produced disappointing or inadequate results. Employees' resistance to BPR can be very strong because of fears that they may be reengineering themselves out of a job.
This drive for fundamentally rethinking how the organization's work should be done differs reengineering from process improvement efforts that focus on functional or incremental improvement.[6]

2.1.3 Business Process Improvement (BPI)

Business process improvemet is an alternative to BPR, an evolutionary approach to changing business processes. It focuses on incrementally improving existing processes. There are many approaches, including the popular Lean approaches. BPI is usually narrowly focused and continuously applied at various stages during the life of a process. BPI includes the selection, analysis, design, and implementation of the (improved) process. This usually results in an initiative or project to improve the performance of a particular process in alignment with the organizational strategy and customer expectations. [7]

2.1.4 Lean Thinking

Lean thinking is a business methodology whose goal is to provide a new way of thinking about how to organize human activities in order to bring more benefits to society and increase value for people while eliminating losses. The goal of lean thinking is to create a lean enterprise that supports growth by aligning customer satisfaction with employee satisfaction, and that offers innovative products or services at a profit by minimizing unnecessary overspending for customers, suppliers and the environment. The basic understanding of thinking is that if you teach each person how the time and efforts are wasted and how to work better together to improve processes by eliminating such losses, the resulting enterprise will generate more profits at lower costs while developing each employee. Confidence, competence and ability to work with others.[8]

2.1.5 ERP systems (Technology)

Enterprise Resource Planning (ERP) is an integrated management of core business processes. ERP is commonly referred to as a business management software category — integrated applications — that an organization can use to collect, store, manage, and interpret data from multiple business operations. ERP provides an integrated and constantly updated view of the processes using databases supported by a database management system. ERP systems track business resources — cash, raw materials,

production capacity — and the status of business commitments: orders, purchase orders, and payroll. The applications share data between different departments (production, purchasing, sales, accounting, etc.). ERP facilitates the exchange of information between all business functions and manages relationships with external stakeholders. [9]
Although early ERP systems were targeted at large enterprises, small enterprises increasingly use ERP systems.
The ERP system integrates various organizational systems and ensures error-free transactions and production, thereby increasing the efficiency of the organization. ERP systems operate on various computer hardware and network configurations, usually using a database as a repository of information. [10]

The main advantage of ERP is that the integration of multiple business processes saves time and money. Management can make decisions faster and with fewer errors. Data becomes visible throughout the organization. Tasks that benefit from this integration include:

- Forecasting sales, allowing you to optimize inventory.
- A chronological history of each transaction by collecting relevant data in each area of activity.
- Order tracking, from acceptance to execution
- Tracking revenue, from account to cash
- Matching purchase orders (what was ordered), inventories (what came in) and cost (what was billed to the supplier)

2.2 Process improvement algorithm

As the basis for composition of the algorithm was taken the scheme of the transition to a process approach in the management of the organization. [11]

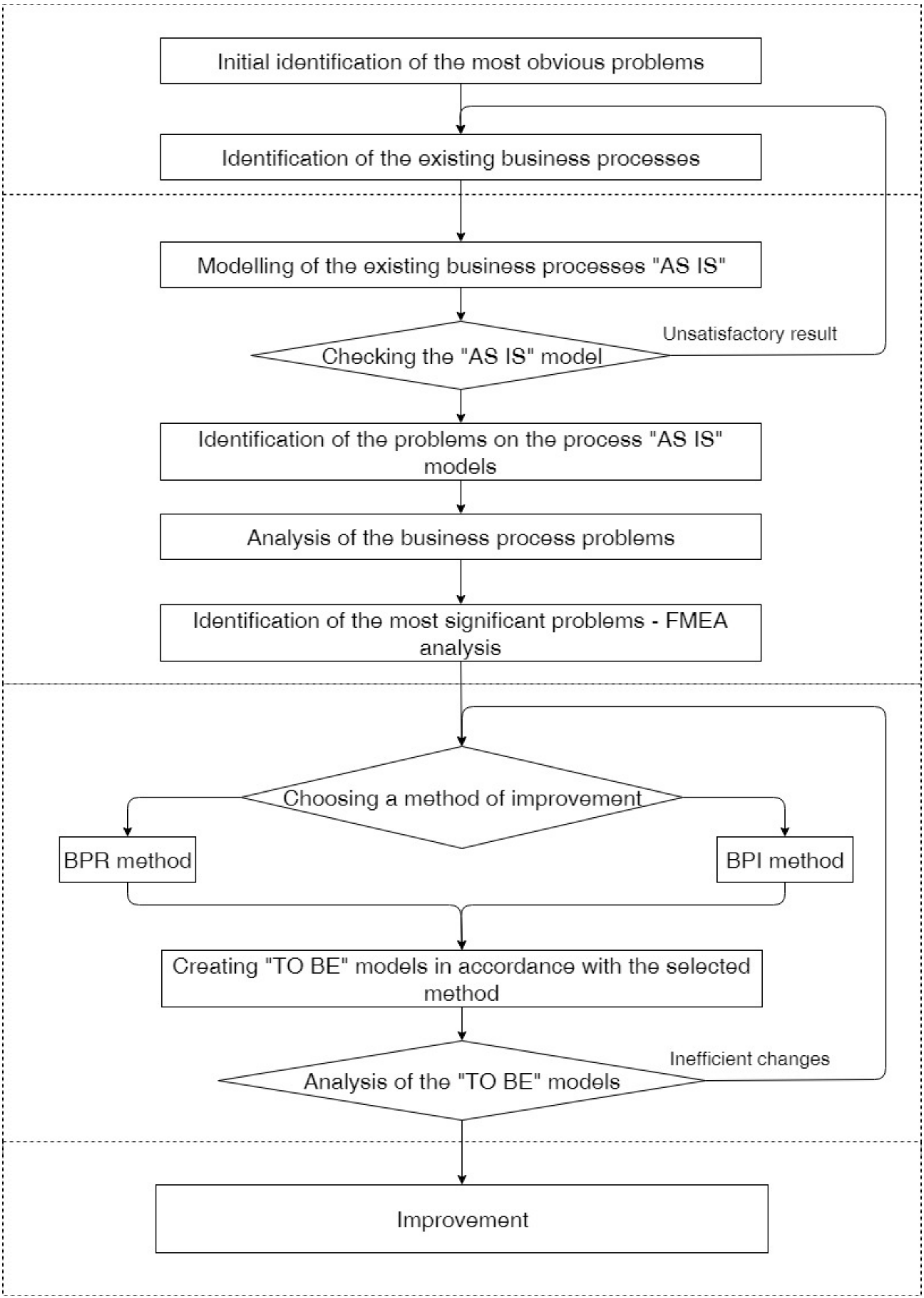


Figure 1.10 Process improvement algorithm

2.2.1 Initial identification of the most obvious problems

There was conducted a survey of the main actors involved in the production process, in particular, in the production of rear loading lifts. The survey involved the production supervisors, procurement assistant, dispatch assistant, warehouse workers, the assembly line workers and welders. The survey identified the most obvious problems:

In management

- Time expenditures when placing the orders for blanks
- Time expenditures in the preparation of calculations (for the same type products)
- Incorrect write-off of parts during shipment processing (quantitative discrepancy between the database and reality)
- There is no analysis of the workload of general employees
- There is no clear prioritization between the products of different masters
- Multiple duplication of information

In the production

- Not enough space on racks for blanks/material
- Time spent on finding the right parts
- Not enough workplaces (the production volume is growing, more welders are needed, but there are no workplaces for them)
- Employment of lifting mechanisms, time expenditures for waiting

3 ANALYSIS OF THE MANAGEMENT PROCESSES

3.1 Identifying the existing business processes

After collecting the primary information, the author should define and describe the simulated business processes, determine their composition and boundaries. More detailed individual interviews were conducted to collect relevant formalized data.

The information should be checked for correctness:

- the event following the execution of function in one department, should be initiating in another department;
- function names must be the same as the official names approved in the division regulations;

  no discrepancies are allowed in the function names.

3.2 Modelling of the existing business processes "AS IS"

3.2.1 Business Process Model and Notation (BPMN)

Business Process Model and Notation (BPMN) - is a system of symbols and their descriptions for modelling of business processes.

The primary goal of BPMN is to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes. Thus, BPMN creates a standardized bridge for the gap between the business process design and process implementation.

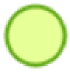
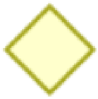
Modelling in BPMN is carried out by means of diagrams with a small number of graphic elements. It helps users quickly understand the logic of the process.

There are four main categories of elements:

- Flow objects: events, activities, gateways
- Connecting objects: sequence flow, message flow, association
- Swim lanes: pool, lane
- Artifacts: data object, group, annotation [12]

Table 2.1 Designation of graphic elements used in the composition of analytical models

Element	Description	Notation

Event (Start)	An event is something that “happens” during the course of a business process. These events affect the flow of the process and usually have a cause (trigger) or an impact (result). Events are circles with open centers to allow internal markers to differentiate different triggers or results.	
Event (end)		
Task	A Task is an atomic activity that is included within a Process. A Task is used when the work in the Process is not broken down to a finer level of Process Model detail.	
Sub-process	A Sub-Process is a compound activity that is included within a Process. A “plus” sign in the lower-center of the shape indicates that the activity is a SubProcess and has a lower-level of detail.	
Gateway	A Gateway is used to control the divergence and convergence of multiple Sequence Flow. Thus, it will determine branching, forking, merging, and joining of paths.	
Sequence flow	A Sequence Flow is used to show the order that activities will be performed in a Process	
Association	An Association is used to associate information with Flow Objects. Text and graphical non-Flow Objects can be associated with the Flow Objects.	
Group	A grouping of activities that does not affect the Sequence Flow. The grouping can be used for documentation or analysis purposes.	
Pool	Usually pool represents major participants in a process, but in this certain case pool represents the „field“ where the lanes belong.	
Lanes	Used to organise and categorise activities within a pool according to function or role, and depicted as a rectangle stretching the width or height of the pool.	

3.2.2 Modelling of the processes

Creating a model of the processes using the modelling program Bizagi modeler 3.3.

In order to verify the adequacy of the model, a third cycle of interviews is conducted with all key persons, who must confirm that the simulated processes relating to them are true.

General model of the main process is attached in the appendices. [APX 1]

For the convenience of identifying and analysing problems, the general model can be divided into 4 main stages:

Figure 2.1 Four main stages of the general process

3.3 Identification of the problems on the process "AS IS" models

3.3.1 "New product price offer" stage investigation

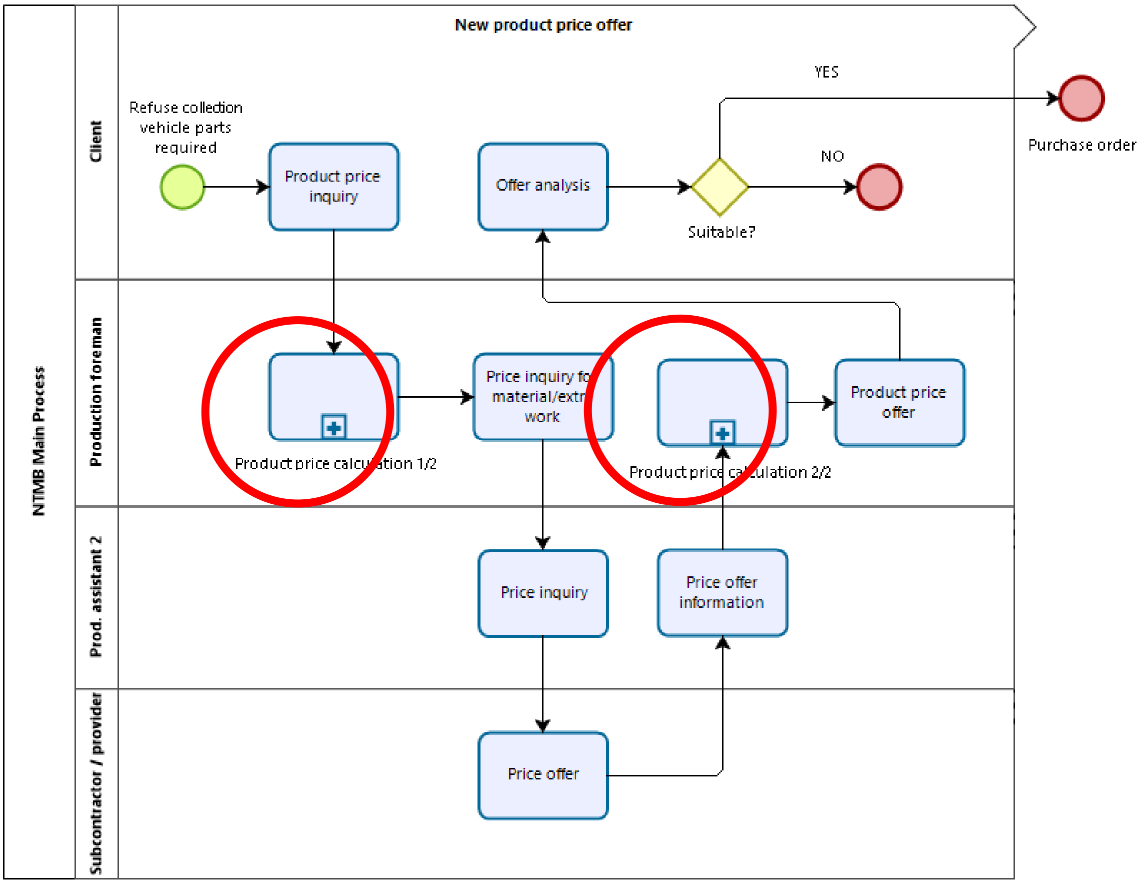


Figure 2.2 "New product price offer" stage model

At the first stage of the main process there is a subprocess "The product price calculation", which is likely to hide flaws that affect the increase in time expenditures during the calculation of prices. This subprocess should be modelled separately and examined in detail for errors.

Product price calculation

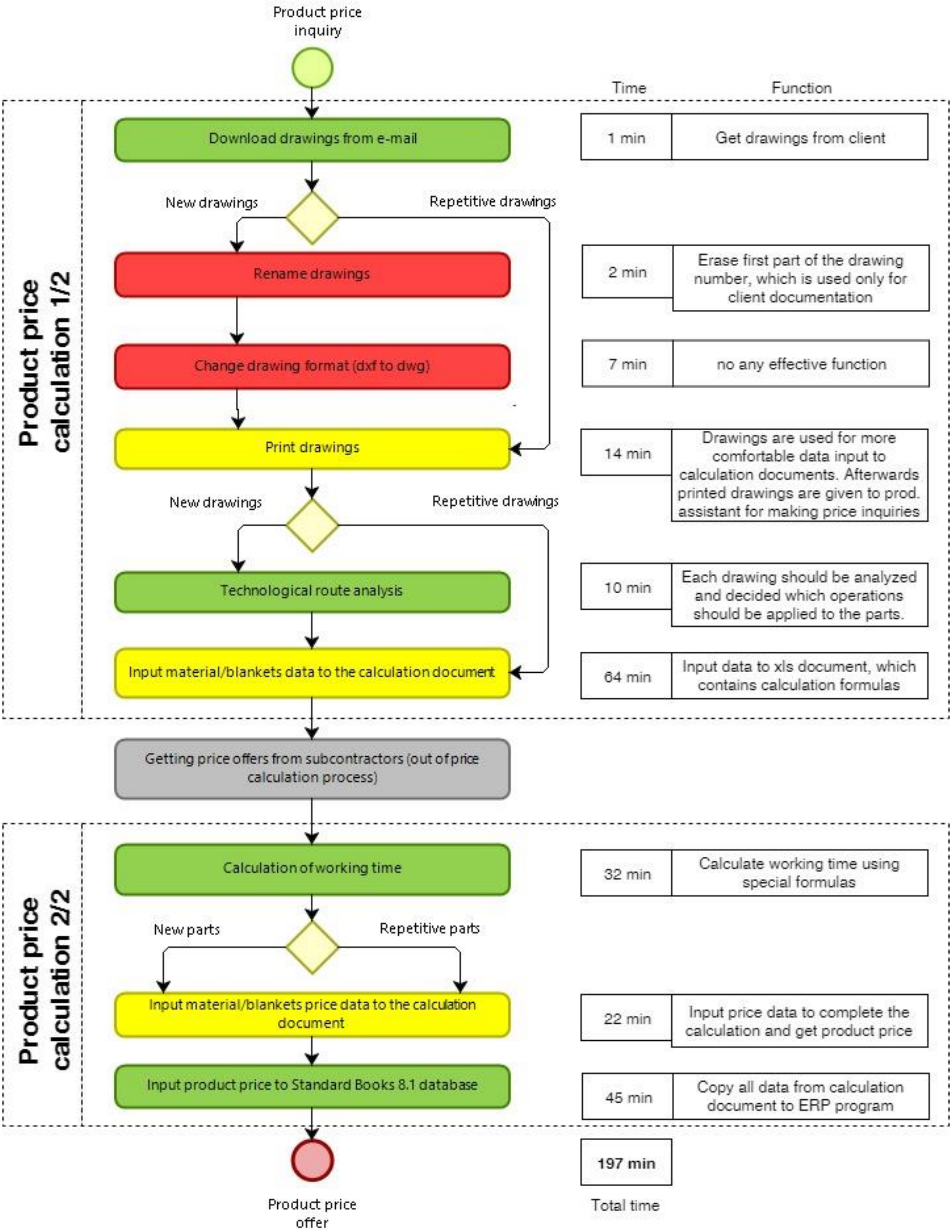


Figure 2.3 “Product price calculation” subprocess model

! It is necessary to note that the calculation of time expenditures was based on a specific model of the product Kärllyft under the drawing number 1000489878. The calculation was made 09.04.2019 [APX 2] [APX 3]

The time spent on the calculation depends on the complexity of the product. Since the models differ significantly from each other in terms of the complexity of technological solutions and the number of component parts, the time calculated in this analysis is an individual indicator and cannot be correlated with all products. The scheme and the time calculated during the analysis reflect the proportional ratio of the studied operations.

In this subprocess there are clearly traceable:

- Unnecessary operations (marked in red)
- Pointless time expenditures on processing of information relating to duplicated drawings (their number is 80% of the total) – printing drawings, input information, calculating time, input price information and data entry in the ERP software.

  The fact is that the currently available EPR system allows you to save assemblies as separate products but does not allow them to be included in the calculation of entire products as a subassembly. It means that all repeating subassemblies are separately re-entered each time and are accounted part-by-part.

3.3.2 "Client order processing" stage investigation

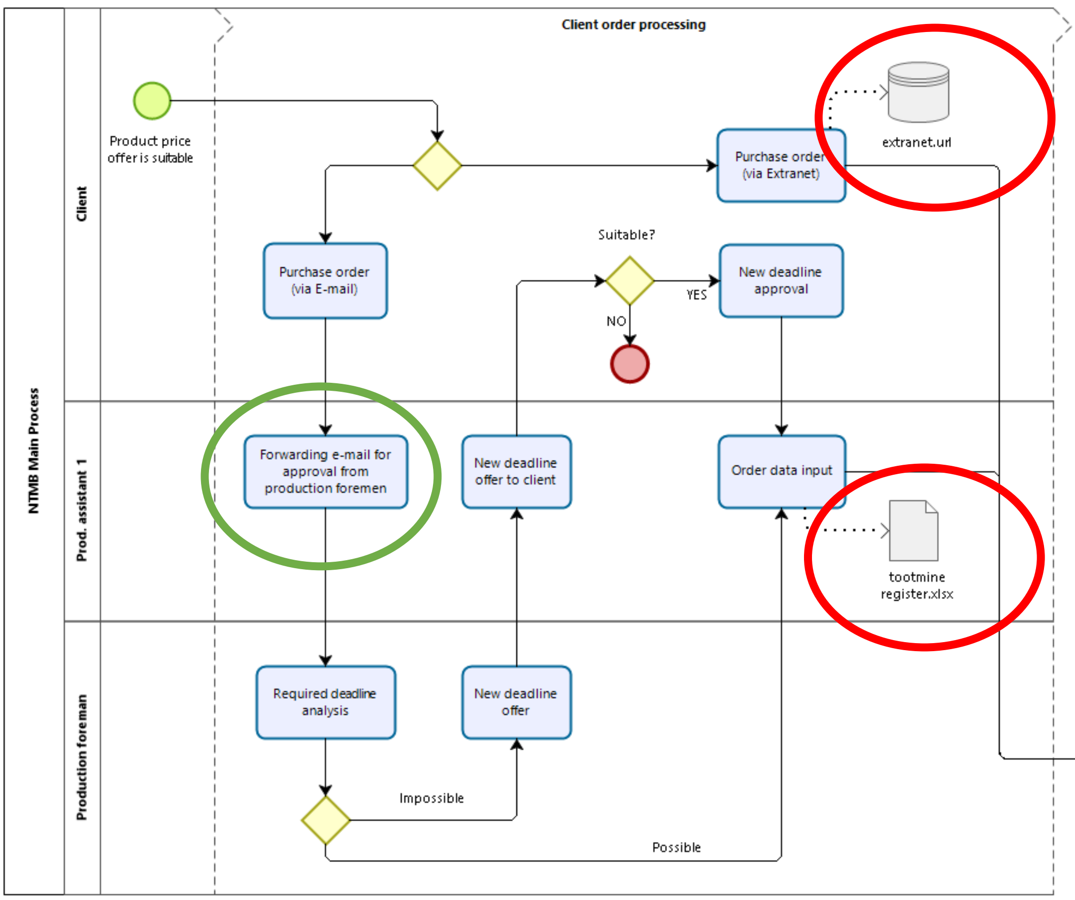


Figure 2.4 "Client order processing" stage model

At this stage, an example of duplication of information was found.

The analysis:

- Time spent – no more than 20 seconds
- Function – auxiliary. The assistant checks the shared mailbox (*sales@ntmbaltic.ee*) times per hour and shall notify the supervisors about new incoming orders. The supervisor does not have to separately check the shared mailbox. All supervisors receive information about orders at the same time.

This process diagram also shows that the customer places orders in two different ways:

- Extranet – a web resource which lists information about the production plans for the NTM FINLAND. The information is displayed as a table compiled specifically for the NTMB. The table shows the production number of the machine on which the components produced at the NTMB will be installed, as well as the required delivery time (specified in weeks).

  Example:

Week number

Vehicle type

If vehicle type has certain component model, then it is marked with word. If the vehicle type can be equipped by different component models, then the component is marked with the drawing number

Vecka 26-2019

Ordernr	**Typ**	**Utp**	**Kärllyft Quatro**	**Kärllyft OM**	**Kärllyft Baklastare**	**Servicestöd**	**Baklucka**	**Transport platta**	**Pendel**
22707	KG-2Bs	utp			1000453370 1000453357	servicestöd		transportplatta	
23254	OM-SBH			kärllyft			baklucka		pendel
23000	KGH-HL	utp			1000276053	servicestöd		transportplatta	
23205	FL-P						baklucka		pendel
23257	OM-SBH			kärllyft			baklucka		pendel
22702	KG-2Bs	utp			1000453370 1000453357	servicestöd		transportplatta	
23186	QUATRO	utp	kärllyft						pendel
23261	OM-2K			1000467194			baklucka		pendel
23337	KGH-HL	utp			1000276053	servicestöd		transportplatta	

Vehicle order number

Figure 2.6 Example of the “Extranet” interface

- E-mail – by e-mail the client sends orders for aftersales, orders for spare parts, experimental samples as well as some orders that are issued in large batches and are not attached to a specific machine.

Information on orders is stored in Excel table “Tootmine register”.

It is important to note that the “Tootmine register” table is the main document that contains information on all products produced at the NTMB, but the information from the Extranet Web-resource is only entered into it “post-factum” at the stage of formalising shipment documents.

This aspect will be discussed in more detail in subsection 2.5.3.

3.3.3 “Production” stage investigation

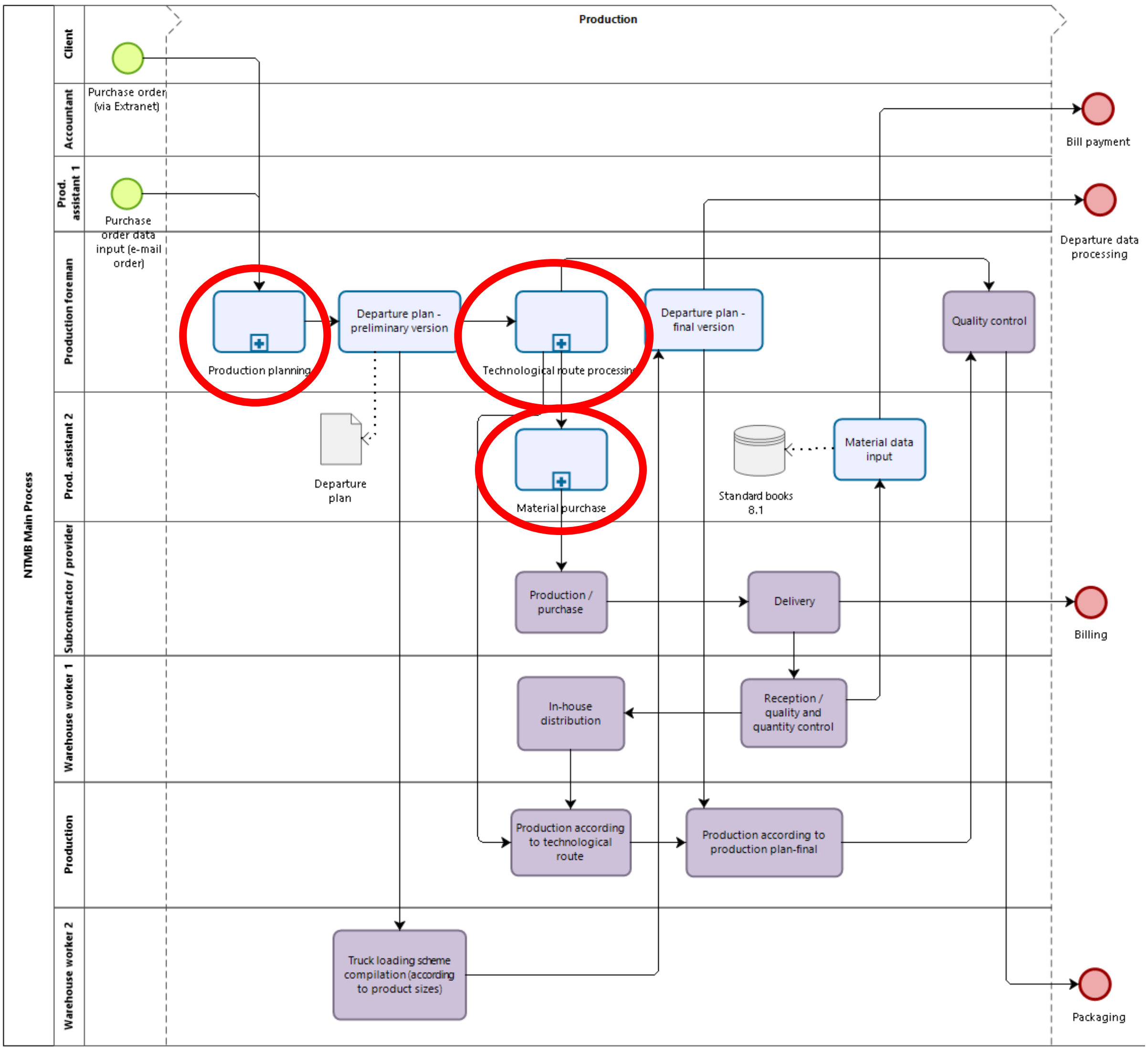


Figure 2.7 “Production” stage model

At the third stage of the main process there are three sub-processes, which are likely to hide the shortcomings that affect the increase in time spent on planning, ordering material and blanks. These subprocesses should be modeled separately and examined in detail for errors.

Production planning.

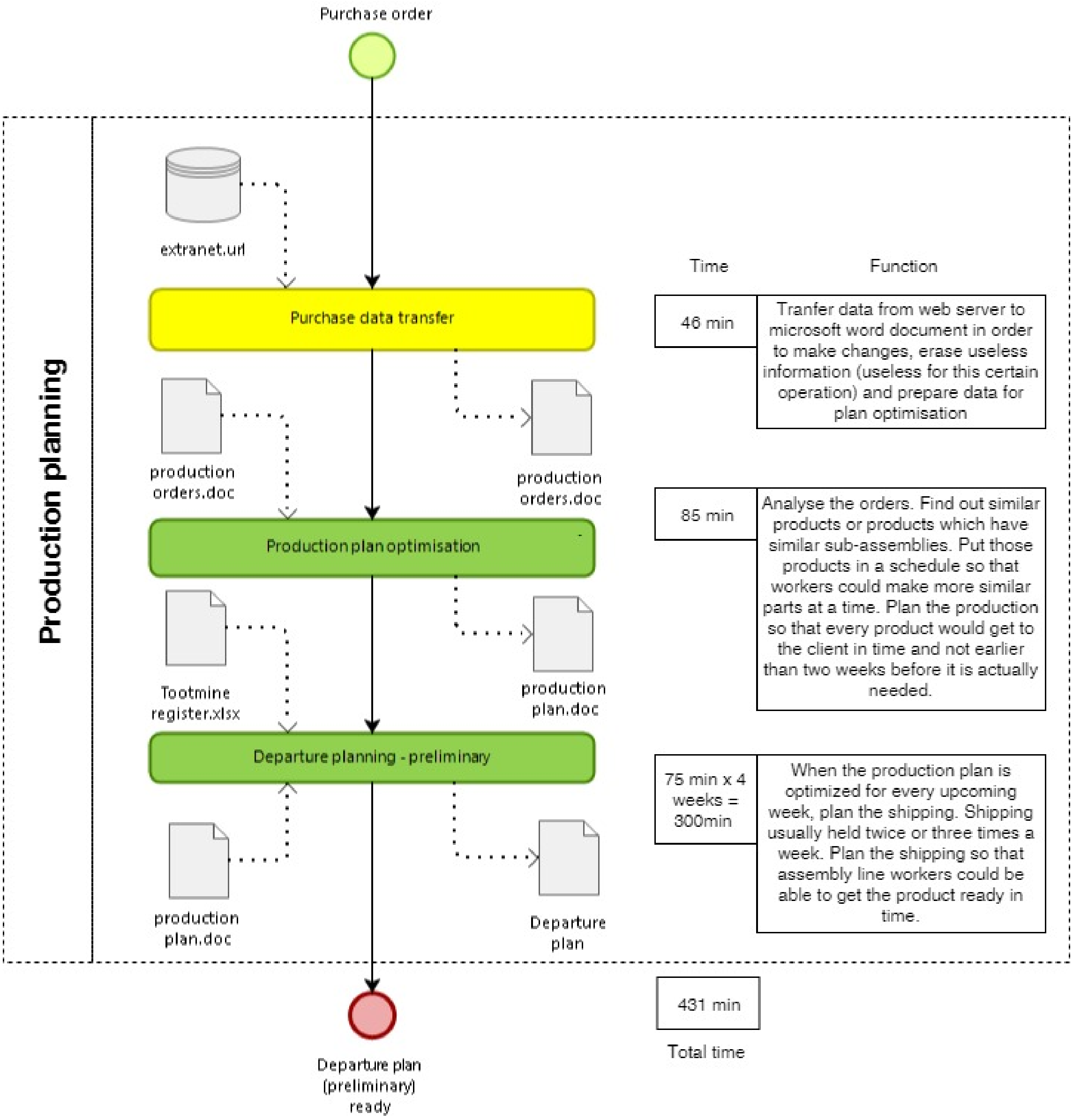


Figure 2.8 “Production planning” subprocess model

! Be sure to note that the calculation of time spent on the basis of production planning for the period from 01.04.19 to 03.05.19 (April). The time spent on planning depends on the number of orders in a particular month. The time calculated in this analysis is an individual indicator and displays only the proportional ratio of the studied operations.

The main problem of this subprocess is that all operations are performed in different documents and a large amount of time is spent on transferring information from one document to another. Everything is done manually and the probability of errors associated with the human factor is included.

Technological route processing.

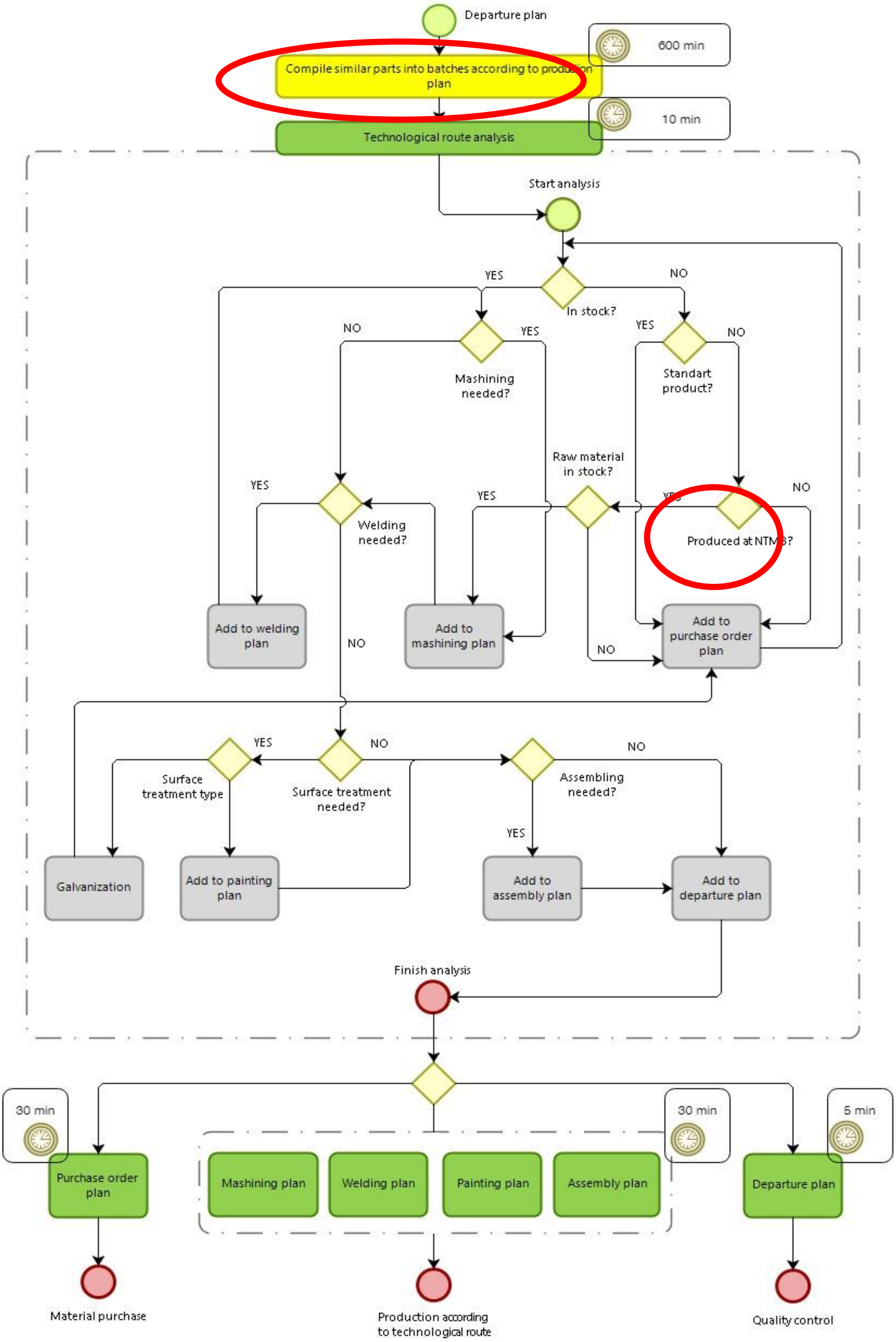


Figure 2.9 “Technological route processing” subprocess model

! It is necessary to note that the calculation of time spent was taken on the basis of the study of the technological route for the products planned for production in the period from 01.04.19 to 03.05.19

(April). The time spent on the development of the technological route, depends on the number of orders in a particular month as well as the complexity of the ordered products. The time calculated in this analysis is an individual indicator and displays only the proportional ratio of the studied operations.

Procurement of blanks is usually carried out for a month in advance and includes all the details necessary for the production of workpieces during this month. Setting of orders into batches is carried out manually and takes a lot of time:

- Counting of orders and compiling identical models into groups
- Viewing drawings and writing out main sub-assemblies
- Compiling into batches and counting identical sub-assemblies
- Viewing drawings of sub-assemblies, writing out and counting of parts.

The work takes an average of about 10 hours and is repeated with cycles per month.

The solution “Produced at NTMB?” is based on many different factors, such as:

- Technological capabilities – if the machine capabilities do not allow to ensure the required accuracy of products, parts are ordered from contractors, as a rule, for the production on CNC machines
- Quantity required – if quantity necessary for the production is more than 100pcs, details are advisable to be ordered from the contractor for the production on CNC machines
- Required delivery time – if the part is usually produced by contractors, but the NTMB receives an urgent order for a small number of products, it is decided to make the workpiece in the NTMB shop.
- Unforeseen situations – if some amount of the details has been damaged, and the number of defects is not significant (up to 10 pieces), it is decided to produce the missing parts in the NTMB shop.
- Availability of material – if in the warehouse there are remnants of the material from which it is possible to produce particular parts, in order to save, the decision is made to use these residues in manufacturing.

It follows that the decision on the distribution of orders between contractors and “in-house” production is always taken individually.
The subprocess „technological route processing” has three outputs – to order material/parts from contractors, to the production, and to the ready-made parts (if such are available in stock). A very serious error was found here – the products directed into the NTMB production are not documented in any way. From the "Production" process a separate clipping is made, which more clearly displays the problem.

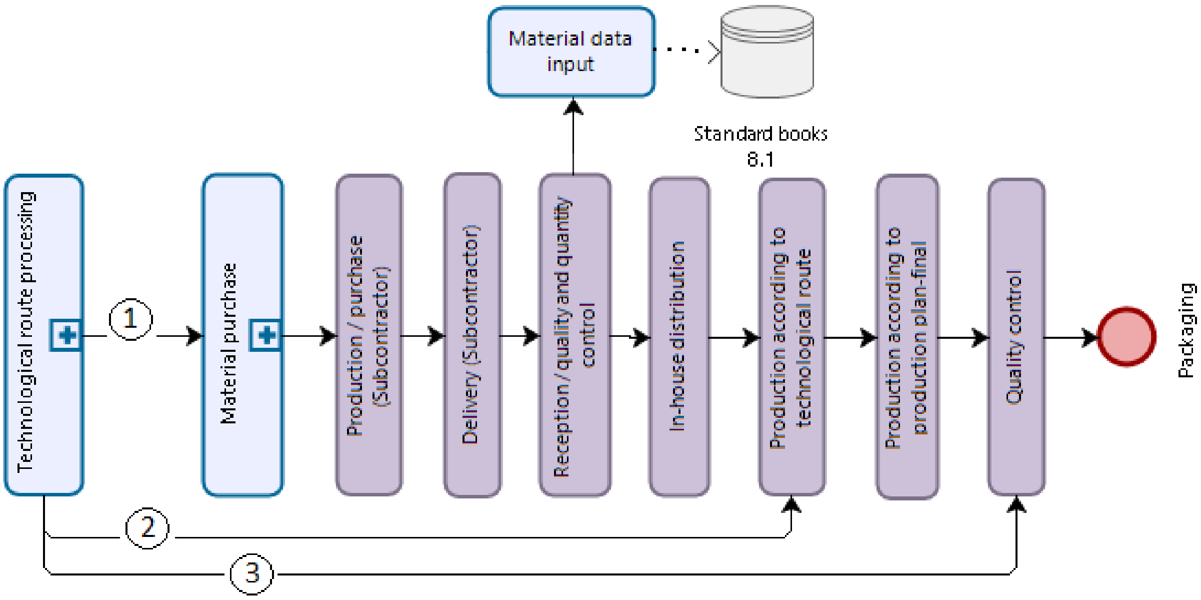


Figure 2.10 Identification of the mistake in production documentation (part1)

During the technological analysis, the supervisor must determine the production route of each part. The elementary details are given into work to the NTMB machining shop. More complex parts, as well as parts the expected one-time order of which exceeds 100 PCs., are ordered from partners, for production on CNC machines.

Blanks ordered from suppliers are recorded in the standard Books 8.1 database, their quantity is tracked and debited at the time of shipment of finished products.

Blanks given to work to the NTMB shop are not registered in any way.

In certain (above) situations the details given into production of the contractors are given to work to the NTMB shop. Their number is not entered into the database.

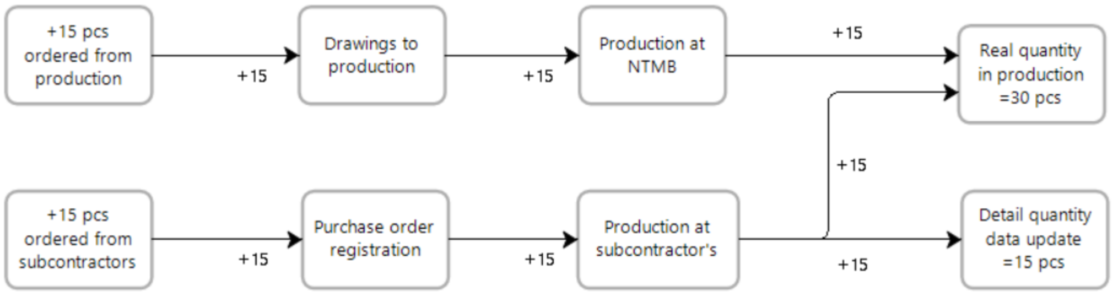


Figure 2.11 Identification of the mistake in production documentation (part 2)

The details given to work to the NTMB shop are not documented in any way. A drawing is printed on paper and given to the employee. Information about what orders are currently in work, their quantity as well as the timing of the work is available only in the drawings of the employee.

Upon completion of the order, the employee carries the finished part to a specially designated rack and does not provide any report on the work done.

- The supervisor does not have a complete picture of which of his parts are in work.
- The supervisor has none information about what other supervisors' orders are in work.
- No information on which orders have priority.
- The employee determines what to do first.

The item „Compile similar parts into batches according to production plan" is an auxiliary action, but it requires a lot of time when compared with the main (green) actions of this subprocess.
The reason for this problem is that the existing ERP system does not have some important functions, namely:

- Does not allow to do "planning" within the program. The program allows the so-called virtual production, which is done post-factum at the time of product shipment, but does not allow you to create a list of products that will be produced and sent in the future.
- Due to the absence of the planning function, it is also not possible to combine the same parts into groups and count the required quantity.
- The supervisor has information about how many products are currently in stock, but there is no information about what part of these products is already reserved for future production, respectively, there is no information about how many "free" parts there are available and how many more you need to order.

Material purchase

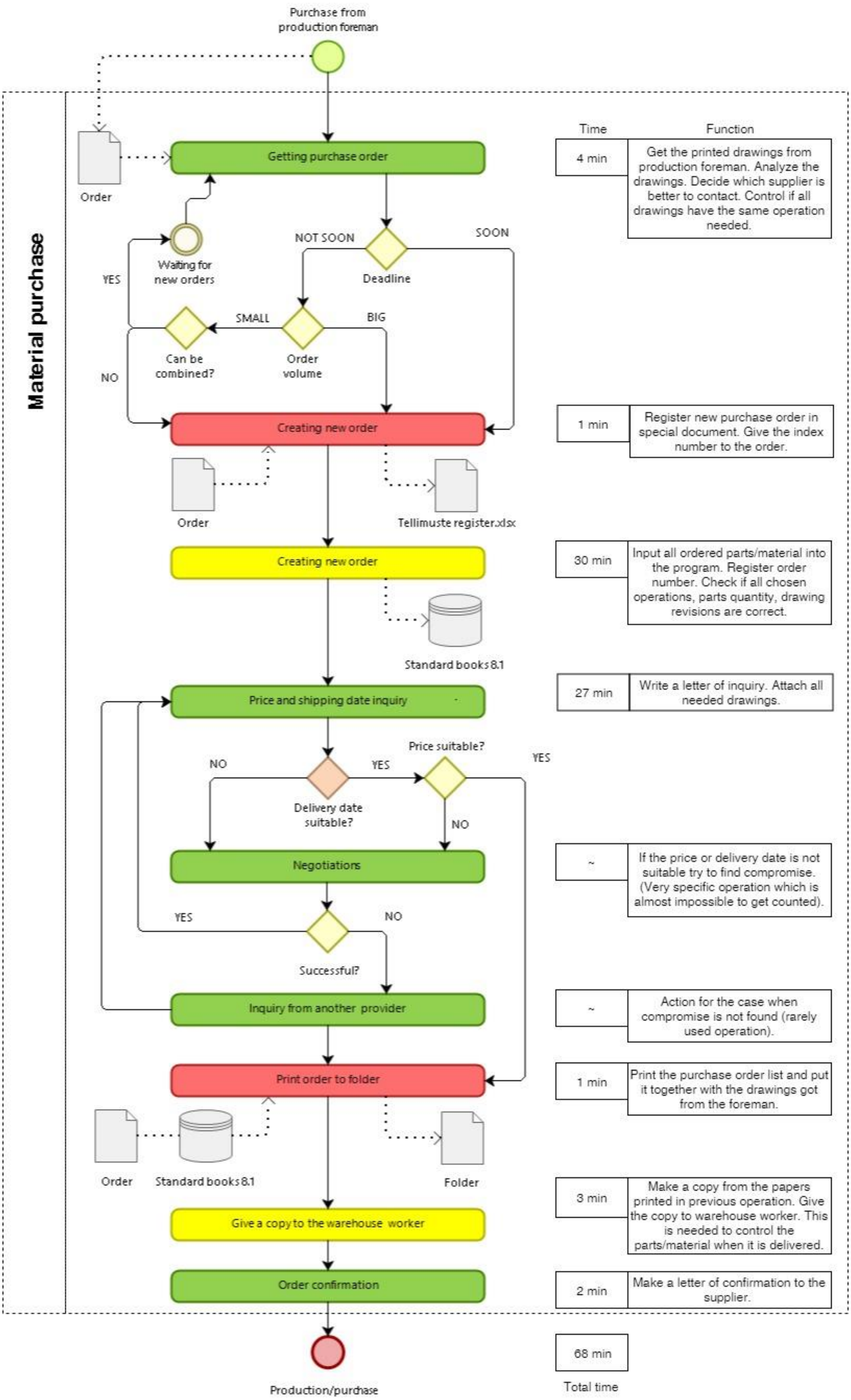


Figure 2.12 “Material purchase” subprocess model

! Be sure to note that the calculation of time expenditures was based on a specific order of parts from laser cutting with the assigned number 5698 [APX 4]. *The time spent on ordering depends on the nature of the order (purchase of material, order of machining, order of laser cutting), the variety of required parts as well as other working points related to the price and delivery time. The time calculated in this analysis is an individual indicator and displays only the proportional ratio of the studied operations.*

3.3.4 "Shipping and billing" stage investigation

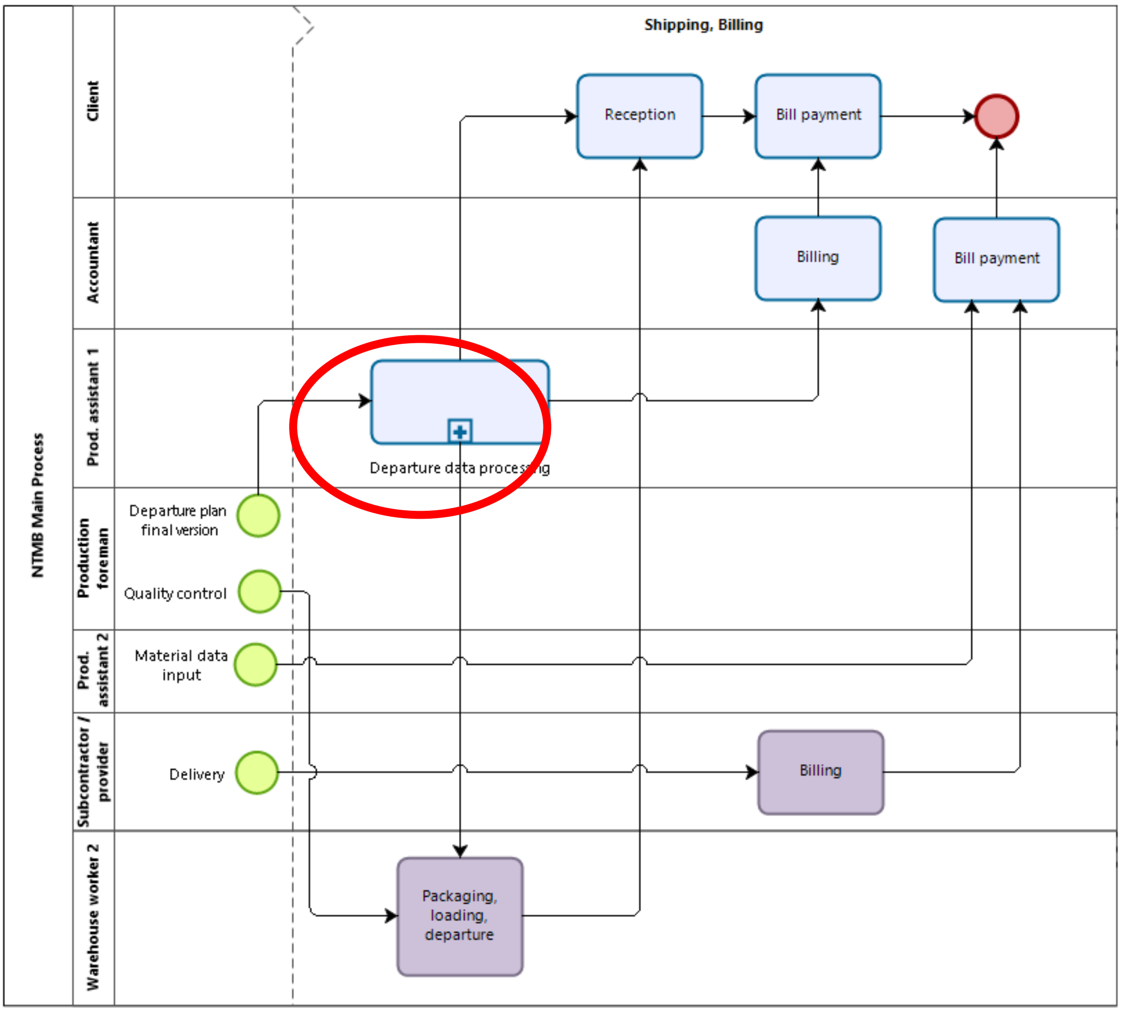


Figure 2.13 "Shipping and billing" stage model

At the fourth stage of the main process there is a subprocess "Department data processing", which is likely to hide flaws that affect the increase in time expenditures. This subprocess should be modeled separately and examined in detail for errors.

Departure data processing

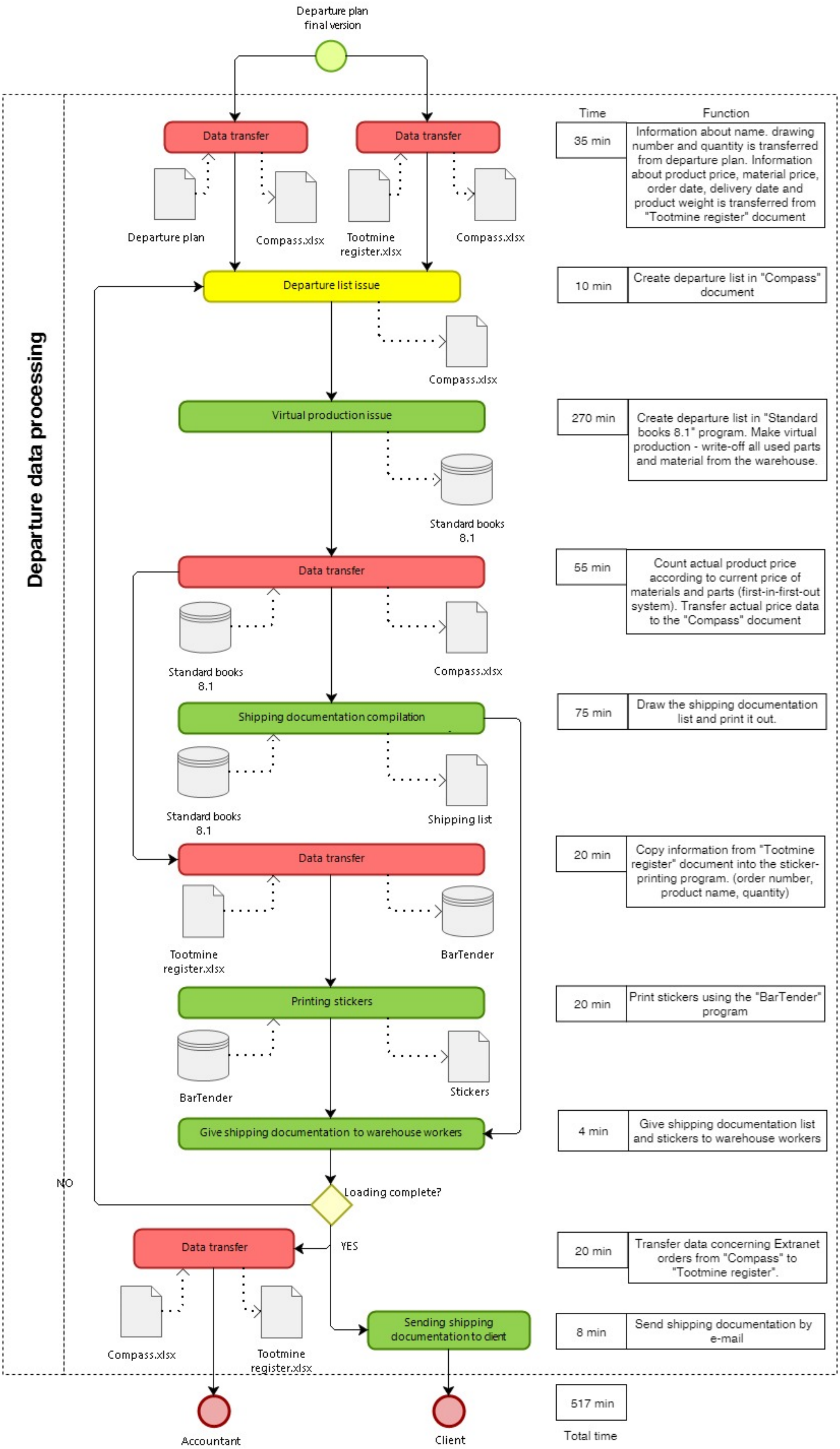


Figure 2.14 “Departure data processing” subprocess model

! Be sure to note that when calculating time expenditures, the data processing of shipment, which took place 12.04.19 was taken as basis. The time spent to process the shipment data directly depends on the number of items that were decided to be shipped on that particular day. The time calculated in this analysis is an individual indicator and displays only the proportional ratio of the studied operations.

4 ANALYSIS OF THE PRODUCTION PROCESSES

All the above-mentioned problems related to the production have long been known, the problems have been mentioned and discussed many times, but no one approached this issue from the point of view of a specific analysis. Therefore, it was decided to consider the production process, using the Lean-Kaizen philosophy.

Kaizen is a daily process, the purpose of which goes beyond simple productivity improvement of individual workstands. In this model, operators mostly look for small ideas which, if possible, can be implemented very fast. [13]

The fundamental part of Lean-Kaizen philosophy is the analytical action called „Gemba Walk“ – this is a action of going to the „genba“ (japanese – „actual place“) where the value is created. In manufacturing the „genba“ means the factory floor. The main idea of Gemba Walks is to see the actual process, understand all aspects of work, ask questions from the workers, learn and understand the nuances. [14]

The basic principle of further performance:

The theoretical base – observation of the technological process in reality – communication with workers who carry out operations – find solutions for existing problems.

4.1 The component movement analysis

The list of the most obvious problems associated with the production includes such key words as: place on the racks, workspace, employment of devices. The BMPN method is not suitable for analysing these problems as it is effective in identifying procedural errors. Problems in the production have specific aspects related to the processes and time expenditures only indirectly.

To solve this problem, it is necessary to analyse the pre-movement of the components of a product under study, the basis for this analysis will be the analysis of the technological route of the same product.

The technological route is the sequence of moving the workpiece parts or assembly units in the shops and production areas of the enterprise in the process of manufacturing or repair. When designing the technological route, the following data about the blank should be taken into the account:

method of obtaining it (laser, plasma, stamping, etc.), its accuracy, which determines the amount of allowances taken during processing. It is desirable to have a drawing of the workpiece with the specifications for its manufacture. The sequence of types of processing (turning, drilling, milling, etc.) may vary depending on the type of production, but it is necessary to strive for their concentration within a single machine. The sequence of operations of one type of processing should be reverse to their accuracy, i.e., the rougher (rough) operations are performed first, while more accurate (smoothing and finishing) are the last ones. [15]

In this case, it will be sufficient to use only the first level of the technological route, which will indicate the sequence of different operations that initiate the movement of parts between the machines and workstations (without specifying the processing operations for each machine).

Table 3.1 Kärllyft Standard 1000276053 - Technological route

					1	2 turn	3 bend	4 drill	5 thread	6 chamfer	7 weld	8 zinc	9 prime	10 assembly
	1000276047	Kam Standard	1	19,1	plasma									
	1000275760	Profilrör	1	7,2	profile									
	1000275642	Ramsida	2	3,2	laser			•	•	•				
	1000141883	Styrning,väster	1	0,3	laser		•							
	1000141920	Styrning, höger	1	0,3	laser		•							
P1	1000267773	Tand	9	0,3	stamping						•		•	•
	1000276005	Ramsida	2	2,7	laser					•				
	1000130134	Stödrör	1	1,4	profile									
	1000096143	Lagringsöra	2	0,4	water	•		•	•	•				
	1000032023	Fjäderfäste	2	0,1	laser									
	1000333455	Autom. Fäste	2	0,1	laser									
	1000333453	Autom. Fäste	2	0	laser									
P2	1000275856	D-gummibalk	1	18,7	laser		•					•		•
P3	1000032678	Fästjärn	2	1,3	profile			•	•			•		•
	1000128638	Holk	1	10,7	profile	•		•	•					
P4	1000121463	Fläns	2	1	laser					•	•		•	•
	1100003340	Stagarm	1	1,5	plasma	•		•	•	•				
	1000032575	Kabel länk	3	0	profile	•								

					1	2 turn	3 bend	4 drill	5 thread	6 chamfer	7 weld	8 zinc	9 prime	10 assembly
	1000128638	Holk	1	10,7	profile	•		•	•					
P5	1000121463	Fläns	2	1	laser					•	•		•	•
	1100003340	Stagarm	1	1,5	plasma	•		•	•	•				
	1000032577	Kabel länk	3	0	profile	•								
	1000275869	Klämplat	1	13,5	laser		•							
P10	1000275871	Klämplatsspalt	1	3,5	sheet		•				•		•	•
	1000270384	Ledarm	4	0,6	laser					•				
	1000271973	Ledarm	4	0,3	laser					•				
P15	1000092591	Tapp	2	0,1	meh									•
P16	1000089087	Mässingurulle	2	0,3	meh									•
P18	1000128651	Lagrinsrör	1	15,7	profile	•					•		•	•
	1000433662	Hylsa	1	0,2	laser									
P19	1000435349	Kam	2	0,9	meh								•	•
	-	Mounting	128	-	-									•

In this table, all parts are arranged according to their belonging to the welding/assembly units in which they are used. Some items are duplicated (used in more than one node at once).

To carry out further analytical work, it is necessary to simplify the table – to arrange all the details according to the principle of identity of their technological route, to remove unnecessary information:

- All methods of production of workpieces outside the NTMB working space will be united in the Purchase operation. (Plasma cut, Laser cut, Water cut, Machining at subcontractors, Stamping → Purchase).
- Individual information regarding workpieces (name, drawing number, weight) will be deleted. There should be left only the number of parts that follow a particular route.

Table 3.2 Kärllyft Standard 1000276053 – detail transfer paths

Route number	Detail quantity	Productional operations					
		1	2	3	4	5	6
1	4	purchase	turn	drill	thread	chamfer	weld
2	2	purchase	drill	thread	chamfer	weld	
3	14	purchase	chamfer	weld			
4	3	purchase	bend	weld			
5	17	purchase	weld				
6	1	purchase	bend	zinc	assembly		
7	2	purchase	prime	assembly			
8	126	purchase	assembly				
9	2	saw	turn	drill	thread	weld	
10	7	saw	turn	weld			
11	2	saw	weld				
12	2	saw	drill	thread	zinc	assembly	
13	1	guillotine	bend	weld			
14	4	welded	prime	assembly			

Note that this table is not the whole picture, depicting the situation of the entire production. The table covers the technology for the production of one model only of one specific product (the simplest standard model).

As a result of the layout and simplification of the technological route, there are 14 separate ways of moving.

For further analysis, all 14 transfer paths should be applied to the production area map.

Production area map

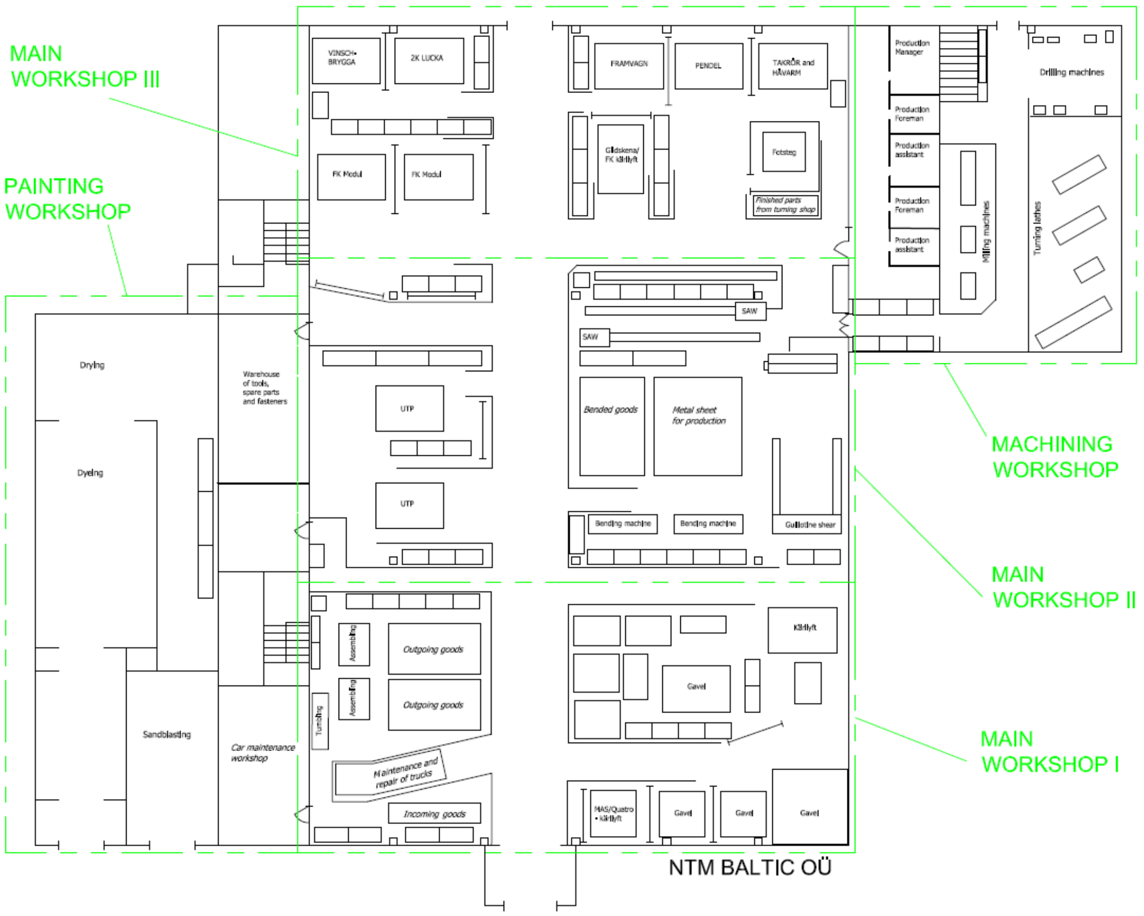


Figure 3.1 Production area map [APX5]

The production area of the NTMB is divided into 5 separate sectors. The machining shop and painting shop are located separately from the main shop. Communication between them is limited. The transfer of blanks and products is possible only with the help of forklifts.

The main workshop can be conditionally divided into 3 working sectors. Over each sector there are suspended guides for the movement of overhead cranes, and 2 cranes hanging in each sector. Functioning capacity of the crane depends on the number of transportations of blanks and finished products in a particular sector.

Transfer of blanks and finished products of model Standard Kärllyft 1000276053

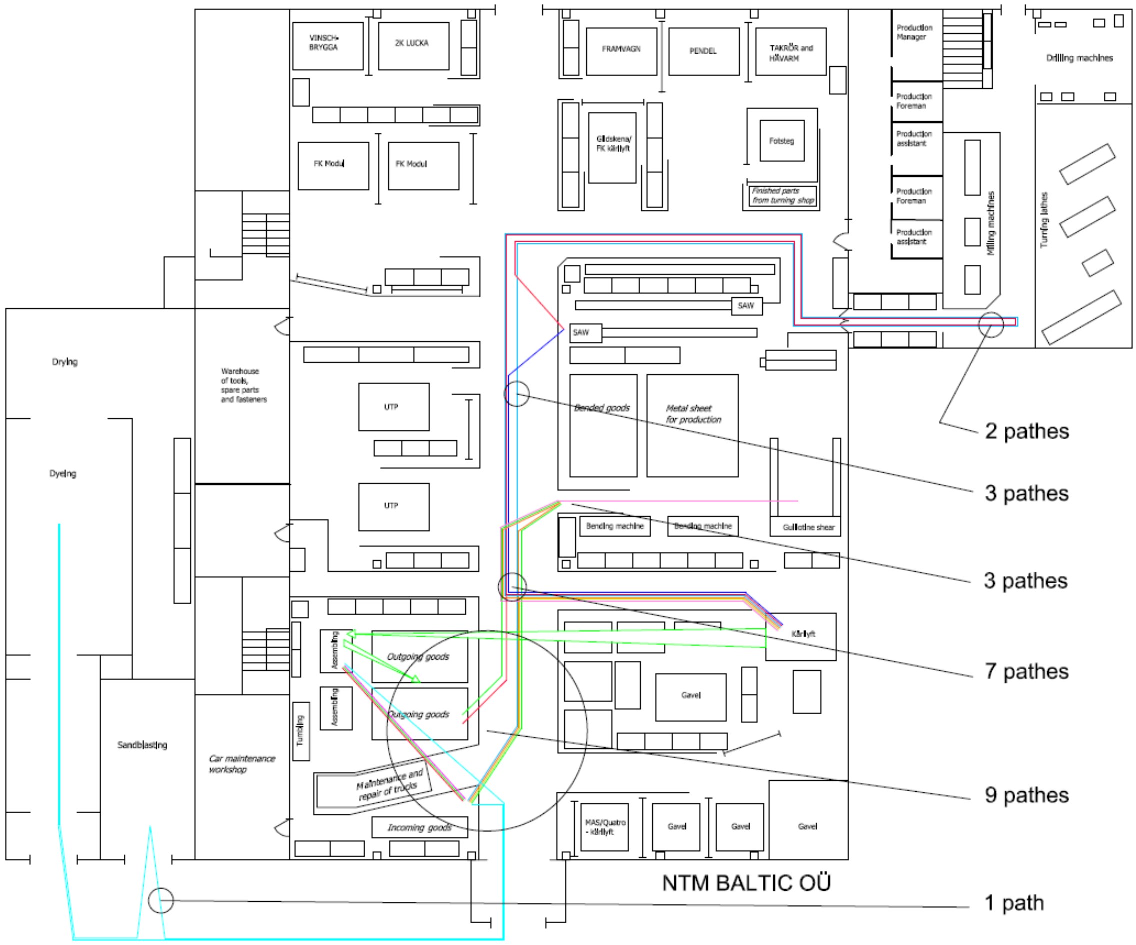


Figure 3.2 Transfer of blanks and finished products of model Standard Kärllyft 1000276053 [APX6]

Based on the results of the schematic analysis, it can be concluded that most of the movements related to the product under study occur in the main WORKSHOP I sector. Based on the data obtained, it was decided to consider the MAIN WORKSHOP I sector for errors leading to the above problems.

4.2 Considering sector for errors

Scheme - MAIN WORKSHOP I

Figure 3.3 MAIN WORKSHOP I scheme

Designation of shop elements by colour:

- Orange – the work table/conductor and the space around it, which is guaranteed to remain free, for the convenient operation of workers.
- Blue (light blue) – stacked racks/shelves for storing workpieces
- Purple – space on the floor, filled with large-sized workpieces and material. Workpieces usually lie on wooden pallets or in special “cassettes” for vertical arrangement.

A red circle indicates the sector in which the space is used inefficiently. Moreover, it is in this sector that an additional workplace for the Kärllyft product should be organised. The reasons for such decision:

- There is no need to install additional racks for blanks of the same product near the new workplace
- There is no need to transport parts by piece to a new workplace from old racks
- All blanks are in one place
- Workers who produce one product can consult and share experience
- Location allows the supervisor to more efficiently distribute and optimise jobs between two workers

! Designing a new workplace in the main WORKSHOP I sector will put additional workload on overhead cranes, which, according to the initial assessment, are already overloaded. To avoid aggravation of this problem, it is necessary to analyse the functional capacity of cranes and offer a solution to reduce their utilization.

4.3 The analysis of utilization of overhead cranes

Scheme - MAIN WORKSHOP I (crane usage)

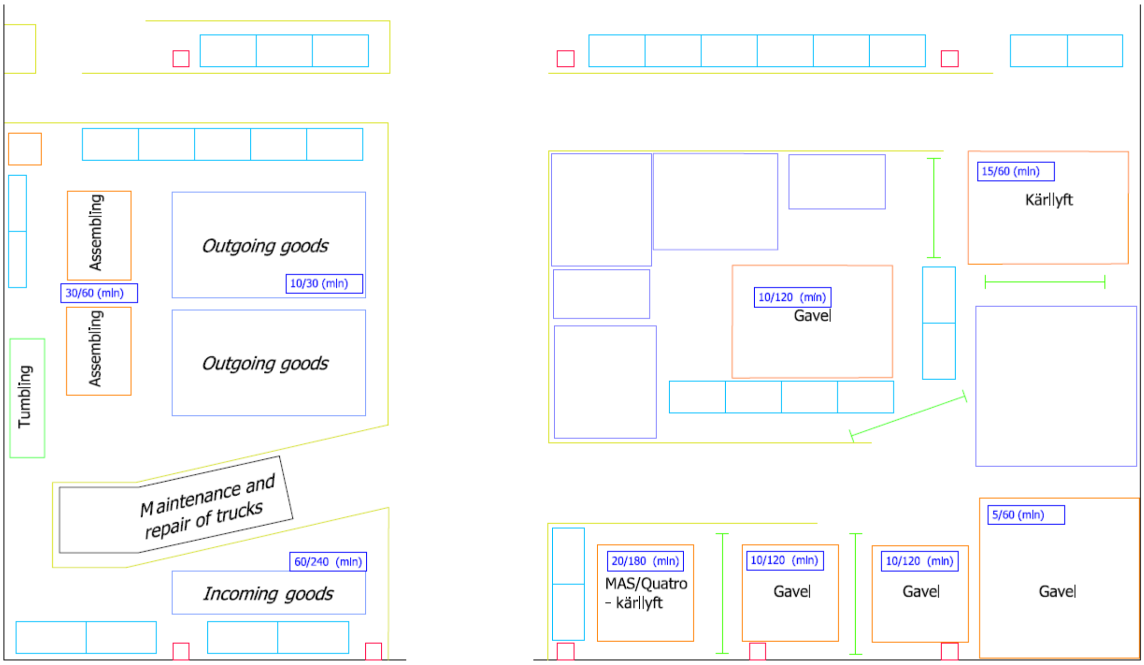


Figure 3.4 MAIN WORKSHOP I crane usage identification

The blue boxes show the time and frequency of the crane use at all workplaces belonging to the MAIN WORKSHOP I sector.

Crane loading performance may vary depending on many factors:

- Production of other models of products that differ in welding technology, require more frequent and long use of the crane and vice versa.
- Implementation of multiple shipments (many cars carrying production to different countries) or their complete absence on a particular day.
- Performing of works on repair and maintenance of garbage trucks.
- The number of subcontractor products accepted by warehouse workers on a particular day.

Due to a large diversity of variations, a more detailed analysis in the form of simulation is not possible and is impractical. The values obtained are approximate. Measurements were made on the ground of observations of the working process on a particular day – Friday (day of dispatch) 05.04.19.
The data obtained are tabulated for a more visual representation of the situation.

Table 3.3 MAIN WORKSHOP I crane usage identification

	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8
«MAS» crane usage (min)	20			20			20	
«Gavel 1» crane usage (min)	10		10		10		10	
«Gavel 2» crane usage (min)		10		10		10		10
«Gavel 3» crane usage (min)		10		10		10		10
«Gavel 4» crane usage (min)	5	5	5	5	5	5	5	5
«Incoming» crane usage (min)		60				60		
«Outgoing» crane usage (min)	20	20	20	20	20	20	20	20
«Kärllyft» crane usage (min)	15	15	15	15	15	15	15	15
«Assembly» crane usage (min)	30	30	30	30	30	30	30	30

Total (min. per. hour)	70	120	50	80	50	120	70	60
Workload percentage	58%	100%	42%	67%	42%	100%	58%	50%

Based on the data obtained, it can be concluded that in some hours the load of suspended lifting mechanisms reaches their maximum, and adding new working spots, obviously, will lead to a significant overload and expenditures on waiting.

Moreover, in fact, the expenditures of waiting for a crane is already present – if there is a load of more than 50% (i.e. if both cranes are busy), the table shows that each employee will satisfy their requests for the use of the crane within an hour, but if more than two workers will need a crane at the same time, then one of them will inevitably spend time waiting for his turn.

The problem can be solved only partially by reducing the time of use of the crane in certain work areas that exploit it more than others.

5 FMEA ANALYSIS

FMEA analysis - failure mode and effects analysis. Generally, it is used as a tool to identify potential nonconformities and prevent their occurrence at all stages of the enterprise life cycle. The method is widely used by a wealth of global companies for development of new designs and technologies as well as for the analysis and planning of the quality of production processes and products. The FMEA methodology allows you to assess risks and possible damage caused by potential process inconsistencies at the earliest stage of design and creation of a finished product or its components. [16]
In the course of this research, the identification of inconsistencies was carried out by means of actual observations and analysis of processes using the supply chain methods. At this stage of the research, the main inconsistencies that require attention have already been identified, they are real and permanent – not potential, so the FMEA method will be used here only partially – to assess the severity of inconsistencies and prioritize their correction.

The following is determined during the study of models:

- defects for each element of the componental model of the object
- causes of defects
- Severity – expert evaluation, usually based on a 10-point scale; the highest score is assigned in cases where the consequences of the defect entail legal liability
- Occurrence is also an expert assessment based on a 10-point scale; the highest score is assigned when the frequency of occurrence is 1/4 or higher;
- Detection – like the previous parameters, it is a 10-point expert evaluation; the highest score is assigned for "hidden" defects that cannot be identified before the consequences.
  In this particular case, all non-responses will be assigned a score of 1, since errors have long been detected.
- Priority number – is the risk parameter of the consumer; It is defined as the product of S x O x D; defects with the highest risk priority factor are to be eliminated first.

Table 4.1 FMEA analysis

Process Step	Failure Mode	Potential effects of failure	Severity (1-10)	Cause of failure	Occurance (1-10)	Current controls	Detection (1-10)	Priority Number	Recommended action
Product price calculation	Unnecessary operations	Loss of time	2	Outdated process structure	8	Mistake is permanent and obvious	1	16	ERP, process correction
Product price calculation	Extra-processing of information	Loss of time	5	Outdated process structure	8	Mistake is permanent and obvious	1	40	ERP, process correction
Client order processing	Unnecessary operations	Loss of time	1	Traditions	9	Mistake is permanent and obvious	1	9	No action needed
Client order processing	Data registration in different databases	Loss of information	6	No single system	4	Mistake is permanent and obvious	1	24	ERP
Production planning	Data registration in different databases	Loss of information	6	No single system	4	Mistake is permanent and obvious	1	24	ERP
Technological route processing	Unnecessary operations	Loss of time	5	No counting tool	7	Mistake is permanent and obvious	1	35	ERP, process correction
Technological route processing	Production operations at NTMB not documented	Wrong inventory data	6	No single system	10	Mistake is permanent and obvious	1	60	ERP, process correction
Technological route processing	Production operations at NTMB not documented	Inefficient labor distribution	6	No single system	10	Mistake is permanent and obvious	1	60	ERP, process correction
Material purchase	Unnecessary operations	Loss of time	2	Additional (unnecessary) control	9	Mistake is permanent and obvious	1	18	No action needed
Departure data processing	Unnecessary operations	Loss of time	4	Outdated process structure	9	Mistake is permanent and obvious	1	36	ERP
Production	Lack of space on the shelves	Irrational use of space	3	Irrational use of resources, too many spare parts	7	Mistake is permanent and obvious	1	21	ERP
Production	Search for the blankets	Loss of time	2	Lack of clear rules	8	Mistake is permanent and obvious	1	16	Labeling
Production	Lack of welding spots	Insufficient production efficiency, delays in order fulfillment	7	Irrational use of space	10	Mistake is permanent and obvious	1	70	Working space optimisation
Production	Lifting mechanisms are busy	Insufficient production efficiency, tool waiting time	5	Irrational use of lifting mechanisms	10	Mistake is permanent and obvious	1	50	Design of additional devices

The guidelines

Table 4.2 Severity guidelines

Severity Guidelines	
10	Injure a customer or employee
9	Be illegal
8	Cause extreme delays and customer dissatisfaction
7	Cause delays and customer dissatisfaction
6	Result in system malfunction
5	Cause significant performance loss
4	Cause minor performance loss
3	Cause a minor nuisance but can be overcome with no performance loss
2	Be unnoticed and have only minor effect on performance
1	Be unnoticed and not affect the performance

Table 4.3 Occurrence guidelines

Occurrence Guidelines	
10	More than once per day
9	Once every 3-4 days
8	Once every week
7	Once per month
6	Once every 3 months
5	Once every 6 months
4	Once per year
3	Once every 1-3 years
2	Once every 3-6 years
1	Once every 6-9 years

Priority attention should be paid to the problems that scored more than 30 points in the “Priority number” column, such problems are highlighted in red in the table.

Methods of their finding are specified in the table in the “Recommended action” column.

Thus, to solve the problems associated with the management processes, it is necessary to design new models of the processes that will eliminate the errors mentioned above.

As a solution to the problems directly affecting the production, auxiliary devices will be designed, which will help optimize the most important operations.

6 IMPROVEMENT

6.1 Product price calculation “to be” model

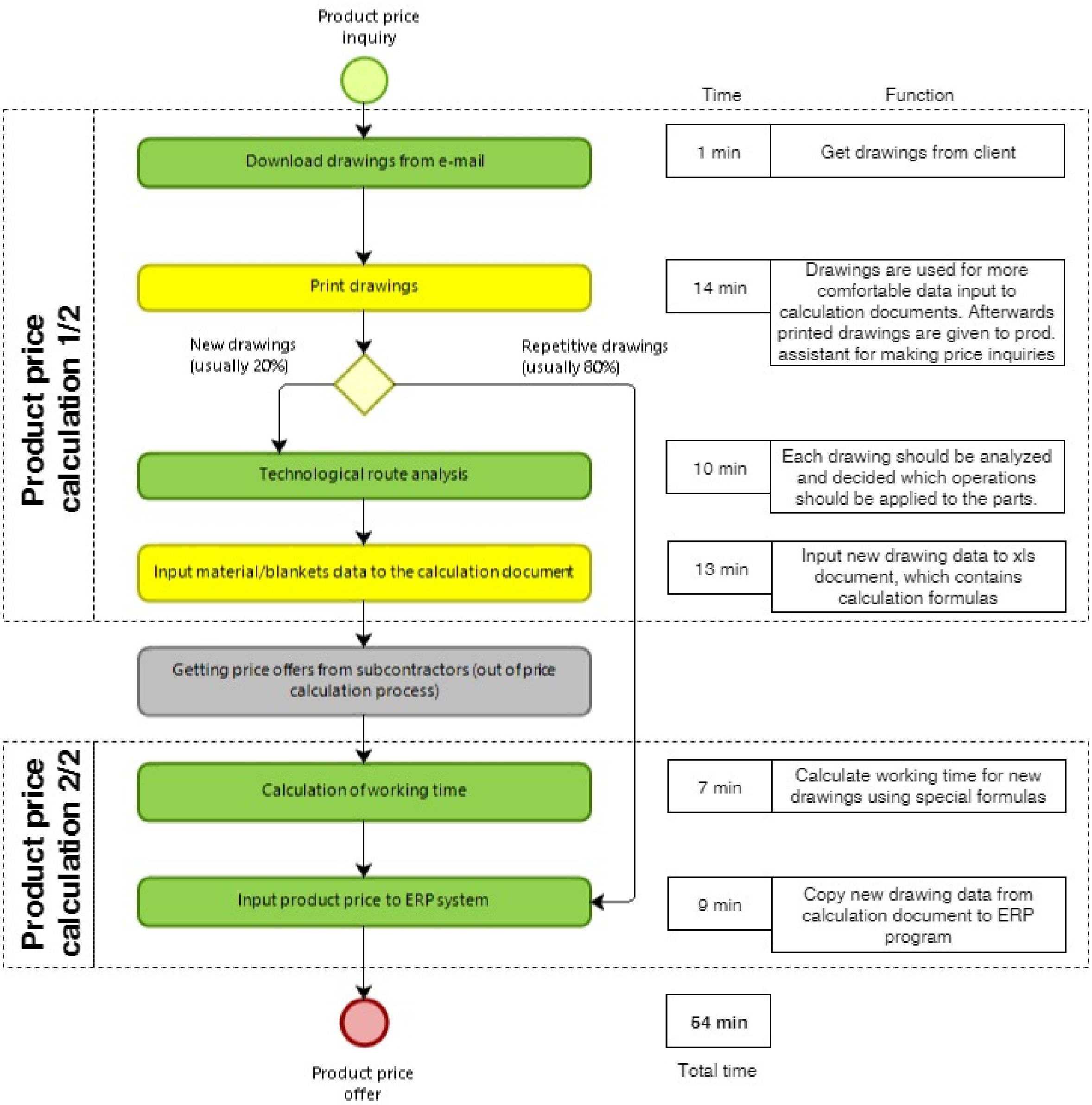


Figure 5.1 Product price calculation “to be” model

Meaningless operations are removed. A significant part of the time spent is reduced by eliminating the processing of repetitive drawings – operations such as “Input data to the calculation document” and “Calculation of working time” are reduced by 80%. Obviously, such changes are possible only when using another, more advanced ERP system that can support all the necessary modules and is able to automatically perform various calculation operations. The estimated time spent on this process after the improvement will be 54 minutes, which is 72% less than currently.

6.2 Technological route processing “to be” model

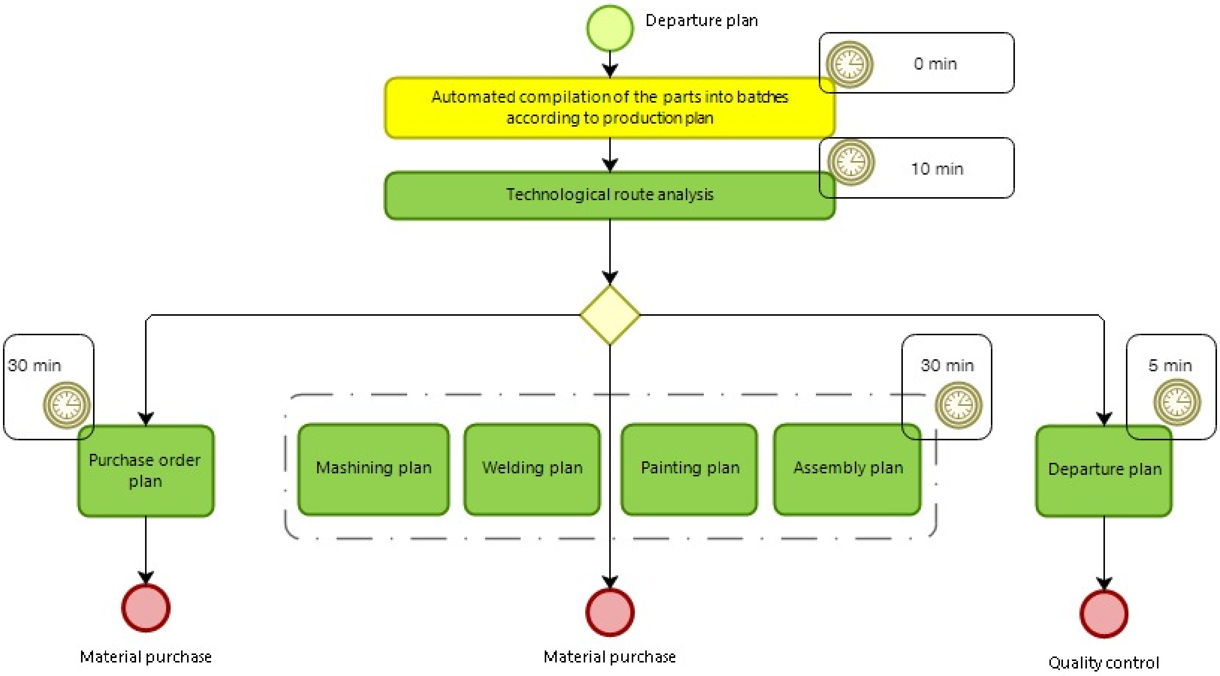


Figure 5.2 Technological route processing “to be” model

With the correct setting of the corresponding ERP system, the main operation of the selection and accounting the necessary parts can be reduced by more than 93%. According to the estimates, the time- and energy-consuming process, which now takes more than 10 hours, can be reduced to half an hour.

It is also worth noting that the exit points from this process have been replaced. Parts considered to be ordered from the NTMB workshop should now be ordered from an assistant too, rather than by sending a drawing to the shop workers. The assistant, in turn, must execute them in the ERP system as an order (as well as an order from contractors), and formalise the reception of parts to the warehouse at the end of their production. (see Figure 5.3)

This solution will work out the problem of quantitative discrepancy between the database and the real warehouse status as well as provide the control over the productivity of workers of the blank shop.

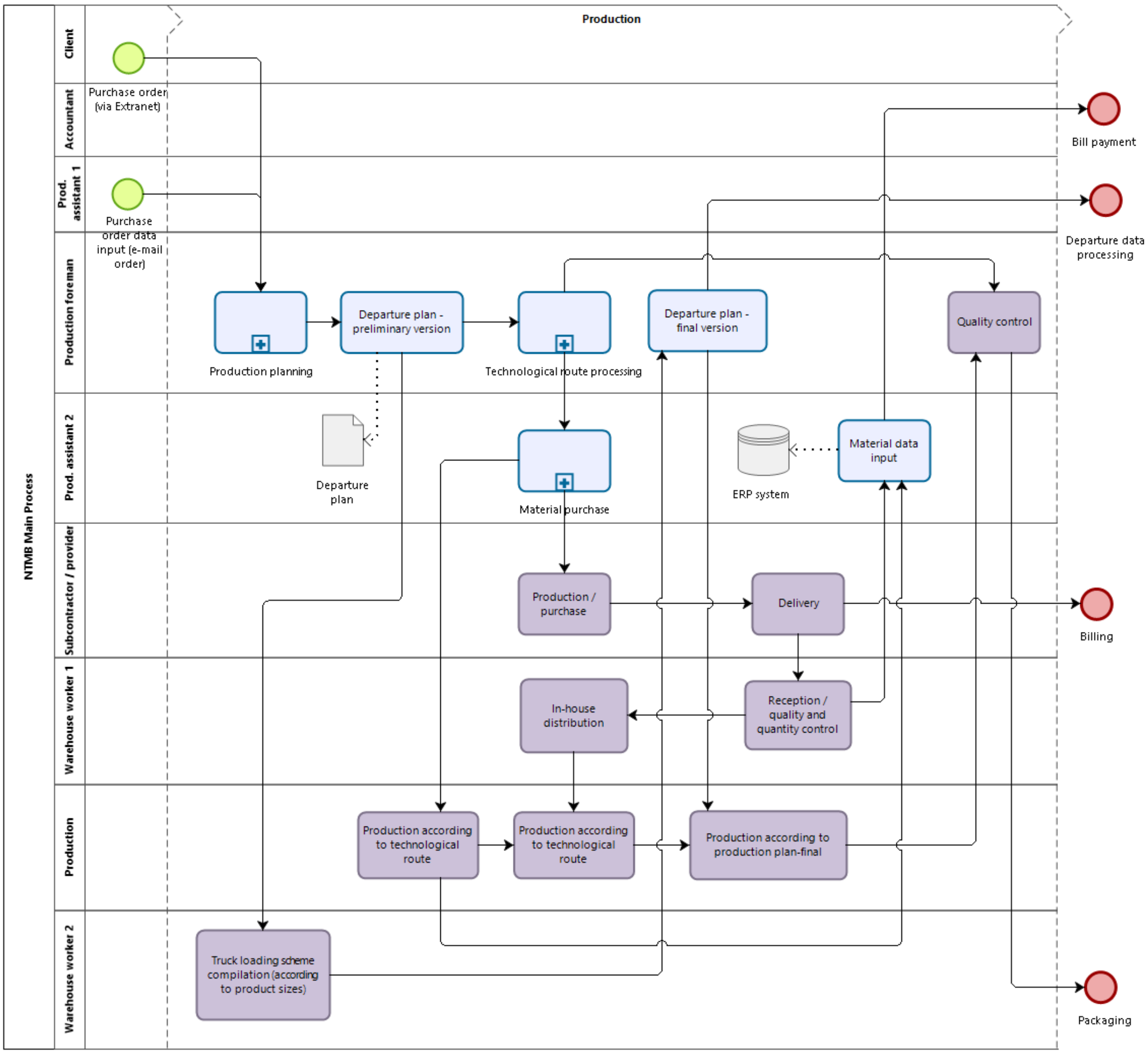


Figure 5.3 Production process “to be” model

6.3 Departure data processing “to be” model

As described in paragraph 5.1, many meaningless operations have been removed from the process. Useless duplication of information between three different databases takes a lot of time. The modern multi-functional ERP system will contain all the necessary information in one database, in addition, the properly configured automatic transfer of data to excel tables and print programs will significantly reduce the time of the main (important) operations.

The estimated time spent on this process after the improvement will total to 55 minutes, which is 89% less than now.

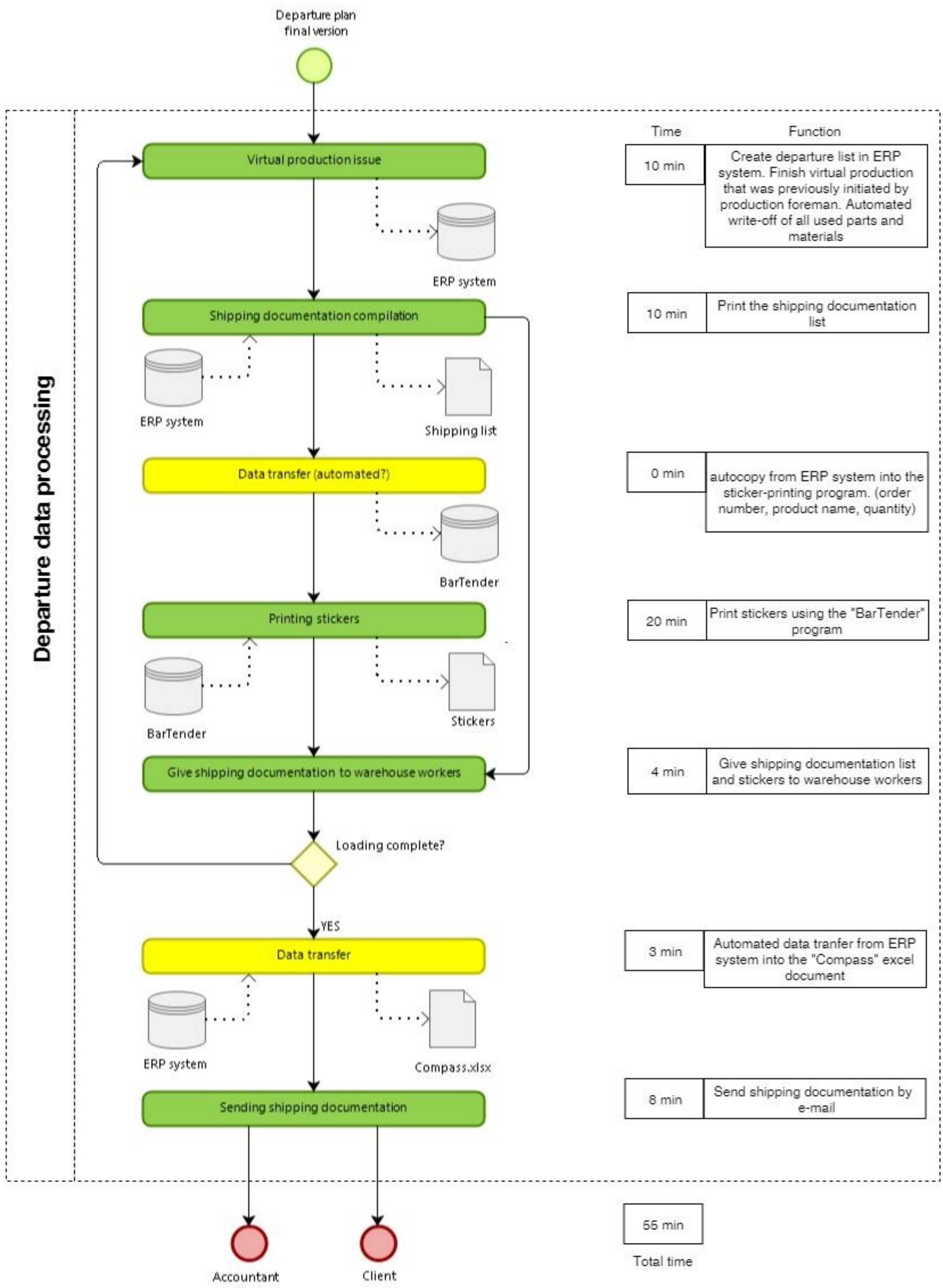


Figure 5.4 Departure data processing “to be” model

6.4 Space optimization. Development of additional welding spot

When analyzing the workspace, it was discovered that a certain working area in sector I, related to the production of the “Gavel”, is used irrationally (marked on the diagram with red dotted lines). There are many unused voids around the welding conductor. Furthermore, it is obvious that a big amount of large-sized material occupies a significant space on the floor, but because of its small height it fills the entire volume of the shop inefficiently. The solution to this problem can be the use of a multi-level method of storage.

Particularly, in order to optimize the workspace, it is necessary to determine whether the storage locations belong to one or another welding spots.

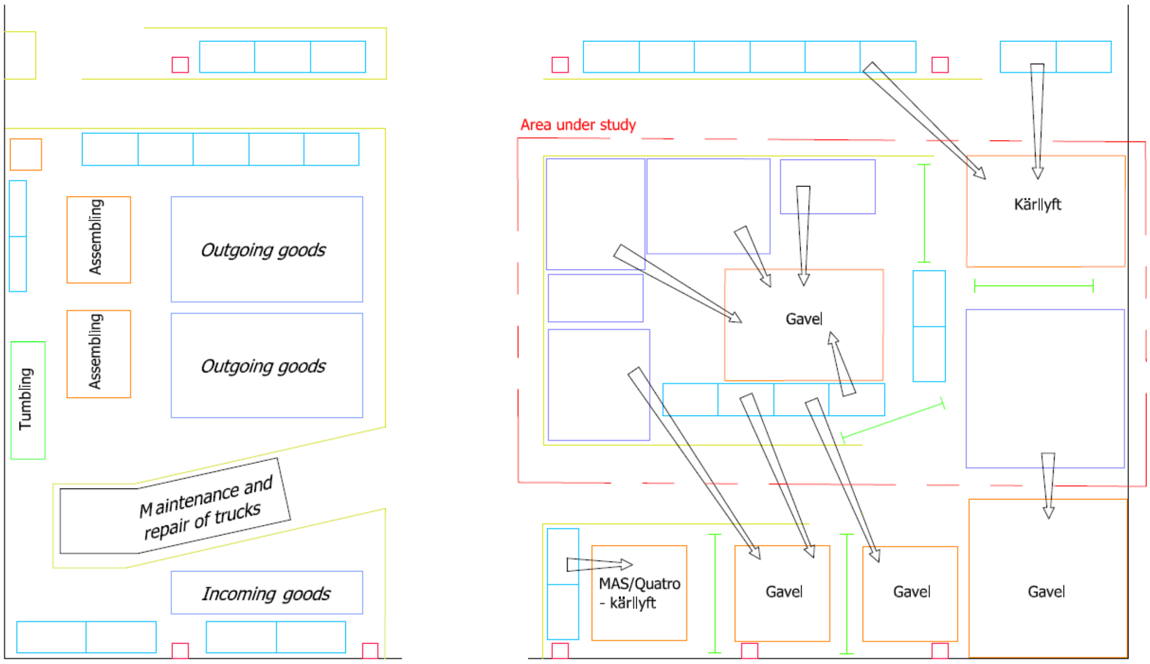


Figure 5.5 Belonging of storage sites to the studied welding spots

As illustrated by this scheme, the intended use of storage sites is distributed rationally, and the reshaping of this aspect will not achieve positive results.

In the course of a more detailed analysis, for the correct distribution, the same type of “packs” of the material are marked with the same numbers. The main packaging characteristics are indicated – the type of material arrangement (vertical/horizontal). Material placed horizontally (parts lying on wooden pallets) does not take up much space in height and can be located on the lower level of storage. The material located vertically (the parts standing in the so-called "cassettes") should be located on the upper level.

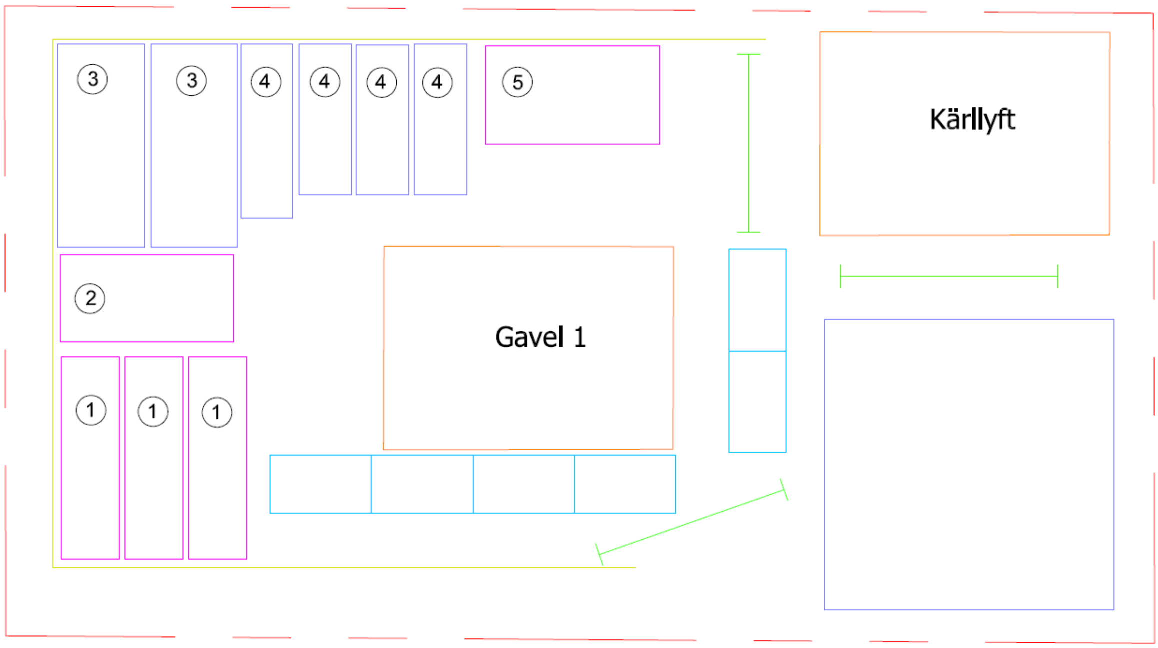


Figure 5.6 Designation of single-type blocks and their packaging characteristics

The cassette number “2” is filled with two different types of parts, and can be divided into two sections, where the method of placing one type of the parts can be changed to the “horizontal”.
Material numbered “4” and partially “2” may be placed under the details “3” and “5”.

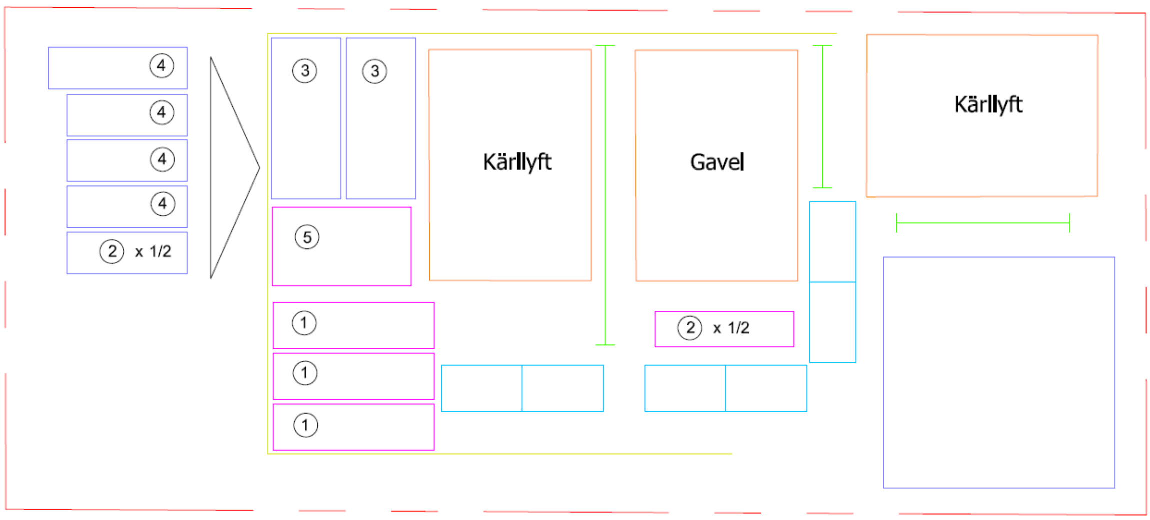


Figure 5.7 New plan of the area under study

Material numbered “4” and partially “2” may be placed under the details “3” and “5”.
The decision was made to design and produce a platform that will serve as a multi-level separator. Since all material, located both on the lower and upper levels, moves through the shop with the help of the crane, special mobile pallets-carts, which will ensure the availability of material from the lower level (with exit from under the platform) should be designed.

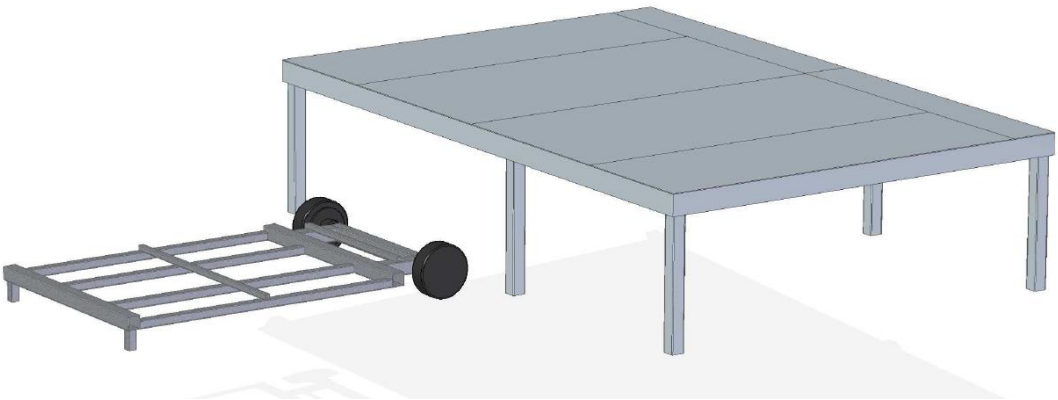


Figure 5.8 Platform and roll out trolley

In order to save money, the materials which are most often involved in the production were used in the design; besides, short pieces of beams left after cutting to the desired size, which have no other application except for the delivery to scrap metal (drawings in the Annex).

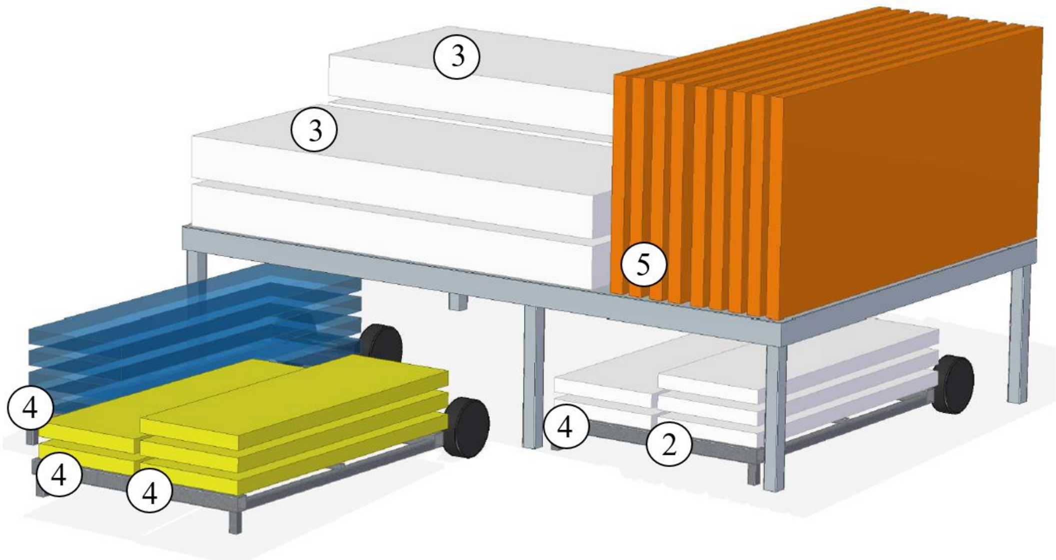


Figure 5.8 The distribution of materials in the two-level storage area

This solution calls to create an additional workplace due to the optimal use of storage space (see Figure 5.7).

6.5 Supporting device for assembling the binlifts. Crane demand reduction

During the assembly operation, for easy access to the fasteners of the product, a product is required to be constantly turned following a certain order. In view of the great weight (137 kg in the simplest model), the manual manipulation of the product is not possible, it is prohibited by the safety rules. [17]

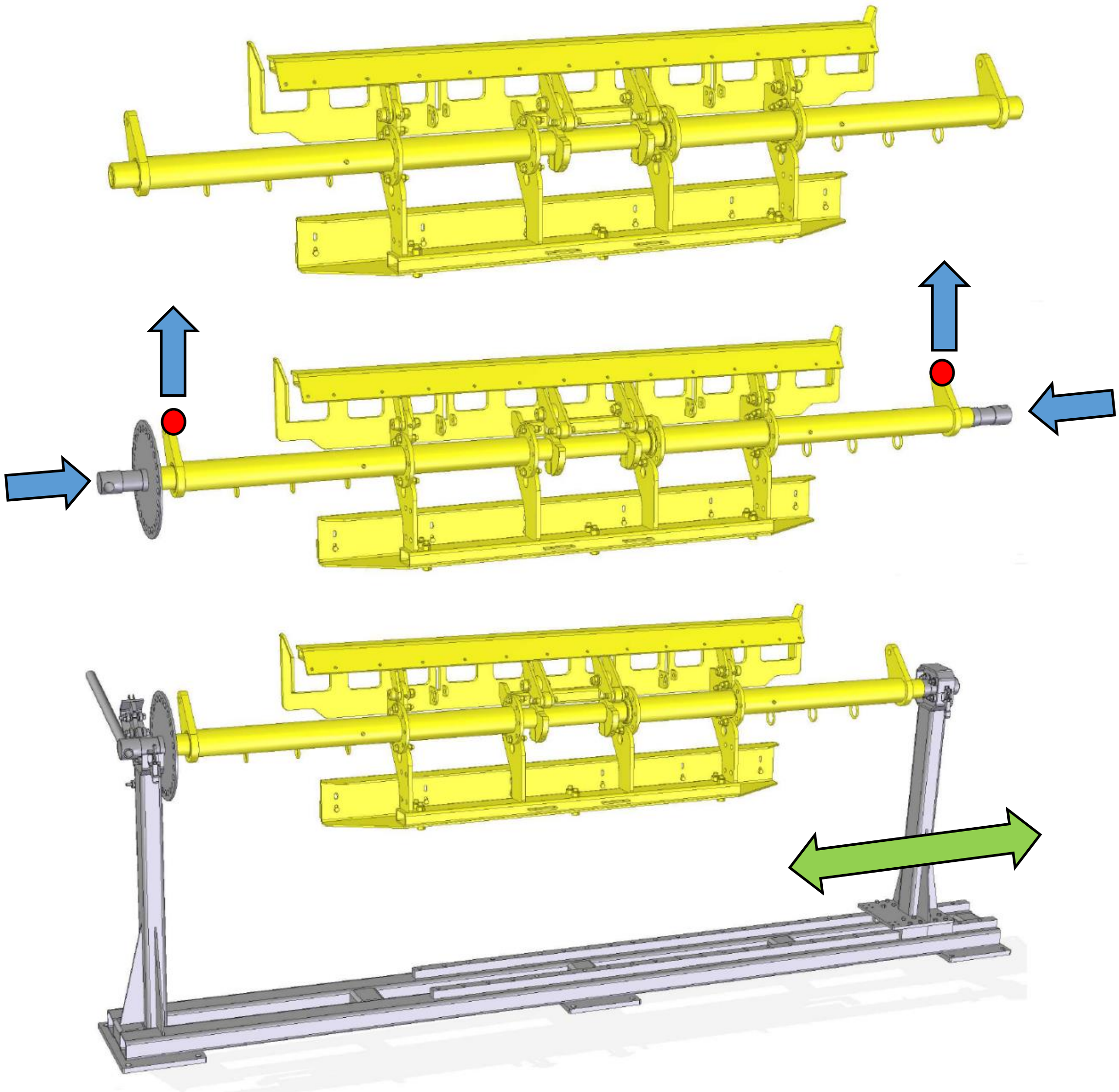


Figure 5.9 Installing of the Kärllyft product into a swiveling assembly jig

All revolutions of a product assembled are carried out with the help of a hanging crane, significantly affecting its functioning capacity – about 30 minutes during each working hour the crane is occupied on the assembly site.

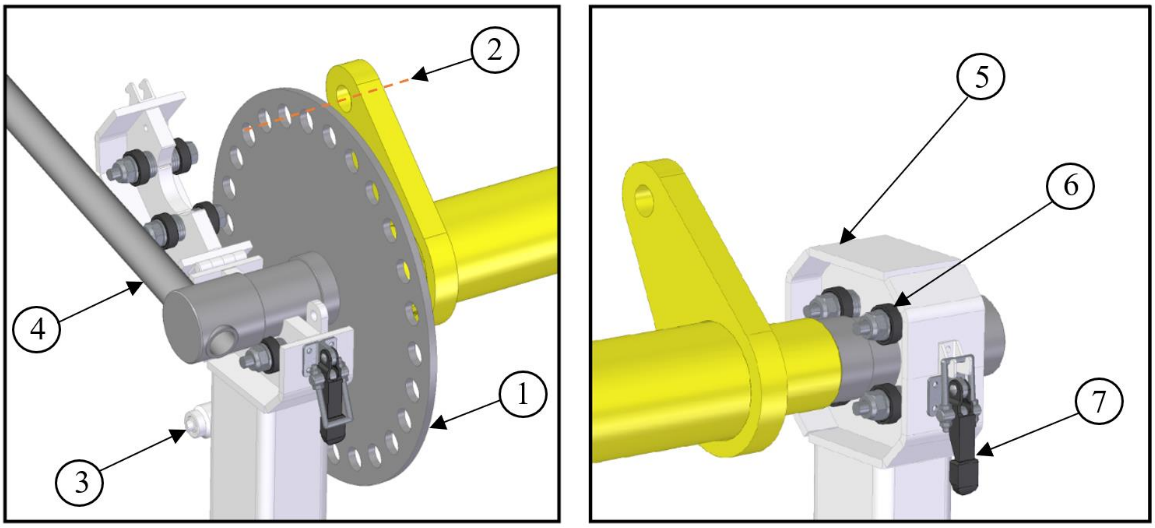


Figure 5.10 Main elements of the assembly jig

1- Rotating wheel. Provides linkage of the assembled product with the swivel arm and the locking gate
2- Axis of connection of the assembled product with the rotating wheel
3- Locking gate, allows you to fix the part at the desired angle
4- Swivel arm
5- Cover, provides tight fixation of parts inside the rack
6- Bearings
7- Eccentric clamp

This auxiliary device is designed to reduce the time of use of the crane on the assembly site. The so-called rotating assembly conductor allows you to set an assembled bin lift in any position.
When using this conductor, the crane is only needed for the installation and removal of a product from the device. Thus, the time-of-use of the crane can be reduced to 5 minutes per hour.
The conductor is a universal device suitable for all types of lifts, due to the movable rack that allows you to adjust the distance between the grips.

CONCLUSION

The study was carried out at the NTM Baltic Ltd. company, which is a subsidiary of the large international NTM Group. The Estonian company produces components and semi-finished products for the parent company.

Over the years the company has been steadily developing, ramping-up the manufacture, expanding staff, improving quality of products, and, in addition, widening their variety. Unfortunately, it was not possible to change the production area along with the manufacture ramp-up and expansion of areas of activity, and new organizational challenges were solved by layering new functions on the management. For the company governance, the combination of the above on this stage of the business activity resulted in facing the problem of insufficient organization of the production as well as the lack of working and storage space. A decision was taken to find ways to remedy the situation in the framework of this research.

The most problematic and time-consuming product Kärllyft, which has the widest model range and the largest number of different parts, was chosen as the object of the study.

At the first stage of the study, various tools and methods for the analysis and improvement of business processes were considered, the most suitable were chosen for their further use. Interviews were conducted with all key persons – the participants of the production process. The surveys identified the most obvious, long-standing problems and outlined the structure of their actions and interactions. Problems not directly related to the processes were investigated in different manner, i.e. using the Gemba Kaizen technique which means the detailed and repeated monitoring of production. The structured data were designed in the form of models and diagrams to facilitate their subsequent analysis.

In the course of the analysis of data obtained, the above-mentioned obvious problems were localised, and the causes of their occurrence/existence were detected. In order to identify the severity factor of the problems and to set priorities for their correction, the FMEA technique, i.e. failure mode and effects analysis, was applied. The most significant errors were forwarded for correction.

The suggestions for correcting the processes are presented in the form of models, where all unnecessary and time-consuming operations are eliminated, and the order and quality of performance of the auxiliary and main (value added) operations are improved. This allows to significantly (by more than 70%) reduce the time spent on their performance.

It should be noted that the nature of the production involves an individual approach to each order, its processing, product manufacture and registration of their dispatch. The manufacture is not mass or serial, each working week is planned separately. Consequently, the results received in the course of the study are not reliable for the entire process, but they only reflect the general state of affairs; although, the errors and their correction certainly affect all products, but they are applicable to each of them to a different extent.

As part of this work, solutions to non-process problems were also provided, namely, the optimisation of the warehouse space and the creation of an additional workplace, as well as the optimisation of the time of use of lifting mechanisms. As a solution, additional devices and metal constructions were designed.

Currently, the suggestions for solving non-process problems have already been dug into. The solution of the process problems involves the implantation of a new modern ERP system, which requires more careful preparation and coordination with representatives of the parent company.

In case of successful coordination and approval of further actions, the data obtained may become the basis for a new project, in which it is necessary to collect information about the ERP solutions presented in the market, to conduct a comparative analysis and choose the most appropriate for the company. Also, after selecting a specific system and its provider, you should study the system modules, their capabilities and limitations in more detail. Based on these data, you can more accurately calculate the possible benefits and assess the profitability of the project.

KOKKUVÕTE

Töö kirjutati firmale NTM Baltic Ltd, mis on suure rahvusvahelise kontserni NTM tütarettevõte. Eesti ettevõte tegeleb emaettevõttele komponentide ja pooltoodete tootmisega.

Ettevõte on oma tegutsemise ajal pidevalt arenenud, suurendanud käivet, laiendanud personali, parandanud toodete kvaliteeti ning laiendanud nende valikut. Kahjuks samaaegselt käibetõusu ja ja tegevusvaldkondade laienemisega ei olnud võimalik muuta tootmispiirkonda ning uued organisatsioonilised väljakutsed lahendati juhtkonna personali arvelt. Kõik see tõi kaasa asjaolu, et ettevõte seisis selle tegevuse etapis silmitsi tootmise ebapiisava korralduse ning füüsilise töö- ja laopinna puudumisega. Otsustati leida võimalusi selle olukorra parandamiseks selle uurimistöö raames.

Uuringu objektiks valiti kõige problemaatilisem ja aeganõudvam Kärllyfti toode, millel on kõige laiem valik mudeleid ja kõige rohkem erinevaid osi.

Uuringu esimeses etapis kaaluti erinevaid protsesse ja meetodeid äriprotsesside analüüsimiseks ja täiustamiseks, kõige sobivamad valiti edasiseks kasutamiseks. Viidi läbi intervjuud kõigi võtmetähtsusega isikutega - tootmisprotsessi osalejatega. Uuringute käigus tuvastati kõige ilmsemad, pikaajalised probleemid ning nende tegevuste ja koostoimete struktuur. Probleeme, mis ei ole protsessidega otseselt seotud, uuriti muul viisil - kasutades Gemba Kaizeni tehnikat - tootmise üksikasjalikku ja korduvat jälgimist. Struktureeritud andmed korraldati mudelite ja diagrammide kujul, et lihtsustada nende järgnevat analüüsi.

Saadud andmete analüüsi käigus kaardistati ülalnimetatud ilmsed probleemid ja tuvastati nende tekkimise / olemasolu põhjused. Probleemide tõsiduse ja nende paranduste prioriteetide kindlaksmääramiseks kasutati FMEA meetodit. Kõige olulisemad vead parandati.

Protsesside parandamise ettepanekud on esitatud mudelite kujul, kus eemaldati kõik mittevajalikud ja aeganõudvad toimingud ning täiustati täiendavate ja suurema lisaväärtusega operatsioonide toimimise järjekorda ja kvaliteeti. See võimaldab oluliselt vähendada (rohkem kui 70%) nende rakendamise aega.

Tuleb märkida, et tootmise viis eeldab individuaalset lähenemist igale tellimusele, selle töötlemisele, toodete valmistamisele ja nende saadetise kujundusele. Tegu pole mass- ega seeriatootmisega, vaid iga töönädal on planeeritud eraldi. Sellest järeldub, et uuringu käigus saadud tulemused ei ole kogu protsessi analüüsimise jaoks usaldusväärsed, vaid kajastavad ainult üldist olukorda - vead ja nende korrigeerimine mõjutavad kindlasti kõiki tooteid, kuid igaühe puhul on need erinevad.

Selle töö raames pakuti lahendusi ka protsessivälistele probleemidele, nimelt - ruumi optimeerimisele ja täiendava töökoha loomisele, samuti tõstemehhanismide kasutamise aja optimeerimisele. Lahenduseks on kavandatud täiendavad seadmed ja metallkonstruktsioonid.

Praeguseks on juba välja töötatud ettepanekud mitte-protsessiliste probleemide lahendamiseks. Protsessi probleemide lahendamine eeldab uue, kaasaegse ERP-süsteemi juurutamist, mis nõuab põhjalikumat ettevalmistust ja kooskõlastamist emaettevõtte esindajatega.

Edasiste tegevuste eduka kooskõlastamise ja heakskiitmise korral võivad saadud andmed olla uue projekti aluseks, mille raames on vaja koguda teavet turul esitatud ERP lahenduste kohta, viia läbi võrdlev analüüs ja valida ettevõtte jaoks kõige sobivam. Peale selle tuleks pärast konkreetse süsteemi ja selle pakkuja valimist põhjalikumalt uurida selle süsteemi mooduleid, nende võimalusi ja piiranguid. Saadud andmete põhjal on võimalik täpsemalt välja arvutada võimalikud eelised ja hinnata projekti kasumlikkust.

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[APX 1] General model of the Main Process

[APX 2] 1000489878 Kärllyft drawing (used for „price calculation“ process modeling)

[APX 3] 1000489878 price calculation (used for „price calculation“ process modeling)

[APX 4] Order 5698 (used for „material purchase“ process modeling)

[APX 5] Production area map (figure 3.1)

[APX 6] Part transfer scheme (figure 3.2)

Multi-lever storage drawing pack:

[APX 7] Drawing MT01.01.00

[APX 8] Drawing MT01.01.01

[APX 9] Drawing MT01.02.00

[APX 10] Drawing MT01.03.00

Assembly Jig drawing pack:

[APX 11] Drawing MT02.00.00

[APX 12] Drawing MT02.01.00

[APX 13] Drawing MT02.01.01

[APX 14] Drawing MT02.02.00

[APX 15] Drawing MT02.02.02

[APX 16] Drawing MT02.02.03

[APX 17] Drawing MT02.02.03.01

[APX 18] Drawing MT02.02.03.01.01

[APX 19] Drawing MT02.02.03.01.01.01

[APX 20] Drawing MT02.02.03.01.01.02

[APX 21] Drawing MT02.03.00

[APX 22] Drawing MT02.03.01

[APX 23] Drawing MT02.06.00

[APX 24] Drawing MT02.06.01

[APX 25] Drawing MT02.06.02