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AN ANALYSIS OF THE SECTION BUILDING PROCESS AT DAMEN SHIPYARDS GALATI

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Internship report

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INTERNSHIP REPORT

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Summary

This report is the result of a three month internship at Damen Shipyards Galati, Romania. During the internship research has been conducted into a part of the shipbuilding process: section building. This report consists of a product- and process description and a process analysis. Almost all of the information has been obtained by observing the yard and interviewing engineers and workers in Galati. This together with the expertise of de supervisors from Damen Gorinchem resulted in a advise report with both small and larger improvements. Improvements are for instance new planning methods, different building floors, implementation of guidelines for storing parts and changes in the structuring of documentation. All of the results of this research have been presented to the managing staff of the Yard and have been discussed with the workforce who will have to use the improvements. Both were sceptical at first but due to a lot of investment in the personal relations always kept an open mind towards the proposed changes. Although the implications of the changes need to be investigated in the field, this reports servers as a guideline for the future improvements of the section building process of the Damen Shipyards Galati yard.

Contents

Chapter 1

Introduction

Within the shipbuilding industry, Damen Shipyards Group is an well-known name. Starting out with one yard in 1927, the company has grown to become a multi-billion company with 33 yards, 9000 employees and 219 vessels delivered in 2016. Largely responsible for this growth is the introduction of highly standardised ships. This resulted in the possibility to build hulls in advance and create a stock which reduced the delivery times substantially. Nowadays Damen Shipyards Group has a lot of different types of vessels, ranging from standardised Tugs and workboats to one-off Navy ships.

The Galati shipyard was founded in 1893 and since its incorporation into the Damen Shipyards Group in 1999 it has been the largest yard within the group. Although sales and engineering is provided by the group, the Galati yard is self-managing regarding the production process. The 2400 employees managed to deliver 24 vessels in 2016. Many different types of vessels are produced in Galati: tugs, patrol ships, Platform Supply Vessels, crane barges, oil tankers, Antarctic Supply Research Vessels, mobile dry docks, Fisheries Research Vessels and much more.

The building process in Galati is comparable with the process in most of the other yards. It is split up in different steps. One of these steps is “section building”. In this process, different panels, sub assemblies and other parts are put together to create a three dimensional part of the hull. These sections are combined into blocks. These blocks will be put together to form a hull.

Although the panel line is currently the bottleneck of the operation, the focus of this project will be on the section building process. This current efficiency of the process leaves room for improvement. By mapping and analysing the flow of information and materials, opportunities for streamlining the process can be found. This should eventually result in a more effective process.

To perform the analysis, inspiration is sought within the lean manufacturing philosophy. Although this methodology is not fully applicable on the process at hand, it can form a basis from which to start. In the analysis of the process, the following steps will be taken:

- A full definition of the product, a section, and its subcategories
- Creating an overview of the required materials and input buffers
- Creating an overview of the required information
- Creating an overview of the production process
- What output product is desired by the customer
- Creating a overview of the entire section building process
- Analyzing the process and its strengths and weaknesses to find opportunities for improvement

The report starts with the problem definition and research method. after which the product is defined. Then the process will be described in depth. Based on this description, a analysis will be performed. This analysis will include recommendations which are summarised together with the conclusion of the report.

1.1 Problem definition

To be able to stay competitive in the shipbuilding industry, efficiency is key. Although Damen Shipyards Galati (DSGa) is the most maturely organised shipyard within the Damen Commercial New Build Division (CNBD), the Yard Support department sees room for improvement in the section building area. This important process is the most time consuming process in the Hull division and uses considerable floor space and crane capacity. Productivity is a function of processes, organisation and facilities. Due to the investments needed to improve the facilities, which is currently not available, this research will focus on processes and organisation. To be able to research multiple possible ways to reach a more streamlined process, the following research question has been defined:

"What are possible improvements of the input flow of materials, flow of information and the assembly process to create an output of higher quality and quantity of the section assembly department?"

To be able to give a proper answer to this question, the following sub-questions are formulated:

1. What is the current input flow of materials?

2. What is the current input flow of information?

3. How is the assembly process currently performed?

’ Research to find answers to the questions stated above will be carried out according to/following the research method defined in the next chapter.

1.2 Research method

The base of this research will be shaped by the principles of the “lean manufacturing” philosophy. Lean is a management methodology developed by the Toyota car company. The goal of this method is to decrease the waste within a production process and create a flow of products. It must be noted that lean is a methodology which is highly applicable on mass production and strongly reduces the possibilities for product variety. A shipbuilding characteristic is that the number of produced ships per series are small. DSGa products range from standard tugs to one-off offshore and navy vessels. However, processes to build these ships are similar/comparable, which makes the Lean philosophy very well applicable for the process.

According to the lean philosophy, two main types of activities can be determined. Value-adding activities and non value-adding activities, better known as waste. In order to increase the efficiency of a process, the waste must be eliminated as much as possible. This will lead to a decrease in interim product lead time and an increase in productivity , thus higher capacity of the section building. A more streamlined process will also lead to a higher quality of the product and reduces the workload.

To be able to properly analyse the current state, the current process will be modelled with the use of flowcharts. This procedure forms the guideline to follow during this analysis. Currently the process is a black box, see fig. 1.1. Materials and information goes in and after the process a section is the output. The specifics/specifications of these input and process flows is yet to be known. To obtain a complete view of the process, the following steps will be taken:

1. Determining the product definition

2. Creating an overview of the current process as well as information and material flows

3. Analysing the current section building process in detail

4. Recommending process improvement

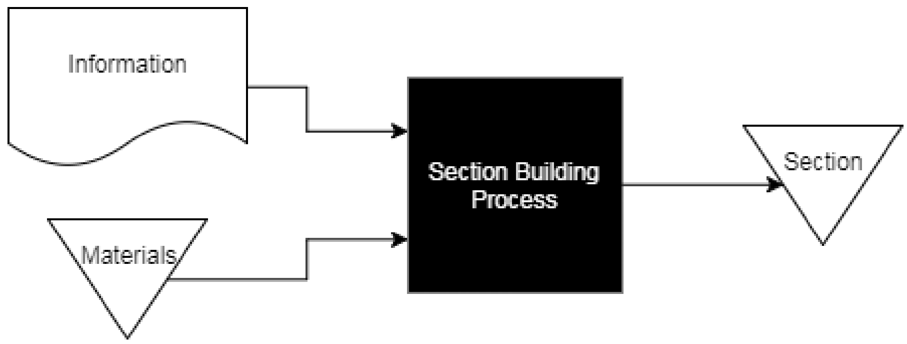


Figure 1.1: Process as black box

1.2.1 Determining the product definition

To be able to determine the boundaries of the research, the boundaries of a section need to be defined. To do so the following questions need to be answered:

1. How is a section defined?
2. What are the existing types of sections and how are they currently defined?
3. Which general steps are required to produce a section?

This product definition will be used to determine the boundaries of the further analysis.

1.2.2 Creating an overview of the current process as well as information and material flows

In order to analyse the current situation, a overview of the process is required. This will be split up in two main parts: the logistics flow and the process flow. To obtain information about these flows, observations at production will be done, as well as information gathered from meetings with foremen and the head of section building. The following questions will be at the center of attention:

1. Where and which information is required, who delivers this information?
2. Where and which material is required, who delivers this material?
3. What resources are required.
4. Which decisions are made by who?
5. Which specific process steps are required to produce a section?

6. Where in the process are buffers of material and where are they located?

As a base for this part of the analysis, the Blue Print Hull Manufacturing as provided by Damen [1] will be used.

1.2.3 Analysing the current section building process in detail

An assessment of the process as described in step 2 will be performed. The focus of this assessment will be on the creation of flow and the minimisation of waste. A very important factor for this assessment is the amount of information which is transferred between production steps in section assembly and between section assembly and internal suppliers and customers. The required data for this analysis is:

1. method of Planning and Control
2. Quality of input materials and buffers
3. Quality of information
4. Use of resources
    - Use of floorspace
    - Use of labour force
    - Use of machines

1.2.4 Recommending process improvement

Based on the assessment, recommendations can be made to improve the process by minimising waste and the creation of flow. These recommendations will be supported by literature and calculations. Based on the assessment, recommendations can be made to improve the process by minimising waste and the creation of flow. These recommendations will be supported by literature and calculations.

Chapter 2

Product definition

This chapter will give a full overview of the definition of a section. This definition is required to define the boundaries of the analysis later in this research. The first step is to define the product, a section, and the different classifications of classes that are described. After this a short description of the process steps needed to produce a section is given. Finally, the boundaries of the definition of a section regarding this research is stated.

2.1 Definition of a section

The product hierarchy is stated in the blueprint. This hierarchy gives the definition of a section, like in table 2.1. A section is defined as a 3D assembly consisting out of main- and sub-panels among other parts produced by other workshops. These parts and their manufacturers can be found in table 2.2. When a section is completed, it is used to construct a block. Blocks and sections are put together to form the hull of a vessel. The painting stage of the production can either take place before combining sections into a block, or after the block has been completed. An overview of a section, and it place within the production steps can be found in fig. 2.1.

	Product	Consists of
1	Vessel	Sections and/or panels
2	Block	2 or more sections
3	Section	Contains item 4 – 7
4	Sub assembly	Could contain item 5 – 7
5	Main panel	Contains items 6 & 7
6	Sub panel	Contains 1 plate and profile(s)
7	Plate/profile part	

Table 2.1: Hull breakdown, product hierarchy

Manufacturer	Part	Sub-parts
Main panel assembly	Main-panels	Deck/tanktop panels Shell panels Bulkhead panels Curved main panels
Sub panel assembly	Sub-panels	Transversal sub panels Transversal t-beams Longitudinal sub panels Longitudinal t-beams
Pre-process	Sub-assemblies Curved plates Curved profiles Small parts	

Table 2.2: List of parts and manufacturers

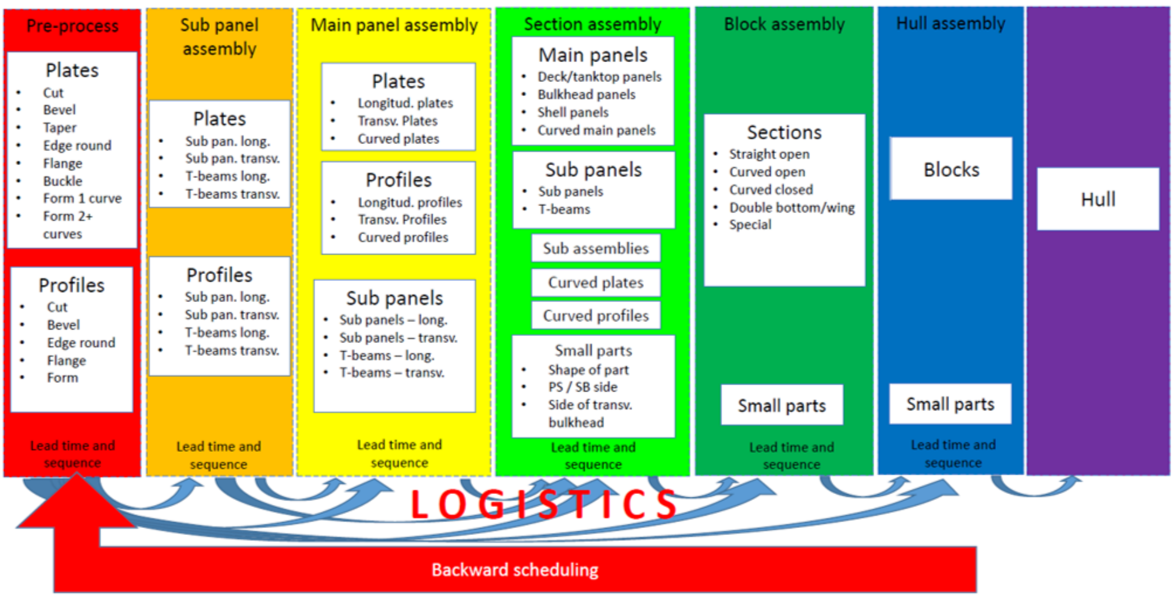


Figure 2.1: Rainbow chart of the product breakdown in parts

2.2 Classifications of sections

The process steps that are taken determine the amount of effort needed to build a section. By categorising the sections, better estimations regarding the takt-time and the number of workhours budgeted can be made. Certain combination of process steps occur on a regular basis. These combinations have resulted in five main classification of sections. Although the process steps determine in what classification the sections is placed, visual characteristics often correspond with these categories. First of which make a kind of subdivision when determining the type of section, this is if the walls of a section are curved or not. Furthermore the type of section can be determined by some key characteristics: Sections with double skins (mostly hull section), sections which are completely boxed but without double skin and sections with one or more open sides. This results in three different main classifications of sections which are used by the foreman. Beside these three classifications, a combination type of these types van make up an section and a “special” category exists. This contains sections that do not fit into any of the other four such as masts. An overview of these classes can be found in table 2.3. Although DSGo describes five other categories according to the “Blue print vessel manufacturing” [1] , up to this point both production planning and the foreman use the classification as is shown in this report, in their planning procedure.

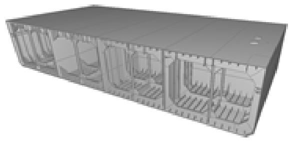
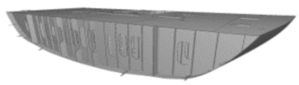
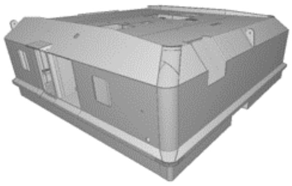
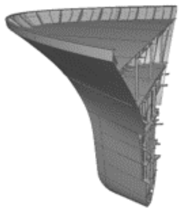
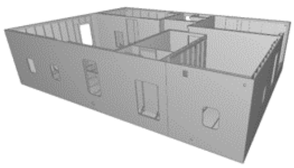
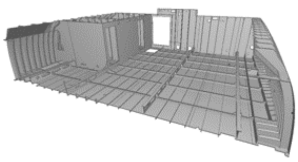
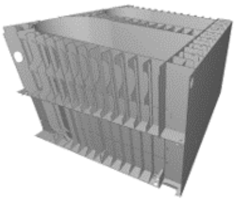
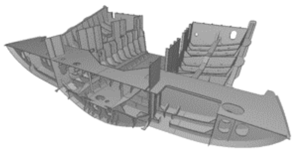
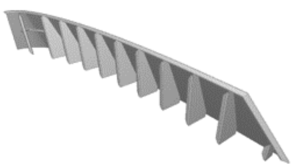
	Type	Straight	Curved
	Double Skin Sections		
Focus Area	Closed sections		
	Open sections		
	Combinations		
	Special Sections		

Table 2.3: Classifications of Sections according to the blue print

Chapter 3

Process Description

This chapter describes the section assembly process. This process consists of input, process and output of a section, these three factors will discussed in this order. The input consists of three main categories: Materials, Information and Resources. The building process and output are both singular. A scematic overview of the process can be found in fig. 3.1.

3.1 Input

3.1.1 Material

Two main types of material serve as an input for the production process, panels and materials coming in on pallets. The panels are produced by the panel line in steel processing and placed in a panel buffer from where they are transported to section building. The pallets can contain many smaller parts or sub-assemblies. They are sometimes transported from steel processing directly into section building, but most of the times put in a buffer first. If there is no space in production to place the pallet, they will simply stay in the outside buffer and parts are taken directly from there. A flowchart of the input of materials can be found in fig. 3.2.

3.1.2 Information

There are many documents used in the production process. This subsection will contain a description of the most important ones. If there are any examples of the documents, they can be found in the document folder attached to this report, a list of these documents can be found in appendix A.

Palletizing list - Contains a list of the pallets and the parts which are on it.

Section Drawings - Detailed technical drawings of the structure of the section, no shell is added in these drawings.

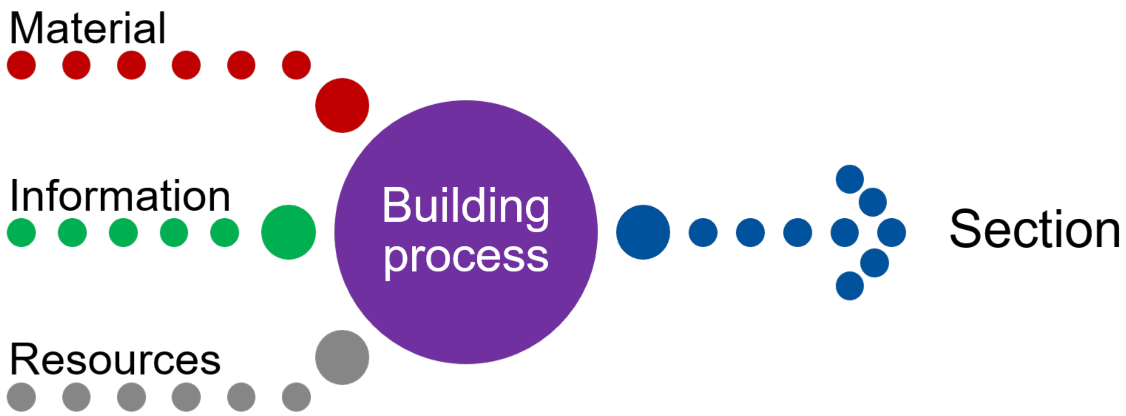


Figure 3.1: Section Building Process

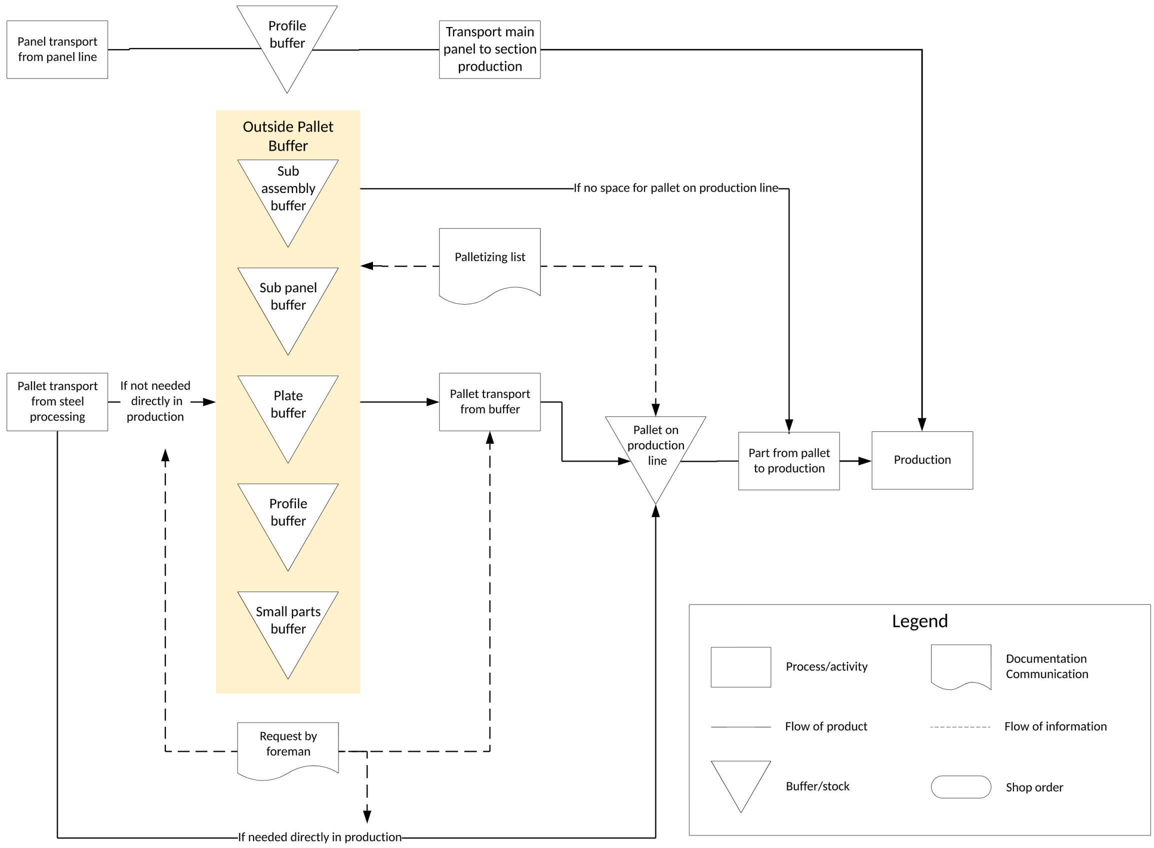


Figure 3.2: Input of materials

Measurement plan - Describes what measurements should take place during production. Both the positions and the tolerances are stated.

Outfit drawings - These drawings are used by the outfitting department (pipes and such) to see where what piece of equipment should be placed.

Quality control documents - Agreements between the customer, project manager, quality manager and yard supervisors on the quality which should be achieved during production.

Welding table - Detailed drawings of the welds which should be done during final welding.

Lifting plan - A drawing containing the placing of hoisting mounts and supports, weight of the section and hoist materials and the centre of gravity. Also the rules and regulations regarding the safety during the turning procedure are printed here.

Building Strategy - Gives a general overview of order in which the sections should be added to blocks and the hull. Also gives an planning of the placement of large equipment from external suppliers such as engines and generators.

Monthly remaining activities and budget - Gives an overview per yard section of the sections to be produced, start and finishing dates of sections, hourly budget and loading percent of manhours of the yard.

Project hull planning - Project planning where the planning of each section can be found for many departments such as Engineering support, steel processing, section building quality control and subcontractors.

Overview of section locations - A living document updated weakly to show where sections are currently placed and where there is space in line to place new sections.

3.1.3 Resources

Resources contains the people, space and machinery required for production. Here the difference between the two yard sections (S1 and S1A) becomes clear. As can be seen in fig. 3.3 the S1A yard is about twice as big as yard S1 when comparing area and workforce. For this project, only the only machinery taken into the analysis are the cranes in the production halls.

3.2 Building Process

Here the possible steps in assembling a section are explained in detail. At the end of this section an overview is given with the input materials per process step.

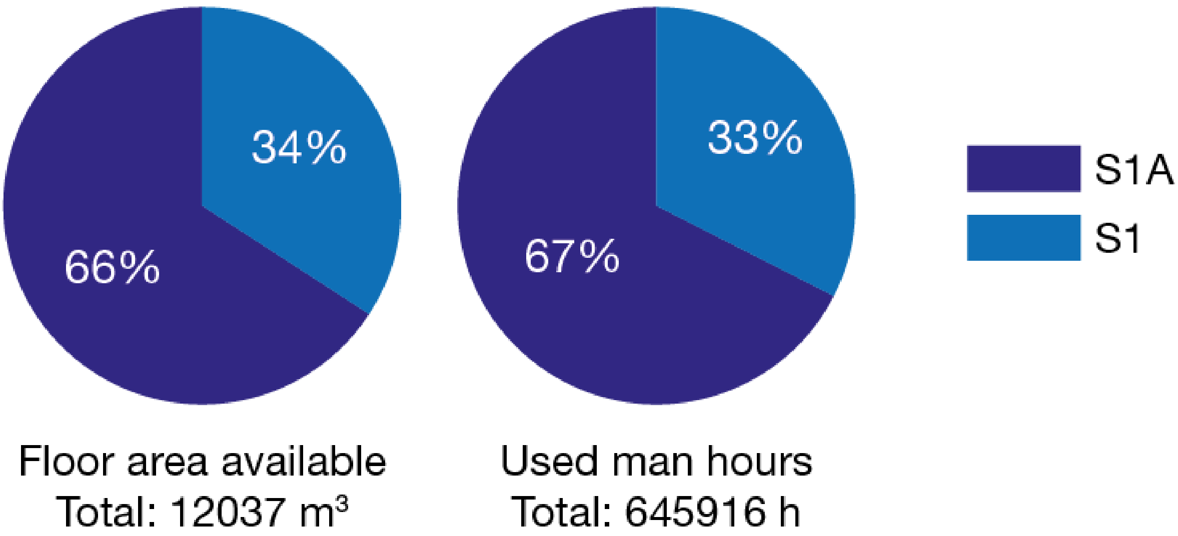


Figure 3.3: Resources comparison S1 and S1A

Building the bed

In almost all the cases, the first step is to prepare the building bed. This bed forms the support for the section during construction. The bed can be created on either a flat-bed, as seen in fig. 3.4, or a pin-bed or the floor. If a section has a flat bed, simple studs are welded on the existing flatbed at an equal height. Not all decks are flat however, sometimes a curved deck is needed. In these cases it is sometimes also possible to place studs at different heights to form the support. Another option is to build a negative of the shape of the deck. These negatives need to be produced by the steel processing workshop and the nesting department needs to create them. Only section 1A features a pin-bed. With this pin-bed the studs are replace by adjustable pins that are able to form the negative shape of the deck. Another situation which requires more preparation time is if the section has different deck heights, e.g. due to a heightened structure on the deck, it is also necessary to build a structure to support the entire deck. A image of a support structure can be found in fig. 3.5.

Position Deck

In this step the first main panel of the section is positioned on the building bed. If this is a flat panel, the panel will be delivered from the main panel line with the stiffeners in place. They are placed in a buffer from which the panels are lifted into place. With this method the main task is to make sure the main panel is in the correct position regarding the building bed. A picture of such a main panel can be found in fig. 3.7. If the first main panel is curved however, the main panel line is not fit to weld

Figure 3.4: Building bed in Galati

Figure 3.5: Support structure

Figure 3.6: Pallet of sub panels

Figure 3.7: Main panel

Figure 3.8: Vertical Assembly finished

Figure 3.9: Final shell welding

the profiles onto the plate. Therefore the panel will be constructed by the section building workshop. The first step in this process is positioning the curved plates of the main panels on the building deck. These plates are taken from a buffer between the steel processing workshop and the section assembly workshop and if required they are tack welded.

Stiffners/sub panels assembly

Although a panel might be prepared on the panel line, not all of the stiffeners might yet be in place. The panel line is only able to weld profiles in one direction. Therefore in some cases extra stiffeners need to be added, consisting out of subpanels. An example can be found in fig. 3.6 If a panel could not be built on the main panel line, none of the stiffeners are not yet in place in this step of the building process. Therefore, the next step is to tack weld profiles and sub-panels onto the main panel to act as stiffeners. All of the parts are taken from the buffer between currently the steel processing and section building.

Horizontal Bulkhead Assembly

The next step is to place the bulkheads. A bulkhead is a wall within the ship and forms the partition between compartments. This is the first vertical part which is put on the deck. A bulkhead is a straight panel coming from the main panel workshop. These panels are only tack welded horizontally, so only to the deck. Vertically tack welding is proponed in order to leave for enough freedom for movement during the next step, leveling the section. If a section has a straight shell, this stage also includes the placing of this shell. These bulkheads are straight and will be produced by the main panel workshop. Section building takes them from the main panel buffer.

Level Section

In this step a form of measurement control is done. In order to check the measurements of the deck, the distance between the supporting studs and the deck is measured. If this gap is bigger than 5mm, action needs to be taken to straighten the deck. This is done by heat treatment and deforming the material with pulleys. In most cases however, the deck is welded onto the supports and is therefore not able to deform so no leveling is required in this stage of the building process.

Vertical Bulkhead Assembly

After the deck of the section is leveled enough, bulkheads placed earlier are welded vertically on each of their crossings. This fixates the construction.

Position Small Parts

Many smaller components are required in a section, these smaller parts are produced by the other workshops within the yard (e.g. locksmiths division or steel processing). These smaller parts can be used for a variety of purposes. Outfitting is one of the main purposes but other parts are used as guiders for alignment during block construction.

Vertical stiffner/sub panels assembly (shell)

In order for the curved shell to be paced on the section, the sub structure first needs to be placed. This can be seen as the skeleton on which the shell is placed. These parts are taken from pallets which come from either the steel cutting workshop or the sub panel workshop. If the section only contains straight shell plates, this step is not required doe to the placement of the shell during the bulkhead assembly.

Weld structur

In the former stages all of the parts have been tag welded, so only short welds have been set to keep all the parts in their place. This step involves welding all the contact points shut. This is done according to welding drawings, which will be discussed later on. If this has all been completed, a section will look as in fig. 3.8.

Shell assembly

In this step the spell plates are positioned and tag welded to the existing structure and each other. In this way a hull will emerge with splits in.

Final welding building position

All of the splits in the hull will be welded shut, this will create a closed hull of a section. Also the final welds on the structure will be done. A picture of final welding can be found in fig. 3.9.

Hoisting and support welding

To be able to turn a section, it needs to be hoisted. This requires hoisting eyes and support beams to be placed. The hoisting eyes will be placed on both the top and the bottom of the section and support structures will be welded to the shell of the section to be able to support it when turned.

Turning the section

Turning the section is done either inside or outside the production hall, depending on the size of said section. If we consider a large section, first the section is hoisted up from the building bed and moved to the end of the hall, where movers will be waiting. The section is placed on the movers and transported outside to a gantry (fig. 3.10). First the crane lifts up the section from the ground (fig. 3.11) and starts turning it about 90 degrees (fig. 3.12), so the section is halfway in the turning process(fig. 3.13). Now the hoisting eyes on the shell of the section have served their purpose and workers will enter the section, while it is in the air, and attach cables from the second hoisting mechanism to the hoisting eyes on the top side of the section, this is the side which was once on the building bed. If the second hoisting mechanism has taken over the weight of the section, the workers come in again to disconnect the first hoisting mechanism from the hoisting eyes on the shelled side of the section. After this, the section is turned another 90 degrees so it has made a full flip (figs. 3.14 and 3.15). It is placed on the movers again and is moved to its next production location. These locations can either be in the production halls, in temporary production locations or outside. Here cranes will lift the section from the movers and place them on the ground, ready to go to the next production step.

Final welding sailing position

Although a lot of welding has already been done, some positions where unreachable in the former position of the section. Therefore some welding still needs to be done in this stage.

Removal of redundant materials

The redundant support structures, which are now on top of the section, and the hoisting eyes on the shelled side are now removed.

Figure 3.10: Attaching section

Figure 3.11: Lifting section up

Figure 3.12: Turning section

Figure 3.13: Reattaching cables

Figure 3.14: Continuing turning

Figure 3.15: Positioning on mover

Measurement and correction

To make sure the final welding steps have not compromised to positions of the parts beyond the set tolerances, the entire structure is measured with laser and 3d measuring devices. If tolerances are not met, the building team will correct it by grinding, cutting and rewelding the structure

Quality control

Finally the quality department comes to check if the section meets the quality demands set by both the shipyard and the client. If a section passes this test, it is regarded as finished and will be pushed to the next stage of production. This could either be block building or painting the section.

3.3 Output

When a section is completed, it is almost ready to be installed into a block or hull. The only step still to be completed, is to paint the section. This can either be done as a section or as an block. This mostly depends on the availability in the paint shop and the size of the section or block.

3.4 General overview

In the former sections, most of the aspects of the section building process have been described. When combining all of these, a more elaborate version of fig. 3.1 emerges. This flowchart can be found in fig. 3.16. The colours of fig. 3.1 correspond with the coloured boxed in fig. 3.16.

A further analysis of the decision making and documentation has resulted in a more detailed version of the entire section building process. This starts at the planning process and ends when the section is pushed to the block or hull assembly. This process flowchart can be found in fig. 3.17. High resolution versions of both flowcharts have been added to this report as separate files.

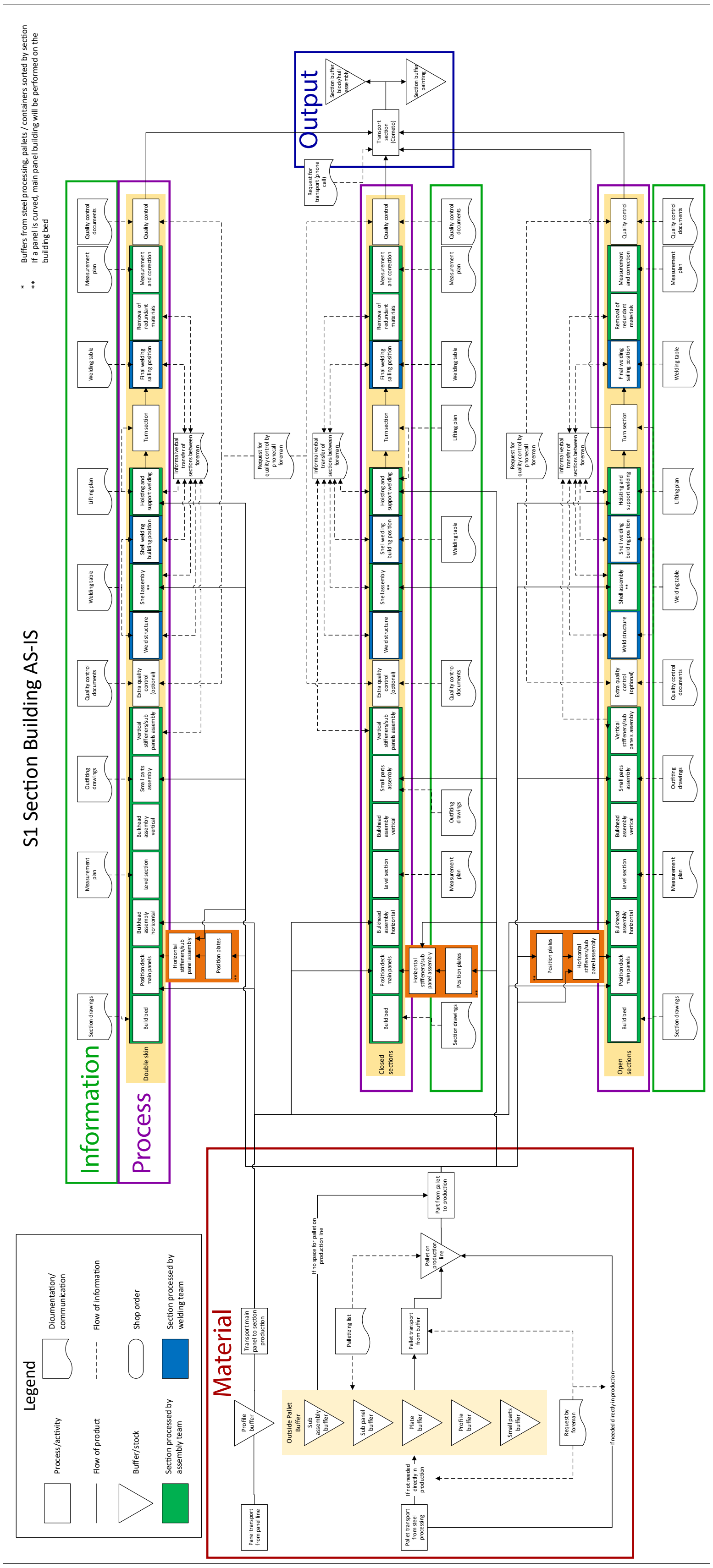


Figure 3.16: Section building flowchart

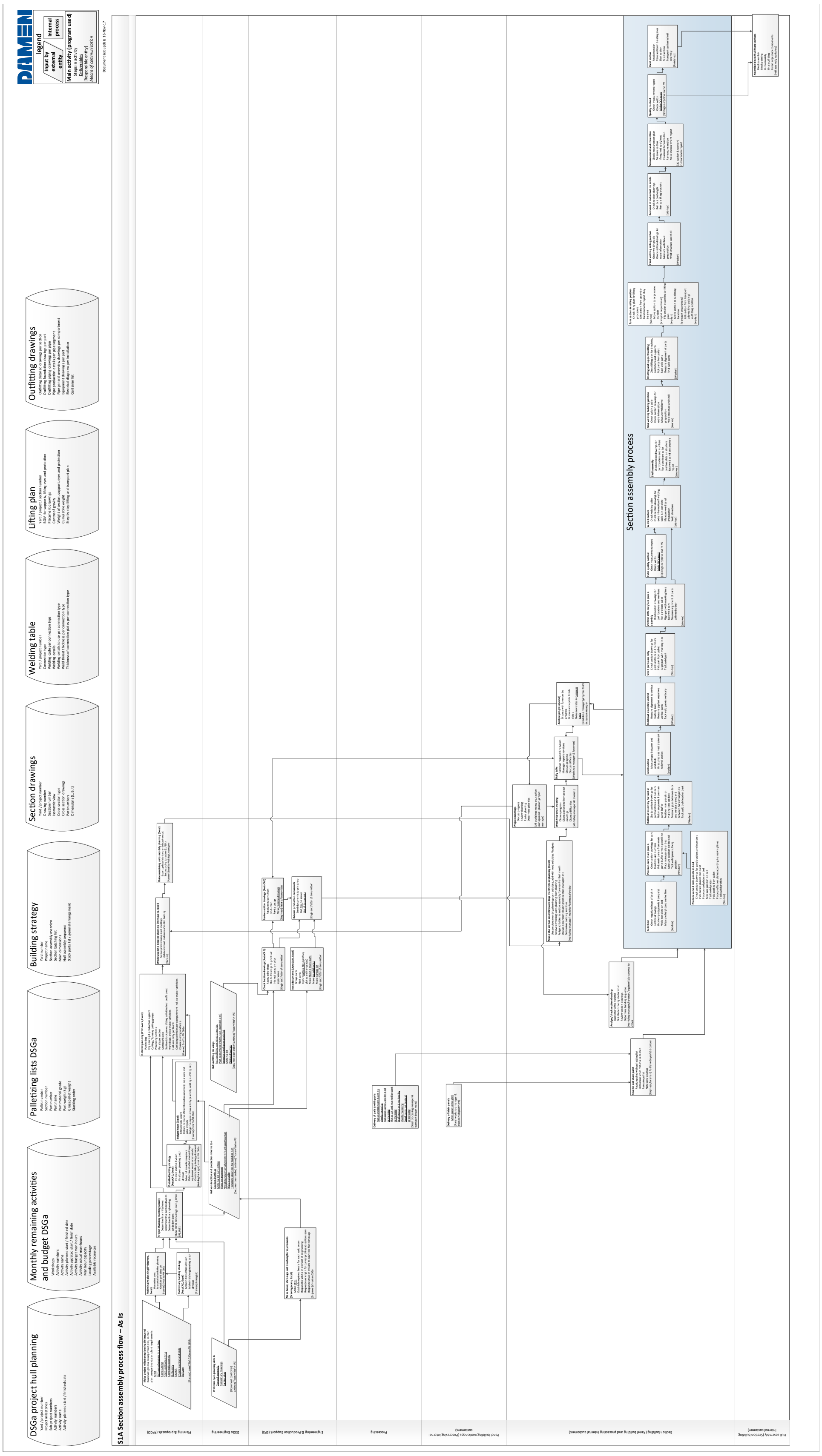


Figure 3.17: Section building process flowchart

Chapter 4

Analysis

4.1 Planning and control

For this analysis the level of detail of planning made is compared to the control loops in the process. A correct system has a control loop on each level of depth of planning [2].

The planning procedures have been analysed by interviewing different people in the planning chain and comparing their statements to the Process flowchart from fig. 3.17. From these interviews, the following levels of depth of planning came forward: the Planning and Proposals department (PPCO), the Worksop manager and the Foremen. These can be seen in fig. 4.1.

The different control loops also have been created by attending different meetings and interviewing the departments stated above. The control loops which have been found can be seen in fig. 4.2. If we couple these to timespans they show a correlation between the control loops and the level of depth of planning. Therefore it can be concluded that there are control loops for each level of planning.

4.2 Use of Resources

The use or resources is split up in three subsections: floorspace, labour and machinery (cranes). These are similar to what has been stated in section 3.1.3.

4.2.1 Use of floorspace

The usage of floorspace has been investigated by doing rounds each week in the production halls. During these rounds the usage of floorspace was mapped and later transfered into tables to give estimations of the usage of floorspace.

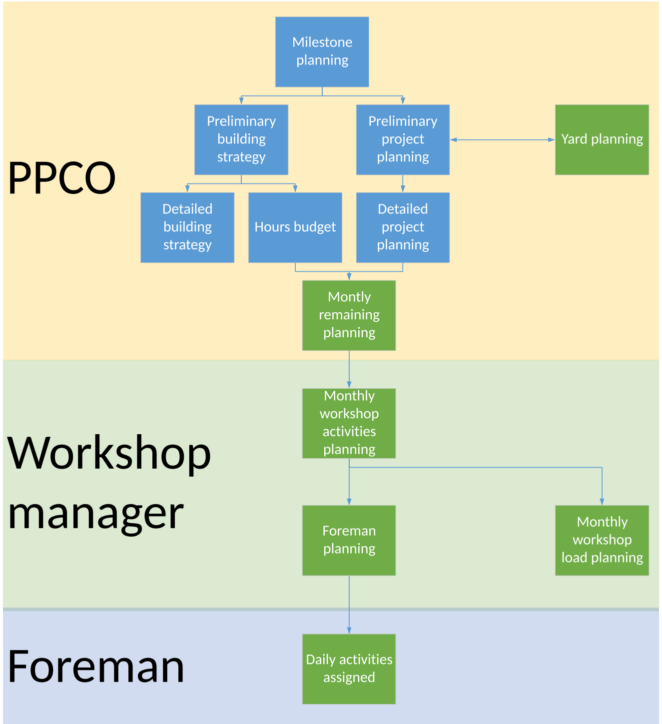


Figure 4.1: Level of depth of planning

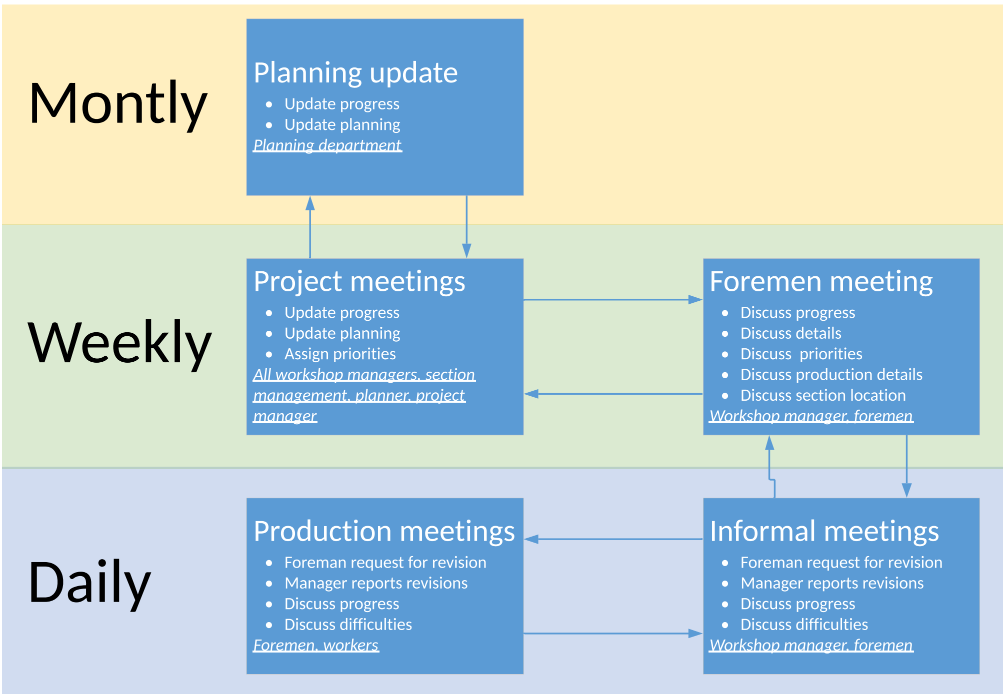


Figure 4.2: Control loops of the section building process

The results can be found in table 4.1. Five categories are shown here, From these five only the section production and sub-assembly are not regarded as waste. Therefore only an efficiency of 63% is achieved.

Function	Usage percentage
Section building (with scaffolding)	60%
Storage of pallets and parts	14%
Sub-assembly building	3%
Hallway	4%
Empty	19%

Table 4.1: Function of floorspace

It as to be said that the storage of parts and the use of hallways are unavoidable in a middle to short term timeframe. Therefore only an estimated improvement of 20% can be achieved by using a different method of planning of section locations. Currently the location of a section is not planned ahead. If work on a section is started, a location is determined. An example of the currently used registration of section locations can be found in fig. 4.3. A different method has been proposed during this project. The method has already been implemented in other Damen yards and has proven its worth there. This method consists of a map in centre of the page. This map represents the location of the building beds and hallways. Therefore a 2d top view of the production hall is shown. In the middle the current location of the sections is also presented. On the sides of this centre the planning for the upcoming weeks is shown. In this way, a foreman is able to create a tighter location of the sections and therefore less space will be used. An example of such a planning is shown in fig. 4.4. This type of planning has also been proposed to the foremen and their assistants and they noted it would be more work than they currently do, but it could also provide a solution of the lack of space they currently have. Another suggestion made by the foremen is switching from the building beds to flatbeds. Examples of both can be found in figs. 4.5 and 4.6. The use of these beds has been tested over the last few months and is considered to enhance flexibility, productivity and safety (due to the lack of height difference).

4.2.2 Use of labour

Saying 63% of the floor is used for section building is not enough to give a proper view of the efficiency of the use of floorspace. to get a complete overview, a comparison is made between the amount of days a section is in production, and the amount of days which is worked on that particular section. The results of analysing historic data of 2017 and 2016 can be found in fig. 4.7.

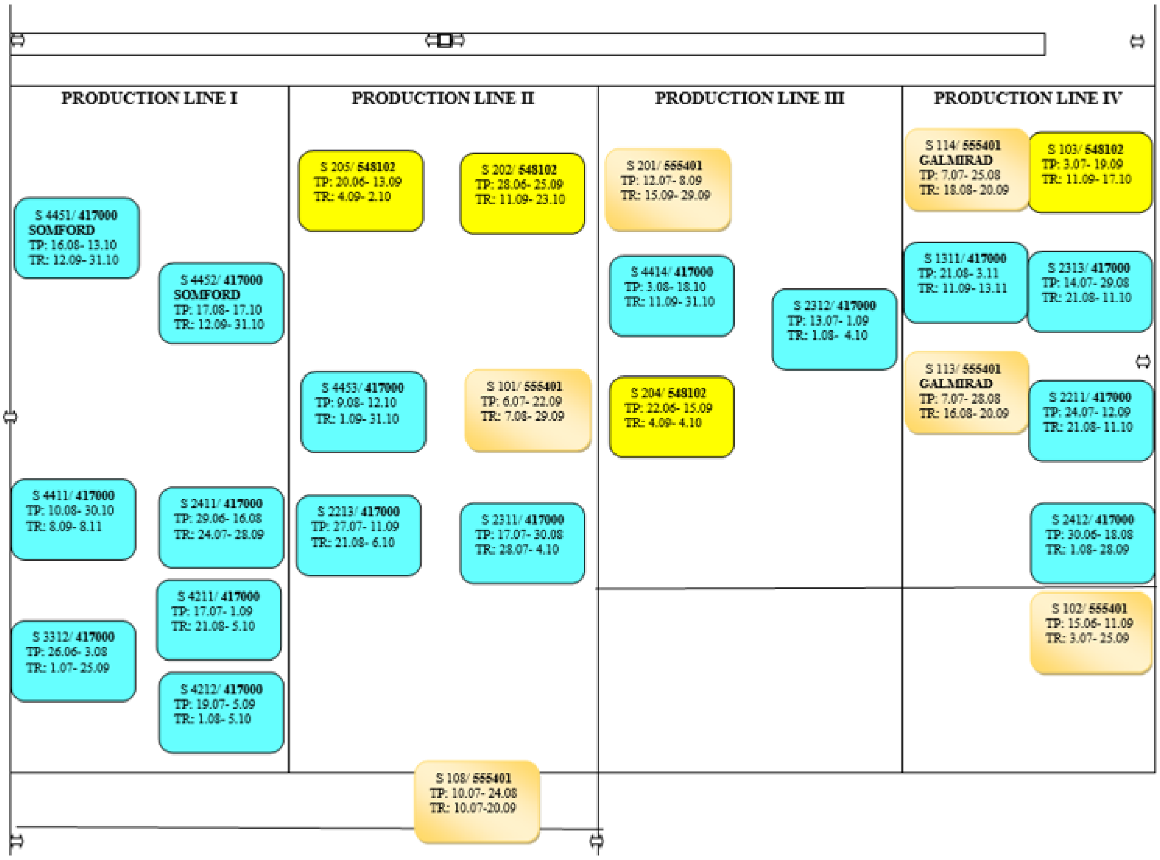


Figure 4.3: Current section location mapping

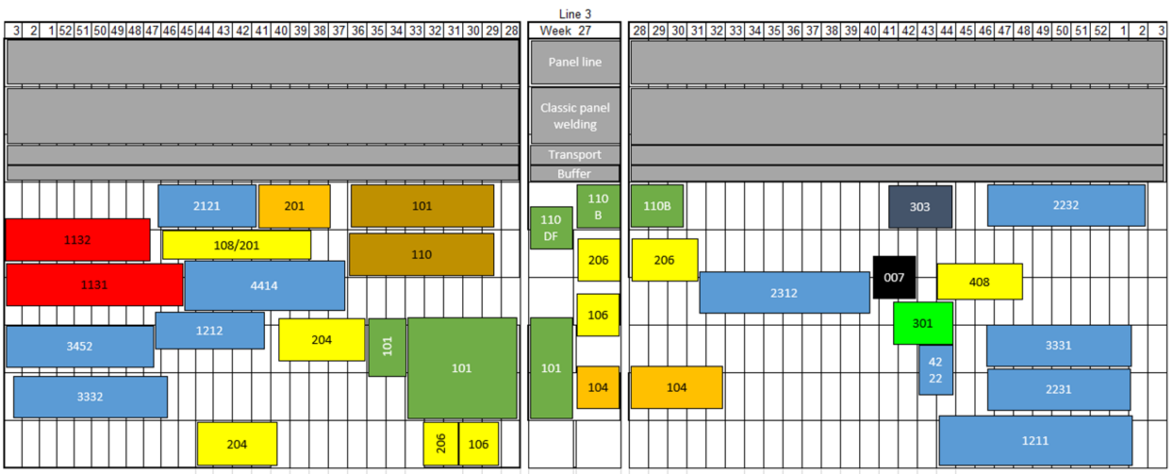


Figure 4.4: Proposed section location planning

Figure 4.5: Building bed

Figure 4.6: Flatbed

What is striking here is only 55% of the sections are being worked on more than 70% of the days they are in production. After interviewing the production personnel, the following reasons came forward the most: there are parts lost during transportation and storage, some parts are delayed by the steel processing plant, sometimes they have to wait for proper documentation of the section and sometimes labour gets directed to other sections which are given priority by block and hull assembly.

In figure figs. 4.8 and 4.9 an overview of the use of labour is shown for 2 sections per week of production. These are good examples of the overall situation. As can be seen there is a substantial gap between two production peaks is present. This dip is due to the turning of the section. Currently a turning request is send oud after the quality control has been done, and the request for quality control is done very late in the process. In order to decrease the waiting time for turning, this turning should be included in the project planning as a milestone. In this way the department responsible for turning the section is also able to make a more advanced planning and waiting times are expected to be reduced. It is important that if milestones are not met, the turning department is notified in time. Therefore it would be advisable to take the turning department into the control loops as described in section 4.1.

4.2.3 Use of cranes

The use of cranes could not be investigated in depth in the timespan of this research. Therefore an investigation has been done to estimate the effectiveness of a future research by interviewing the workforce.

During interviews with the foremen it was mentioned that the cranes have an high occupation rate. The foremen saw this as a indicator of their effectiveness, but also told that most of the times workers will either have to wait or take up other tasks due to long waiting times. What has been observed in the hall was the use of the large cranes for small parts, this is not considered very efficient.

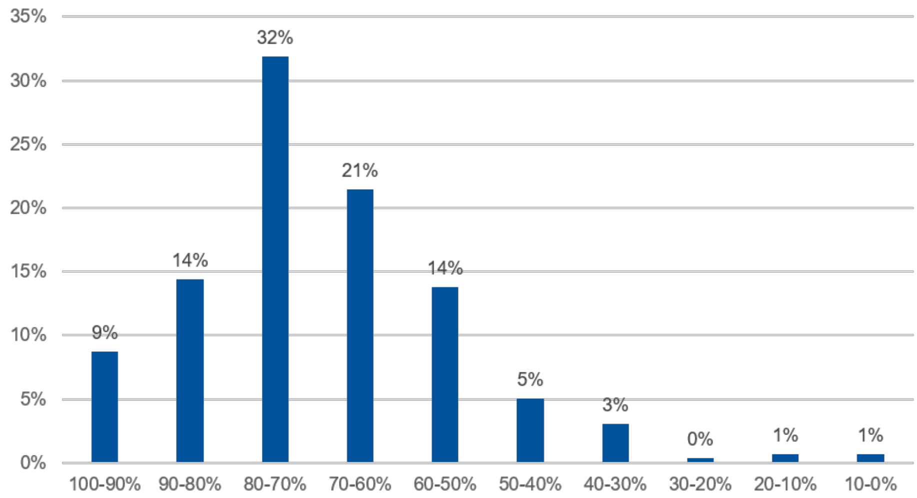


Figure 4.7: Days worked on a section VS days in production

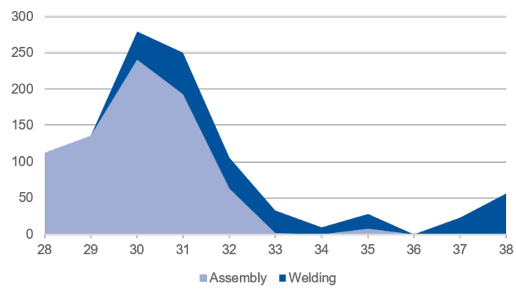


Figure 4.8: Labour hours per week example 1

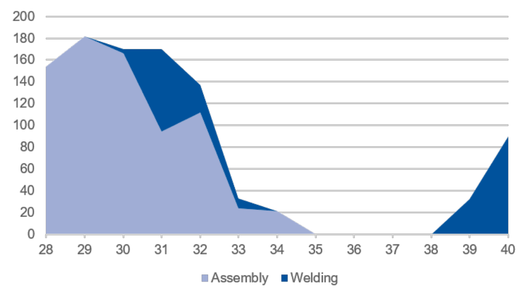


Figure 4.9: Labour hours per week example 2

To tackle the high workload, more smaller cranes are required, according to the foremen. To properly investigate this, a simulations of the current use of cranes and the effect of placing new cranes should be carried out.

4.3 Input of Information

The input of information has been investigated by intervieuwing workers, the work preperation department and the foremen.

From these interviews could be concluded that a lot of information is required in a project, and the quality is sometimes lacking, this is probably due to the large amount of manual work the preparation departments need to do. A complaint heard many times is the information being incomplete at the start of projects. This results in a faulty planning on the foremen level. Also a lot of documentation is build up to suit the departments producing the information. Due to this ordering system, the workers have the feeling they spend to much time searching for the required documentation.

In order to improve the quality of information, more use of the build in functionalities of CatMatic, the currently used design software, should be used. This would result in less work and more standardized documents. Moreover, the documentation for a project should all be finished at the start of the building procedure. Also a shift in document organization and bundling should be made to suit the workers and therefore reduce their effort of searching. Most of these changes can me done or monitored by using a project planning tool such as Nestix.

4.4 Logistics Flow and Buffers

To investigate the performance of the logistic flow and buffers, the location of each pallet in the buffers has been mapped out every day. To create these maps, for 2,5 months each day at 3 in the afternoon a round was made through the buffers. These maps have been transferred into tables which have than be used to analyse the amount of time a pallet is in the buffer and how many times a pallet would be moved. These rounds also gave an insight into the way the buffers where organised.

From the date the following remarkable points emerged. The average time a pallet spends in the buffer is 15 days. Each day 30 to 61 pallets are in a buffer and 4 to 1- main panels are in their buffer. This all is a lot of time and points out the lack of just in time (JIT) logistics. Also some other examples of poor storage methods could be seen. Many of the containers were not stacked in a logical order of their proposed date of use, or due to parts sticking out blocked other pallets. This resulted in a lot of

Figure 4.10: Overlapping 1

Figure 4.11: Overlapping 2

moving around the pallets while they remained in the buffer, which in turn results in a lack of capacity of the cranes and thus waiting times. Due to method of noting the section numbers on the parts, the section a part belongs to is sometimes unclear, as can be seen in figs. 4.12 and 4.13 where the same picture is rotated 180 degrees and can be read in both ways (this was section 1141). There were also a lot of large bins, such as in fig. 4.14, with smaller parts in it which resulted in the workers having to search through these bins in the search of the correct parts. The amount of loose lying parts on a pallet resulted in losing the parts during transportation and in having to reproduce these parts. The sorting of the parts on a pallet or in a bin is currently only based on the section. This results in many restacking and searching efforts within the correct pallet to find the correct part or subassembly because sometimes to bottom part is required.

To improve the method of storing the parts and panels between steel processing and section building. The following is advised. By using a shop floor management tool (such as Nestix) the JIT ration should be increased and storage planning should result in a lower relocating of pallets. Printing the section and part numbers on the parts will increase the clarity of the parts and combined with predefining the locations of pallets will decrease the time it takes to search for a part. By using a better pallet system the amount of parts which are lost can be reduced. Also sorting the parts on a lower level within the section, location on the section for instance, will also reduce the relocating and searching efforts within a pallet.

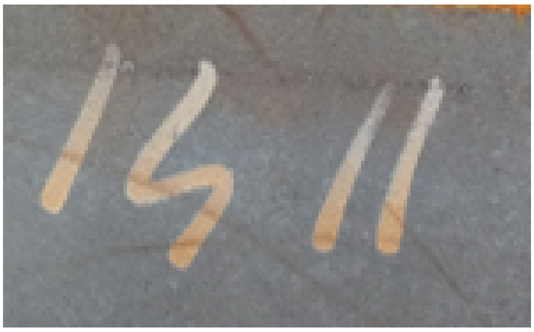


Figure 4.12: Section 1411

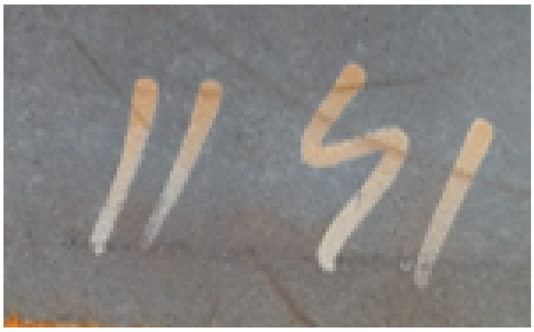


Figure 4.13: Section 1141

Figure 4.14: Parts in a bin

Chapter 5

Conclusion and recommendations

During this research the production process of the section building department of Damen Shipyards Galati has been reviewed to find an answer to the research question as stated in section 1.1: *"What are possible improvements of the input flow of materials, flow of information and the assembly process to create an output of higher quality and quantity of the section assembly department?"* This has been answered by suggesting improvements in chapter 4. These recommendations are summarised in the list below. The sub-questions have been answered in chapter 3.

- Recommendations for improvement
  - Implement the elaborate method of section location planning
  - Preventing loss of parts to reduce waiting times
  - Have all the documentation ready at the start of the building process
  - Better synchronisation between steel processing and section building
  - Make section turning a milestone in the project planning and take the turning department into the control loop
  - Make more use of the possibilities of the CatMatic software
  - Sort of the documentation to better fit the production process
  - Implement a shopfloor management tool to improve JIT delivery of parts
  - Print part numbers in stead of handwriting them
  - Reduce loss of parts by using a better pallet system
  - Sort the parts by location in the section
- Recommendations for future research
  - Create an analysis of the current crane usage and impact of installing new cranes

Bibliography

[1] "Blueprint vessel manufacturing - hull processing," *Damen Shipyard Group Shipyard Management*, pp. 10–26, 2014.

[2] G. Pritschow and H.-P. Wiendahl, "Application of control theory for production logistics – results of a joint project," *CIRP Annals*, vol. 44, no. 1, pp. 421 – 424, 1995. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0007850607623555

Appendix A

List of production documents

A1 - Building Strategy [excel, autodesk].PDF
A2 - Project planning [primavera].pdf
A3 - Monthly remaining planning [excel].pdf
A4 - Paletizing list [excel].pdf
A5 - Section drawing (with bevel) [autodesk].pdf
A6 - Welding table schelde [autodesk].pdf
A7 - Lifting plan [autodesk].pdf
A8 - Overview section location S1 [word].pdf
A9 - Overview section location S1A [word].pdf
A10 - Section Building Blowchart.pdf
A11 - Section building process flowchart.pdf