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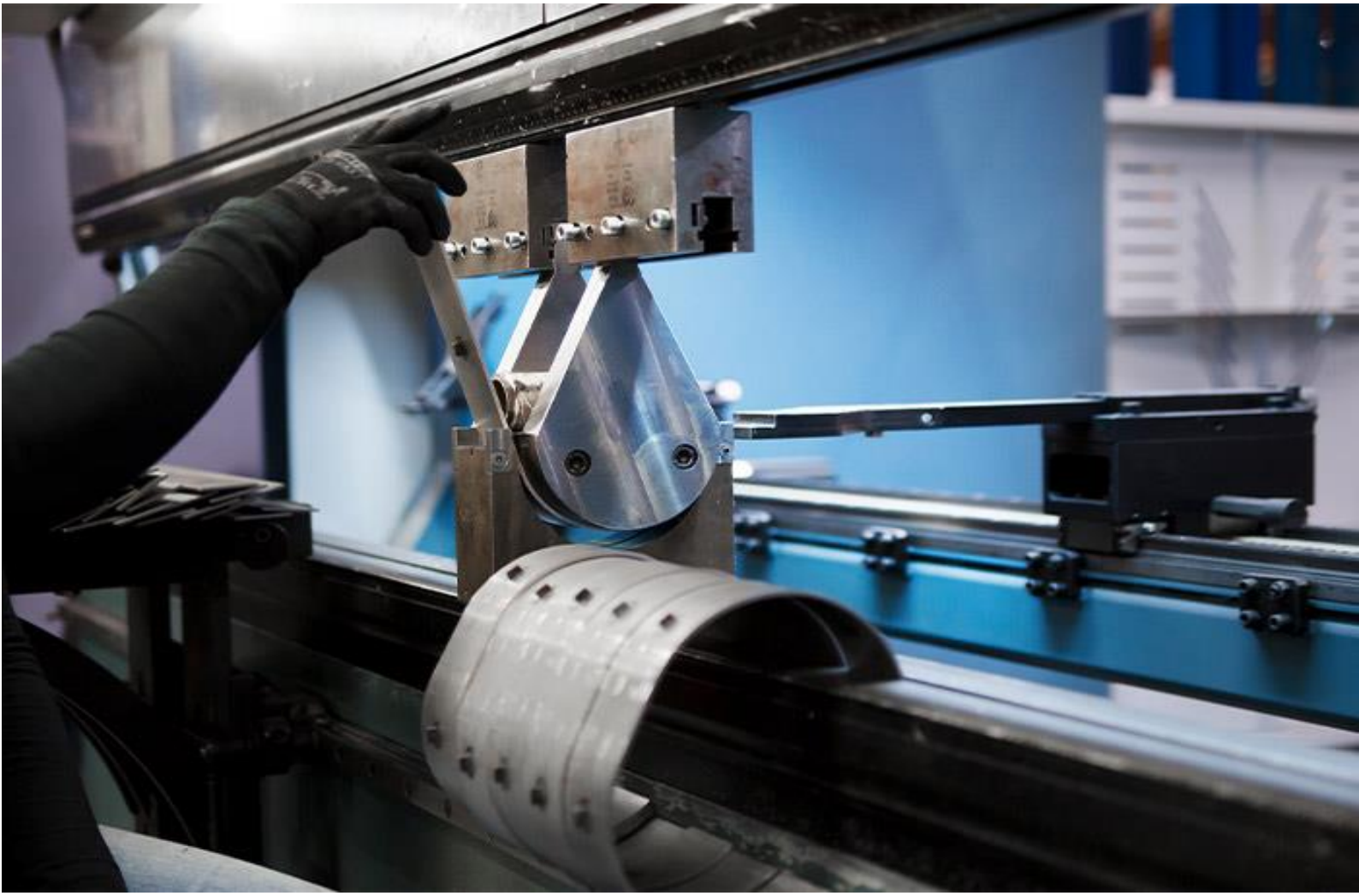

DIGITAL TRANSFORMATION OF ORDER PROCESSING BAAS METAAL B.V.

Bachelor Assignment Industrial Engineering & Management

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Bachelor's Thesis Industrial Engineering and Management

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PREFACE

Dear reader,

During the course of my thesis, I had the privilege of working at Baas Metaal B.V. located in Almelo, a metal company that produces customer-specific products for machine and equipment construction, the agricultural sector and the food industry, under the guidance of Leonard Baas.

First, I would like to thank Leonard Baas for allowing me to do my research in his company, his support, his valuable insights, and his support throughout this Thesis. I hope that with this Thesis I can contribute to making Baas Metaal B.V. a more efficient company.

I also want to extend my appreciation to my supervisors, Dr. rer. nat. D. Braun (Daniel) and Ir. R.L.A. Harmelink (Rogier), for their guidance, expertise and support throughout the Thesis process. Their knowledge and feedback have been invaluable in forming this Thesis.

Additionally, I would like to thank all the employees of Baas Metaal B.V. who, directly and indirectly, helped me in enriching my research. Their collaboration was very important in the successful completion of this thesis.

Lastly, I would like to express my appreciation to my friends and family for their support, understanding and encouragement throughout this Thesis.

Ben Pikkemaat

University of Twente, Enschede, August 2024

MANAGEMENT SUMMARY

Baas Metaal wants to improve its efficiency more and more to stay competitive and ensure high production capacity. After identifying the problem cluster for this research, the inefficient processing of orders is considered the core problem of this research. The use of paper production orders has been identified as core problem and a potential cause of low productivity, as it leads to time being wasted during order processing. To solve this problem, a suggestion to substitute the current way of working with a digital way of working has been made. Therefore, the research question of this research will be:

How to successfully initiate a digital transformation regarding the order processing of Baas Metaal B.V.?

In this case, 'successfully' means that it increases the labour productivity and reduces the amount of paper used in the process significantly.

This research follows the Kaizen methodology arising from the lean philosophy. It focuses on the continuous improvement of processes by following the PDCA-cycle. The PDCA-cycle is a management method used in business for the improvement and control of processes. To analyse these processes better, the Business Process Management (BPM) methodology is addressed. With the help of Business Process Modelling and Notation (BPMN), business processes could be visualized, and inefficiencies could be identified. This research answers its research questions by conducting both quantitative- and qualitative research.

Out of this research it could be concluded that Baas Metaal is able to successfully initiate a digital transformation regarding its order processing with its current digital systems. This is possible since the current systems can satisfy the user requirements as found by qualitative research. The shopfloor control software of MKG, called 'Shopfloor Manager', becomes important in the digital transformation of the order processing. This system shows the right abilities to support the digital transformation by satisfying all user requirements. See the table under for the established user requirements.

DEPARTMENT:	REQUIREMENTS:
WORK PLANNER	- Ability to create an order/half fabricate to which manufacturing drawings and STEP-files can be linked. - Ability to make comments that appear at other departments. - Ability to print manufacturing drawings when necessary.
PROGRAMMER	- Ability to print sticker pages. - Ability to make comments that appear at other departments. - Ability to have insight into comments made by work planners. - Ability to sort orders based on material and thickness
LASER	- Ability to see the program numbers and measurements of the residual plate.
UNBOXER	- Ability to attach stickers to products. - Ability to have access to product information (quantity, image, order number, delivery date, dimensions, and next adjustment). - Ability to start and stop the time needed to unbox a program. - Three extra screens required. - Ability to clock unboxing time. - Ability to give input for an internal rejection.
BENDING	- Ability to sort orders based on urgency and V-groove.
BENCHING	- One extra screen required at manual drilling machines.

	- Two extra screens required at CNC-controlled machines, placed on top of the machines' screen.
WELDING	- Ability to print manufacturing drawings when necessary.
EXPEDITION	- Ability to have insight in the half fabricates/orders that are reported ready.
GENERAL	- Ability to sort orders based on urgency. - Ability to start- and stop the timer of the employees' adjustment time in the lowest number of actions. - Ability to have insight into the drawings in the lowest number of actions. - Ability to see drawings in both 2D and 3D in the lowest number of actions. - Ability to zoom in on the drawings. - Ability to take measurements themselves in the lowest number of actions. - Ability to have insight into product location in the lowest number of actions. - Ability to have insight into comments in the lowest number of actions.

To satisfy all the user requirements, the gap between the current- and desired way of working needs to be closed. To close this gap, several actions need to be taken. See the table under for these actions.

WHAT?	WHO?
Add comment section to planning programmer	Arkoni/MKG + Process manager
Connect scanners to Shopfloor Manager	Arkoni/MKG
Buy scanners (3x)	Management
Buy screens (9x)	Management
Buy NUC's (9x)	Management
Create new design stickers	Process manager
Assign QR-codes to shelfs	Process manager
Create a button in Shopfloor Manager to pause the timer of the adjustment time	MKG
Install CAD-program on all devices	Process manager
Create planning in Shopfloor Manager that can be sorted on urgency (+ V-groove)	MKG
Implement new way of working among employees	Process manager

After the execution of these activities, Baas Metaal owns the right necessities- and has satisfied all its user requirements to implement a digital way of working properly. The costs of these activities are estimated at €14.800. In combination with the average yearly cost saving of approximately €168.367,50, the payback period would equal 33 days. If the recommended solution is implemented successfully, an overall and average increase of 14% in labour productivity can be expected. The most time savings will take place in the work planners-, programmer-, and expedition department. Furthermore, an average paper usage decrease of 79% can be realised.

CONTENT

1 INTRODUCTION

In a world with constantly increasing competition, businesses and individuals face both opportunities and challenges. Competition is influenced by five factors: product features, the number of sellers, barriers to entry, information availability and location (Investopedia Team, 2023). Regarding number of sellers, the increase in competition is not caused by more companies being formed but mainly because the largest players are getting more entrenched. For this reason, smaller companies are facing stronger rivals, and it is getting harder to start new companies (Dilmegani, 2024).

The developments in the metal industry are also uncertain. For example, the impact of the developments in China is high. China's economic climate is being threatened by multiple economic stagnations. For this reason, companies in China who are producing metal(parts) are focusing on export. As a consequence, other metal(part) producers from Asia, Japan and Vietnam will be doing the same. This will result in strong competition if the European Commission does not intervene (MetaalKrant, 2024). Besides this, Dutch metalworking is being confronted by employee shortage, raising costs for digitalisation and high investment costs for machines. The question is whether the large number of relatively small companies within this sector can bear these costs.

However, the competitive position of the Dutch metal industry is still doing well. According to a report of the ABN-AMRO, the revenue of metalworking companies will increase from 2,8 billion in 2022 to almost 5 billion in 2030 (ABN-AMRO, 2023). However, due to the ageing workforce and a shortage of technical personnel, it is slowly coming under pressure. According to the Rabobank, to keep up with the competition, the industry should increase their labour productivity heavily between now and 2035; approximately up to 60% (Cramer & Schipper, 2023). To resolve this problem, processes should be automated where possible. To grow as an industry, two things can be done: more employees or a higher labour productivity. Statistics of CBS StatLine (2024) show that the Netherlands has one of the highest vacancy degrees in Europe in the metal industry. For this reason, the first option is not feasible. So, the only option is to increase the labour productivity per employee. This is, on the other side, a benefit of competition: it is a fundamental driver of productivity and output growth.

Metal company Baas B.V. has been around for more than 35 years and is a metal company that produces customer-specific products for machine and equipment construction, the agricultural sector, and the food industry. It is mostly active in the Netherlands but also has some customers in Germany and Belgium. Metal company Baas B.V. was founded in 1987 and is located in Almelo, at Bedrijvenpark Twente 105. Metal company Baas B.V. has both full-time employees and temporary workers. The number of employees varies and depends on the workload. Baas Metaal B.V. may be considered a SME (small or medium-sized enterprise). It supplies customer-specific steel, aluminium, and stainless-steel products for various industries. Baas Metaal can take care of (part of) the process from product development to production, assembly, and delivery. Baas Metaal B.V. does several metal processing steps (Baas Metaal B.V., 2024). Figure 1 shows these steps. The steps between unboxing and expedition are optional and differ in the order of execution for every order.

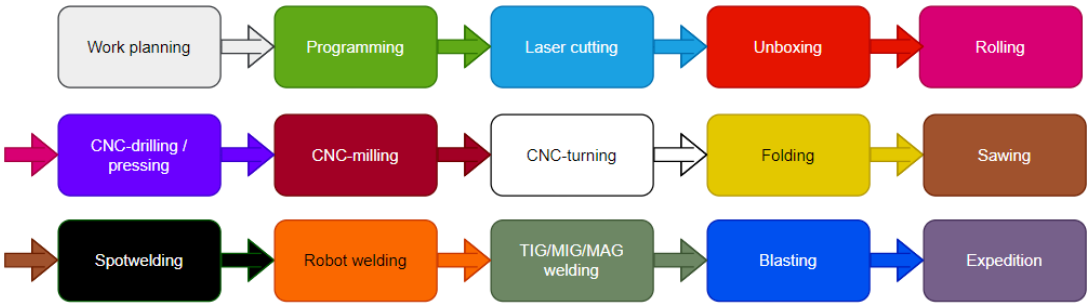


Figure 1: possible processes Baas Metaal

From this introduction, it can be concluded that efficiency in the Dutch metalworking sector is considered important to stay competitive while investment costs are rising, and the amount of available technical personnel is decreasing. For this reason, Baas Metaal needs to improve its business processes and look for solutions that increase its efficiency. Baas Metaal has done large investments in machinery, software systems and other resources to improve its production capacity. To optimize the usage of these investments more, the processing of orders needs to improve. When an order is processed in the correct way and in the shortest possible period, the resources can produce value output more optimally. Therefore, the subject for the undertaken bachelor's assignment is:

"How to improve the order processing of Baas Metaal B.V.?"

2 METHODOLOGY

This section will discuss the literature concerning the used methodology.

This research concerns the improvement of the order processing of Baas Metaal by minimizing waste during this process. In this case, waste can be divided into both waste-activities and the amount of paper used during the processing of orders. The philosophy that concerns the improvement of business process while minimizing waste, is the lean methodology. This research will therefore be based on the principles of the lean methodology, also called lean manufacturing. There are multiple definitions of lean management. For this research, the definition of Lean Enterprise Institute (2019) fits best:

> *Lean methodology is a systematic approach to continuous process improvement through the minimization of waste. The core idea is to maximize customer value while minimizing waste.*

Lean is focused on the elimination of waste. A working environment is being developed in which the customer is central, and waste is eliminated as much as possible. Lean methodology can be divided into several methodologies (Bureau Tromp, 2024). Since the employees of Baas Metaal and its order processing are considered the most important factors regarding the research on how to successfully initiate a digital transformation, the customer value becomes less important. Therefore, the decision to continue with the Kaizen method has been made since this method focuses more on the improvement itself, rather than the increase in value for the customer. The customer value comes second since this is still considered an important factor in the lean methodology.

Kaizen is one of the methods provided by the lean methodology. It is a Japanese term meaning change for the better or continuous improvement in which it tries to implement an optimal working- or production environment. Kaizen emphasises that improvement suggestions can come from any employee at any time (Hargrave, 2024). Therefore, 'Hansei' becomes an important aspect in this case. This practice is about self-reflection which let employees reflect on their own tasks while being part of a larger process. This let employees think about improvements that could possibly improve the process or their own work performance (Subikash, 2016). Besides this, Kaizen is a process that occurs every day. In combination with 'Hansei', employees are stimulated to address inefficiencies every day and, in this way, improve processes continuously (Quality-One, 2024).

Kaizen Institute (2024) states 5 principles that are embedded in the event Kaizen implementation:

- Know your customer: Creating customer value.
- Let it flow: Everyone in your organization should aim to create value and eliminate waste.
- Go to Gemba: Value is created where things actually happen. So, perceive what is happening there.
- Empower people: Set the same goals for your team, and provide a system and tools to reach them.
- Be transparent: Performance and improvements should be tangible and visible.

There are two ways to 'conduct' kaizen: Daily Kaizen and Kaizen Event. In both cases it is the goal to improve the process. However, Daily Kaizen requires the team to meet on a regular basis while a Kaizen Event can generally be described as a longer team-based improvement activity which stops when the improvement is implemented and where meetings on regular basis are unnecessary. After this, another event can be started (Quality-One, 2024).

According to Lean Six Sigma Groep (2024), for an improvement to be a Kaizen Event several conditions need to be met:

- The problem should be urgent with a limited scope and complexity.
- All the employees involved must be available during the Kaizen event.
- It is always with people from that specific process.
- Typically, it focuses on the process at activity level.
- It looks for creative solutions first before spending money.
- Implement good solutions, do not keep looking for the perfect solution.
- A plan is only good if it can be implemented.

This research is conducted in the form of a Kaizen Event since there is a process that requires improvement in which the employees from that specific process are the most important factors. All these employees are available during this Kaizen Event and the research focuses on their activities. Furthermore, a solution is only considered to be good when it can be implemented. This means that it needs to satisfy the requirements set by the different stakeholders.

A Kaizen-Event follows the PDCA-cycle, which can be distributed into the actions as shown in Figure 2. PDCA is a management method used in businesses for the improvement and control of processes. First, the employees of Baas Metaal are notified about this research. This encourages the employees to start their 'Hansei'. Then, the problem is identified after which it is analysed by mapping the facts. After this, a solution is developed based on the facts gathered in the last step. The check- and act steps are not completed due to time constraints. (Lean Six Sigma Groep, 2024)

Figure 2: PDCA-cycle

'Gemba' is closely related to the problem analysing step of the PDCA-cycle. This activity is all about perceiving what is happening on the shopfloor. It is expected that during a 'Gemba Walk' the researcher tries to observe and understand the process. Communication, transparency and trust are important values in this case. (Lean Six Sigma Groep, 2024)

Bicheno & Holweg (2016) state that lean is about moving closer to an uninterrupted flow in the sequence of operations that deliver quality, in other words, becoming more of a time-based competitor. 'Flow' not only means the physical products and services but also the necessary designs and information to run the operation. For this reason, lean requires continuous improvement in three dimensions:

(1) Waste reduction
(2) Value enhancement
(3) People involvement

By people involvement is meant the condition under which people can achieve their maximum potential.

The lean methodology identifies three lean enemies: Muda (waste), Muri (overburden), and Mura (overproduction). This research focuses on waste. Muda implies inefficiency, pointlessness, and worthlessness. It focuses on the activities that consume resources, but do not add value for the customer (Shedge et al., 2022). Muda distinguishes eight different types of waste (Skhmot, 2017; Simplilearn, 2024):

- Transport: waste in transportation includes movement of people, tools, inventory, equipment, or products further than necessary. The excessive movement of people and equipment can lead to unnecessary work.
- Defects: errors or defects in products or services that require rework or correction.
- Overproduction: waste from making more products than customer or next process demands.
- Waiting: waste resulting from time spent waiting for the next process step to occur.
- Unused talent: waste resulting from underutilizing people's skills, talents and knowledge wastes potential and can lead to employee dissatisfaction.
- Inventory: waste resulting from excess products and materials that are not processed
- Motion: waste resulting out of unnecessary movement of people, equipment, or machinery.
- Extra-processing: doing more work or adding more features to a product than what is valued.

Value means the fulfilment of customer requirements. Koskela & Sharpe (1994) defined the value-adding activity as "activity that converts material and/or information towards that which is required by the customer". These activities increase outputs without increasing inputs. Non-value-adding activities, defined as any losses produced by activities that generate direct or indirect costs but do not add any value to the product from the point of view of the client, can be divided into non-value adding activities but required, and waste activities (Formoso, Isatto, & Hirota, 1999).
Non-value-adding but required activities are work elements that do not directly add to output but are generally required and sometimes essential in carrying out an operation. This concerns, for example, receiving instructions. On the other hand, waste activities are those that are pure inefficiencies and add no value. They include activities of Muda (Olomolaiye, Jayawardane, & Harris, 1998). (Zhao & Chua, 2003).
In this research, the following activities will be distinguished based on the definitions mentioned above:

- Value-adding-activities (VA)
- Non-value-adding-activities, but required (NVA-R)
- Waste-activities (W)

As lean manufacturing comes with many benefits like efficiency improvements, cost lowering, sustainability improvements and customer satisfaction improvements, it comes with challenges also. Firstly, there is a potential to negatively affect employees. It must be considered to cut not too much in the pursuit of reducing waste and improving quality. Secondly, the well-being of employees must be considered also. Thirdly, it might be that when an organization is too focused on cutting waste, it may not see the broader picture of future needs. It is therefore necessary to keep thinking of possible future needs (Association for Supply Chain Management , 2024). Also, the resistance to change and lack of commitment should be considered when applying lean methodologies (Simplilearn, 2024).

The observations and understandings require clarification. This can be done by visualizing the process. It will be done according to the Business Process Management (BPM) methodology. This methodology focuses on improving an organization's business processes. Gartner (2024) defines BPM as a discipline that uses various methods to discover, model, analyse, measure, improve and optimize business processes. A business reflects the behaviour of people, systems, information and things to produce business outcomes in support of a business strategy (Gartner, 2024).

To specify and visualise the process, the principles of Business Process Modelling and Notation (BPMN) will be applied. IBM Cloud Education (2022) defines BPMN as the global standard for modeling business processes, a fundamental part of BPM. It allows stakeholders to visualise business processes, making it easier to make workflows more effective and efficient. The reason for choosing BPMN is that it offers a combination of standardization, extensive notation capabilities, understandability, IT integration, analytical possibilities that many other methods cannot match. In general, BPMN uses a standardized notation which is acknowledged and used around the world. (Eby, 2016)

The BPMN language is based on flowcharts and graphical notations. IBM Cloud Education (2022) seperates four categories for diagramming:

- Flow objects: Descriptive objects that are used to define a process, such as events, activities and gateways. In general, processes are triggered by a start event, have activities/tasks and decision points in the middle and conclude with an end event.
- Connecting objects: Symbols that are used to connect flow objects, such as message flows, sequence flows and associations. The flows are represented by dashed or straight lines with arrows, while associations use a dotted line to show that specific documents or artifacts are linked to an event or gateway.
- Swimlanes: Containers that separate a set of activities from others. In BPMN diagrams, pools represent the major particapant in a process. A different pool might be a different company, department or customer involved in the process.
- Artifacts: Supplemental information about the process, such as data objects, groups and annotations.

3 PROBLEM IDENTIFICATION

This section concerns the problem identification in which the root causes of the action problems are analysed. Problem identification is part of the Planning phase in the PDCA cycle.

To improve the efficiency in the production of Baas Metaal B.V., several measures have already been taken. For example, firstly, a fully automated warehouse in combination with an automated laser cutting system can work 24/7. The automated warehouse, a Trumpf Liftmaster called STOPA, is able to communicate autonomously with the three lasers from TruLaser. This ensures continuous production. Secondly, Baas Metaal makes use of both robot welding and manual-driven welding. The welding processes are in possession of the ISO 3834 and 1090 certificates. Lastly, Baas Metaal has several CNC-controlled machines. This is the computer-numerical-controlled arrangement that allows quick and accurate action in making metal partsl. These machines can operate automatically after being programmed.

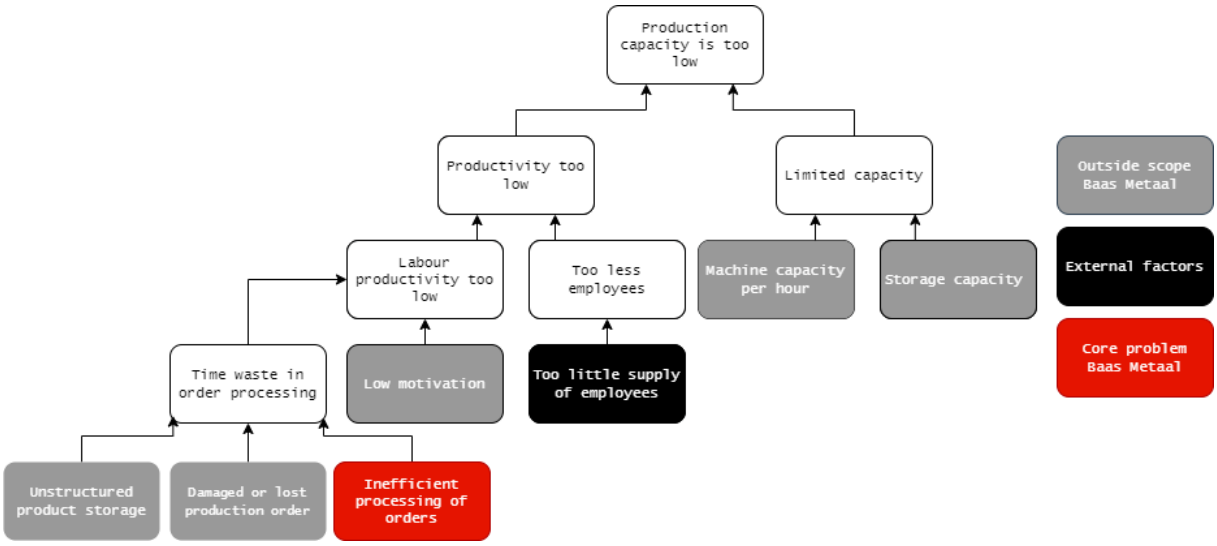


Figure 3: problem cluster

Figure 3 shows the problem cluster identified for this research. The problem cluster defines two reasons for the production capacity being too low: a limited capacity and a too-low productivity. The production capacity is defined as the maximum production or output which can be produced in business with the help of available resources (Bhasin, 2020). The capacity constraints of Baas Metaal are bounded by the machine capacity per hour and the storage capacity of the raw materials. The constraints could be remedied by an investment. However, this is a large investment and could require layout changes. Therefore, it is considered to be out of the scope of Baas Metaal. For this reason, this research will focus on the left side of the problem cluster.

Figure 4 shows the 'zoomed-in' problem cluster identified for this research. The problem cluster defines two reasons for the productivity of Baas Metaal being too low: a too-low labour productivity and too less employees.

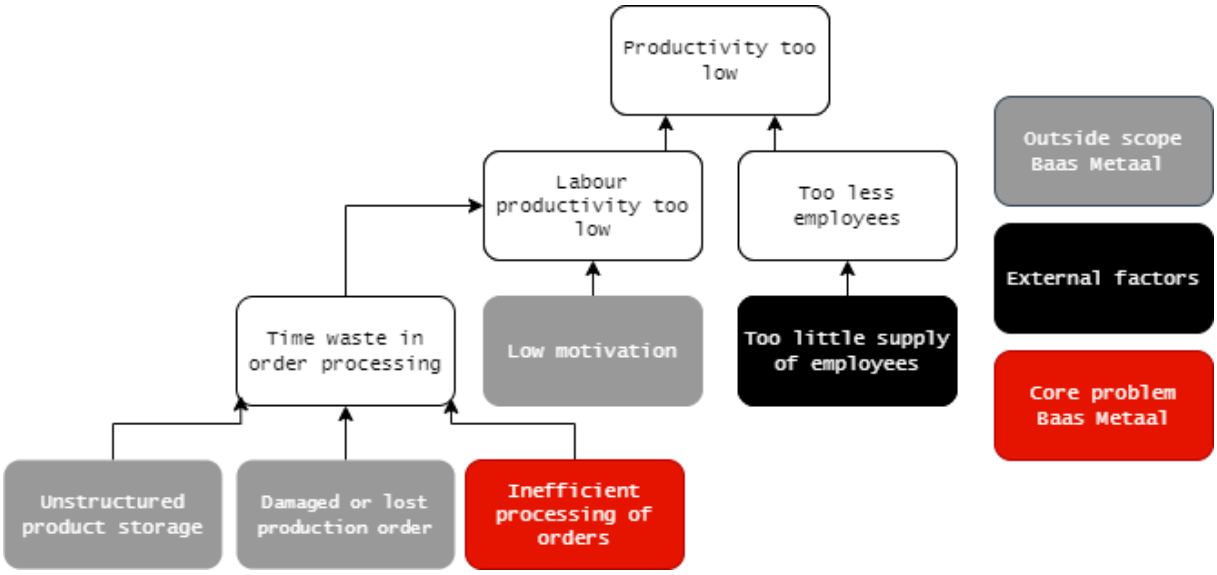


Figure 4: zoomed-in problem cluster

The labour productivity of Baas Metaal being too low can be explained by the low motivation of employees and the time wasted in the order processing. The time wasted in the order processing has three different causes. The first reason is an unstructured product storage. This concerns two points of attention. Firstly, due to the amount- and size of the orders, parts are sometimes not being stored in the storage racks but on the floor. This is also done when one specific order cannot be completed out of one sheet of raw material. The unpackers then place the incomplete order on the ground and store it properly when it is completed eventually. Secondly, when a part is being stored, the position needs to be written on the paper production order. This is not always written correctly, or clear for the employee of the next process. For this reason, the employee of the next process must search for the part. On the other hand, the shopfloor manager sometimes brings parts to the next process. To solve this, the shopfloor managers should make clear arrangements with their colleagues. This can be considered the responsibility of the production employees and therefore not within the scope of this research.

The second cause are the sometimes damaged or lost paper production orders. This occurs due to the transportation of these orders through production. Therefore, it can be considered the responsibility of the production employees themselves. To solve this, a production order can be printed again easily. Just as with the product storage, this can be considered the responsibility of the production employees and therefore not within the scope of this research.

The third cause regards an inefficient processing of orders. When an order is accepted by both the customer and Baas Metaal, it is printed. From this point on, it is called a production order. This production order consists of an order guidance card and (several) manufacturing drawing(s). When the production order is complete, it is put into a specific folder. Then, the order is transported to the programmer of the laser who is on the other side of the building. Here, the orders are sorted and eventually end up in the production department. This process is influential and asks for optimization.

Another reason for the labour productivity being too low is the low motivation of employees. This could however be caused by many (personal) reasons and is therefore considered out of the scope of this research. The too less employees can simply be explained by the too little supply of employees. This is an external- and non-influential factor and can therefore not be considered a core problem. To conclude, the core problem of this research is:

The inefficient processing of orders

Figure 5 shows the current way of processing the orders. Out of this mapping, several conclusions can be made. Firstly, the transportation of the production orders between the different departments can be considered waste. This is an unnecessary motion and happens between the work planners, shopfloor managers and programmer. It also happens inside the production hall between the different adjustments. Besides this, it sometimes happens that a production order gets lost or damaged in the production hall. Result is that it needs to be printed again, which results in time loss and unnecessary movement. Based on a questionnaire, it could be concluded that out of the 22 production employees present on the 5th of March 2024, 6 once or more lost a production order and 6 once or more received a damaged production order that required reprinting.

Secondly, there is time wasted due to the need to print the production order, put it in a coloured folder and sort it. This results in waiting time. Time loss also occurs when the printer requires an ink replacement. Both cases are considered waste activities. However, those activities are in the current way of order processing essential to carry out the operation.

Then, production employees are being directed by the shopfloor manager. The shopfloor manager decides which production orders need to be executed based on the planning provided by the ERP-system. He then distributes the production order among the different employees. This, again, results in time loss due to the transportation and searching for the production orders. Other waste activities occur when the control questions are not answered clearly. This results in time loss since parts can not be found or other instructions are unclear.

The defects that occur due to a human- or machine error damages the throughput time of the order and may be considered waste also. This is however not a factor that can be influenced by Baas Metaal. The only thing they can do is to emphasize the need to work carefully. In some cases, it occurs that the work planners forgot to add a certain measurement to the manufacturing drawing. The production employee is in that case not able to conduct his work properly. This employee is then obligated to enter the office where he/she receives the missing measurements.

In conclusion, the BPMN-model shown in Figure 5 reveals the occurrence of waste activities, as defined by lean methodology. These include unnecessary motion, transportation of paper production orders, waiting time, and defects. To improve the order processing of Baas Metaal, these inefficiencies should be eliminated or minimized.

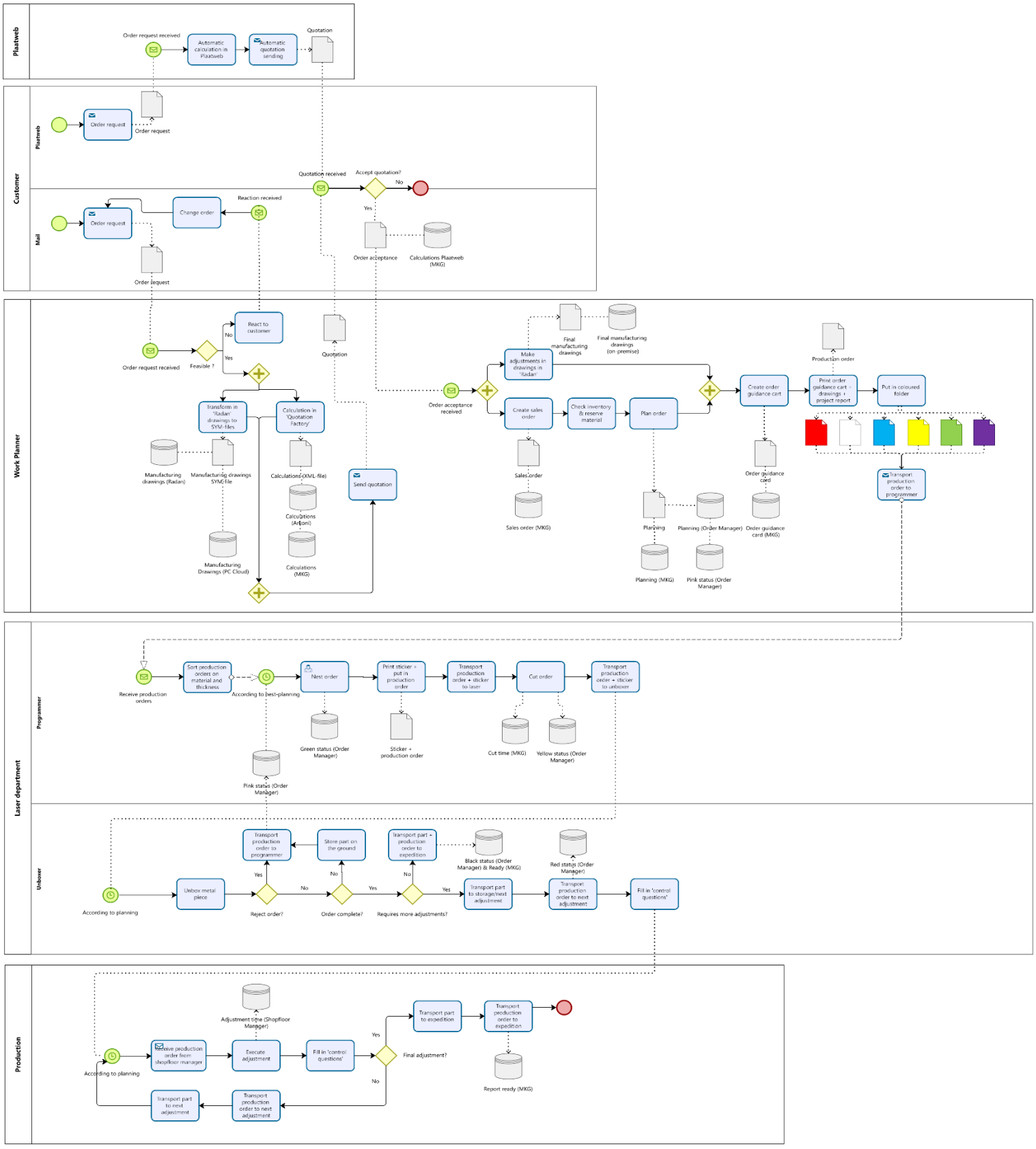


Figure 5: BPMN-model current way of working

To eliminate the waste activities as mentioned above, the suggestion to digitalise the order processing of Baas Metaal has been made. With the implementation of a digital solution, Baas Metaal might create the possibility to 'transport' the digital files without the unnecessary movement of employees. There might be a possibility to sort the orders based on thickness and material also. This will erase the time lost in the transportation, printing, and sorting of the production orders. Besides, by connecting these to a planning tool, the need for the shopfloor manager to distribute the production orders becomes unnecessary. This planning might be able to update continuously which makes it possible to insert urgent orders in between. When digitalizing, the problems of unstructured product storage and damaged/lost production orders might be resolved also.

To measure the effects of this problem, the researcher defines the labour productivity as the variable of the action problem. In this research, the labour productivity is the average, percentual time invested in producing valuable-, non-valuable but required- and waste output per time unit of labour input in the current situation.

Labour productivity measures the efficiency and effectiveness of labour in generating goods or services (Quickonomics, 2023). The reason for not taking productivity as a variable is because the throughput time, the amount of time it takes a manufacturer to complete a product from the first step in the production process to the last step (Indeed, 2023), of Baas Metaal differs very much per product. It is therefore hard to determine the possible effects of problem-solving. At this stage, the current labour productivity is unknown. For this reason, it is not possible to set a norm and reality. However, by making a comparison between the labour productivity before and after the implementation of a possible solution, an estimation of the possible effects of this digital transformation can be measured.

The reason for not choosing a norm and reality regarding the 'amount of paper used in the process', is that when focusing on the amount of paper, the labour productivity could be negatively affected. This is the opposite of what Baas Metaal wants. Therefore, the effect on the labour productivity will be investigated. The goal here is to improve the labour productivity in comparison with what it is now and minimize the amount of paper used in the process.

As mentioned, the use of paper production orders is chosen as the core problem and one of the possible causes of the too low productivity due to the time wasted in order processing. To solve this problem, a suggestion to substitute the current way of working with a digital way of working has been made. This research investigates the possibilities and consequences for Baas Metaal to turn into a paperless office. Therefore, the research question of this research will be:

How to successfully initiate a digital transformation regarding the order processing of Baas Metaal B.V.?

In this case, 'successfully' means that it increases the labour productivity and reduces the amount of paper used in the process significantly. By executing this research, a conclusion can be made whether it is possible for Baas Metaal to turn into a paperless office and whether this transformation affects the labour productivity positively. If both statements can be answered positively, the order processing of Baas Metaal becomes a more efficient process and will lower the time waste in order processing. This increases the labour productivity of Baas Metaal and therefore its productivity.

4 RESEARCH QUESTIONS AND APPROACH

In this section, the approach to the research question mentioned on the last page will be formulated. It states the research questions within this research with its limitations, relevance, and deliverables. The knowledge questions are used to answer the research question eventually. Formulating an approach is part of the Planning phase of the PDCA cycle.

(1) What are the potential obstacles and benefits of a paperless order processing?

Based on literature, the obstacles and benefits of a paperless order processing will be established. These will be used in the recommendation of the implementation of a paperless order processing. Also, the obstacles will be considered by the researcher while doing research on the user requirements. Limitations of this research would be that the literature is in most cases about a paperless process in general and not particularly based on a (metal) production company. However, the benefits and obstacles will still contribute to this research since Baas Metaal could also come across these benefits and obstacles.

(2) How does the current order processing of Baas Metaal B.V. look like?

By conducting interviews and observations, the current- and desired order processing can be established. The data will be analysed with the help of a business process management model. Out of this model, bottlenecks may be defined. The outcome of this research question will provide the researcher with a clear image of the current way of working including the current usage of digital systems.

(3) What are the user requirements to realise the desired order processing?

The third question concerns a user requirement analysis. Out of this analysis, a list of requirements can be formulated that need to be fulfilled to realise the desired order processing. This list will form the basis for answering the fourth knowledge question. Knowledge question (2) & (3) establishes the gap between the current- and desired way of working. The user requirement analysis will be conducted according to the four stages stated by Maguire & Bevan (2002). Limitations in this research might be that the data is too general since users do not know in advance what they want from the future system, a too-general requirement list will be the consequence.

(4) How can the identified user requirements be satisfied?

This research question will look at how the user requirements can be satisfied by connecting them to (digital) tools. In the end, it will provide the affairs that need to be executed to successfully satisfy the user requirements as stated in question (3). The need to get familiar with the systems relies on observations and help from others, this limits the research.

(5) What is the labour productivity of work planners and production employees with the current- and desired order processing of Baas Metaal B.V.?

By doing a direct and unstructured observation, the activities performed by the work planners and production employees can be mapped. Based on this, an estimation of the labour productivity can be made. Limitations in this research are the possibilities of biases due to the presence and mentioning of conducting observations. This estimation will be used to establish the effect of initiating the digital transformation at Baas Metaal.

(6) What are the costs of the current- and desired order processing of Baas Metaal B.V.?

The sixth question concerns a cost estimation on both the cost concerning the waste in the order processing, and the actual costs made by making use of paper production orders. This research question will provide an image of how costly the current way of working is. Eventually, it will also provide a payback period of possible investments that must be done. The limitation of this estimation is that it relies on other estimations and/or assumptions. For this reason, it could deviate from reality.

(7) What recommendations and outcomes can be given to Baas Metaal B.V. regarding solutions and implementations?

Based on the research questions above, a clear recommendation and outcome of the initiation of a paperless order processing can be made. This will include the consequences and affairs that need to be executed to satisfy the user requirements. Also, this question provides a BPMN-model that describes the new way of working. This question gathers all the information necessary to answer the research question. However, a limitation of this question would be that it is all based on theory gathered from practical interviews and observations. This could mean that, when implementing this recommendation in practice, it could encounter bottlenecks that have not been considered.

5 LITERATURE REVIEW

This section elaborates on the existing literature of the 'paperless office' with its benefits and obstacles. This concerns the first question out of Section 4.

5.1 Paperless Office

One of the efforts undertaken by governments to reduce the impact of increasing deforestation is by changing all governmental processes from traditional to digital by optimizing the use of Information Technology (Firdausy, 2012). This effort is known as the Paperless Office. The Paperless office concept was introduced by George Pake, head of Xerox Corp.'s Research Centre, in an article published on June 30th, 1975, (Firdausy, 2012). Paperless Office is a work environment that emphasizes the reduction or even complete elimination of the use of paper (Ramdhani, 2015). The idea of a paperless office was predicted almost forty years ago, despite the worldwide technology has developed, the paperless office has not really materialized (King & Toland, 2014). Baas Metaal concerns both an office and a production facility. It could therefore mean that certain obstacles are more difficult to overcome than when it concerns an office only. For example, production employees might have more difficulties (in comparison with office personnel) with working with digital systems rather than the paper production orders.

Paperless offices concern, besides governments, companies also. To remain competitive in the market, companies have increasingly recognized the need for digitalisation (Gamido, Gamido, & Macaspac, 2023). Digitalisation has already spread to many production sectors, presumably because there is strong evidence that the digitalisation of a company has a positive influence on its performance (Fernandez-Portillo et al., 2022). A vital component of this digital transformation is the adoption of DMS (Document Management System), also known as paperless business solutions (Knut-H & Ole, 2021). Implementing DMS is crucial for organizations today, it results in many more benefits than cost reduction purposes only. On the other hand, certain obstacles need to be overseen before implementing DMS in the processes of a company.

5.1.1 Benefits Paperless Process

After the successful implementation of a digital transformation, a flow of information with attached documentation occurs. The use of this DMS offers many advantages for organizations and their users.

The management of extensive document volumes incurs significant financial costs for organizations. After the implementation of a DMS, organizations can automate and streamline their document management processes. This will result in notable cost reductions. Eventually, it will allocate resources more effectively towards beneficial business processes (Zabukovsek et al., 2023). The cost reduction can be explained due to the decrease in two factors: the decrease in paper usage and the decrease in waste activities that lower the labour productivity.

Logically, digitalising reduces the usage of copiers and printers, as well as less need or repair and maintenance of such equipment, and of paper and related supplies. This will reduce the costs. Also, by shifting from physical paper to a digitally oriented approach for storing, disseminating, and processing information, firms can improve processes and reduce the costs associated with administration and processing (Keumars, 2022). Regarding storage, one sheet of paper may not take up a ton of space, but looking at the fact that Baas Metaal has about 3.500 production orders per month, where one production order consists of at least 2 papers, it takes up a lot of storage. Also, when thrown away directly. Besides this, it has the potential to reduce human errors. This regards errors linked to administrative- and manual tasks. Digitalisation now automatically documents data (e.g., time worked on certain manufacturing processes) instead of having to do it manually. (Amankwah-Amoah et al., 2021)

The other cost reduction lies in the improvement of the labour productivity. Developments of digitalisation open new opportunities to increase and manage productivity. The core strategy here is to change either the input (time, material, etc.) or output (number of goods, etc.) of the labour productivity (Institut für angewandte Arbeitswissenschaft, 2016). Productivity improvements can be reached by using information and communication technologies like document management systems. In the case of Baas Metaal, it will decrease the input of the employees per order and therefore contribute to an improved labour productivity. The input will decrease since the employees are no longer obligated to print, sort and transport orders. This will lower the time invested per order. (Weber et al., 2017).

Besides cost benefits, DMS also allows efficient and convenient access to information, eliminating the need for physical presence in the office, and allowing DMS users to save time and focus on other work-related tasks. An early advance of document management systems is that it creates the way for many organizations and individuals to search for- and find documents with accuracy and speed (Keumars, 2022). This eliminates waste activities like tasks associated with finding documents.

In combination with the fact that the cost of communication, storing information and the size of devices has decreased, while the possibilities and capabilities of the latter have increased, it creates possibilities to perform the activities of the employing organization from other places than the office. For Baas Metaal this would mean that work planners are, when having access to their ERP-system, able to create orders everywhere. This would contribute to the continuity of the processes of Baas Metaal. When having a user-friendly DMS, productivity and efficiency will increase since it simplifies the search for data, information, files and processes (Zabukovsek, Jordan , & Bobek, 2023). This will increase the productivity of both the work planners and production employees of Baas Metaal.

Lastly, another logical benefit and consequence of going paperless, is that it contributes to a more sustainable organization. Unilever (2017) conducted a study that states that a third of all global consumers are now choosing brands they believe are doing environmental good. Perhaps, one of the best examples of digitalisation that has a positive impact on both the environment and business performance is the paperless office (i.e., reducing the use of paper in business processes) (Xiong, 2021). More fundamentally, a paperless office reduces negative impacts on the environment like natural resource consumption, pollution, and waste. So, for Baas Metaal this would mean that they can reduce their carbon footprint and therefore improve their image as a sustainable organization.

To conclude, the benefits of a paperless process can be divided in an increase in labour productivity, a reduction in costs caused by the decrease in paper usage and a decrease in waste activities that lower the labour productivity, a decrease in errors, the ability to access information everywhere and the improvement of sustainability.

5.1.2 Obstacles Paperless Process

As going paperless brings many benefits, it also brings obstacles that need to be overcome so that there is no risk of losing information that might be important from both a personal and business point of view.

In the current digital age, all our actions leave digital crumbs that can be used by (other) organizations through the collection of personal data. To strengthen the protection of personal information and transparency, general laws are made. These laws aim to protect personal data in both physical and digital environments and recognise that for the individual to control the flow of their personal data, it is necessary to assign rights to those who are responsible for controlling this data (Feigelson, Becker, & Camarinha, 2020). Baas Metaal needs to ensure data safety to its clients. This can be achieved by

having good cyber security and making sure that only personnel with the right authorization can access certain information.

Furthermore, a challenge to be overcome is the existing restrictions on digital preservation both in terms of technology and in perpetuity of repositories (Perfetto et al., 2023). This comes down to restrictions in both hardware- and software technology. To overcome this, Baas Metaal should make use of the most actual technological possibilities. Also, they should maintain consistency by working according to the same principles repeatedly and making use of the same file formats. For information to be of value to a company, it should fulfil certain characteristics. These can be stated as: accessible; exact; complete; economic; flexible; relevant; reliable; secure; simple; submitted on time and verifiable (Perfetto et al., 2023). For the work planners and production employees of Baas Metaal to be able to execute their work properly, the information should fulfil those requirements.

Another obstacle regarding technology is that the company depends on online programs and a stable connection. If, for example, a program crashes, the whole organization can not work. Besides this, by relying more on online programs, the company becomes more vulnerable to cybernetic attacks (Oliveira, Azevedo, Ferreira, Gomes, & Lopes, 2021). Again, to prevent this, Baas Metaal should ensure good cyber security and reliable connections.

Adam (2007) states that the implementation of a DMS is not just about technology, this represents the 'easy' part. It is more about organizations, people, cultural change and strong, good, yet flexible management. Thus, an essential part of the implementation is people's readiness since interaction with technology also includes emotional factors. The study conducted by Gelashvili & Pappel (2021) states that interviewees highlighted personal attitudes and perceptions as an internal barrier by providing a detailed description of the staff resistance they were facing. The 'Theory of Reasoned Action and Diffusion of Innovation' showed matching factors. This theory originates from social psychology. It is developed to define the links between the beliefs, attitudes, norms, intentions, and behaviours of individuals. The theory assumes that a person's behaviour is determined by the person's behavioural intention to perform it, and the intention itself is determined by the person's attitudes and his or her subjective norms towards the behaviour (Korpelainen, 2011).

The resistance of accepting the technology comes out of scepticism and distrust towards the change. This resistance comes out of the fear of failure. This barrier, such as being afraid to fail to accomplish a certain task, has prevented many organizations from incorporating DMS in their daily activities. Staff members indicated that they were concerned and sceptical about risks regarding the storage of documents, preserving their work and performing certain activities. Consequently, when it was not obligated to perform a certain activity digitally, it was most of the time conducted in the traditional, paper-based method. (Gelashvili & Pappel, 2021)

Before new and innovative routines can be adopted, firms must abandon long-standing procedures and routines. Abandoning routines and established practices can be challenging, especially in older firms. This is because new knowledge that leads to novel routines tends to conflict with existing operations and models (Amankwah-Amoah et al., 2021). Different studies agree that performance improvements do not occur until the company and its human resources have the necessary 'expertise' (Hernández-Ortega et al., 2009; Tomas et al., 2004; Ravinesh Kumar, 2016; Hsiu-Fen & Szu-Mei, 2008).

As can be concluded from these articles, one of the biggest obstacles in implementing a digital transformation is people's readiness. The employees of Baas Metaal who are linked to this transformation need to be willing to accept the change. This will be based on their norms. Besides this, the concerned stakeholders need to have the right expertise. If they do not own the right expertise, they should be offered the right guidance. Other obstacles are the protection and transparency of personal data, and the restrictions in technology.

6 PROBLEM ANALYSIS

This section answers the research questions (2) as stated in Section 4. It provides an elaboration on the current order processing.

6.1 Current and Desired Order Processing

This section provides an elaboration on the current order processing of Baas Metaal. It discusses the current digital system owned by Baas Metaal and the BPMN-model of this process. For a more detailed explanation of the current order processing, refer to Appendix D.

6.1.1 Current Digital Systems

At the moment, Baas Metaal uses the following systems: 'Plaatweb'; 'MKG'; 'Quotation Factory'; 'Radan'; 'Order Manager'; 'Machine Manager'; 'Shopfloor Manager' 'TruTops Fab' and 'Arkoni'. This section elaborates on how these systems are currently used within Baas Metaal.

Plaatweb is the automatic quotation system of Baas Metaal that is used for providing quotations for laser cutting work only, or both laser cutting- and bending work. MKG is the ERP-system of Baas Metaal. It is considered the most important system since it is leading in all cases and brings the information of different departments together. In the current setting, employees can use MKG to plan orders, set processing times, create production-/sales-/purchase- orders and view customer overviews. Quotation Factory is an online calculation system that can determine the price, adjustments needed, and the corresponding adjustment times needed to fulfill customers' order requests. It is used for generating a quotation quickly and easily and determining the necessary adjustment times.

Radan converts customers' files into the formats needed for production. Besides the ability to transform files, Radan is also able to make changes in customers' manufacturing drawings. This is sometimes necessary to clarify drawings more and prevent mistakes during production. Radan makes the final 'nest' for the laser cutting machine to cut. A nest is the process of making optimal usage of a metal sheet, this is done by combining several (different) orders.

Colour	Status
	Ready, at expedition
	Ready, next process
	Work Planner
	Cutted, not unboxed yet
	Programmed as nest

Table 1: statuses Order Manager

An extension of Radan is Order Manager. This program declares the status of the cutting-related processes and provides the planning in combination with MKG when the programmer should nest a certain order. See Table 1 for the different statuses in Order Manager. Another extension of Radan is Machine Manager. This program gives the input for status changes in Order Manager. For example, when the laser is done cutting, it gives the input to Order Manager that the machine is done. Machine Manager tracked the time, and Order Manager changes the status of the order to yellow.

Then there is Shopfloor Manager. This program activates when a work planner plans the order and keeps track of the time invested in a certain adjustment by a certain employee. This is connected to MKG and therefore exchanges data smoothly.

TruTops Fab is the program that is in connection with the automated raw material warehouse and states the inventory of the materials. TruTops Fab is connected to Radan to make sure that a nest only can be made if the right material is available. Arkoni is a software system that provides data from other systems to MKG. For example, the calculations from Quotation Factory are first synchronized by Arkoni. After this, they are automatically being imported into MKG.

6.1.2 BPMN-Model

Figure 5 in Section 3 shows the visualisation of the order processing of Baas Metaal based on the principles of BPMN. Appendix C shows an enlarged representation of the BPMN-model.

It all starts with the customer making an order request. This can be done by contacting the work planners of Baas Metaal via 'Plaatweb' or Mail. Plaatweb is only used for order requests that require cutting work only. When the order is accepted by both the customer and Baas Metaal, the work planners ensure that the right manufacturing drawings are uploaded in Radan and on-premise, that the calculations are uploaded in MKG, that a sales order is created in MKG, that the order is planned in MKG and that a production order with all the necessary documents is brought to the programmer in a coloured folder. The coloured folders, see Table 2, represent the next adjustment after being cut by the laser.

Colour	Meaning
	Urgency/Rejected
	Cutting only
	Bending
	Welding
	Machining/Rolling/Blasting
	Internal rejection

Table 2: meaning coloured folders

After the complete documentation of all the necessary information in the digital systems of Baas Metaal, the production order is printed. A production order consists of an order guidance card, manufacturing drawings and a project report. Appendix E shows an example of a paper production order. An order guidance card could be a 'main order' or a 'copy order'. For orders where multiple products, or products are made from multiple types and thicknesses of materials, an order consists of a main order and copy order(s). The main order contains all products that belong to that specific production order. A copy order is created per thickness and/or type of material.

The order guidance card displays the materials (including V-groove) and all the required adjustments to create that specific part. Furthermore, every adjustment has its barcode. Production employees must scan this code to establish the duration of their adjustment time in MKG. The possibility to select employees and keep track of their time is made possible by Shopfloor Manager. Besides a barcode, there is a QR-code. This code is scanned by expedition employees which reports the production order ready in MKG.

After being printed and put into a coloured folder, the production order is transported to the programmer. The programmer firstly sorts the incoming (copy) production orders based on material and thickness. The provided planning by Arkoni, based on the delivery date in MKG, gives the working scheme of the programmer. Based on this, the programmer nests the orders. Then, a sticker page is printed corresponding to the production order. See Appendix F for an example. The sticker page contains stickers, cutting program information and an image of the cut plate. The production order, including the sticker page, is now being transported outside the office to the laser. Once the laser work is completed, the production order will be transported to the unboxing department.

Depending on the delivery date of the production order as mentioned in MKG or instructions of the programmer, the unboxers will request the specific order from the STOPA (the automatic warehouse). The unboxers will then unbox the cut parts out of the material sheet. After unboxing a certain part, it will be stickered with the sticker that was delivered with the production order. The stickers provide the unboxer with, for example, an image of the part and the required number of one specific part necessary to fulfil the production order. The purpose of the sticker page is mainly for the unboxers' identification and to find the parts in storage more easily. Also, it helps unboxers to conclude faster which orders are complete and which are not.

It could be that an order is rejected internally due to a mistake during one of the adjustments. An employee then rejects the order and transports the production order back to the programmer who reports the production order (partly) rejected in Order Manager and nests the order again according to the possibilities in the planning. If the order is not rejected, complete and requires no more adjustments, both the production order and part(s) will be brought to the expedition where it will be reported ready. If the production order however requires more adjustments, the part will be brought to the storage or to the next adjustment. After this, the control questions on the production order are answered. The questions, who/date/amount/where, keep track of the part in the production hall and need to be answered after every adjustment. The production order will be brought to the planning bin of that specific adjustment or to the planning bin of the shopfloor managers who then divide it among the production employees later according to the planning of MKG.

After a production employee receives both the production order and the part, he/she scans the corresponding barcode on the production order. The time needed to fulfil the adjustment will then be saved in the database of Shopfloor Manager. If this adjustment is the final one, the production order and part will be brought to expedition where it will be reported ready by the shopfloor manager. This ends the order processing. If this is not the final adjustment, the part and production order will be stored and the production order will be brought to the next adjustment after filling in the control questions.

6.2 User Requirements

Understanding user requirements is an integral part of information system design and is critical to the success of interactive systems. However, specifying these requirements is not so simple to achieve. It is now understood that successful systems and products begin with an understanding of the needs and requirements of the users. By doing this correctly, benefits like increased productivity, reductions in support and training costs, enhanced quality of work, and improved user satisfaction can be realized. The basis for the application of different user requirements methods is a simple process. See Figure 8, the method by Maguire & Bevan (2002) describes four elements.

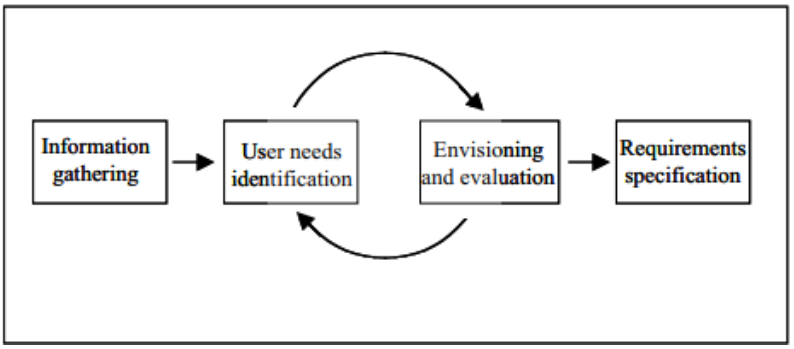


Figure 6: elements user requirement method (Maguire & Bevan, 2002)

6.2.1 Information Gathering

Gathering background information about the users, stakeholders and the processes that currently take place, is the first step in the user requirement analysis. This section therefore conducts a stakeholder analysis. The analysis identifies all the users and stakeholders who might be influenced or impacted by the system. Besides this, it identifies, for each user, their main roles, responsibilities, and task goals in relation to the system. (Maguire & Bevan, 2002; Bronwen, 1990)

The BPMN-model of the current order processing of Baas Metaal identifies the stakeholders that are connected to this process. Those are the customers, work planners and production employees. The production employees are, in this user requirement, considered to be different users since it might be that the employees who work at different adjustments desire different requirements of the system. Other people that are affected by this digital transformation are the director- and other employees of Baas Metaal, and the supplier(s) that provide the resources for the current way of working.

The users are mapped in the Mendelow stakeholder matrix. This matrix was created in 1991 by Audrey L. Mendelow as a way to manage stakeholders during a project. It analyses their attitudes across two key variables: power and interest. Power is defined as the ability of a stakeholder to coerce, induce, or persuade another group to take a specific course of action. On the other hand, interest is defined as the likelihood that a stakeholder will be motivated to exert their power to have their needs met. (Latha, 2023)
This results in four categories (Cuofano, 2024; Latha, 2023):

(1) High power – High interest (key players): these are the stakeholders that are decision makers and have the biggest impact on the project's success and therefore must manage their expectations.
(2) High power – Low interest (keep satisfied): these stakeholders need to be kept satisfied even though they are not interested. These types of stakeholders should be dealt with cautiously since they might use their power in an undesired way in the project if they become unsatisfied. This regards mostly regulatory bodies.
(3) Low power – High interest (keep informed): these types of stakeholders should be kept informed to ensure that no major issues are arising. These people can be very helpful with the details of your project. They may be directly affected by the organization’s actions or decisions but not have the authority to influence those decisions. However, they may lobby a more powerful group to have their needs met.
(4) Lower power – Low interest (low priority): these are the stakeholders with the lowest ability to impact a project and are not interested in doing so.

To start, the management of Baas Metaal is considered to be a key player. Management is in this case defined as the owner/director of Baas Metaal. The director has the power and influence to carry through certain decisions. Managing relationships with this stakeholder is critical for the successful implementation of the digital transformation.

The employees of Baas Metaal are placed in the 'keep informed' quadrant. It might be that the employees are not satisfied with the new way of working, this could result in resistance from this group. Therefore, it is very important to establish the needs of this group. Otherwise, their influence will result in lobbying a more powerful group to have their needs met.

Persons that need to be kept satisfied are those of regulatory bodies. For example, it might be that environmental regulations obligate companies to decrease their carbon footprint. Since these persons have the power to carry through those regulations, Baas Metaal should follow them.

Last, customers and suppliers are considered to be of low priority. The customers will not experience any change in making an order request, they still provide the same information as usual. This makes their power and interest in the digital transformation low. The same applies to suppliers of materials that make the current way of working possible (e.g. paper, printer supplies). They do not have any kind of power or interest in the digital transformation of Baas Metaal, they now only get less turnover from Baas Metaal.

Figure 7 shows the Mendelow stakeholder matrix of Baas Metaal regarding the stakeholders that might be influenced- or impacted by the system.

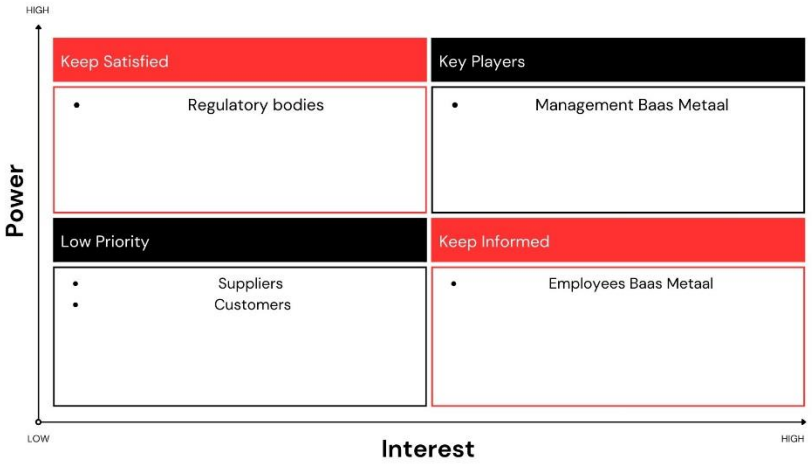


Figure 7: Mendelow stakeholder matrix Baas Metaal

6.2.2 User Needs Identification

Once the user data has been collected, the user needs can be identified. This research focuses on conducting interviews in combination with 'scenarios and use cases'. Interviewing is a commonly used technique where stakeholders are questioned to gain information about their needs or requirements. By combining this with scenarios and use cases – detailed and realistic examples of how users may carry out their tasks in a specified context – the researcher can provide examples of future use as an aid to understanding and clarifying user requirements. However, the researcher should make sure that he does not put answers/words in one's mouth to ensure the reliability of the results. (Maguire & Bevan, 2002)

In this section, interviews will be conducted to identify the requirements of the problem owner and users. In other words, the group that has a high interest in the digital transformation will be interviewed. For the employees of Baas Metaal, focused on the work planners and production employees, it is important to clearly determine their requirements. If not, the employees might show resistance when they are not satisfied with the new way of working.

In this research, to guarantee validity and reliability as much as possible, several measures will be taken. To start, multiple people from all the different departments will be interviewed. This creates a balanced research sample and therefore justifies the data gathered with the interviews mostly. The participant error and bias will be minimized by informing the participant about the goal of this research part and assuring them that there are no right or wrong answers. Also, the researcher emphasizes the importance of providing honest responses. This will ensure that the participants answer in a way they think about certain processes and do not provide answers because they think that is what the researcher wants to hear. The interviews will be taken one-on-one in a quiet area to ensure honest answers that are not influenced by others.

The data will be gathered by making use of an audio recording, permission for this will be asked beforehand. In the end, this recording will be deleted. This way of data recording is the most accurate one when there is a need to process the data afterwards. Also, every participant will be asked the same questions, in the same order. Lastly, the researcher ensures confidentiality to the participant by not mentioning his name in both the audio recording and transcription of the interview. (Brink, 1993)

To visualize the desired order processing, the researcher will be conducting interviews with the problem owner and users. The problem owner is the owner/director of Baas Metaal B.V. and the users are employees of Baas Metaal. Appendix G shows the interview with the problem owner, whereas Appendix H shows the interview with the users.

6.2.3 Envisioning and Evaluation

After the collection of user needs, it is important to develop a structured list of requirements. But firstly, a clear conclusion about the needs of users needs to be established. This section will conclude the interviews as stated in Appendix G & H. Besides this, during the observations, several user requirements were established. Those are taken into account also.

Problem owner

Based on the interview, the problem owner expects that the desired order processing will use no paper except for the sticker pages. The stickers will contain a barcode that can be scanned to determine the time invested in a particular adjustment. If the previous adjustment has not been reported as ready, the production employee cannot start the next adjustment. Additionally, Machine Manager will be used to determine the exact time invested in unboxing the metal parts. There should also be a digital option for working with half-fabricates. Finally, control questions and the ability to place comments will be handled through Shopfloor Manager.

Work Planner

Work planners print the production order, including order guidance cart, manufacturing drawings and project report. When necessary, they want to make comments that appear at the concerned department. The work planners think that they will not encounter big problems themselves when turning paperless. It will save them time by removing the need to print, sort and transport the production order. However, they do think that problems might occur in the workshop due to the habit of working with paper and the complexity of some welding assemblies.

In their view, they need to be able to create a digital production order with all the necessary files attached. These files are elaborated as much as possible. This means that a production employee should be able to execute his work without having to make measurements himself. However, if things are unclear, he can take measurements himself and is able to watch the order in 3D.

Programmer

The programmer makes use of paper by printing the stickers needed for the unboxing department. He thinks that the stickers, or something equivalent, should stay to ensure the right identification of parts. The programmer states that he does not need the paper production orders to do his work, all the required information to do his work (e.g. SYM-files) can be found in the system.

The programmer decides, based on the planning, what needs to be unboxed or cut by another employee by passing on the paper production orders and stickers. When going paperless, this action needs to be done by either the stickers (or something equivalent) or a digital solution.

The programmer wants to have the possibility to pass on comments. Besides this, the programmer should have a comment field next to his planning that displays information about, for example, specific plate information. The reason why employees come to his office is because of an internal rejection. This can also be done with the stickers only. Lastly, the programmer thinks that there are opportunities for clocking the time during unboxing. By making more use of Machine Manager, a more accurate unpacking time can be realised.

Laser

The employee setting up the laser uses paper to look up scrap pieces and request the cutting programs. This concerns the sticker pages only; the production orders are not important for the laser department. The information which is used from the sticker pages regards the measurements of the residual plate and the program numbers. By keeping the stickers pages, the laser employee can execute his work like he is used to. However, when turning completely paperless, the laser employee needs a screen at the STOPA to have insight into the dimensions of the scrap pieces and a screen at the laser to have insight into the planning.

Unboxer

The unboxers are convinced of the use of stickers. This does not only concern their department, but also others. They think it is important for the identification of the products and will cause problems in the production chain if not being used. Regarding paper, the unboxers use the sticker pages only. The production order is only used for passing along the location.

The information on the sticker page is used for several purposes. Firstly, the program number is used to acquire the right cut plate from the STOPA. Secondly, the sticker pages provide an image of how the plate is cut. Then there are the stickers themselves. Those are used to attach to the product. According to the unboxers, all the important information is on the stickers as they are being structured now.

Regarding the rejection, now, when there is a rejection, an unboxer writes this down on the sticker of that specific product and returns it to the programmer. However, when providing screens to the unboxers, they think they might be able to reject orders themselves. Also, the unboxers might be able to keep track of their unboxing time themselves. At the moment, it is not being used properly since it takes too much time in the current setting and is therefore filled in manually based on an estimation.

Bending

The bending department uses the production orders to clock their time, set up the machine and look at the drawings to execute their bending activities properly. Important information here are the bending dimensions: angles, lengths, and V-groove. Since it takes some time to change V-groove, the production orders are sorted based on a mix of urgency and V-groove. This prevents the V-groove from being changed too much unnecessarily. According to the bending employees, there should be a possibility to sort the production orders based on urgency and V-groove. Besides this, the employees should be able to have access to all drawings in both 2D and 3D where measurements can be made themselves.

The bending employees need to have access to their needs most easily. This means that the drawings and other necessary information should be visible in the least number of actions according to a planning. Also, the determining of the products' location should improve. Now, it occurs too often that products lie in the wrong place, or the location of the products can not even be established since the handwriting is not clear enough. To solve this, the employees would like to see a comment field where the location is being stated.

Benching

After receiving a production order, the product is being searched. Most of the time, the products that need to be adjusted by this department are near the adjustment tools. However, employees state that they often still must search thoroughly for the right product. They think this can be solved by creating more fixed locations and passing on the locations in some way. After finding the product, the production order is used to scan the barcode which starts the timer of the adjustment. Then, the right drawing of this specific department needs to be found after which the adjustment can start according to the manufacturing drawing.

When it concerns a simple adjustment, the drawing is kept in the folder and the adjustment is memorized. However, when it concerns a more complex adjustment, the drawings are kept closely next to the employee or machine. This means that, when digitalizing the process, the employees at the manual benching machines require zooming abilities to see the drawings from a distance on the screen properly. Also, the manual benching machine requires an extra screen when multiple people are working at the same time.

Regarding the CNC-controlled benching machines, the employee stated that he requires at both the machines a screen that is on top of the machines' screen. On these screens, the employees should have the possibility to clock their adjustment time, see the orders sorted on urgency and the drawings attached to these orders. The benching employees state that a 2D drawing is sufficient to execute their activities. However, a 3D possibility could help them when there are missing measurements that can only be seen in 3D. Regarding clocking the adjustment time, this could be improved. A suggestion has been made that the employee can start the timer himself where the timer stops whenever the next order is started.

Welding

With the production order, welders start the timer of their adjustment by scanning the concerning barcode, and they look at the drawings. Sometimes the welding adjustment can be remembered, but this is not always the case since there are often difficult assemblies too. In this case, the paper drawings are convenient since they can lie physically next to the product. When going digitally, it would mean that the welder has to turn constantly to his screen. Some welders think this can be solved with the use of a tablet, but others think it will get in the way of their operations.

Welders still prefer a paper-based way of working since they can look more easily at both the product and drawing at the same time. When going digitally, this problem can be solved by providing the welders with all the necessary drawings in both 2D and 3D. Features like the ability to zoom in, rotate, take measurements themselves and make notes should be included in the digital transformation.

According to the welders, the process of clocking their time needed to fulfil the adjustment needs to be improved. Now, the welders are not able to start the timer again after it has been stopped due to the urgency of another task which requires to be timed also. To start the timer again, the welder must execute many manual activities. Their request is to be able to clock in and out at any time with any product. Eventually, they should be able to report the product ready.

Regarding product location establishment, according to the welders, this should improve. They think the location should be stored digitally and visible to all the concerned employees. It could also be done manually: after reporting the adjustment ready, the employee is asked to give input of a location where the product is stored.

Expedition

After an adjustment is done, the expedition receives this production in a specific folder. At this point, the expedition employee is responsible for the sorting of this production order based on what the further requirement of this order is. The continuous need for sorting the production orders is considered an inefficient process of the current way of working. Another activity where paper is being used in the expedition department is to make notes. Expedition states that it would like to have the possibility to make notes digitally.

Now, a copy order is not being reported ready digitally. Only once the main order is done, it is reported ready in the system. Expedition states that they now chase after the products (copy orders) themselves. In the future, the expedition is however able to report every kind of order ready. Regarding location, they think that the location should be established digitally by making use of

scannable codes on both the product and the shelf. Who takes care of the storage, still needs to be established.

The expedition department thinks that it is possible to work with the sticker pages only. Last, since expedition walks around a lot with paper, it would be easy to have something portable (e.g. tablet) that could scan a code to check which product it is. But also, to see when it was cut and from which sheet.

General

The digital transformation should, generally, not create difficulties or waste-activities among the employees. This means that the employees should be able to have access to all the necessary information in the lowest number of actions. For example, it should not take an employee more actions than what is digitally possible and required to access the drawings. Other requirements like the ability to zoom-in, have access to both 2D and 3D drawings and the ability to start- and stop the timer of their adjustment time, is desirable for every department and therefore considered to be a general requirement.

6.2.4 Requirements Specification

After the evaluation of the requirements, they should be specified. This section will create a 'cleaned' list where the different requirements are connected and summarized into a concise requirement list per department. This section will do this with the 'task/function mapping' technique. This technique specifies the system functions that each user will require for the different tasks that they perform. Maguire & Bevan (2002) state that a benefit of this technique is that it avoids including too many functions.

After collaboration with management, it was decided to continue with the sticker pages and give unboxers the ability to clock their time- and give input for internal rejections themselves. Besides this, the location establishment will be arranged by the employees themselves in such a way that they can give input for the location digitally after reporting the order ready. This will be done with the help of QR-codes.

The current situation does not show consistency in who and when takes care of the internal transport of products. In some cases, it is done by a shopfloor manager who brings it to the next adjustment or puts it on a shelf. This could be directly after the adjustment, or after a while when multiple different products are collected from the same adjustment. However, in other cases, the employee of the last made adjustment itself brings the product to the next adjustment or puts it in a shelf. For this case, the same applies, it could be directly after the adjustment or after a while when multiple different products are collected from the same adjustment.

Table 3 shows the requirements of both the different departments and the problem owner.

DEPARTMENT:	REQUIREMENTS:
PROBLEM OWNER	- No paper is used, except for the sticker pages. - The stickers will contain a barcode that can be scanned to determine the time invested in a particular adjustment. - Machine Manager is used to determine the time invested in unboxing the metal parts. - Ability to work with half-fabricates digitally. - Ability to answer the control questions digitally.
WORK PLANNER	- Ability to create an order/half fabricate to which manufacturing drawings and STEP-files can be linked. - Ability to make comments that appear at other departments. - Ability to print manufacturing drawings when necessary.
PROGRAMMER	- Ability to print sticker pages. - Ability to make comments that appear at other departments. - Ability to have insight into comments made by work planners. - Ability to sort orders based on material and thickness
LASER	- Ability to see the program numbers and measurements of the residual plate.
UNBOXER	- Ability to attach stickers to products. - Ability to have access to product information (quantity, image, order number, delivery date, dimensions, and next adjustment). - Ability to start and stop the time needed to unbox a program. - Three extra screens required. - Ability to clock unboxing time. - Ability to give input for an internal rejection.
BENDING	- Ability to sort orders based on urgency and V-groove.
BENCHING	- One extra screen required at manual drilling machines. - Two extra screens required at CNC-controlled machines, placed on top of the machines' screen.
WELDING	- Ability to print manufacturing drawings when necessary.
EXPEDITION	- Ability to have insight in the half fabricates/orders that are reported ready.
GENERAL	- Ability to sort orders based on urgency. - Ability to start- and stop the timer of the employees' adjustment time in the lowest number of actions. - Ability to have insight into the drawings in the lowest number of actions. - Ability to see drawings in both 2D and 3D in the lowest number of actions. - Ability to zoom in on the drawings. - Ability to take measurements themselves in the lowest number of actions. - Ability to have insight into product location in the lowest number of actions. - Ability to have insight into comments in the lowest number of actions.

Table 3: user requirements

7 SOLUTION GENERATION

This section reflects the second phase of the PDCA-cycle, known as the 'Do' phase. During this phase, a solution will be developed and implemented. This research, however, only discusses the solution development. In this research, a solution may be considered well when it satisfies the requirements as mentioned in Section 6.2.4, it increases the labour productivity and reduces the amount of paper used significantly. The determination of the labour productivity will be done in Section 7.1 where cost calculations of both the current- and new way of working will be done in Section 7.2.

After meetings with both the management of Baas Metaal and representatives of MKG, several possibilities regarding requirement satisfaction became clear. These possibilities were used to create a new way of working as mentioned under. The solution seeks to satisfy as many requirements as possible while improving the process as a whole and making it function properly.

Work planners

Starting at the work planners' department. They need to have the ability to create orders or half fabricates to which all the worked-out manufacturing drawings and STEP-files can be attached. This is possible with the current systems by attaching the documents to the order in MKG. It will then be visible to the employees who make use of Shopfloor Manager and log into that specific order.

The possibility to create half fabricates is ensured by MKG. The main order will then be displayed as XXXX/1, while the copy order(s) will be displayed as XXXX/2; XXXX/3; etc. Besides this, Shopfloor Manager can display comments per production order made by a work planner in MKG. This satisfies the requirement that makes the work planner able to make comments. The red box in Figure 8 shows where the comments will be shown. This also shows the current adjustment that is being worked on.

Programmer

For the programmer to do his work properly, the SYM-files need to be attached to the production order in Radan. This is already satisfied in the current situation. The same applies to the possibility of sorting orders based on material and thickness. However, the programmer can not see possible comments made by work planners about a specific material sheet that needs to be used by the programmer. To make this possible, a connection between MKG and the programmers' planning needs to be made. This can be realised by Arkoni by adding a comment field to the programmers' planning screen. If the programmer wants to make a comment for production employees, he can do this via MKG. The employees using Shopfloor Manager can see this on their screen. The ability to print the sticker pages remains just like in the current situation.

Laser

The sticker pages provide all the necessary information – program numbers and measurements of the residual plate - for the laser department to execute its activities properly. This department does not experience changes.

Unboxer

The same applies to the unboxing department which receives the sticker pages including the corresponding stickers containing information about the quantity that has been cut in that specific plate, the delivery date, order number, customer name, reference number, images, next adjustment, and the measurements of the product. This is already in the current situation. However, in the new way of working every sticker contains a QR-code generated by MKG.

Another thing that is going to change for the unboxing department is that they are now able to clock their unboxing times per cutting program and can give input for internal rejection themselves. To accomplish this, the unboxers require a screen next to their table which runs Order Manager. In this

program, they can start- and stop the timer of their unboxing time and give input for internal rejection. This might however require some explanation and training since some of the unboxers are unfamiliar with the programs. Since there are three unboxing tables, there is a need of three extra screens. The internal rejection will be displayed on the programmers' screen in Order Manager. It is then his responsibility to plan- and nest the order again.

Bending

Regarding the bending department, they need to have the possibility to sort the orders based on both urgency and V-groove. This minimizes the need for bending employees to frequently change the V-groove while still allowing them to meet order deadlines.

Benching

To continue with the benching department. Firstly, they require three more screens. This concerns one at the manual drilling machines and two at the CNC-controlled machines. The manual drilling side requires one more screen since there is now only one screen and often two people. At the side of the CNC-controlled machines, there are no screens. Since there are two machines, there need to come two screens. These need to be placed on top of the machines' controlling screen. These three screens should run Shopfloor Manager.

Welding

For the welding department it is decided that, when needed for too complex assemblies, it is possible to request manufacturing drawings in either A3 or A4. This to prevent possible mistakes in the last production step.

Expedition

The requirement for expedition to have insight into the status of the half-fabricates can be realised by MKG. All types of orders – copy/main orders - can now be reported ready individually. An order will automatically be reported ready when the final adjustment has been completed.

General

The possibility to link QR-codes to a specific production order is already there. However, its purpose needs to change. Besides this, every storage unit has its own scanning station, next to which there is a map that connects every possible place in that storage unit to a QR-code. By firstly scanning the QR-code on the product and then on the map next to the station, it is possible to connect a product to a location digitally. This location will then be made visible in Shopfloor Manager per production order. The current Shopfloor Manager can display locations. However, this needs to be linked to the scanning stations. Baas Metaal should request Arkoni and MKG to make this possible.

In the case where, after the product is reported ready for a certain adjustment and there is no shelf location added to it, the product will automatically receive a general location of the next adjustment (e.g. 'Bending') in Shopfloor Manager. It is then the responsibility of either the employee of the last adjustment or the shopfloor manager to make sure that the product ends up at that general location at the time the employee of the next adjustment will be executing his activity. How this internal transport can be done in the most efficient way, requires further investigation.

It is already possible to have insight into the last- and next adjustment of the order. The condition here is that the order is put in the system completely and correctly by a work planner. When an employee starts the timer of an adjustment, the location will change to that specific adjustment and will get the status that an employee is working on it.

In some cases, a future order is being cut already since it optimizes the nest more. These parts are then stored temporarily in a storage unit where the location is stored digitally. Just as in the other

cases, when an order is not assigned a shelf location, it will automatically be assigned the location of the next adjustment. For the unboxers it will happen right after clocking their unboxing time in Order Manager. Again, Baas Metaal should make a request to MKG to ensure that when the unboxer stops the timer, the location of the next adjustment will be made visible in Shopfloor Manager if a shelf location is not entered. This is possible since Radan and MKG are partners of each other.

Furthermore, Shopfloor Manager provides all the employees with a planning that can be sorted based on urgency (+ V-groove), the manufacturing drawings, STEP-files, the location of the product, a timer that can be started, paused and stopped, the last- and next adjustment, and comments made by colleagues.

A production order only becomes visible in the planning of a certain adjustment when the previous adjustment is reported ready in Shopfloor Manager. This happens after the timer has been stopped. See the yellow box in Figure 8 for where the planning can be found.

To open the STEP-files, every screen should have a CAD-program installed. This makes it possible to see the products in 3D and take measurements. To let production employees take measurements in 2D drawings, Radan should be installed on the screens. When accepting an order from the planning of Shopfloor Manager, possible comments become visible immediately (red box Figure 8). After logging in, it requires two actions: go to the planning and accept the order. The product location is, after accepting an order, visible in one action.

Now, there is a possibility to pause the timer of the employees' adjustment time. However, this requires too many actions. Therefore, Baas Metaal should ask MKG to simplify this process by designing a button just like the start- and stop button (see the purple box in Figure 8).

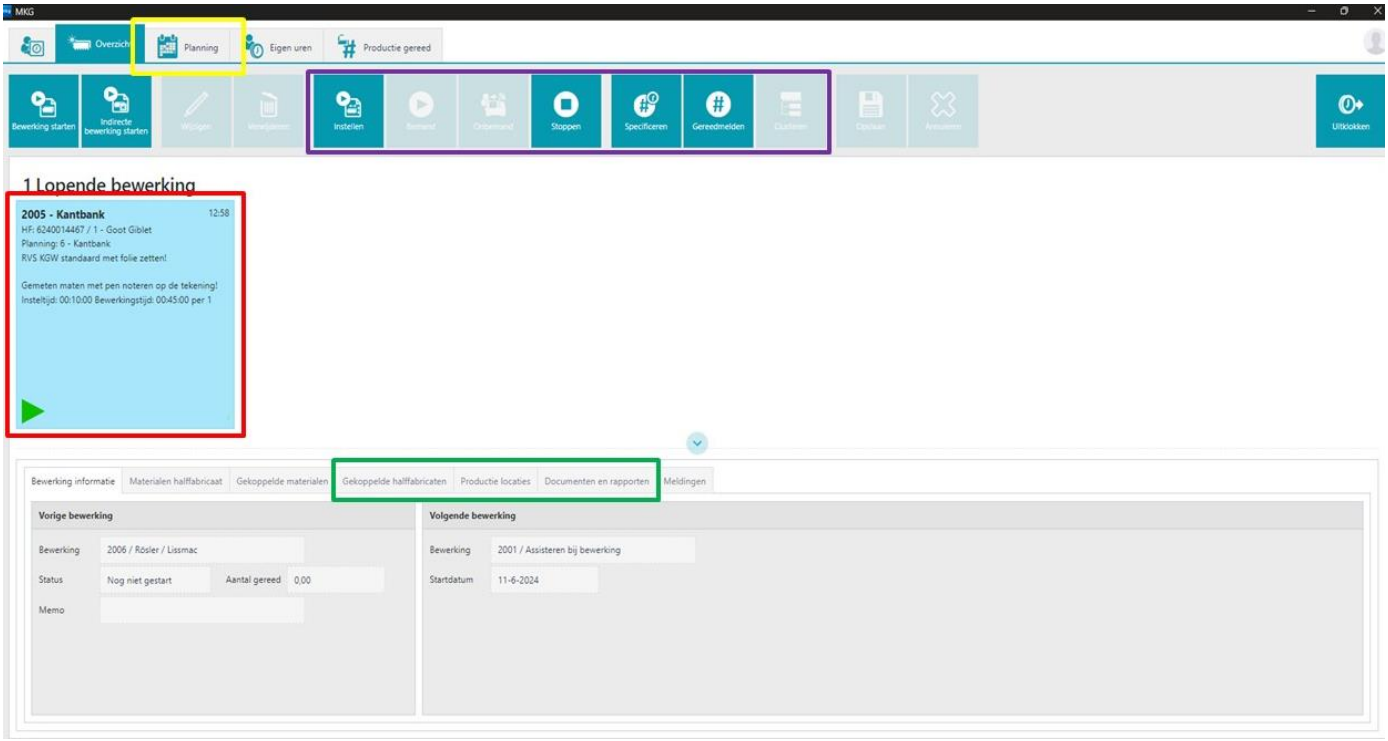


Figure 8: starting menu Shopfloor Manager

All the necessary documents are, after accepting an order, visible in one action. This regards all the manufacturing drawings, STEP-files, location, and possible half fabricates of that product. See the green box in Figure 8. The condition here is that it is added correctly by colleagues.
So, compared to the current situation, several steps need to be taken before transitioning the order processing at Baas Metaal to a paperless system. Table 4 shows what needs to be done, and by who. With the implementation of the new way of working among employees is meant that the process manager should guide the employees in adapting to the new way of working. This requires explanation and several 'test rounds'. It is important to do this since different studies agree that performance improvements do not occur until the company and its human resources have the necessary 'expertise' (Blanca Hernández-Ortega, 2009; G.Tomas M. Hult, 2004; Hsiu-Fen & Szu-Mei, 2008; Kumar, Stauvermann, & Samitas, 2016).

Last, the NCU's are necessary to run programs on the new screens. NUC stands for "Next Unit of Computing" and is a small box-shaped computer that contains an entire system into a small chassis (STOBING, 2016).

WHAT?	WHO?
Add comment section to planning programmer	Arkoni/MKG + Process manager
Connect scanners to Shopfloor Manager	Arkoni/MKG
Buy scanners (3x)	Management
Buy screens (9x)	Management
Buy NUC's (9x)	Management
Create new design stickers	Process manager
Assign QR-codes to shelfs	Process manager
Create a button in Shopfloor Manager to pause the timer of the adjustment time	MKG
Install programs on all devices	Process manager
Create planning in Shopfloor Manager that can be sorted on urgency (+ V-groove) where an activity only appears when the last adjustment is reported ready.	MKG
Implement new way of working among employees	Process manager

Table 4: activity list Baas Metaal to implement new way of working

After the successful completion of the activities as mentioned in Table 4, Baas Metaal can standardize their new way of working. This concerns the 'Act'-phase of the PDCA-cycle. Figure 9 shows the BPMN-model of this new way of working. By comparing the new way of working with the current way of working, it can be concluded that most of the waste-activities of the order processing disappear due to the digital transformation. The only Muda activity still present is the transportation of the sticker pages from the programmer to the laser and unboxers.

As mentioned in Section 3, unstructured product storage and damaged or lost production orders also contribute to the time wasted during order processing. By digitalizing the order processing as described above, the problems can be resolved also. The digital environment of Shopfloor Manager in combination with the QR-scanners offers a more organized approach to location establishment. Losing or damaging a paper production order becomes impossible since these will not be used anymore.

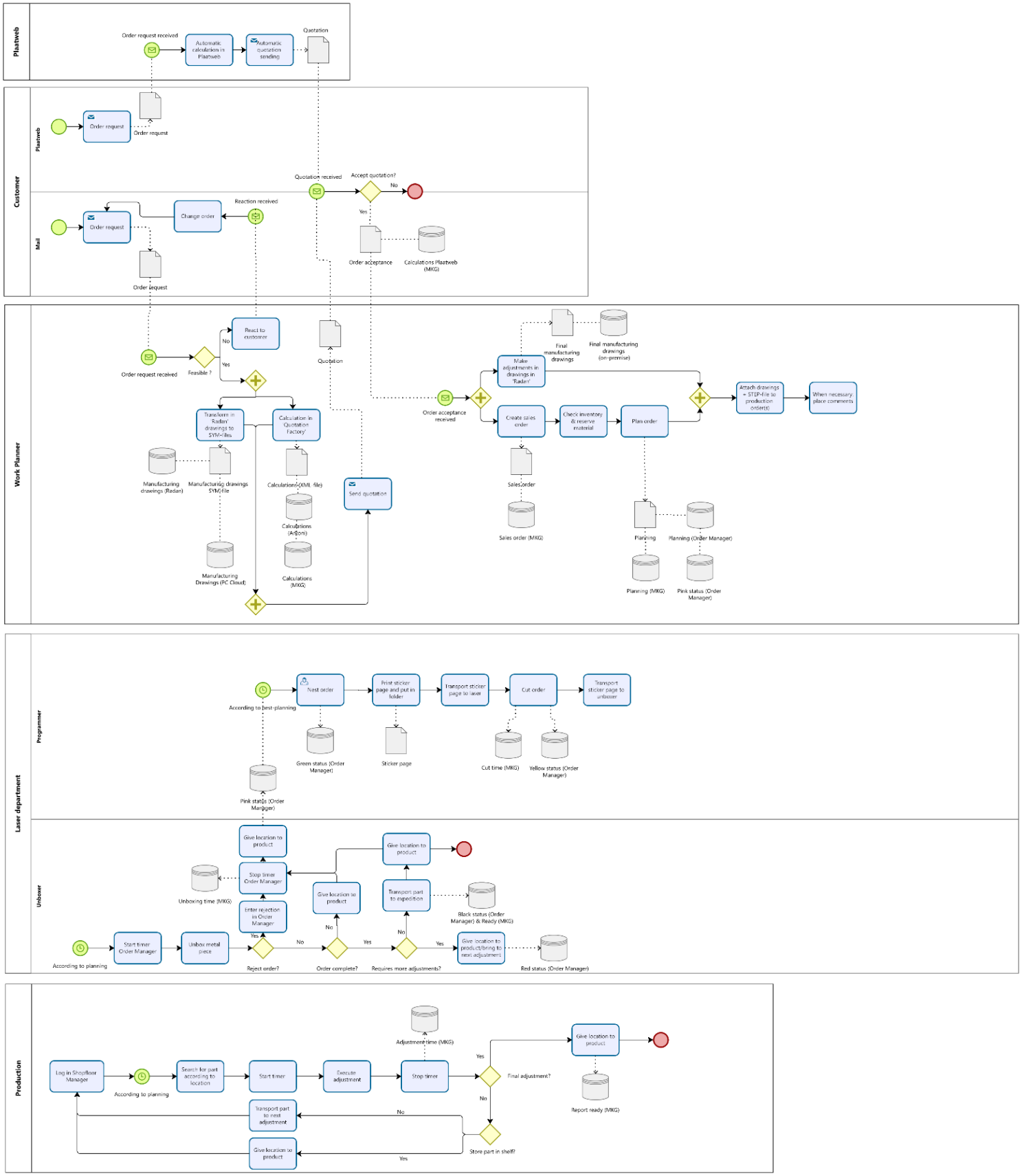


Figure 9: BPMN-model new way of working

7.1 Labour Productivity

To estimate the labour productivity, several observations will be made. In this case, it concerns a direct and unstructured observation method within a time sample of half an hour. This means that the observer is physically present and personally monitors what takes place. Besides this, the observation method is conducted in a free and open manner in which the researcher observes and records any behaviour or event that occurs without predetermined categories (Cooper & Schindler, 2014). At the concerned departments, multiple observations on different days/times with different participants will be executed.

In this case, the labour productivity is the average, percentual time invested in producing valuable-, non-valuable but required- and waste output per time unit of labour input in the current situation. The labour productivity measurement in this research will be combined with the principles of Muda. Value means the fulfilment of customer requirements. Refer to Section 2 for the definitions regarding valuable-, non-valuable but required- and waste activities.

For this determination, the activities that will disappear due to the implementation of the solution as described in Section 7, are considered waste. This means that current waste activities, that occur now and in the new way of working, are not considered waste since they will remain. After the implementation of the solution, the time that no longer needs to be spent on waste activities can now be spent on either value-adding activities or non-value adding but required activities. This improves the labour productivity of the employee. However, the new way of working could create new sorts of waste also. The goal is to minimize these activities and make sure that the amount of time spent on waste activities is lower than in the current situation. The amount of waste activities will, in this case, determine the height of the labour productivity since they influence the time an employee of Baas Metaal can execute VA or NVA-R activities.

As mentioned, this estimation is based on excluding the activities that occur in the current situation but will disappear in the new way of working. However, labour productivity is affected by many more factors. It could, for example, be both negatively and positively affected by the energy and personal attitudes, the available equipment, the style of the leader and the working environment (Naoum, 2016) (Gamelearn Team, 2024). To minimize these factors, multiple observations per department are conducted.

An activity is considered a ‘paper-activity’ when the paper production order is physically touched or watched. Out of these activities, the times lost in paper activities that will disappear after the implementation of the solution are considered waste. These activities are called waste-paper activities.

Table 5 shows the results of the observations. It states the percentual amount of time invested in paper-related activities and the time of waste activities that occurred within this. The waste-paper activities column represents the average, percentual time spent on activities that disappear when implementing the solution as stated in Section 7. In this research, a labour productivity of 100% means that the department is constantly working on VA-, NVA-R- and W activities in the current situation. In other words, the department is not conducting any waste activities that will disappear when implementing the solution. Therefore, this department will not experience an increase in time they can either spent on VA-, NVA-R-, or W activities per day. Or in other words, an increase in labour productivity.

The time that now becomes available is expected to be spent mostly on VA- and NVA-R activities, this will increase the labour productivity. However, it could also be spent on waste activities. This will then suppress the labour productivity. Appendix I shows the complete and detailed observations.

DEPARTMENT / VARIABLE	Paper activities	Waste activities	Waste-paper activities	Labour productivity
Work Planner	27%	100%	27,0%	73%
Programmer	36%	81%	29,2%	70,8%
Laser	3%	0%	0%	100%
Unboxer	23%	13%	3,0%	97,0%
Bending	20%	53%	10,6%	89,4%
Benching	20%	33%	6,6%	93,4%
Welding	3%	69%	2,1%	97,9%
Expedition	47%	71%	33,4%	66,6%

Table 5: results observations (%)

The conclusion is that the work planning-, programmer-, and expedition department will experience the most benefits in terms of labour productivity. Overall, Baas Metaal will experience, on average, an increase of 14% in terms of labour productivity.

7.2 Costs

The current way of order processing at Baas Metaal brings costs that are redundant when digitalizing this process. The costs consist of two parts. The first part is the costs that occur due to the material usage, the second part is caused by the waste-paper activities that occur when executing the current way of order processing.

YEAR / VARIABLE	Cost Paper	Cost Printer	Cost Folders	Amount paper packages	Pieces paper
2018	€ 1.153,60	€ 859,99	€ -	600	300000
2019	€ 925,45	€ 8.268,15	€ -	422	211000
2020	€ 916,23	€ 1.322,86	€ -	431	215500
2021	€ 1.208,21	€ 600,12	€ 7,61	387	193500
2022	€ 1.245,39	€ 418,69	€ 131,16	371	185500
2023	€ 1.343,36	€ 270,29	€ -	346	173000
Average:	€ 1.132,04	€ 1.956,69	€ 23,13	426	213083

Table 6: results invoices

Based on invoices from the last 5 years, the following costs and amounts could be determined. Table 6 shows the results. The costs do not include VAT (21%) since Baas Metaal makes his purchases for business purposes. Since it is not necessary to buy new folders every year, there are no folder costs in some of the years. The high printer costs in 2019 can be referred to the purchase of new printers. On average, a business-grade printer could last between 5-10 years (McAllister, 2023). This could mean that Baas Metaal requires a new printer somewhere between now and the upcoming 5 years.

Based on the results mentioned in Table 6, the costs that occur on average due to material usage equals rounded €3.112 per year. Besides this, Baas Metaal orders, on average, about 426 packages of paper. One package of paper contains 500 sheets of paper. This means that Baas Metaal orders, on average, more than 213.000 sheets of paper per year to conduct business.

DEPARTMENT / VARIABLE	Waste-paper activities	#FTE present	#Working hours	#Waste working hours (paper activities)	Average hourly wage	Costs
Work Planner	27,0%	4	6984	1886	€ 30,00	€ 56.570,40
Programmer	29,2%	1	1746	509	€ 30,00	€ 15.274,01
Laser	0,0%	2	3492	0	€ 30,00	€ -
Unboxer	3,0%	3	5238	157	€ 30,00	€ 4.698,49
Bending	10,6%	4	6984	740	€ 30,00	€ 22.209,12
Benching	6,6%	3	5238	346	€ 30,00	€ 10.371,24
Welding	2,1%	4	6984	145	€ 30,00	€ 4.337,06
Expedition	33,4%	3	5238	1748	€ 30,00	€ 52.437,62
Total:						€ 165.897,94

Table 7: costs waste-paper activities

To calculate the costs that occur due to the paper waste activities of the current way of working, there is a need for additional information. Firstly, the time invested in paper waste activities. This is determined in Section 7.1. Secondly, the number of employees of a certain department with their concerning average hourly wage. The information regarding hourly wage is provided by Baas Metaal's administration and is in collaboration with the internal supervisor set at €30. Currently, Baas Metaal has 42 employees. This is a combination of full-time employees and on-call employees. On the 27th of May 2024, 24 full-time employees were present. This only concerns employees who are of interest in this research. Table 7 shows the distribution of these employees for that specific day. Then, lastly, by combining these results with the number of hours worked per year, the total costs per year that occur due to the paper waste activities of the current way of working can be calculated. The total number of hours worked per year equals approximately 1.800 hours (Werktijden.nl, 2024). This is based on a 40-hour work week with 25 vacation days and 10 public holidays. However, according to MKG, Baas Metaal has an average sickness absence of about 3%. This means that the average hours worked per year, per full-time employee equals approximately 1746 hours. Table 7 shows the results.

To conclude, on average, the current way of working costs Baas Metaal approximately €169.009,79 per year on material supplies and time wasted in activities connected to working with the paper production orders that could have been spent on a value-adding activity or a non-value-adding but required activity.

By implementing the solution as described in Section 7, a cost reduction can be expected. However, this does not equal the costs as determined above. Since the sticker pages remain, not all the paper disappears. So, the material costs will not decrease by €3.111,85. Based on data provided by MKG, the average amount of production orders from 2018-2023 equals 43.981. Also, based on invoices from the same period, the average amount of pieces of paper equals 213.083. This means that, when turning paperless while still using the sticker pages, approximately 21% of the costs remain. On the other hand, Baas Metaal uses, after implementation of the solution, 79% less paper. As a result, when implementing the new way of working, the material costs are reduced by €2.469,56. This would come to a total cost reduction of €168.367,50.

Cost	Average yearly cost
Material Cost:	€2.469,56
Waste-paper activity cost:	€165.897,94
Total:	*€168.367,50*

Table 8: average, yearly total cost

Implementation of the new way of working brings costs also. To accomplish the new way of working, several investments need to be made. Firstly, there need to be bought six more screens. For the benching department it concerns one bigger screen and two smaller screens, the unboxing department requires three smaller screens. Then, several scanners need to be bought.

This concerns a wireless QR-code scanner in combination with a screen. After collaboration with management, it was decided to install this combination at three different central locations. Figure 10 shows these locations (A/B/C). All the new screens require a NUC to run the digital programs. At the moment, the 11th generation NUC of Intel is used. The price of these NUCs is set at €500 per unit. It is assumed, after collaboration with management, that MKG/Arkoni needs five days to implement all the requirements of Baas Metaal into their system properly. With an hour hourly rate of €100, this would come to a total of €4000.

One of the activities that needs to be done before being able to turn into a paperless office is that the process manager should implement the new way of working among the users. This will increase the costs since the production employees require explanation which causes the production process to be stopped. It is assumed that every employee requires at least four hours of training. This includes elaboration on the new way of working, but also resolving difficulties/questions that arise when executing the new way of working.

As mentioned, full-time- and on-call employees combined, Baas Metaal has 42 employees. Out of these 42 employees, 35 employees are in interest of this cost calculation since they are production employees or work planners and therefore require training. The process manager is also included in this amount since he will be working on the implementation instead of other tasks. In total, 140 hours of training is necessary to implement the new way of working among all these employees and make it run smoothly. Since the average hourly wage is set at €30, the total cost of implementation among the employees comes to €4.200.

Table 9 shows the estimated costs to bridge the gap between the current- and new way of working. With an average yearly cost saving of approximately €168.367,50 and an estimated required investment of €14.800, the payback period would equal 33 days.

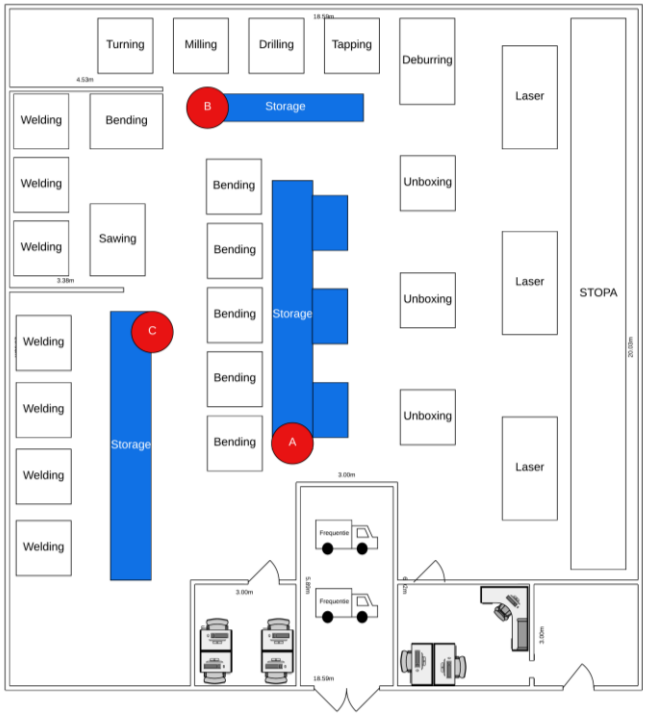


Figure 10: map Baas Metaal including scanning locations

WHAT?	COST
Smaller screens (5x)	≈ €1000
Bigger screen (1x)	≈ €500
Wireless QR-code scanners + screens (3x)	≈ €600
NUC (9x)	≈ €4500
Provided services MKG/Arkoni	≈ €4000
Implementation among employees	≈ €4200
Total:	≈ €14.800

Table 9: costs implementation new way of working

8 CONCLUSION & REFLECTION

This section presents the conclusions to Baas Metaal and reflects this research. The recommendations are based on the research questions answered above.

As mentioned in Section 3, the research question for this research was stated as follows:

How to successfully initiate a digital transformation regarding the order processing of Baas Metaal B.V.?

In this case, 'successfully' means that it increases the labour productivity and reduces the amount of paper used in the process significantly. To answer this question, several research questions were answered with the help of quantitative- and qualitative research.

Out of these results, it can be concluded that with the current digital systems, Baas Metaal can successfully initiate a digital transformation regarding its order processing. The current systems of Baas Metaal can satisfy the requirements as stated in Section 6.2.4. The main change is that the use of Shopfloor Manager must be expanded where the location establishment is arranged by a combination of scanners at central points in the production hall and a QR-code on the stickers per product.

To close the gap between the current- and desired way of working, several actions need to be taken first. Table 10 shows these actions.

WHAT?	WHO?
Add comment section to planning programmer	Arkoni/MKG + Process manager
Connect scanners to Shopfloor Manager	Arkoni/MKG
Buy scanners (3x)	Management
Buy screens (9x)	Management
Buy NUC's (9x)	Management
Create new design stickers	Process manager
Assign QR-codes to shelfs	Process manager
Create a button in Shopfloor Manager to pause the timer of the adjustment time	MKG
Install CAD-program on all devices	Process manager
Create planning in Shopfloor Manager that can be sorted on urgency (+ V-groove)	MKG
Implement new way of working among employees	Process manager

Table 10: activity list Baas Metaal to implement new way of working

After the execution of these activities, Baas Metaal is ready for the digital transformation to become a paperless office regarding its order processing. The costs of these activities are estimated at €14.800. In combination with the average yearly cost saving of approximately €168.367,50, the payback period would equal 33 days. If the recommended solution is implemented successfully, an overall and average increase of 14% in labour productivity can be expected. The most time savings will take place in the work planners-, programmer-, and expedition department.

This research backs up the benefits of a paperless office as stated in literature. As mentioned in Section 5.1.1, a paperless office will benefit from a reduction in costs, an increase in labour productivity, a decrease in paper usage and, if there is a possibility to connect to the local server, the possibility to work remotely. In comparison with the current way of working, the costs can, yearly on average, be reduced by €168.367,50; the labour productivity can increase, on average overall, by 14% and an average paper usage decrease of 79% can be realised.

Literature also states obstacles that need to overcome before being able to undergo this digital transformation. As mentioned in Section 5.1.2, a paperless office will encounter obstacles in technology constraints and a moderate readiness and expertise.

The technology constraints in terms of hard- and software will be overcome by executing the tasks list above. The readiness of employees is something that can not be overcome easily, they are used to the long-standing procedure of working with paper, show signs of scepticism and are afraid of (system) failure. To solve this, including the lack of expertise, the new way of working should be guided among the employees by executing tests and providing a consistent working guide. This will be done during the implementation period as mentioned in Section 7.2.

When implementing the solution as described in Section 7, a new way of working arises. Appendix I shows an enlarged representation of the BPMN-model of this new way of working. From this model, it can be concluded that several Muda activities like transport, motion, and waiting disappear after the successful implementation of the solution. For example, the programmer does not have to wait anymore before a work planner has printed, sorted, and transported a production order to him. This will contribute to the improvement of the labour productivity.

Regarding reflection, there should be reflected on the used methods and the results. As mentioned in Section 7.1, due to time- and resource constraints, the sample size of the observations is smaller than needed to be sufficiently representative. For this reason, the results regarding labour productivity should be treated with caution in drawing definitive conclusions. However, in this research, the results are assumed to be representative enough to perform further calculations and draw conclusions.

The sample size of the labour productivity is based on the number of employees available per department where the sample size increases as there are more employees available. This will minimize external factors. Also, to ensure a higher reliability of the observation, this research conducted multiple observation sessions on different days/times with different employees. In this way, the labour productivity could be averaged and therefore contribute to a better reliability. Since the participants are aware of their participation, an increase in participant's error and bias could occur. This is however averaged by conducting multiple observations. The researchers' error and bias are minimized by recording the data directly. This means making notes during the observation and ensuring, in this way, an exact as possible recording of the gathered data.

The results of the of the observations are also used in the cost calculation. For this reason, these results should be treated with caution also. It might be that the costs are lower/higher than calculated in Section 7.2.

Regarding the interviews, the interviews are executed in a way that lowers the biases to a minimum. The only point of attention here is that the participants found it difficult to image a paperless process. The researcher tried to remedy this by combining the questions with 'scenarios and use cases'. This, however, did not contribute as expected since most of the time the participant still found it difficult to imagine a paperless process.

Lastly, the recommendation does not confirm that the solution as stated in Section 7 is the most optimal solution. To investigate this, the solution should be implemented and possible bottlenecks should be eliminated. Also, to improve the order processing of Baas Metaal even more, it should be investigated how and when to store products- and how and when to transport products most optimally. Now, there are no clear instructions and task division on these processes.

REFERENCES

ABN-AMRO. (2023, 03). *Consolidatie in de metaalbewerking*. Opgehaald van ABN-AMRO: https://www.abnamro.nl/nl/zakelijk/insights/sectoren-en-trends/industrie/consolidatie-in-de-metaalbewerking.html

Adam, A. (2007). *Implementing Electronic Document and Record Management Systems.* New York: Auerbach Publications.

ADOBE. (2024). *STEP-bestanden.* Opgehaald van ADOBE: https://www.adobe.com/nl/creativecloud/file-types/image/vector/step-file.html

AESC. (2021, 04 08). *DXF BESTAND: WAT IS HET EN WAT KUN JE ERMEE?* Opgehaald van AESC: https://www.aesc.nl/nieuws/wat-is-een-dxf-bestand/#:~:text=DXF%20staat%20voor%20%E2%80%98Drawing%20eXchange%20Format%E2%80%99.%20DXF%20is,DXF%20format%20is%20in%201982%20ontwikkeld%20door%20Autodesk.

Amankwah-Amoah, J., Khan, Z., Wood, G., & Knight, G. (2021). COVID-19 and digitalization: The great acceleration. *Journal of Business Research*, 611.

ASQ. (2024). *WHAT IS VALUE STREAM MAPPING (VSM)?* Opgehaald van ASQ - Exellence Through Quality: https://asq.org/quality-resources/lean/value-stream-mapping#:~:text=Value%20stream%20mapping%20(VSM)%20is,times%2C%20and%20implement%20process%20improvement.

Association for Supply Chain Management . (2024). *Principles of Lean Manufacturing*. Opgehaald van ASCM: https://www.ascm.org/lp/principles-of-lean-manufacturing/

Bhasin, H. (2020, 06 18). *Production Capacity – Definition, Calculation And Examples*. Opgehaald van Marketing91: https://www.marketing91.com/production-capacity/#:~:text=Production%20capacity%20is%20defined%20as%20maximum%20production%20or,capacity%20according%20to%20the%20demand%20from%20the%20market.

Bicheno, J., & Holweg, M. (2016). *The Lean Toolbox, 5th edition. A handbook for lean transformation.* Buckingham: PICSIE Books.

Blanca Hernández-Ortega, J. J.-M.-D. (2009, 01 30). The effect of experience on web procurement: An intersectorial analysis of small firms. *International Journal of Entrepreneurial Behavior & Research*, 7-24.

Brink, H. (1993). VALIDITY AND RELIABILITY IN QUALITATIVE RESEARCH. *Society of Nurse Researchers' Workshop* (p. 4). Curationis.

Bronwen, T. (1990). The HUFIT planning analysis and specification toolset. *Third International Conference on Human-Computer Interaction* (pp. 371-376). Amsterdam: IFIP TC13 International Conference on Human-Computer Interaction.

Bureau Tromp. (2024). *Het verschil tussen Kaizen en Lean*. Opgehaald van Bureau Tromp: https://kaizenmethode.nl/kaizen-en-lean/

Caldeira, M., Serrano, A., Quaresma, R., Pedron, C., & Romao, M. (2012). Information and communication technology adoption for business benefits: A case analysis of an integrated paperless system. *INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT* , 202.

CBS StatLine. (2024, 02 14). *Vacatures; vacaturegraad naar SBI 2008*. Opgehaald van CBS StatLine: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/80567ned/table?ts=1710490631477

CertificeringsAdvies. (2023, 08 14). *Wat is ISO certificering?* Opgehaald van CertificeringsAdvies: https://certificeringsadvies.nl/wat-is-iso-certificering/

Cooper, D. R., & Schindler, P. S. (2014). *Business Research Methods.* New York: McGraw-Hill/Irwin.

Cramer, Y., & Schipper, d. K. (2023, 12 18). *Arbeidsproductiviteit in industrie moet fors omhoog*. Opgehaald van Rabobank: https://www.rabobank.nl/kennis/d011402203-arbeidsproductiviteit-in-industrie-moet-fors-omhoog

Cuofano, G. (2024, 01 08). *Mendelow Stakeholder Matrix*. Opgehaald van FourWeekMBA: https://fourweekmba.com/mendelow-stakeholder-matrix/

Dilmegani, C. (2024, 01 11). *How does increased competition affect markets?* Opgehaald van Multiple Research: https://research.aimultiple.com/increased-competition/

Dudovskiy, J. (z.d.). *Inductive Approach (Inductive Reasoning)*. Opgehaald van Business Research Methodology: https://research-methodology.net/research-methodology/research-approach/inductive-approach-2/

Eby, K. (2016, 11 28). *Beginners Guide to Business Process Modeling and Notation (BPMN)*. Opgehaald van Smartsheet: https://www.smartsheet.com/beginners-guide-business-process-modeling-and-notation-bpmn

Feigelson, B., Becker, D., & Camarinha, S. M. (2020). *Comentários à Lei geral de proteção de dados.* Revista Dos Tribunais.

Fernandez-Portillo, A., Almodóvar-González, M., Cruz Sanchez-Escobedo, M., & Luis Coca-Pérez, J. (2022). The role of innovation in the relationship between digitalisation and economic and financial performance. A company-level research. *EUROPEAN RESEARCH ON MANAGEMENT AND BUSINESS ECONOMICS* , 10.

Firdausy, K. (2012). *PAPERLESS OFFICE BERBASIS WORDPRESS DI ITTC UAD.* Yogyakarta: Universitas Ahmad Dahlan.

Formoso, C., Isatto, E. L., & Hirota, E. H. (1999). Method for waste control in the Building Industry. *IGLC-7 proceedings*, 221-232.

G.Tomas M. Hult, R. F. (2004). *Innovativeness: Its antecedents and impact on business performance.* Elsevier.

Gamelearn Team. (2024). *5 factors with an impact on labor productivity*. Opgehaald van Gamelearn: https://www.game-learn.com/en/resources/blog/5-factors-with-an-impact-on-labor-productivity/

Gamido, M. V., Gamido, H. V., & Macaspac, D. P. (2023). *Electronic document management system for local area network-based organizations.* Tarlac: Institute of Advanced Engineering and Science.

Gartner. (2024). *Business Process Management (BPM)*. Opgehaald van Gartner Glossary: https://www.gartner.com/en/information-technology/glossary/business-process-management-bpm

Gelashvili, T., & Pappel, I. (2021). Challenges of Transition to Paperless Management: Readiness of Incorporating AI in Decision-making. *Eighth International Conference on eDemocracy & eGovernment (ICEDEG)* | (p. 7). Tallinn: ResearchGate.

Hargrave, M. (2024, 02 27). *Kaizen: Understanding the Japanese Business Philosophy*. Opgehaald van Investopedia : https://www.investopedia.com/terms/k/kaizen.asp

Heerkens, H., & van Winden , A. (2017). *Solving Managerial Problems Systematically.* Groningen/Houten: Noordhoff Uitgevers.

HKT Consultant. (2019, 10 23). *Observation Methods – Definition, Types, Examples, Advantages*. Opgehaald van HKT Consultant: https://phantran.net/observation-methods-definition-types-examples-advantages/#:~:text=The%20different%20types%20of%20observation%20method%20are%20as,naturalistic%20observation%20method.%20...%203%203%29%20Participant%20observations

Hsiu-Fen, L., & Szu-Mei, L. (2008). Determinants of e-business diffusion: A test of the technology diffusion perspective. *The International Journal of Technological Innovation, Entrepreneurship and Technology Management*, 103-170.

IBM Cloud Education. (2022, 01 06). *Explore the key elements of BPMN models and how they help bridge the communication gap between business and IT teams.* Opgehaald van IBM: https://www.ibm.com/blog/bpmn/

Indeed. (2023, 02 04). *What Is Throughput Time? (With Benefits and Formula)*. Opgehaald van Indeed: https://www.indeed.com/career-advice/career-development/what-is-throughput-time

Institut für angewandte Arbeitswissenschaft. (2016). *Digitalisierung und Industrie 4.0: So individuell wie der Bedarf - Produktivitätszuwachs durch Informationen.* Bergisch Gladbach: Heider Druck.

Investopedia Team. (2023, 08 23). *5 Factors That Influence Competition in Microeconomics*. Opgehaald van Investopedia: https://www.investopedia.com/ask/answers/042115/what-factors-influence-competition-microeconomics.asp#:~:text=In%20microeconomics%2C%20competition%20is%20influenced,%2C%20information%20availability%2C%20and%20location.

Kaizen Institute. (2024). *Definition of KAIZEN*. Opgehaald van Kaizen Institute: https://kaizen.com/what-is-kaizen/#:~:text=There%20are%205%20Fundamental%20KAIZEN%E2%84%A2%20Principles%20that%20are,Go%20to%20Gemba%2C%20Empower%20People%20and%20Be%20Transparent.

Keumars, A. S. (2022, 05 30). *What is the paperless office?* Opgehaald van ITPro.: https://www.itpro.com/business-strategy/31666/what-is-the-paperless-office

King, K., & Toland, J. (2014). *iPads and the paperless office: The impact of tablet devices on paper consumption in higher education.* New Zealand: Computing and Information Technology Research and Education (CITRENZ).

Knut-H, R., & Ole, H. (2021). Managing Path Dependency in Digital Transformation Processes: A Longitudinal Case study of an Enterprise Document Management Platform. *International Conference on enterprise Information Systems* (pp. 1-1254). Oslo: Elsevier.

Korpelainen, E. (2011). *Theories of ICT System.* Helsinki: Aalto University.

Koskela, L., & Sharpe, R. (1994). *Flow process analysis in construction.* Highett: Elsevier Science B.V.

Kumar, R. R., Stauvermann, P. J., & Samitas, A. (2016). The effects of ICT∗ on output per worker: A study of the Chinese economy. *Telecommunications Policy*, 102-115.

Latha, T. r. (2023, 04 14). *Stakeholder Analysis using the Power Interest Grid*. Opgehaald van ProjectManagement.com: https://www.projectmanagement.com/wikis/368897/stakeholder-analysis--using-the-power-interest-grid#_=_

Lean Enterprise Institute . (2019, 05 10). *Why We Believe A Strong Customer Focus Is Needed To Drive A Lean Strategy*. Opgehaald van Lean Enterprise Institute : https://www.lean.org/the-lean-post/articles/why-we-believe-a-strong-customer-focus-is-needed-to-drive-a-lean-strategy/

Lean Six Sigma Groep. (2024). *Gemba*. Opgehaald van Lean Six Sigma Groep: https://leansixsigmagroep.nl/lean-agile-en-six-sigma/gemba/

Lean Six Sigma Groep. (2024). *PDCA Cyclus* . Opgehaald van Lean Six Sigma Groep: https://leansixsigmagroep.nl/lean-agile-en-six-sigma/pdca-cyclus/

Lean Six Sigma Groep. (2024). *Wat is Kaizen?* Opgehaald van Lean Six Sigma Groep: https://leansixsigmagroep.nl/lean-agile-en-six-sigma/kaizen/

Maguire, M., & Bevan, N. (2002). *User requirements analysis.* Montreal: Kluwer Academic Publishers.

McAllister, J. (2023, 09 10). *How Long Do Printers Last? A Guide to Printer Lifespan*. Opgehaald van HowLongDoesItLast: https://howlongdoesitlast.org/how-long-do-printers-last/

MetaalKrant. (2024, 02 23). *ONTWIKKELINGEN OP DE STAALMARKT ONDER GROTE INVLOED VAN ECONOMISCHE ONTWIKKELINGEN IN HET VERRE OOSTEN*. Opgehaald van MetaalKrant: https://metaalkrant.nl/2024/02/23/ontwikkelingen-op-de-staalmarkt-onder-grote-invloed-van-economische-ontwikkelingen-in-het-verre-oosten/

Miele, F., & Tirabeni, L. (2020). Digital technologies and power dynamics in the. *Sociology Compass*, 14.

Naoum, S. G. (2016). Factors influencing labor productivity on construction sites: A state-of-the-art literature review and a survey. *International Journal of Productivity and Performance Management*, 20.

Oliveira, J., Azevedo, A., Ferreira, J. J., Gomes, S., & Lopes, J. M. (2021). An insight on b2b firms in the age of digitalization and paperless processes. *Sustainability*, 21.

Olomolaiye, P., Jayawardane, A., & Harris, F. C. (1998). *Construction Productivity Management.*

PEGA. (2024). *Business process management (BPM)*. Opgehaald van PEGA: https://www.pega.com/business-process-management?utm_source=bing&utm_medium=cpc&utm_campaign=B_NL_NonBrand_BPM/CM_IA_Exact_(CPN-

111047)_EN&utm_term=bpm%20process&gloc=152290&utm_content=pcrid||pkw|kwd-81982575588123:loc-129|pmt|e|pdv|c|&gclid=37e72943376e

Perfetto, F. V., Reis, S. G., & Paletta, F. C. (2023). Digital information management possible paths. *RDBCI-Revista Digital de Biblioteconomia e Ciencia da Informacao*, 14.

Quality-One. (2024). *Kaizen*. Opgehaald van Quality-One: https://quality-one.com/kaizen/

Quickonomics. (2023, 10 25). *Labor Productivity*. Opgehaald van Quickonomics: https://quickonomics.com/terms/labor-productivity/

Ramdhani, N. (2015). Kajian Psikologis Mengenai Komunikasi Berbasis Paperless Office. *Jurnal Universitas Gadjah Mada*, 19.

Schuh, G., Franzkoch, B., Prote, J.-P., Luckert, M., Sauermann, F., & Basse, F. (2017). Analysis of the Potential Benefits of Digital Assembly Instructions for Single and Small Batch Production. *IFIP Advances in Information and Communication Technology*, 353.

Shedge, D. G., Kadam, S. S., Mulani, M. S., & Bhosale, A. A. (2022). *Muda Mura And Muri Analysis.* IJEDR.

Simplilearn. (2024, 04 03). *What Is Lean Methodology? Principles, Integration, and Examples*. Opgehaald van Simplilearn: https://www.simplilearn.com/lean-methodology-article

Skhmot, N. (2017, 08 05). *The 8 Wastes of Lean*. Opgehaald van TheLeanWay: https://theleanway.net/The-8-Wastes-of-Lean

St. Charles County. (sd). *Recycling Facts and Figures*. Opgehaald van St. Charles County: https://www.sccmo.org/863/Recycling-Facts#:~:text=The%20amount%20of%20wood%20and,about%20650%20pounds%20per%20person

STOBING, C. (2016, 09 21). *What is a NUC PC, and Should You Get One?* Opgehaald van How-To-Geek: https://www.howtogeek.com/231978/htg-explains-what-is-a-nuc-pc-and-should-you-get-one/

Subikash, R. (2016, 12 05). *Hansei: Continuously Engaging People in Improvement*. Opgehaald van Process Excellence Network: https://www.processexcellencenetwork.com/lean-six-sigma-business-performance/articles/hansei-continuously-engaging-people-in-improvement

Unilever. (2017). *Report shows a third of consumers prefer sustainable brands.* London: Unilever.

Volsche, S., & Hasnain, A. (2022, 08 21). *Introduction to Evolution Human*. Opgehaald van The process of Science: https://boisestate.pressbooks.pub/evolutionhumanbehavior/chapter/2-1-the-process-of-science/

Weber, M.-A., Jeske, T., Lennings, F., & Stowasser, S. (2017). *Productivity Strategies Using Digital Information Systems in Production Environments.* Hamburg: Springer.

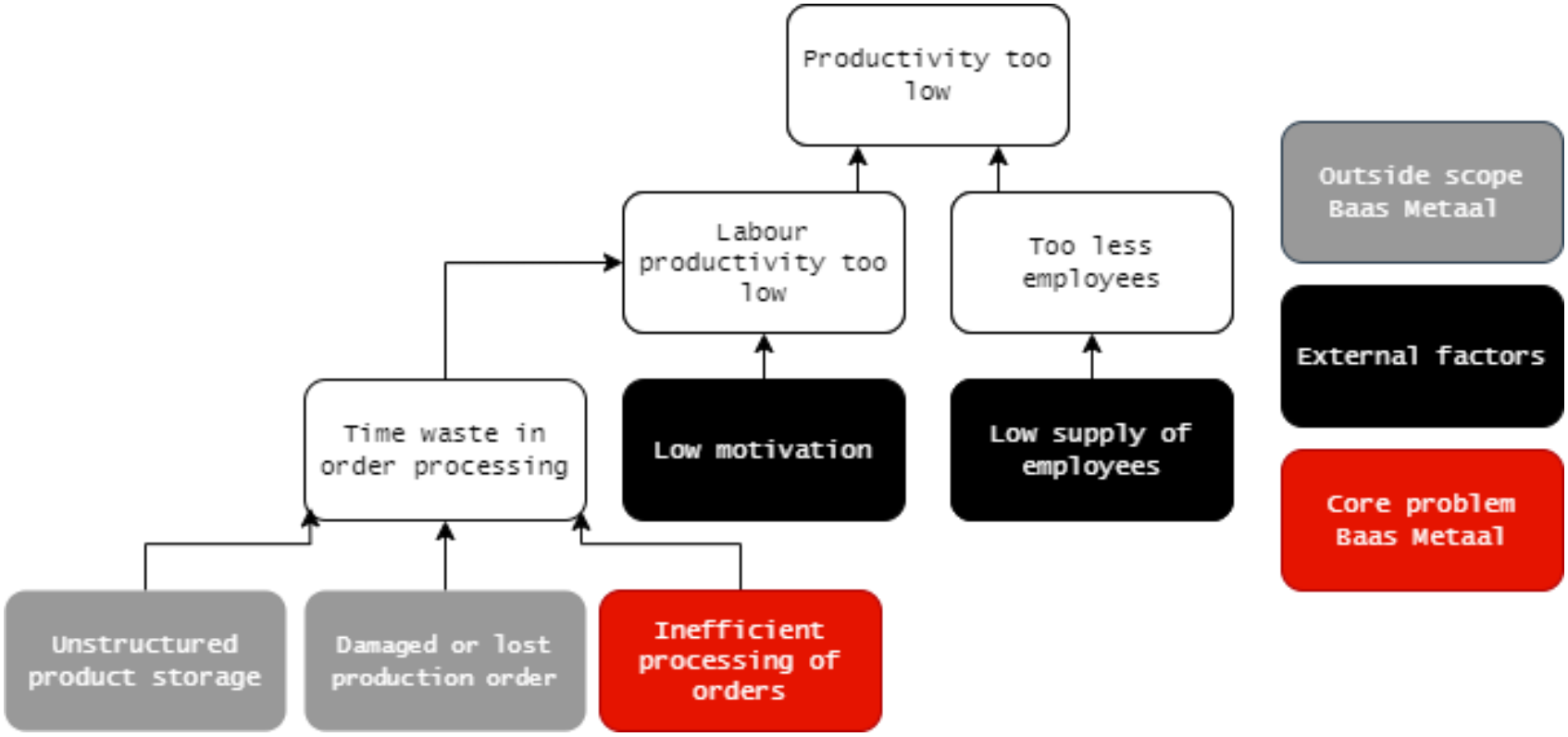
Werktijden.nl. (2024, 01 03). *Hoeveel uren en dagen werken we per maand en per jaar?* Opgehaald van Werktijden.nl: https://werktijden.nl/werkuren-werkdagen-maand-jaar

Xiong, E. (2021). *The Sustainable Impact Of A Paperless Office.* Jersey City: Forbes Media.

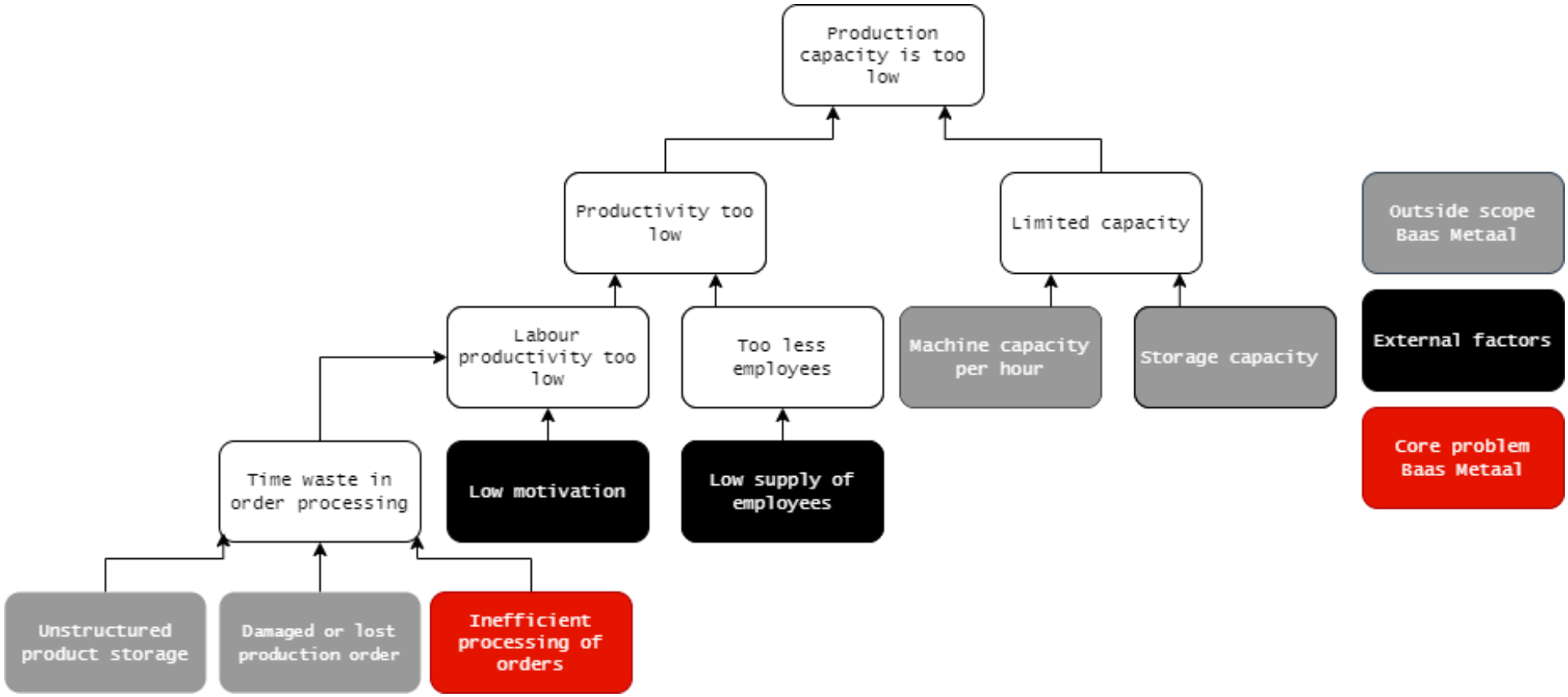
Zabukovsek, S. S., Jordan , S., & Bobek, S. (2023). Managing Document Management Systems' Life Cycle in Relation to an Organization's Maturity for Digital Transformation. *Sustainability*, 35.

Zhao, Y., & Chua, D. K. (2003). *RELATIONSHIP BETWEEN PRODUCTIVITY AND WASTES: A NEURAL NETWORK MODEL.* Singapore.

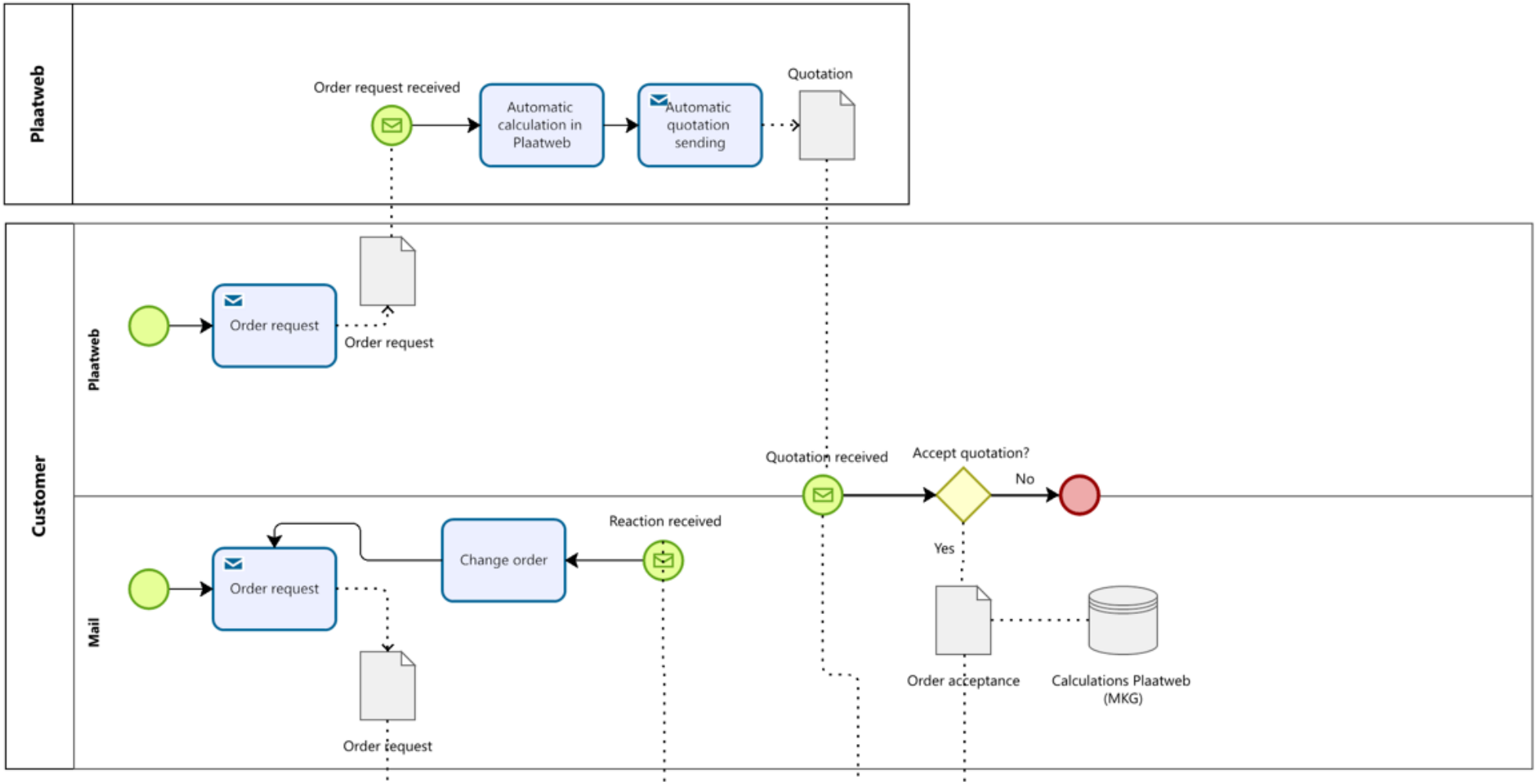
APPENDIX A: PROBLEM CLUSTER (1)

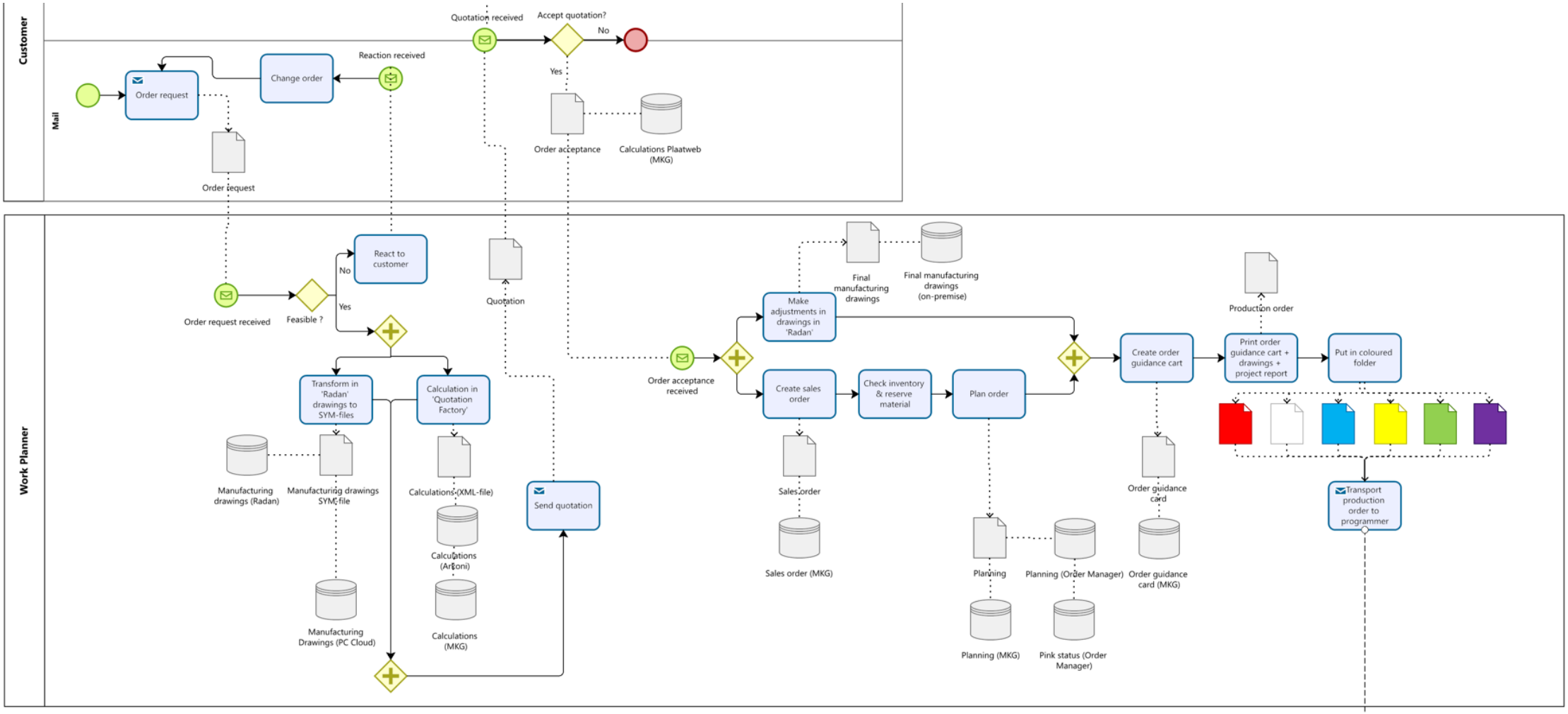


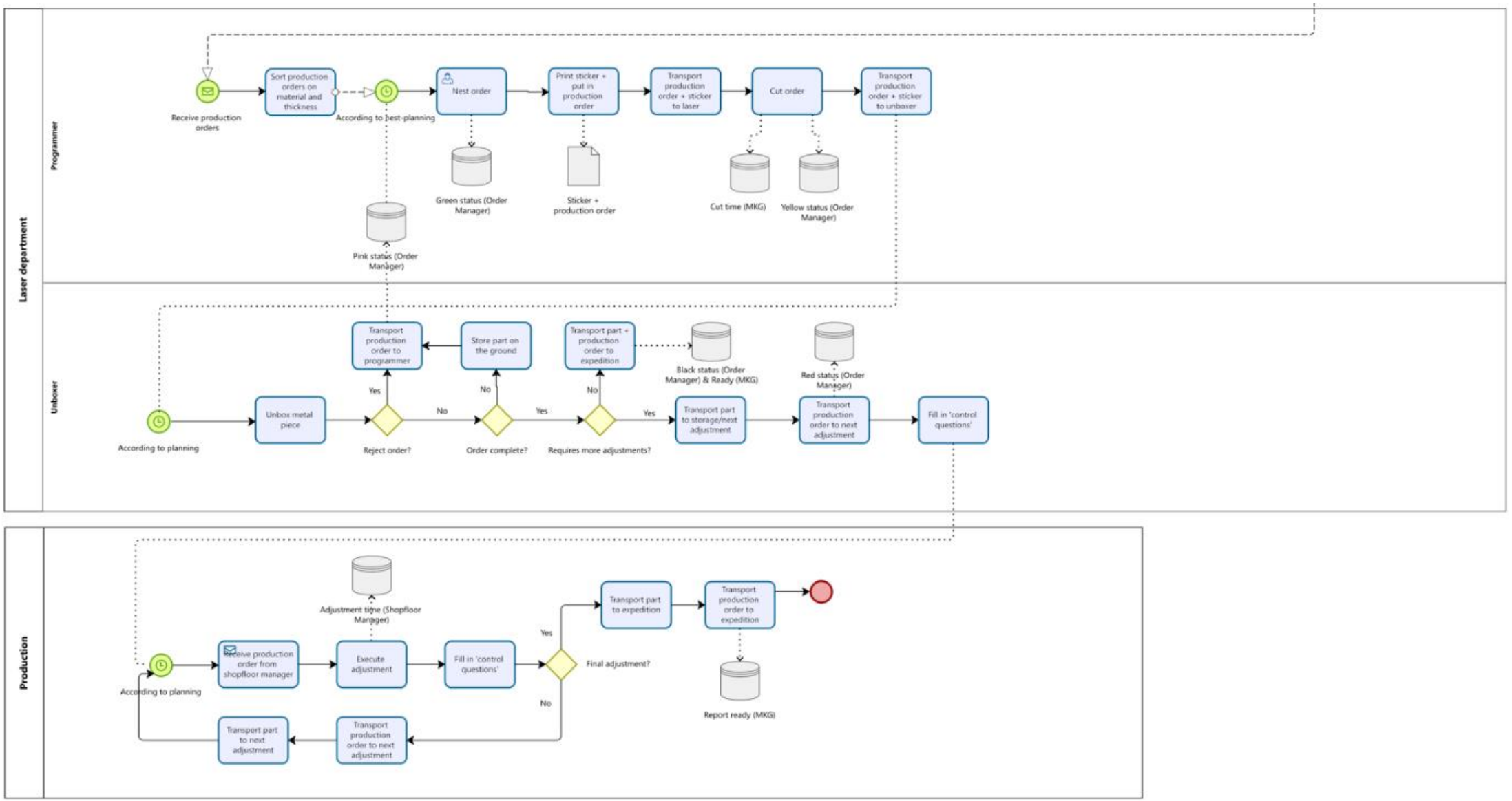
APPENDIX B: PROBLEM CLUSTER (2)



APPENDIX C: BPMN-MODEL CURRENT ORDER PROCESSING




Customer
Mail
Order request
Change order
Reaction received
Order request
Quotation received
Accept quotation?
No
Yes
Order acceptance
Calculations Plaatweb (MKG)
Work Planner
Order request received
Feasible ?
No
Yes
React to customer
Transform in 'Radan' drawings to SYM-files
Calculation in 'Quotation Factory'
Manufacturing drawings (Radan)
Manufacturing drawings SYM file
Calculations (XML-file)
Calculations (Artoni)
Manufacturing Drawings (PC Cloud)
Calculations (MKG)
Quotation
Send quotation
Order acceptance received
Make adjustments in drawings in 'Radan'
Final manufacturing drawings
Final manufacturing drawings (on-premise)
Create sales order
Check inventory & reserve material
Plan order
Sales order
Sales order (MKG)
Planning
Planning (Order Manager)
Planning (MKG)
Pink status (Order Manager)
Create order guidance cart
Order guidance card
Order guidance card (MKG)
Production order
Print order guidance cart + drawings + project report
Put in coloured folder
Transport production order to programmer


Laser department
Programmer
Receive production orders
Sort production orders on material and thickness
According to best-planning
Nest order
Print sticker + put in production order
Transport production order + sticker to laser
Cut order
Transport production order + sticker to unboxer
Green status (Order Manager)
Sticker + production order
Cut time (MKG)
Yellow status (Order Manager)
Pink status (Order Manager)
Unboxer
According to planning
Unbox metal piece
Reject order?
Yes
No
Transport production order to programmer
Order complete?
No
Yes
Store part on the ground
Requires more adjustments?
No
Yes
Transport part + production order to expedition
Black status (Order Manager) & Ready (MKG)
Red status (Order Manager)
Transport part to storage/next adjustment
Transport production order to next adjustment
Fill in 'control questions'
Production
Adjustment time (Shopfloor Manager)
According to planning
Receive production order from shopfloor manager
Execute adjustment
Fill in 'control questions'
Final adjustment?
Yes
No
Transport part to expedition
Transport production order to expedition
Report ready (MKG)
Transport part to next adjustment
Transport production order to next adjustment

APPENDIX D: DETAILED EXPLANATION CURRENT ORDER PROCESSING

Before looking at the current way of working, the digital systems of Baas Metaal will be discussed. Now, Baas Metaal uses the following systems: 'Plaatweb'; 'MKG'; 'Quotation Factory'; 'Radan'; 'Order Manager'; 'Machine Manager'; 'Shopfloor Manager' 'TruTops Fab' and 'Arkoni'.

Plaatweb is the automatic quotation system of Baas Metaal that is used for providing quotations for laser cutting work only, or both laser cutting- and bending work. MKG is the ERP-system of Baas Metaal. It is considered the most important system since it is leading in all cases and brings the information of different departments together. In the current setting, employees can use MKG to plan orders, set processing times, create production-/sales-/purchase- orders and view customer overviews. Quotation Factory is an online calculation system that can determine the price, needed adjustments and the corresponding adjustment times needed to fulfil the customers' order request. It is used for generating a quotation quickly and easily for the customer and determining adjustment times.

Radan is used to transform customers' STEP-file into a SYM-file. More on these sorts of files later. Besides the ability to transform files, Radan is also able to make changes in customers' manufacturing drawings. This is sometimes necessary to clarify drawings more and prevent mistakes during production. Radan makes the final 'nest' for the laser cutting machine to cut. A nest is the process of making optimal usage of a metal sheet, this is done by combining several (different) orders.

An extension of Radan is Order Manager. This program declares the status of the cutting-related processes and provides the planning in combination with MKG when the programmer should nest a certain order. See table 1 for the different statuses in Order Manager. Another extension of Radan is Machine Manager. This program gives the input for status changes in Order Manager. For example, when the laser is done cutting, it gives the input to Order Manager that the machine is done. Machine Manager tracked the time, and Order Manager changes the status of the order to yellow.

Colour	Status
	Ready, at expedition
	Ready, next process
	Work Planner
	Cutted, not unboxed yet
	Programmed as nest

Table 11: statuses Order Manager

Then there is Shopfloor Manager. This program activates when a work planner plans the order and keeps track of the time invested in a certain adjustment by a certain employee. This is connected to MKG and therefore exchanges data smoothly. TruTops Fab is the program that is in connection with the automated raw material warehouse and states the inventory of the materials. TruTops Fab is connected to Radan to make sure that a nest only can be made if the right material is available. Arkoni is a software system that provides data from other systems to MKG. For example, the calculations from Quotation Factory are first synchronized by Arkoni. After this, they are automatically being imported into MKG. Arkoni is a partner of MKG and therefore works perfectly together.

Appendix C shows the current flow of order processing. It all starts with the customer making an order request. This can be done by contacting the work planners of Baas Metaal via 'Plaatweb' or Mail. Plaatweb is used for laser cutting work only, or both laser cutting- and bending work. If the customer only needs to get something cut, it is sufficient to upload a DXF-file. However, if the customer's order requires bending also, it is necessary to upload a STEP-file. A Drawing eXchange Format file (DXF) is a 2D format including text and graphical elements of how the part should look. It is most of the time a simplified version of the full drawing. Since this only concerns a simplified version, it is only used for cutting (AESC, 2021). A Standard for the Exchange of Product Data file (STEP) makes it possible to read- and save a full 3D-model, this concerns more than just the basic geometries. It ensures a high degree of accuracy. Since all the data of the 3D-model is saved as text, it can be opened and adjusted in different CAD-systems (ADOBE, 2024). Both Plaatweb and Quotation Factory base their calculations on the provided STEP-file (or DXF-file when order requires cutting only) by the customer. However,

Quotation Factory is used for the more 'complex' orders. This is the case when there are more adjustments needed than cutting- and bending. All the calculations are then transformed into an XML-file which is imported in MKG automatically after being synchronized in Arkoni. This is also the case when placing an order via Plaatweb. The only difference here is that the order only is imported into MKG after the acceptance of the order by the customer.

When the order is accepted by both the customer and Baas Metaal, the final tasks take place before the order is ready for manufacturing. This is about creating a sales order in MKG, finalizing the manufacturing drawings in Radan, saving them on-premises, and finally, making sure that the order is incorporated in the planning of MKG and Order Manager. This changes the status of the order in Order Manager to pink.

After the complete documentation of all the necessary information in the digital systems of Baas Metaal, the production order is printed. A production order consists of an order guidance card, manufacturing drawings and a project report. Appendix E shows an example of a paper production order. The order guidance card, shown in the first two pages of the example, is directly generated by MKG. An order guidance card could be a 'main order' or a 'copy order'. For orders where multiple products, or products are made from multiple types and thicknesses of materials, an order consists of a main order and copy order(s). The main order contains all products that belong to that specific production order. A copy order is created per thickness and/or type of material. Both are put in different folders. In general, the main orders are kept by the shopfloor managers and the copy orders go through production as they are being divided over the different adjustments and production employees by the shopfloor managers. In this way, the shopfloor managers have an overview of what still needs to be done to fulfil the main order. Whether the shopfloor managers expect something to be done depends on the pre-determined adjustment time.

The order guidance card displays the materials (including V-groove) and all the adjustments that need to be done to create that specific part. Furthermore, every adjustment has its barcode. Production employees must scan this code to establish the duration of their adjustment time in MKG. The possibility to select employees and keep track of their time is made possible by Shopfloor Manager. Besides a barcode, there is a QR-code. This code is scanned by expedition employees which reports the production order ready in MKG and therefore ready for shipment.

Next to the order guidance card, a production order contains manufacturing drawings and project report(s). The project reports are there to give visualization to the unboxers when there are multiple parts of the same copy order. In other words, there are more parts of the same thickness and material that belong to the same main order. The project reports are there to distinguish them but still make sure that they are being 'connected' to the main order. This is however not used intensively.
All of this is put into a coloured folder. The colour displays the first adjustment after being cut. So, for example, if a production order is in a blue folder, it means that it requires bending after being cut. This ensures that unboxers easily perceive where to bring the folder next without having to check the production order. Table 2 shows the meaning of the different colours.

Colour	Meaning
	Urgency/Rejected
	Cutting only
	Bending
	Welding
	Machining/Rolling/Blasting
	Internal rejection

Table 12: meaning coloured folders

The whole production order is then transported by one of the work planners to the programmer on the other side of the building. After this, the programmer sorts the production orders based on material and thickness in a storage shelf (see Figure 4). The programmer conducts his work according to a planning made by Arkoni with the help of MKG and Order Manager. The delivery date as mentioned in MKG is taken as the starting point from which is counted back until the cutting adjustment with the help of estimated adjustment times (as calculated in Quotation Factory) of all the steps necessary after cutting. When the planning tool of the programmer states that a certain order needs to be cut, the programmer searches for the production order on the shelf and uses the SYM-file from Radan of the production order to program the laser.

Figure 6: order shelf programmer

The programmer then prints a sticker page which will be put in the folder also. See Appendix E for an example. The sticker page contains stickers, cutting program information and an image of the cut plate. The production order, including sticker page, is now being transported outside the office to the laser. The programmer then programs the laser according to the program number corresponding to the production order. Now, the laser starts cutting the part out of a residual- or new material plate. When the laser is done cutting, the status of the production order will change to yellow in Order Manager directed by Machine Manager. Machine Manager tracked the time.

After this, the production order is brought to the unboxers. They will, depending on the delivery date of the production order as mentioned in MKG or instructions of the programmer, unbox the cut parts out of the material sheet. Then, after unboxing a certain part, it will be stickered with the sticker that was delivered with the production order. The stickers provide the unboxer with, for example, an image of the part and the required number of one specific part necessary to fulfil the production order. The purpose of the sticker page is mainly for the unboxers' identification and to find the parts in storage more easily while the production orders lie in the planning bins of a certain adjustment. Also, it helps unboxers to conclude faster which orders are complete and which are not.

If an order is not yet complete, because it could not fit on one raw material sheet, the production order will be transported to the programmer who will nest the missing parts later according to the planning possibilities. It could be that an order is rejected internally due to a mistake during one of the adjustments. An employee then rejects the order and transports the production order back to the programmer who reports the production order (partly) rejected in Order Manager and nests the order again according to the possibilities in the planning. The status in Order Manager will change in both cases to pink since the order is considered again as if it just came from the work planners. When a customer rejects the order (external rejection), it is taken as a new order in MKG.

If the order is not rejected, complete and requires no more adjustments, both the production order and part(s) will be brought to the expedition where it will be reported as ready in Order Manager and MKG by scanning the QR-code on the production order. If the production order however requires more adjustments, the part will be brought to the storage and the production order will be brought to the planning bin of that specific adjustment or to the planning bin of the shopfloor managers who then divide it among the production employees later according to the planning of MKG. After this, the control questions on the production order are answered. The questions, who/date/amount/where, keep track of the part in the production hall and need to be answered after every adjustment.

As mentioned, when a production order requires more adjustments than cutting only, the stickered part is stored in storage while the production order lies in the planning bin of the concerned adjustment or the shopfloor managers' folder holder. According to the planning based on the delivery date in MKG, the shopfloor manager divides the work at the different adjustments.

The production employee then executes the concerning adjustment after scanning the corresponding barcode on the production order. The time needed for the adjustment will then be saved in the database of Shopfloor Manager. If this adjustment is the final one, the production order and part will be brought to expedition where it will be reported ready by the shopfloor manager. If this is not the final adjustment, the part and production order will be stored and the production order will be brought to the next adjustment after filling in the control questions. The process then repeats. It could for example be that all the copy orders are executed, but it all needs to be welded together. The shopfloor manager then brings the main production order with all the parts (copy orders) to the welder. The welder fulfils the main order, after which the shopfloor manager retrieves the complete order later (based on pre-determined times). Lastly, the shopfloor manager reports the order ready in MKG.

To clarify the current order processing more, it will now be discussed per department that Baas Metaal provides.

Work planners:
It all starts with the work planners, the connection between customers and production. They ensure that the right manufacturing drawings are uploaded in Radan and on-premise, that the calculations are uploaded in MKG, that a sales order is created in MKG, that the order is planned in MKG and that a production order with all the necessary documents is brought to the programmer in a coloured folder. The order has now the status 'pink' in Order Manager. Orders concerning multiple products, or products made from multiple types and thicknesses of materials, consist of a main order and copy order(s). The main order contains all products that belong to the customers' order. It could be that one customer has more than one main order. A copy order is created per thickness and/or type of material. Both are put in different folders. In general, the main orders are kept by the shopfloor managers and the copy orders go through production as they are being divided over the different adjustments and production employees by the shopfloor managers. In this way, the shopfloor managers have an overview of what still needs to be done to fulfil the main order. Whether the shopfloor managers expect something to be done depends on the pre-determined adjustment time and the planning.

Programmer:
The programmer firstly sorts the incoming (copy) production orders based on material and thickness. The provided planning by Arkoni based on the delivery date in MKG gives the working scheme of the programmer. Based on this, the programmer nests the order and lets Machine Manager (due to making a nest in Radan) change the status in Order Manager to green. Then, a sticker page will be printed corresponding to the production order after which the production order(s) will be transported to the laser where the laser will be programmed to start. When the laser is done, Machine Manager records the time needed to cut and declares a yellow status in Order Manager. The production orders are then transported to the unboxers.

Unboxers:
Depending on the delivery date of the production order as mentioned in MKG or instructions of the programmer, the unboxers will request the specific order from the STOPA (the automatic warehouse). The unboxers will then unbox the cut parts out of the material sheet and put it back in the STOPA as a residual piece or they throw it away. When starting to unbox, Machine Manager needs to be started manually to keep track of the time. However, the time is not exactly tracked. It is just started- and stopped- or filled in manually by an employee, this ensures that Machine Manager still directs Order Manager to change his status to red or black. The sticker, provided by the programmer, is now used for identification purposes. If the order is not rejected and is complete, it will be brought to the next adjustment. If cutting was the only required adjustment, the part and production order will be brought to expedition who reports the order ready in MKG and Order Manager. To pass along the

location of the part, the unboxer answers the control questions on the production order. If the order is rejected or not complete, the production order will be brought back to the programmer and the parts will be stored temporarily on the ground. The status in Order Manager will change to pink.

Bending:
When a part requires bending after being unboxed, an unboxer will bring the part to the storage in front of the bending machines (see Figure 5). The production order will be brought to the folder holders which are also in front of the bending machines (see Figure 6). The production orders are sorted on V-groove. The shopfloor manager decides which bending employee executes which production order. This is based on the planning as stated in MKG where the most urgent cases are considered first, the V-groove, the experience of the bender and the characteristics of the bending machine. Before the bending employee may start his activities, he/she should login with his personal profile in Shopfloor Manager (see Figure 7) and scan the barcode on the production order corresponding to the bending activity. This way, the hours are tracked and it is clear who has processed which order. Based on the working drawing, the bending employee sees what needs to be done. The manufacturing drawing often just lies on a table aside the bending machine. When the bending employee has finished the operation, the products are then transported to the next department, or are being transported via the expedition (shopfloor managers) to the next department, or, if bending is the last operation, stored at the expedition. The control questions are answered afterwards: the date on which the operation was performed, the name of the person who operated, the number of products and the location of the products are written on the order guidance card.

Figure 5: storage in front of bending machines

Figure 6: folder holders in front of bending machines

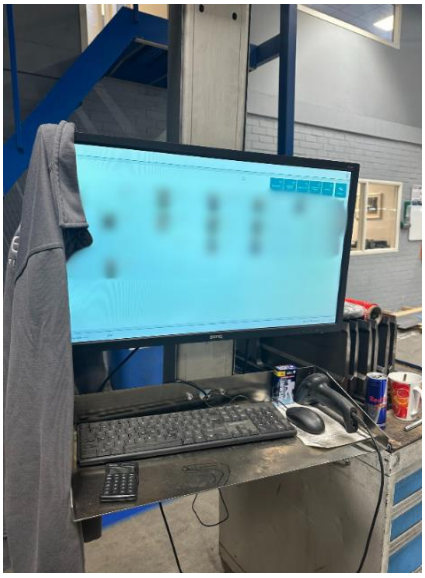


Figure 7: Shopfloor Manager

Benchwork:
Benchwork is understood to mean all the activities concerning rolling, drilling, milling, turning, sawing, and blasting. Just as with bending, the benchwork employees have to login to Shopfloor Manager to keep track of the adjustment time. Also, the production orders lie here in a folder holder and are distributed by a shopfloor manager. The parts that require benchwork adjustments, are brought there by a shopfloor manager or need to be searched by a benching employee himself. After the adjustment, the control questions are answered, and the production order is brought to the next adjustment or to the expedition. In some cases, the part is being retrieved by the shopfloor manager who brings it to the next adjustment or the expedition.

Welding:
Welding may be considered, when applicable, a final adjustment before going to expedition. When all the copy orders are completed, the shopfloor manager collects all the parts of the main order and brings this to a welder based on the planning provided by MKG. The welder welds all the parts together and hence finalizes the production order. He does this according to the drawings which were given to him/her by a shopfloor manager. Before doing this, the welder needs to login to Shopfloor Manager and scan the barcode corresponding to the welding adjustment to keep track of his/her adjustment time. After finalizing the order, the production order is brought to expedition and the final part is being retrieved by a shopfloor manager who reports the production order ready in MKG. As always, the control questions are being answered.

Expedition:
Finally, at the expedition, the shopfloor manager receives all the production orders that are ready to be shipped or need to be welded first. The production orders that are done with the previous adjustment also come here. All these orders are put in a folder holder. If the order requires to be welded together, the production order will be put in another folder holder. If, however, the copy- or main order is complete, but the order request of the customer is not yet fulfilled, the production order will be placed on a big shelf where the production orders are sorted based on the name of the customer. Eventually, when the complete order request is fulfilled, the production order will be placed in the folder holder called ‘pick-up’. Then, based on the planning an order will be made ready for shipment. Based on the control questions from the last made adjustment, the order is collected, packed, and provided with a packing receipt.

APPENDIX E: EXAMPLE PRODUCTION ORDER

baas metaal
PERFECTIE MET PASSIE.

Metaalbedrijf Baas B.V.
Ordergeleidekaart per eindproduct (2)
[redacted] 15-03-2024 / 07:46

HOOFDKOPIE	BEWERKING
6 st.37	Snij - las

V-GROEF

Productieorder: 6240007785/

Eindproduct

Productieorder : 624000778S/1
Omschrijving : Snij - zet - las
: Diverse materialen
Tekening : 454004110-D - kit
Productie aantal : 5 st.
Planning : 03-04-24

LASsen
5t

documenten \\SRV2016-data\tekeningen[redacted]Aanvraag 25-10-2023\filterkast DM10\454004110-D - kit.sym

Klant :
Contactpersoon :
Telefoonnummer :
Afleveradres :
[redacted]

Klantinfo :

Bestemming : VO:302401410/1 [redacted]
Aantal : 5
Referentie : I24-0214
Levering : [redacted]

Materiaal

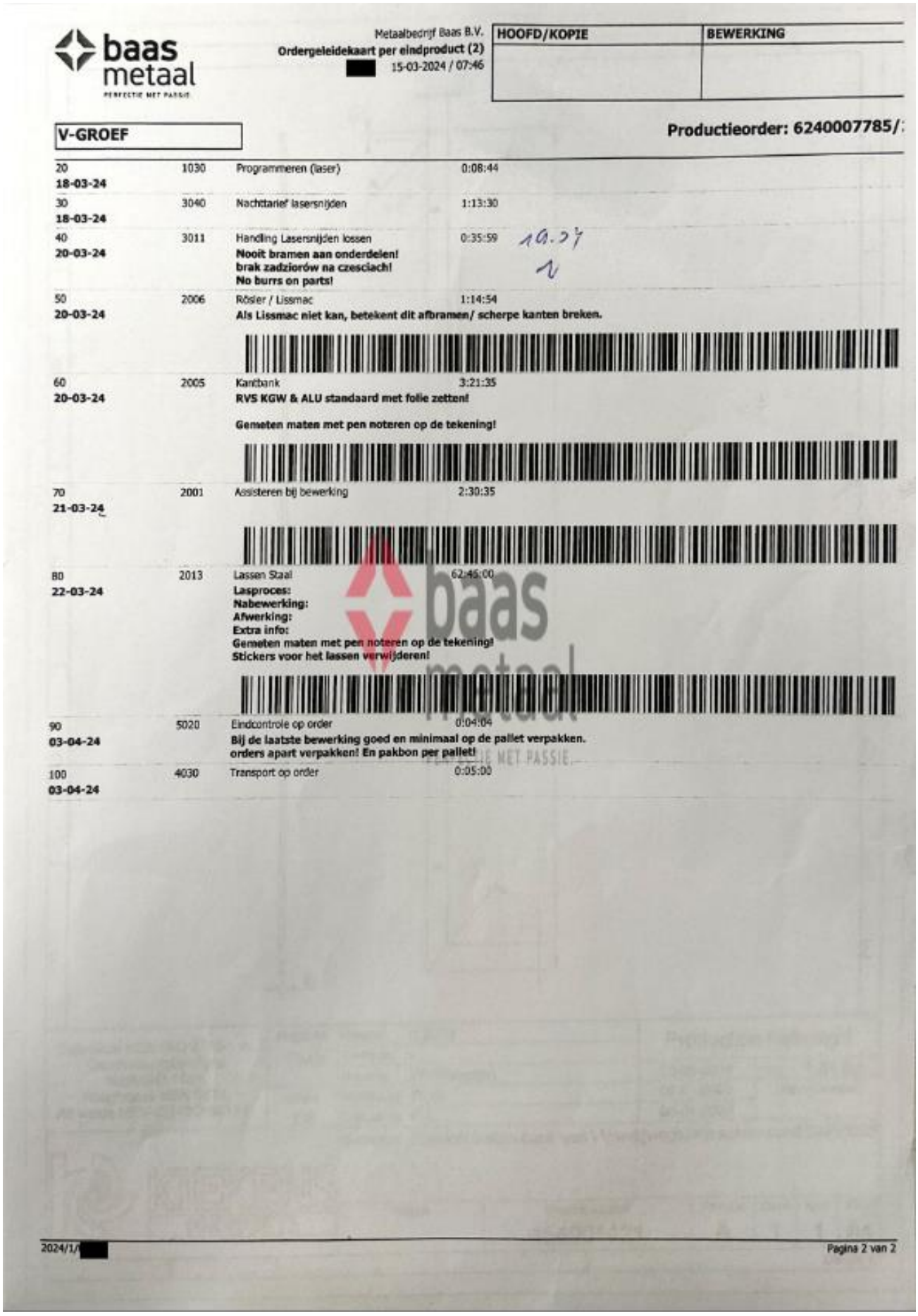
Volgorde	Artikel	Omschrijving	Tekening	Aantal	Totaal aantal	Gewicht (Kg
1	PL 1.0330 2500X1250X2	881,74x881,74x2 Plaat St37 DC01	454004117	1,00 st.	5,00 st.	62,2[illegible]
					V-GROEF: V12	
10	PL 1.0330 2500X1250X3	1637,41x1637,41x3 Plaat St37 DC01	454001111	1,00 st.	5,00 st.	321,73
					V-GROEF: V20	
11		las stiftbout		3,00 st.	15,00 st.	
12		Blindklinkmoer M8 HUPx30		24,00 st.	120,00 st.	
2	PL 1.0332 2000X1000X6	217,96x217,96x6 Plaat St37 DD11	454001121	1,00 st.	5,00 st.	11,40
					V-GROEF: V50	
3	PL 1.0332 2000X1000X6	263,86x263,86x6 Plaat St37 DD11	454001122	2,00 st.	10,00 st.	33,42
					V-GROEF: V50	
4	PL 1.0330 3000X1500X3	79,33x79,33x3 Plaat St37 DC01	454001119	2,00 st.	10,00 st.	1,51
					V-GROEF: V20	
5	PL 1.0330 3000X1500X3	38,06x38,06x3 Plaat St37 DC01	454001115	4,00 st.	20,00 st.	0,70
					V-GROEF: V20	
6	PL 1.0330 3000X1500X3	1637,98x1637,98x3 Plaat St37 DC01	454004114	1,00 st.	5,00 st.	321,96
					V-GROEF: V20	
7	PL 1.0330 3000X1500X3	1637,98x1637,98x3 Plaat St37 DC01	454004113	1,00 st.	5,00 st.	321,96
					V-GROEF: V20	
8	PL 1.0330 3000X1500X3	257,79x257,79x3 Plaat St37 DC01	454001112	2,00 st.	10,00 st.	15,95
					V-GROEF: V20	
9	PL 1.0330 3000X1500X3	264,57x264,57x3 Plaat St37 DC01	454001112	2,00 st.	10,00 st.	16,80
					V-GROEF: V20	
						1.107,62

Bewerking

Volgorde	Bewerking	Omschrijving	Totaaltijd	Controleur + Datum	Aantal + Waar
10	1020	Werkvoorbereiding	0:10:00		
15-03-24					

2024/1[redacted]

Pagina 1 van 2



baas metaal
PERFECTIE MET PASSIE.

Metaalbedrijf Baas B.V.
Ordergeleidekaart per eindproduct (2)
[redacted] 15-03-2024 / 07:46

HOOFD/KOPIE	BEWERKING

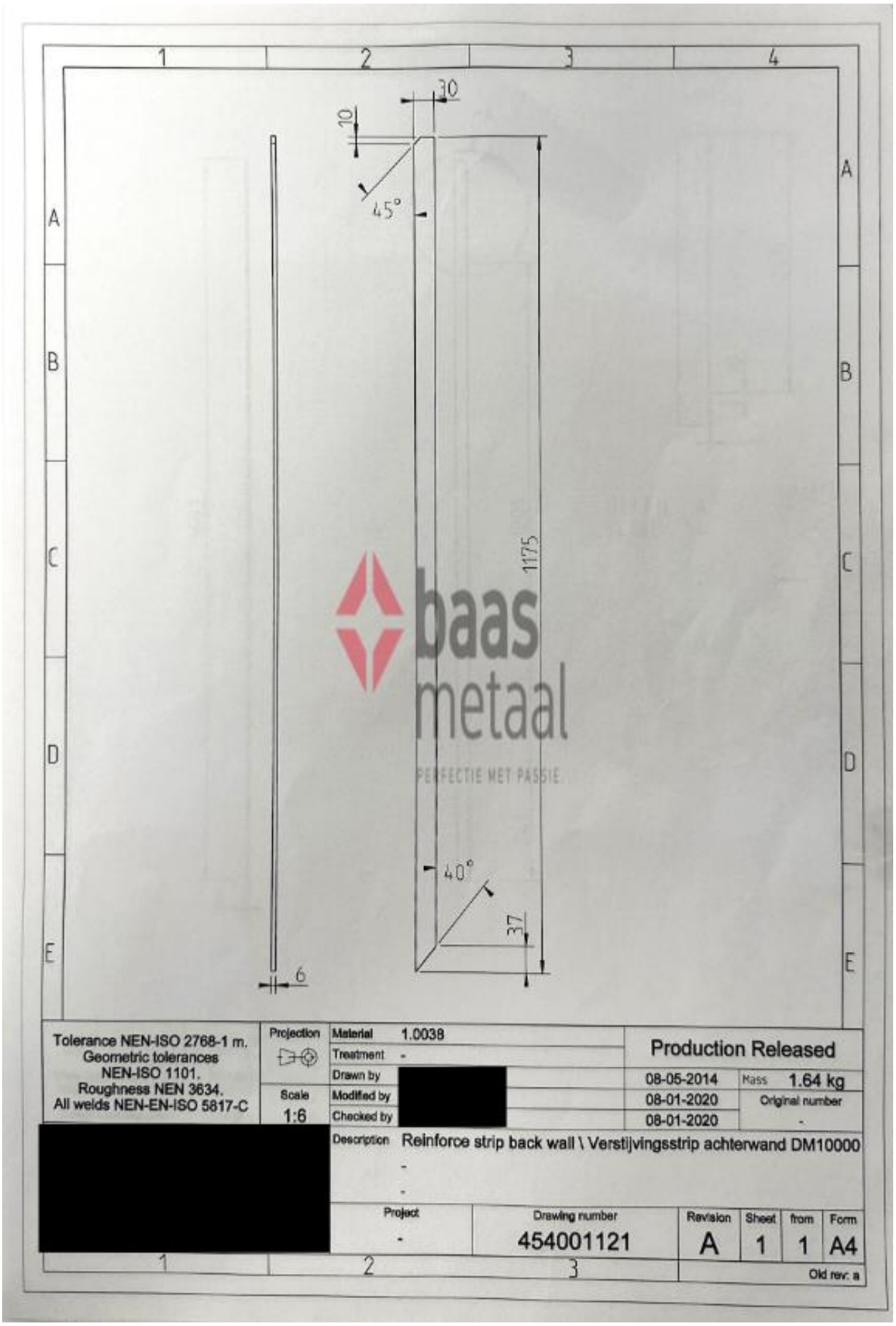
V-GROEF

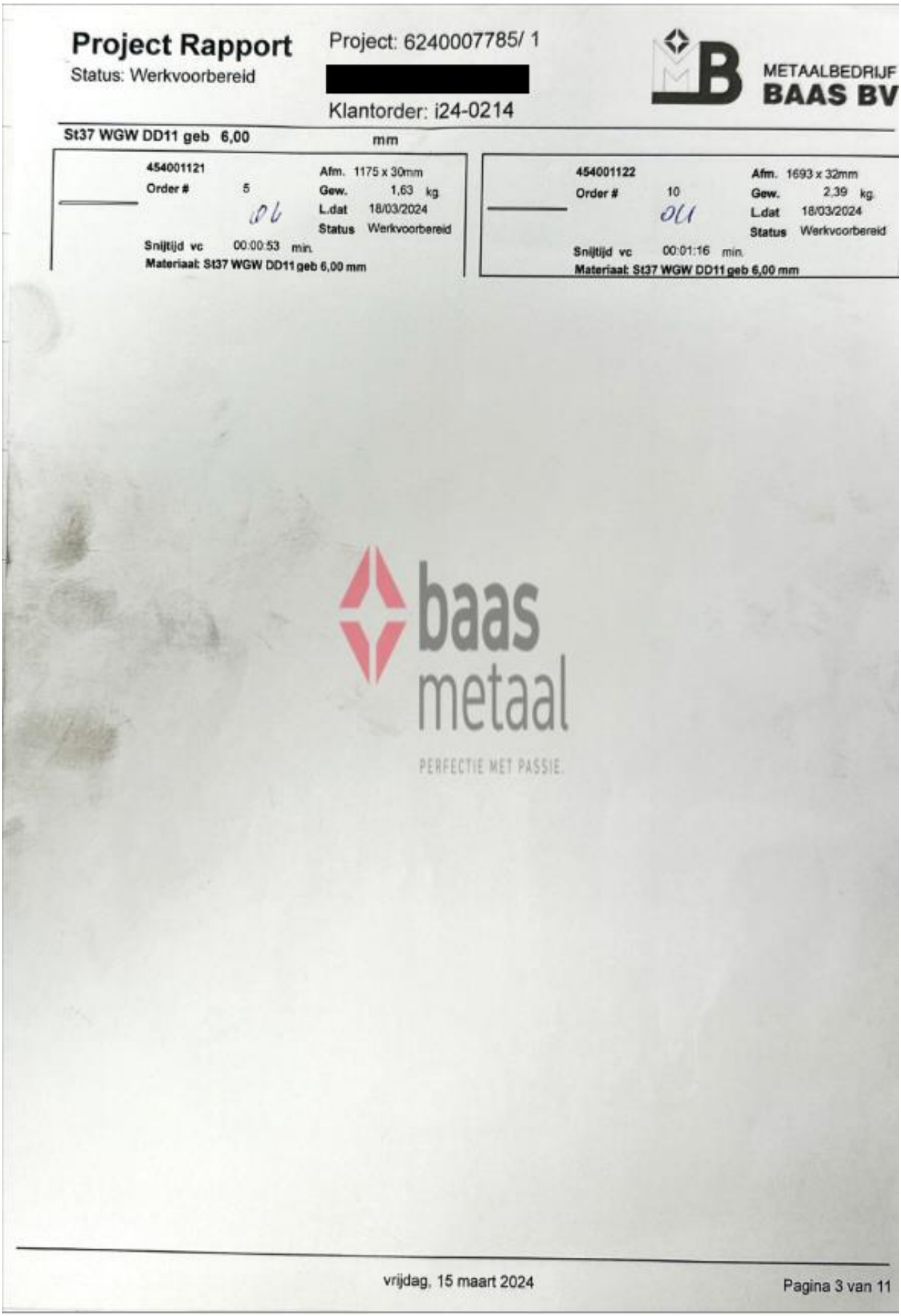
Productieorder: 6240007785/

20 **18-03-24**	1030	Programmeren (laser)	0:08:44	
30 **18-03-24**	3040	Nachtarief lasersnijden	1:13:30	
40 **20-03-24**	3011	Handling Lasersnijden lossen **Nooit bramen aan onderdelen!** **brak zadziorów na czesciach!** **No burrs on parts!**	0:35:59	19.2 ✓ 2
50 **20-03-24**	2006	Rösler / Lissmac **Als Lissmac niet kan, betekent dit afbramen/ scherpe kanten breken.**	1:14:54	
60 **20-03-24**	2005	Kantbank **RVS KGW & ALU standaard met folie zetten!** **Gemeten maten met pen noteren op de tekening!**	3:21:35	
70 **21-03-24**	2001	Assisteren bij bewerking	2:30:35	
80 **22-03-24**	2013	Lassen Staal **Lasproces:** **Nabewerking:** **Afwerking:** **Extra info:** **Gemeten maten met pen noteren op de tekening!** **Stickers voor het lassen verwijderen!**	62:45:00	
90 **03-04-24**	5020	Eindcontrole op order **Bij de laatste bewerking goed en minimaal op de pallet verpakken.** **orders apart verpakken! En pakbon per pallet!**	0:04:04	
100 **03-04-24**	4030	Transport op order	0:05:00	

2024/1/[redacted]

Pagina 2 van 2


1
2
3
4
A
B
C
D
E
30
10
45°
1175
40°
37
6
baas metaal
PERFECTIE MET PASSIE
Tolerance NEN-ISO 2768-1 m.
Geometric tolerances
NEN-ISO 1101.
Roughness NEN 3634.
All welds NEN-EN-ISO 5817-C
Projection
Scale
1:6
Material 1.0038
Treatment -
Drawn by [redacted]
Modified by
Checked by
Production Released
08-05-2014
08-01-2020
08-01-2020
Mass 1.64 kg
Original number
-
[redacted]
Description Reinforce strip back wall \ Verstijvingsstrip achterwand DM10000
-
-
Project
-
Drawing number
454001121
Revision
A
Sheet
1
from
1
Form
A4
Old rev: a



Project Rapport

Status: Werkvoorbereid

Project: 6240007785/ 1

[redacted]

Klantorder: i24-0214

METAALBEDRIJF BAAS BV

St37 WGW DD11 geb 6,00 mm

454001121	Afm. 1175 x 30mm
Order # 5	Gew. 1,63 kg
01	L.dat 18/03/2024
	Status Werkvoorbereid
Snijtijd vc 00:00:53 min.	
Materiaal: St37 WGW DD11 geb 6,00 mm	

454001122	Afm. 1693 x 32mm
Order # 10	Gew. 2,39 kg
011	L.dat 18/03/2024
	Status Werkvoorbereid
Snijtijd vc 00:01:16 min.	
Materiaal: St37 WGW DD11 geb 6,00 mm	

vrijdag, 15 maart 2024

Pagina 3 van 11

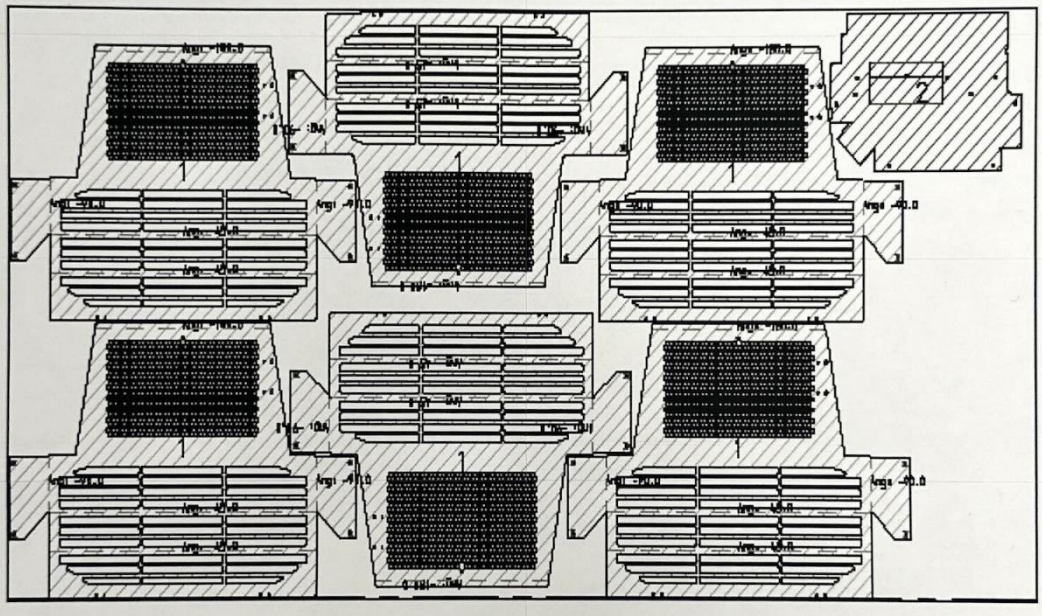
APPENDIX F: STICKER PAGE PRODUCTION ORDER

Programma:	P3 2418423		Pagina 1 van 1
Materiaal:	RVS304 KGW 2B 1zf		2-5-2024
Afmetingen:	3000x1500x1,50mm		13:25:52
Aantal Platen:	2	Rendement:	46,30 %
Snij tijd:	65,29 minuten	2001	*B-135552

baas metaal
PERFECTIE MET PASSIE.

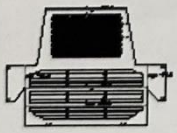
Materiaal: RVS304 KGW 2B 1zf
Dikte: 1,50mm 2001

0



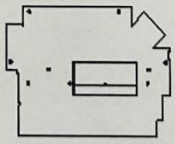
Onderdeel info

1



6240011963/1	
Aantal/Order Aantal:	12 van 15
Leverdatum:	17/05/2024
Uw referentie:	4500385381
Afmeting:	1001 x 697 x1,50 mm
Nabewerking:	Rösler / Lissmac
3000306449-REV-01	0

2



6240011091/1	
Aantal/Order Aantal:	2 van 20
Leverdatum:	06/06/2024
Uw referentie:	4500384754
Afmeting:	548 x 400 x1,50 mm
Nabewerking:	Rösler / Lissmac
3000304474-REV-06	0

APPENDIX G: INTERVIEW PROBLEM OWNER

Explanation about purpose of interview and asking for permission to make a recording, to mention the name of the participant and to transcribe the full interview

How do you envision the ideal situation? Do you foresee a reduction in paper, or the complete elimination of paper? I see the ideal situation as having no paper at all. **So no more stickers either?** The stickers, yes, I don't see them as paper. We use them to identify the product. You could do that with text, which I still find useful. **Could there be a barcode on them?** Yes, that's possible, and I think it would be useful too. But for the problems you encounter, you should ask the guys (the employees of Metaalbedrijf Baas B.V.) who work with them. You really have to involve everyone. Where does it start? You have to involve everyone in work preparation, individually, maybe even sit down with each person for a quarter-hour, five minutes to fifteen minutes, and ask questions.
Another thing that needs improvement is how Machine Manager is used by the unpackers. Currently, *name* (leader unboxing) estimates this by starting and immediately stopping the clock. Then a time is manually entered. This is often checked by *name* (administration) to see if the estimate is still reasonable. I'd like this to be improved. How do you envision this? Would you like screens near the unpacking stations? Yes, exactly, then the guys can clock themselves on how long it takes them to unpack. We would then have a better idea of how long it takes to unpack, which we can later use to improve planning. I also want the guys to be able to report internal rejects immediately.

We've discussed this before; you want to work digitally with semi-finished products in the future. Can you clarify this a bit more? Each order has its own production order line number, how can I say this, this section consists of two parts. Scrap 1 is the cup, scrap 2 is the mug, and scrap 3 is the handle. They will then bend those, when that's done, they report scrap 3 ready. Making this thing, that's scrap 2 ready, and then they can weld or glue it together. **And then it's all done?** Yes, then it's all done, and you can report scrap 1 ready.

How do you see the control questions, as they are currently written on paper? With SmartClient. **With shop floor? So in this, the times and persons can be linked to the actions?** Yes, because they still must clock the hours. And what about the locations? Also, in Shopfloor Manager. **Do you have to enter this manually, or would you also like to use scanners?** Still to be investigated.

After successful implementation, what do you see in the production hall? I see a space with screens where the only paper left are the stickers. The guys use the screens with the drawings displayed on them. Shopfloor Manager is heavily used. **Do you also see a change in storage?** There are many ideas about this, but for now, I don't see any changes there. We are working on a number change, I find the current format too extensive, and it can be much simpler by just numbering with 1, 2, 3, etc.

What do you hope to improve? Is it about reducing paper, or easiness of usage, etc.? I think every aspect improves. The road to get there is certainly long. But everything will be much easier. Just look at the time the preparation spends on preparations; putting the orders in folders, then it has to be placed in the right thickness and taken out again per program. In the factory itself, I do see some problems coming, but not really big ones. **What kind of problems exactly?** Maybe with unpacking, the stickers have to work well. They must know exactly where everything should go.

Looking at the BPM model, from which point do you see no more paper? Right from the start (referring to customer order request). Everything must be linked so that no paper is needed for the entire processing. This year I still put copies of receipts in the folder for administration. Next year I want to print nothing, not even those receipts. It's all redundant what I keep. You find everything much easier in the computer. **Do you expect it to be possible digitally to achieve all this?** Yes, the programs are largely linked already. Nothing is needed for that. You just have to find out what people

will miss when the paper is gone. For example, they now make an order and sometimes write a handwritten note on the paper, for example, when tapping 'be careful, it's fine thread'. **Could you put a comment in Shopfloor Manager?** Yes, this might have to be done in Shopfloor Manager. That's possible. Maybe something with a pop-up notification.

You are currently using various barcodes on the production orders. For each adjustment, you have a different code. Can you also use a barcode for all adjustments, for example, on the sticker? If you want it perfect, you should do it like this: if the previous operation has not been reported as completed, you cannot start with the next one. This would mean that everyone gets to see what they need to start with. **As in a planning?** Yes, exactly. This means that if he says he has put a part aside, it's done, the next process in his schedule gets a new task. Maybe in combination with V-grooves. A lot should be possible in Shopfloor Manager. The guys should also be able to open STEP files themselves.

APPENDIX H: INTERVIEWS USER REQUIREMENTS

Explanation about purpose of interview and asking for permission to make a recording and to transcribe the full interview

Work planner

(1) **Could you describe how and when you use paper during your activities?**
I print out the purchase order so I can easily make notes on the paper. Eventually, I also print out the drawings and order guidance cards.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V?
The drawings themselves, not every process requires a drawing. For example, we print out a bending drawing while there's a screen at the bending machine that could display it. **You think this process can be digitalized easily?** Yes, all the necessary information and drawings can be displayed on the screens. **What do you think about the project reports?** When unpacking, they need to know how many products there are and what they look like. **Aren't stickers used for that?** *Name programmer* prints the stickers, so the reports do eventually become unnecessary. However, sometimes it provides extra clarity on which parts exactly need to be unpacked from the same sheet for the same order.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
I do not think that I encounter problems myself. Especially with assemblies, in welding. Different parts are assembled. I think it would become too complex because everything would be mixed up.

How do you imagine a paperless order processing at Baas Metaal B.V.?
Everything runs via screens. When I receive an order, I enter it into the system along with the drawings. I do think this should happen in stages, per phase. So first, for example, the bending adjustments are being done digitally, then another process follows.

a. **What functionalities would you like to see in digital order processing?**
I think it's important for people in the workshop to see drawings in 3D and also be able to take measurements themselves.

What do you prefer: a paper-based or digital-based way of working?
If everything goes smoothly, I would prefer a digital method because sometimes I have orders consisting of 15 production lines, and therefore also 15 times printing and filing.

b. **Why do you prefer this?**
It takes a lot of time to print and sort orders consisting of multiple production lines.

Why do production employees sometimes walk into the office?
Something in the drawing is unclear to them. I clarify this using the computer.

c. **Do you think this could be answered without paper too, but in a digital way?**
Yes, they might also be capable of resolving this themselves.

How do you imagine dealing with copy and main orders digitally?
It will be structured differently in the future, with ‘schrap’ numbers. Each part will then have a product number to which drawings can probably be attached. There are screens almost everywhere in the factory where clocking the time per adjustment can be done.

(2) Could you describe how and when you use paper during your activities?
For creating orders, such as printing the order guidance carts and drawings. Some assemblies, for welding, I sometimes print on A3 because it's easier. On a screen, they could then zoom in themselves.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V?
It's a habit, and it consumes a lot of time, paper, and folders with large orders. We are very busy with printing and sorting paper when an order consists out of multiple copy orders.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
I think it shouldn't be a problem for me if a clear new way of order processing is established. However, I believe production employees might find it more challenging. How exactly? They are used to working with drawings. I also think some may find it difficult to read everything digitally, especially in welding. Why especially in welding? Some assemblies become too complex, which is easier and clearer to read on a large paper (A3) than digitally.

How do you imagine a paperless order processing at Baas Metaal B.V.?
I don't see everything going through screens. Sometimes it's useful to have drawings for large projects with many assemblies.

a. What functionalities would you like to see in a digital order processing?
   It would be convenient if production employees could see the drawings in 3D and zoom in themselves. But, in reality, a drawing remains easier, especially for large assemblies.

What do you prefer: a paper-based or digital-based way of working?
A digital method would save us less work and could certainly be used in some areas of production, but I don't think everywhere. So, my preference would be a combination of both.

b. Why do you prefer this?
   As I said, I'm afraid some assemblies would become too complex via screens. But digital can certainly be convenient for checking main lines and measuring dimensions.

Why do production employees sometimes walk into the office?
They have questions about dimensions or other uncertainties.

c. Do you think this could be answered without paper too, but in a digital way?
   Certainly, the welders sometimes already open a STEP file themselves to see it in 3D. They can then measure things themselves or see uncertainties themselves.

How do you imagine dealing with copy and main orders digitally?
If everyone can register a location somewhere, then the expedition can gather everything when all copy orders are ready.

(3) Could you describe how and when you use paper during your activities?
Throughout the day. Sometimes I print quotes because I find it easier to read from there, but this goes beyond making the order paperless. Otherwise, I mainly print orders: order guidance carts, nest reports, (set) drawings. **Do you also often make comments here?** Sometimes, if the customer specifically requests material that must not have scratches, then I write that down and highlight it. This also applies to notes for certain operations that require extra attention.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V?
A big downside for me is the amount of paper we use, but it is an efficient system that really works.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
I don't necessarily encounter any issues myself, but probably in the workshop. Currently, they see a drawing of what it should be or what it is for. I think they might miss things on the drawing or that there are no things attached to an order. **Suppose they have the ability to view the drawings in 3D and measure dimensions digitally themselves, do you think it will work out?** Yes, then I think it could work. I think, for example, also that if I print an urgent order in and put it in a red folder, then everyone immediately knows that everything needs to be done quickly. Now I can put in a short delivery date, but I'm afraid that colour will have more influence than a date they have in the system.

How do you imagine a paperless order processing at Baas Metaal B.V.?
What I envision is that the work planners will send the drawings well and clearly worked out via a system, I think that could be done via MKG, to the workshop. The production employees can then open the STEP files and other drawings and measure dimensions themselves.

a. **What functionalities would you like to see in digital order processing?**
   Production employees should be able to view the order in 3D themselves. Sometimes they come to me with questions about how something should be set, then I show them the 3D model and that's clear to them. They cannot determine exact values for angles from the 3D models, so they also need to be provided with drawings to see the angles.

What do you prefer: a paper-based or digital-based way of working?
The current method works efficiently. But if it can be digital, I think it's also a good method. You will undoubtedly encounter things with a digital system, but we still encounter things with paper now. Ultimately, digital would be my preference.

b. **Why do you prefer this?**
   The amount of paper decreases significantly, and it saves me a lot of printing and sorting work. Ultimately, I think it can be at least as efficient as working with paper.

Why do production employees sometimes walk into the office?
See above

c. **Do you think this could be answered without paper too, but in a digital way?**
   See above

How do you imagine dealing with copy and main orders digitally?
I think it should be possible. A main order is created when you have a project consisting of multiple parts. You then receive a copy order per material type and thickness. So, I think it should be possible, but I'm not sure exactly how. It could surely be automated if you attach multiple things to something that can be called up from the system. What that solution is, I have no idea.

Programmer:

(1) Could you describe how and when you use paper during your activities?
Printing the programs, this involves printing the stickers. Other than that, I don't use paper, only occasionally to make a note. So, you don't really need paper? No, I don't need paper for my work. I only need the sticker sheets that I pass on to production. All the cutting files are in the system, and you could work without the paper orders? Yes, that's correct. Except for the stickers for the programs, I do need those. Can you explain a bit more about how you use the stickers with the laser? If it's a leftover piece, so not an automated plate, then it's more complex. If it's an automated plate (unused plate), then all the information is on the laser. For automated programs, as a laser programmer, you don't need stickers. You can call up the programs with all the information at the laser. The programs you choose at the laser are based on the planning you have at the office via MKG, but how do other laser programmers know this? They receive program after program that I give to them. So, I just keep an overview. So, once again, you could perform your tasks the same way without paper? Yes, that's correct. What I do now, but that's because we work with paper, is the following. Suppose I want to process 2mm stainless steel. I then select 2mm stainless steel and go through all the orders. I check if I actually have all the orders. It may happen that I don't have a certain order because it's already cut. Or it hasn't been entered correctly? Indeed, that can happen too. Or it's on hold. All drawings, cutting files, etc., are also just behind the production numbers in the system? Yes, everything I get from a printed order, I can also get from the system.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V.?
You only know that when you start working differently. I don't really have a problem with how it's currently done. The only downside, I think, is the amount of paper being used. Also, for example, not the back-and-forth walking between different departments? That could indeed be done more efficiently, but I don't just walk there to move orders. Often, I also give instructions, etc. For example, to say they should be careful not to let things fall out. Do you write that kind of thing on the order? Normally, I just tell them, but if I'm leaving in the afternoon, I write it on a separate note. That has nothing to do with the order.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
Basically nothing, I just wouldn't be able to check the order the way I do now.

How do you imagine a paperless order processing at Baas Metaal B.V.?
That's not up to me. Once it's implemented, I'll see how it goes. But do you see, for example, screens or tablets, etc.? I don't know, and I don't want to think about that.

a. What functionalities would you like to see in a digital order processing?
I don't know. I can do my work digitally and don't need any extra features for that.

Why do production employees sometimes walk into the office?
When they come with an order, it's often a rejection, then I fill in the reason, etc., in the system. Do you think it's possible to let multiple people do this? It could be, but I wouldn't do it. I expect chaos and that colleagues wouldn't honestly admit their rejections.

b. Do you think this could be answered without paper too, but in a digital way?
Without paper, yes, but I would only leave it to a few people. So not everyone.

How do you make use of Machine Manager?
For cutting, everything goes well, right? Because once the cutting is done, it gets recorded automatically? Yes, that's correct. Clocking during unpacking happens less, what do you know about that? Orders are not clocked individually. Unpacking is done via Machine Manager, and an estimated duration of the unpacking is given. For a whole plate? For unpacking a program, which can mean multiple plates. So, they don't specifically clock per order. Do you think that's possible? I think there are opportunities if you go paperless. I think you could get a more accurate unpacking time and thereby also better understand your operations. On the other hand, it's only nice for larger batches. With small batches, you keep scanning. There are opportunities here.

Sometimes there is a plate specifically ordered for a certain order. This is then written on the production order, do you think this can be solved digitally also?
This can easily be solved with a comment field. Do you expect this to be solved via Order Manager? I don't know, but I can imagine that it can be done via MKG and then displayed on my screen. Some customers also don't want stickers on their products. Do you expect it to be possible to go digital without stickers? I think you need something for identification. Otherwise, you're just looking at a cut piece of metal. But I'm not saying that a sticker is sacred; there could be an alternative. But what that is, I don't know.

Laser:

(1) Could you describe how and when you use paper during your activities?
I use paper to look up scrap pieces and request programs. These are mainly the sticker sheets, right? Indeed, I don't really use the production orders. What information do you get from the sticker sheets? These include the program numbers, sheet sizes for the scrap pieces, and which table the metal sheets are stored on. How do you know in which order to handle the orders you receive? Sometimes *name programmer* determines the order, but sometimes I decide myself. And where do you base your planning on? It depends; if I have multiple sheets stacked on top of each other with different thicknesses, I place the thickest ones at the bottom (last) and the thinnest ones on top (first).

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V.
No, I'm not used to anything else, and in my tasks, I don't experience any significant inefficiencies.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
Switching completely to paperless would cause problems with the scrap pieces, but if the stickers remain, I have no issues. I need a number and dimensions for the scrap pieces. It's convenient to take the sticker sheets with me. Do you think this could be solved digitally somehow? I wouldn't know.

How do you imagine a paperless order processing at Baas Metaal B.V.?
I have no idea; I would need to see it first. If you have a screen at the STOPA for the scrap pieces and a screen at the laser for planning, would you be able to perform your tasks? Yes, but it would take a lot of getting used to. I just have doubts about that, I actually need three screens. I deal with scrap pieces, so there needs to be an extra screen at the STOPA where I can see which scrap pieces I need if I no longer have paper. Then there should be screens at both lasers because I need to know what goes to which laser. Why do you need a screen for the scrap pieces? If I don't have paper and I'm working with a scrap piece, I can sometimes forget its dimensions. Then I have to constantly walk back and forth between the laser and the STOPA. Especially when dealing with multiple scrap pieces. Do you have to manually load all those scrap pieces into the laser yourself? Yes, I have to manually take them out of the STOPA and load them into the laser. I've had situations where I had 10 scrap pieces, and with paper, I can see which table has what. But if I only have this information on a screen at the laser, I would have to walk back and forth constantly because I can't remember the dimensions of 10 scrap pieces. So, you look at the paper to see which scrap piece you need? Yes, but it's already programmed. I look on the paper to see which table the scrap piece is on. So, you need a screen at the STOPA for the scrap pieces, and a screen at the laser for planning? Yes. Do you foresee any problems other than getting used to it? No, that will become clear over time.

What do you prefer: a paper-based or digital-based way of working?
I would choose paper; it's just much easier for me.

a. Why do you prefer this?
Because I often take the paper with me. I walk with the scrap piece and sticker sheet to the laser. Then I have all the numbers and information on hand. I can enter it immediately and place the sheet in the laser correctly.

Why do production employees sometimes walk into the office?
When there is a problem with a program, or a sheet is not available. These are things I can't solve myself.

Unboxer:

(1) *Could you describe how and when you use paper during your activities?*
Name programmer gives me paper, this contains the production orders and the cutting programs (stickers). I use the cutting program number to get the right metal plate from the STOPA, then I put this metal plate on the unboxing table. That's all. So, you only need information about the program numbers? Yes, that's true.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V?
No, I think it is all good. You think that everything works perfectly for both your activities as well as the ones from others? What about the distribution and transport of production orders? That's true, that could be more efficient. I think that can solved by going digitally. How? By providing a digital planning.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
With or without the cutting programs with stickers? Because I think for the unboxers it is important to have stickers. Why do you think this? They need to have something for identification and the amount that has been cut. I think this is also important for others at, for example, bench work. Also, if I only get to see the program number, I don't know what parts are being cut. With the stickers, I can.

How do you imagine a paperless order processing at Baas Metaal B.V.?
I have been working here for more than 11 years. The only important thing for me is the program number and orders. Why are the orders important to you? Because sometimes the stickers states that the next adjustment is benching. However, when looking at the drawing you can see that the part is not supposed to go to benching. I know this because of the drawing. So, there is a mistake in the order guidance cart? Yes.

a. *What functionalities would you like to see in a digital order processing?*

I would like to see a digital planning, which shows the cutting programs based on a planning.

What do you prefer: a paper-based- or digital-based-way of working?
A digital way.

b. *Why do you prefer this?*

I have been working with computers a lot, so I am used to them. Would you say that you can do your activities with the stickers and a digital planning projected on a screen? Yes, but unboxers need paper. Why? Or they need a screen. And what kind of information do they require? The same as on the paper. The screen should be right beside the table. They should be able to see that a certain plate contains these specific products that belong to these specific order numbers. So, that's exactly what the stickers do? Yes, that's true. What should be else on the screen? The next adjustment, and whether a product is complete or not. That can also be achieved with the sticker, right? Yes, true. They also need to see an image. If a product is rejected, there should be a button with which an unboxer can reject a product. Now, we write it down on the order. This is brought to *name programmer* who nests the part again according to the planning.

How do you make use of Machine Manager?
I do not make use of Machine Manager anymore. I did it a few years ago, now *name administrative employee* does it. Why do you not use it anymore? Because I don't have time for is. Sometimes I get too much cutting program at much, that is just too much to record in Order Manager. So, you think it cost too much time? Yes, I do. And what if, for example, the unboxers have beside their table their own screen on which they can clock the time themselves? I think that is a good idea. How do you envision this? The unboxer starts the timer, then unpacks one program and stops the time himself. We have done this before. However, I think the software is not good enough. Why? Every unboxing table has its own window. The first two tables are okay, but the third table's window crashed often. But I don't know if that's still the case. This happened before. Do you think this can be implemented again? I can try, but I think it is better for now to let it stay the same. Also, *name colleague* tells me it must be exactly 8 hours per day, but when there are more people working, this becomes more than 8 hours. If a program takes, for example, 1 hour to unpack, I record in the system 15 minutes. But this is not correct. So, you do this to stay under the 8 hours? Yes, that's correct.

(2) Could you describe how and when you use paper during your activities?
We receive a stack of folders with orders. Then, sticker sheets containing three programs for a nest number arrive. This results in three metal sheets, one from each laser. These three sheets are placed on the table, then I look at the sticker(s) that come from the folder and pick out the corresponding part. I apply the sticker to this part. And what happens next? Then, I take the part with the sticker to the next adjustment or expedition. What do you pay the most attention to when receiving a folder? First, I look at the order number on the order guidance card, then I look at the sticker. The sticker indicates the quantity of the order. If I miss anything, I write it on the order and return it to *name programmer*. The most important parts of the sticker for you are the image and the quantity. Would you like to see anything else added here? No, nothing more is needed for unpacking. I write the location on the order guidance card.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V?
No, everything flows smoothly step by step.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
Completely paperless wouldn't be possible; as an unboxer, I need stickers to identify parts. What if the sticker is displayed on a screen? That could work for me, but it might cause issues in the subsequent processes that poorly identify the parts. How would you handle internal rejections if you only have the sticker? That has happened before. I write the quantity of rejection on the sticker and give it to *name programmer*. Does this work well? And where do the good parts go? Yes, it works well. We temporarily place the non-rejected parts on the ground until the order is complete.

How do you imagine a paperless order processing at Baas Metaal B.V.?
I think it's possible to work solely with the stickers. The sticker would then include the quantity, an image, order number, and whether there is a rejection or not. That's important. How do you currently handle a rejection? If there is a rejection, I write the quantity of rejection on the order. This order goes back to *name programmer*, and he reworks the order.

a. What functionalities would you like to see in a digital order processing?
   A sticker that includes at least the quantity, an image, order number, quantity of rejection, location, delivery date, and the next operation.

What do you prefer: a paper-based or digital-based way of working?
Paper is my preference; otherwise, I can't do anything. Do you mean you need at least a sticker? Yes, exactly. This is a minimum requirement.

b. Why do you prefer this?
   Otherwise, I can't do my job well.

Why do production employees sometimes walk into the office?
I walk into the office to report a rejection, but this often happens through the compartment outside the office.

c. Do you think this could be answered without paper too, but in a digital way?
   I'm not sure, but if I can access the system where this is filled in, it might be possible.

How do you make use of Machine Manager?
I'm not familiar with the program. You use it for clocking in, and it provides input for order manager, which represents the status of an order. I don't use this; the times also vary a lot. If there's a sheet with large parts, it can be done within half an hour. But if there's a sheet with many small parts, it can take up to an hour and a half. So, you don't really use the clocking feature? No.

How do you think that the use of Machine Manager during unboxing can be improved?
I think clocking the time is important. Sometimes, I see others spending a whole day on one sheet. That's not feasible. Do you think it's possible for individuals to clock their own time with, for example, a screen next to each unboxing table? I've never done that, and it's not really kept track of. The times also vary a lot.

Benching:

(1) Could you describe how and when you use paper during your activities?
I use paper when I need to pick up a new order; I first scan it. Scanning means that I clock in my operation. After that, I need to check which drawing applies to me, and from the drawing, I see what I need to do exactly. How about the product location? No, not the location. Both the production order and the product have an order number. I read that off. So, you go looking for the product? Yes, indeed. What do you do next with the drawing? I read it to see what I need to do. The drawing indicates whether I need to drill or tap. The drawing shows where to drill or tap and the diameter? Yes, exactly. Do you remember that, or do you keep the drawing next to you? It depends if it's very simple, like 2 drill holes, I remember it. But if there are multiple things, I just keep it next to me. Do you think you can see that from the screen hanging near you? It's possible, but it needs to be zoomable. Sometimes, the drawing is too small indicated. So, the ability to zoom in is a feature you'd like to see in a digital environment? Yes, definitely. Does that also apply to 3D? Yes, but I don't think it's necessary for drilling and tapping. Everything is perfectly readable from a 2D drawing.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V.?
During the observations, you've already mentioned that you find the storage of products unstructured. Are there any other things? The storage of products is my biggest inefficiency point. You have to search for the products every time, which takes a lot of time. Sometimes it can take up to 5 minutes. If products had a fixed location, which is also mentioned on the drawing, that would be great. Also, the clocking of times. Do you also find that inefficient? More that if you digitize it, it could be much easier because you combine everything; the drawings, information, and clocking. Now you must take several steps to complete your tasks completely: looking, searching, clicking, walking, working.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
I don't think I would encounter any issues if the drawings are well-prepared and I can easily access everything.

How do you imagine a paperless order processing at Baas Metaal B.V.?
You have a system on the computer, and from there, you have a list of orders sorted by date. You can then work from top to bottom. When you click on an order, the drawings and other information appear.

a. What functionalities would you like to see in a digital order processing?
A pre-made schedule by date with the drawings and other information attached. It would also be nice if you could clock in directly on the computer. You would press start on the computer, and as soon as you start the next order, the clocking for the previous one stops.

What do you prefer: a paper-based or digital-based way of working?
If you can see everything digitally, that would be great, and paper would no longer be needed. However, it is useful if you have to work somewhere else where there is no screen. What kind of places are these? You have a tapping table where I'm not sure if you can see the screen. So, there might need to be an additional screen? I think so, otherwise, you have to walk. In that case, paper is easier because you can take it everywhere. Or would you say, you actually need a tablet? That's not a bad idea either. Do you see any problems with that? Or maybe a movable screen is an idea? Then you have cables to deal with. A tablet would be the best due to its portability.

Why do production employees sometimes walk into the office?
If I have a drawing that doesn't clearly show what I need to do, sometimes things aren't mentioned. What, for example, isn't mentioned? Whether to tap or drill. What do they show you that makes it clear? They look up the order and then get other information. Sometimes they don't know either, and it's sorted out later. Do you also miss certain measurements? I haven't encountered that often. But I do have situations where I don't know whether to drill or tap. It only shows a hole. Do you think you can see that yourself on the drawing? No, I need someone else for that.

(2) Could you describe how and when you use paper during your activities?
I use paper for clocking in and for reading the drawings, from which I know what I need to make. What do you do with the drawing? I read the dimensions and see where the holes need to be drilled. During the observation, I saw that you often hang up the drawing; what is your reason for this? Otherwise, I would have to keep turning around to the table. So, in case of digitalisation, do you need something close to the machine? Yes, indeed. Something close to the machine's screen. Or would you say, just give me a tablet? A tablet doesn't seem handy because I can't easily place it somewhere close by. So preferably a screen next to the machine? I would put a screen above the milling machine, probably above the lathe as well. Above the machine's control panel? Yes, indeed.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V.?
I don't have any problems with it in my activities; I've been working with it for years. For example, you never have to search for products? No, all products are delivered to my workspace.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
The only issue I would face is not having a screen close to my machine. Are there any other issues? No, not really. I just need to have it at the machine; otherwise, I'm just walking around. Do you think you would face any personal digital problems? No, I can handle that. What do you think about the clocking system? A colleague of yours, for example, would like to start and stop the time themselves. I think it's fine the way it is, I've been used to it for years.

How do you imagine a paperless order processing at Baas Metaal B.V.?
Besides the drawings, I should be able to clock in on the screen; that would be convenient. Then I wouldn't have to keep walking back and forth. Where do you clock now? I clock in at the drilling machine. There used to be a screen in between, but it's broken. So now I walk to the drilling machine, but before, I would go to that screen. How would you feel about having a schedule on your screen?
I already have that. How is it sorted? It's sorted by date, just like the work planners have it. *Name work planner* has that schedule, I believe. Is that on the screen you have at the machine now? No, it was on the screen I had. It's the one that is broken now. I could switch between two tabs where I got the schedule by date, with the most urgent tasks at the top.

a. What functionalities would you like to see in a digital order processing system? Do you see added value in 3D drawings, for example? Sometimes it's useful if certain dimensions are not provided. For example, we sometimes get drawings from a customer that are missing certain dimensions. Work planners then measure the dimensions in SolidWorks, but I could do that myself if they forget something.

What do you prefer: a paper-based or digital-based way of working?
It's always nice if things can be improved. Why do you think digital is an improvement? You can do a lot more via a screen, for example, look at the bending department. They have everything right in front of them. I don't have that yet; I have to keep walking back and forth. Of course, you will always have that to some extent. But if there's already a screen above the machine, it would save a lot of time.

Why do production employees sometimes walk into the office?
When certain dimensions are missing, or I need to order something. Do they then measure it for you? Yes, they use certain programs to determine the dimensions. Or they contact the customer if they can't find it.

b. Do you think this could be answered without paper too, but in a digital way?
If I have the same programs, then yes.

Bending:

(1) Could you describe how and when you use paper during your activities?
What kind of measurements do you need to see in the drawing?
I look at the drawing and the bending dimensions. I get the angles, bending dimensions, and lengths from the drawings. Basically everything. Is this always indicated? It should be, but it's not always the case. Then I have to go to the office. Can you set up the machine based on a complete drawing? Yes, that's correct. I don't need anything else for that.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V?
I am used to it, so I find it works well. Is there nothing you miss in the current system? Not that I can think of quickly. Do you have examples? Suppose there is something unclear in a drawing... Then I go to the office. Exactly, but what if you could solve this uncertainty yourself by taking measurements or seeing the part in 3D? I would like to see 3D. Then you can see what it will look like. I often get a bending drawing, and then I don't know how to start. How would you feel about working from a screen? It would take some getting used to, but eventually, I think it would be fine.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
I don't know. If everything is well detailed in the drawing and you can view everything while working through a plan, do you see any problems? No, I think that would be possible. The only thing I'm worried about is the system crashing. I mean, how often does MKG go down? Also, it should be easy for me to access the drawings. It should not take many actions; this will slow me down.

How do you imagine a paperless order processing at Baas Metaal B.V.?
I imagine that I can view all the drawings, including in 3D, and just work through a planning. But how does it work with locations? How do you see that? I would then link a comment field to each order, so you can fill in the location yourself.

(a) What functionalities would you like to see in a digital order processing?
It would be convenient to measure angles and other dimensions myself, besides the ability to view in 3D. On paper, some things related to bending are not easy to see.

What do you prefer: a paper-based or digital-based way of working?
I prefer working with paper because that's what I'm used to. But if I can access everything easily and everything is worked out properly, I think I can get used to working digitally.

(2) Could you describe how and when you use paper during your activities?
What kind of measurement do you need to see in the drawing?
We get a few orders. Firstly, I look at the order with the same tool (V-groove), because it takes a lot of time to change the V-groove. So, you sort them based on V-groove, instead of delivery date of the customer? Sometimes I sort them on delivery date since this is of course more important, but I try to create a mix of V-groove and delivery date. Do you think those are the most important sorting options? Yes, I do. I think it would be nice to be able to sort them based on V-groove and/or delivery date. What do you think of receiving many orders at the same time? I don't mind, I just sort them and get to work. But sometimes there are red orders as well. What do you do with them? If it is possible I sort them based on V-groove, but this is not always possible since the red orders are urgent at that time. I then ask the shopfloor manager how urgent the order is. If it needs to be done very soon, I will change the V-groove. However, if it could wait a couple hours, I will first do the order with the same V-groove. What kind of information do you get out of the drawings? For bending, we only need a bending drawing. It gives me the length, material, thickness, angle, and the V-groove. I always say to them that it would be nice to receive the customer drawing. You do not receive the customer drawing always? No, but sometimes they do not have the drawing either. Do you want it to be included? Yes, because I can see the length of the product after bending.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V?
I don't know, I have no problems with how it is now. So, if they would go digitally now, you would not see any improvements? Depends on how easy I can find all the information in comparison with now. Because sometimes now, they have folders inside folders. This is quite chaotic. Image, you have your own planning where you can access all the necessary drawings easily, would that work for you? Yes, that would be nice. If I only need to have the order number to access the drawings, that would be an improvement in comparison to now. Do you have to search for the parts yourself, or does *name shopfloor manager* brings them to you? It depends, if I receive a production order and I see the location, I go there and see that the product is not there. Before, it was different, we tried to find the product ourselves. Now, if I can't find the product, I give the production order back and ask if they can find the product. Otherwise, I will lose too much time. Also, sometimes the location is not written correctly. What I don't like is that, with many orders, I need to sign-in and scan many times. Also, I need to fill in the control questions many times, open the drawings, and find the location.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
I do not what order to do first. But what if there is a planning made for you personally? Then I think I would not have any problems. Only if the drawings are completely attached, and I could see them myself. Also, in 3D would be nice.

How do you imagine a paperless order processing at Baas Metaal B.V.?
I can see all the drawings on my screen.

(a) What functionalities would you like to see in a digital order processing?
It would be nice to take measurements myself and see the part in 3D. Also, it needs to be very easy to get to the drawings and it would be nice that a customer drawing is included.

What do you prefer: a paper-based- or digital-based-way of working?
It is better to work via the screen.

(b) Why do you prefer this?
I think it is faster, and that is important for the company. For me, if they give me many orders and I need to look at all the numbers, and sometimes the stickers are not attached to the right product, I make a mistake. This is mainly because the product is just a bit different.

Why do production employees sometimes walk into the office?
Sometimes on the drawing it looks like I only have to bend two times, however this is more and with many products. The time set for this order is then way too low. Also, when something is wrong with a product, I report this. But then I get the comment to do it just like the last time since this went well. However, I think this is not always the right solution. Also, when it is my first time making a certain product and I am not sure what to do exactly, I go to the office. They can see it in 3D.

(c) Do you think this could be answered without paper too, but in a digital way?
Maybe, if we can see it ourselves in 3D.

Welding:

(1) Could you describe how and when you use paper during your activities?
First, I look at the drawings, then I determine where it's best to start. **Do you also write this down on the drawing?** No, I just remember it. But I can also write it down on paper so that someone else can follow the same process. The problem is that the drawing gets thrown away. So, if the drawing doesn't come to the office and no copy is made, the notes are lost, and you have to start over. **What do you think of the drawings in general?** In some cases, you really need a larger drawing so you can see the dotted lines and the backside more clearly. **Are you referring to complex welding work, or also to detailed work?** Both detailed and complex, but nowadays we already have the detailed ones on the computer. **Do you think all of this could be digital?** Complex cases might be difficult. But I think, in some ways, it could work and in others, it couldn't. For example, I prefer paper because I can place it next to the product. I obviously can't take the whole screen with me. **So, you would need something portable?** Yes, something like a tablet. **And why do you think it could work digitally?** Some things, like dotted lines, can indeed be displayed digitally. You can't always see this on the paper drawing.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V.?
For certain standard products, the welding instructions are no longer provided because we know them by heart. For *name customer*, you know it has to be blasted, but this isn't indicated on the order. **So, you're saying that sometimes certain processes are missing from the order guidance card?** Yes. It needs to be clearer about what needs to be done.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
That remains to be seen in practice. **So, you don't foresee any issues like difficulties with the drawings for now?** We'll have to experience it first.

How do you imagine a paperless order processing at Baas Metaal B.V.?
Everything runs through screens; we can view the drawings on them. **And how do you see the time clocking process working?** I don't know. Time clocking doesn't always work. If you clock in once and then clock out to work on something else, you can't clock in again. You must enter everything manually, which takes a lot of time.

(a) **What functionalities would you like to see in a digital order processing system?**
I'd like to see everything possible. You can rotate the product, bring it closer, measure things, and determine angles.

What do you prefer: a paper-based or digital-based way of working?
I prefer paper, but if it can't be helped, then digital. You'll naturally see what you run into. You can always print it out if needed.

(b) **Why do you prefer this?**
I can more easily look at both the product and the drawing at the same time.

Why do production employees sometimes walk into the office?
This happens because they have uncertainties about the drawing, but this doesn't really happen with us.

(2) Could you describe how and when you use paper during your activities?
Constantly, all orders go through paper. I get an order from a shopfloor manager which includes the drawings. Additionally, I get a pallet with all the parts that need to be welded together. Do you sometimes have to look things up yourself? Yes, usually. Everything should be prepared and ready, but this is not always the case. And how about clocking in since there is no screen at your workbench?
I walk to the screen on the wall, but the clocking in does not work as it should. Why does it not work now? It used to be different. Suppose I clock in on an order, the previous operations are then completed and marked as done, if something came up in between, I could stop it in the program. It would then indicate that it was not yet completed, but temporarily not being worked on. But since an update from MKG, that is no longer possible. If I do something else and later want to clock in again, I get the message that the operations are already completed. It eventually works via a workaround. But for clocking in, I no longer scan barcodes, I manually enter the order number and then clock in my time via a workaround. This can only be done if it has not yet passed the expedition stage. I find it a bit nonsensical, but it is apparently necessary for the laser or something like that. I do not know exactly. So, you would like to see another way of clocking in? I would like it to be the way it was before, that seemed clear to me. For example, sometimes it was reported as not completed, and then I could not clock in. You had to solve this in the office. The best thing is that you can start and stop clocking in whenever you want. You should then also be able to clock in again later on the same product and eventually mark it as completed. But it apparently has to be marked as completed to be visible on other screens.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V.?
I have to do a lot of actions for clocking in my times; which operation, unlinked... Can't you just scan the barcode to start clocking in? That is how it should be. I then have a package, I scan them all, and then I make a cluster of them if possible. What do you mean by a cluster? Those are almost all the same products from usually the same customer. But this can only be done if there is no operation in between.

What would you encounter if Baas Metaal B.V. implements a paperless order processing? Imagine you have a screen where you can see a schedule that you can work through, you get all your required products at your table, you can start the time yourself and locations are listed in the system. The drawings are available in both 2D and 3D, in which you can take measurements yourself. What else do you get from the drawing? Yes, basically everything that is on the drawing could also be on a screen. We always just take the drawing, and if we really do not know, we look at it in 3D. Often it is just looking, but some cannot even read a drawing. What do you think of the drawings? Some people find them, for example, too small. I can still read small letters well, but sometimes the lines overlap. Then you need a larger drawing, but that is not always easily provided. On a larger drawing, you see everything much more easily. But via a screen does not seem great either. Why not? You just have the drawings in front of you, and you can easily draw on them. If you have the customer's drawing and ours, and then a 3D model on the screen, that would be convenient.

How do you imagine a paperless order processing at Baas Metaal B.V.?

a. What functionalities would you like to see in a digital order processing?

I think you welders also need 3D drawings? Yes, indeed. Sometimes something is not included, and you can measure it yourself. Only the program cannot do everything. And sometimes the files are not correct either. Are you familiar with SolidWorks? I have seen it often enough, but you just need to know where the actions are. The locations must also be correctly reported. You should determine the locations digitally with a mobile device. I have often had to search for products for a long time here, also because previous operations do not correct the location after they have taken it. What would you think if this process were done manually? After reporting the operation as completed, you get asked where you placed the product. If your workshop is well divided into sectors, and if it is too full, you place it at the expedition, then this could also work. If the locations can be recorded correctly in some way, it would save a lot of time. I think, before you switch to paperless, you need to be able to record the locations well.

What do you prefer: a paper-based or digital-based way of working?

I tend to prefer paper. I can easily place them next to each other. If there is a screen behind me, you are constantly turning around. You can also easily turn a drawing next to the product. Sometimes it is also useful to place the customer's drawing next to it. Then you sometimes get different insights. What do you think of working with a tablet? At the bending machine, it might be convenient, but for welding, I do not think so. It would rather get in the way with the fire.

Expedition:

(1) Could you describe how and when you use paper during your activities?
I gather the main orders together, and for the copy orders, you need paper. I also often make notes on paper. Do you still sort the orders like *name colleague* does? Not much anymore, I used to. If I have extra time, I might help them out. How do you keep track of the orders? With the help of markings. What do you mean by this? Where they place them. Everything has a number; for example, they put 65 on the order, and then I know that everything is there. Everything is then also on that pallet. Once all the copy orders are reported ready, you can weld everything togehter. The copy orders are initially not reported ready. The copy orders come to me separately in a folder holder until everything is together, then everything is welded, and eventually, the main order is reported ready. You want to move to a system where it's intended to report each copy order ready and then also the main order ready. That's correct. *See last question*.

What are the main pain points or inefficiencies with the current paper-based way of working at Baas Metaal B.V.?
I think it works quite well. And all that sorting of the orders? Ideally, everything should come directly from the laser onto a pallet. What do you mean? Then one of us would have to walk less, but only good products should be put in there (at the expedition) because you have different people here all the time. It often happens now that an order that is not yet completely cut ends up in our storage. And the production order then also ends up in my folder holder. We then think the order is complete. They just don't pay attention when unpacking. That's why we have to check everything after each operation.

What would you encounter if Baas Metaal B.V. implements a paperless order processing?
I walk around a lot with paper, so I think it would be easy to have something portable like a tablet. You could then use a QR code, or something similar, to check which product it is. But also see when it was cut and from which sheet. Do you think it's possible to work only with stickers? I think so. Each department would then have a screen with planning to which the production orders with drawings can be linked. Then small products would have to be stored separately from the large products. What do you mean? A different way of storage so that those products don’t get mixed up. This mainly applies to cutting, where small and large parts are placed together. Do you think this can be solved by linking an online location to it? After you report something ready, you would have to add a location to it in a certain way. I wouldn't know.

How do you imagine a paperless order processing at Baas Metaal B.V.?
I see everything on the screens. Only with making notes, I wouldn't know how. What kind of notes do you make? Driving schedules, things I shouldn’t forget, etc. This can be solved with a comment field visible to the different departments. But will everyone get screens then? That's possible. Why not use a QR code that everyone can scan? Where you can scan which cabinet you place a product in. That could work, but the stickers are necessary for identification and to prevent misunderstandings, in my opinion. This would also mean everyone needs to have a device. Couldn’t one person do it? Do you think one person can handle your order volume? That would mean you and *name colleague* would constantly have to walk with products between different departments. Then you let ten different people do it. But then you have ten people walking with products? At the bending machine, for example, you could place a cart, then you put everything in that cart, and one of them goes to walk. Do you think someone would take this on? I think that's one of the things that would work without paper. Just scan a sticker and link an online location to it. No need to search anymore. So, two QR codes? Yes, one on the product and the other on the rack.

How do you imagine dealing with copy and main orders digitally?
I've been told you want to work with scraps where each production line can be reported ready separately. I'm open to everything. How do you see this? I think it would be handy. Because then I can also see exactly which sheet has already been cut if, for example, sheets of different thicknesses are needed for a product. If things can be reported ready separately, that would be useful. From a copy order? Yes, indeed. But on the other hand, I don't really know what benefit it brings. How does it work now? We check it off ourselves. Later, you can see what's still missing before you can weld the order. Or do you see problems with this? We basically do the same thing now; only it would be more convenient for the office employees. They can see in the system how things are going and better inform the customer. Because you do everything on paper now? I chase after the products myself, and if something is complete, I check it off on paper by putting a number on it. This reflects the location. Whether I see that it's ready on a screen or on paper doesn't matter to me.

APPENDIX I: LABOUR PRODUCTIVITY OBSERVATIONS

Work planners

Observation Schemes			
Department:	Work Planning		
Sample size:	3		
Date:	21-5-2024		
Time:	15:25:00 - 15:55:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	589		
Observed time paper waste activity (sec):	589		
Observed #1			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Adjusting drawing customer	402	Adjusting customer drawings	302
Checking mail	17	Processing data	50
Waitig for printing order	17		
Answering questions colleague	68		
Putting order in folder	26		
Checking mail	20		
Talking to colleague	118		
Processing data	159		
Waitig for printing order	14		
Refill paper printer	77		
Printing orders	91		
Putting orders in folders	149		
Transporting order to programmer	215		
Talking to colleague	37		
Checking mail	38		

Observation Schemes			
Department:	Work Planning		
Sample size:	3		
Date:	22-5-2024		
Time:	07:49:00 - 08:19:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	816		
Observed time paper waste activity (sec):	816		
Observed #2			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Processing invoices	230		
Planning order Ordermanager	44		
Printing orders	48		
Putting orders in folders	208		
Sending order confirmation	170		
Putting order in compartment	10		
Processing orders	540		
Printing orders	160		
Explanations to colleague	208		
Putting orders in folders	182		

Observation Schemes			
Department:	Work Planning		
Sample size:	3		
Date:	23-5-2024		
Time:	09:20:00 - 09:50:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	38		
Observed time paper waste activity (sec):	38		
Observed #3			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Checking orders	38		
Purchasing parts projects	198		
Gathering files order	216		
Processing orders	164		
Calling customer	152		
Checking mail	49		
Calling customer	199		
Changing format drawings	21		
Completing drawings	232		
Executing calculations	105		
Checking mail	222		
Executing calculations	220		

Programmer

Observation Schemes			
Department:	Programmer		
Sample size:	2		
Date:	24-5-2024		
Time:	13:26:00 - 13:56:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	809		
Observed time paper waste activity (sec):	697		
Observed #1			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Going through orders	108	Putting stickers in folders	10
Making nest	65	Transporting folders	231
Sending mail	32	Sorting orders	28
Checking nest programs	105	Making nest	192
Printing stickers	32	Printing stickers	20
Adjusting settings nest programme	168	Putting stickers in folders	30
Starting program laser	59	Transporting folders	160
Transporting production order	84		
Talking to colleague	55		
Looking at orders	10		
Starting program laser	153		
Checking laser	83		
Going through orders	76		
Making nest	79		
Printing stickers	20		

Observation Schemes			
Department:	Programmer		
Sample size:	2		
Date:	27-5-2024		
Time:	09:05:00 - 09:35:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	484		
Observed time paper waste activity (sec):	354		
Observed #2			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Process internal rejection	42	Checking execution	218
Transporting folders	56	Printing sticker	16
Sorting orders	17	Putting in folder	10
Going through orders	43	Transporting folder	44
Making nest	133	Starting program laser	177
Printing stickers	14	Transporting folders	17
Putting stickers in folders	10	Going through folders	90
Transporting folders	10	Making nest	220
Starting program laser	29	Checking execution	112
Checking execution	160		
Talking to colleague	28		
Transporting folders	89		
Sorting orders	22		
Going through orders	46		
Making nest	197		

Laser

Observation Schemes			
Department:	Laser		
Sample size:	2		
Date:	22-5-2024		
Time:	15:07:00 - 15:37:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	20		
Observed time paper waste activity (sec):	0		
Observed #1			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Starting programm laser	35		
Dealing with material residual	166		
Unloading cutted sheet	79		
Requesting metal plate	70		
Filling laser with metal plate	231		
Looking at stickers	20		
Starting programm laser	149		
Checking execution	632		
Requesting metal plate	101		
Transporting metal plate	147		
Filling inventory	170		

Observation Schemes			
Department:	Laser		
Sample size:	2		
Date:	24-5-2024		
Time:	10:34:00 - 11:04:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	78		
Observed time paper waste activity (sec):	0		
Observed #2			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Requesting metal plate	82		
Filling laser with metal plate	251		
Looking at stickers	34		
Starting programm laser	128		
Filling inventory	348		
Checking execution	298		
Requesting metal plate	114		
Transport metal plate to unboxer	58		
Looking at stickers	44		
Starting programm laser	146		
Checking execution	297		

Unboxing

Observation Schemes			
Department:	Unboxing		
Sample size:	3		
Date:	21-5-2024		
Time:	13:38:00 - 14:08:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	259		
Observed time paper waste activity (sec):	129		
Observed #1			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Unboxing	42	Unboxing	629
Attatching stickers	58	Attatching stickers	67
Transporting part to pallet on ground	50		
Searching for new stickers	15		
Unboxing	175		
Removing residual metal plate	50		
Unboxing	30		
Searching order	50		
Talking colleague	60		
Transporting part to pallet on ground	30		
Unboxing	220		
Attatching stickers	40		
Transporting part to pallet on ground	191		
Search order	29		
Transporting part to pallet on ground	54		

Observation Schemes			
Department:	Unboxing		
Sample size:	3		
Date:	23-5-2024		
Time:	10:18:00 - 10:48:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	744		
Observed time paper waste activity (sec):	0		
Observed #2			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Putting parts in bags	72		
Packing parts on pallets	86		
Applying stickers	54		
Packing parts on pallets	868		
Applying stickers	412		
Making notes on production orders	278		
Bringing parts to next process	30		

Observation Schemes			
Department:	Unboxing		
Sample size:	3		
Date:	24-5-2024		
Time:	11:21:00 - 11:51:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	252		
Observed time paper waste activity (sec):	38		
Observed #3			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Remove residual plate	43	Removing residual plate	75
Looking at orders	38	Looking at stickers	10
Packing parts on pallet	370	Placing parts on pallet	237
Looking at stickers	12	Applying stickers	65
Applying stickers	5	Prepare pallets	32
Packing parts on pallet	95	Looking at stickers	6
Applying stickers	35	Placing parts on pallet	132
Looking at stickers	28		
Remove residual plate	58		
Packing parts on pallet	371		
Looking at stickers	10		
Packing parts on pallet	40		
Applying stickers	30		
Packing parts on pallet	90		
Looking at stickers	13		

Bending

Observation Schemes							
Department:	Bending						
Sample size:	4						
Date:	14-5-2024						
Time:	08:28:00 - 08:58:00						
Observed time (sec):	1800						
Observed time paper activity (sec):	410						
Observed time paper waste activity (sec):	130						
Observed #1							
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**	**Activity:**	**Time (sec):**	**Activity:**	**Time (sec):**
Bending	49	Changing V-groove	41	Bending	60	Measuring	5
Filling in control questions	20	Measuring	22	Filling in control questions	30	Setting up machine	10
Setting up machine	24	Bending	16	Transporting production order	30	Bending	5
Changing V-groove	38	Measuring	10	Watching drawings	15	Product re-preparation	150
Watching drawing	46	Bending	30	Picking up part	45		
Bending	26	Filling in control questions	28	Logging in Shopfloor	15		
Measuring	27	Transporting production order	31	Talking with colleague (unreleated)	45		
Bending	20	Logging in Shopfloor	21	Setting up machine	49		
Bending	140	Watching drawing	20	Undefined	45		
Measuring	30	Setting up machine	66	Changing V-groove	66		
Bending	72	Bending	34	Setting up machine	27		
Filling in control questions	52	Measuring	10	Bending	30		
Transporting to expedition	45	Setting up machine	10	Measuring	11		
Logging in Shopfloor	57	Bending	10	Setting up machine	11		
Talking with colleague (unreleated)	125	Measuring	10	Bending	11		

Observation Schemes							
Department:	Bending						
Sample size:	4						
Date:	15-5-2024						
Time:	11:35:00 - 12:05:00						
Observed time (sec):	1800						
Observed time paper activity (sec):	670						
Observed time paper waste activity (sec):	411						
Observed #2							
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**	**Activity:**	**Time (sec):**	**Activity:**	**Time (sec):**
Drilling	200	Watching drawing	45	Logging in Shopfloor	13		
Setting up machine	19	Asking clarification	142	Changing V-groove	65		
Bending	53	Logging in Shopfloor	14	Setting up machine	25		
Measuring	48	Setting up machine	22	Bending	53		
Filling in control questions	19	Bending	30	Measuring	15		
Logging in Shopfloor	20	Measuring	18	Bending	40		
Watching drawing	24	Bending	29	Measuring	15		
Changing V-groove	45	Measuring	9	Searching for new gloves	45		
Setting up machine	24	Bending	24	Filling in control questions	43		
Bending	109	Measuring	12	Transporting production order	50		
Measuring	24	Talking to colleague	26	Talking to colleague (unrelated)	30		
Bending	128	Filling in control questions	14				
Measuring	22	Transporting production order	32				
Filling in control questions	19	Watching drawing	1				
Transporting production order	50	Asking for new drawing	184				

Observation Schemes			
Department:	Bending		
Sample size:	4		
Date:	16-5-2024		
Time:	13:47:00 - 14:17:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	0		
Observed time paper waste activity (sec):	0		
Observed #3			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Bending	301		
Placing on pallet	189		
Bending	373		
Talking with colleague (related)	24		
Bending	522		
Placing on pallet	112		
Bending	279		

Observation Schemes			
Department:	Bending		
Sample size:	4		
Date:	17-5-2024		
Time:	15:45:00 - 16:15:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	327		
Observed time paper waste activity (sec):	203		
Observed #4			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Bending	241	Setting up machine	54
Filling in control questions	49	Bending	12
Transport production order to expedition	30	Measuring	20
Transport part to next process	140	Resetting machine	30
Looking at drawing	50	Making calculations + measuring	50
Changing V-groove	50	Resetting machine	40
Setting up machine	40	Bending	62
Searching part storage	60	Measuring	50
Bending	40	Resetting machine	13
Measuring	60	Bending	65
Filling in control questions	20	Measuring	12
Transporting production order	70	Bending	58
Looking at drawings	30	Filling in control questions	34
Searching part storage	80	Cleaning	296
Looking at drawings	44		

Benching

Observation Schemes			
Department:	Benching		
Sample size:	3		
Date:	22-5-2024		
Time:	08:38:00 - 09:08:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	997		
Observed time paper waste activity (sec):	363		
Observed #1			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Logging into Shopfloor	20		
Getting new drawing	363		
Searching part	77		
Tapping	585		
Storing part	43		
Logging into Shopfloor	17		
Looking at drawing	140		
Asking clarification	447		
Logging into Shopfloor	10		
Searching part	70		
Tapping	30		

Observation Schemes			
Department:	Benching		
Sample size:	3		
Date:	23-5-2024		
Time:	08:42:00 - 09:12:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	62		
Observed time paper waste activity (sec):	0		
Observed #2			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Looking at drawing	38	Setting up machine	113
Setting up machine	80	Benching	107
Starting program	8		
Checking execution	134		
Fixing error machine	284		
Benching	337		
Changing settings machine	30		
Benching	59		
Adjusting error product	65		
Measuring	15		
Benching	215		
Measuring	45		
Benching	228		
Looking at drawing	24		
Searching part	18		

Observation Schemes			
Department:	Benching		
Sample size:	3		
Date:	24-5-2024		
Time:	10:59:00 - 11:29:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	40		
Observed time paper waste activity (sec):	0		
Observed #3			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Searching for part	330		
Benching	1070		
Looking at orders	33		
Placing adjusted order on pallet	120		
Looking at orders	7		
Transporting order to expedition	150		
Benching	90		

Welding

Observation Schemes			
Department:	Welding		
Sample size:	3		
Date:	17-5-2024		
Time:	14:54:00 - 15:24:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	87		
Observed time paper waste activity (sec):	55		
Observed #1			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Welding	15		
Adjusting	10		
Welding	95		
Adjusting	20		
Welding	200		
Adjusting	29		
Welding	191		
Adjusting	16		
Grabbing new part	24		
Welding	770		
Checking	104		
Filling in control questions	32		
Packing parts	124		
Transporting production orders to expedition	55		

Observation Schemes			
Department:	Welding		
Sample size:	3		
Date:	21-5-2024		
Time:	13:05:00 - 13:35:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	0		
Observed time paper waste activity (sec):	0		
Observed #2			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Welding	130		
Checking	30		
Talking to colleague	40		
Welding	150		
Checking	10		
Welding	363		
Changing tungsten	27		
Welding	335		
Sharping tungsten	45		
Welding	403		
Adjusting	47		
Welding	220		

Observation Schemes			
Department:	Welding		
Sample size:	3		
Date:	28-5-2024		
Time:	10:18:00 - 10:48:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	57		
Observed time paper waste activity (sec):	44		
Observed #3			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Welding	184		
Looking at drawing	13		
Checking	39		
Transporting production orders to expedition	44		
Grabbing new part	31		
Welding	255		
Checking	22		
Welding	154		
Checking	32		
Welding	220		
Checking	21		
Changing tungsten	36		
Welding	586		
Checking	163		

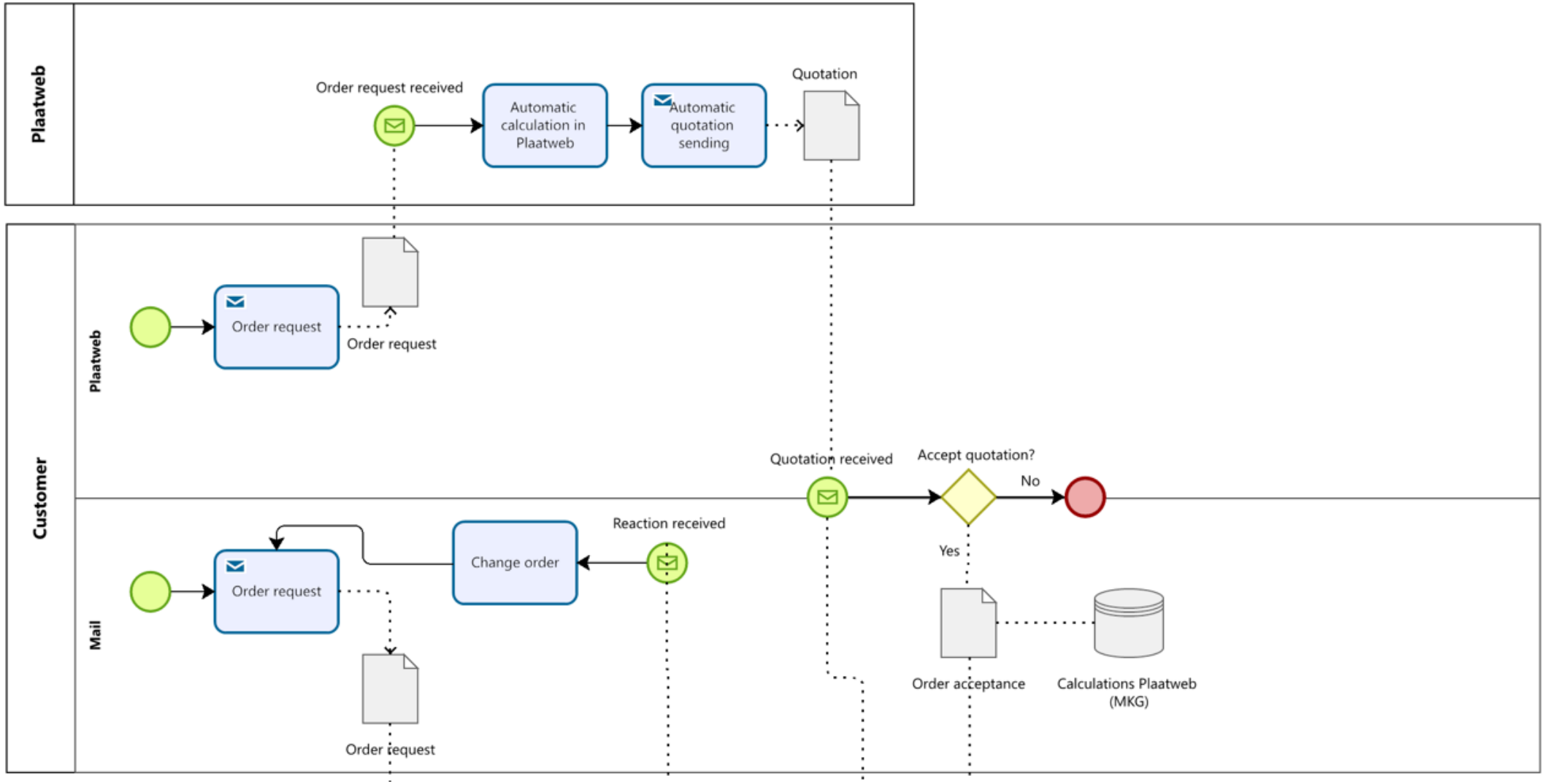
Expedition

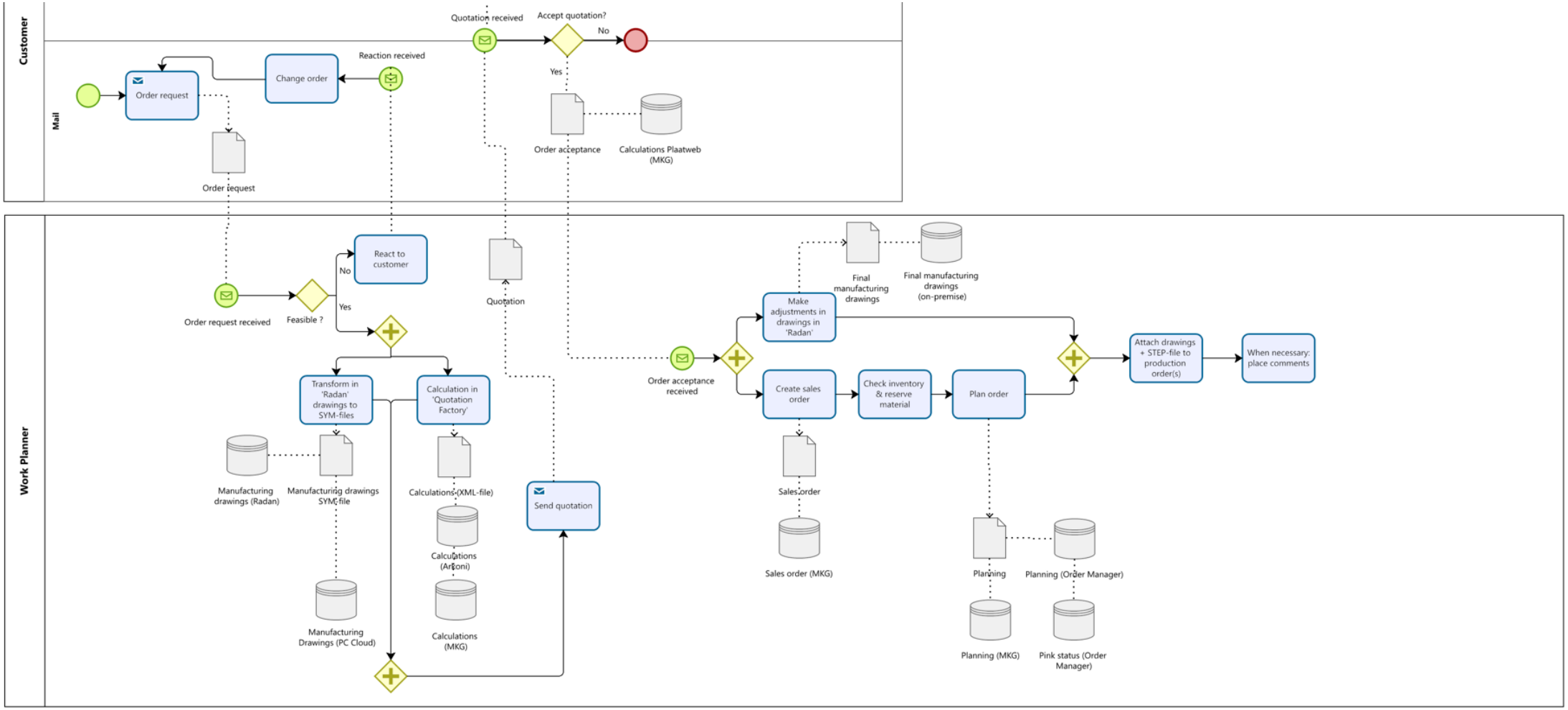
Observation Schemes			
Department:	Expedition		
Sample size:	3		
Date:	27-5-2024		
Time:	15:41:00 - 16:11:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	480		
Observed time paper waste activity (sec):	180		
Observed #1			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Checking product	223	Packing parts	133
Asking help	67	Talking to colleague	189
Looking at drawing	50	Looking at drawings	79
Checking product	188	Collecting parts	121
Looking at drawing	24		
Checking product	85		
Reporting order ready MKG	25		
Checking if order is complete	18		
Arranging production orders	159		
Looking at drawings	29		
Collecting parts	83		
Arranging orders	21		
Reporting order ready MKG	26		
Looking at drawings	67		
Collecting parts	213		

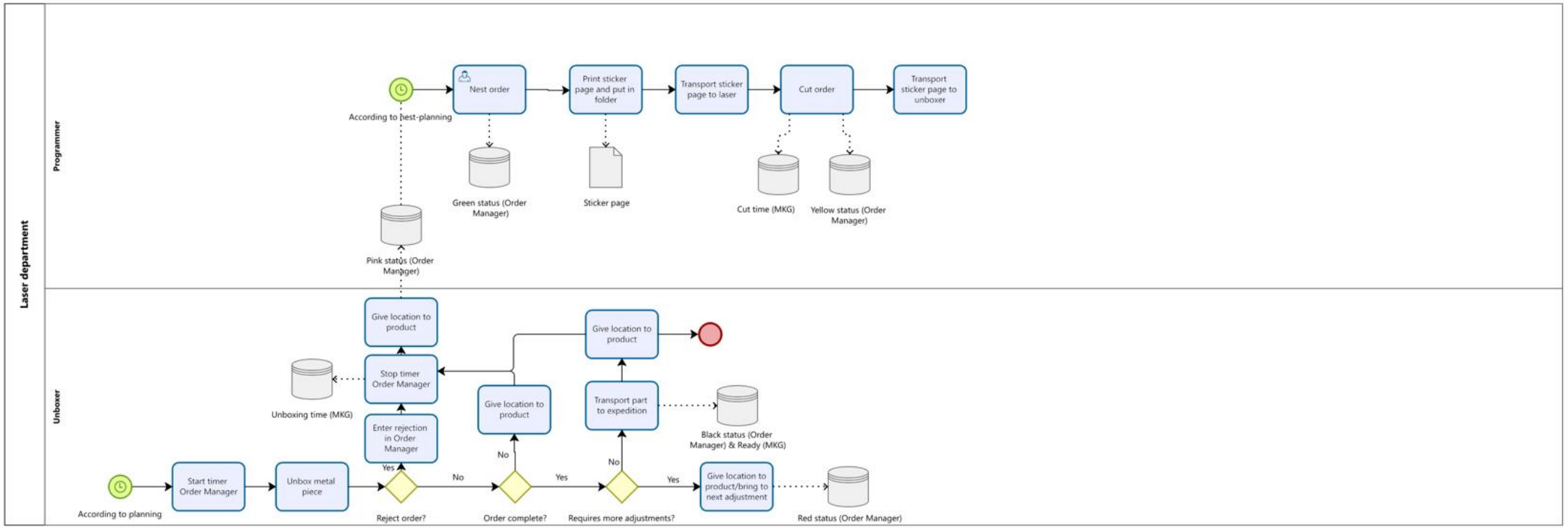
Observation Schemes			
Department:	Expedition		
Sample size:	3		
Date:	28-5-2024		
Time:	11:10:00 - 11:40:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	1670		
Observed time paper waste activity (sec):	1349		
Observed #2			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Reporting ready MKG	32	Reporting ready MKG	57
Arranging production orders	78	Checking if order is complete	23
Checking if order is complete	11	Packing parts	130
Arranging production orders	57		
Checking if order is complete	24		
Arranging production orders	78		
Checking if order is complete	28		
Arranging production orders	232		
Checking if order is complete	38		
Arranging production orders	325		
Checking if order is complete	72		
Reporting ready MKG	17		
Arranging production orders	257		
Checking if order is complete	19		
Arranging production orders	322		

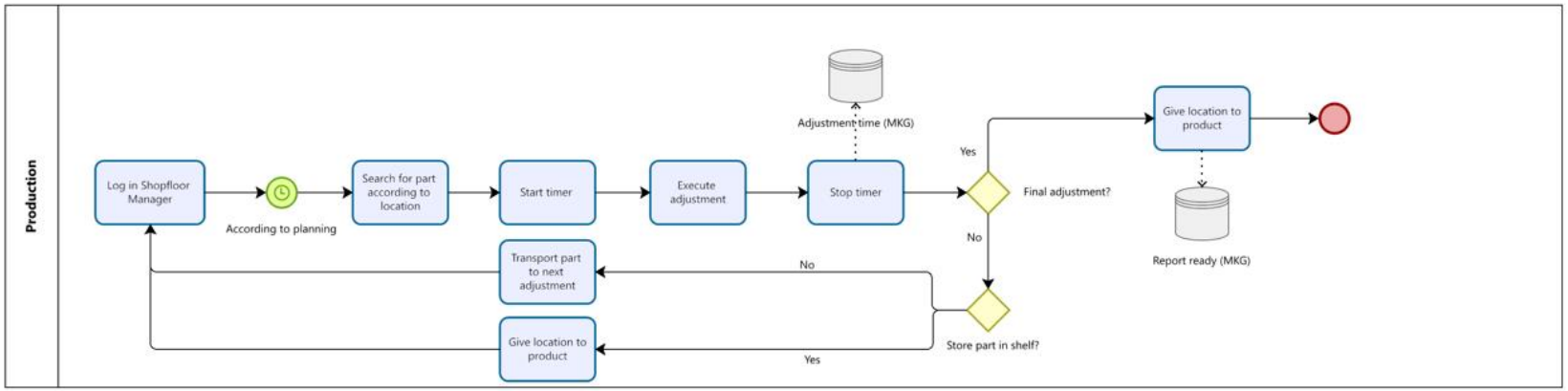
Observation Schemes			
Department:	Expedition		
Sample size:	3		
Date:	29-5-2024		
Time:	14:50:00 - 15:20:00		
Observed time (sec):	1800		
Observed time paper activity (sec):	370		
Observed time paper waste activity (sec):	258		
Observed #3			
Activity:	**Time (sec):**	**Activity:**	**Time (sec):**
Transporting parts	189		
Distributing production orders	37		
Arranging production orders	195		
Checking if order is complete	58		
Reporting order ready MKG	15		
Looking at drawings	22		
Collecting parts	201		
Packing parts	227		
Talking to colleague	140		
Looking at drawings	17		
Collecting parts	209		
Packing parts	189		
Talking to colleague	74		
Transporting parts	201		
Distributing production orders	26		

APPENDIX J: BPMN-MODEL NEW ORDER PROCESSING




Customer
Mail
Order request
Change order
Reaction received
Quotation received
Accept quotation?
No
Yes
Order acceptance
Calculations Plaatweb (MKG)
Order request
Work Planner
Order request received
Feasible ?
No
Yes
React to customer
Quotation
Transform in 'Radan' drawings to SYM-files
Calculation in 'Quotation Factory'
Manufacturing drawings (Radan)
Manufacturing drawings SYM-file
Calculations (XML-file)
Calculations (Arboni)
Calculations (MKG)
Manufacturing Drawings (PC Cloud)
Send quotation
Order acceptance received
Make adjustments in drawings in 'Radan'
Final manufacturing drawings
Final manufacturing drawings (on-premise)
Create sales order
Check inventory & reserve material
Plan order
Sales order
Sales order (MKG)
Planning
Planning (Order Manager)
Planning (MKG)
Pink status (Order Manager)
Attach drawings + STEP-file to production order(s)
When necessary: place comments


Laser department
Programmer
According to nest-planning
Nest order
Print sticker page and put in folder
Transport sticker page to laser
Cut order
Transport sticker page to unboxer
Green status (Order Manager)
Sticker page
Cut time (MKG)
Yellow status (Order Manager)
Pink status (Order Manager)
Unboxer
Give location to product
Stop timer Order Manager
Unboxing time (MKG)
Enter rejection in Order Manager
Give location to product
Give location to product
Transport part to expedition
Black status (Order Manager) & Ready (MKG)
According to planning
Start timer Order Manager
Unbox metal piece
Reject order?
Yes
No
Order complete?
No
Yes
Requires more adjustments?
No
Yes
Give location to product/bring to next adjustment
Red status (Order Manager)


Production
Adjustment time (MKG)
Log in Shopfloor Manager
According to planning
Search for part according to location
Start timer
Execute adjustment
Stop timer
Final adjustment?
Yes
No
Give location to product
Report ready (MKG)
Transport part to next adjustment
No
Store part in shelf?
Give location to product
Yes

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