Ensuring an Approval of the Steel Coil Stowage Plan

A Problem Analysis and Solution Proposal of the Quay Discussion at Tata Steel IJmuiden

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A Problem Analysis and Solution Proposal of the Quay Discussion at Tata Steel IJmuiden

by

J.J. Oudshoorn

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TU Delft

Executive Summary

Right before the actual loading of a ship at the quay of steel production company Tata Steel IJmuiden starts, the ship management has to agree upon the stowage plan. However, the company experienced the stowage plan approval was more often accompanied by complex discussion with the ship management. This is expected to cause delays which result in extra costs and severe plannings disruption at the harbour. Therefore an answer is sought to the following research question:

How could Tata Steel IJmuiden cope with the rising number of discussions with the ship management on the approval of the stowage plan?

The stevedoring department (S&W) contemplates several probable causes complicating the stevedoring process and method and causing a discussion. These probable causes, concerning the company production and its processes, the shipping industry and climate changes, are analysed by means of interviews, literature or data analysis. Several trends are found based on this analysis:

1. More further finished zinc-coils are exported which are often not allowed to carry another coil on top and thus an increase in topstowage coils is expected.
2. Due to the growing safety awareness, more coil handling and allocation restrictions (in the ship with respect to its construction) are imposed.
3. Tata steel has already initiated processes to increase the maximum coil weight to 38,5 ton.
4. The importance of provided information will grow due to more imposed restrictions and focus on Just-in-Time delivery

Currently, S&W generates a stowage plan based on average coil weights and dimensions per cluster. In this plan, for a higher throughput, tanktop area in the bulk carrier hold is left empty for forklift manoeuvrability, resulting in higher stacking of coils (3 coils high, preferred by S&W) against the bulkheads. When calculating the tanktop load according to regulations by Bureau Veritas (class society), stowing 3 coils high with the average coil weight and size exported by Tata Steel IJmuiden, results in a tanktop load of $27,5 ton/m^2$. When the weight is distributed over the tanktop and coils are stacked only 2 high, the load decreases to $19,3 ton/m^2$, which corresponds better with the average tanktop strengths (approx. $19 ton/m^2$) of reference ships found in the previous data analysis. The two case studies confirmed the findings from expert interviews and the regulations; the ship management demands the coil weight to be distributed over the tanktop (no empty area for the forklift). On top of that, case studies showed S&W only has minor influence on the ship chartering and financial and plannings consequences appeared to be insignificant.

Combining the notions about the stowage process and method with the findings of the probable cause analysis, results in defining three main bottlenecks:

1. Suitability of ships: restrictions on coil handling (for product quality) and allocation (imposed by the ship management) decreases S&W's stowage flexibility, and due to their little influence on the ship nomination, the suitability of ships is decreasing.
2. Late Availability of Information: the decreasing stowage flexibility of S&W increases their dependency on cargo information provided by Outbound Planning which is, due to a focus on Just-in-Time delivery, not expected to expedite.
3. Less Stacking and More Dunnage: the increased restrictions and regulation calculations results in less flexibility in stowing height. On top of that, more dunnage is requested by the ship management. Both requirements result in incompatibility of the current stowage method.

To give reference to and boundaries of possible solution to these bottlenecks, the internal and external power of S&W is analysed. Internally, when looking at uncertainties, S&W is mainly dependent on Outbound Planning and the Chartering department. S&W only grants power due to its irreplaceability and immediacy

when warehouses tend to overflow during harbours malfunctioning. However, since S&W has no central position in the companies workflow, the magnitude of influence with respect to these departments is low. Externally, due to the lack of legitimate rights and responsibilities and without being able to exert pressure on counter parties, S&W only has power based on cooperative incentive of the counter party.

Due to the significant higher costs on chartering (35 euros/ton) and the stevedoring costs (4 euros/ton), optimisation at the expense of Chartering lies not within the solution boundaries. Therefore solution ideas such as chartering more feasible ships or decreasing the hold utility are dismissed. Buying and operating own ships by Tata Steel comes with too many uncertainties and risks proportional to the size of the problem and is therefore not a recommended solution. Solution Ideas affecting the products produced, such as decreasing coil weight or producing coils with less handling restrictions, are dismissed based on the company strategy; S&W is a supporting department of the production facilities. Residual solution directions within the area of influence of S&W, fitting company wide strategies and initially not expecting to influence chartering cost are adjusting the current, or adapting another stowage method.

Three solutions proposals are found in similar shipping industries: stowing the coil vertically (rotating coils 90°, applying cradle cassettes (coil gutters) and distributing the weight of the cargo evenly over the tanktop (not leaving forklift manoeuvrability area empty). Although the application of cradle cassettes scored highest in the multi-criteria-analysis, due to its large practical challenges, high investment costs and difficult logistical management of returning the cradle cassettes, the solution is perceived as not viable on the short term.

It is recommended for Tata Steel IJmuiden to distribute the cargo weight over the tanktop area and so decreasing the burden on the tanktop. During a field visit to the Port of Antwerp, where this method is applied, it is verified no discussions with the ship management occurs, so the problem (the discussion) will be solved by distributing the cargo weight. Moreover, by generating more upper (top) locations for coils, the increased topstowage coils is dealt with either. Calculation show this causes a higher hold capacity in number of coils and a similar throughput. However, since the ships capacity is limited by the allowed tonnes (determined at fixing the ship), it mainly results in an increase flexibility of coil allocation by the stevedoors.

However, it is also recommended for Tata Steel IJmuiden to executed further research on two topics. First, to validate the conclusions on insignificant plannings and costs consequences and the frequency of the discussion, it is recommended to collect more data to establish more grounded conclusions on the magnitude of the problem. Secondly, the already initiated “Smart Steel Factory” project aiming to align the different IT-systems should be benefit from. To do so, proper and close management of the implementation is required to improve the communication and provide earlier information in the stowage process.

Preface

This report is written to document the graduation research in order to obtain the degree of Master of Science at the Delft University of Technology. This graduation research has been carried out from September 2017 to June 2018 at the stevedoring department of Tata Steel IJmuiden.

The stevedoring department of Tata Steel IJmuiden has noticed more often complicated discussion with the ship management about the approval of the stowage plan. Since this is disruptive for the planning and processes of the harbour, research was needed towards multiple probable causes, their trends and future bottlenecks.

Readers interested in the research approach, guiding as a framework to solve this problem, are referred to Chapter 2. Those who are not familiar with steel production or transporting coils and its financial perspective, I recommend reading Chapter 3. The data analyses conducted to find noteworthy trends in factors contributing to the problem, can be found in Chapter 4. Readers interested in a detailed description of the current system, containing two case studies, I refer to Chapter 5. The determination of the problem solution with an in-depth power analysis of the stevedoring department can be found in Chapter 6. Multiple solution proposals are reasoned out in Chapter 7, where a Multi-Critera-Analysis selects the most promising solution. Readers interested in the practical implementation of the solution proposal are referred to Chapter 8. Chapter 9 finishes this report by stating the validation, limitation, conclusions and further recommendations to this research.

Several individuals deserve special acknowledgement for their direct or indirect contribution to this research. First of all I want to thank my daily supervisor, Sebastian Borsje, for his guidance through Tata Steel IJmuiden and his help on connecting me with helpful and kindhearted colleagues. I want to show gratitude to my academical supervisor, Jeroen Pruyn, for challenging me every step of the process, providing feedback and being a sparring partner when practice an theory, to my dissatisfaction, did not correspond.

My boyfriend, Dirk de Bruijn, deserves special acknowledgement for his faith in my independence and unconditioned support and encouragement in every step I take. Moreover, I want to thank my friends and family for their support over the last years; enabling me to start and finish this meaningful but challenging chapter of my life.

J.J. Oudshoorn
Delft, June 2018

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1 Introduction

Tata Steel IJmuiden is a steel production site with their own stevedoring department which is responsible for loading ships with finished products, the steel coils, to the customers. Since the ship management is responsible for his cargo, he should agree upon the stowage plan before the loading procedure can start. Lately, Tata Steel IJmuiden experiences more often discussions at the quay with the ship management about the stowage plan. This is likely to result in additional costs and causes disruption in the planning.

In this research, an in-depth problem analysis is executed to analyse probable causes regarding the discussions, map the current situation and evaluate the future bottlenecks in order to form an advice towards Tata Steel IJmuiden how to cope with the rising discussion. To do so, the following research question needs to be answered:

How could Tata Steel IJmuiden cope with the rising number of discussions with the ship management on the approval of the stowage plan approval

Due to the indistinction of the problem, raised in a practical environment, the used methodology aims to provides a theoretical framework to incorporate practice and theory in defining the problem and its constituent factors.

After the methodology explained in Chapter 2, background information regarding steel products, coil transport, corresponding costs is given in Chapter 3. Hereafter the probable causes indicated by the stevedoring department are analysed in Chapter 4 after which further bottlenecks are sought in the current system, described in Chapter 5. Solution boundaries are complemented with findings in a power analysis of the stevedoring department in Chapter 6. A solution solving the bottlenecks within the solution boundaries is selected in Chapter 7. Chapter 8 embodies the verification of the solution. Finally, the conclusions and recommendations are given in Chapter 9.

2

Methodology: The Deweyan Inquiry

This chapter explains the approach and methodology used to execute the research on the rising complexity and number of discussions between Tata Steel IJmuiden and the ship management. First the problem situation is defined (Section 2.1), after which the research objective is stated in Section 2.2. To ensure the research approach and methodology match with the content of the research, two main characteristics of the problem situation are determined (2.3) followed by the the research design. The research questions are defined in Section 2.4. This chapter will close by explain the scoping possibilities in Section 3.4.

2.1. Problem Situation

Before starting the loading procedure of a ship moored at the quay, the Stevedoring & Warehousing department (referred to as S&W) of Tata Steel IJmuiden plans the cargo in the ship with a stowage and cluster plan. This cluster plan consists of the sequence of products supplied based on dimension and hold combination. The stowage plan determines the weight distribution over the different holds of the ship and the order of the different holds to be loaded.

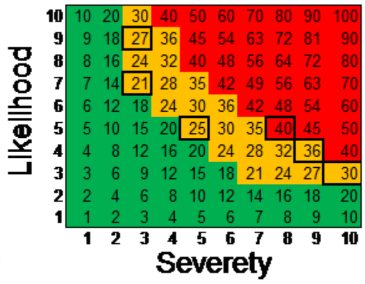
Since the ship management has responsibility over its ship and the cargo during the voyage, it has the final say on where the cargo is located in the ships hold and how it is secured. So it has to agree upon the stowage and cluster plan of S&W. When the ship management criticises these plans and tends to refuse to proceed with the plan, a discussion between the ship management and S&W starts to get to an agreement. So far, S&W has always been capable to adjust the plan or apply extra measures to satisfy the ship management, often in the form of extra securing or better weight distribution over the tanktop. Unfortunately these extra activities often come at the expense of the loading speed or cause demurrage (costs due to ships' delay).

To examine the effects of persistent disagreement, a brief risk assessment is executed. It involves reviewing as many aspects as possible to identify failure modes (manners by which a failure occurs), and their causes and effects. The failure modes and their resulting effects on the rest of the system are recorded in a specific FMEA (Failure Mode and Effect Analysis) worksheet, as shown in Figure 2.1a. The potential causes and effects are obtained by interviewing multiple employees in working class and management boards. There are four aspects on which the ship management has to agree upon and could cause disagreement and thus forms a potential failure mode, as shown in Figure 2.1a: the cargo, the stowage method, the used dunnage (supportive wood underneath the steel coils) and the lashing (steel cord securing the coils). When no agreement is found and the cargo cannot be loaded, loaded wagons at the quay will stay occupied by coils. Not only can this cause a logistical infarct, but if it continues and warehouses tend to overflow, production has to stop. However, less severe but still significant, are the consequences at the harbour. The ship might be delayed which could cause further disruption in the harbour planning. Moreover, if S&W has to perform extra activities or add material, expenses for S&W will increase. If S&W is not able to comply with the ship managements demand, further consequences could follow-up for the chartering department; they could get more restricted in which ships to charter. These mentioned potential effects of failure and causes can be found in the third and fourth column of Figure 2.1a, with corresponding severity (SEV) and probability of occurrence (OCC) and resulting

Risk Priority Number (RPN)[1]. From this assessment one can conclude the financial consequences for S&W are marginally and acceptable while the effects and consequences for the planning and transport flow can have severe impacts and is critical.

Process Function or Step	Potential Failure Modes	Potential Effects of Failure	SEV	Potential Cause(s)/ Mechanism(s) of Failure	OCC	RPN = SEV*OCC
Discussion at quay	1. Captain refuses (part of) cargo	Occupied wagons -> warehouses -> may result in production stop	10	Ship is delayed	3	30
	2. Captain demands different method for stowage (dropstowage/not during rain etc)	Logistical Infarct	9	Products need to return to warehouses	4	36
		Delivery Reliability decreases	8	Products don't reach customer on time	5	40
		Followup planning is disrupted	8	Next ship will also be delayed	5	40
	3. Captain demands other extra material	Financial results of S&W degrades	5	Stowage method with lower throughput is used	5	25
	4. Captain demands more lashing	Additional Material and Personnel Costs	3	Extra time and personnel is needed to apply extra lashing material	9	27
		Chartering Department more restricted and has less options for chatering ships	3	Ship ends on the 'Blacklist'	7	21

(a) Brief Risk Assessment of Quay Discussion



(b) Standardized Risk Matrix
Red = Not Acceptable, Orange = Critical, Green = Acceptable

Figure 2.1: Brief risk assessment on the discussion at the quay
Composed and validated in discussion with Dhr. S. Borsje (Production Manager OSL - S&W).

According to experts of S&W, several current trends are likely to complicate the loading conditions even further in the future, therefore the expected probability of this discussion is rising. These expected trends are shown in Figure 2.2 and are based on the gut feelings of employees in working class or management boards. First, the customer demands might be changing resulting in different product packaging, requirements and characteristics which can complicate the stowage method. Secondly, an internal change in the process is perceived; more last-minute alteration to orders and less time between production and transportation. Moreover, S&W senses changes in the shipping industry. Ship managements more often complain about exceedence of tanktop capacity and point to regulations and restriction in legislation. Another point S&W feels influences the situation is the climate change; severe weather conditions at sea and more rain influences the stowage method and planning. Section 4.1 explains and analyses these factors further. Tata Steel IJmuiden wants to proactively anticipate on these premonitions, and therefore this research is initiated.

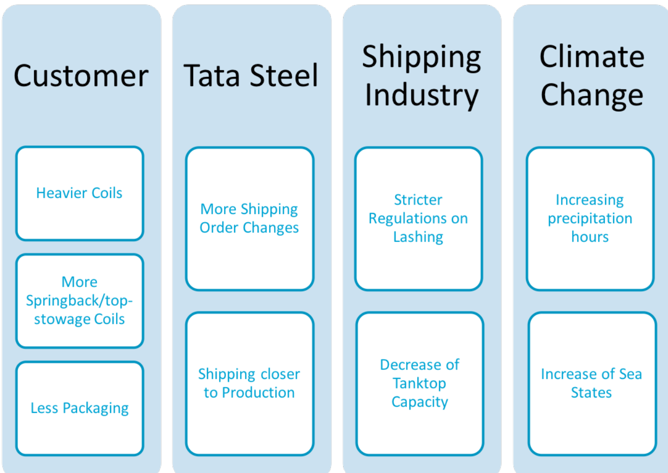


Figure 2.2: The different factors causing more complex loading condition

[1] By multiplying the quantified (rated from 0-10, with 10 extremely severe) severity and likelihood, the Risk Priority Number (RPN) is found. The generally accepted Risk Matrix in Figure 2.1b are shown with corresponding RPN. Red means the risk is not acceptable, so one should consider if executing a certain activity is responsible without managing the risk. Orange means the risk is critical, one should manage the risk conformingly. Green means the risk is acceptable.

2.2. Research Objective

Considering the risk involved in the doubtful situation, the costs for S&W are not seen as most dominant. The effects of an disagreement reach further than costs solely. For example, when S&W becomes unable to load ships properly and on time, decreased delivery reliability and quality might cause greater negative effects for the whole company in forms of loosing orders. Therefore this research will not be focused on costs reduction or improvement of the hold utilisation. The prevailing research objective is lowering or eliminating the risks regarding the discussion at the quay.

2.3. Research Approach and Methodology

This section explains the approach and methodology used to execute the research on the above-mentioned discussion between the stevedoors of Tata Steel IJmuiden and the Ship Management. To ensure the research approach and methodology match with the content of the research, two main characteristics of the problem situation are distinguished; the practical environment in which the problem raised (Section 2.3.2) and the indistinction of the problem (Section 2.3.1). The Deweyan Inquiry is a research methodology focusing equally on practice as on theory with a holistic problem approach. Therefore it is suitable to cope with the two distinguished problem characteristics.

Deweyan Inquiry The Deweyan Inquiry (DI) was first introduced in 1938 by John Dewey, an American philosopher, psychologist and pedagogue. His recognition for the need of a pragmatic method for scientific purposes with an equal focus on theory and practice resulted in an inquiry theory shown in Figure 2.3 and defined as follows:

> "Inquiry is the controlled or directed transformation of an indeterminate situation into one that is as determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole. [5]"

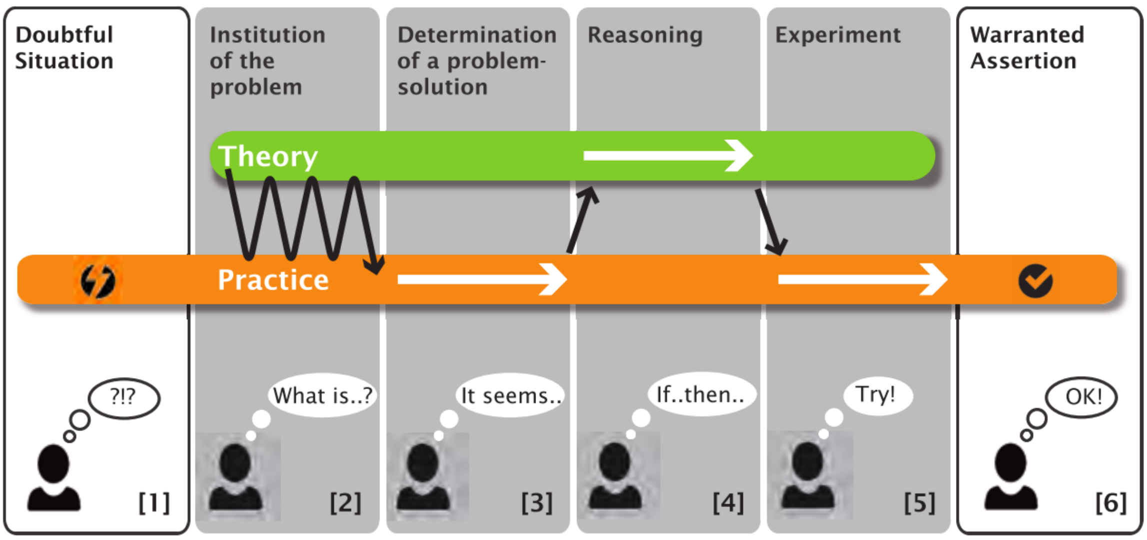


Figure 2.3: Deweyan Inquiry Overview [24]

The Deweyan Inquiry consists of 6 steps visualised in Figure 2.3 [24] and are described as followed:

1. Doubtful Situation: It starts with the recognition that 'something' in the course of events 'somehow' violated the expectations. This first step is deciding that a situation requires inquiry.
2. Institution of the Problem: This step frames 'what' will be attended to in the inquiry, the potential constituents of the doubtful situation are addressed. Such a frame must have its foundations both in practice and in theory.
3. Determination of the Problem Solution: This step concerns the controlling reconstruction of the existing situation to gain deeper understanding of the problem and give reference to possible solutions.

4. Reasoning: In this step the different problem solution combinations that are expected to solve the constituent factors are reasoned out with an if-then approach.
5. Experiment: In this step the optimal solution form the previous step will be tested against reality; do the problem solution actually have the expected effect?
6. Warranted Assertion: This step draws conclusions on the adjusted process; is the new situation an improvement?

2.3.1. Indistinct Problem

To ensure a firm and correct base for the research, a thorough analysis with clear constituents of the problem situation should be clarified first. Applied in this research, it results in a focus on the first three steps of the Deweyan inquiry on (1.) the Doubtful Situation, (2.) the Institution of the Problem and (3.) the Determination of the Problem Solution. Therefore the practical approach of the Deweyan inquiry is used to analyse the current situation: a theoretical current system description should be supported by testing it against practice. This enables a correct and realistic mapping and charting of the current situation.

2.3.2. Practical environment

Since the discussion at the quay is raised in a practical environment (as also required for the first step of the DI), the research approach should be practice-oriented to increase the probability of a realistic outcome and effective solution to the problem. The DI also shows practice is constantly involved in (2.) the Institution of the Problem. To incorporate practice in step 2, case studies will be executed. To give reference to the results of the holistic Institution of the Problem, the outcome of a theoretical power analysis (3.) the Determination of the Problem Solution, will guide as a framework for the practical solution boundaries in (4.) the Reasoning. After gaining insight from practice (field research and interviews), a theoretical Multi Criteria Analysis gives reference to the optimal solution. By means of a practical field research at the Port of Antwerp, the solution will be tested against reality to verify its application in (5.). This research will be finalised by placing its approach and findings into perspective with practice by means of the (6.) Warranted Assertion.

2.3.3. Research Design

The research approach and methodology, as determined in the previous sections, result in the research design as shown in Figure 2.4. The white balloons indicate the different steps to execute in this research. These steps are assigned to "practice" or "theory", based on where the steps find their basis.

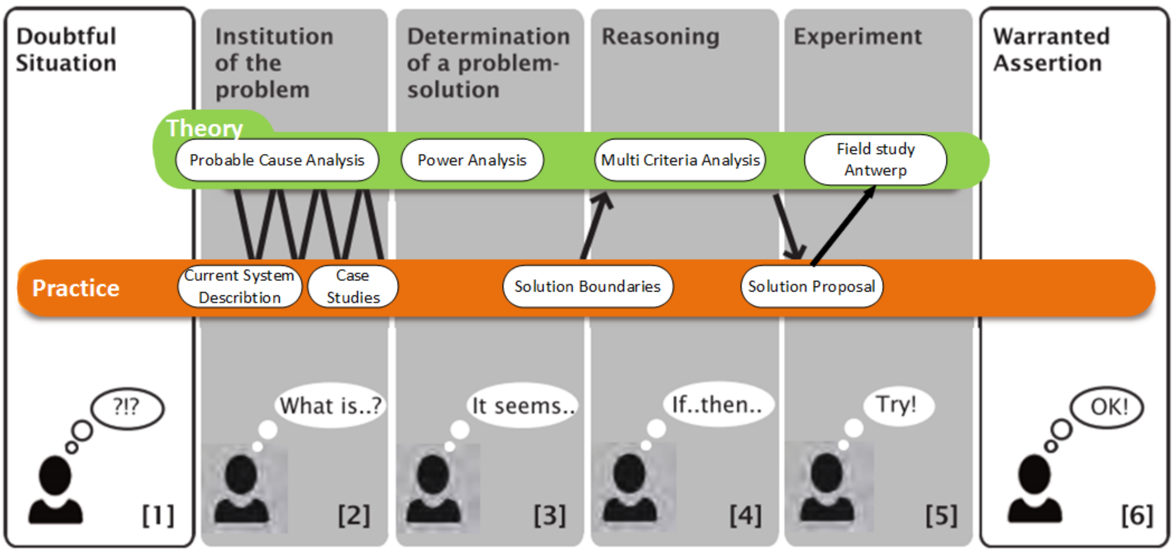


Figure 2.4: Research Design: Combining Practice with Theory

2.4. Research Question

A well formulated research question with sub questions enhance the construction of the research and so increases the potential of solving the problem situation. First a main question is formulated, which is supported by following subquestions. Due to the indicated (by S&W) probable causes of the quay discussion, this research starts with investigating these probable causes.

How could Tata Steel IJmuiden cope with the rising number of discussions with the ship management on the approval of the stowage plan?

Institution of the Problem

1. How do the probable causes, indicated by the stevedoring department, contribute to the disagreement of the ship management?
2. How does the information flow and decision procedure (the process) contribute to the disagreement of the ship management?
3. How does the stowage and securing procedure (the method) contribute to the disagreement of the ship management?

Determination of the Problem Situation

4. How does the area of influence of the stevedoring department constitute to the boundaries of the solution?

Reasoning

5. What solution is able to cope with the current and future bottlenecks regarding the approval of the stowage plan by the ship management?

Experiment

6. Does the solution have the desired effect regarding effectiveness, safety, costs and practicality?

2.5. Undefined Research Scope

A problem analysis, such as this research, require inductive reasoning and a holistic approach of the problem. This ensures all probably elements to the problem are included in the inquiry. Only after broader knowledge on the matter and its problem is acquired, the researcher is aloud to eliminate aspects based on rigour grounds. Diverging the analysis will finally lead the researcher towards defining the constituents to the problem.

However, this required holistic and inductive approach to the research also implies scoping at this point of the research, with only little knowledge on the problem environment, is not appropriate.

3

Doubtful Situation: the Problem Environment

To explore different aspects to the problem situation, different background fields need explanation. Therefore, a first introduction to the steel production of Tata Steel IJmuiden is given in section 3.1 Hereafter the concerning transportation activities of the company are explained in Section 3.2. Section 3.3 gives an overview of the corresponding costs involved in the outbound transportation.

3.1. Steel Production

Tata Steel IJmuiden is a steel factory with its expertise in differentiated high quality steel. With different furnaces, casting factories, rolling and pickling mills, a high variety of products is produced. In Figure 3.2 a schematic overview of the production process of Tata Steel IJmuiden is given. Different production factories and processes are shown with their corresponding output in product types. Within this research a selection of products transported over deep sea is taken into account. ETTS (Eye To The Skye, vertically placed coils) and slabs are not considered due to their physical differences with respect to horizontal coils, explained in the last paragraph of this Section. The products considered in this research are the horizontally K-, G-, W-, V-, and Z-coils as shown output in Figure 3.2. The type of coil determines if it needs packaging or not, however it is not an indication for the restrictions as topstowage or springback.

- **W-coils** are coils from the Hot Rolling Mill ("Warmband Walserij") and can be pickled or not. This type of steel is allowed to rust and is therefore not wrapped and not (always) required to stay dry.
- **K-coils** are coils from the Cold Rolling Mill ("Koudband Walserij") but further untreated and not packed.
- **Z-coils** are coils with a zinc layer and is sensitive to rust and therefore always packed.
- **G-coils** are zinc coils with extra oil, always packed.
- **V-coils** are painted zinc coils, always packed

Packed and non-packed coils For the stowage process the first important product characteristic is the package. However, the type of package has no impact on the stowage condition, therefore the only categories considered in stevedoring are packed or non-packed. Packed coils are always required to stay dry, so outdoor coil handlings during the stevedoring process cannot be performed during precipitation.

Topstowage When a coil has the label 'topstowage', it is not allowed to stack other material on top of it. This label is put on weak or thin material, or material with a lot of oil in between the layers of the coil; these characteristics increase the chance of sagging, showed in figure 3.1a. Although these coils should always be on top in the ships hold, this restriction does not hold for warehouses since their time in the warehouses is short enough not to induce sagging. The topstowage label is not related to the packaging of the coils. However, most material types qualifying for topstowage often also require package.

Springback A springback coil consists of material with internal tension in the material which could induce sudden unwinding (Figure 3.1b) or abrupt smacking of the outer wrap (Figure 3.1c). Since a deadly incident with a springback coil in Finland and two injured employees in 2000 and 1999 [17], Tata Steel IJmuiden has strict procedures concerning the handling of springback coils. The coils are required to be sealed with more (5 instead of 3) metal bands and are always to be placed right on the outer wrap to minimise the risk of unwinding.

(a) Damaged coil due to sagging (b) Partly unwinded springback coil (c) Springback outer wrap opened

Figure 3.1: Damaged coils

3.2. Transportation

Once the production is completed, the different types of steel have to be transported worldwide to the customers. This can be done by train, truck or ship, which latter option is of topic for this research. With IJmuiden being at the coast and by having three different outer quays and one inner quay, the company is capable of mooring their chartered ships. With their stevedoring department, also the loading and stevedoring procedure is done internally.

The loading of a ship will generally be performed with quay cranes. Depending on the type of material, the width and hold shapes (box or bulk type) of the ship, it may be necessary to locate material with fork lifts placed in the hold. Of the three outer quays, one is used for import of bulk raw materials and two outer quays are used for mooring and loading vessels with finished products for the customers. These latter quays are of interest for this research, their specifications are given in Table 3.1. Even though quay 1 is longer, quay 3 is the bigger quay by means of crane capacity and allowed draught. Therefore quay 3 is mainly used for the bigger deep sea going ships.

Table 3.1: Harbour specifications of the two outer harbours used for export

	Quay 1	**Quay 3**
Quay Length	414 m	250 m
Quay Height	4.20 m above mean sea level	8.00 m above mean sea level
Airdraft top hatch coaming	27.50 m above mean sea level	18.60 m above mean sea level
Max. draught	9.00 m	11.00 m
Nr. of Cranes	1	2
Lifting Capacity	18-35 ton	58 ton
Outreach from quay edge	-	20.50 m

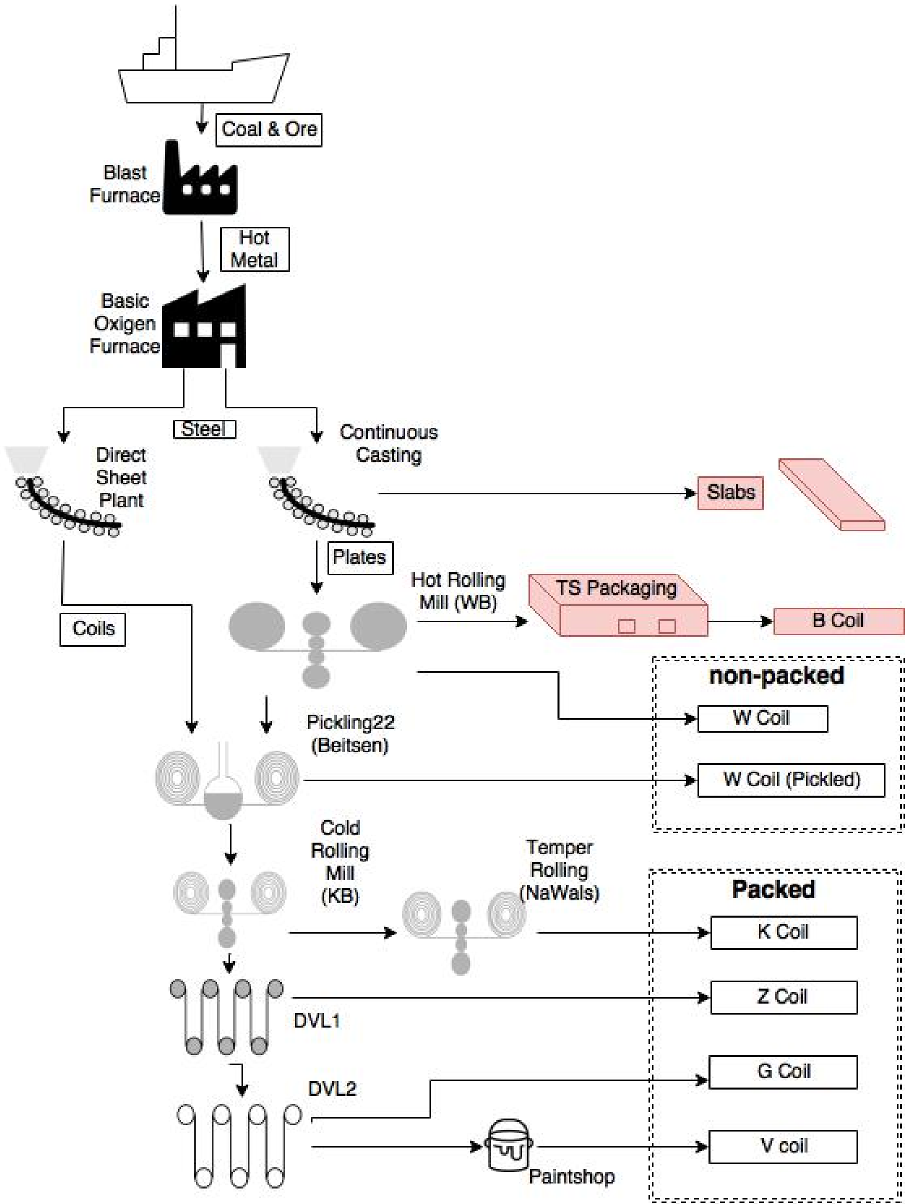


Figure 3.2: Simplified Production Process with corresponding product type output

Production Process: First the raw material, iron ore and coal, are inserted in the Blast Furnace. Hot compressed air transforms the raw materials into liquid hot metal. Together with scrap metal, the basic oxygen furnace oxidises the metal and forms liquid steel. In the direct sheet plant or at the continuous casting line, the liquid steel is molded into coils or slabs of solid steel. Both outputs can be stored in warehouses and will be called for following treatments when specifications and timing, determined by the customer, are known. Coils can then be pickled, zinced at DVL 1 or 2 (Dompel Verzink Lijn) and painted. Slabs first go through the Hot Rolling Mill before further treatment can be applied. After the Hot Rolling Mill, coils can go to Tata Steel Packaging (TS packaging) where ETTS coils are made. These are all continuous processes, which run 24/7. However, most of these factories have their own warehouse, storing the product output until called for next treatment (determined by customer demands and production planning). With these warehouses, Tata Steel IJmuiden has established buffers when customer demands in- or decrease and the output of the factories depend on the production planning.

3.3. Financial Perspective

Before executing this research, it is important to understand the impact magnitude of changes and potential improvements. Therefore a ballpark estimation of the expenses of transporting the coils is elaborated in this section. For this estimation, the deep sea transportation costs is calculated per transported tonnes and divided over three cost groups: chartering, stevedoring and coil damage costs. Chartering is chosen as separate groups since this entails a separate department, with a major focus on economical optimisation. The stevedoring costs (including the port tariffs) should be placed in perspective to the chartering costs, to analyse if adjustments to ship chartering lays within the solution boundaries. The coil damage costs are interesting to look at, in order to see if the current stowage method induce extra costs on damage.

3.3.1. Stevedoring Costs

All activities performed at the harbour concerning the stevedoring process are logged by the 24/7 operating SIC (Stukgoed Informatie Centrum). They register the duration of activities and the amount of actual loaded tonnes of steel, categorised by modality: deep sea, short sea and inland shipping. This is done for the inner port (where sometimes also deep- and short sea vessels are loaded) and for the outer port. The registered activities and their corresponding cost are allocated by the ATCE (Accounting & Transactions Centre of Excellence) over different categories of expenditure. These categories and their corresponding percentage of the total are given in 3.2 for the annual plan of 2015-2016 (fiscal year from April 2015 to March 2016). This table shows that within S&W, the personnel forms the main expense and harbour material (depreciations and maintenance) forms only a small percentage (5%+8%) of the total costs. All these costs will be translated to port tariffs, as will be explained in next paragraph.

Table 3.2: Cost Allocation S&W Annual Plan 2015-2016

Costs AP 2015/2016	% of total
Personnel	48
Internal services	17
Other services	2
Internal ICT	1
Transport services	2
Maintenance	8
Depreciations	5
Other Costs	17
Total costs	100

Port Tariffs A Port Tariff is a annually calculated compensation for the loading activities at the port, so a generalisation of the above mentioned stevedoring costs divided over ship and product types. The Port Tariffs in euro's per ton are calculated by the controllers of the financial departments of Tata Steel IJmuiden. First the stevedoring costs are calculated per crane hour. When this is divided by the throughput per hour, a gross costs per tonnes is obtained. Adding a correction for the costs of stowage materials results in the Port Tariff (euro's per tonnes). The resulting Port Tariffs for deep sea transported coils per product types and the ships hold types are given in table 3.3, pointing out the following:

- For the Hot Rolled Coils (W-coils) the tariffs are given in a range, since the Annual Plan specifies the tariffs also for stained coils. But since the stevedoring does not handle stained or normal coils different, and they are not researched to that detail in this report, their port tariff is grouped.
- The average weight of the coils is the main reason for the difference in the Port Tariffs (W-coils are on average heavier as other coils) since they are calculated per ton. With a higher average weight per coil, less handling per tonnes are needed (so a higher throughput, since handling time barely depend on coil weight), so the personnel costs per ton is lower, resulting in a significant decrease of the port tariff.
- In the Annual Plan the Port Tariffs of Z-, G- and V-coils are grouped thus so they are in this table.
- The difference in costs per ship type is caused by the throughput difference. Bulk type ships have an higher average throughput of tons/hour so the costs in €/ton is lower.
- According to the controller of S&W, bulk type ships are less expensive to load as box type ships. This is, however, against expectations of S&W, stating that preparing bulk holds is more labour-intensive as will be explained further in Section 5.1.2. This could be explained by the many other factors indirectly

influencing the throughput or port tariffs, of which this information is not conclusive about and at this point in the research, not found relevant to investigate.

Table 3.3: Port Tariffs deep sea transported coils [€/ton] and their average weight per coil in 2015-2016

	Box		Bulk		
	Port Tariff [€/ton]	Throughput [ton/hour]	Port Tariff [€/ton]	Throughput [ton/hour]	Average coil weight [ton]
W-coils	3,74 - 4,27	296-345	3,86 - 4,12	308-332	22,2
K-coils	4,46	281	4,19	303	15,9
Z-, G- ,V-coils	4,13	307	3,96	323	14,2

3.3.2. Chartering Costs

To transport the different coils overseas, ship are chartered by the Outbound Shipping department of Tata Steel. By keeping track of the costs per ton per destination, the department has a database of reference pricing for indication and target pricing. However, since the costs are highly dependant on the length and route of the voyage, the average costs has a wide range: for deep sea the average costs for transporting steel coils varies between €30 to €40 euro per tons.

3.3.3. Coil Damage Costs

Besides the costs for the chartering and the stevedoring, there should also be costs allocated to the repair or loss of material. Since this research is focused on the outbound transportation, only the damage costs which can directly be traced back to the harbour activities should be considered. This contains the coil damage costs caused by handling at the harbour or during shipment due to insufficient lashing and securing. Unfortunately, since different hubs within Tata Steel IJmuiden are assigned to different business units with each their different financial control and system, these exact costs could not be tracked down within the scope of this research. Apparently, the financial control department does not see the coil damage expenses (due to harbour activities) as significant to keep track on.

3.4. Research Scope

Now knowledge is obtained on background information of the problem it is possible to diverge the research scope, while ensuring constituents to the problem are still within the research boundaries.

Products As mentioned in section 3.1, the steel plates from the continuous casting line and tin (ETTS) coils produced in the Tata Steel Packaging (shown in Figure 3.3) are not considered in this research. Due to the significant physical difference of plates compared to horizontal coils, the discussion at they quay mentioned in 2.1 is not a problem in the plate shipping. Although ETTS coils (30% of the deep sea transported coils) seem only 90 degrees rotated, their stowing and securing is very different as of horizontal coils. This has mainly to do with the type of stacking (pyramidal but straight on top of each other) and the lashing and dunnage used since every single ETTS coil has its own pallet.

Transport Routes In this research only deep sea shipping is considered, because the inland and short sea shipping is less influenced by the different factors mentioned in 2.1. Since the coasters and inland ships transport less coils per shipment, the order changes and type of products on board have little influence on the loading procedure. Besides that, the ship management of these ships is less strict on the lashing and securing of the cargo, since the coils are often not stacked and due to the less significant influence of the weather. Due to these reasons, the possible discussion at the quay only happens sporadic and will be very different of nature.

Departments of Tata Steel involved This research is focused on a problem in the shipping activities of Tata Steel IJmuiden. However, the core business of the company is producing steel and so the companies focus and priorities lies at the production. The shipping activities are secondary and must be supportive to the production. Therefore the production activities together with the supply and availability of products from the factories will be assumed as a fixed input to the shipping activities. Moreover, it can be concluded the chartering costs with €30,- to €40,- per tons is far more significant as the stevedoring costs of roughly €4,-

per tons. Therefore, when searching for a solution of a problem, and not necessarily a costs optimisation, one could say financial adverse adjustment should be sought in the area of less influence on expenses. Financial adverse adjustments in terms of percentages to the Chartering department will have an absolute greater negative effect as the same percentage to the stevedoring process.

Figure 3.3: Eye To The Skye coils (ETTS, left) and slabs (right), out of research scope

4 Institution of the Problem: Probable Cause Analysis

In this step of the Deweyan Inquiry, the connection between theory and practice is used to judge and analyse the doubtful situation. In this chapter, the expected causes by S&W are analyse, both to check their presentiments and to find trends in factors influencing the quay discussion. This chapter covers the fist part of the Institution of the Problem answering the first research question:

1. How do the probable causes, indicated by the stevedoring department, contribute to the disagreement of the ship management?

As a starting point, first the probable causes according to S&W are explained in Section 4.1. The following section discuss and analyse the probable causes per origin; company production (Section 4.2), company process (Section 4.3), shipping industry (Section 4.4) and the climate changes (Section 4.5). The findings are summarised in Section 4.6.

4.1. Probable Causes

As mentioned in Section 2.1, S&W has had several trends in mind which might influence the discussion at the quay. These probable causes are shown again in Figure 4.1 and explained in the next paragraphs. Hereafter three factors are already eliminated prior to the in-depth analysis based on logical reasoning and expected influence on the defined research problem.

Customer Customers are becoming more critical and demand higher quality and with changing customer demands, the output of Tata Steel IJmuiden is changing. S&W feels this results in heavier coils which need to be transported with less packaging (since this is waste for the customer). It is also expected more springback and topstowage coils are exported since these are the high finished products which Tata Steel IJmuiden is focused on and specialised in.

Tata Steel The stevedoring planning officers at the harbour need information about the cargo before the stowage plan can be drafted. The earlier this information is available the better, since this enables early communication about the cargo planning with the Ship Management and leaves room for more iteration and thus optimisation in the stowage plan. However, the stevedoring planning officers notice this time span is decreasing. Besides that, last minute changes in orders happen more frequently, according to them.

Shipping Industry Another factor in the shipments of the products is the shipping industry. Their legislation an regulations are applied and to be complied with by the ship manage- ment, which is expected by S&W to complicate the stowage plan even further. Moreover, on top of the regulations, S&W feels the ship management is less and less willing to utilise their full tanktop capacity which decreases the stacking flexibility of the stowage plan.

Climate Change Last but not least, S&W sees a probable cause in the global climate change. More precipitation hours complicates the planning of dry material and increases the quay time of ships. Another climate change, the increase of sea states, could affect the safety awareness of the shipping industry and therewith the regulations and restrictions on the stowage plan.

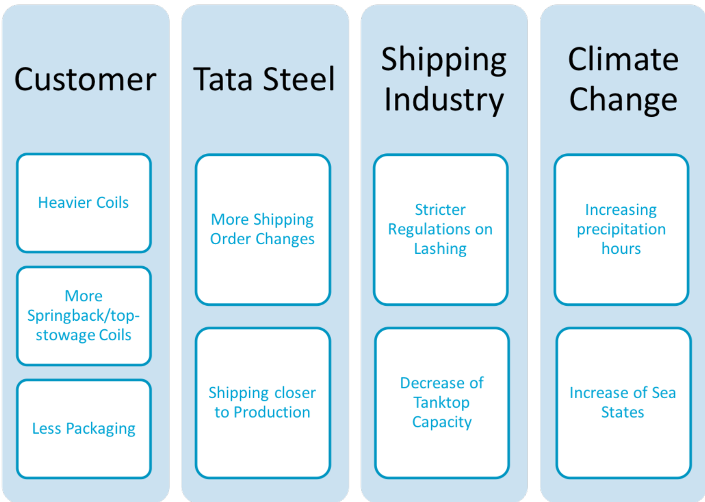


Figure 4.1: Probable Causes indicated by Tata Steel IJmuiden

Before executing an in-depth data or literature analysis on trends of these factors, some can be eliminated beforehand due to insignificant influence on the discussion at the quay. These insights are based upon interviews with different experts (attached in Appendix B) and discussions with the problem owners.

- **Increasing Precipitation Hours:** Although precipitation could disrupt the harbour planning, especially for shipments with high percentage of dry cargo, it does not influence the discussion at the quay directly: Ship Management and S&W understand and agree up on the corresponding restrictions of dry cargo. Moreover, there is no clear trend visible once looking at the precipitation hours since 2016 (as OSP found in their data, see Appendix C.2).
- **Less Packaging:** With customers demanding less and less packaging over time, it is a challenge for Tata Steel IJmuiden to still protect the coils properly against damage due to coil handling, stacking and stowing. However, since the damage costs are found insignificant, as explained in Section 3.3, and no direct problem is found with the current packaging, this probable cause is not found relevant for this research.

After this distillation several clearly identifiable key factors potentially complicating the stevedoring process in the future are identified as shown in Figure 4.2. The next subsections contain a data or literature analysis of the factors and will elaborate on why this factor is of interest, how the information (data/literature) is gathered, what trend the data shows and which conclusions can rightfully be drawn upon this analysis.

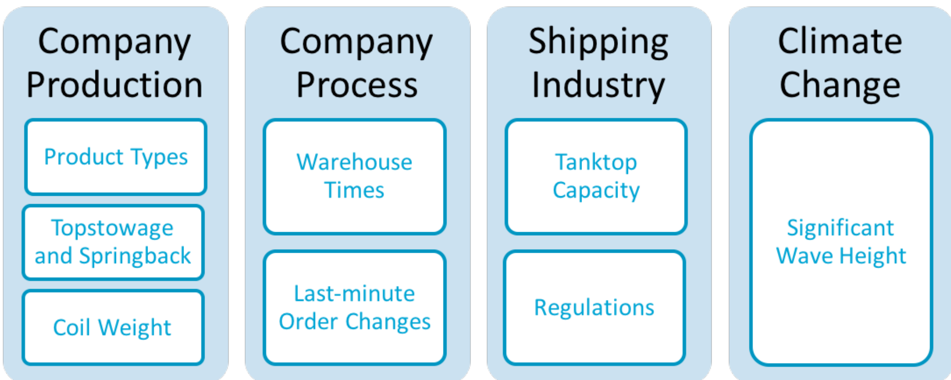


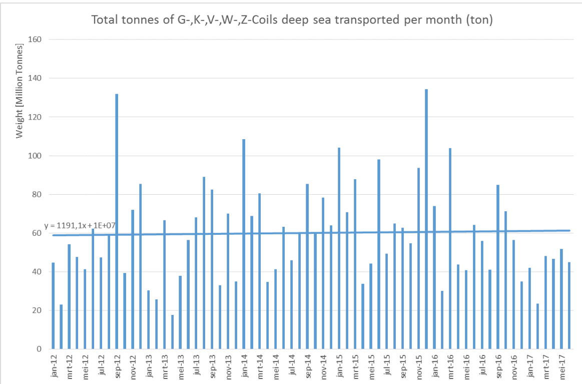
Figure 4.2: Distilled input for the Factor analysis

4.2. Company Production

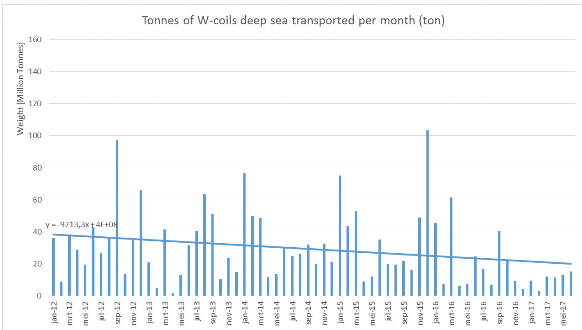
The core business of Tata Steel is making money with selling steel products to customers. To ensure future businesses, it is important to satisfy customers and thus to comply with their demands. Therefore these demands determine the type and characteristics of the products to be transported. In this situation, the transportation activities are inferior and ancillary to the production activities and so the harbour just has to deal with the products. So the product types and characteristics are seen as input and cannot be influenced by S&W. Therefore it is important for S&W to foresee and cope with changes in product types and characteristics and so these are to be analysed

4.2.1. Product Types

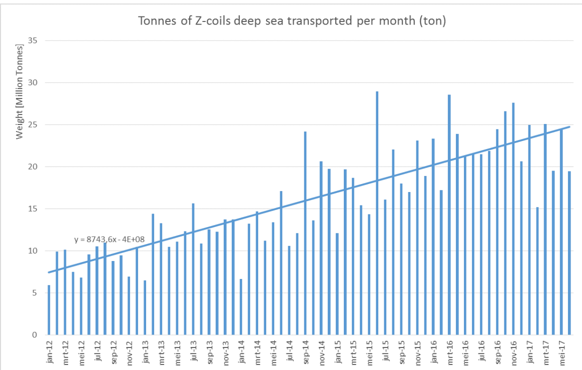
Different product types come with different characteristics and requirements for the stowage plan, for example the packaging and fragility of coils. For instance, all but W-coils (Hot Rolled, but further untreatened) requires packaging and therefore cannot be loaded during precipitation (also see Figure C.3 in Appendix C.2 for the precipitation and caused loss). Besides the packaging, the fragility of the coils determines if stacking is allowed. To analyse trends in product types, data is retrieved from the historical database of NM&D (Network Management and Development) department. The coil data (characteristics, material, weight, size etc.) is stored together with different stage dates (birth date of coil, send-ready date, actual transportation date etc.) after the whole production and stevedoring process is complete and the coils are on the way to the customer. This information is subtracted and analysed from 01-01-2012 to 01-06-2017 only for deep sea transported coils. For computer capacity reasons, NM&D could provide this data from no earlier as 01-01-2012. The trends and data of all material types are found in Appendix C.1 but the most important findings are shown in Figure 4.3.



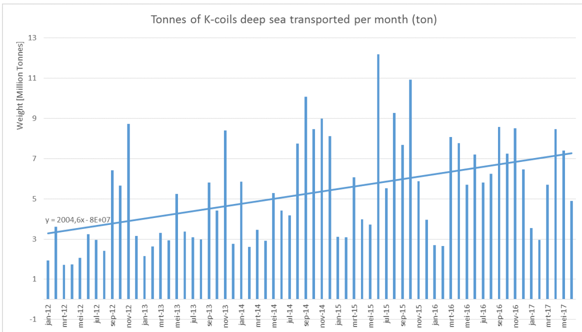
(a) Total exported tons



(b) Transported tons of W-Coils



(c) Transported tons of Z-Coils



(d) Transported tons of K-Coils

Figure 4.3: Different product types and total tons exported deep sea

So while the total amount of tons does not change significantly, the number of Z- and K-Coils are increasing and the tons of W-coils are decreasing. This results in an increase in packed and dry cargo. Besides that, Z-coils are more often labelled as topstowage (due to their high finished, fragile characteristics) so it is likely to also find an increase in topstowage coils. Moreover one should notice the graphs show trends in tons, and not in number of coils, this is also a reason the coil weights are to be analysed as well.

4.2.2. Topstowage coils

The label topstowage is given to material which is not permitted to carry any weight and should therefore always be stowed on top during shipments. The expectation of a growing number of topstowage coils is derived from the company wide target: selling (and thus exporting) more high-end and far finished products. This comes with a trend of lighter, more fragile material such as the Z-coils (see the trends in Figure 4.3c), which is more often labelled as topstowage. However, Figure 4.4 shows a very fluctuating number of coils per month labelled as topstowage deep sea transported per month.

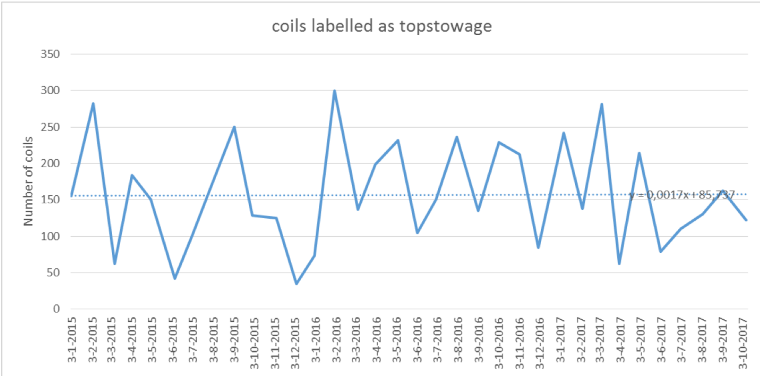


Figure 4.4: Number of coils labelled as topstowage over time

4.2.3. Springback coils

Material with a Springback label comes with strong restriction on its handling and locating due to its increased safety-risks. So a higher number of topstowage or springback coils within a cargo will complicate the cargo arrangement and loading procedure. Since the focus on Springback coils is growing due to several safety accidents internal and external from Tata Steel (as explained in Section 3.1, the procedure and labelling of Springback coils has become more strict. Therefore a growing number of coils with the springback label is expected. However, the data of Tata Steel IJmuiden does not show this (Figure 4.5 represents the number of coils labelled as springback over time).

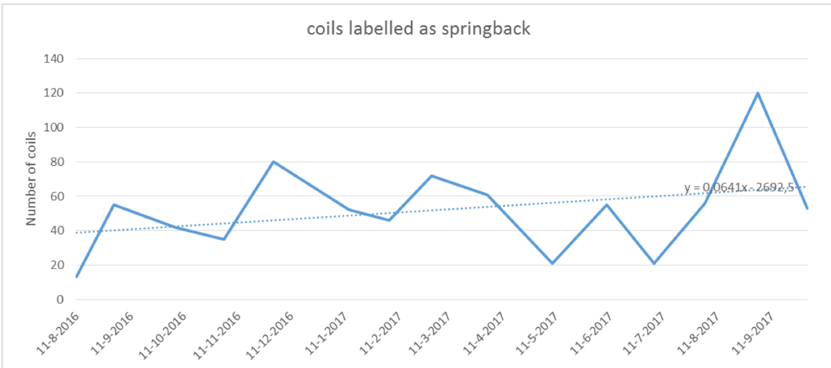


Figure 4.5: Number of coils labelled as springback over time

Unfortunately Tata Steel IJmuiden does only report and administrate the labelling of topstowage and springback material since March 2015 and November 2016 respectively. Moreover, it is not clear if the administration since then has been accurate. The labelling is done at over more than four different production sites with own specific system and administration tools. Therefore this information is not reliable and no well-grounded conclusion can be drawn upon this information.

4.2.4. Coil Weight

During the stevedoring process the arrangement of coils in the ship is strongly dependent on the coil weight; lighter coils are placed on top of heavier coils. Besides the stacking, the weight distribution over the tanktop should also be taken into account to comply with the demands of the Ship Management (is responsible for the ship and its cargo). It can be stated that: the heavier the coils, the more complicated the stowage plan will be. And since the discussion with the ship management occurs more often and the coil weight is core subject of the discussion, the S&W department expects an increase in coil weight over the past years. To look at the weight distribution of deep sea transported coils, the same database as used for the product types (from NM&D) is consulted.

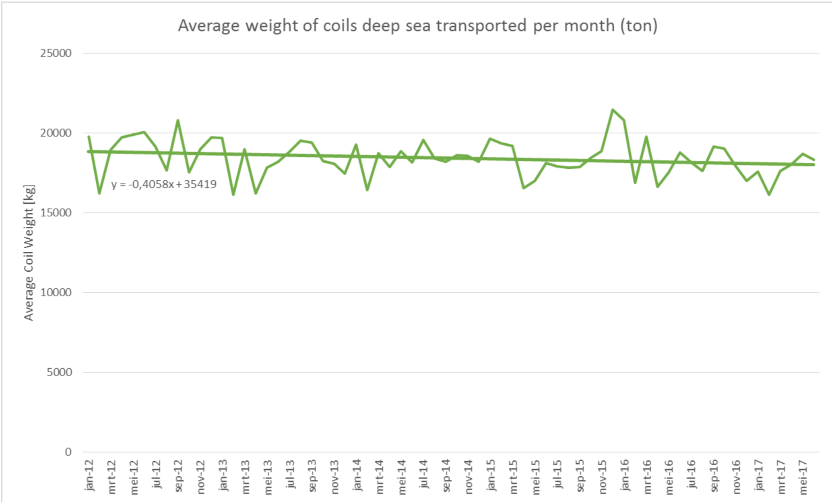


Figure 4.6: Average weight of coils transported by Tata Steel IJmuiden

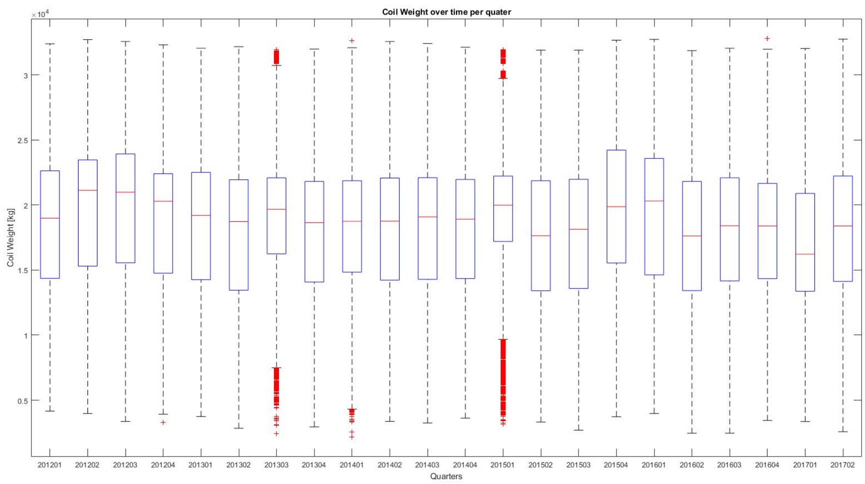


Figure 4.7: Distribution of coil weights over time

As shown in Figure 4.6 slight decrease in average coil weight is shown. Unfortunately this is opposite as expected and noticed by S&W. Moreover, even if we look at the distribution of the weights in Figure 4.7, neither an increase in more extreme (and so also heavier) coils can be distinguished. However, it is known heavier coils will be produced by Tata Steel IJmuiden in the near future. Where the whole site was formerly equipped for a maximum of around 32 t per coil (with maximums more being an exception as a norm), production sites such as the Hot Rolling Mill are already preparing and adapting to a maximum weight of 38,5 ton per coil. So although there is no current increase in coil weight, S&W and the stevedoring process should prepare for these extreme coil weights.

4.3. Company Process

For the ease of reading this section, a rough schematic overview of the process is given in Figure 4.8. Important is the information needed to make the cluster and stowage plan (plannings on cargo loading sequence and method, explained further in Section 5.1.1). Before the ship management can approve on the stowage and cluster plan, these need to be established with detailed information (dimensions and weight) of the cargo.

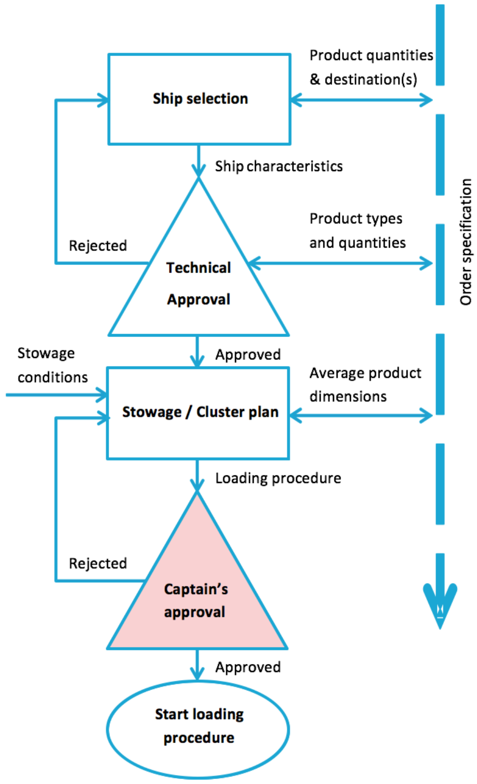


Figure 4.8: General Steps from Ship Selection to Loading

4.3.1. Warehouse Times

Due to a company-wide focus towards Just-In-Time delivery, the warehouse times of coils is expected to be decreasing over all different warehouses of Tata Steel IJmuiden. Shorter warehouse times could affect the timing of information, which will have a major influence on the timing of generating a stowage plan and communicating the stowage plan towards the Ship Management. Fortunately, the company keeps track of the intake dates of all product types in warehouses. Since there are no consequences for the stevedoring process regarding the specific warehouse coils are delivered from, the distribution of warehouse times is not specified per warehouse of the site. The specific data used for this analysis is made available by Mr. T. Balm (Data & Information Coordinator at (COM BPS R&A CRE)). The intake and actual transport times specified per coil are available from 2012. However, this data does not consider the send-ready date. After the coil intake, a quality control check is done per coil during which the coil is blocked for transport. After the coil passed the check, it becomes ready for transport and thus the transport date is assigned to the coil. So for the timing of the transport of the coil to the harbour, the send-ready date is important. Unfortunately the data of the send-ready date is only temporarily saved data due to its extend size of storage. Therefore, the retrieved data is not reliable for a proper trend analysis but does give insight in the distribution of send-ready to transportation time for 2017. On average in 2017, 1,4 days were between Birth and Send-Ready date. For the duration between Send-Ready to Transport, an average of 13,4 days was found (see Appendix C.3).

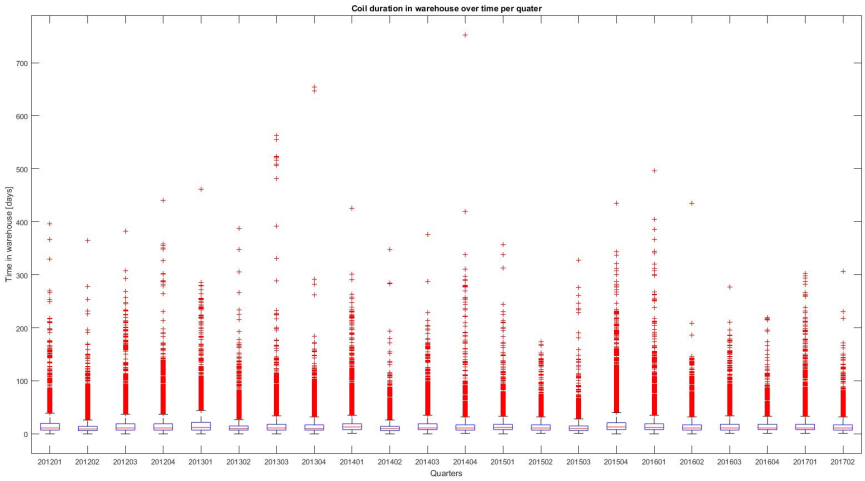


Figure 4.9: Distribution of warehousetimes (in days) per coil over time (per quarter)

As visualised in Figure 4.9 there is no remarkable trend visible in the distribution of the warehouse times over the past five years and the weight lies under the 15 days. We can state this is no normal distribution and therefore a frequency analysis is executed on this data. Since OSP (On Site Planning department) generally breaks down the gross cargo planning to a coil-level specification around 24 hours before transportation, it is interesting to look at the shorter warehouse times since these affect the stevedoring planning more directly.

Once we take a closer look at the frequency trends in the shorter warehouse times (Figures 4.10), we find, against expectations, a decrease in percentage of coils transported within 7 days or less after their warehouse intake.

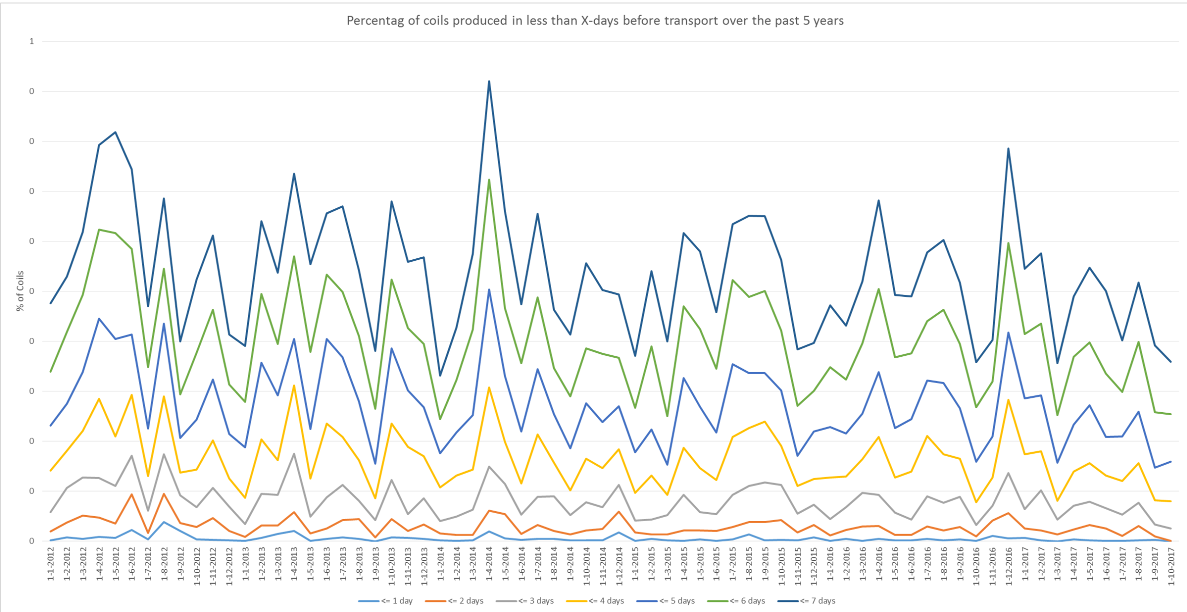


Figure 4.10: Percentage of coils transported within X amount of days after Birth Date

However, although no trend in percentages is seen, an absolute growth in last minute coils will also affect the stowage planning. Therefore, Figure 4.11 zoom in on the number of coils transported within 1, 2 and 3 days after their intake in the warehouse. But also with this data visualisation, no trend is shown in an increased number of coils with a short duration in the warehouses.

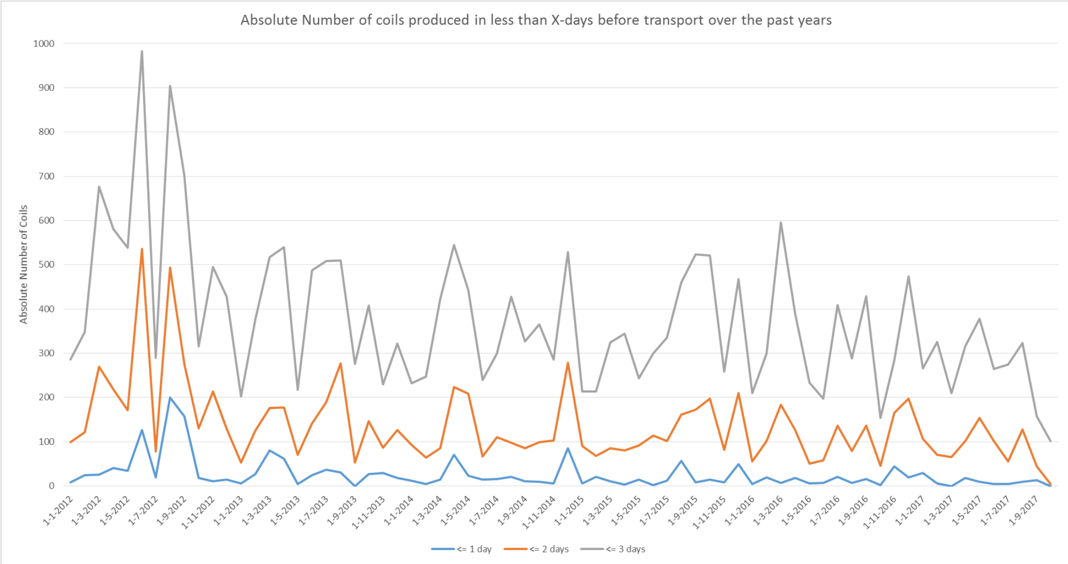


Figure 4.11: Number of coils transported within X amount of days after Birth Date

4.3.2. Last-Minute Order Changes

Besides the above mentioned data on late time of readiness-for-transport, there is no data available on last-minute order changes since these activities are difficult to translate to raw data. Therefore Mr. van Roon, head of Outbound Operations, is interviewed to obtain his view on the amount of last-minute order changes (notes of the interview are attached in Appendix B.6). His department is responsible for assigning and planning products to shipments. In this planning, three sides of input need to come together: the shipments, the production and the customers call. An increase in last-minute order changes, caused by the custormer or sales changes, is not a very obvious trend seen by him. However, he does notice his work becomes more complex and crucial, and more discussions and deviations of the normal process occur. He assigns these changes not to the focus of Tata Steel on customer flexibility, but to the production backlogs and very tight production planning, leaving no buffer, which results in last-minute changes in cargo composition.

4.4. Shipping Industry

4.4.1. Tanktop Capacity

Tanktop Strength A ships tanktop strength determines the weight in ton/m^2 the floor of the hold can withstand. For the transport of the steel coils, ships designed for bulk cargo are deployed. But due to the more concentrated load of the weight of steel coils, the tanktop strength is often the limiting factor for the cargo capacity of the ship. Out of a database of 395 reference ships, made available by Belgo-Iberian Maritime NV[1], the average tanktop strength per new-build year is obtained[2]. At first, different experts talking about the tanktop capacity trend, mentioned a decrease in tanktop strength. However, as shown in figure 4.12, an opposite trend in tanktop strength for ships per building year is shown.

[1] Belgo-Iberian Maritime NV is a chartering Broker for Break-bulk Cargoes (Specialised in steel and project cargoes). BIM also operates as Port and Husbandry Agent at the Port of Antwerp. `http://www.belgo.be/`

[2] After Clipper Bulk in Copenhagen makes a selection of bulk and box type vessels able for steel coil transport, BIM enters the ships in their database before tested against any other restrictions and therefore these reference ships are assumed as representative sample of the bulk- and box type chartering market.

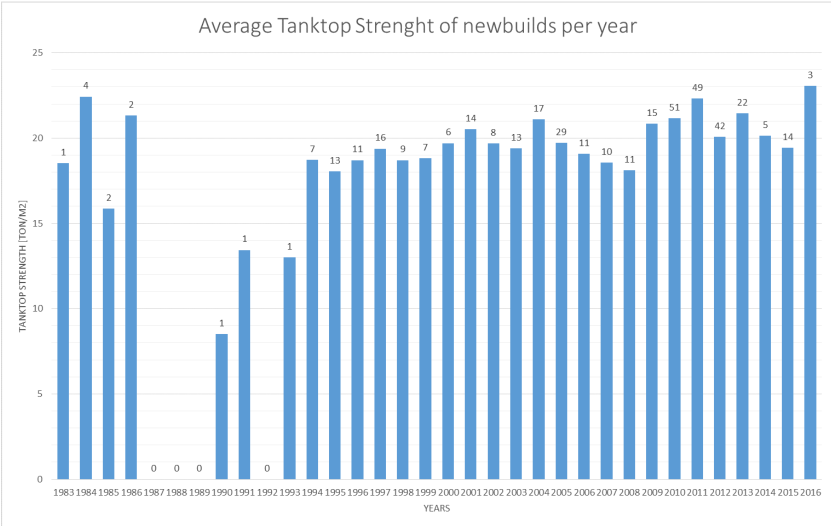


Figure 4.12: Average tanktop load of reference ships per building year in ton/m^2.

Tanktop Capacity Now it is important to note the difference between tanktop strength and tanktop capacity. Even if we cannot distinguish a decreasing trend in tanktop strength in Figure 4.12, this does not deny a decrease in tanktop capacity. The capacity is not only dependent of the tanktop strength, but also on the arrangement of its construction frame underneath. More often the S&W department notices the ship management of eastern-build ships (which are growing in quantity) demand coils to be located right on top of supporting girders. So although we see a slight increase in the average tanktop strengths, due to the limitation coming with eastern-build ships, we cannot conclude on an increasing trend in tanktop capacity.

4.4.2. Regulations

Since there is no data available on stricter or more regulation regarding steel coil shipping (for example: the Cargo Safety & Securing Manual in Appendix D, already established in 1996), Capt. A. Lenting, Managing Director at Siri Marine [3] is consulted for his view on ships motion, corresponding forces and relations to regulations. The interview can be found in Appendix B.3 and the main conclusions are listed below.

- Since governments or Class Societies do not account for lighter weather condition in their regulations, ships management will neither and so high safety margins are applied at all times.
- No trend in number of claims is seen, but insurance companies more often hire lawyers. This results in higher costs and more often not covered by the insurance companies. Therefore, the responsible parties such as ship owners, ship management, brokers or shipping companies become more cautious and strict on regulation enforcement. Resulting in a more frequently involvement of Surveyors for their independent view on the stowage method.

Although no change in regulations is seen, section 5.1.2 compares the current stowage manual of Tata Steel IJmuiden with the regulations regarding steel coil stevedoring.

Maritime Safety Awareness Another factor of influence on the regulation is the safety awareness in the maritime industry. All around us we see people, organisations and companies focusing more and more on safety. This forces organisations to a stricter enforcement and compliance with the rules regarding safety. If this trend is happening in the maritime industry as well, can be indicated by a document index literature analysis regarding safety in the maritime industry. In cooperation with the European Union "European Regional Development Fund", such literature analysis is conducted regarding Maritime and Seaport Safety & Security in November 2016. Figure 4.13 shows the results: an increase in amount of publications from 2003 to 2016 [14]. So although the regulations have not changed significantly, the enforcement and thus the level of compliance with the regulations is probably changing due to growing safety awareness in the maritime industry.

[3] Siri Marine is a company specialised in measuring, visualising and analysing motions and the forces that influence such motion and relating these to laws and legislation in the maritime industry. `http://sirimarine.com`

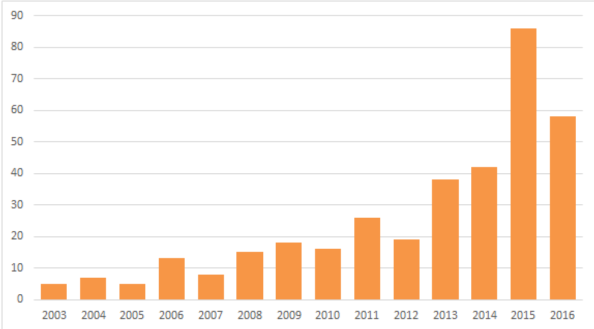


Figure 4.13: Number of Documents published on Maritime Safety & Security by year of publication [14]

4.5. Climate Change

Significant Wave Height Due to the global warming, the onshore and offshore climate is changing. The offshore weather, particularly the significant wave height (mean wave height of the highest third of the waves, H_s), directly affects the forces ships endure on their routes. These forces on their turn indirectly influences requirements the ship management holds for lashing and securing their cargo. Therefore it is important to take a look at developments in average significant wave heights and the expected trends. Since it is not in the scope of this research to investigate and process raw data obtained by offshore buoys, the data on significant wave height is obtained by literature study. Several different studies are reviewed and addressed here to substantiate the expected increase in significant wave height. From the data of ERA-40 wave reanalysis from the European Centre for Medium-Range Weather Forecasts [29] a global linear trend of and increase of significant wave height of 4,6 cm per decade is shown in Figure 4.14 .

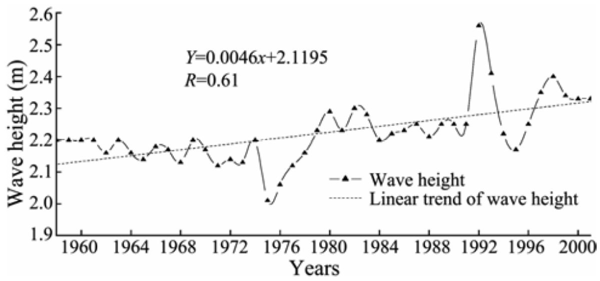
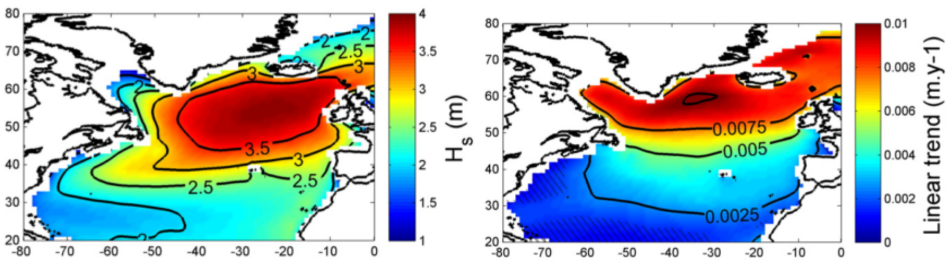


Figure 4.14: Linear trend of global ocean average significant wave height from year 1958 to 2001 [29]

Once we take a deeper look into the main routes of Tata Steel IJmuiden over the North Atlantic Ocean, we find somewhat lower results. As shown in Figure 4.15b, the highest significant linear trend at the North Atlantic is 1 cm per year (roughly 10 cm per decade from 1900 to 2008) [1]. However, researchers using different methods obtain different results. Gulev & Grigorieva 2004 [11] find a linear trend in H_s of 8 to 10 cm per decade (1900-2002) and Dodet & Bertin 2010 [6] find a trend up to 2 cm per year (20 cm per decade) (1953-2009). Not only differences in methods but also in time frame and specified area are reason for the different results. But it can still be concluded that the significant wave height is increasing over the years.



(a) Mean Significant Wave height $[m]$

(b) Linear trend in Hs $[m/y]$

Figure 4.15: Mean H_s and linear trends in H_s computer over 1900-2008 at the North Atlantic [1]

4.6. Summary of Probable Cause Analysis

The overview of factors expected to influence the stevedoring process an method (the probable causes) are given in Figure 4.16. The numbers in the diagram correspond with the numbering of the conclusions from the analysis. Taking into account the results of the analysis, a concluding overview is given in Figure 4.17.

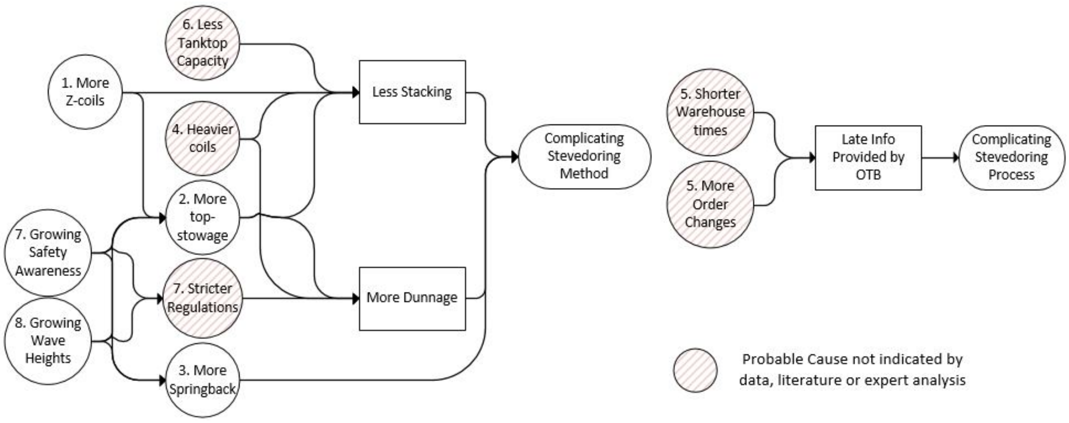


Figure 4.16: Overview of factors influencing the stevedoring process and method

1. The number of tonnes exported deep sea by Tata Steel IJmuiden does not change, however, the composition of product types differ: untreatened W-coils are primarily subsituted by further finished Z-coils.
2. With an increase in Z-coils, an increase in topstowage coils is expected, but not shown by data due to the inaccurate process of labelling and the storage of information.
3. Although data was not reliable the focus on springback material is expected to be growing due to previous accidents. So therewith the amount of labelled springback coils is expected to grow.
4. Although reliable data does not show an expected growth in coil weight, different production facilities are preparing and adapting to increase their maximum coil weight to 38,5 ton per coil, so S&W should expect and prepare for these heavier coils as well.
5. Although the company focuses on Just-In-Time delivery, no trend is found in a decrease in warehouse times. However, the head of Outbound Operations perceives production backlogs results in last-minute changes in cargo composition, complicating the stowage planning process.
6. Data does not show a decrease in tanktop strength, but due to the limitation coming with eastern-build ships, the allocation of coils in ships holds is growing in complexity.
7. As expected, the significant wave height, primarily determining the forces a ship as to endure, is growing globally and at the North Atlantic Ocean (main deep sea exportation route).
8. Although the globally safety awareness in the maritime industry is growing, regulations are not per se getting stricter. However, the awareness, together with insurance companies increasing the involvement of lawyers, is probably the cause for a stricter adherence of regulations, legislation's and loading manuals.

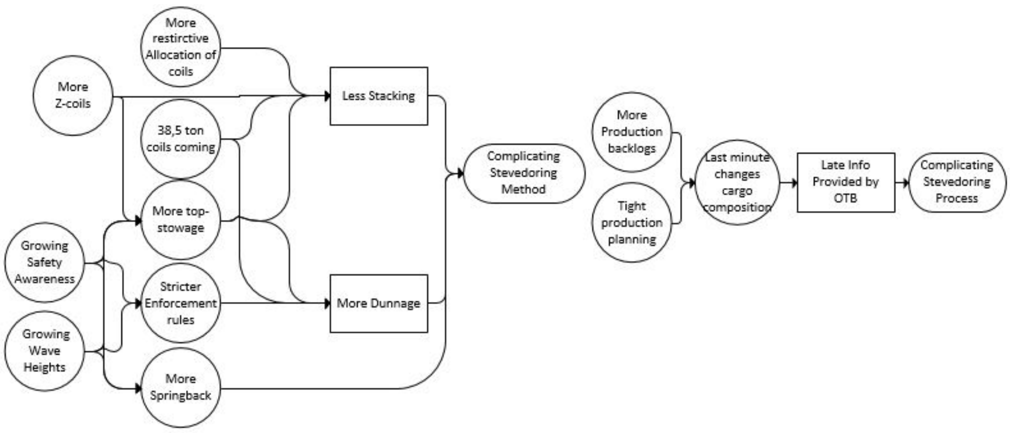


Figure 4.17: Concluding Overview of factors influencing the stevedoring process and method

5

Institution of the Problem: Current System Description

This chapter describes the second part of the Institution of the Problem; the current system description. Bottlenecks which are constituents to the quay discussion are sought by analysing the current system, to answer the second and third research questions:

2. How does the information flow and decision procedure (the process) contribute to the disagreement of the ship management?
3. How does the stowage and securing procedure (the method) contribute to the disagreement of the ship management?

First the theoretical approach of the current system is described in 5.1, devided over the stowage process (Section 5.1.1) and the stowage method (Section 5.1.2. Whether the stowage method of S&W complies with regulations is explained in Section 5.1.3. Hereafter, the practical system is analysed by means of case studies to complete theoretical findings (Section 5.2). Hereafter a cross case analysis is conducted in Section 5.3 to find discrepancies between theoretical and practical approach. This Chapter closes with combining the conclusions of Chapter 4 with the cross case analysis.

5.1. Theoretical Current System Description

To describe the current system for the planning and stevedoring of coils exported from Tata Steel IJmuiden, the theoretical process should be mapped. First, the theoretical decision and information flow (the process) prior to the establishment of the stowage plan is mapped in Section 5.1.1. Hereafter, the theoretical method for the stowage and securing of seagoing ships is explained in Section 5.1.2.

5.1.1. Process: the Decision and Information Flow

To accurately analyse the current process, the information flows and corresponding decisions concerning the final stowage plan should be structured to obtain a clear overview. A first rough draft is visible in Figure 5.1 and shows two iterative dialogues (recognised by the possibility to reject the decision in another step) in the complete process. So the two main points of discussion are the ship selection and the final stowage plan which are the focus points for this section. But first, to understand the different actions and documents specified in the process, it is important to understand what the following terminology means. Letters or number between brackets, (), refer to corresponding letters or numbers in the detailed decision & information flowchart in Figure 5.3.

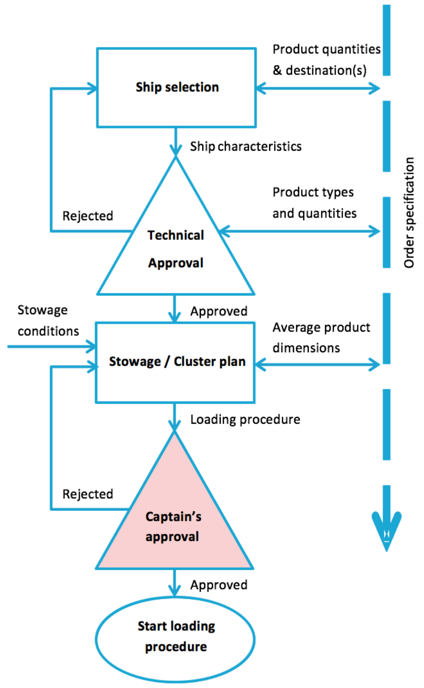


Figure 5.1: General steps from ship selection to loading [21]

- **Loading Manual of Tata Steel (A):** The stowage method of Tata Steel IJmuiden is drawn up in the "Stowage and Securing on sea going vessels" attached in Appendix E, referred to as the Loading Manual of Tata Steel. The most important content and conclusions which are drawn from this document, are summarised in the theoretical stowage and securing method of Section 5.1.2.
- **Stowage conditions (B)/Ship's Loading Manual (C):** This document is provided by the ship management or shipping company and can very significant in content; some contain very detailed preferences on stowage method by requiring special dunnage or lashing, others only give a tanktop strength or weight distribution over different cargo holds. This Loading Manual is a major argument the ship management stands by in the discussion at the quay. This information can be split in two, rough requirements of the stowage conditions send by the shipping company (document B in Figure 5.3) or detailed manual (document C), and therefore indicated seperately in the flowchart.
- **Breakdown (11):** A breakdown is a more specified version of the order quantity (amount of tons per shipment) with corresponding date. Although it is still a rough estimation, at this point the tons (ETTS or normal coils) per destination are known together with the ratio of packed/unpacked material.
- **Programming (17):** During the programming of material, information on coil specific level is finalised. This can only be done once a whole cluster (specific coil group) is complete and the coils have reached their final location (warehouse) at the site. These two limitations are imposed by the different systems which do not cooperate and communicate sufficiently with each other.
- **Stowage plan (12, 18):** contains instructions about the allocation of the cargo to the ship's cargo holds. It determines the weight distribution and the number of coils over the ships holds based on the destination and material type (ETTS and coils weights play the major role due to the physical properties). This plan is made by S&W in collaboration and with input of the Ship Management. The plan can only be completed once all material is programmed.
- **Cluster Plan (12):** plan with preferred loading sequence towards cluster of cargo to be supplied to the quayside by rail transport. The current location of the coil and the average weight and size per coil-group (of same material and location) is specified. These clusters are planned by S&W.

For a more thorough analysis of the theoretical situation of the stowage process, the different steps are captured by discussions with the different actors involved. From all concerned departments, the person who is most involved in practice is interviewed on his decisions and received or distributed information [1]. This way practice is closely involved in the theoretical approach of the process.

[1] An explanation of different departments can be found in Appendix A and its corresponding interviewees in Table A.1 of Appendix A

After the interviews, the decisions of departments regarding the process are mapped and relations between processes, decisions, in- and outputs are structured in a flowchart description showing different steps as boxes and their order and relationships by connecting them with arrows. The corresponding symbols used in a flowchart are explained in Figure 5.2. Figure 5.3 shows the structured (average and simplified) process from ship nomination to the final loading of the ship. The following paragraphs explain the corresponding decision and information flows in the process at Tata Steel IJmuiden. Numbers between brackets, (), refer to corresponding numbers in the detailed decision & information flowcharts in Figure 5.3.

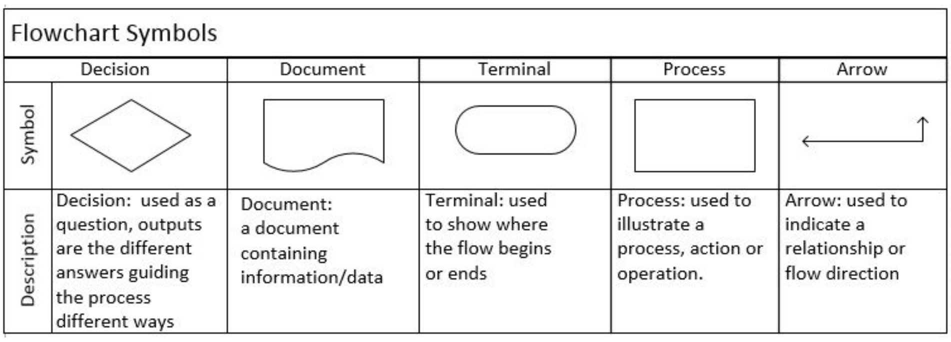


Figure 5.2: Flowchart Symbols

Order Planning From the sales department, OTB receives information on customer demands regarding material and timing of products (step 1 in Figures 5.3). Then, OTB breaks this information down to orders (quantity of coils), and shipments and communicates this to Chartering. Chartering is responsible to charter suitable ships for these orders. However, not all information is available at the time Chartering starts searching for a ship (step 3) and thus information is gathered (in step 4 and 6) before OTB has to approve the ship (step II).

Ship Nomination (steps 2, 3, 5, A, B, I, II, III) So the Chartering department is responsible for chartering the best possible (economical and practical) ship for the different cargo transportation over seas. It is in close contact with OTB to match the cargo quantities and dates with available ships. It is important to understand that ships are chartered based on the total weight to be transported. Since steel coils are heavy cargo for the chartered bulk carriers with respect to their more common bulk cargo, the limiting factor for the shipped number of coils is the weight, and not the volume.

Once a ship is selected by Chartering, an approval is required from OTB and S&W (step II and III respectively). When one of the departments has a valid reason to reject the ship, a feedback loop as shown in steps 8, 9 and 10, occurs and the proposal is adjusted (step 5) or another ship is searched for (repeating step 3).

Many of these ships are chartered more often and therefore do not need repeated approvals. However, despite long-term charter contracts, now and then a shipping company has no ships available for the agreed voyage and subcharters a ship for the cargo. At such moments Tata Steel IJmuiden and the shipping company are not familiar with the ship and thus the original approval process withstands.

Unfamiliar ships are more often accompanied by quay discussions, due to the strict enforcement of regulations or ships loading manuals by the ship management (since he is less experienced with the stowage method of S&W). This often results in the deployment of a port captain and taking responsibility for additional costs (by the shipping company) resulting from granting Ship Managements' demands.

Unfortunately, the information available on cargo and ship (symbolised by document B) are limited premature in the process. Due to a political and economic game, Chartering is not always free to ask for all ships information such as the Loading Manual (since this could run up the price for the ship). Therefore additional requirements or demands from the Ship Management might not be visible upon accepting the ship. The chartering department always prematurely sends document A, the "Stowage and Securing on Seagoing Vessels manual" (the Loading Manual of Tata Steel IJmuiden, see Appendix E) to the ship management, so the captain is aware of the stowage method used in IJmuiden.

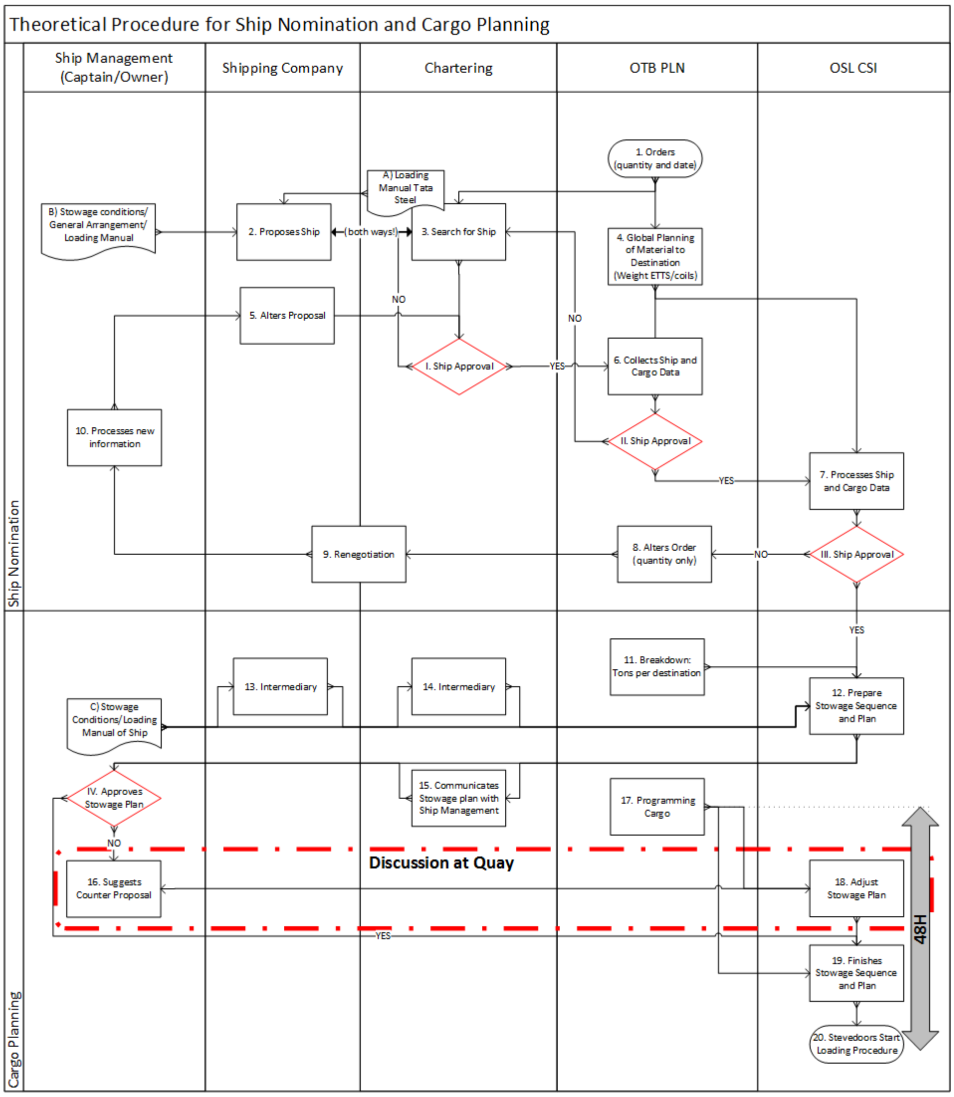


Figure 5.3: Theoretical process from order planning to stevedoring activities

Cargo Planning (steps 11, 14, 15, 16, 17, 18. 19, C At the moment the ship is approved by all departments, the next step is for OTB to breakdown the cargo in tons per coil type (ETTS or horizontal coils) per destination (step 11), often circa 5 days before loading. Based on this information, S&W awaits stowage preconditions, such as loading sequence and the hold allocation of the different cargo loads per destination, provided by the ship management (document C). Sometimes the chartering department plays a role in this communication (step 14). In the end, in collaboration with the ship management (step 16), S&W prepares a stowage plan which the ship management has to approve (with or without intermediation of Chartering in step 15).

However, coil specific information is only available after OTB has programmed the material in step 17. This programming can only be done once a whole cluster (specific coil group) is complete (produced) and the coils have reached their final location (warehouse) at the site. These two limitations are imposed by the different systems which do not cooperate and communicate sufficiently with each other. Moreover, even if prematurely programming is possible, OTB will wait until the information is certain. Because by programming, the information has to pass the customs for a check on customs duties etcetera. However, in an agreement with S&W, OTB has agreed to program the cargo no later as 48 hours prior to loading. Unfortunately, reprogramming occurs occasionally, which results in an adjustment to the stowage plan (step 18 and 19). Once the Stowage plan is complete, it is forwarded to the shift workers to prepare and start the loading procedure (step 20). Definite large deviation in coil characteristics are coped with by not planning the stowage coil specific, but leaving room for the stevedores to decide on the best allocation and stacking of coils.

Loading Activities and Communication (step 20) After the ship nomination and cargo planning procedures are finished, the shift workers receive the stowage and cluster information as shown in Figure 5.3. Figure 5.4 shows from left to right the successive loading activities of the three parties involved in the actual stevedoring activities, coordinated by the team leader of the harbour. Once the Cluster and Stowage Plan is finished and all parties from Figure 5.3 approved the plans, they are forwarded to the SIC ("Stukgoed Informatie Centrum" or Cargo Information Centre). The SIC enters the plans in their IT system and translates it to coil lists and a stow plan counting down the coils and so keeping track of the loading progress. The coil lists form a reference for the crane operators and the basis for the tier building. However, the stowage plan does not state coil specific locations. Therefore, the Crane Team Coordinator (KTC) arranges the coils according his own insight, trying to place as many as possible coils on one tier. So he decides which coils are loaded in which sequence to which location, where the stevedores in the hold of the ship function as supportive workforce, (de-)hitching the coils and applying lashing and dunnage where needed. Finally the stevedoors scan the coils as a final check for the IT systems the coil is actually on board.

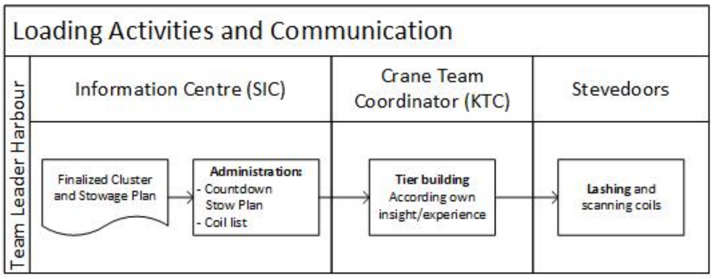


Figure 5.4: Three parties the Team Leader Harbour coordinates with corresponding successive loading activities

Supply of Coils by Rail The sequence and timing of the coil supply towards the harbour by rail is important for a smooth loading process since, as explained in above paragraph, the Crane Team Coordinator can only pick coils of the wagon or out of the Transit hall to complement its tiers, which is crucial for a proper stowage method. Once cargo is programmed (48 hours before loading), the cluster plan is established by S&W and forms the basis for the supply sequence of coils by rail. Rail needs this information at least 8 hours prior to loading, so the wagons can be loaded with the specific coils at different warehouses to consolidate at the shunting yard into complete trains. These trains transport the steel coils towards the harbour were coils can be loaded directly in the ship, or stored in the Transit Hall.

5.1.2. Method: the Stacking and Loading Method

Tata Steel IJmuiden has developed an own method over the years for the stowage and securing of sea going ships. The stacking method is defined in the Stowage and Securing Manual, enclosed in Appendix E, and distinguishes bulk- and box-type holds in ships. This method is certified in 2004 by the Dutch Rijkswaterstaat (a copy is attached in Figure F) but no more checks or approvals by regulations or class societies have been done since. First the stacking method of S&W is explained, after which the loading method and allocation of the coils is explained. Per topic, concepts requiring understanding are explained.

Stacking Method

- **Tier:** coils are set-up in rows across the width of the ship (transversal), 1, 2 or 3 coils high stacked. This complete row, including the coils on the second or third level.
- **Dunnage:** wood used between the coils and the tanktop to distribute weight, protect the tanktop and provide friction.
- **Wedges:** the triangular shaped wooden pieces tightened between coils and dunnage.
- **Lashing** metal bands through the coils eyes securing their position.
- **Key Coils:** do not rest on the tanktop but on two dissociated coils, securing the tier by pressing the other coils of the tier sideways (see Figure 5.5).

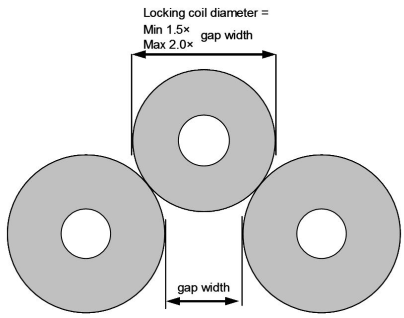
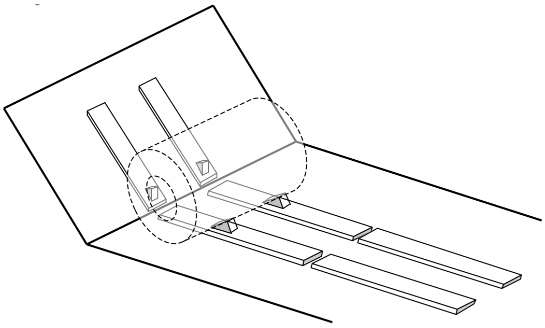
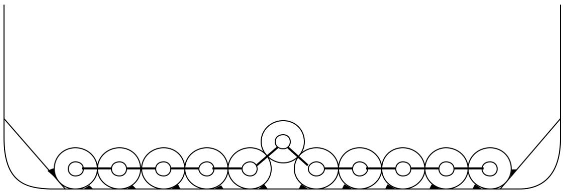


Figure 5.5: Key Coil with dimension requirement

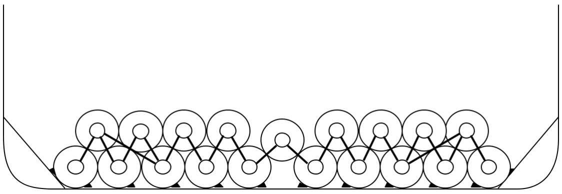
Figures 5.6 and 5.7 show the stacking method for bulk and box type holds respectively. The black lines connecting the eyes of the coils represent steel bands, called the lashing. Dunnage is used between the coils and the tanktop. Figure 5.6a first shows how the coils in the side of the hold are supported by two lines of dunnage and two pairs of wedges. Proper tightened wedges are required between the extreme coils and the dunnage on the hopper tank. Figure 5.6b shows how a key coil ensures vertical pressure to tighten the coils even more. Next, Figures 5.6b, 5.6c and 5.6d shows how the tier is build with 1, 2 or 3 coils high respectively. This type of stowage is called Pyramidal Stowage, which means the steel coils of the upper rows do not rest on the sides of the ships hold. This is different for stacking coils in box type holds, as shown in Figure 5.7. With Figure 5.6a showing no dunnage in the side is used, and Figures 5.7b, 5.7c, 5.7d showing the stacking method for 1, 2 or 3 coils high.



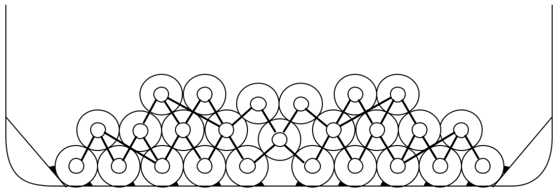
(a) Bulk ship: coil set-up and wood position



(b) Bulk ship: tier set-up 1 high

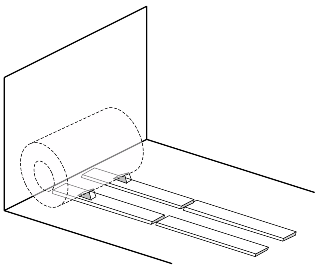


(c) Bulk ship: tier set-up 2 high

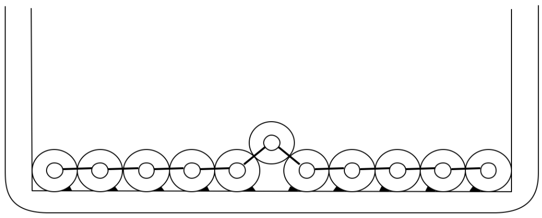


(d) Bulk ship: tier set-up 3 high

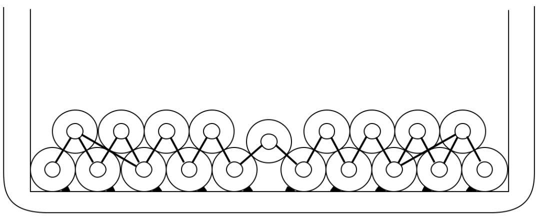
Figure 5.6: Standardised Stowage and Securing Method of Tata Steel IJmuiden for Bulk Type Holds



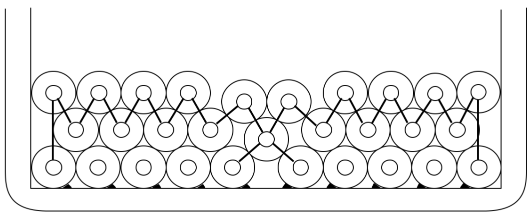
(a) Box ship: coil set-up and wood position



(b) Box ship: tier set-up 1 high



(c) Box ship: tier set-up 2 high



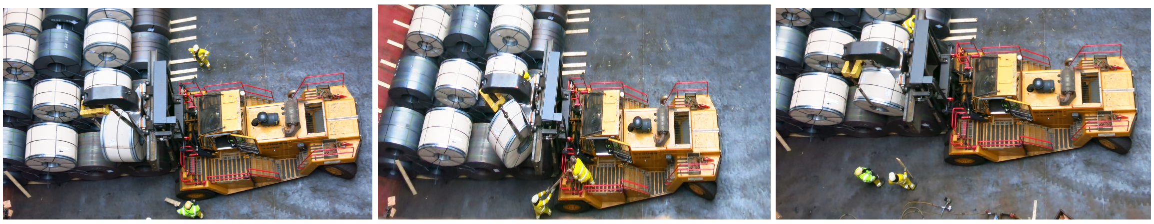
(d) Box ship: tier set-up 3 high

Figure 5.7: Standardised Stowage and Securing Method of Tata Steel IJmuiden for Box Type Holds

Loading Method

- **Square:** Tanktop area of bulk type ships right underneath the hold or hatch opening. Open hatch holds have a square from side to side, but front and aft of the of the hold are roofed. Closed hatch holds have besides the front and aft, also a roofed area at both sides of the hold.
- **Dropstowage:** When coils are lifted from the quay or wagon into the ship, done by quay cranes, they are placed in the square of the ship.
- **Thorn:** equipment on the forklift to lift coils in front of the coils eye, shown in Figure 5.8.
- **Goosenecken:** Sideways allocation of coils by special equipment on the forklift, able to rotate the coil as shown in steps in Figure 5.9.
- **Forklift Manoeuvrability Area** This area is kept free from cargo so a forklift of the loading and unloading harbour can reach all cargo and is minimal 10 meters in ships longitudinal direction.

Figure 5.8: Allocating coils by Forklift with thorn



(a) Step 1: lifting the coil (b) Step 2: turning the coil (c) Step 3: placing the coil

Figure 5.9: Goosenecken: sideways allocation by forklift

Generally, coils are lifted from the quay (out of the Transit hall or from the rail wagons) into the ship by quay cranes. How coils are moved to their final destination in the hold depends on the hold type, width of the ship and presence of ship cranes. In Figure 5.10 the steps determining the loading method in the upper diagram, numbered from most preferred (1) to leas preferred (4). Figure 5.11 also shows the top-view of different hold layouts, arranged from most to least preferable for S&W per hatch type (open or closed). First the steps in determining the loading method are explained in next paragraphs, whereafter the hold layouts are explained.

Hold Type First, the loading method is dependent on hold type, see decision step 1 in Figure 5.10. Open hatch holds do not have hatch parts at the side of the ship, and therefore the square is much wider, resulting in easier access for the quay cranes. Although no quantitative data is available, experts of S&W indicated 60% of ships loaded at the quay in IJmuiden are closed hatch, and 40% are open hatch type ships. And, for closed hatch type ships, the hatch overhang fore/aft and at the side are approximately 3 and 5 meters respectively.

Accessibility of Location The next step is determining if the coils can be reached by the quay crane (second decisions in Figure 5.10). If so, they are dropstowed by the quay cranes (Loading Method 1). If not, the next step depends on the hold type. In Closed hatch ships, a forklift will be placed to allocate the coil by thorn (loading method 2) or gooseneck (loading method 4) to locate the coils outside the square. For Open Hatch ships, coils can be taken over by the ships crane (loading method 3) if available (which is rarely the case by these type of ships according to experts of S&W), and otherwise again the forklift with thorn or gooseneck is applied.

Preference Loading Method Dropstowage is the preferred loading method since it requires less personnel and material (because no forklift is used, one extra handling per coil is eliminated). However, allocating coils by forklift equipped with a thorn has the same throughput as dropstowage, 13 coils per hour, and therefore, allocating coils by forklift equipped with a thorn (loading method 2) is the second preferred loading method. Allocating coils with the ship's crane (loading method 3) occurs only rarely and due to the crane drivers experience with the quay cranes, loading with ship's cranes is slightly slower. Coils are only allocated by gooseneck when no other option is possible. Because the coils have to be turned 90 degrees (see Figure 5.9) when hanging in the forklift, this loading method (4) requires more time, decreasing the throughput to at least 11 coils per hour. When these coils have to be stacked, the throughput can decrease even further to 9 coils per hour.

Hold Layout Closed Hatch The numbers in the lower topviews of the hold layouts, refer to the used loading methods and the little medal with its number is symbol for the preference. The left part of Figure 5.11 shows the topviews of the hold layouts for closed hatch holds, Layout A1 and A2:

- **Layout A1:** most coils are stacked and room for the fork lift manoeuvres is kept empty is preferred by S&W due to the appliance of preferred loading methods. No goosenecking is required.
- **Layout A2:** requires goosnecking at the side of the square where a forklift with thorn cannot manoeuvre. This disadvantage of the layout does not overcome the advantage of more dropstowaged coils and less stacking. One should keep in mind, to load the same amount of cargo, tier in layout A1 will on average be stacked higher as in layout A2.

Hold Layout Open Hatch The lower right part of Figure 5.11 shows the topviews of the hold layouts for open hatch holds, Layout B1, B2 and B3:

- **Layout B1:** The tiers in the front and aft of the square will have to be placed by forklifts, but the rest can be build up by dropstowage, which is the ideal situation.
- **Layout B2:** a more realistic situation for open hatch deep sea ships is a width greater as the reach of the quay cranes (20,5 m, indicated by dotted line). Same as for closed hatch holds, S&W prefers to load by forklift with thorn and thus leaves room for forklift manoeuvre and stacks higher as with full distributed weight.
- **Layout B3:** the other option for ships wider as 20,5 m, where the full tanktop needs to be filled, is loading by the ships crane.

Hold Capacity One should note that stacking three coils high does not have the advantage of increasing hold capacity. This is because the hold capacity is not limited by the volume placed in the hold, but by the total weight loaded. Bulk carrier designs come with a ships specific Dead Weight Tonnage (DWT); a measurement for the total mass a ship can transport. This (DWT) varies with the ships depth, depending on its route; water depth or locks might limit the maximum ship depth). Since steel coils have a much higher density as the regular bulk cargo which the bulk carriers are designed for, the cargo weight is the limiting factors for steel coil capacity. And therefore, the arrangement of coils in the holds is not likely to reduce the hold capacity. Thus stacking three coils high is not beneficial regarding hold capacity. The same applies to increasing the tanktop strength. By increasing the tanktop strength, higher stacking becomes possible, but does not increase the total hold capacity, which is limited by the ships' DWT.

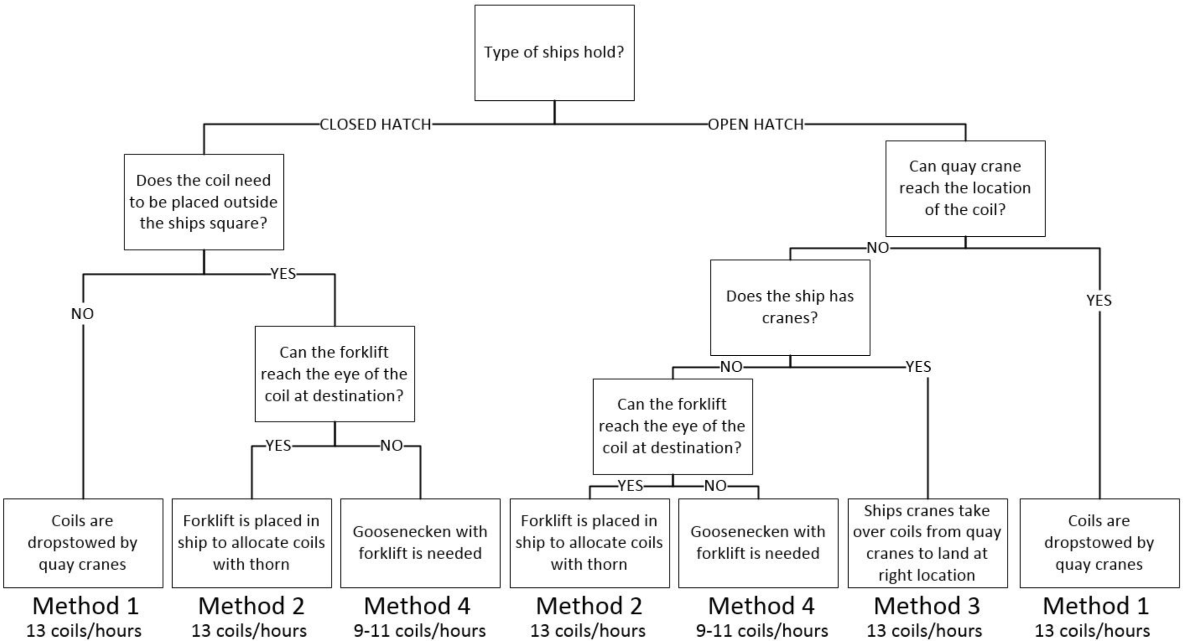


Figure 5.10: Steps determining loading method

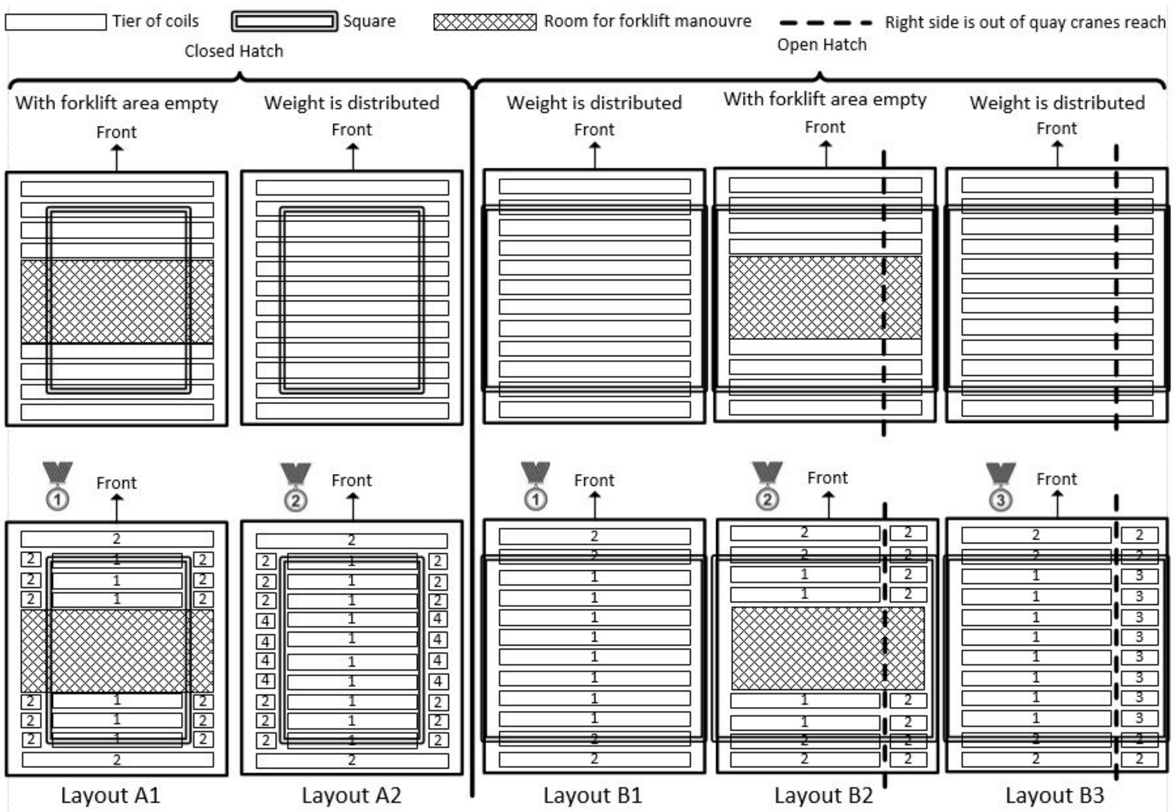
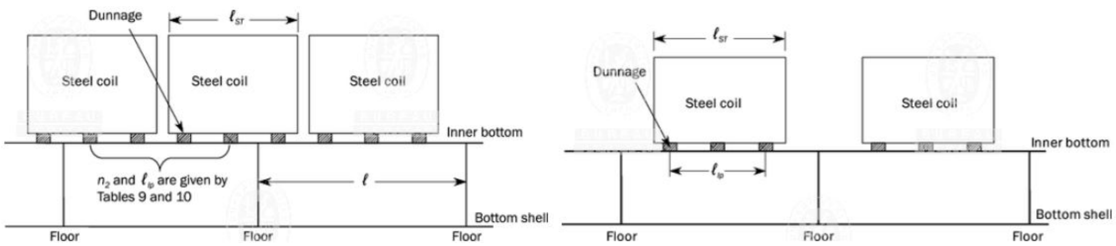


Figure 5.11: Top view of hold layouts for open and closed hatch holds

5.1.3. Regulations: Calculating the Tanktop Load

To check if the stowage method of Tata Steel is according to the regulations, regulation determined by class societies regarding steel coil loading in bulk carriers are looked into. Since these regulations are similar for different class societies, the e-rules of VeriSTAR (Bureau Veritas)[2] are used for this analysis due to their easy access. The VeriSTAR e-rules CSR, Pt 1, Ch 4, Sec 6, [4] (Common Structural Rules Part 1, Chapter 4, Section 6, Article 4) elaborates on steel coil load in cargo holds of bulk carriers. The following paragraphs describes the different steps and parameter values in calculating the tanktop load according to this article. Table 5.1 summarises the parameters with corresponding value, description and source.

Coil Allocation First, the Common Structural Rules distinguishes two types of loading; independent of inner bottom floors locations, and between inner bottom floors, as show in Figure 5.12. Since S&W does not reckon with the floors when allocating the coils, thus the configuration as in Figure 5.12a is applied.



(a) Independent of Floors (b) Between Floors

Figure 5.12: Distinguished coil allocation with respect of inner bottom floors (e-rules VeriSTAR CSR, Pt1, Ch 4, Sec 6, [4])

Cargo Parameters An average coil weights around 25 ton, has a width (in this case referred to as length) of 2,0 and a diameter of 1,8 m. However, since tiers are placed with roughly 20 cm distance, the area of the coil is determined by $(1,8+0,2)*1,8=3,6m^2$. S&W prefers to stack 3 coils high with 2 lines of dunnages under each tier. Due to the pyramidal stowage, even when all rows of the tier are filled with coils, the upper rows contain less coils as the lower row. With a ship width of (for example) 22 m and a hold width of 18 meters, roughly 10 coils could be placed side by side on the tanktop. The second and third row will contain 9 and 6 coils respectively (in the example of a bulktype hold), as shown in Figure 5.6d. Therefore, instead of a stacking height of 3, n_1 is set to $n_1 = 2,5$.

Dunnage Parameters The number of load point dunnages per elementary plate panels (EPP, unsupported area of tanktop) has to comply with the table 9 in CSR, Pt 1, Ch 4, Sec 6, [4.1], as show in table 5.2. n_2 is the number of load point dunnages per EPP and n_3 the number of dunnage lines under each tier, set to 2 as determined in the loading manual.

Tanktop Parameters In the calculation towards the tanktop burden, the distance between the supporting structure underneath the tanktop should be considered. The distance between the inner bottom floors (l), and thus the length of the EPP, is maximum 3,5 m or 4 times the side frame spacing (often 0,75) (see CSR, Pt2, Ch 1, Sec 2, 3.1.4). Therefore the floor spacing is set to 3 meters. With the determined $l_{st} = 2$ and $l = 3$, $\frac{l}{l} l_{st} = 1,5$ and Table 5.2 determines $n_2 = 3$.

Vertical Acceleration Besides a static load induced by the mass resting on the tanktop, ship motions also induce a dynamic load. This dynamic load is dependent on the vertical accelerations of the ship in m/s^2. Captain A. Lenting, Managing Director at Siri Marine, recorded different accelerations for research at the Federal Oshima (bulk carrier) on a shipment over the North Atlantic. With the ship's GM of 5,3 m and a significant wave height of 4,0 meter, the maximum vertical acceleration recorded was 0,31 m/s^2 and therefore used as an indication for the vertical acceleration of this calculation.

[2]VeriSTAR Info provides the Marine Community with a wide range of information, including details on Bureau Veritas products and services in the marine business in general and on its classed fleet in particular. `https://www.veristar.com/portal/veristarinfo`

Tanktop Load Now the required variables are determined, the load on the inner bottom can be calculated by summing the static and dynamic load, which are calculated as respectively:

- $F_{sc-ib-s} = M * g$, with g the gravitational ($9,81 m/s^2$)
- $F_{sc-ib-d} = M * a$, with a the vertical acceleration due to ship motion

Where M, the mass of the cargo burdening the tanktop, is calculated with:

- $M = K * W * \frac{n_1 * n_2}{n_3}$

By using the parameter values as determined in previous paragraphs and shown in Table 5.1, the static and dynamic load result in 919,7 and 29,1 newton respectively. Summed and divided over the coil area of $3,6 m/s^2$, results in a tanktop load of $26,9 ton/m^2$. This is a much higher load as the average tanktop strength of the reference ships in Figure 4.12 (Section 4.4) could endure.

Table 5.1: Input parameters VeriSTAR e-rules coil tanktop load calculation

Symbol	Value	Unit	Description	Source
l	3,0	m	Distance between inner bottom floors	CSR, Pt2, Ch 1, Sec 2, 3.1.4
l_{st}	2	m	Length of coil	Tata Steel - S&W
d	1,8	m	Diameter of coil	Tata Steel - S&W
W	25	ton	Weight of coil	Tata Steel - S&W
n_3	2	#	Number of dunnage	Stowage Method S&W
n_1	2,5	#	Stacking height	Stowage Method S&W
n_2	3	#	Number of load point dunnages per EPP	CSR, Pt2, CH 1, Sec 2, [3.1.4]
g	9,81	m/s^2	Gravitational acceleration	-
K	1.0	-	Coefficient, determined by e-rules	CSR, Pt1, Ch 4, Sec 6, [4.3.1]
M	93,75	ton	Equivalent mass of steel coils	CSR, Pt1, Ch 4, Sec 6, [4.3.1]
$F_{sc-ib-s}$	919,7	Newton	Static load on inner bottom	CSR, Pt1, Ch 4, Sec 6, [4.3]
$F_{sc-ib-d}$	29,1	Newton	Dynamic load on inner bottom	CSR, Pt1, Ch 4, Sec 6, [4.4.2]
F_{total}	**26,9**	ton/m^2	**Resulting tanktop load per squared meter**	$\frac{F_{sc-ib-s}+F_{sc-ib-c}}{l_{st}*d}$

Decreasing Stacking Height When using the exact same parameters but only changing the stacking height to 1,9 (one full row with 10 coils and the second row consisting of 9 coils), the mass reduces to 71,3 ton and the resulting tanktop load becomes $20,4 ton/m^2$. When looking at the average tanktop load of reference ships in Figure 4.12, this tanktop load is still critical; most tanktops are not strong enough.

Constituent to Quay Discussion With a significant decrease of stacking, the load on the tanktop decreases as well. While stacking 3 coils high appears to result in a load significantly above the average tanktop strength of reference deep sea bulk carriers (Figure 4.12), stacking only 2 high result in a tanktop load better compassed by the average tanktop strength of those reference ships. These findings are likely to be a constituent to the discussion at the quay; the underlying reason for the ship management not willing to stow 3 coils high at times S&W want to leave an area empty for the forklift manoeuvres. Additionally it should be mentioned that these calculations are made for bulk type holds. Since box type holds does not apply pyramidal stowage, the third row will contain the same amount of coils as the first row, increasing the tanktop load even further with a stacking height of 3 coils. Moreover, one should note n_1 will increase further with respect to the stacking height when the width of the hold increases. This is caused by the growing ratio between coils on the second (and third for bulk type holds) row and the first row.

Table 5.2: Number n2 of load point dunnages per EPP (CSR, Pt 1, Ch 4, Sec 6, [4.1.3], table 9)

n_2	n_3			
	2	3	4	5
1	$0 < \frac{\ell}{\ell_{st}} \leq 0,5$	$0 < \frac{\ell}{\ell_{st}} \leq 0,33$	$0 < \frac{\ell}{\ell_{st}} \leq 0,25$	$0 < \frac{\ell}{\ell_{st}} \leq 0,2$
2	$0,5 < \frac{\ell}{\ell_{st}} \leq 1,2$	$0,33 < \frac{\ell}{\ell_{st}} \leq 0,67$	$0,25 < \frac{\ell}{\ell_{st}} \leq 0,5$	$0,2 < \frac{\ell}{\ell_{st}} \leq 0,4$
3	$1,2 < \frac{\ell}{\ell_{st}} \leq 1,7$	$0,67 < \frac{\ell}{\ell_{st}} \leq 1,2$	$0,5 < \frac{\ell}{\ell_{st}} \leq 0,75$	$0,4 < \frac{\ell}{\ell_{st}} \leq 0,6$
4	$1,7 < \frac{\ell}{\ell_{st}} \leq 2,4$	$1,2 < \frac{\ell}{\ell_{st}} \leq 1,53$	$0,75 < \frac{\ell}{\ell_{st}} \leq 1,2$	$0,6 < \frac{\ell}{\ell_{st}} \leq 0,8$
5	$2,4 < \frac{\ell}{\ell_{st}} \leq 2,9$	$1,53 < \frac{\ell}{\ell_{st}} \leq 1,87$	$1,2 < \frac{\ell}{\ell_{st}} \leq 1,45$	$0,8 < \frac{\ell}{\ell_{st}} \leq 1,2$
6	$2,9 < \frac{\ell}{\ell_{st}} \leq 3,6$	$1,87 < \frac{\ell}{\ell_{st}} \leq 2,4$	$1,45 < \frac{\ell}{\ell_{st}} \leq 1,7$	$1,2 < \frac{\ell}{\ell_{st}} \leq 1,4$
7	$3,6 < \frac{\ell}{\ell_{st}} \leq 4,1$	$2,4 < \frac{\ell}{\ell_{st}} \leq 2,73$	$1,7 < \frac{\ell}{\ell_{st}} \leq 1,95$	$1,4 < \frac{\ell}{\ell_{st}} \leq 1,6$
8	$4,1 < \frac{\ell}{\ell_{st}} \leq 4,8$	$2,73 < \frac{\ell}{\ell_{st}} \leq 3,07$	$1,95 < \frac{\ell}{\ell_{st}} \leq 2,4$	$1,6 < \frac{\ell}{\ell_{st}} \leq 1,8$
9	$4,8 < \frac{\ell}{\ell_{st}} \leq 5,3$	$3,07 < \frac{\ell}{\ell_{st}} \leq 3,6$	$2,4 < \frac{\ell}{\ell_{st}} \leq 2,65$	$1,8 < \frac{\ell}{\ell_{st}} \leq 2,0$
10	$5,3 < \frac{\ell}{\ell_{st}} \leq 6,0$	$3,6 < \frac{\ell}{\ell_{st}} \leq 3,93$	$2,65 < \frac{\ell}{\ell_{st}} \leq 2,9$	$2,0 < \frac{\ell}{\ell_{st}} \leq 2,4$

5.2. Practical Current System Description

Observations in practice can give a deeper understanding in the different steps in the cargo loading process and different reasoning behind actions and decisions. Therefore this section conducts two case studies to confirm and find additional constituents to the quay discussion. To properly execute the case studies and guarantee the quality of the analysis the research design protocol of Yin will be followed. According to Yin [27], a case study is an acknowledged method to do exploratory research in contemporary issues in real life context with no control over the events. The different steps required to accurately execute a case study are shown in Figure 5.13.

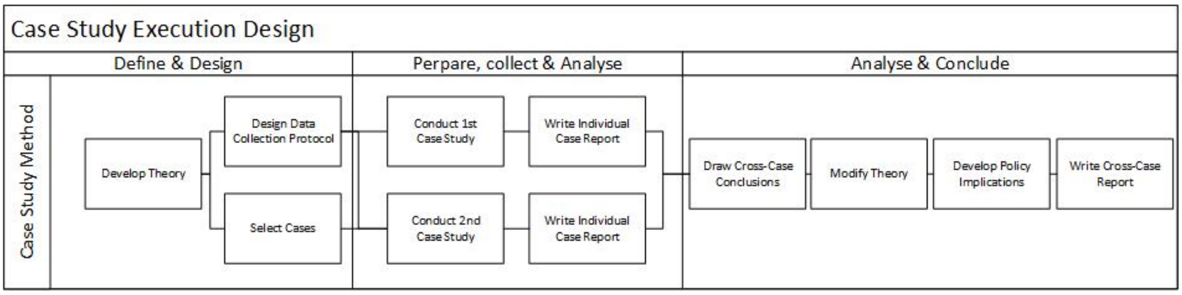


Figure 5.13: Method Design for Executing Case Studies (Yin, [27])

First the Define & Design stage is executed by setting up requirements for the selection of cases and the data collection protocol, which is done in Section 5.2.1. Next, in the Prepare, Collect & Analyse stage, the chosen case studies are executed and different findings are reported, in Sections 5.2.2 and 5.2.3. Hereafter, findings are compared to draw cross-case conclusions forming the constituent factors of the problem solution.

5.2.1. Execution of the Case Studies

Theory The problem situation framed in Section 2.1 will guide as the basis for this case study research. The theoretical current system description as explained in Section 5.1 is in this situation the developed theory for the case studies.

Case selection To ensure no facets of the problem are disregarded and the a holistic approach is applied, multiple case studies are carried out. The first criteria is the dimension of the discussion. Assuming the more difficult the situation and the discussion, the more aspects the case study will entail and thus the more complete analysis will become. This criteria is met by choosing the more difficult cases, indicated by the planning officers of S&W. As second criteria, the scope of this research should be taken into account, meaning a discussion around horizontal coils (no ETTS) on a deep sea route. Moreover, enough data and information needs to be available on the case for a thorough analysis.

During discussions with and consultation of S&W the two historical cases where found conforming these requirements: MV ID Mermaid (December 2015 to Diliskelesi, Turkey) and the MV Sunshine (April 2017 to Housten, Altamira and Veracruz).

Data Collection Protocol Due to the two different parts of the shipping procedure (decision & information process and Stowage & Securing method) distinction is made in the type of data to be collected per part:

- **Decision & Information flow** Due to the qualitative nature of these flows, data is sought by interviewing involved actors, in e-mail conversations or in stored exchanged documents such as the breakdowns and loading manuals. Since almost all internal and external communication is done via e-mail, this is the primary source of information. However, the ship management is not interviewed. Since the captain an crew change regularly, they are therefore not retraceable.
- **Stowage & Securing method** The stowage and securing method is mainly saved in exchange documents: temporary or terminal stowage plans and manuals. These documents are accurately documented and stored by S&W and sufficient available afterwards.

5.2.2. Case Study 1: MV ID Mermaid

The first case study is conducted on the shipment to Diliskelesi, in Turkey, with the MV ID Mermaid in December 2015. The characteristics of the ship are found in Table 5.3. Tata Steel IJmuiden was familiar with this ship due to a shipment in January to Camden, USA, in the same year under time charter via Clipper[3]. However, in this case the ship is chartered from the spotmarket and the chartering department was in contact with the ship broker. The responsibility to match the cargo with the ship is for Tata Steel IJmuiden. The planned cargo (at the time of contracting) contained approx. 21 000 ton of horizontal coils to be divided over all five holds of the ship.

Figure 5.14: MV ID Mermaid (Source: Fleetmom.com)

MV ID Mermaid			
Length	179 m	Building Year	2001
Width	26 m	Tanktop Strength	23
Draught	6.9 m	Type	Bulk
Deadweight	27105t		

Table 5.3: MV ID Mermaid Characteristics

The nomination of the MV ID Mermaid went as agreed upon and as shown in the theoretical approach: the chartering department found an available ship at the spot market and checked with Outbound Planning and S&W if it matches with the cargo. Since all departments were familiar with the ship, it was approved with no second thoughts and the ship received the Loading Manual of Tata Steel prematurely. At the time of fixing the cargo, packing lists were not available yet, as usual, so no detailed information was exchanged. After the ship received the breakdown, the communication to plan the stowage was started. The timeline with key communications and corresponding exchanged documents is shown in Table 5.4.

Table 5.4: MV ID Mermaid process

Date	From	To	Document	Content
27-11-2015 10:00	S&W	Ship	Breakdown	21520t (1158 coils) whereof 10562t unpacked (wet)
27-11-2015 11:45	S&W	Ship	Detailed Breakdown	Estimation of # coils, average weight and wet/dry requirement on coil level
27-11-2015 14:50	Ship	S&W	Pre-Stow plan	See Figure 5.15
28-11-2015 17:30	S&W	Ship	Packing list	per certain coil group: # coils, average weight and wet/dry requirement - final
28-11-2015 18:20	Ship	S&W	Stow plan	Additional requirements to stow plan
28-11-2015 20:00 till 29-11-2015 15:15	Intensive discussion between Broker, Ship, S&W and Chartering which ends in an agreement on the final stow plan, see Figure 5.16			
28-11-2015 17:30	S&W	Ship	Packing list	Revised version, previous version was incorrect
20-11-2015 08:20	Ship	S&W	-	Coils>15t need 3 lines of dunnage, coils outside dimensions will be refused for tanktop load reasons
01-12-2015 until 04-12-2015	**Loading ship**			

The Ship Management requested a packing list on coil level, to start with the stowage plan. However, this is only available after programming, so max. 48 hours before loading. In this case, three days prior to loading, a more detailed breakdown with corresponding wet (unpacked, able to load during precipitation) tons of coils was send to the ship, although this is not usual. With this information the first draft of the stowage plan, wet/dry holds with corresponding weight distribution is set up as showed in Figure 5.15. However, after receiving the packing list of S&W, the captain replied with severe additional requirements to the stowage derived from the ships stowage manual and tanktop load calculations. These calculation gave red flags to several coils, so S&W checked their calculations and found incorrect dimension/weight ratios in the previous send packing list created by Outbound Planning.

[3]Clipper is a shipping company and operator originated in 1972 with a fleet of 150 bulk carriers; handysize, supramax and ultramax. http://www.clipper-group.com/

At this point the all parties involved were alarmed and an intense discussion arose around both stowage manuals and why these were not communicated before (brokers' responsibility). Due to time pressure, a rapid agreement was found in disadvantage of Tata Steel IJmuiden. The weight was to be distributed, so a maximum of 1 to 2 coils high, and coils were to be be placed on more dunnage (exact final amount not known). The final stowage plan is found in Figure 5.16. The Ship Management refuses to stow to higher levels or with less dunnage due to latent but lastly severe consequences to the tanktop condition. Arguments of the captain pointed to warning documents established by classification societies years ago [4]. Due to the hatch dimensions, cargo could only be dropstowed in the square, and therefore goosenecking was required.

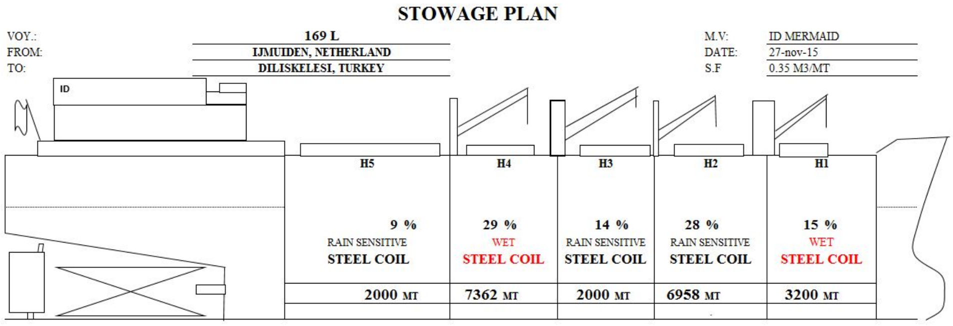


Figure 5.15: MV ID Mermaid Pre-Stow plan of 27-11-2015

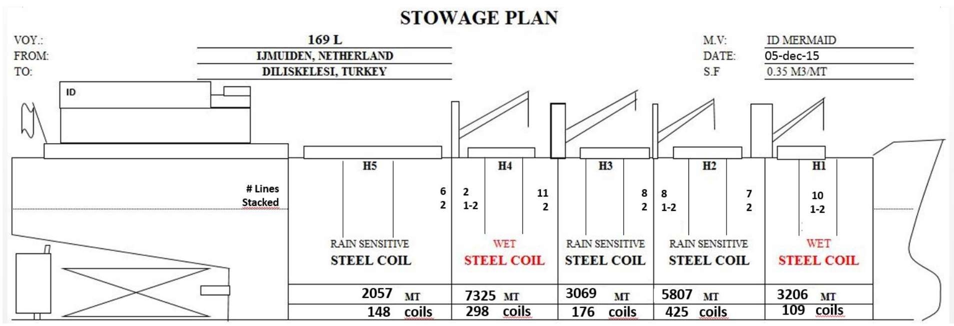


Figure 5.16: MV ID Mermaid Final Stow plan of 05-12-2015

Results The final resulting timeline of the MV Mermaid at quay are given in Table 5.5. So a demurrage of 958€ (1024 USD, exchange rate 0.92 EUR[9]) due to a 4 hour and 28 minutes delay was incurred. This demurrage is of no significance and therefore not charged and tracked down to the responsible party.
Eventually, no cargo was left behind due to the efficient use of tanktop surface by the full weight distribution.

Table 5.5: Final Laytime Sheet MV Mermaid

Description	Date	Time
Vessel arrived roads/waiting berth	27-11-2015	00:54
Berthed	01-12-2015	10:00
Commenced Loading	01-12-2015	11:20
Completed Loading	04-12-2015	13:35
Completed Lashing	04-12-2015	14:30
Vessel sailed for Diliskelesi	04-12-2015	16:15
Total laytime used	4d 22h 56m	
Laytime availabel	4d 18h 28m	
Laytime Lost	4h 28m	
Demurrage day-rate	5500	USD
Demurrage pro-rata	1024	USD

5.2.3. Case Study 2: MV Sunshine

This second case study is conducted on the MV Sunshine shipping a total of 7 620 ton to Houston, USA, Puerto de Altamira and Veracruz, Mexico in April 2017. The ship was chartered via a time charter contract with Grieg Star Shipping b.v.[4] who runs a regular liner service for steel shipping and therefore upcoming performers are assigned and known months in advanced. In this rare case, Grieg Star did not have a ship available from their own fleet and therefore sub-chartered the MV Sunshine outside their fleet. In Table 5.6 the characteristics of the MV Sunshine as showed in Figure 5.17 are given.

Figure 5.17: MV Sunshine Photo (Source:MarineTraffic.com)

MV Sunshine			
Length	178 m	Building Year	2009
Width	28 m	Tanktop Strength	22
Draught	8.1 m	Type	box
Deadweight	37317t		

Table 5.6: MV Sunshine Characteristics

In this situation, responsibilities over matching the cargo with the ship does not change with respect to a normal time chartered ship, so Grieg Star is responsible for the matching. Therefore, the nomination went as usual for time chartered ships, no absolute approval was needed and no extra attention was given by S&W or Outbound Planning. However, S&W and Outbound Planning did see the ship at the time of fixing and were alerted by Grieg Star which expected stowage difficulties. Therefore at the time of fixing it was known a full weight distribution was inevitable and the harbour planning took this into account. Goosenecking would not be needed due to the open hatch structure of the ship.

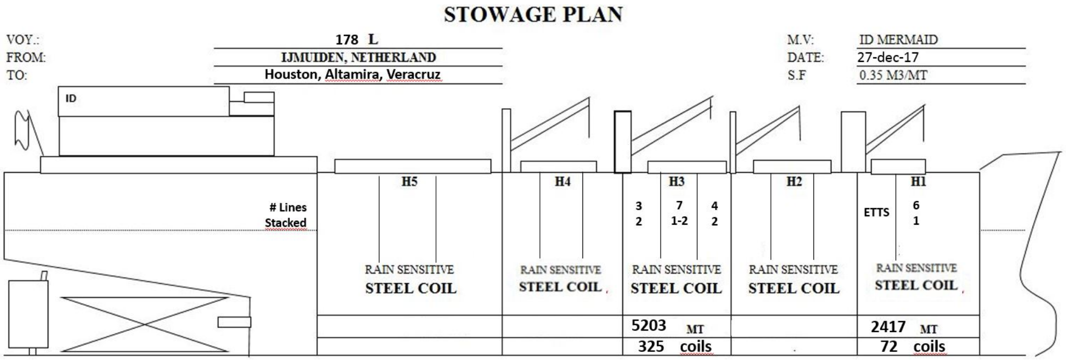
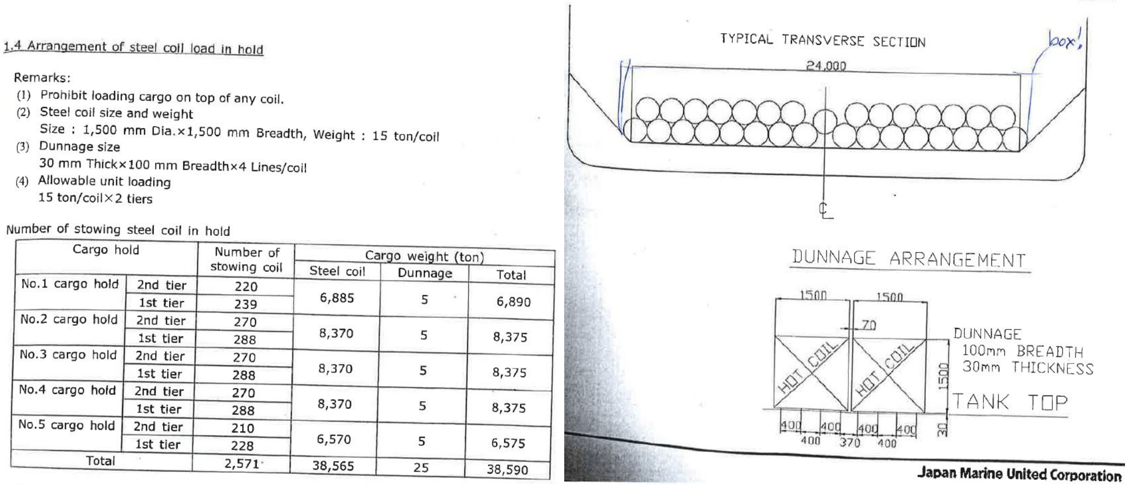


Figure 5.18: MV Sunsine Final Stow plan of 27-04-2017

In this case the communication on the type, weight and number of coils was not a problem, the Ship Management did not requested this information before Tata Steel could make it available. Therefore the information and decision flow is not relevant in detail and went as elaborated in the theoretical description in Figure 5.3. However, once the ship received the breakdown of the cargo 5 days prior to loading, it responded with additional requirements on the dunnage and the stacking of maximum 1 high in Hold 1 and 2 high in hold 3. The captain derived these requirements from his Loading Manual, which showed the information as in Figure 5.19. This meant the coils could not be stowed more than 1 and 1 to 2 coils high in holds 1 and 3 respectively. Additionally the dunnage should consist of 4 lines of 3 layers thick dunnage of hardwood. As explained in Section 5.1.2, Tata Steel IJmuiden normally uses 2 lines of one layer thick dunnage of softwood and is not able to supply hardwood in such short notice. Therefore S&W advised against accepting the ship but got overruled by Chartering. However, since it was on the account of Grieg Star that this ship with these specific requirements was chartered, they arranged last minute hardwood dunnages at their expense. Eventually cargo was to be placed in hold number 1 and 3 and with weight distribution as shown in Figure 5.18.

[4]Grieg Star Shipping b.v. is a shipping company specialised in bulk chartering and operates their own fleet (the G2 Ocean pool) of 40 ships. https://www.griegstar.com/.


1.4 Arrangement of steel coil load in hold

Remarks:
(1) Prohibit loading cargo on top of any coil.
(2) Steel coil size and weight
Size : 1,500 mm Dia.×1,500 mm Breadth, Weight : 15 ton/coil
(3) Dunnage size
30 mm Thick×100 mm Breadth×4 Lines/coil
(4) Allowable unit loading
15 ton/coil×2 tiers

Number of stowing steel coil in hold

Cargo hold		Number of stowing coil	Cargo weight (ton)		
			Steel coil	Dunnage	Total
No.1 cargo hold	2nd tier	220	6,885	5	6,890
	1st tier	239			
No.2 cargo hold	2nd tier	270	8,370	5	8,375
	1st tier	288			
No.3 cargo hold	2nd tier	270	8,370	5	8,375
	1st tier	288			
No.4 cargo hold	2nd tier	270	8,370	5	8,375
	1st tier	288			
No.5 cargo hold	2nd tier	210	6,570	5	6,575
	1st tier	228			
Total		2,571	38,565	25	38,590

Figure 5.19: Key Information of the Sunshine Loading Manual

Results Since extra quay time was taken into account in the preliminary stage, no delays compared to the planning and no demurrage was incurred. The only additional costs made was the supply of hardwood, what was at the expense of Grieg Star (a discount due to the saving of own softwood was given by Tata Steel IJmuiden). Although the planning (see table 5.7)and financial results were not disappointing, extra risks were found by the use of hardwood. During the dropstowage of a key coil, preparatory placed hardwood slipped on the floor and therefore a sudden change to more frictional resistant softwood was needed before the coil, still hanging in the crane, could be placed. This resulted in a Safety Issue Notification and a notice to Grieg Star and the ships owners Tata Steel IJmuiden will not work with hardwood as dunnage again. Figure 5.20 shows the stowage in hold 3, where four lines of three layers thick dunnage is used and coils are stacked maximum two high.

Table 5.7: Final Laytime Sheet MV Sunshine

Description	Date	Time
Vessel arrived roads/waiting berth	24-04-2017	09:00
Berthed	27-04-2017	20:25
Commenced Loading	28-04-2017	05:00
Completed Loading	29-04-2017	18:30
Completed Lashing	29-04-2017	18.45
Vessel sailed for Destination	29-04-2017	20:00

Figure 5.20: Hold 3: 4 lines of 3 layers thick hardwood dunnage, stacked max. 2 coils high

5.3. Cross Case Analysis

Now the baseline case (the theoretical current system description) and the two case studies are discussed in Section 5.1 and 5.2 respectively, this section reviews the similarities, differences and other notions regarding the stowage process and method.

5.3.1. Stowage Process

Ship Nomination As shown in the diagram in Figure 5.3, all departments involved in the process are asked for a check and approval before a ship is fixed. However, the MV Mermaid did not get checked by the departments due to the familiarity with the ship. Besides that, counting on the broker to pass on information to the Ship Management appeared to be wishful thinking. Moreover, S&W has little influence on the nomination; even though problems were expected and warned for by the shipping company, S&W does not have the power to refuse a ship, as experienced with the MV Sunshine of case 2.

Cargo Planning What is remarkable about the cargo planning process is the high dependence on information provided by Outbound Planning. Only after they have their information complete, S&W can start with creating a stowage plan. On top of that, in both case studies, information is a starting point for trouble. The captain of the MV Mermaid requested packing lists in the early phase resulting in S&W pressuring Outbound Planning to draw up a packing list even though too little information was known and so creating unnecessary chaos around unreliable information. In the case of the MV Sunshine, a discussion started after providing the breakdown to the captain. However, it was not the content of the cargo information what constituted the discussion: the unexpected request for hardwood in the Loading Manual was the topic of the discussion. And although S&W advised against accepting the ship at the quay, the ship was loaded and complied to the captains demands.

5.3.2. Stowage Method

Dunnage In the first case, more dunnage as in the Loading Manual of Tata Steel IJmuiden is used, but since it was not brought up in the discussion by S&W, it can be seen as insignificant in perspective with the weight distribution. So deviating from the loading manual regarding the dunnage, is not considered problematic with respect to the distributed weight. In the case of the MV Sunshine, the soft wood dunnage was the bottleneck, but this request is highly exceptional as validated by an anonymous former captain (see interview in Appendix B.9) and S&W. Therefore, softwood dunnage is not perceived as a structural constituent to the quay discussion.

Weight distribution In both cases the discussion resulted in S&W distributing the weight over the tanktop of the ships, with a maximum height of 2 coils. This request seems to be logical due to its correspondence with the regulation calculations from Section 5.1.3.

For the MV Sunshine the planning was adjusted to this in advance and so no disruptions or demurrage was caused. But although the MV Mermaids' planning was not calculated on total weight distribution, still no significant demurrage resulted. So the potential Effects of Failure, found in the risk assessment of Figure 2.1a does not apply with these two cases; the planning disruptions caused by applying different loading method are found insignificant. This statement is verified by M. Botterhuis (from Chartering, see interview B.1) and P. Korf (from OTB, see interview B.2).

5.4. Conclusions

Combining the notions about the stowage process and method in Section 5.3 with the results of the factor analysis of the probable causes in Section 4.1, different bottlenecks can be identified. Per three main bottlenecks, first the causes with corresponding analysis are pointed out, where after the bottleneck itself is explained.

5.4.1. Less Suitable Ships Chartered

Causes:

- More restrictive allocation of coils - If the captain has a Loading Manual on board containing more restriction on coil allocation, stacking or securing, S&W has to comply with these demands. Due to the growing safety awareness, these requirements are not expected to diminish and so regulation enforcement will become stricter.
- S&W does not have the final say in the ship nomination.

Although the average tanktop strength of newbuilds per year is not decreasing (Figure 4.12), a stricter compliance with the concerning regulations is expected (as explained in Section 4.4) which decreases the flexibility for S&W. On top of that, the chartering department often overrules S&W in the ship nomination process. So since S&W has little to say about the ships nomination and their flexibility is decreasing (also due to coil restrictions), the suitability of ships are likely to form a bottleneck for the future.

5.4.2. Late Availability of Information

Causes:

- S&W will, in the future, depend even more on the information provided by OTB.
- For the sequence of loading the coils, and thus the cluster and stowage plan, S&W depends on the coil supply by Rail.

The high dependence of S&W on information provided by Outbound Planning indirectly means a high dependence on the duration of coils in the warehouses and the number of last minute order changes. Since this is not likely to change in favour of S&W (shorter warehouse times or less order changes are not expected) the power relation between S&W and Outbound Planning will grow in importance.

Less Stacking and More Dunnage

Causes:

- More restrictive allocation of coils - If the captain has a Loading Manual on board containing more restriction on coil allocation, stacking or securing, and has regulations supporting these damands, S&W has to comply with these demands. Due to the growing safety awareness, these requirements are not expected to diminish and so regulation enforcement will become stricter.
- More topstowage and Springback - Safety is a major focus of Tata Steel and a cause for the growing topstowage and springback coils. Also the growing weight of coils results in more topstowage coils and the requirements for more dunnage and less stacking.
- An increase in requirements for more dunnage and less stacking is expected. However, as far as the case studies show, the financial and planning consequences seem insignificant.

Although no current trend in coil weight was visible in Figure 4.7, it is known that heavier coils, up to 38,5 ton, need to be shipped in the near future. Besides that, the growing safety awareness induces more springback labelling at the Tata Steel side of the story and more stricter compliance of regulations at the side of the Shipping Industry. This means an even further decrease of flexibility over the stowage and securing method (distributed weight and more dunnage or lashing). Therefore, it is unlikely the preferred loading layouts (Figure 5.11, Layout A1 and B2 with high stacking of coils) established in Section 5.1.2 will still be compatible.

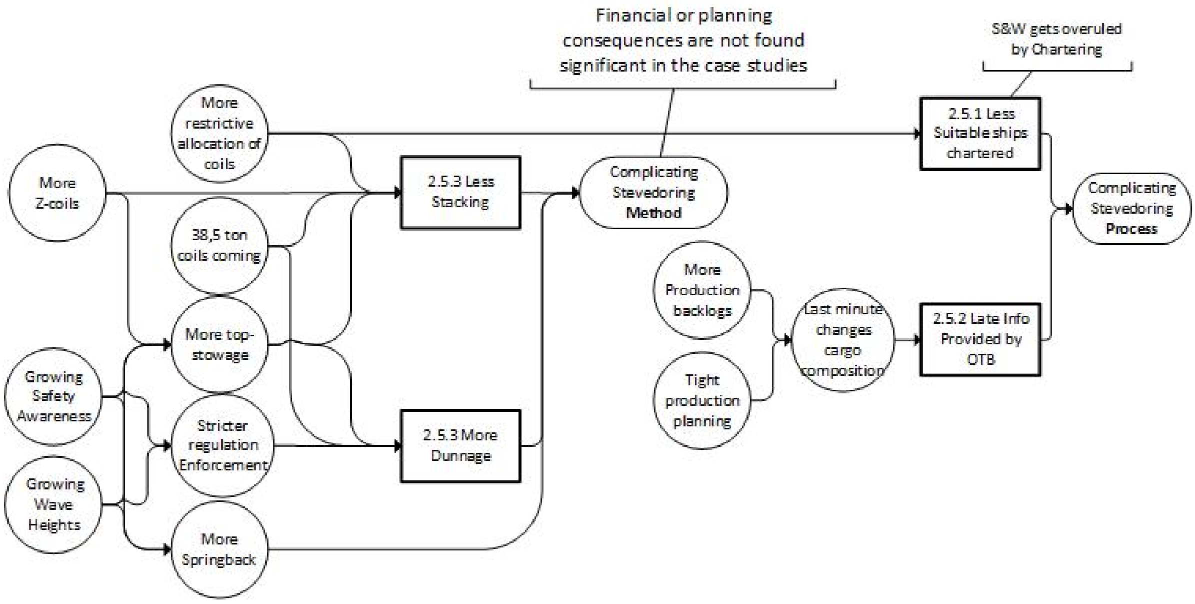


Figure 5.21: Bottlenecks found in Case studies combined with probable causes and concluded on importance

6

Determination of a Problem Solution: Power Analysis

This step of the Deweyan Inquiry concerns the reconstruction of the existing situation for deeper understanding of the problem, so analysing the constituent to the boundaries of the problem solution. With this understanding, this chapter is dedicated to answer research question 3:

3. How does the area of influence of the stevedoring department constitute to the boundaries of the solution?

First, some understanding regarding power distributions in organisations is established in Section 6.1 in order to find a proper methodology to map the power position of S&W. Next, the internal power position of S&W is analysed in Section 6.2, followed by the external power in Section 6.3. The conclusions can be found in Section 6.4, followed by the area of influence regarding solution directions in Section 6.5.

6.1. Power in Organisations

In Section 5.3 it is concluded S&W was overruled by other parties involved in the ships stevedoring process and method. In section 5.4 is also concluded the bottlenecks for S&W in the process (S&W wanted to reject a ship but was overruled by Chartering) were caused by interdepartmental power distribution and, in the stowage method, S&W got overruled by the Ship Management. Therefore, this section focuses on the power distribution internally and externally regarding the stowage process and method. To do so, first, a literature study is executed to find a scientific framework for analysing the power distribution. Hereafter the power of S&W is analysed with respect to other departments. And in the last section the power position with respect to external parties is analysed.

6.1.1. Literature Overview

Power Definitions In literature, power is defined different ways. Emerson [8] says power of A over B, is the amount of resistance by B, which A can overcome. Similarly, Blau [2] sees power as "the imposition of will despite resistance". Weber [26] defines power as pressure and coercive force. These different definitions rise from different approaches and bases of power. The three main bases of power found in literature are discussed in the next three paragraphs.

Power Based on Competitive Forces: Five Forces Model Michael E. Porter[16], from Harvard's Business School, developed the Five Forces Model where power is defined by five specific factors determining whether or not a business can be profitable. These factors relate a business's position and relationship to other businesses in the industry, based on the exchange of service, time, goods or money. However, the power of S&W, with respect to other departments, is not enough based upon exchange since the company wide optimisation is dominant over department optimisation. This way, a common goal is found and bargaining power becomes less relevant. Hence, Porters' Five Forces Model, based on competitive forces, is not applicable.

Power Based on Participants' Perception: French & Raven French & Raven [10] defined power as "the determination of the behaviour of one social unit by another". This theory does not focus on competitive sources of power solely, but is concerned with the perceptions of the parties involved as explanation for power differences. Therefore, this theory could be applied in any environment were multiple parties, consisting of different people, are involved. This criteria is met in the problem situation of this research and is therefore applicable.

Power Based on Structural Forces: Theory of Strategic Contingencies Besides the sources of power based on competitive forces and perception of participants, Hickingson et al. [12] developed the Theory of Strategic Contingencies, relating the power of a sub-unit to its coping with uncertainties, substitutability and centrality. This theory is specified to interdepartmental power and is already widely applied in the field of IT departments (Saunders et al.[20] and Settertrom et al.[22]). However, due to its universal character, the theory can be applied to any interdepartmental power [13], thus also the problem situation of this research. The Theory of Strategic Contingencies and its application is further explained in Section 6.2.

6.1.2. Methodology for determining power position S&W

Selecting Theory With S&W being dependent of OTB for its information and Rail for the coil supply, while Chartering overrules S&W on the ship nomination, it is necessary to correctly analyse the power position of S&W with respect to other departments. Therefore, Theory of Strategic Contingency is applied since it is specified to interdepartmental power. However, with this theory the power position of S&W with respect to external parties, such as the ship management and the shipping company, cannot be analysed. So the theory of French & Raven will be applied to analyse the external power position of S&W. Moreover, the behaviour and attitude is seen as an important aspect in the discussion at the quay.

Measuring Method Previous research applying the Strategic Contingencies Theory in industries, primarily analysing IT Departments, had send questionnaires to several directors of similar departments or institutes. However, this problem situation is very specific for only the Stevedoring & Warehouse department of Tata Steel IJmuiden and such department is not really common. Moreover, we are only interested in the power position of S&W at Tata Steel IJmuiden which only has one director. Therefore, to gain understanding in the uncertainties and how S&W copes wit them, the head of S&W, Mr. E. Lute is consulted by means of an in-depth interview. Since the Theory of Strategic Contingencies extends over more departments, the head of On Site Logistics (the superordinate department) Mr. D. Triezenberg is interviewed. On top of that, different participants in the problem situation are interviewed regarding their perception on power distribution among parties involved. Captain J. Michielssen of Fednav [1] is interviewed for the perspective of the Shipping Company (Appendix B.5). An anonymous former deep sea bulk carrier captain is consulted for the perspective of the Ship Management. And Captain A. Lenting is interviewed for his independent but expertly perception of power distribution in this problem situation.

[1] Montreal-based Fednav is Canada's largest ocean-going dry-bulk shipping company. Fednav is the leader in international shipping on the Great Lakes, as well as the Canadian Arctic, boasting the world's largest fleet of ice-class bulk carriers. `http://www.fednav.com/en`

6.2. Constituents of Internal Power: Theory of Strategic Contingencies

Now two theories are chosen for analysing the power position of S&W, this chapter will explain and apply the Theory of Strategic Contingencies on the internal power distribution of S&W. First the theory will be explained with the help of Figure 6.1, where after the three main constituents (in Section 6.2.1 Coping with Uncertainties, Section 6.2.2 Substitutability and Section 6.2.3 Centrality) are clarified and applied to S&W.

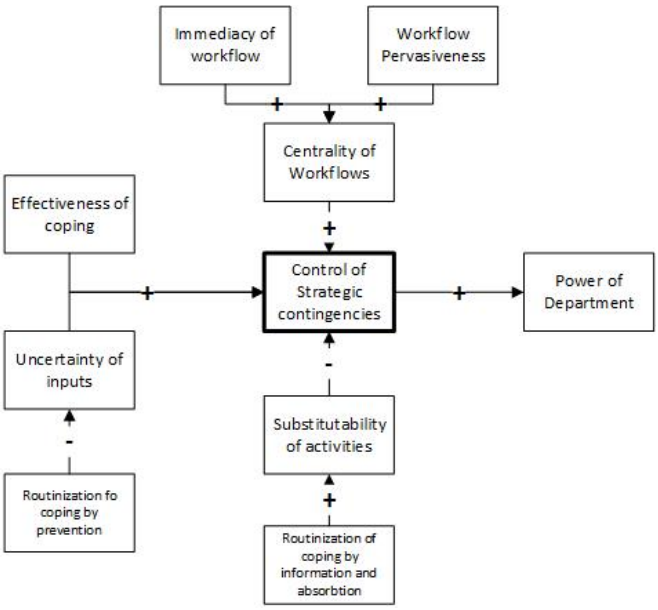


Figure 6.1: Theory of Strategic Contingencies: increasing a departments' power by an increase in centrality and coping with uncertainties but decreasing it subsitutability. [12]

The theory of Strategic Contingencies is based on the assumption that power is gained with the ability and amount of contingencies controlled by the department. A contingency in this context is "a requirement of the activities of one department which is affected by the activities of another department"[12]. Assuming the behaviour of another department is rather unpredictable, a contingency is as well. Figure 6.1 shows the constituents and its relation to the power of a department:

- Effectiveness of coping with- and the amount of uncertainties has a positive relation to power since it increases the independency, explained in Section 6.2.1. A more routinised department prevents uncertainties, and so decreases its power position.
- The more substitutable a departments activities are, the less power it will have. This application will be explained in Section 6.2.2.
- Power is gained by more centrality of workflow pervasiveness and its immediacy, which will be explained in Section 6.2.3.

6.2.1. Coping with Uncertainties

Hickson et al.[12] states that uncertainties in an organisation (for example unknown production quantities or requirements regarding the loading conditions) itself do not give power to departments, but the ability to cope with uncertainty does, since it increases the independency of a department by the "shock absorber function". Therefore, avoiding or reducing uncertainties should not be the self-contained objective. Coping with uncertainty means the activities of the department will be performed regardless of the inputs taken by the department.

Uncertainty of Inputs The need to cope with uncertainties is demonstrated in the risk analysis in Section 2.1. It shows that the consequences for S&W for not or incorrectly dealing with uncertainty, and thus increasing the probability of potential failure effects, can be significant. S&W can be considered as the end of a dog tail: small deviations prior to the shipment diverge to large fluctuations the stevedoring process has to cope with. Head of S&W Mr. E. Lute (interview attached in Appendix B.4) identified several uncertainties S&W has to deal with:

1. **Cargo Characteristics:** materials, dimensions, weight, safety requirements (springback/topstowage)
2. **Coil Supply:** quantity and sequence of coils supplied by rail
3. **Weather Conditions:** rain or strong winds could postpone operations
4. **Ships Timing and Conditions:** exact ETA and condition (clean holds, no damages etc.) of the ship
5. **Ship Management Requirements:** additional requirements on the stowage and securing method

The uncertainties of the cargo characteristics and the ship management requirements correspond with the findings in the case studies of Section 5.2, where the late cargo information formed a bottleneck and the ship management suddenly requested hardwood dunnages. The importance of proper supply of cargo is stressed in the theoretical system description in Section 5.1 and underlined by the investigation towards the warehouse times in Section C.3. Uncertainty 3. and 4. have not been recognised as a uncertainty yet, in this research, due to their insignificant influence on the discussion at the quay. The postponement of operations due to bad weather is accepted and in the interest of both parties. The timing and conditions of a ship can be seen as a separate element and discussion in the shipment process. It could influence the quay planning, however, it does not directly influence the loading and stowage method.

Effectiveness of Coping So coping with uncertainty is crucial for S&W. Its ability to do so can be measured by the existence of coping strategies associated with the areas of uncertainties (as validated by Hickson [12]). The above mentioned uncertainties all have their own corresponding validated coping strategy, respectively:

1. Close cooperation with OTB ensures information is directly passed on to S&W when known at OTB. Ship Management is prematurely informed that cargo information will only be available to him 24 hours before loading. Definite large deviation in coil characteristics are coped with by not planning the stowage coil specific, but leaving room for the stevedores to decide on the best allocation and stacking.
2. Rail and S&W aims to have all material located at the Transit Hall at the harbour. However, this goal is often not achieved and then coils can be loaded directly from the wagon into the ship. The Transit Hall also serves as a buffer storage for supply of coils when other warehouses tend to overflow. When speed is of the essence to empty the wagons, on-call employees are deployed.
3. Weather Forecasts are consulted to foresee downtimes in crane operations and helps with the personnel planning, which can, due to on-call employees, be adjusted on short notice.
4. Occasionally, ships, in particular old ships, are checked on their condition in the harbour prior to IJmuiden to anticipate on contingent cleaning or maintenance activities. The occupation of the quay is planned with some buffer. Some smaller and less expensive ships are used as buffer when the larger deep sea going ships are delayed, so stevedoring activities can be continued.
5. The last uncertainty and (in this research) the core problem of the situation, is difficult to foresee due to complicated and often late communication with the captain. Since S&W does not have a standardised coping strategy to this uncertainty, this research is conducted.

The first uncertainty, the cargo characteristics, has two main components which determined the coping strategy for S&W: the provided information and the deviations in cargo characteristics. The latter one has been analysed in Section 4.2, concluding more topstowage, springback and heavier coils are expected. For the provided information, S&W depends on OTB, as also noticed in the case studies and concluded in Section 5.4. Both components combined it can be stated that: the sooner OTB provides S&W with cargo information, the better S&W can cope with the different cargo. Together with the uncertain supply of cargo by rail, which is now only known for certain 8 hours before loading, it is not possible to generate a coil specific stowage plan (planning the exact location in the hold per coil) [21].

As Mr. E. Lute (head of S&W) pointed out, Tata Steel IJmuiden is currently working on the project “Smart Steel Factory”. This project aims to align all disparate IT system over the whole production site to ensure transparent and easy information exchanges and reduce the uncertainties of unknown product characteristics, and so reduce the dependence of S&W on OTB. The advantage of more accessible information could also improve the performance of Rail (department) and thus the supply of coils to the harbour. So the “Smart Steel Factory” could improve S&W’s coping with uncertainty 1 and 2.

The uncertainty and its coping strategy of the weather condition and the timing and conditions of ships is important for planning activities. However, although it influences the power position of S&W, it is not relevant regarding the problem situation of this research; the stowage approval by the Ship Management. The same holds for the uncertain conditions of arriving ships.

6.2.2. Substitutability

Hickson defines substitutability of a department as “the ability of the organisation to obtain alternative performance for the activities of the department”. According to Hinings [13], there are three different categories of substitution: Internal, departmental and external substitutability. Since the activities of S&W are supportive to the production of Tata Steel IJmuiden and the On Site Logistics department (OSL) coordinates the logistical activities, the head of OSL is interviewed regarding the substitutability of S&W. Explained and applied to S&W, the substitutability can be measured by the following aspects:

- **Internal substitutability:** whether particular tasks could be done by other members of the same department, this directly depends on the difficulty of the job. At S&W, during high occupation of the harbour, additional personnel is needed mostly in the position of lesser skilled labour: the on-call employees of S&W. They can be arranged on short notice by an employment agency and have followed several trainings before they were skilled to start. However, per quay crane operation team there is a limit to the on-call employees, since they are less skilled and experienced as regular Tata Steel harbour employees. So internal substitutability, to a certain amound, is possible and already applied.
- **Departmental substitutability:** whether activities of other departments could replace the activities of S&W. Applied to Tata Steel IJmuiden, one should consider if train or truck transportation are alternatives for shipping the products to customers. However, due to the high costs, these alternatives are not feasible in the near future. For now, only when it is at the expense of the customer, Tata Steel IJmuiden considers these alternatives. So departmental substitutability is not an option.
- **External Substitutability:** whether tasks could be done from outside the organisation. As already developed in other steel production companies, the whole on site logistics chain could be outsourced. However, this is an even more long term plan which should be initiated by a change in company wide strategy and objectives. This is not expected for Tata Steel IJmuiden due to its current strategic advantage obtained by the internally organised logistics combined with the strategic location at sea. So external subsitutability would not be a logical step for Tata Steel IJmuiden.

Regarding the substitutability of the harbour activities, S&W’s power position can be seen as rather stable: Substituting the activities or the whole department are strategically and financially not a logical option. Only specific low skilled work can be outsourced and arranged by an employment agency, while supervision is still done by S&W’s own harbour personnel.

6.2.3. Centrality

Centrality of a department is seen by Hickson as “the degree to which its activities are interlinked into the system of the organisation”. The level of centrality of a department, determines the magnitude the substitutability or coping with uncertainty affects the power of the departments and being part of an organisation inevitably means there is a form of centrality. Two categories of centrality are identified by Hickson and Hinings: workflow pervasiveness and immediacy

Workflow Pervasiveness One constituent to centrality is the extend of interaction with other departments regarding the task and activities of the department: the workflow pervasiveness. However, the level of workflow pervasiveness and its corresponding power, is only of meaning relative to other departments, and so in this case compared to the workflow pervasiveness of other departments involved in planning, scheduling and executing exporting activities: Rail, On Site Planning and OTB. At Tata Steel IJmuiden, the ship at the quay can be seen as the final destination of products exported via deep sea. This means S&W and its activities form the final stage of the production site. And for its stevedoring activities, the interaction with other departments are mapped in the decision and information flow of the ship nomination an cargo planning progress in Figure 5.3. Although S&W is not a central player, it cooperates (mainly) with Rail, OTB and Chartering. But once looking at Figure 6.2, showing the global information flow of the company at the outbound side. It can be seen, S&W is not the most central player, and since it is the final destination for products on site, it has a rather one-sided information flow and other departments are not dependent of S&W’s information. However, the whole production site and especially its warehouses (and thus logistics) depend on S&W for exporting their products and thus emptying the warehouses. Once these tend to overflow, and there is no room for new produced materials, the production facilities have to stop. This is where the immediacy of the department becomes relevant for its power position.

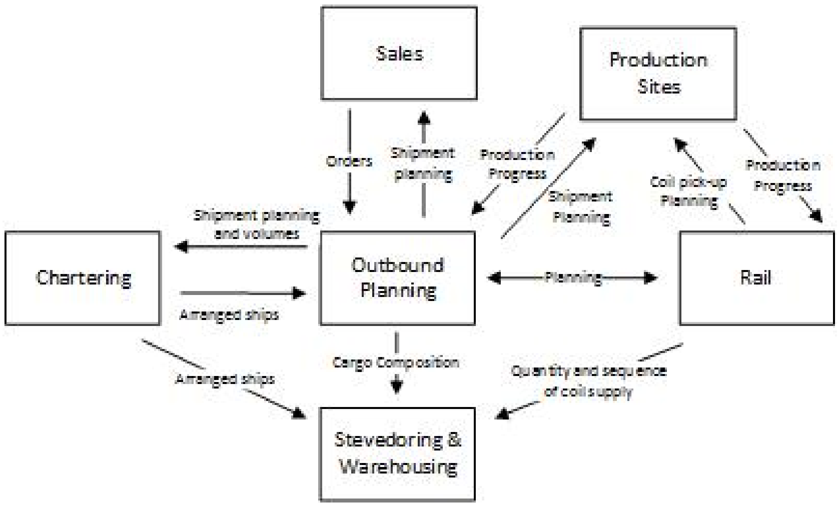


Figure 6.2: Centrality: workflow pervasiveness of the Stevedoring & Warehousing department. It can be seen the workflow is one-sided towards S&W, while other departments involved in the outbound activities have more dimensional workflows.

Immediacy The second constituent to centrality is the “speed and severity with which the workflow of a department affects the final outputs of the organisation” [13]. The main workflow (primary activity) of S&W is the loading of steel coils into the ships and the dependence of other departments on S&W is based on the outward flow of coils. Therefore the immediacy is based on the logistical infarct the disfunctioning of S&W could induce. Such infarct can be foreseen by keeping track of warehouse occupation level, but once the warehouses tend to overflow, this infarct will have impact on production continuity within a few hours. So no activity at the harbour, while warehouses have a high occupation level, will have a immediacy on the production activities of only a few hours. For this reason, it is important for the whole company, S&W overcomes all bottlenecks and keeps loading the ships.

So S&W’s power position regarding centrality is mainly based on the immediacy of overflowing warehouses. Although it is the responsibility of OTB (for the planning), Rail (for translocating the coils) an S&W (for actually exporting the coils) together, if S&W for some reason cannot export the coils, it takes only a few days for a logistical infarct. However, the centrality in workflow pervasiveness is low since the information and product flow is rather one-sided by S&W being the final product destination, as illustrated in Figure 6.2.

6.3. Constituents of External Power: French & Raven

The five external power constituents determined by French & Raven [10] in 1995 are based on social behaviour and perception of the parties involved. It states that "the strength of power of O over P in some system x is defined as the maximum potential ability of O to influence P in x." In other words: one party has power over another in a certain situation, when it is capable of influencing it in that situation. So to determine the external power position of S&W we first need to determine who the other parties are and what the situation (domain) is. Hereafter, the five bases of external power are analysed in the Sections 6.3.1, 6.3.2, 6.3.3 and 6.3.4.

Parties involved The external parties involved are based upon the decision and information flow regarding the stevedoring as mapped in Section 5.1.1, Figure 5.3. Since the participating departments are already analysed in the internal power analysis, only the external parties are considered. However, even though the mediation of a broker might be relevant for the communication and information flow, agreements and contracts are established between Tata Steel and the shipping company. Therefore, the ship broker is not considered in this power analysis. The ship management is considered since, by influencing them and so ensuring agreements on the stowage plan, the problem situation is solved.

Domain So French & Raven define a "system x", meaning a determined domain where the power has influence. For example, an employer has influence on the agenda of his employee during office hours. However, outside office hours, when the employees is at home, the employer cannot influence his agenda to the same level. So the domain regarding the power of the employer over the employees agenda is limited to office hours. Applied to S&W the domains per party should be chosen such, that we can analyse the power in the direction S&W wants to influence the other party, so the domain in which S&W would want to have power over the other party. In the problem situation of this research the discussion at the quay is the domain for analysing the power position of S&W regarding the the shipping company and ship management. One should note that the situation in which the problem occurs, is for all parties a repeating activity. S&W, the ship management and the shipping company are familiar with chartering and stevedoring a ship and corresponding activities. Therefore the perceptions of the three parties, on which the theory of French & Raven is based on, has developed over the years and became more objectively. So perceptions might not necessarily grant eventual power, but the objective facts behind it (known to all due to experience with the situation) are therefore seen as most relevant base behind the power perceptions.

6.3.1. Coercive and Reward Power

A shipping company is rewarded by Tata Steel in monetary terms for its services. The exact costs for chartering a ship are established in a negotiation process and, since presumably the chartering department will face the shipping company again in the future, a steady relationship is desired from both parties. On top of the agreed price for the services, Chartering could this way reward the shipping company with future business. However, since steel shipping is only a small field in shipping and is very strenuous for the ships construction, Tata Steel does not have a strong position to start with.

Opposite to rewarding the shipping company with future business, Tata Steel can take this business away as punishment, but this might harm Tata Steel as much as the shipping company. Moreover, S&W itself can only reward the ship management by being cooperative and friendly; the business is done with the Chartering department. Therefore eventual threats of S&W will not have a large influence on the shipping company.

The coercive and reward power of S&W over the ship management is even less since the ship management is contracted by the shipping company and therefore not directly rewarded (in monetary terms) by Tata Steel. With ships, and especially ship managements, that often recur to the harbour, a relationship could be build up. The only way S&W could reward the ship management is the same as with the shipping company, being a pleasant party to work with, which is a pleasant working environment for all.

6.3.2. Legitimate Power

based on legitimacy, the power of S&W over the shipping company is low, S&W does not close contracts with shipping companies and by regulations or law, S&W does not have more rights. However, Chartering does close contracts with shipping companies based on the total tonnes to be transported. Therefore, Chartering can instigate recovery procedures on the shipping company when not all tonnes are shipped (when cargo is left behind). And thus Chartering can put pressure on the shipping company, which on its turn will put pressure on the captain to at least make sure all cargo will be shipped. On the other side, regulations (class societies) and insurance companies put pressure on the Ship Management because of its responsibility over the cargo and its ship at sea. Since the Ship Management is fully aware of its responsibility, thus based on legitimacy, it is not likely to deviate from its loading manual (which is approved by the class societies so backed by insurance companies). Therefore, S&W has very limited influence on the Ship Management regarding the agreement on the stowage plan.

6.3.3. Referent Power

Due to the common interest in making profit with the transportation of cargo over sea, all involved parties have high incentive to cooperate and come to a solution. This is probably the reason why so far, no severe consequences of the current problem situation are recorded or found in the case studies in Section 5.2. However, due to the lack of reward, coercive or legitimate power, S&W depends on the shipping company, broker or Ship Management to grant them their way of stowing. Therefore referent power is important for S&W. Fortunately, S&W can influence this type of power (increasing its referent power) by building a relationship with the ship management or shipping company. With a good relationship, it is more likely the ship management or shipping company will cooperate with S&W's stowage plans.

6.3.4. Expert Power

Regarding the stowage and securing method of Tata Steel IJmuiden (as explained in Section 5.1.2), S&W is an experience stevedoring department. However, ship management transporting steel more often, is also experienced and has seen different harbours with different stowage and securing methods. Therefore, S&W's expert power relative to the ship management depends on the familiarity of the ship management with steel coil shipping. However, inexperienced ship management could cause discussion due to ignorance and severe cautiousness, strictly holding on to their loading manual. So even though theoretically S&W would have expert power over inexperience ship management, due to their consciousness over their responsibility (based on legitimate power), they are barely influencable by arguments based on experience of S&W.

6.4. Conclusion: Power of S&W

Internal Power Regarding internal power of S&W, following conclusions are drawn:

- **Uncertainties:** S&W is mainly dependent on OTB to provide cargo characteristics early enough in the process. Since this information is provided on short notice, the coil supply by rail, is also uncertain while S&W depends on it.
- **Substitutability:** Substituting the harbour activities or the department as a whole is strategically and financially not a logical option. Only specific low skilled work can be outsourced and arranged by an employment agency, while supervision is still done by S&W's own harbour personnel.
- **Centrality** S&W's power position regarding centrality is mainly based on the immediacy of overflowing warehouses. The centrality in workflow pervasiveness is low since the information and product flow is rather one-sided because S&W is the final on-site destination for overseas transported products.

So Looking at the uncertainties, S&W is mainly dependent on Rail, OTB and Chartering. But S&W only grants power due to its irreplaceability and immediacy when warehouses tend to overlow. However, due to S&W's low centrality, the magnitude of influence with respect to these departments is low.

External Power With S&W having no coercive, reward or legitimate power, the level of influence it has on the shipping company and ship management is based on referent and expert power. Although S&W could theoretically have expert power, ship management will hold on to their Loading Manual, based on their legitimate power, and thus S&W is not able to influence the ship management based on experience. So referent power is left as the only base for S&W to influence their counter-parties.

6.5. Area of Influence Regarding Solution Directions

The aim of this research is not to increase the power position of S&W but to analyse its current position so boundaries for possible problem solutions based on the are of influence of S&W are known. Now the complete problem situation is established in the Chapters 3, 4 and 5 as well as the boundaries to the situation from this chapter, different solution direction can be proposed. To do so, for all three bottlenecks defined in Section 5.4 solution directions are devised and show in Figure 6.3 and the expected influence of S&W is explained below.

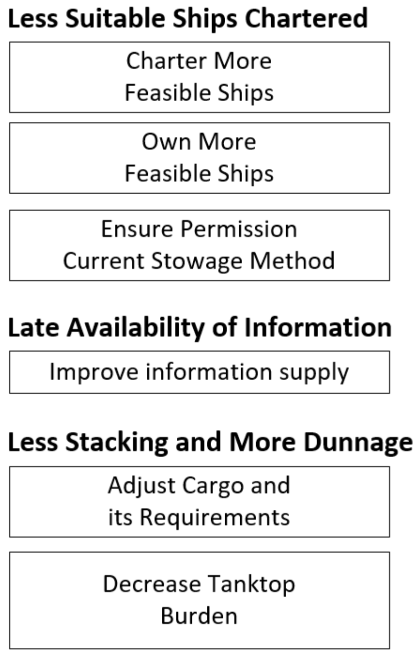


Figure 6.3: Bottlenecks with corresponding solution directions

Les Suitable Ships Chartered Due to the growing safety awareness, the requirements of the ship management regarding the stowage plan, are not expected to degrade. Based on legitimacy and seen in the case studies, S&W has limited influence on the chartered ships. To increase the suitability of loaded ships, three possible solution directions are distinguished: chartering more feasible ships, own more feasible ships and ensuring a permission for the current stowage method anyway.

Late Availability of Information The second bottleneck defined in the stevedoring planning is the supply of cargo information. The earlier S&W has this information, the better it can prepare its stowage plan and the information provided to the ship management. This will reduce uncertainties and could help streamlining the discussion and expedite the approval of the ship management (Section 6.2.1). The dependency of S&W on OTB is not likely to decrease, as stated in Section 5.4. However, due to the immediacy of overflowing warehouses as stated in Section 6.2.3, S&W can put pressure on OTB to provide information earlier in the process. Therefore, to overcome the late availability of information, the information supply to S&W could be improved.

Less Stacking and More Dunnage Besides that the more restrictions imposed by the ship management influences the suitability of the chartered ships, it primarily influences feasibility of the current stowage method. Hence, in Section 5.4 it was concluded that the increasing restrictions together with the increasing topstowage and springback coils, will result in a negative trend in allowed stacking height and used dunnage. Moreover, current regulation were found to be supporting less stacking (Section 5.1.3. This bottleneck would be solved if the cargo was adjusted to the restrictions coming with the ship or the burden on the tanktop would be decreased (conform the demands of the ship management). One should note that by applying less stacking and more dunnage, not only this particular bottleneck is coped with, but the less suitable chartered ships are coped with as well.

7

Reasoning: Selecting a Solution

In this chapter, the fourth step of the Deweyan Inquiry, the different problem solution ideas that are expected to solve the problem are reasoned out. Once several solution directions are dismissed, a Multi-Criteria-Analysis will rate the residual proposals. This way, an answer will be sought to research question number five:

5. What solution is able to cope with the current and future bottlenecks regarding the approval of the stowage plan by the ship management?

First, a solution objective is defined and derived from previous research findings, in Section 7.1. After the solution objective is clear, more solution ideas are generated and evaluated in Section 7.2, based on defined research boundaries. From the approved solution ideas, three specified solutions are proposed in Section 7.3. To incorporate practice and theory, Section 7.4 embodies a multi-criteria-analysis consulting four experts of S&W, ranking the three solution proposals.

7.1. Solution Objective

To be able to actually determine and rate several solution ideas, a clear solution objective should be formulated. To do so, a recap of previous research findings and conclusions is summarised here to form a framework leading for a definite solution objective.

- From the risk assessment in Section 2.1 it is concluded that the financial consequences for S&W are marginally and acceptable while the effects and consequences for the planning and transport flow can have severe impacts and is critical. This corresponded with the financial perspective from Section 3.3, showing chartering costs is almost ten times larger as the stevedoring costs. Therefore this research will not be focused on cost reduction or improvement of the hold utilisation, but on lowering the risks regarding the discussion at the quay.
- This research is initiated because S&W wants to proactively anticipate on expected trends regarding customer demands, internal processes, the shipping industry and climate changes.
- The probable cause analysis of Section 4.1 demonstrated that more coil restrictions and heavier coils are expected in the future, increasing the dependence on information provided by OTB which is not expected to expedite or improve, while expecting that the ship management will enforce their stowage restrictions even further.
- The case studies in Section 5.2 showed that deviating from the loading manual regarding dunnage, lashing or stacking height did not cause significant costs increase or planning disruptions (concluded in Section 5.3). This is contradictory to the conclusions drawn from the risk analysis.
- Although a lot of data was not adequate to conclude on future trends, combining the probable cause analysis with the case studies established the following insights:
    1. The suitability of ships is likely to form a bottleneck in the future
    2. The power relation between S&W and Outbound Planning will grow in importance
    3. The preferred loading layouts (A1 for closed hatch and B2 for open hatch ships) will probably not be compatible in the future: less stacking and more dunnage will be required.
- The power analysis from Chapter 6 reasoned that looking at internal influences, S&W is mainly dependent on Rail, Outbound Planning and Chartering and S&W only grants power due to its irreplaceability

and immediacy when warehouses tend to overflow. Due to S&W's low centrality, the magnitude of influence with respect to these departments is low. Externally, S&W's only base to influence their external counter-parties is referent power.

Due to the insignificance of the costs increase or planning disruptions (the consequences of the discussion), the solution objective should be less focused on the risks involved as as the initial research objective "lowering the risks regarding the discussion at the quay". Considering the above mentioned conclusions, the solution must aim to increase the probability of, or ensuring, an approval of the stowage plan by the ship management. The next Section will introduce distinct solution directions which could solve the problem accordingly.

7.2. Solution Ideas

The different solution directions defined in Section 6.4 have to be diverged to solution ideas, represented in the right column of Figure 7.1 The following sections will elaborate on the different solution ideas.

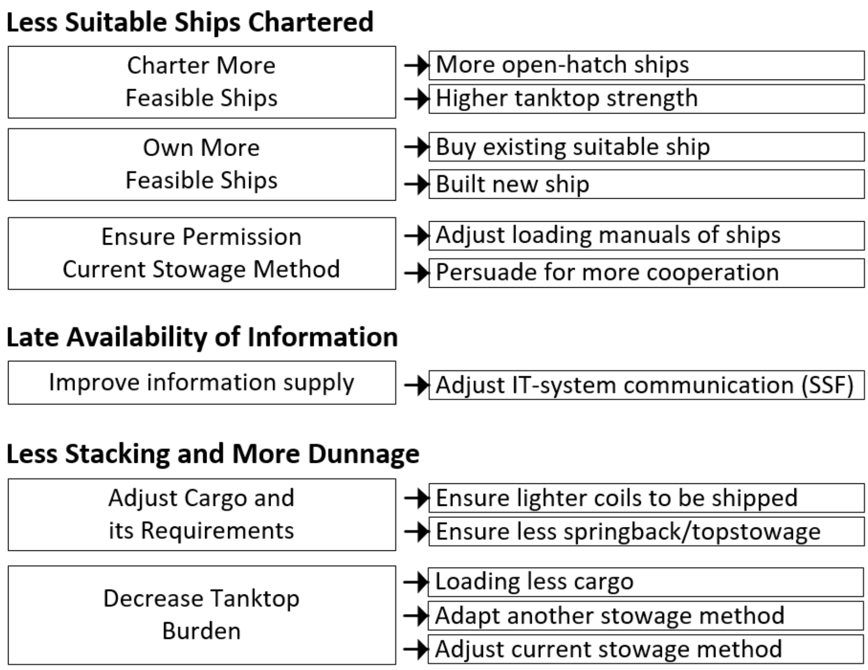


Figure 7.1: Bottlenecks with corresponding solution directions

7.2.1. Charter More Feasible Ships

When S&W keeps their current stowage method and prefers to adjust the type of ships to resolve the problem, there are two preferred ship characteristics: open hatch type ships and high tanktop strengths. Having these two characteristics, would loosen the requirements of the ship management and allow S&W to execute stowage layout B1 from Figure 5.10: leaving no room for the forklift manoeuvre but being able to load coils by dropstowage, without the use of the gooseneck. However, although this would be a satisfying solution for S&W, it limits the number of ships as an option for the chartering department. And due to the relative high expenses on chartering the ship (see Section 3.3), which would further increase by restricting the options, this solution would not be conform company wide optimisation.

7.2.2. Owning More Feasible Ships

Instead of above proposed chartering adjustments, to ensure more feasible ships, Tata Steel could also buy better suitable (for coil shipment) ships. By owning more suitable ships not only Tata Steel could influence the restriction imposed by the ship management, also the chartering expenses will be reduced to only the costs made by the ship (consisting of operational, capital and voyage costs) which is likely to be less than the average 35 euro's per ton chartering costs. To own a more suitable ship, Tata Steel could buy an existing ship meeting the requirements, or built a perfectly suitable ship for coil shipments. Unfortunately, when buying an existing ship, the same regulations set out by the class societies will apply. Tata Steel could influence these regulations enforcements partly by accepting more structural damage to the ship due to high stacking of coils, but this will induce large maintenance and depreciation costs. So therefore, buying existing ships is not seen as a viable solution. By building a new perfectly suitable coil carrier, Tata Steel can ensure their stowage method is permitted. However, building a new ship requires several years and thus will not solve the problem on short notice.

On top of these disadvantages, owning a ship will only be profitable when the ship is operated frequent enough. The current one-way coil shipments to America should therefore be utilised on their return to IJmuiden to make the ship profitable (at least less expansive as 35 euro's per on). So owning ships creates financial risks and requires additional management activities. These induced disadvantage and risks are not proportional to the magnitude of the problem and therefore it is not a recommended solution.

7.2.3. Ensure Permission Current Stowage Method

So if chartering other ship types lies not within the solution boundaries, the problem would be resolved if the ship management would nevertheless allow S&W to use their preferred stowage method. This permission could be achieved by influencing the ship management towards approval or by ensuring the loading manuals of all ships are altered. Unfortunately, the latter is not an option due to world wide regulations which are not influencable by Tata Steel IJmuiden solely. Moreover, S&W and Tata Steel IJmuiden should consider if it is morally acceptable to bend safety and securing restrictions imposed by regulations and class societies towards their benefit and so increase corresponding risks. The first option, persuading the ship management, requires power of S&W over the ship management. However, as concluded in Section 6.2, S&W only possesses referent power to influence the ship management. However, due to the unpredictable outcome caused by the dependence on the identification of the ship management with S&W, it is not recommended as reliable solution strategy.

7.2.4. Improve Information Supply

In Section 5.1.1 it was explained postponement of information provided by OTB was mainly caused by incompetence of the IT system. To cope with this bottleneck, the IT systems should be adjusted. A company wide improvement project is currently developed to establish better communication between the different IT-systems over the entire production site. This is called "The Smart Steel Factory" and was briefly mentioned in Section 6.2.1. The project should ensure transparent and easy information exchanges and so will reduce the uncertainties of unknown product characteristics. This way S&W would be less dependent on OTB and with earlier coil specific information, S&W will have time to generate a coil specific stowage plan instead of leaving the specific allocation to the experienced crane team coordinator (as explained in Section 5.1.1).

7.2.5. Adjust cargo and its requirements

By adjusting the cargo (especially the weight and size of the coils) and its corresponding requirements (such as topstowage and springback), S&W could meet the ship management in its demands for less burden on the tanktop. Unfortunately, at the time of contracting the ship, coil specific cargo information and the ships requirements are not known yet so S&W cannot see whether it matches the ships requirements. Moreover, since producing steel for its customers is Tata Steels' core business and S&W executes supportive activities, it would not be according company wide optimisation or focus. Therefore it is not realistic to adjust the transported products to the chartered ships and its requirements.

7.2.6. Decrease tanktop burden

Note that increasing the tanktop capacity is different as increasing the tanktop strength, since this would imply a construction modification. Increasing the tanktop capacity means a more efficient utilisation of the tanktop size and strength. This could be done by loading less cargo or adjusting or replacing the current stowage method to lessen the tanktop burden and so meeting the demands of the ship management. Since the price per shipped tons expend by chartering is significantly more as for the stevedoring activities, less cargo per tanktop area would increase the total costs drastically. Since adjusting or replacing the current stowage method lies within the area of influence of S&W, several alternatives are further analysed in Section 7.3.

7.2.7. Dismissing Solution Ideas

The previous sections explained the solution ideas of which some are dismissed as possible solution. Figure 7.2 summarises the solution directions and corresponding conclusion, containing four reasons for dismissing the solution:

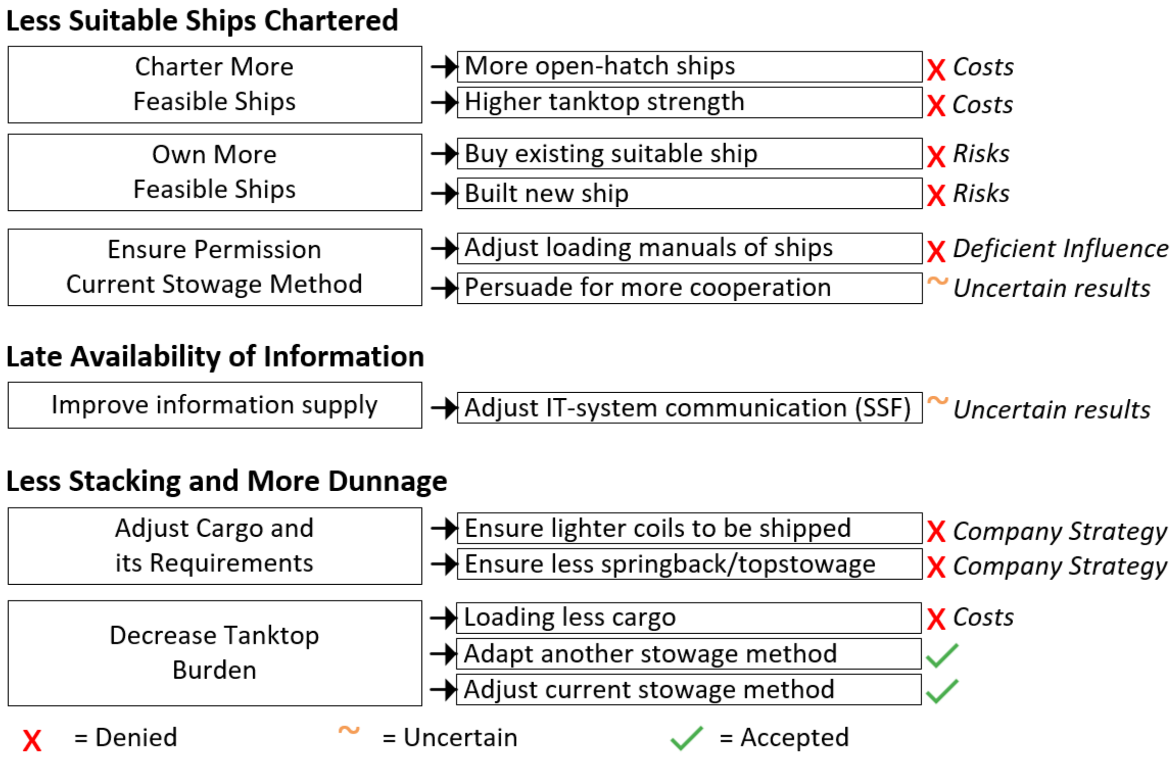


Figure 7.2: Concluding dismissal and approval of solution directions

- Due to the high *costs* per transported tons for chartering a ship compared with the stevedoring costs (see Section 3.3), adjustments in disadvantage for the chartering department are hereby eliminated from the solution alternatives. Therefore Figure 7.2 shows a red cross behind “more open-hatch ships”, “higher tanktop strengths” and “loading less cargo”.
- Due to the *risks* induced by owning a ship, this solution is not perceived proportional to the size of the problem and is therefore not a recommended solution.
- Due to the *deficient influence* of S&W on external parties and aspects (the ship management and regulations), the ship loading manuals and thus the ship managements’ demands cannot be changed by S&W and is therefore dismissed as solution direction.
- Due to the *uncertain results* of persuading the ship management with referent power or adjusting IT-system communication (implementing “the Smart Steel Factory project”), these solution directions are uncertain and therefore not seen as a sound solution.
- Due to *company wide strategies* and optimisations, S&W cannot adjust production output to their preference. Therefore ensuring lighter coil and less springback and topstowage is not seen as feasible solution.

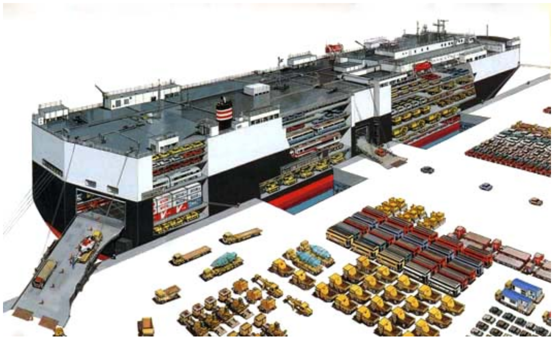
These above dismissals have left S&W with two solution directions within their area of influence, fitting company wide strategy and with self-influencable outcomes: adjusting the current, or adapting another stowage method. The next section (7.3) will explore the different alternatives to the stowage method or the required adjustments.

7.3. Solution Proposals

As concluded in Section 7.2, adjusting or replacing the current stowage method are the two solution direction satisfying the solution objective and boundaries. A brief evaluation of unit cargo in other shipping industries is conducted for potential solutions (Section 7.3.1). Hereafter three different solutions are found; two alternatives to (derived from outside and inside the steel shipping industry) and one adjustment of the current stowage method are proposed.

7.3.1. Unit Cargo Shipping in Other Industries

Other examples of unit cargo are:EU-pallet stacked material (Figure 7.3b, vehicles in RoRo-ships (Figure 7.3a), one-off special units (Figure 7.3d or paper roll carog (Figure 7.3c).



(a) RoRo ship transporting vehicles (Source: `http://www.exship.com/roll_on_roll_off.aspx`)

(b) EU-pallet cargo loaded in container (Source: `http://www.cremisan.org/html/export_info_.html`)

(c) Paper Roll Cargo: vertically oriented (Source: `http://www.osy.co.jp/english/bulkers/secondary.php`)

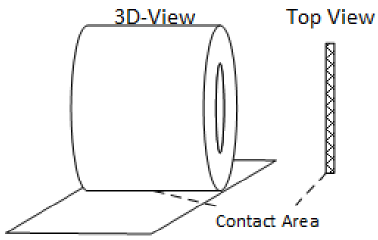
(d) Special unit shipping, one-offs (source: `http://ecmtrainingservices.com/breakbulk-shipping/`)

Figure 7.3: Different types of unit cargo

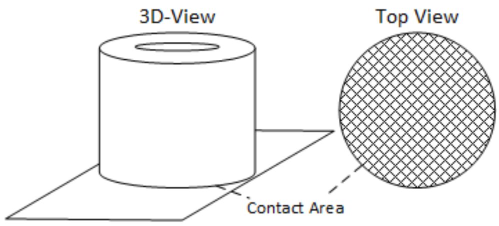
However, Eu-pallet cargo is often smaller, packed in boxes and therefore easier stackable. Due to the physical differences compared with steel coils, this is not seen as a possible solution proposal. One-offs special unit shipping is based on tailor made solutions, specialised per operation. Since steel coils are shipped in larger quantities, more standardised solutions are sought. Special purpose ships, such as the RoRo-ships, similarly exist for steel coil shipping. Within inland shipping or in some liner services, special hold equipment is applied to ensure easier stacking and securing. The second alternative stowage method is based on this principle and will be explained in Section 7.3.3. The first alternative is derived from the paper shipping industry, as will be elaborated in Section 7.3.2.

7.3.2. Alternative Method: Vertically Stowed Coils

The problem why horizontally stowed coils are such a burden for the tanktop, originates from their small contact area due to the shape of the coil (as illustrated in Figure 7.4a). When rotating the coil to vertical position, this area increases significant, distributing weight more evenly (see Figure 7.4b) and so decreases the burden on the tanktop. This method is derived from the paper industry, stowing paper roils vertically as shown in Figure 7.3c and is very similar to the stowage of Eye To The Sky coils, also vertically stowed due to their fragility (increased risk on ovalising when horizontally stowed).



(a) Horizontally Stowed Contact Area



(b) Vertically Stowed Contact Area

To enable this type of stowage, coils need to be rotated 90 degrees. But Since S&W does not have sufficient influence to change the whole logistic chain of Tata Steel IJmuiden towards vertically coils (think of warehouse and wagon layout or equipment), coils could only be rotated after they have arrived at the harbour. Equipment for such operation are already developed and showed in Figure 7.5.

The handling techniques for horizontal stowed paper rolls are different as for the ETTS coils of Tata Steel IJmuiden. Figure 7.7 shows paper coils are lifted based on friction by double clamps. However, the heavier steel coils would require far more friction to be lifted that way, so clamps should apply more force, increasing the risk for damaging the outer wrap or telescoped coils (as shown in Figure 7.6). To overcome this disadvantage, pallets should be placed under the vertical coil, so pick up by forklift becomes practical. This loading method is similar as for the allocation of ETTS coils and therefore the same throughput is expected, namely 13 coils per hour (which is equal to allocation with a thorn-equipped forklift) equal as the throughput for vertically stowed coils.

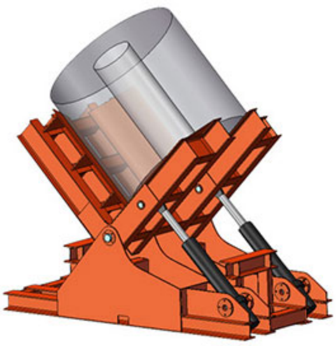


Figure 7.5: Coil rotating equipment (Source:http://prestar.cz/en/obchod/zvedaci-technika/dle-bremen/hydraulicky-sklopny-stul/)

Figure 7.6: Telescoped Coil (Source: http://www.stormcoil.com/services.html)

Figure 7.7: Paper roll lifted by clamp (Source:http://www.kellytractor.com/eng/products/forklifts/cat/Combustion-8000-15500-Lb.aspx)

7.3.3. Alternative Method: Cradle/Cassettes

To avoid heavy burden on the tanktop, multiple specialised solutions for shipping steel coils are developed by Langh Cargo Solutions [1]. Many of these solution propose stuffing specialised containers with steel coils, designed for loading container ships. However, since S&W also stows slabs or ETTS in the same bulk carriers as the horizontal coils, chartering container ships only for the advantage of horizontal coils does not lay within the solution boundaries due to the chartering cost aspect.

When looking at the solution applicable for bulk carriers, Langh Cargo Solution has developed cradle cassettes forming coil gutters which distribute the weight of the coils over the tanktop and replace the current use of wooden dunnage (see Figure 7.8). Straps provided with the cradle cassettes replace the current steel bands as lashing. Pyramidal tacking of coils will still be possible and due to the more stable positioning of the coils, no specific positioning of a key coils is required anymore. Time will be gained since loading a cradle cassette on board is less consuming as preparing separate pieces of wooden dunnage.

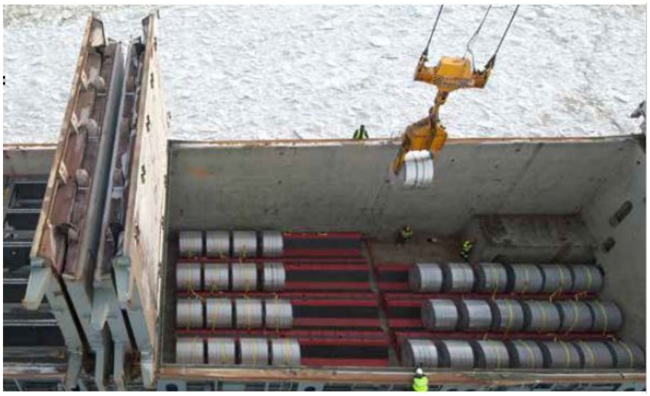


Figure 7.8: Cradle tween decks

However, since the solution boundaries do not allow special ships being chartered for this solution, it should be applicable at regular bulk carriers. This means the coil cradle cassettes should be removable and require flexibility for different widths of ships. Unfortunately it does not lay within the scope of this research to design such system. But since the application has already been developed and tested by Langh Cargo Solution, we assume removability lays within the future possibilities. When this solution appears to be optimal, further investigation towards its removability will be required.

Investment in new coil handling equipment is not needed to load the coils in this situation. The tare weight of a cradle cassette is 7,2 ton and thus the quay cranes are suited to load the cradle cassettes. However, S&W will need to invest in new crane equipment (see Figure 7.9) to enable the quay cranes to load a cradle cassette. Further research towards the investment in the cradle cassettes is needed. The cassettes could be bought by S&W and reused, or might be leased in some form and rotated between users around the world.

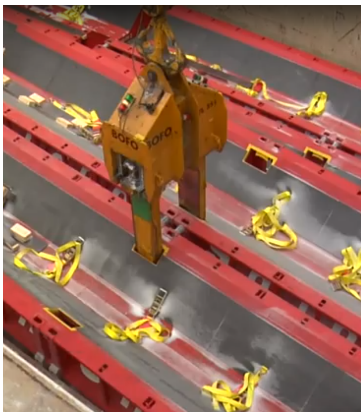


Figure 7.9: Crane equipment to load cradle cassette

[1] Langh Cargo Solutions provides special containers and other transportation units for demanding transportation needs, specialised in steel coils, steel sheets, bulk and liquids cargo.

7.3.4. Adjust Method: Distribute Weight

To increase the probability of, or ensuring, an approval of the stowage plan by the ship management, S&W could aim to meet the demands by altering its stowage method, especially the hold layout. Looking at the currently applied hold layouts, the stacking height could be significantly reduced if the whole tanktop area would be utilised for placing coils, and thus not leaving room for forklift manoeuvres. The stacking height and the amount of used dunnage was primarily found as the bottleneck for approval by the ship management. Therefore, by adjusting these, it is expected the ship management is more likely to approve the stowage plan. So stacking less high, while still loading all cargo,and applying more dunnage, would meet the demands of the ship management. By applying this on default on all ships, a discussion at the quay with the ship management is less likely. Moreover, at the time of contracting the ship, the ship management has approved on loading a certain quantity of cargo and therefore will be cooperative to load all cargo. When all coils will be evenly distributed over the tanktop, as the ship management expected since most harbours distribute their weights (validated by anonymous captain, see Appendix B.9), the ship management is not likely to refuse cargo based on the amount of tons. Figure 7.10 shows for both open and closed hatch ships the hold layouts as currently applied by S&W.

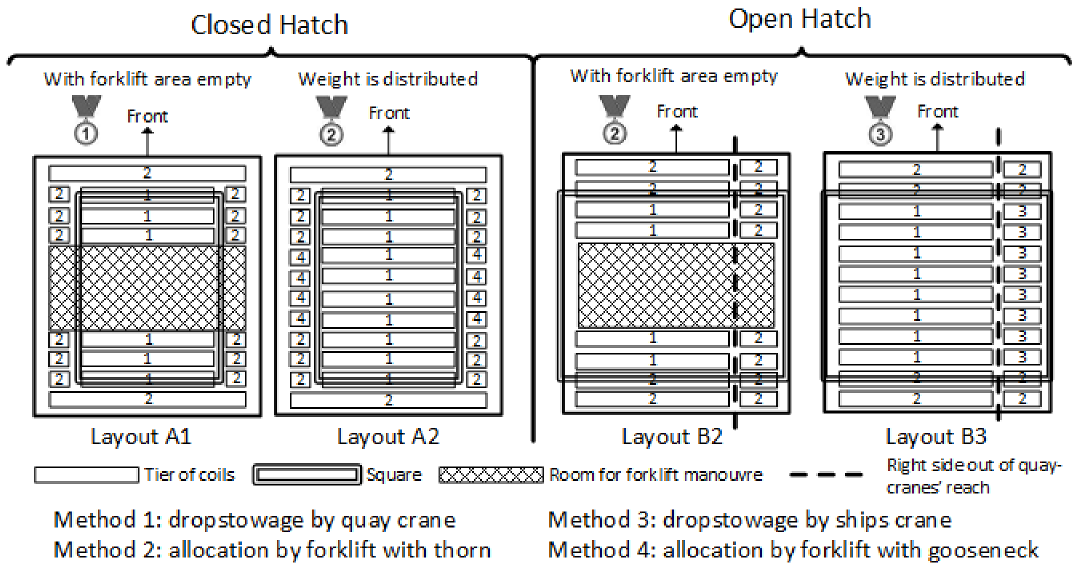


Figure 7.10: Top view of hold layouts with corresponding loading methods without and with distributing weight

As explained in Section 5.1.2, S&W prefers layouts A1 and B2 for closed and open hatch type respectively, due to the unfavourable use of the gooseneck. Moreover, since coils up to 38,5 tons need to be transported in the near future, the current gooseneck (able to load until 21,5 ton) does not suffice. So if more goosenecking will be required when applying Hold Layouts A2 and B3 on default, investing in a heavier gooseneck is required. But on the other hand, the additional costs regarding demurrage, material or extra personnel did not prove to be significant, as shown in the case studies of Section 5.2. And since Hold Layouts A2 and B3 are currently already applied by S&W, no investments in trainings or personnel is needed. So, besides from the gooseneck, the current harbour equipment and personnel is competent to perform Layouts A2 and B3.

However, a disadvantage of these layouts is the practicality at the discharge harbours, which do not have equipment such as the gooseneck to discharge coils which are not reachable by a thorn. Currently these harbours use the quay or ships crane to “drag” the coils out of their place. Unfortunately this is very sensitive to damage due to the friction of the coil with the tanktop. Currently there is no data available on the frequency, severity or costs coming with this discharge method, so further research towards this damage is recommended.

7.4. Multi Criteria Analysis

To ensure the best solution out of the three proposals is choosen, an Multi Criteria Analysis is conducted in this section. First the appropriate selection tool, the Analytic Hierarchy Process (AHP), is chosen from literature (Section 7.4.1) and is explained. Hereafter, Section 7.4.2 elaborates its application to this research and the choosen solution criteria. Section 7.4.3 explains how consults are selected whereafter their rating process follows in Section 7.4.4. The results of the AHP can be found in Section 7.4.5.

7.4.1. Method Selection

Literature on MCA In literature, numerous research is done on differences and similarities of existing Multi Criteria Decision Making (MCDM) tools. According to several of these comparisons, statistically and analytically the different tools do not show significant deviations in results [28]. However, in application the most considerable difference is the ease of use and understanding of the method [25]. Partly for that reason, the Analytic Hierarchy Process is selected to apply in this research.

The Analytic Hierarchy Process The Analytic Hierarchy Process [19] is a MCDM tool known for its intuitive pairwise comparison. Its results are in ordinal form, meaning it conducts a ranking rather than a absolute score. The AHP is widely applied, especially in the marine industry [3], due to its decomposition of a complex problem into a multi-level hierarchical structure containing objectives, decision criteria and alternatives [18]. The AHP provides priorities of the criteria of which alternatives are weighted against. This ensures eventual importance of the alternatives related to the goal are ordinally quantified.

Application to this research Due to the qualitative character of this research, quantifying criteria or solutions is rather speculative and could cause inaccurate indication or cardinal scores. And therefore, together with the easy-to-understand pairwise comparison, the Analytic Hierarchy Process is chosen as MCDM tool for this solution finding. Moreover, this approach is not chosen for its statistically significance, but is meant to guide as a framework and give reference to and an indication of the solution selection and preference. This is also the reason the statistically significance or a sensitivity analysis will not be executed. The remaining steps as an approach and application of the AHP in this research are as following:

1. AHP decomposition: selecting Goal, Criteria and Alternatives
2. Selecting Consultants: experts on the matter to weight the different criteria
3. Rating Criteria and Alternatives: on the basis of pairwise comparison
4. Conducting the Results: mathematical calculation resulting in solution preferences

7.4.2. AHP decomposition

For the solution finding problem of this research, the decomposition of the levels of the AHP are shown in Figure 7.11, with the objective as defined in Section 7.1 and the three solution as defined in Section 7.2. The chosen criteria are explained below.

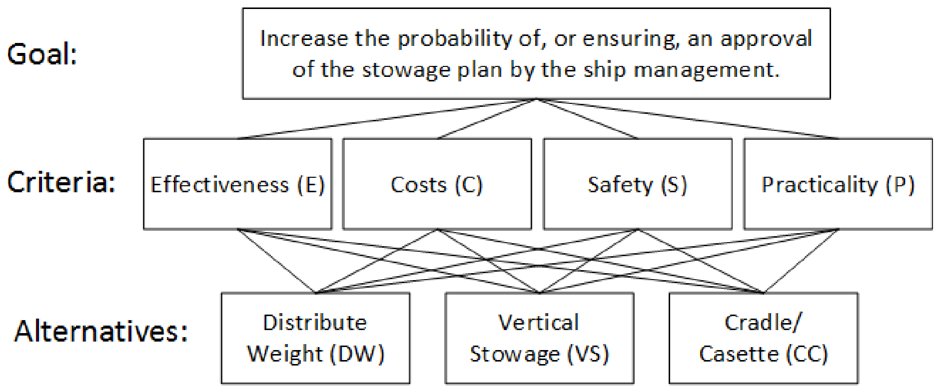


Figure 7.11: AHP decomposition application

Solution Criteria The solution criteria represent different aspects on which the different solutions should be compared to in the pairwise comparison. The four chosen criteria are as follows:

- **Effectiveness** First of all, it is important the solution solves the problem and therefore the effectiveness forms the first criteria. The more effective a solution, the better. This criteria also considers the quality of the solution regarding coil handling, so whether or not it is sensitive for damaging the coils.
- **Safety** Producing and transporting steel is a heavy industry forming a working environment where risk management regarding employee safety requires close attention and focus. Therefore safety is the number one priority of Tata Steel IJmuiden, so an important criteria in solution finding for this research as well.
- **Costs** Since the additional expenses on demurrage or materials where found insignificant in the case studies, a solution is not likely to be even cheaper as the current coping strategy. Moreover, since Tata Steel IJmuiden as a whole, but also S&W has department, is a commercial organisation measuring its performances in profitability, expenses are important to manage. Therefore a low cost solution is preferred and thus the costs is a criteria. Not only the one-time investment costs, bus also periodic or variable additional costs should be considered under this criteria.
- **Practicality** An solution might be cheap, save and effective regarding solving the discussion, however, these criteria do not count for practicality, such as feasibility for the discharge harbour or large organisational changes. So this requirement leaves room for additional advantages or disadvantages of the solution, beyond the effectiveness, safety and cost criteria.

7.4.3. Selecting Consultants

Since adjusting or renewing the current stowage method (the basis of the three alternatives) requires practical implementation and close cooperation from management board and employees in working class, next to the manager of S&W and its production manager, also a plannings officer and a harbour team leader from the shift workers is interviewed. This ensures multiple insights and arguments from different levels are considered in the pairwise comparison. Moreover, since adjusting or renewing of the stowage method barely influences the workflow of other departments (which corresponds with the solution boundary, defined by the area of influence of S&W in Chapter 6), interviewing only employees withing S&W is considered to generate sufficient base and counselling for reliable assumptions and implementation of the pairwise comparison. First the four individuals are consulted for their rating of the solution criteria, whereafter they are asked to fill in the expected compliance of the alternatives w.r.t. each criteria, with alternatives compared in pairs.

7.4.4. Rating the Criteria and Alternatives

Rating the Criteria To rate the criteria by a pairwise comparison, four individuals (two managers, one planning officer and one harbour teamleader) are asked to fill in a form, comparing all four solution criteria against each other. Table 7.1 explains the ranking scale of the comparison. After all four individuals had ranked the criteria (see appendix G), the ranking matrix is filled in accordingly as showed in Table 7.1 column 3. There is no weight applied regarding the four individuals since their opinion is perceived equally important. However, due to the expected better vision of the management board, their vision is weighted extra by consulting two individuals of the management board. The plannings officer and the harbour team leader are not considered in the same corporate level in the company, and therefore both represent other levels. After their rating of the criteria, the geometric mean of these four matrices is normalised, the priority vector is calculated representing the normalised weights per criteria, as shown in Figure 7.2. A value above 1 means the criteria on the left of the matrix, is seen as more important as the one stated above and visa versa. The detailed mathematical steps can be found in Appendix G.

Table 7.1: Explanation of the used AHP ranking scale

Score	Explanation	Translated to matrix
-2	Strongly less importance/compliance left criteria/alternative	9
-1	Moderate less importance/compliance left criteria/alternative	5
0	Equal importance/compliance	1
1	Moderate more importance/compliance left criteria/alternative	1/5
2	Strongly less importance/compliance left criteria/alternative	1/9

Table 7.2: Geometric mean matrix of criteria ranking with corresponding priority vector **CR=0.15**

	E	S	C	P	Priority Vector (PV)
Effectiveness (E)	1,00	0,11	4,10	1,60	**0,14**
Safety (S)	9,00	1,00	8,00	8,00	**0,72**
Costs (C)	0,24	0,13	1,00	3,80	**0,09**
Practicality (P)	0,63	0,13	0,26	1,00	**0,06**

Interpreting Results of Criteria Ranking So looking at the priority vector of the criteria, we can conclude Safety is by far most important. This corresponds with the motto of Tata Steel: "Safety First". Next in the ranking is the effectiveness, followed by Costs. Practicality is seen as least important, which can be assigned to the knowledge of the individuals that S&W is a supporting department and therefore is aware it might have to bend over backwards to ensure coils are loaded and shipped to its customers. The low priority of the costs on the solution alternative can be assigned to the knowledge of the individuals that expenses on stevedoring are significant less as for chartering (Section 3.3). One should note that the wide distribution of the priorities originate from the rating scale; the individuals rated regarding the Likert-scale (5-scale) which is translated to a 17-point scale. Therefore the order of preference of the solutions is seen as more relevant as the absolute difference in priority.

Rating the Alternatives To rate the criteria, the four individuals have filled in the same pairwise comparison form, attached in Appendix G. Per pair of alternatives, the individuals indicated their preference per criteria. Translating this as given in Table 7.1 and clustering per alternative, the following tables (7.3) show the ranking indicated by the individuals with corresponding priority vector.

Table 7.3: Geometric mean matrix of alternative ranking with corresponding priority vector

Effectiveness	DW	VS	CC	priority vector
Distributed Weight (DW)	1,00	2,78	0,11	0,134
Verticle Stowage (SW)	0,36	1,00	0,14	0,073
Cradle/Casette (CC)	9,00	7,11	1,00	0,793

(a) Effectiveness, **CR=0.15**

Safety	DW	VS	CC	priority vector
Distributed Weight (DW)	1,00	0,44	0,14	0,08
Verticle Stowage (SW)	2,29	1,00	0,14	0,14
Cradle/Casette (CC)	7,11	7,11	1,00	0,77

(b) Safety, **CR=0.07**

Costs	DW	VS	CC	priority vector
Distributed Weight (DW)	1,00	4,73	9,00	0,70
Verticle Stowage (SW)	0,21	1,00	9,00	0,25
Cradle/Casette (CC)	0,11	0,11	1,00	0,05

(c) Costs, **CR=0.24**

Practicality	DW	VS	CC	priority vector
Distributed Weight (DW)	1,00	7,67	5,00	0,74
Verticle Stowage (SW)	0,13	1,00	4,73	0,19
Cradle/Casette (CC)	0,20	0,21	1,00	0,08

(d) Practicality, **CR=0.39**

Interpreting Results of Alternatives Ranking So looking at the results, loading steel with a cradle cassette system is seen as most effective and the safest. This can be assigned to the sturdy and robust nature of the solution; the cargo support is completely devoted to the shipment of coils. However, distributing the weight is seen as the less costly and most practical solution, on which both the cradle cassette alternative score rather low. This can be assigned to the fact S&W currently already distributes the weights when required by the ship management, and the costs or planning disruption showed to be insignificant in both case studies 5.2. Leaving the vertical stowage solution scoring most overage on all four criteria.

7.4.5. Conducting the Results

Combining Priority and Alternative Ranking By combining (multiplying and summing) the ranking of the alternatives per criteria (see previous Tables in 7.3) with corresponding criteria weights (previous Table 7.2, results of the total ranking of the solution alternatives are obtained and shown by the priority ranking in following Table 7.4.

Table 7.4: AHP results: weighted criteria ranking the alternatives

	Effectiveness	Safety	Costs	Practicallity	Priority Ranking
Criteria PV:	0,14	0,72	0,09	0,06	
DW	0,13	0,08	0,70	0,74	**0,18**
VS	0,07	0,14	0,25	0,19	**0,15**
CC	0,79	0,77	0,05	0,08	**0,67**

Interpreting Results So although the cradle cassette solution only scored highest on two criteria (safety and effectiveness) in Table 7.3, due to the weights of these criteria, the overall preference seems in favour of the cradle cassette solution. Moreover, distributing the weight has become second in ranking, while scoring highest on two criteria as well.

Consistency So cradle cassette is perceived as the optimal solution by the average of the four individuals. However, the consistency should be taken into account as well. For the linear 1-9 AHP scale, a consistency ratio (CR) ≥ 0.12 indicates an inconsistent rating of the criteria or alternatives. The consistency of the criteria rating of 0.15 can still be considered sufficient, since this difference can be assigned to the scale translation from the 1-to-5 likert scale to the 1-9 AHP scale, amplifying small differences indicated by the four individuals. The same holds for the Effectiveness CR. However, the Safety CR does show a satisfying value of 0.07, so consistently the four individuals ranked the alternatives regarding safety. Unfortunately the CR's of the Costs and Practicality (0.24 and 0.39 respectively) are not acceptable. This means, regarding these two criteria, the individuals are too inconsistent, which can partly be assigned to scale discrepancies. However, another main cause for inconsistency is lack of knowledge; meaning the individuals have too little information to base their opinion on. This might be caused by the conceptual nature, and thus lack of detailed information of the three proposed solutions. Eventual lack of insight, assessment or judgement of the four individuals could also play a role in the inconsistency.

8
Experiment: Solution Application

In the fifth step of the Deweyan Inquiry, the optimal solution from the previous chapter will be tested against reality; does the problem solution actually have the expected result? Therefore,this chapter will be dedicated to the verification of the established problem by answering the following research question:

6. Does the solution have the desired effects regarding effectiveness, safety, costs and practicality?

Section 8.1 will discuss the previous found solution, the cradle cassettes, and its effects regarding costs and practicality. This results in rejudging the solution selection, which will be done in Section 8.2. Next, the Weight Distribution solution is analysed regarding effectiveness, safety, costs and practicality, which will be verified in the final section of this chapter, Section 8.3.

8.1. Cradle Cassette Application

First of all, some point of critic regarding the AHP results are required to put the interpretation in perspective. As already discussed in Section 7.4.5, the consistency is important to take into account while inconsistency implies one should be careful with drawing conclusions. In the MCA of previous chapter, inconsistency was found on two criteria: costs and practicality. Therefore the consequences of the cradle cassette application requires further investigation regarding costs and practicality, which is done in the following sections. Section 8.1.1 elaborate on different costs made when the cradle cassette solution is applied at the harbour of Tata Steel IJmuiden. Since there is no quantitative data available on costs coming with implementing the cradle cassettes, the section contains a qualitative reasoning to analyse the related costs.

8.1.1. Costs

The costs are analysed divided over S&W (the Port Tariff as discussed in Section 3.3) and Chartering. The costs for chartering are traced back to the port tariffs, as discussed in Section 3.3. A new stowage method will mainly influence the Port Tariff on its throughput and used material, but it is also important to take a look at initial investment costs. These three will be discussed in the following three paragraphs. The costs consequencees for Chartering will be discussed in the last paragraph of this section.

Throughput By using the cradle cassettes in chartered ships, allocating coils by forklift will not be needed anymore. But since dropstowing coils has an equal throughput, no definite time gain is expected regarding the loading method. Allocating the cradle cassettes is expected to be less time consuming as placing the wooden dunnage and therefore only small time gain is expected.

Material use The current wooden dunnage used to distribute the weight and keep the coil at its initial location is replaced in the application of the cradle cassettes. So costs are saved on dunnage, but cradle cassettes need to be acquired. This also holds for the lashing, replaced by the bands attached to the cradle cassettes. However, these cradle cassettes are larger and expected to be more expensive (no prices available) as the wooden dunnage currently used. And therefore, although the current dunnage is disposed after one time use, the cradle cassettes should be reused. To do so, proper logistics management is needed to return the cradle cassettes to S&W. A quick estimation of corresponding costs is made based on the weight of the cassettes and steel coil freight costs:

With a cradle cassette length of 12 m and stowing 3 coils high, one cradle cassette should carry 18 coils (12/2*3=18) of average 25 tonnes, so 18*25= 450 tons loaded per cassette. However, the suggested cradle cassette of 7,2 ton has a maximum payload of 192,3 ton. So, or a heavier cradle cassette should be designed (with expected increased tare weight), or the hold utility decreases significantly. Since this latter is not within the solution boundaries as defined in Section 7.2.7, a cradle cassette with at least double the strength and so at least double the weight should be used. Applying the same costs per ton at the cradle cassettes as for the steel coils, €35,-/ton for shipment to America, the costs for one cassette cradle to return (with a weight of 14,4 ton) is approximately €500,-.

Investment Costs The loading of coils will not require addition equipment with respect to current applied dropstowage. However, the cradle cassettes need to be loaded with the quay crane, which capacity (58 ton) is sufficient to load the cradle cassette (7,2 ton or the above double weight of 14,4). But this crane does require a new crane hook, as shown in Figure 7.9 to be able to lift the cradle cassettes. Besides such crane hook also the cradle cassettes should be acquired. Since the return of these cradle cassettes might take a few weeks (return from America) and roughly estimated 80 (8 in width of the hold, 2 in length of the hold, 5 holds per ship) cradle cassettes per ship are needed, a major investment is required to equip all ships with cradle cassettes

Chartering Costs The same bulk carriers as currently chartered are assumed to be fit for applying the cradle cassette. However, since the width of the cradle cassette is fixed, regardless of the coil diameter, smaller coils will take up the same space as larger coils, and so decreases the utility of the hold capacity (stacking more as 3 high is prohibited due to safety issues). Thence, the chartering costs per ton will increase significantly. Moreover, the weight of the cradle cassette should be summed with the coil weight to find the total cargo weight per shipment.Therefore, besides the costs or returning the cradle cassettes, also a decreases the allowed coil weight is expected and thus an increased chartering price per tons of coils.

8.1.2. Practicality

Some practicality issues, such as the return of cradle cassettes, are explained above and the costs to solve these are quickly estimated. However, other obstacles in practicality are found in the use of cradle cassettes by means of their size, accessibility of coils and the discharge at destination harbours. These three are explained in the next paragraphs and seen as practicality bottlenecks, no costs to solve these issues is reasoned out, due to the scope of this research.

Size of the Cradle Cassettes In previous paragraph, a fixed width of the cradle cassettes is assumed and concluded to decrease the hold utility and so increases chartering costs. To ensure the length of the cradle cassette (which multiple should correspond the ships' hold length) is not increasing the chartering costs any further, the length of the cradle cassettes should be or adjustable, or multiple different lengths are required to be available at the harbour. This will increase the investment in cradle cassettes even further, or due to a more complex design increasing the costs per cradle cassette, or due to the greater quantity of the cradle cassettes.

Accessibility of coils Currently, when stowing coils under the hatch, unreachable by forklift, a gooseneck is required to allocate the coil. When applying cradle cassettes, similar allocation challenges rise. Since a forklift cannot drive over the cradle cassettes and thus dropstowage will be the main loading method, a solution should be sought for allocating coil under the hatch.

Discharge harbours Since the coils have to be discharged at destination harbour, required adjustments or challenges are expected there either. First of all, harbours are to be equipped with the same crane hook as in Figure 7.9 to be able to unload the cradle cassettes. Next, when the cradle cassettes are unloaded, storage location for the cradle cassettes, waiting for a shipment back to IJmuiden, is needed. Especially the latter one, the storage area can be costly or not even available. When S&W wants to apply the cradle cassettes, it is recommended to investigate per discharge harbour what the possibilities are.

8.2. Rejudging Solution Selection

Although the Cradle Cassette alternative resulted as the best solution to the problem, due to the above generated deeper understanding of the solution, rejudging the solution is found necessary.

First of all, implementation uncertainties start with the financial investment in the cradle cassettes. As explained in previous section, large quantities of cradle cassettes in several sizes or with complex designs further increase the required investment. The continuous time (and thus costs) saved by replacing time consuming dunnage by the cradle cassettes is found insignificant with respect to the continuous costs to return the cradle cassettes. Moreover, bottlenecks are induced with the difficult allocation of coils under the hatch and the utilisation of the hold due to the cradle cassette size.Implementing the cradle cassettes is expecting and required to diminish uncertainties regarding stowage plan approval. However, these uncertainties are replaced by (yet) unresolved new bottlenecks and uncertainties.

Primarily based on the major required investments for acquiring the cassettes and the difficulties for implementation at closed hatch ship with respect to the concluded magnitude of the problem and its consequences, the cradle cassette is not perceived as a viable solution on the short term.

So now the MCA winning solution is dismissed and the second and third solution scored relatively close in the MCA (0,67, 0,18 and 0,15 respectively, as shown in Figure 7.4), it is time to take a critical look at the MCA again. The most remarkable and most determining criteria is safety. It is weighted extremely high with respect to the other three criteria (namely 0,72 against 0,14, 0,09 and 0,06). Therefore it can be stated that safety is definitely the most determining criteria in ranking the solutions. However, the two remaining solutions (Vertical Stowage and Distribute Weight) have scored almost similar with respect to cradle cassette regarding safety (namely 0,08 and 0,14 against 0,77). But still, the safety score is rated almost double for Vertical Stowage w.r.t. distributing the weight. Therefore, first, it should be reconsidered whether this relative large difference is representative.

Both stowage methods are currently applied at the harbour; Vertical Stowage in the stowing of ETTS coils, and Weight Distribution when the stacking height is restricted (as shown in the case studies). For both stowage methods, different handling techniques are required with corresponding different safety measures. Without an in-depth analysis of these different measures, we can state, due to the current application, both methods are perceived save by Tata Steel IJmuiden and S&W especially, while having already very strict and high safety standards. So if “safe enough” is the criteria, and not “how safe” it is, we can state both stowage methods should score similar at the safety criteria and the remaining criteria become relevant to take a look at.

Next, we should take a look at the scores of both methods on the remaining criteria; Effectiveness, Costs and Practicality. Since distributing the weight scores better on all of these criteria, it is perceived more interesting for S&W to implement the weight distribution solution, even though the final results for Weight Distribution and Vertical Stowage were cloes.

Due to the inconsistency of the MCA, the practicality of distributing the weight require further investigation and verification. The verification of the solution regarding effectiveness and safety is done by a field study at the Port of Antwerp. Due to the default application of weight distribution there, the safety and effectiveness of the solution can be tested against reality to verify these criteria are met. This verification is found in Section 8.3.

8.3. Distributing the Weight: Application and Verification

Experimental testing is unfortunately not possible within the scope of this research due to the cost involved for S&W. Namely, to validate not only the solved discussion but also the above stated corresponding throughput and other effects, one identical ship with identical cargo should be loaded twice; once with the current stowage method and once while distributing the weight. Such situation does not occur within the normal operation of S&W and therefore an experiment to validate these effects will become to costly.

However, due to the current application of distributing the weight not only at Tata Steel IJmuiden but also at the Port of Antwerp, a rigour analysis can be executed based on experiential findings. Therefore, to test the solution against reality and verify its effectiveness, a qualitative analysis by means of a field research in Antwerp is executed and explained is this section. Moreover, to verify not only the assumption that the solution solves the problem, but also its effects on Safety, Cost and Effectiveness, these criteria are evaluated in following sections as well. They are by means of calculations, experiential findings by current application or findings during the field study at the Port of Antwerp.

The notes of this field research can be found in Appendix H, but first the stowage method at the Port of Antwerp is explained.

8.3.1. Stowage Method of the Port of Antwerp

At the steel terminal at the Port of Antwerp, steel coils of different customers (steel production companies) are loaded in ships and transported to harbours in America. When a ship arrives at the harbour, the shipping management gets handed the loading manual of the harbour first. In this manual, the type of dunnage and lashing is specified, so the ship management is aware of the securing method of the cargo. Most of the coils (80%) are located in the transit halls at the terminal prior to the destined ships' berth. When the ship is berthed, the loading procedure starts. Since the terminal is equipped with more than 6 movable quay cranes, they are able to load multiple holds at the same time.

The most important difference (w.r.t. the validation of the solution in this chapter) with the stowage method of S&W is the used dunnage and lashing and the stacking height. The stevedoors in Antwerp use more dunnage and lashing and when the ship management requires even more lashing, it is applied without any discussion. The type of lashing is different w.r.t. the lashing of S&W. In Antwerp, not only lashing between coil eyes, but also diagonal cross-wise lashing is used, as shown in Figure **xxxxx**. The stacking height in Antwerp is determined by the weight of the coils and the loading manual of the ship. Since the loading manual of the ship already takes the tanktop strength into account, the stacking height is adjusted to it subsequently. Figure 8.1 shows a bulk type hold being loaded. The Figure shows clearly the large quantity of dunnage and the cross-wise lashing. Moreover, it is shown no forklift area is left empty and the stacking height does not exceed 2 coils.

Another difference is the order of allocating and securing. At S&W, the coils are loaded and allocated per coil after which each coil immediately gets secured by applying lashing. At the Port of Antwerp, first a whole tier is build, before the lashing is applied.

Figure 8.1: Bulk type hold loading in progress at the Port of Antwerp

8.3.2. Effectiveness of Distributing the Weight

Analysing and verifying the effectiveness of distributing the weight is executed by referring back to the bottlenecks in Figure 5.21 of Section 5.4. First of all, as concluded in Section 7.2.7 in the solution dismissals, changing the produced products and their characteristics is not within the solution boundaries due to company wide strategies. The same holds for changing the production timings influencing the late info provided by OTB. Therefore, all causes for the bottlenecks are found outside the bottlenecks as shown in Figure 8.2.

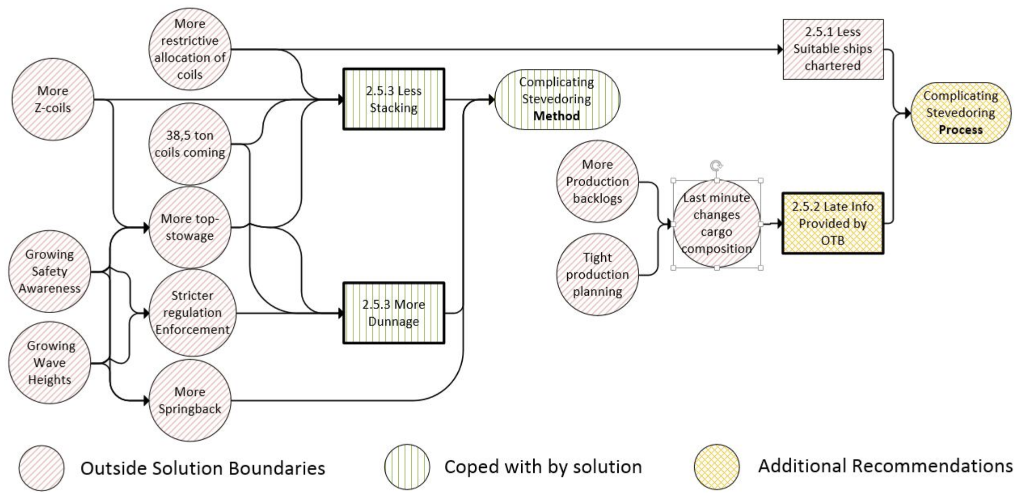


Figure 8.2: Coping effect of solution on (causes of) bottlenecks

Section 7.2.7 also concluded changing the chartered ships neither lies withing the solution boundaries due to the significant expenses difference of Chartering and S&W. Therefore, subsequent (of the more restrictive allocation of coils) less suitable ships chartered are to be dealt with by S&W, as shown in Figure 8.2 as well.

As concluded after the Power Analysis in Section 6, the dependency and collaboration with OTB can be influenced based on the power gained by immediacy of overflowing warehouses. However, distributing the weight does not influence this bottleneck and therefore additional actions are required to overcome this (implementation of the Smart Steel Factory for example). But since it is only a part of the bottlenecks, first it is verified if only distributing the weight is sufficient to solve the problem (the quay discussion).

The stacking height and used dunnage does lie within the solution boundaries and the weight distribution solution also affect these bottlenecks significantly, as visualised in Figure 8.2. The effectiveness of distributing the weight can be verified by the current application by S&W and at the Port of Antwerp.

Current Application by S&W As became clear in the case studies, distributing the weight was eventually required and executed to solve the discussion subsequently and start loading. This verifies that distributing weight, (eventually) satisfies the requests of the ship management and thus solves the discussion. However, now it is the question whether is prevents the discussion if distributing the weight is proposed to the ship management in advance. Since this is the method used at the Port of Antwerp, the effect their can verify if distributing the weight in advance will prevent a discussion.

Application at the Port of Antwerp As described in Section 8.3.1, at the Port of Antwerp, the stacking height is adjusted to the loading manual of the ship and thus takes the tanktop strength into account in advance. As shown in Figure 8.1, no forklift area is left empty thus we can state the weight is distributed on default. The Port Captains of Antwerp indicates discussion are prevented thereby.

8.3.3. Safety of Distributing the Weight

Currently, S&W distributes the weight of the cargo only after severe discussions with the ship management have taken place. So, although seen as a last resort, S&W does accept (with some unwillingness) the suggested solution and its corresponding level of safety. However, one point of critic regarding the safety of the application of weight distribution is the use of the gooseneck.

As explained in Section 5.1, when the weight is distributed and hold layouts A2 and B3 are applied, goosenecking will be required more often. Currently, since the 21.4 ton gooseneck is already found deficient in capacity, a purchase process is already initiated and proposed to acquire a new gooseneck. This gooseneck will be equipped with automatic rotation of the coil, so stevedoors do not have to touch the load to manually rotate the coil. So while the current application of distributing the weight is found safe enough, the new gooseneck will increases the safety and ergonomics of stevedoors further.

8.3.4. Costs of Distributing the Weight

Costs requiring further investigation are firstly sought in required investments in equipment. Next, the influence of the solution on chartering costs is explained whereafter the main constituent to the port tariff are elaborated: the throughput and material costs.

Investment Costs As stated in Section 7.3.4, new gooseneck equipment is desired when distributing the weight. The current gooseneck equipment is aloud to load up to 21,4 ton, which is not expected to be sufficient when taking into account the future heavier coils. Therefore, when weight will be distributed more often, S&W should invest in heavier gooseneck equipment enabling allocating 38,5 ton by gooseneck. Currently, since the 21,4 tons gooseneck is already found deficient, a purchase process is already initiated and proposed to acquire a gooseneck with the following characteristics:

- Gooseneck able to load 38,5 ton with a larger range so coils can be allocated higher and further away.
- Automatic rotation of the coil, so stevedoors do not have to touch the load to manually rotate the coil, which increases the safety and ergonomics of stevedoors.
- The current 37-ton-forklift will be equipped with an additional dismountable counterweight, so it is qualified to load up to 38,5 ton.

However, since this equipment is already ordered prior to the conclusions of this report, it is not seen as costs initiated by implementing this solution. Therefore, no additional investment in equipment is required for the application of weight distribution solution.

Chartering Costs Since, while distributing the weight, less coils are stowed per tier (max. 2 coils high) but more tiers are build (no forklift area left empty), it is important to see whether or not the capacity will decrease since this influences the the chartering price per ton. To do so, a quick calculation is made to compare the number of coils when weight is distributed or when the current stowage method of S&W is applied. At the time of chartering a ship, the cargo volume in tonnes is the limiting factor on the amount of cargo. But since this is agreed upon in the Chartering department in advance, the challenge for S&W only consist of allocating the coils and thus a calculation on how many coils can be loaded will suffice.

The calculation is based on stacking one bulk type hold of 23 meters long and 18 meters wide. With an average coil length of 2 meters, 11 tiers can be build in the length of the ship when all tanktop area is utilised (weight is distributed). When a forklift area of 10 meters is left empty, only 6 tiers can be build, as shown in Table 8.1. As explained in Section 5.1.3, at the first row, 10 coils can fit side by side (in width) with a average coil width (diameter) of 1,8 meters. However, the second row will only contain 9 coils due to the pyramidal stowing of Figure 5.7. The third row, when weight is not distributed, will only contain 6 coils, shown in Table 8.1 as well. Multiplying the number of tiers by the number of coils per tier, results in the total number of coils: 209 and 150 for Distribute Weight and the current system respectively.

Table 8.1: Capacity calculated for the current stowage method and distributed weight

		Current System	Distribute Weight
# coils per row	row 1	10	10
	row 2	9	9
	row 3	6	0
# coils per tier		25	19
# tiers		6	11
# coils total		150	209
# topstowage locations		36	99
Total cargo weight (ton)		3750	5225
Average tanktop load (ton/m2)		9,1	12,6

So when distributing the weight, a significant amount of coils more can be stowed. Therewith, also the number of topstowage coils is larger (99 against 36, found by multiplying the number of coils at the top row with the number of tiers). However, as mentioned, the total tonnes cargo loaded is not determined by the volume of the coils, but the agreed cargo by Chartering, and therefore is just implied in the table as an indication. The same holds for the tanktop load, in this table it is not calculated according to the regulations, and forms therefore just a utilisation indication. Namely, with the same cargo and hold dimensions as used in Section 5.1.3, a tanktop load of 26,9 ton/m^2 was found according to regulations.

Throughput The first large constituent to the costs of S&W (translated in the Port Tariffs) is the loading throughput. Since the different loading methods are known (explained in Section 5.1.2) with corresponding throughput (see table 8.2) it is possible to calculate the throughput of the complete hold. For this calculation, the same coil characteristics and the same hold is chosen as in the capacity calculations (23 x 18 meters), with an hatch overhang of 4 meters (fore, aft and at both sides). The ships hold is split in different areas, as shown in Figure 8.3. Coils in areas 1 (a and b) symbolise the square and thus are dropstowed, 2 (a and b) are allocated by forklift and in area 3 have to be located by gooseneck. The number of coils are calculated per area. Area 3 is split in the lower row of coils with a throughput of 11 coils/hour and 9 coils/hour for coils stacked with the gooseneck. With this input, the loading duration per area is calculated and shown in the right two columns of table 8.2.

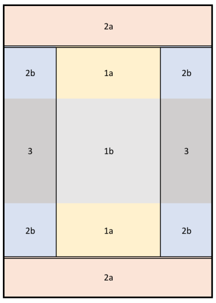


Figure 8.3: Hold division for capacity calculations

Area	Loading Method & Throughput		# Coils		Duration (hours)	
			CS	DW	CS	DW
1a	Dropstowage	13	26	36	2,00	2,77
1b	Dropstowage	13	0	27	0,00	2,08
2a	Forklift (thorn)	13	100	76	7,69	5,85
2b	Forklift (thorn)	13	24	40	1,85	3,08
3	Gooseneck (1st row)	11	0	18	0,00	1,64
3	Gooseneck (stacked)	9	0	12	0,00	1,33
Total			150	209	11,54	16,74
Average Throughput (coils/hour)					**13,00**	**12,49**

Table 8.2: Loading durations for Distribute Weight (DW) and the Current Stowage Method (CS)

However, the total number of coils loaded in this case, is different for both applied systems, so the total durations should not be compared, but on should look at the average throughput. On top of that, the specific coil allocation depends on the decisions made by the Crane Team Coordinator during loading. Therefore, the exact throughput cannot be calculated coil specific beforehand. To still compare the current system with the distributed weight, the average throughput per coil should be determined. For weight distribution, this results in $209/16,74 = 12,49$ coils/hour and for the current system we get $150/11,54 = 13,00$ coils/hour. So for these hold dimensions, the throughput for both stowage systems is quite similar, which corresponds with the insignificant planning disruptions concluded from the case studies.

When the current system is applied, the average throughput will stay 13 coil/hour, independently from the hold dimensions. However, for distributing the weight, the average throughput changes with different hold dimensions. The percentage of coils allocated by gooseneck (with respect to dropstowage and forklift allocation) will decrease with longer holds, and thus increases the average throughput. But a larger overhang of the hatches at both sides will increase the percentage of goosenecked coils, and thus decreases the average throughput. Nevertheless, distributing the weight will per definition be slower (at closed hatch hold types) as the current situation due to the inevitable use of the gooseneck. For open hatch holds, the throughput is expected to be similar for both methods, since all coils can be dropstowed (no need to gooseneck).

Due to the differences with the Port of Antwerp regarding the deployment of workteams, number of stevedoors, availability of cargo and applied allocations methods (no gooseneck used), their throughput cannot be compared with the throughput of S&W.

Material Use Due to adding more tiers of coils, more dunnage will be used. Although the corresponding costs are found insignificant in the case studies, regarding organisation, S&W should still be prepared to get sufficient amount of dunnage supplied to the harbour and the expenses on dunnage will grow. The amount of lashing will slightly decrease by lowering the stacking height.

8.3.5. Practicality of Distributing the Weight

Discharge harbours As mentioned in Section 7.3.4, unloading coils which are unreachable by a forklift equipped with a torn, might induce damage to coils at discharge harbour due to pulling and dragging the coil out of its place. Unfortunately, Tata Steel IJmuiden currently has no data available on additional damage expenses as a result of this unloading method at currently weight-distributed shipments. Therefore, addition costs regarding damage cannot be estimated rigorous yet, but should be closely monitored by the Quality Transport & Safety department to ensure the product quality does not decreases. At the Port of Antwerp, distributing the weight is done on default without the use of a gooseneck but by carefully pushing (with the forklift) the coil to its position (as explained in Appendix H). At the discharge harbours the coils are dragged out by pulling the coil out of its place (by forklift and chain through coils eye). The Port Captain of Antwerp indicated it is a significant source of damage but it out-weights the (costs) advantage of higher throughput and capacity of the ship.

Plannings Consequences OTB benefits from reliable, predictable and preferably short, harbour activity durations. The quay discussion could unexpectedly causing delays because, even although the planning consequences were found insignificant during the case studies, uncertainties are not desired by OTB. Therefore, smoothing the approval of the stowage plan by the ship management is beneficial for OTB. This advantage might even outweigh the increase of throughput time. However, it is recommended to measure the stability of the throughput after distributing the weight in several real life cases, before the planning is adjusted. This prevents too optimistic planning and corresponding unexpected costs on demurrage in the initial phase of the solution implementation. The throughput when weight is distributed should not be compared with the throughput at the Port of Antwerp. This is party because they work with more workteams at a ship, and have a different order of allocating and securing the coils (as explained in 8.3.1). Moreover, the Port of Antwerp is devoted to stowing ships, where Tata Steels' primary work is producing steel. Therefore the Port of Antwerp is more focused on optimising its stevedoring process and so increasing its throughput with respect to S&W, as a supporting department.

Coping with Topstowage As shown in the capacity calculations (Table 8.1) as well, more locations suitable for topstowage coils are generated by distributing the weight. Since it is expected that the amount of topstowage coils are growing, it is seen as important additional advantage of the solution proposal. At the Port of Antwerp, the Port Captains indicated the allocation of topstowage coils is often a difficult puzzle and therefore definately benefit of more topstowage coils. The same holds for the

Coil Specific Allocation In the cluster plan, the plannings officers of S&W sort the coils by their lenght, so a tier consist of coils with similar length and thus optimise the tier utility. Therefore, with distributing the weight, sorting the coils becomes more important, since also tiers for smaller coils need to be build, instead of stowing these on top of longer (lighter) coils. However, to sort the coils better, coil information is needed. At the Port of Antwerp, majority of cargo is available prior to loading and therefore earlier in the process, this sorting and puzzling of coils can start early. At S&W however, coil specific information is only known 2 days prior to loading and sometimes coils are still not produced and available at the harbour during loading. The Crane Team Coordinator currently sorts and allocates coils according own insight and experience. But since this puzzle is becoming more critic when distributing the weight, challenges are expected regarding the coil sorting. To start earlier with this puzzle and so cope with the challenge, coil specific information from OTB is needed earlier. As mentioned in Section 8.3.2 and shown in Figure 8.2, the Smart Steel Factory (improving the IT-system as stated in 6.4) could form a solution in this challenge. And as concluded in Section 6.5, S&W can expect cooperation of OTB in this area, based on the immediacy of overflowing warehouses.

9

Warranted Assertion: Validity and Advice

The final part of the Deweyan Inquiry, the warranted assertion, draws the conclusions on the research outcomes. To answer to what extend conclusions can be draw, Section 9.1 explains the validity of the research, contributing to the research limitations in Section 9.2. Section 9.3 forms the recommendations, and thus the conclusions from this research, towards Tata Steel IJmuiden as an answer on the main research question:

How could Tata Steel IJmuiden cope with the rising number of discussions with the ship management on the approval of the stowage plan?

9.1. Research Validation

Many literature is available on validation methods of qualitative research, referring to validation in terms of the trustworthiness of the research. Scientific research often referred to four aspects of trustworthiness, namely: truth value, applicability, consistency and neutrality. Egon et al. [7] distinguishes rationalistic and naturalistic inquiry with both different approach and terms used in demonstrating this trustworthiness. Naturalistic inquiry is characterised by its holistic and open-ended approach; no hypothesis is defined initially but developed inductively. This means the researcher starts with observations and pattern finding, which will then be followed by hypothesises and theories. Rationalistic inquiry works the other way around; theory will be followed by observations.

This research started with a data analysis to find trends (the observations) followed by the current system description and case studies (pattern finding). At that point, no hypothesis or theory of possible bottlenecks were defined and therefore, this research can be perceived as a naturalistic inquiry. Egon et al. [7] and Guba & Lincoln [15] define validity and thus trustworthiness in naturalistic inquiry in terms as Credibility, Transferability, Dependability and Confirmability. Next sections will discuss these terms and their application in this research.

9.1.1. Credibility: Data Triangulation

Credibility is the aspect of validation concerning the reliability of the research sources. Therefore, credibility can be demonstrated by triangulation of data collection [15]; using more methods of data collection on the same topic to generate understanding and validate the research findings. In this research, three different data collection methods are applied:

- **Interviews:** An extend use of expert consultation by in-depth interviews ensures multiple views and insights are gathered on the problem situation. Internally, different departments and varying corporate levels at the company were involved in defining probable causes, creating the current system description, analysing the power distribution and finally in the solution finding. External experts from multiple concerned parties (shipping companies, port captains, ship management, independent experts) are consulted for their view on the same topics. Multiple interviewees supported and added research findings regarding constituents to the quay discussion. Capt. A. Lenting (independent expert) stated high safety margins applied on top of the already strict regulations causes dissatisfaction and incomprehension between ship management (obeying its loading manual) and stevedoors (endeavouring to load all cargo). Capt. J. Michielsen (shipping company) adds regulations do not become stricter, but coils become heavier and thus less stacking is allowed by the ship management.

- **Quantitative Data:** For background information and problem perspectives, quantitative data is consulted, as well as for the probable causes analysis. Although data used in the Probable Cause Analysis of Chapter 4 did not always showed the expected results or was not competent, still constituents to the quay discussion were found. The main constituent found in quantitative data is the increase in produced Z-coils, which are more often labelled as topstowage, and so increasing the complexity of allocating coils and challenging the stevedoors. Moreover, a growing safety awareness, supported by a grow in significant wave height (the probable cause), supports the statements made by the interviewees; higher safety margin, stricter regulation enforcement and so less stacking allowedd an more dunnage required by ship management. Moreover, the regulations of Bureau Veritas on coil stowage support the findings from the interviews.
- **Field Observations:** More data is gathered firstly by historical field research (case studies), by means of email conversations or reports saved on the stowage process. This data study showed that after the problem arose (a quay discussion occurred), stacking height was the main topic in the discussion and eventually S&W had to lower the stacking height. Observational field research is not only done at the harbour of Tata Steel IJmuiden, but also by visiting the Port of Antwerp and collect findings by observing the current system and coping strategies in an external but similar situation. This data is in the form of field notes by the researcher herself and demonstrated that when stacking height was lowered (which is done on default at the Port of Antwerp), no discussions occurred. And thus confirming on top of the quantitative data and the interviews, more dunnage and less stacking and the growing safety awareness are main constituent to the quay discussion.

By these three extend methods of data collection, all pointing towards similar bottlenecks in the stowage method, research findings can be considered as a true reflection and representation of reality. However, this validity in terms of credibility by data triangulation is only applied to the research findings regarding the problem analysis.

9.1.2. Transferability: External Validity

Transferability can be compared to external validity; demonstrating the research findings can be generalised to other similar situations. In this research, the transferability of research findings are demonstrated in by external field research and external interviews:

- **External interviews:** Experts on the steel coil stevedoring process of external parties such as a captain (anonymous from Royal Wagenborg), port captain (J. de Smedt from the Port of Antwerp) and shipping company (Capt. J. Michielsen from Fednav) have been consulted for their broader view on the topic, with experience in more harbours. Although the problem and its constituents rises especially at the harbour of Tata Steel IJmuiden in this research, these parties confirmed the system behind the problem (regulations and discrepancies between loading manuals) occurs in more steel coil harbours, but since coping strategies and procedures may vary, subsequently the constituents to the discussion varies.
- **External Field Research:** Analysing the steel coil stevedoring activities and conditions at a different harbour, the Port of Antwerp, showed their coping strategies with restrictions on coil allocations; mainly by distributing the cargo weight and adjusting the stacking height to the loading manual of the ship (which is perceived necessary to avoid the discussion).

So combining the confirmation of the experts with the field study of the Port of Antwerp, the transferability (of problem constituents at other harbours) of the research findings (less stacking and more dunnage) is confirmed.

9.1.3. Dependability: Method Triangulation

Demonstrating the dependability of the inquiry involves proving its reproducibility. According to Egon et al. [7], this can be done by method triangulation, showing a different angle of approach (method) does not produce different outcomes. Note this is different as data triangulation used in Section 9.1.1 to demonstrate credibility. By method triangulation, different overlapping methods are used to validate the research findings. In this research, the following methods applied to the same topic showed similar results:

- **Current System Analysis:** From the current system description, and especially the current regulation analysis, it is concluded the stowage height is a likely constituent to the problem situation.
- **Data Analysis:** The qualitative data analysis, based on probable causes collected by interviewing experts, resulted in dismissing and appointing probable causes and resulted in the findings shown in Figure 4.17. Especially the growing safety awareness and therewith the stricter regulation enforcement support the constituent found in the current system analysis: the stacking height.

- **Case Study Research:** In a case study research, an exploratory research in real life context with no control over the events (Stake, [23]) is executed to gain a deeper and holistic understanding of the decisions and procedures in the steel coil stevedoring process and thus so constituents to the problem with corresponding significance. The constituents to the problem in the stowage process and method indicated by the case studies are shown in Figure 5.21. These findings also point towards the bottleneck of the stacking height.

All three above mentioned methods point towards the stacking height being the main constituent to the problem situation. Note that the dependability is not only validated for this precise constituents to the problem. However, due to the qualitative character and the holistic approach of the research, it is not realistic to expect the outcomes different methods to correspond on all aspects. However, in this research the three methods do confirm or append each other findings thus on the main problem constituents. Therefore, the dependability is hereby validated regarding the problem analysis. However, the same as holds for the credibility is also applicable here: the validity in terms of credibility is by method triangulation is only applied to the research findings regarding the problem analysis.

9.1.4. Confirmability: Academical Examination

Confirmability is the aspect of validation concerning the unbiasedness and objectivity of the researcher itself. Especially qualitative research is sensitive to the interpretation and therewith subjectivity of the researcher. Therefore, to ensure validity, research findings should be supported by the actual data collected when examined by other researchers. If findings are corroborated or confirmed by others who examine the data, then no inappropriate biases impacted the data analysis and conclusions. Unfortunately, since this research is executed as a master thesis which is an individual assignment, it is not within the scope of this research to have other academics examine that data and corresponding research findings. However, this thesis is to be defended and examined by an assessment committee, consisting of more than one academic. After this defence, provided that no critics or comments on biased analysis arise, this research is validated concerning confirmability.

9.2. Research Limitations

Although previous section elaborates on the validity, this research has limitations and additional research recommendations, presented in this section.

Trend Analysis The Probable Cause Analysis of Chapter 4 consisted mainly on qualitative data gathering and analysis in order to find trends complicating the stevedoring process and method. The data found on different topics are only used as an indication of future trends. For example; the increasing amount of zinc-coils are not translated towards and exact expected amount of zinc coils in the future, but only an indication in terms of *increase* or *decrease* is generated. For a more precise analysis and future outlook, proper significance analysis is required. The same holds for other trends indicated in the probable cause analysis.

Case Studies To analyse the practical side of the problem two case studies are conducted in Section 5.2. Although initially the cases were selected based on the magnitude of the problem and the discussion around horizontal, the main bottleneck was finding enough data for executing a case study. Therefore only 2 case studies could be performed and thus conclusions regarding the practical current system description are only based on two case studies, which is too little to ensure a certain representation of reality.

Multi Criteria Analysis As stated before, the Multi Criteria Analysis is based on the input of only four individuals. Although the MCA, its criteria and solution alternatives were explain to the individuals, their interpretation of the criteria and operation of the solution alternatives differed significant. To cope with these deviations in interpretation, it is recommended to:

1. Define the criteria and solution alternatives more strict
2. Explain the criteria and solution alternatives (with their
3. Consult more than four individuals to capture and take the mean of the remaining deviations, expected to be caused by actual understanding and resulting opinion of the consultant and thus resulting in a realistic representation of the perceptions of the participants of the MCA.

9.3. Conclusions: an advice towards Tata Steel IJmuiden

Due to the advisory nature of this report, the conclusions drawn from the executed analysis form the recommendations for Tata Steel IJmuiden. Therefore, there is no separate section devoted to recommendations solely. The scientific limitations, resulting in additional research recommendations, are found in previous Section 9.2.

This research was initiated by the stevedoring department (S&W) of Tata Steel IJmuiden as a result of a growing number of discussion with the ship management on the stowage plan. S&W perceived this discussion led to extra costs and harbour planning disruptions. Therefore this research answers the following question:

How could Tata Steel IJmuiden cope with the rising number of discussions with the ship management on the approval of the stowage plan?

As a result of this research, the stevedoring department is recommended to distribute the cargo and its corresponding weight over the tanktop area of a ships' hold. To substantiate this statement, first the research findings of the problem analysis are pointed out regarding the stowage method and process, in Section 9.3.1 and 9.3.3. The reasoning to the proposed solution and its implementation is given in Section 9.3.2.

9.3.1. Stowage Method: Less stacking and more dunnage with unchanging ship types

Analysing the probable causes indicated by S&W and the current situation regarding the stevedoring process and method firstly concludes the constituents to the discussion: less stacking and more dunnage while chartering does not adjust its ship types.

Changing Product Characteristics First, the growing amount of zinc coils induce a growing amount of topstowage coils, which reduces the stacking possibilities. Furthermore, Tata Steel IJmuiden is currently preparing to increase its maximum coil weight to 38,5 tons. Heavier coils are less stackable due to the induced load on the tanktop, and thus also reduce the stacking possibilities. Due to company wide strategy (producing coils with characteristics as desired by the customer) S&W cannot influence the coil characteristics and thus has to cope with these changes.

More Safety Restrictions The growing safety awareness causes more focus internally at Tata Steel IJmuiden on hazardous springback coils and subsequently generates more coils being labelled as springback. This causes more restriction on coil handling and foremost restrict the stevedoors in coil allocation.

Furthermore, the growing safety awareness, especially in the maritime industry, causes stricter regulation enforcement by the ship management. A growing focus on their tanktop burden imposes more coil allocation restrictions and requests for more dunnage and lashing. Moreover, currently, the stowage height of S&W is not based on local tanktop load calculations defined by regulations but on total hold capacity according to the tanktop strength. Therefore, the desired stacking height of the current stowage plan might not be in compliance with regulations.

On top of that, ships are more often accompanied by a loading manual determining the maximum tanktop load and subsequently the stacking height of coils, which the ship management has to obey. Since the ships' captain (head of the ship management) is the lawful person responsible, he has the final say regarding the final stowing and securing method. S&W only relies on referent power, based on affiliation, thus can only persuade the ship management to agree upon the stowage plan by generating intrinsic motivation with building a good relationship and collaboration.

Coping with the cargo and imposed restrictions The previous mentioned trends lead to reducing the stacking height and requiring more dunnage. As a result, the allocation of coils becomes stricter and thus the flexibility for S&W decreases, causing the suitability of the ships to form a bottleneck. Due to the greater costs spend on chartering (approx. €35,- per ton) with respect to the stevedoring costs (approx. €4,- per ton), it is not desired to restrict the chartering department in ship types (hold types or tanktop strength etc.).

Consequences and Recommendations In the case studies the additional costs and plannings disruptions caused by the discussion were found insignificant. Since no data was available on the amount of discussions and corresponding plannings and costs conse- quences in the past years, the conclusions regarding the consequences is based (only) two case studies. Therefore, it is recommended to Tata Steel IJmuiden, and subsequently to S&W, to validate these findings by collecting data on the frequency and severity of occurring discussions to established more grounded conclusions on the (now low) magnitude of the problem.

9.3.2. The Solution: Adjusting the Stowage Method

To overcome above concluded bottlenecks and cope with the mentioned changes, S&W should adjusting the current stowage method or adopting a new stowage method.

Requirements and Criteria First, as mentioned in 9.3.1, the solution is sought to fit company wide strategy to avoid departmental sub-optimisation. Moreover, it has to lie within the area of influence of S&W since the problem arose and affects S&W the most (apart from immediacy of overflowing warehouses) and not restricting the chartering department. In a multi-criteria-analysis, solution proposals are ranked by four employees of S&W regarding four criteria: Effectiveness (if the solution solves the problem), Safety, Costs and Practicality (how achievable the solution is).

Opportunity: Cradle Cassettes Application Applying cradle cassettes at the stowage process scored highest on the four criteria, mainly since it was perceived as the safest which is perceived the most important. A practical challenge rises with allocating coils under the hatch, without the use of a forklift. However, the primary challenge (and cost aspect) of applying the cradle cassettes is returning them to IJmuiden to reuse, since disposing after one-time use is too costly. Therefore this solution is perceived to come with too many uncertainties, additional challenges to overcome and high costs with respect to the concluded magnitude of the problem and therefore not advised to implement on the short term. On the long term however, this solution might become viable if collective use of the cradle cassettes with other steel coil shipment parties is set up. Therefore, further investigation by Tata Steel IJmuiden is recommended on the logistical and financial aspects of reusing and returning the cradle cassettes.

Recommended: Cargo Weight Distribution On the short term, it is advised to Tata Steel IJmuiden to distribute the cargo weight over the tanktop on default. Currently, a quay discussion often results in S&W distributing the cargo weight over the tanktop area and thus not leaving empty space for the forklift manoeuvres. From the case studies, it appeared the resulting costs and plannings disruptions are insignificant. These findings are verified by calculation the number of coils located per loading method (dropstowage, forklift or gooseneck), resulting in a similar throughput for both the current and the weight distributed stowage method. The case studies and the application at the Port of Antwerp show this approach prevents the discussion. Moreover, the solution complies with the (stricter enforcement of) regulations and can cope better with heavier and more topstowage coils.

9.3.3. Stowage Process: Provided Information More Important

Dependency Due to more critic coil allocation by distributing weight, the importance of cargo information is growing. Namely, late availability of this information provided by OTB reduces the possibilities of coping with these challenges by S&W. Since the information provided by OTB depends on the time between coil-birth and transport, which is not likely to change due to the focus on Just-in-Time delivery, the informa- tion is not expected become earlier available. However, the second limitation for the information flow is the inconvenient communication between IT-systems of different departments. Due to the immediacy of overflowing warehouses, S&W can expect cooperation of other departments to improve the information supply.

Recommendation: Benefit from Smart Steel Factory Opportunities To improve the information supply and enable S&W to cope better with the restrictive coil characteristics, it is recommended for Tata Steel IJmuiden to ensure a better communication between IT-systems. Besides the desired earlier cargo information provided to S&W, further research is needed to map all requirements and bottlenecks this improvement might be able to cope with. Currently, a project called "The Smart Steel Factory" is initiated improve the communication between IT-systems and thus it is recommended for S&W to manage this implementation closely and assure the stowage process benefits from the implementation.

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Appendices

A

Tata Steel IJmuiden Departments

This appendix elaborates on the different departments within Tata Steel IJmuiden which are consulted for this research.

A.1. On Site Logistics (OSL)

On Site Logistics is the logistics service provider of Tata Steel IJmuiden and is the umbrella organisation of all different logistic activities executed at the production site IJmuiden. On site Logistics takes care of the semi-finished products transportation between different factories and full-finished products towards the customer.
It is their mission to provide excellent distribution for the customer and the transport sector. The department aims to disburden the sales department of the distribution responsibility and disburden the manufacturing department of the warehouse planning.

A.1.1. Rail

The transportation of products (semi- and full finished) over the site is mainly organised by rail. Therefore OSL owns an extensive rail network, wagons and locomotives, managed by the Rail department. They are responsible for timing the wagons with corresponding products from and to different locationsat tghe site

A.1.2. Stevedoring & Warehousing (S&W)

The different interim and final storage locations are managed by the Stevedoring & Warehousing department. Finished products from the warehouses will be loaded onto trucks or wagons to be transported to the customer. Stevedoring & Warehousing is responsible for the occupation of these different locations and the stevedoring/ loading procedure. Besides the different warehouses, S&W has the responsibility over the inner and outer harbour of the IJmuiden site. Inland and deep sea vessels are loaded with finished products and from there shipped to customers all over the world.

A.1.3. On Site Planning (OSP)

On Site Planning is the planning and scheduling department of OSL which plans the product transportation over the whole site. Moreover, OSP is responsible for the planning and scheduling of different ships at the quays of the inner and outer harbour.

A.2. Outbound Logistics - Business Planning & Supply Chain

A.2.1. Network Management & Development (NM&D)

The core task of the Network Management & Development department of Tata Steel IJmuiden is optimising the transportation route from the production site to the customer. This means finding the best solution in combining train, truck or ship as transportation resource. The best solution is found as a optimisation in costs, quality and time.

A.2.2. Quality, Transport & Safety (QTS)

The Quality, Transport & Safety department is responsible for tracking the quality of transport and the safety procedures. This means QTS tracks the quality of the transport, so the damaged to the products and their correspon- ding claims. Moreover QTS keeps up with the safety issues and notifications and manages corresponding procedures.

A.3. Shipping - Chartering

The Chartering department of Tata Steel IJmuiden is responsible for selecting and hiring the best ships for the planned cargo. This means the ships characteristics (hold size, tanktop strength etc.) should be fit to transport the particular cargo in the available time lock of the quay. Since the chartering costs are most dominant in the transportation costs, the chartering department focuses on costs optimisation withing the range of available and suitable ships.

A.4. Outbound Planning

The Outbound Planning department (OTB) receives information on orders (from the Sales department) placed by customers and translating these to timing and cargo-volumes of shipments. It is their responsibility to plan the output of the production facilities with an fixed ship (contracted by Chartering) and provide S&W with product information.

Table A.1: Overview of different interviewees of different departments involved

Department	Interviewee	Position	Responsibilities
Shipping company	Capt. J. Michielssen	Manager Cargo Operations and Director	Contact person for Tata Steel IJmuiden for timechartered ship of Fednav (Belgium) N.V.
Chartering	J.C. Iacono	Chartering Deep Sea	Charterin ship for all deep sea routes, via timecharter or spotmarket
Outbound Planning	M. Visser	Outbound Planner America Shipments	Provides breakdown planning to S&W on time
S&W	P. Groot & W. Kloosterman	Planning Officer	Approval of nominated ship and providing stowage and cluster plan to stevedores
Supply Chain	G. de Vries	Orderplanner	Ensure the products planned for shipment are available on time and location and coil characteristic information is processed

B

Interviews

This Appendix contains details of informative interviews which resulted in statements, conclusions, explanations, insights or other forms of useful input for this research. The content of the interviews are summarised down to short subjects and primary point of views of the interviewee. For convenience, the interviews are listed in alphabetical order of interviewee name and elaborate on their position, relevant background and responsibilities.

B.1. Mr.M. Botterhuis, Manager Outbound Chartering

- Previous to contracting a ship, the shipping company agrees upon the Loading Manual of Tata Steel IJmuiden
- Due to the ongoing negotiations on chartering pricing, S&W should not contact the ship management prior to contracting, it could run up the prices
- The shipping company determines if a port captain will be deployed
- Now the main discussion between S&W and Chartering is about the timeframe and matching throughput for different ship types. However, Chartering experiences S&W almost never exceeds the planned timeframe for loading due to their solution creativity when problems arise.
- At contracting, the minimum and maximum amount of weight to be transported is agreed upon and included in the contract. The shipping company or broker base their prices on the minimum weight, and thus every ton extra makes the shipment cheaper.
- When the ship management refuses to load cargo, and so refuses tonnes, the ship management or the shipping company are in default and can be claimed by Chartering.
- Chartering would benefit from sharper estimation of throughput of S&W, since it is then possible to ensure tighter planning and reduces chartering costs.

B.2. Mr. P. Korf, Planner at On Site Planning

As a Planner at the On Site Planning department, Mr. P. Korf is responsible for planning enough quay time for loading upcoming ships, taking into account throughput, type of ships, personnel availability and weather conditions.

- Outbound Planning determines a time frame for a certain ship with certain cargo to be shipped. This time frame is longer as the duration of the loading procedure, leaving room for plannings flexibility for OSP.
- Prior to the loading procedure, an estimation on required loading methods (as explained in Figure 5.10) is made, to determine the expected quay time of a ship.

- Eight hours before the loading procedure, Rail requires the Cluster Plan so wagons can be loaded on time at different warehouses. Approx. four hours before loading the coils of corresponding wagon, Rail plans to have the coils ready at a central point for transportation to the harbour.
- During loading the ship, the forklift is the determining factor in the throughput. Placing the coils in the hold with quay cranes is faster as the forklift can position the coils.
- Throughput of positioning the coils by forklift is 13 coils per hour, similar as with the dropstowage method.
- The throughput of Goosenecken is around 11 coils per hour, decreasing towards 9 or 10 coils per hour when stacking three coils high.
- An uniform loading procedure is helpful for OSP since it increases the planning simplicity, resulting in less deviation of the planning w.r.t. the execution.
- According to Mr. P. Korf, there is enough buffer in the current yearly quay occupation to still load the same amount of ships even when weight is more often distributed (resulting in higher throughput).

B.3. Captain A. Lenting, Managing Director/Owner Siri Marine

- The origin of the disucssion is probably derived from the insurance companies and corresponding liabilities. Insurance companies become more strict and more often involve lawyers for resolving disputes, which costs a lot of money.
- Often, shipping companies have no idea what stevedoring really is and therefore they err on the side of caution and apply unreasonable high safety margins.
- The Cargo Stowage and Securing Manual (CSS, attached in Appendix D)of the IMO is nationally accepted and leading for the shipping companies and ship management.
- More often Surveyors are hired for an independent view on the stowage method and to guide as an mediator. Therefore they follow the CSS most strictly.
- RoRO-ships (roll-on-roll-off ship, for vehicle transport) and Ferries the lashing is weather dependent, governments consent with it less lashing when good weather is expected. When this happens, ship management can follow and is more accepting.

B.4. Mr. E. Lute, Head of Stevedoring & Warehousing

- Equipment or personnel of the harbour is not seen as an uncertainty, the downtime of cranes is negligible and for personnel absence, external hired temporary workers can be arrange on short notice.
- the input of material type is seen as uncertain. Often the expected material types are not delivered this can be due to several reasons: factory downtimes, supply by rail or changing priorities for cargo.
- S&W serves as a absorber for fluctuation in coil supply quantity. This absorber is in the form of crane capacity (loading a ship faster) or warehouses next to the quay (coils can be stored temporarily)
- However, the output of material is dependent on the planning and timing of ships. Their ETA is often only known 12 hours before mooring at the quay, so for a long time it is uncertain.
- Weather plays a large role in the planning due to the loading of dry coils. Forecast are consulted to prepare for and capture a part of the uncertainty, but is not reliable enough to fully depend on. Flexibility of S&W is still important.
- The supply of coils per wagons is fluctuating due to the utilisation of wagons. The wagon drivers require a 2 year training on site and are therefore not replaceable during sickness. This is the main reason for the fluctuation in available wagons (currently 12% absenteeism).
- S&W always tries to unload a wagon as quick as possible, so it is free to return to warehouses and pick up new material and so the quay is available again for other wagons.

- When a wagon at the quay cannot be unloaden directly into the ship, S&W can store the coils in the warehouses at the harbour temporarily.
- Lately, Warehouses at the site are almost 100% full, which results in coils also stored at the warehouse at the harbour, dismissing its function of Transithall
- Once the TRH is full, and warehouses at the site are, S&W will have to call for a stop of material supply. Which results in factories to shut down. This is a very unacceptable failure mode.
- The power of S&W is only felt when this call for a stop happens.
- On the output side of S&W, the loaded ships, such call for a stop only happens when a unsafe situation occurs. At that moment all managers of Tata stand behind S&W (so also of different department) and S&W has the power to stand up to the broker or shipping company which will change the situation.
- Quay occupation is almost 100 %, only at Christmas and New Year they attempt not to plan a ship.
- Loading faster with more cranes often makes no sense, since the supply of coils by rail is the bottleneck
- the immediacy can be found in the logistics chain getting stuck which will have direct (within a few hours) results for the continuity of the production facilities.
- In short term S&W is not substitutable. However, some other steel production companies do have their whole logistical chain outsourced.
- Some personnel is easily subsitutable at the harbour. However, crane drivers, harbour team leaders and quay boatswains require experience and are therefore not replaceable. (8 workers are on total place per operating crane)
- However, this is different for some inland roll-gutter ships, these can be loaded with 4 workers per operating crane
- The cluster and stowage plan planners, Mr. W. Kloosterman and Mr. P. Groot, are required to be experienced and therefore not replaceable.
- Loading ships is a less uniform operation as lading truck, trains or operations in the warehouses.
- Occasionally, trucks with coils are sent to Russia, coil is transported by train. However, this only happens at times the customer requires such high priority speed and so the transport costs are at the expense of the customer. Outside these occasions, these transport modes are financially not feasible.
- It does occur more often that trucks or inland ships transport coils to Antwerp or Rotterdam transferring coils there to deep sea ships.
- Since S&W can be considered as the end of a sweeping tail, encountering diverged fluctuation in workflow, it does barely serve as input generator for other departments. Nevertheless, looking at the bigger picture (involving Sales and Supply Chain etc.), S&W plays a central role in the feedback loop of the logistical chain.
- The TRA is structurally used as fall-back option when other warehouses on site are full.

B.5. Captain J. Michielssen, Manager Cargo Operations and Director Fednav (Belgium) N.V.

Captain John Michielssen is Manager Cargo Operations and Director of Fednav N.V. in Belgium [1]. With Tata Steel IJmuiden as a client for 'the shipping of raw materials and steel coils, Capt. J. Michielssen is familiar with the harbour in IJmuiden and its problem situations.

[1] Fednav is ship owning and chartering group from Canada, specified in ocea-going dry-bulk shipping on the Great Lakes, as well as the Canadian Arctic, boasting the world's largest fleet of ice-class bulk carriers. `http://www.fednav.com/en`

- Nowadays, all ships are being “route”, meaning before departure the route is analysed on weather conditions and some ships have an economical model on board, checking what route adjustments have economical advantages.
- For shipping companies, shipping steel coils is a specific field requiring additional skills. This also applies of ship management. Therefore ships often have their own loading manual, to support and guide the shipping management.
- In the chartering contract, is often recorded which loading manual will be applied to the cargo.
- Fenav ships all have similar loading manuals since these are mostly sister ships.
- For IMO there is little interest so far in researching the conflicts and solutions for discussions between stevedoring planners and shipping management.
- Shipping management is not becoming stricter on its loading manual due to the insurance companies behind it, but because the coils are becoming heavier and heavier.
- The lashing method of Tata Steel often contains less lashing as usual. Because they have a record or approx. 95% damage free shipping, says Tata their lashing suffices. Fednav would like to see calculation proving it before accepting less lashing.
- At insurance companies there is no norm for the amount of dunnage available yet, because IMO doesn’t have one. So internationally there are no standards for lashing and thus discussions to convince each other occur to achieve conformity over the premiums on damage.
- The interests in this topic are similar for Tata Steel IJmuiden and Fenav, even though Fenav sees Tata Steel as lax in their prevention of cargo shifts.
- The process and methods are comparable for other harbours, everyone has their own safety systems, methods and measures.
- Operationally speaking, the captain has the last say. However, the chartering contract says which loading manual to follow. The ship management should be informed about it so there is already an agreement on rough stowage method. However, at the quay the discussion start around exceptions on the loading manual. If the captain holds on to its opinion, he is responsible and the shipping company will have to listen. Tata Steel can, in that case, add lashing on expense of the shipping company. So the shipping company is in between the shipping management and the stevedores.
- Since China and Japan entered the shipbuilding market, the world fleet gained may low quality ships. In the past, many of these ships have experienced damage on the tanktop, so to speak from the shipping of steel coils. However, it is not clear if it is due to overs-stowage or brutal placing of the coils by unskilled stevedores and crane personnel. Due to these incidents, some regulations see coils as point loads. But then only very little cargo can be placed in the holds. This raised the use of loading manuals on board. However, these often do not match with reality: dimensions and weight ratio’s are not realistic. The advantage of lager sized coils is easier loaction on top of the tanktop girders, resulting in a better support.
- Bulk carrrier normally able to load 55 000 ton can only carry 33 000 ton of steel coils, which is especially typical for Eastern build ships.
- Classification societies do have some regulations for loading steel coils, but only very poorly.
- Older ships are more popular at shipping companies for shipping steel coils. The old Polstream ships have never shown structural damage on girder due to steel coil shipments.
- Arcelor Mittal has specific coaster on regular service to Greece with coil-gutters.
- The future for coil shipping is in the dimension of coils. Lower (smaller diameters) but longer (width of the coiled plate) coils will improve the shipment potential.

B.6. Mr. M. van Roon, Head of Outbound Operations

Mr. M. van Roon, as head of Outbound Operations, is supervising and managing the planners programming the cargo. This means combining the output, cargo call offs, from the sales department, with the ships chartered by the chartering department and with the production planning of different production hubs at the site.

- Production is the limiting factor in available information and timing of products. The customer is not, since this is generally attuned in advanced with shipments.
- For shipments to America, products are called 30 days in advance. Outbound Planning is responsible for planning and call over the ship at the Chartering department. This has to be done before the cargo is certain.
- At times with production backlogs, as experience lately with the hot rolling mill, the 30 day planning and call over of shipments is not achieved with all cargo and so last-minute changes in order composition occur.
- Only a week before the loading date of a ship, its Estimated Time of Arrival is known and detailed planning can be made (for exact cargo composition and on site logistics).
- Due to some new amendments of President Trump, 'dumping' of foreign material and products in the USA is prohibited. This means, products of Tata Steel IJmuiden has to be traded with normal profit margin in the USA or domestic products favoured. So normal market value as to be sustained and no room for expensive alternatives to shipping is possible (for example by freight flight).
- The consequences of late information about cargo composition are known by all parties. However, since S&W is good at coping with last-minute order changes and creative in finding solutions, that particular part of the consequences is not seen as a bottleneck for outbound operations.

B.7. Mr. J. De Smedt, Port Captain - Engineer at Belgo - Iberian Maritime NV

Mr. J. De Smedt often visits the harbour in IJmuiden to manage the stevedoring process as an independent agent. He is hired by Grieg Star Shipping b.v. to guide shipments arranged by Grieg Star, in IJmuiden and Antwerp.

- Since a Port Captain is independent and an experienced expert on loading ships. The ship management is more often disposed to accept his suggestions on deviations of the loading manual. Therefore a Port Captain is a very useful agent in a discussion on stowage method.
- When a sound stowage plan is presented to the ship management, Mr. J. De Smedt significantly less and often no resistance against his plans.
- Cooperative and benevolent approaching the captain is key in persuading the ship management to agree on the stowage plan
- When the ship management ask for only small extras, such as extra dunnage, these request should be granted. The win regarding cooperative attitude outweights the costs for extra dunnage or lashing.

B.8. Mr. D. Triezenberg, Head of On Site Logistics

- In Britain, the steel production company has outsourced their harbour activities. However, due to the great dependence upon these activities, the stevedoring company (British Port Association, which now performs the stevedoring activities) raised their price and the British steel company has no choice but to just pay.
- The location in IJmuiden, was historically chosen due to its strategic position with respect to inland (via the North Sea Channel) and deep sea (via the North Sea). This strategic location is also used mentioned as strategic advantage in the current negotiations on the Joint Venture between Tata Steel Netherlands and Thyssenkrupp in Germany. Therefore it is not realistic to think Tata Steel IJmuiden would ever consider to outsource the harbour activities.

- On top of the first two arguments, Thyssenkrupp nowadays exports many products via the harbour of Antwerp or the Bremerhaven, with America shipments roughly once in 14 days. Combining this with the shipments of Tata Steel, a regular liner service of one shipment per week could improve the logistical service greatly.
- Opportunities lie in the stevedoring process, especially the information flow. With the project “Smart Steel Factory”, the company aims to align all different IT systems and databases, so information on coil level can be supplied to S&W a lot earlier, and even possibilities to cluster and stowage planning might become automated.
- S&W, and OSL idem, has te

B.9. Former Captain of deep sea bulk carrier at Royal Wagenborg

The captain (anonymous) has experience with transporting steel coils for Royal Wagenborg [2] at different harbours all over the world (Chicago, Detroit, Oxelosund, Antwerp, IJmuiden etc.) and has worked with different harbour personnel. In a phone meeting, the captain was willing to share is experience with- and view of the steel coil loading procedures in these different harbours, including Tata Steel IJmuiden. Several findings, collected in the phone call on Sunday 14^{th} of January 2018, are listed below.

- A Cargo Securing Manual, on board of every ship and specified per ship, is leading in determining the cargo allocation, distribution and lashing. This manual is approved and certified by a classification society and a Captain will not deviate from this document.
- Preferably, the captain loads his ships with one Officer (of the ship) at the quay and one in the ship’s hold for a strict supervision over the loading procedure. This way instructions and adjustments can be coordinated, supervised and controlled by the ships crew.
- Working with a Port Captain (deployed by the harbour) could clarify and structure the loading procedure by being the point of contact, making decisions and mediate between the Captain and cargo planners of the harbour.
- At sea, cargo is checked everyday for shifts or other forms of damage. Dunnage and lashing will be restored if necessary.
- A deviation is found in the experiences of captains with transporting steel coil and therefore the captain understands harbour personnel developed their own method and has become steadfastly. But they must understand the Cargo securing Manual is always leading and overruling the harbours loading manual.
- Discussion on the stowage procedure and method often occur, but the severity and resistance of harbour personnel differs.
- In Antwerp, steel coils are often heavier and therefore the loading sequence and coil allocation is more important and determinant. However, at this harbour, the stevedores are at service of loading the ship and closely consult and ensure the Captain is satisfied with the loading conditions.
- In Oxelösund (Sweden), the topic of discussion is often the locking coil with its critical 1/3 to 2/3 depth between other coils.
- The captain has negative experience with the harbour of Tata Steel IJmuiden. He has experienced resistance of the stevedores when asking for extra lashing or dunnage and believes there is low work ethics among the harbour personnel. However, this varies strongly between the different shifts. He believes the inexperience of stevedores at sea is to blame for the low collaboration and understanding for the Captains opinion.
- A Captain is always aware of the type of chartering of his ship but experiences this has little effect on the loading procedure. The occasional presence of an agent (from the agency/shipping company)at the quay to guide the loading procedure is an advantage of sailing commissioned by a shipping company.

[2] Royal Wagenborg is an international shipping company with a modern fleet of 173 ships offering logistic solutions and services to exporting industries. `https://www.wagenborg.com/nl`

C
Factor Analysis

Without an in-depth analysis, not all different aspects influencing the difficulty of the stevedoring process and cargo loading condition can be identified. However, during interviews with several experts and discussions with the problem owner, several clearly identifiable key factors complicating the stevedoring process in the future are identified and shown in Figure C.1. This Appendix contains a brief analysis of the factors not discussed in Chapter 4.First, a more detailed display is given on the produced weight per product type in C.1. Next, the precipitation is analysed in C.2, followed by the warehouse times of coils in C.3.

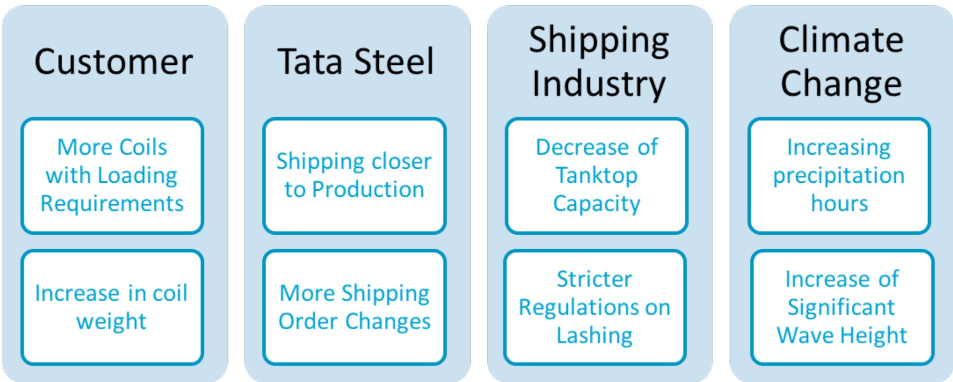


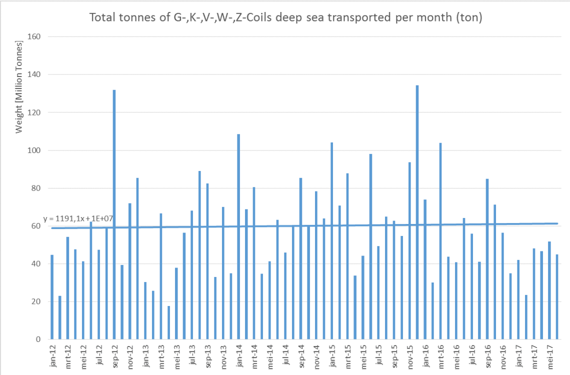
Figure C.1: The different factors causing more complex loading condition

C.1. Product Types

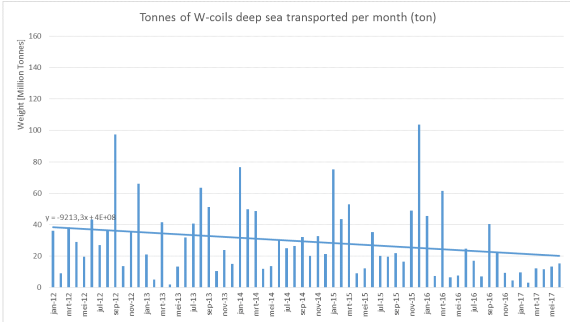
Influence Different product types come with different characteristics and requirements for the stowage plan, for example the packaging and fragility of coils. All but W-coils requires packaging and so determines if a coil can be loaded during precipitation (also see C.3 for the precipitation and caused loss). Besides the packaging, the fragility of the coils determines if stacking is allowed. Since G-coils have and increased risk on ovalising, these are often labelled as topstowage (also see topstowage trend).

Data The data is retrieved from the historical database of the NM&D department. After the whole production and transportation procedure, the coil characteristics (material, weight and size) is stored together with the different stage dates (birth date of coil, send-ready date, actual transportation date etc).

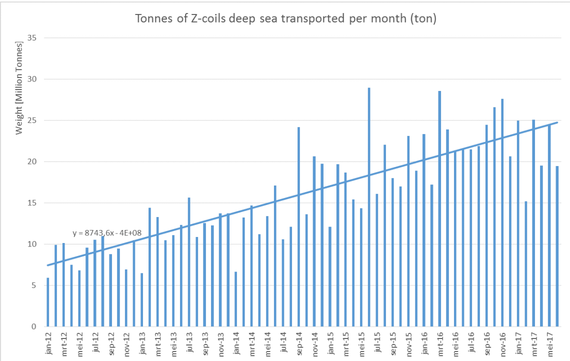
Trend As shown in Figure C.2 a few trends can be seen. First a clear (linear) doubling of the exported tons of zinced (Z-) coils is shown when looking at the linear trend (Figure C.2c). Next a yearly oscillation with its peak right before winter is shown for G- and K-coils (Figure 4.3d and C.2e). It is also shown that the export of the W-coils is decreasing ans also not constant (Figure 4.3b); for the years 2014, 2015 and 2016 high peaks are shown in January.



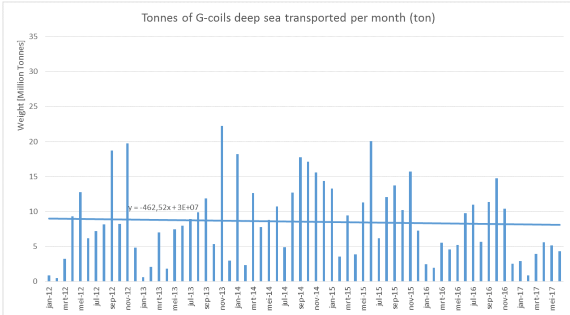
(a) Total exported tons



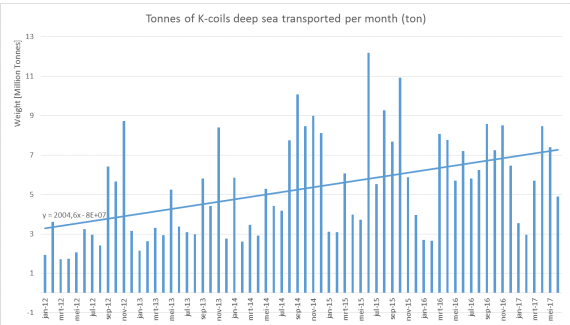
(b) Transported tons of W-Coils



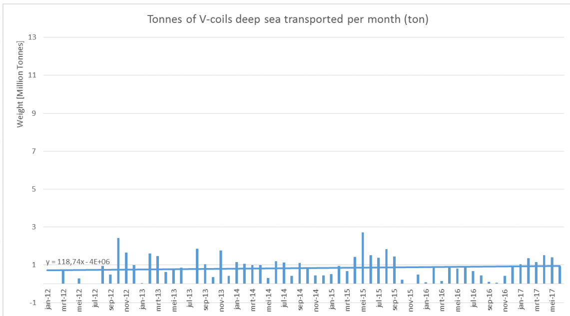
(c) Transported tons of Z-Coils



(d) Transported tons of G-Coils



(e) Transported tons of K-Coils



(f) Transported tons of V-Coils

Figure C.2: Different product types and total tons exported deep sea

C.2. Increasing Precipitation

Influence Since all packed coils cannot be loaded in the ship during precipitation, the precipitation time is complicating the planning of the harbour. Th

Data Since no reliable KNMI (Koninklijk Nederlands Meteorologisch Institute, Royal Dutch Meteorological Institute) data is available on the precipitation hours around IJmuiden, data tracked by On Site Planning is used. Convenient is the corresponding loss in kilo tons of loading capacity at the harbour, since this is the core reason why the precipitation hours are relevant (especially for OSP). Unfortunately Tata Steel IJmuiden only keeps track of this information since January 2016, which makes it unreliable for an proper outlook.

Trend The absolute number of precipitation hours and the caused loss (kilo tons)in the loading procedure of the harbour is presented in Figure C.3. Although a long term outlook based on this data is not reliable, we can see that more precipitation hours result in more losses. However, this relation is shown not be linear.

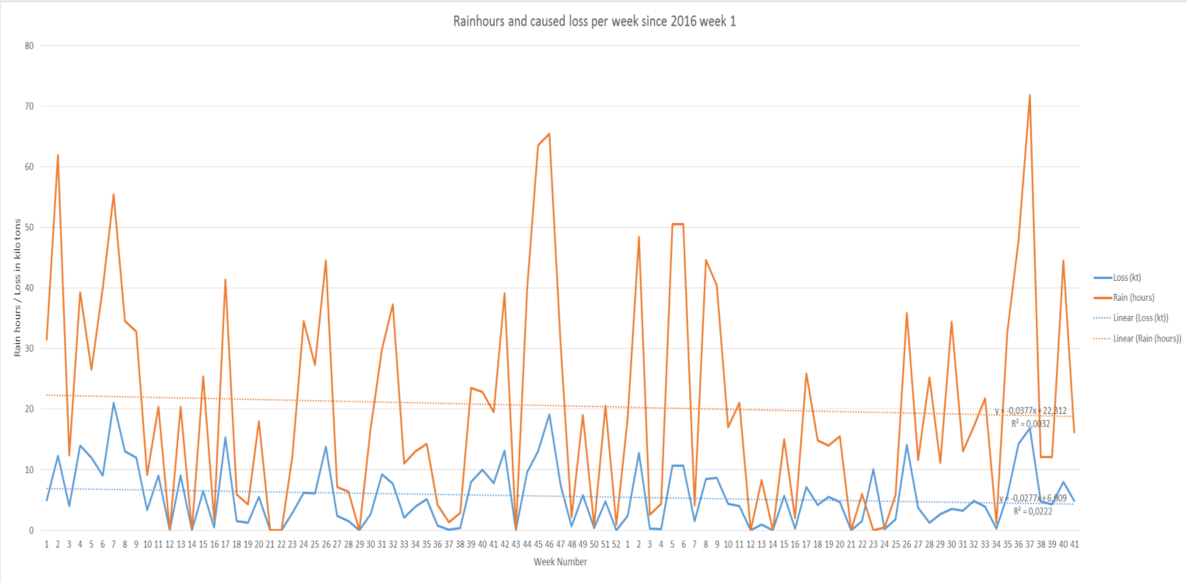


Figure C.3: Precipitation [hour] and caused loss [kilo ton] per week since week 1 from 2016

C.3. Warehouse Durations (Quality check)

After a coil-intake in a warehouse (indicated by the birth-date of a coil), a quality control check is done per coil to ensure high quality and damage free material is send to customers. Before the coil passes the check, it is blocked for transportation in the IT systems. Once the blockade is removed, the Send-Ready label is given to a coil. In Figure C.4 the distribution in number of days between the birth date and send-ready date is given for 2017 in the left boxplot. The right boxplot shows the distribution of duration between the send-ready date and the eventual day of transport. Since this only shows the distribution over 2017 (more data was not available), no trend over time can be analysed. However, a median of 1.37 days is shown for the duration between Birth to Send-Ready date. Besides this low median, the distribution shows only very few outliers (15) occur per year. The right boxplot shows a larger distribution for the Send-Ready to Transport duration. This is explained by the coils produced before an order is placed for these exact coils. Since Steel Production is a continues process (turning down and starting up a blast furnace is not workable due to the needed energy and time), ocasionally coils are produced so the different factories and machines do not have to turn down. Therefore the demand for these coils may come with a delay, resulting in a later transport date.

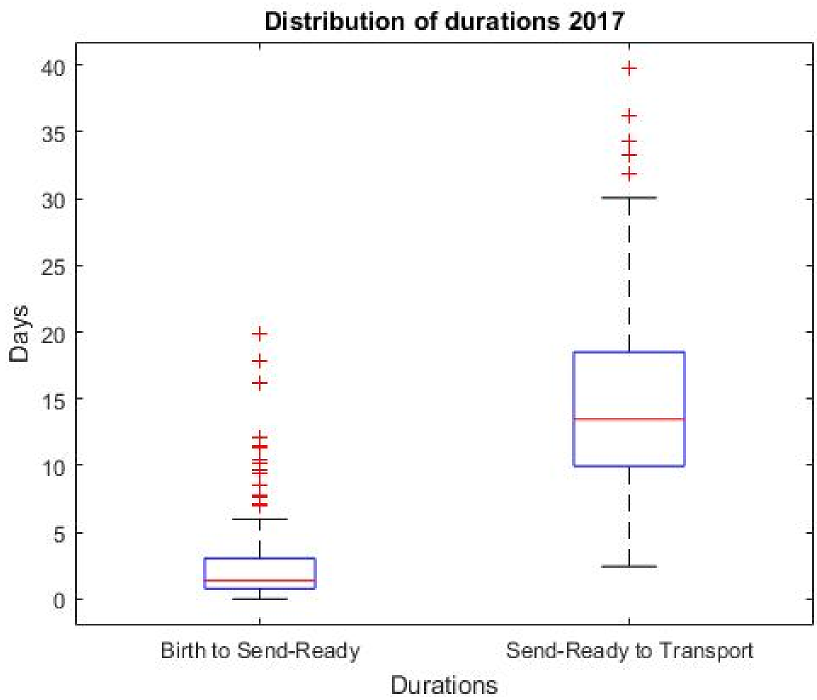


Figure C.4: Distribution in number of days between Birth to Send-Ready (left) and Send-Ready to Transport (Right)

D

Cargo Safety & Securing Manual (CSS)

ANNEX 6: Safe Stowage and Securing of Coiled Sheet Steel (page 51-53)

This appendix shows regulation regarding steel coil stowage established by the International Maritime Organisation (IMO) in 1996.

Title	CSS-Code Code of safe practise for cargo stowage and securing - Res. A.714(17)
Source	Human Environment and Transport Inspectorate - Ministry of Infrastructure and the Environment
Commencement Date	01-07-1996
Retreived at	16-01-2018
Retreived from	`https://puc.overheid.nl/doc/PUC_2092_14/3`

Appendix III – Applicable Annexes from the CSS Code

ANNEX 6 Safe stowage and securing of coiled sheet steel

1 General

1.1 This annex deals only with coiled sheet steel stowed on the round. Vertical stowage is not dealt with because this type of stowage does not create any special securing problems.

1.2 Normally, coils of sheet steel have a gross mass in excess of 10 tonnes each.

2 Coils

2.1 Coils should be given bottom stow and, whenever possible, be stowed in regular tiers from side to side of the ship.

2.2 Coils should be stowed on dunnage laid athwartships. Coils should be stowed with their axes in the fore – and – aft direction. Each coil should be stowed against its neighbour. Wedges should be used as stoppers when necessary during loading and discharging to prevent shifting (figures 1 and 2).

2.3 The final coil in each row should normally rest on the two adjacent coils. The mass of this coil will lock the other coils in the row.

2.4 If it is necessary to load a second tier over the first, then the coils should be stowed in between the coils of the first tier (figure 2).

2.5 Any void space between coils in the topmost tier should be adequately secured (figure 3).

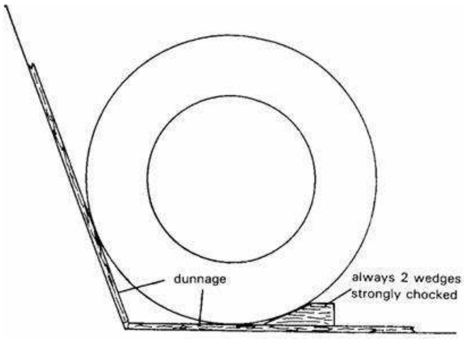


Figure 1 – Principle of dunnaging and wedging coils

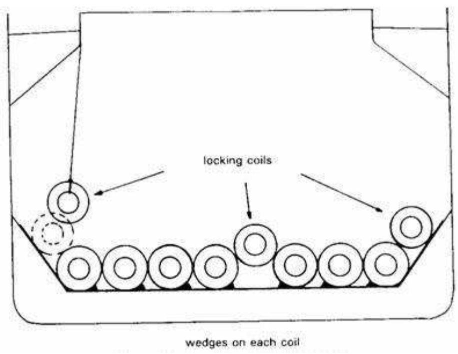


Figure 2 – Inserting of locking coils

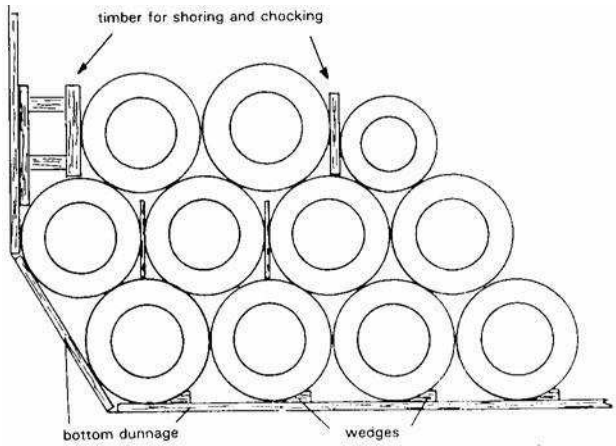


Figure 3 – Shoring and chocking in voids between coils

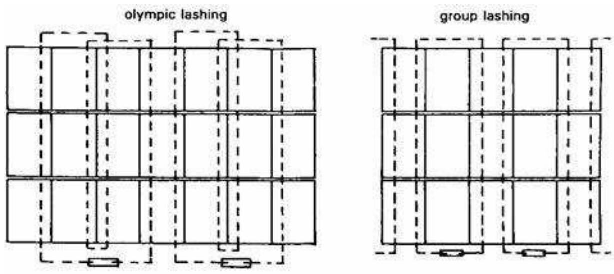


Figure 4 – Securing of top tier against fore-and-aft shifting (view from top)

3 Lashings

3.1 The objective is to form one large, immovable block of coils in the hold by lashing them together. In general, strip coils in three end rows in the top tier should be lashed. To prevent fore-and-aft shifting in the top tier of bare-wound coils group-lashing should not be applied due to their fragile nature; the end row of a top tier should be secured by dunnage and wires, which are to be tightened from side to side, and by additional wires to the bulkhead. When coils are fully loaded over the entire bottom space and are well shored, no lashings are required except for locking coils (figures 4, 5, and 6).

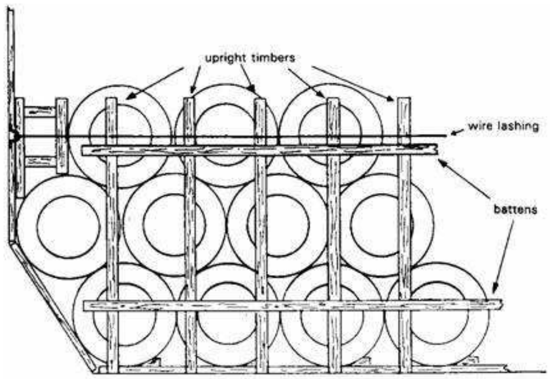


Figure 5 – Securing of end row in top tier against fore-and-aft shifting

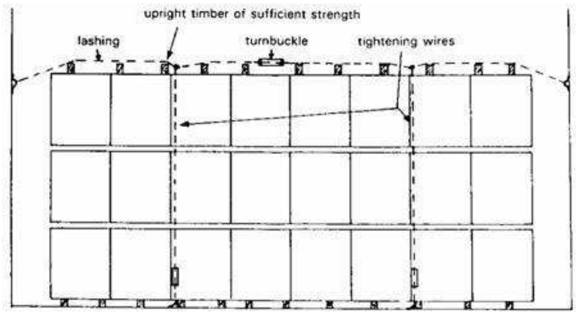


Figure 6 – Securing of end row in top tier against fore-and-aft shifting (view from top)

3.2 The lashings can be of a conventional type using wire steel band or any equivalent means.

3.3 Conventional lashings should consist of wires having sufficient tensile strength. The first tier should be chocked. It should be possible to re-tighten the lashings during the voyage (figures 5 and 6).

3.4 Wire lashings should be protected against damage from sharp edges.

3.5 If there are few coils, or a single coil only, they should be adequately secured to the ship, by placing them in cradles, by wedging, or by shoring and then lashing to prevent transverse and longitudinal movement.

3.6 Coils carried in containers, railway wagons and road vehicles should be stowed in cradles or specially made beds and should be prevented from moving by adequate securing.

ANNEX 7 Safe stowage and securing of heavy metal products

1 General

1.1 Heavy metal products in the context of this Code include any heavy item made of metal, such as bars, pipes, rods, plates, wire coils, etc.

1.2 The transport of heavy metal products by sea exposes the ship to the following principal hazards:

.1 overstressing of the ship's structure if the permissible hull stress or permissible deck loading is exceeded;
.2 overstressing of the ship's structure as a result of a short roll period caused by excessive metacentric height; and
.3 cargo shifting because of inadequate securing resulting in a loss of stability or damage to the hull or both.

2 Recommendations

2.1 The cargo spaces in which heavy metal products are to be stowed should be clean, dry and free from grease and oil.

2.2 The cargo should be so distributed as to avoid undue hull stress.

2.3 The permissible deck and tank top loading should not be exceeded.

E

Tata Steel IJmuiden Loading Manual - Stowage and Securing on Seagoing Vessels

This appendix contains the Loading Manual of Tata Steel IJmuiden, describing the stowage method. Prior to chartering a ship, this manual is sent to the shipping company so the ship management is aware of the stowage method of the stevedoring department of Tata Steel IJmuiden.

Figure 1 in the stowage method shows how the stevedoors want to stow coil against the bulkheads of the ship (indicated in grey), and leaving free space for the forklift maneouvres in the middle of the holds. Section 2.2 and 2.3 of the manual show the stacking method of the steel coils for bulk and box type holds respectively.

Stowage and securing
on seagoing vessels

Table of contents

1. General information

1.1 Introduction

Tata Steel Stevedoring uses two methods for loading and securing of steel products:
1. Stowage in vessels with hopper-type holds: pyramidal stowage;
2. Stowage in box-type ship's holds: stowage from side to side.

In either case the securing will be realised by using steel bands which has proven to be a safe and efficient way of lashing.

The loading of the ship will normally be performed with quay cranes. It may be necessary to place fork lift trucks in the hold of the vessel. This depends on the type of material to be loaded, the width of the ship and the exact shape of the hold. In general the tiers in the hold will be built up as shown in the next figure.

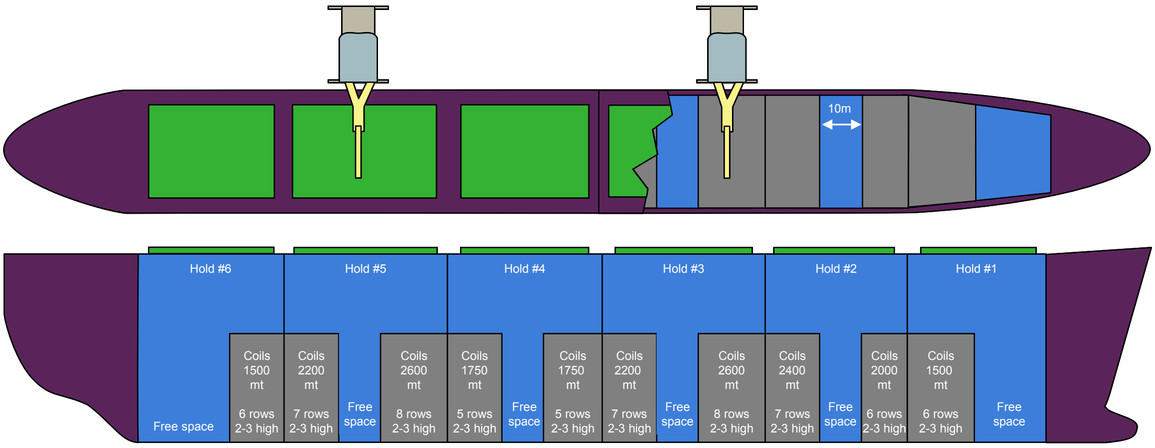


Figure 1 General build of steel products in the hold

The number of coils, tiers and the height of the tiers differ per shipment and ship. The tank-top load is taken into account when calculating the best setup. Free space between the blocks of tiers in a hold is necessary to allow manoeuvring space for the forklift truck.

1.2 Agreement on stowage plan and loading sequence

Tata Steel IJmuiden is a production company with limited storage capacity at the ports. Not all the material for ship is physically present at the quay. A large part of the material will be delivered by railroad to the harbour *Just in Time* (JIT). The planning for the JIT delivery is achieved through a very critical network planning. This network plan is constructed following the *first in, first out* principle; material which is loaded first into the ship will be loaded first on wagons. Therefore an agreement on a "loading sequence" is essential. Last minute changes are very disruptive and will often cause delay.

The exact load data will become available only a short time before loading. This gives Tata Steel the opportunity to meet as much as possible the final customer's wishes. On average the cargo is programmed for shipping two days before, but even when loading has started cargo can be added. Thus the making of a packing list can usually only be done just before or even during loading.

A stowage plan is prepared when the cargo to be shipped is known. The decisive factor is the capacity of the ship; width / length of the holds, capacity of the tanktop, and available space in m^2. In addition, the cargo, material type, dimensions and weight are taken into account. At first the information is not yet at a single coil detail. The available information consist of average dimensions and weights, including the maximum coil weight.

Initially we always contact the ship's officers (or a representative of the charter), to whom the available charge information is provided. This information includes metric tons by destination and type of material. At that time the information is still preliminary, as changes can be made at the last moment (see above).

The ship's officers (or a representative of the charter) will then be asked to create a (pre) stowage plan, and loading sequence based on the cargo brake down. This is then returned to the Tata Steel front office which will assess whether it is an acceptable plan for Tata Steel. If adjustments are required this will be communicated with the parties involved. On acceptance there must be an agreement for the stowage plan and the specified loading sequence.
After acceptance the stowage plan will be further processed into various warehouses, ports and cluster plans.

1.3 Wood

The dunnage and wedges used are made of new Douglas - lariks - inland pine. For destinations that require so heat treated wood conforming to ISPM 15 will be used, recognisable by the logo in figure 3. Certificate of treatment will be provided after loading.

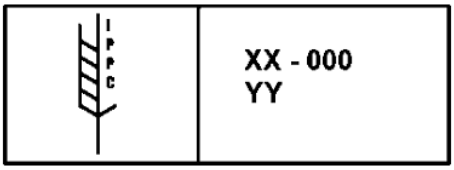


Figure 2 ISPM 15 HT example marking

The size of the dunnage used is 2000 x 150 x 30mm with a tolerance of 2mm. Bark- and dustfree. The size of the wedges are 280x150x150mm where 150mm is the height.

1.4 Lashing and securing equipment

Securing will always be realised by using steel bands, which has proven to be a safe and efficient way of lashing. The securing is done using certified steel bands. The tail ends of the steel bands are pneumatically sealed by compressive metal joints. The steel-strip lashing system causes each row of material to be a more massive structure (see *tier set up* for more information).

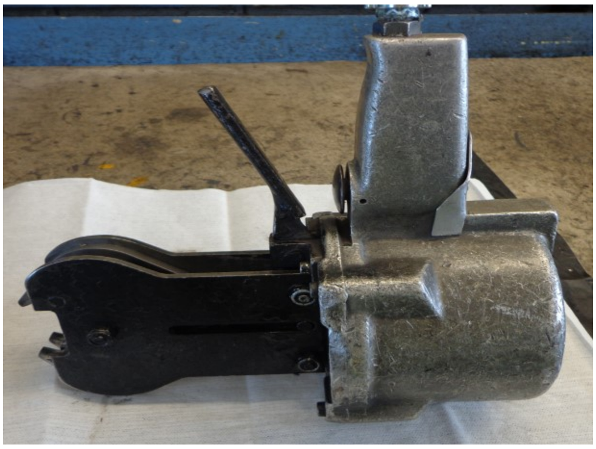
1.4.1 High tension lashing steel strip

Supplier: Theis
Type: Elite – High-Tension – Steel strip / HL
Breaking strength: 38.2*KN* / 3820*Kg* (minimal)
Elongation: ca. 12*%*
Dimension Steel strip: 31.70 × 1.12 *mm*

1.4.2 Tensioners

Pressure setting: 4.7*bar*
Traction power: 11*KN* (minimal) - 18*KN* (maximal)

1.4.3 Sealers



Pressure setting: 7.2*bar*
Total power of sealing system (strapping): 36.3*KN* (minimal)

1.5 Harbour specifications

Outer harbour quay nr. 1	
Quay length	414*m*
Quay height	4.20*m* above mean sea level
Airdraft top hatch coaming	27.5*m* above mean sea level
Max. allow. draught: East quay (50-315*m*)	8.50*m* (28*ft*) with a guarantee of always afloat to L.L.W.S.
Max. allow. draught: West quay (315-450*m*)	9.80*m* (32*ft*) with a guarantee of always afloat to L.L.W.S.
Nr. of cranes	1
Lifting capacity	18-35*t*

Outer harbour quay nr. 3	
Quay length	250*m*
Quay height	*8.00m* above mean sea level
Airdraft top hatch coaming	18.6*m* above mean sea level
Max. allow. draught: Quay (90-250*m*)	11*m* (36*ft*) with a guarantee of always afloat to L.L.W.S.
Nr. of cranes	2
Lifting capacity	58*t*
Outreach from quay edge	20.5*m*

Inner harbour nr. 3 / All Weather Terminal	
Total quay length	212*m*
All Weather Terminal quay length	120*m* (covered)
Quay height	*4.00m* above N.A.P.
Max. allow. draught	6.5*m* (21’33”)
Door Height All Weather Terminal	11.30*m* above N.A.P.
Nr. of cranes	1
Lifting capacity	40*t*
lifting height	8*m* from quay deck
On-shore Power Supply	400 V – 32 A – 3ph

2 Stowage

2.1 Introduction in stowage

Tata Steel Stevedoring uses two methods for loading and securing of steel coils:
1. Stowage in vessels with hopper-type holds: pyramidal stowage;
2. Stowage in box-type ship's holds: stowage from side to side.

2.2 Pyramidal stowage (hopper-type hold)

The stowage of steel coils will be achieved in a special way of stowage, the so-called "pyramidal stowing". Stowing the coils this way avoids difficult loading and discharging procedures and the use of extra equipment, (forklifts, mobile hoisting cranes etc.) Also this kind of stowage has proven to be successful in reducing the amount of damages during the discharging of the coils.

This special way of stowage means that the steel coils are not to be loaded from side to side in the different holds. This pyramidal stowing is also possible due the modern, high quality lashing equipment.

The next figures show some possible configurations of stowage and securing.

2.2.1 Dunnage

Dunnage will be used between the coils and the tank top (c.q. hopper tank). Between the outside coils and the dunnage on the hopper tank, wedges have to be used which have to be placed securely.
Two lines of dunnage on the tank top and in the side, wedging of coils with a minimum of two wedges.

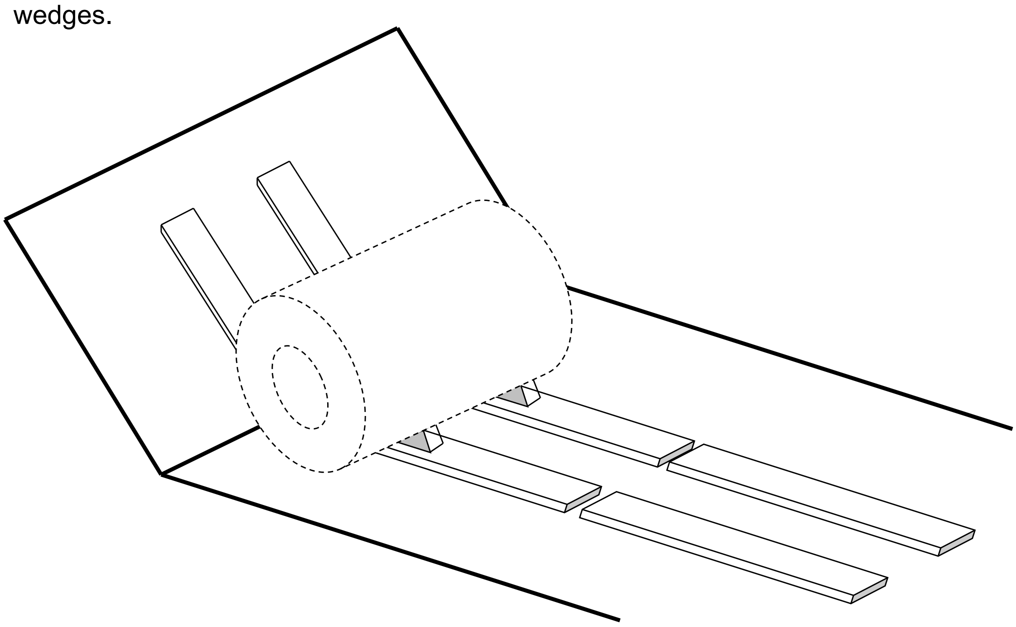


Figure 3 Position of wood on tank top and wing tanks

2.2.2 Tier set up

Coils are placed against each other from the sides of the hold. The final coil in the bottom-row is a locking coil.

It is general use to keep a distance between rows of about 10 -15 cm in order to keep space to attach the lashings, for using braided wire-slings and to avoid damage when lifting or using forklifts.

In the final row more vertical lashings will be used to “lock up” the other coils/rows.

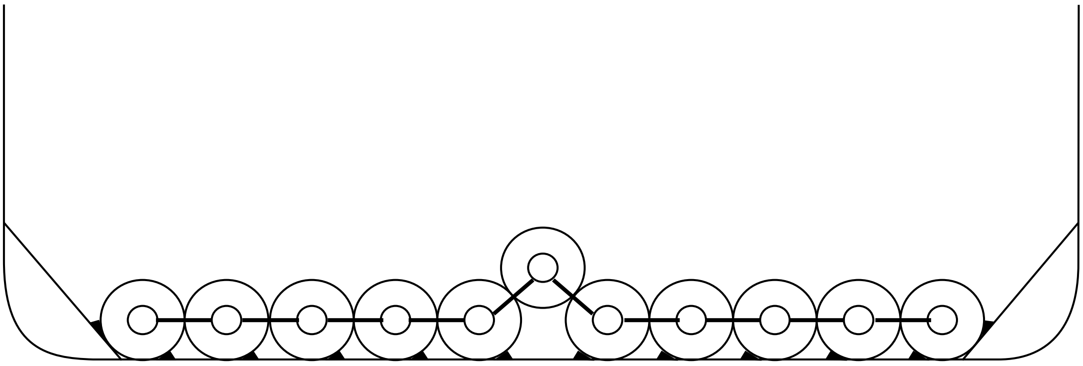


Figure 4 Stowage 1-high begin- and end row

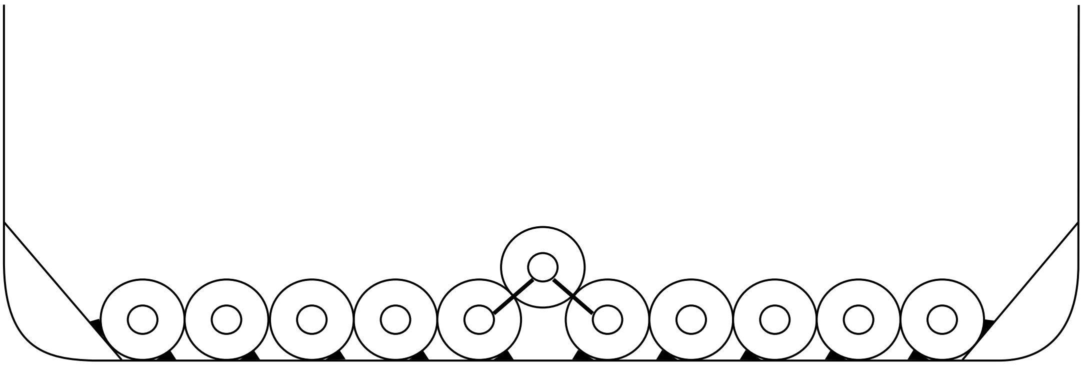


Figure 5 Stowage 1-high between begin- and end row

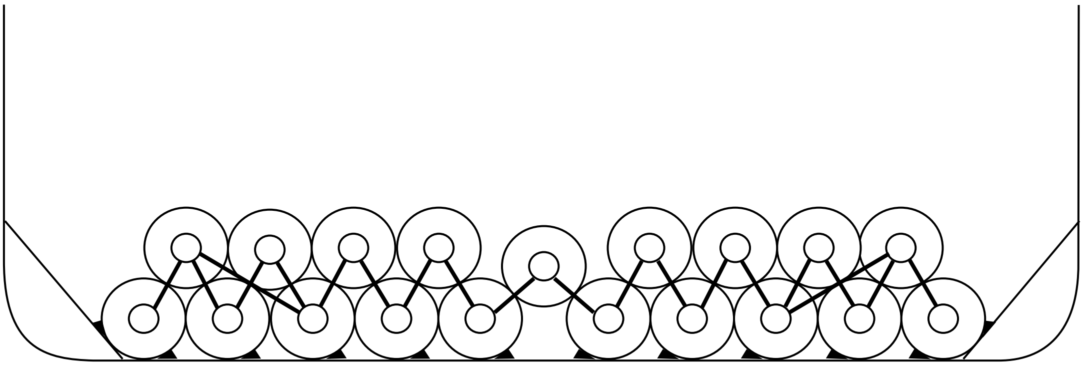


Figure 6 Stowage 2-high

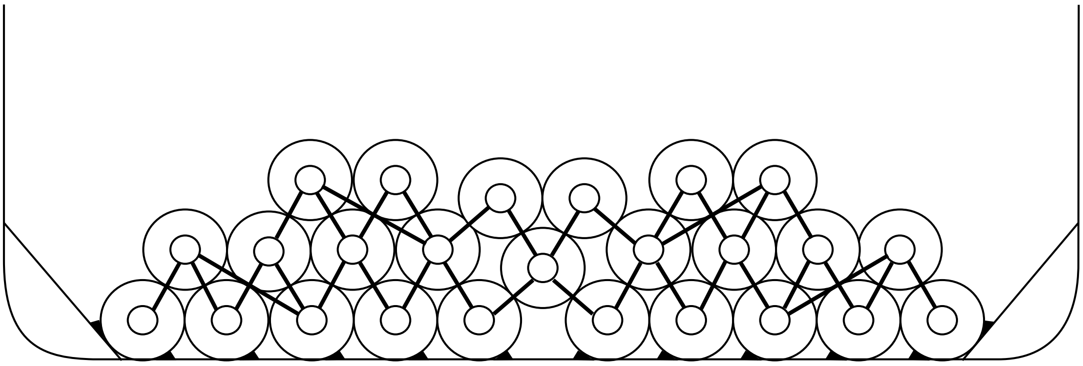


Figure 7 Stowage 3-high

2.2.3 Block stowage

For deepsea vessels the first or last tiers of every block near empty space in the first hold receive additional lashing. These two tiers are chocked and lashed in block stowage.

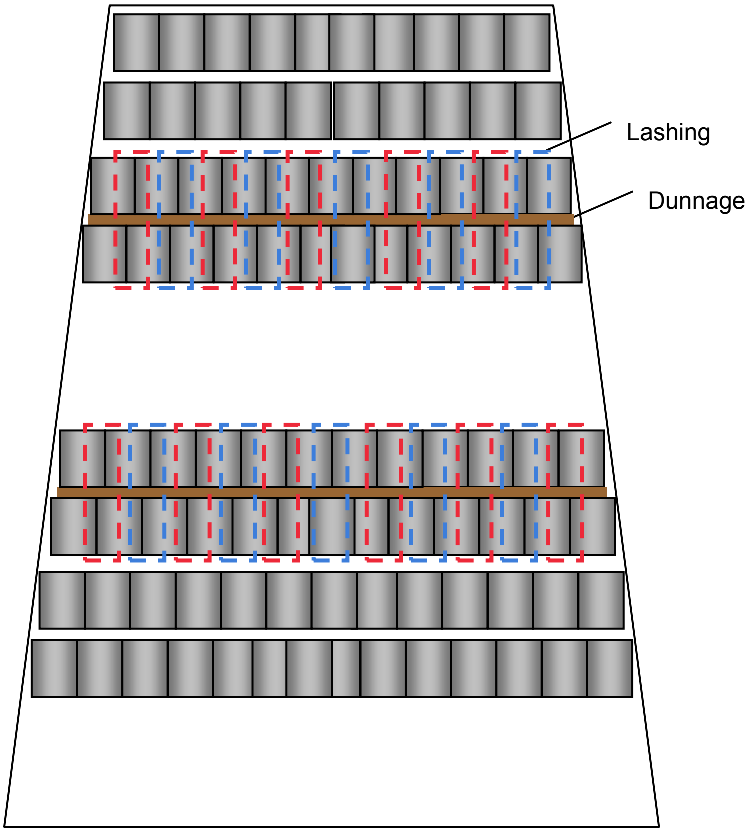


Figure 8 Block stowage in hold #1

2.3 Side to side stowage (box-type hold)

In ships with box-type holds, the coils will be loaded from side to side.
The next figures show some possible configurations of stowage and securing.

2.3.1 Dunnage

Two lines of dunnage are used on the tank top, wedging of coils with minimum of two wedges.

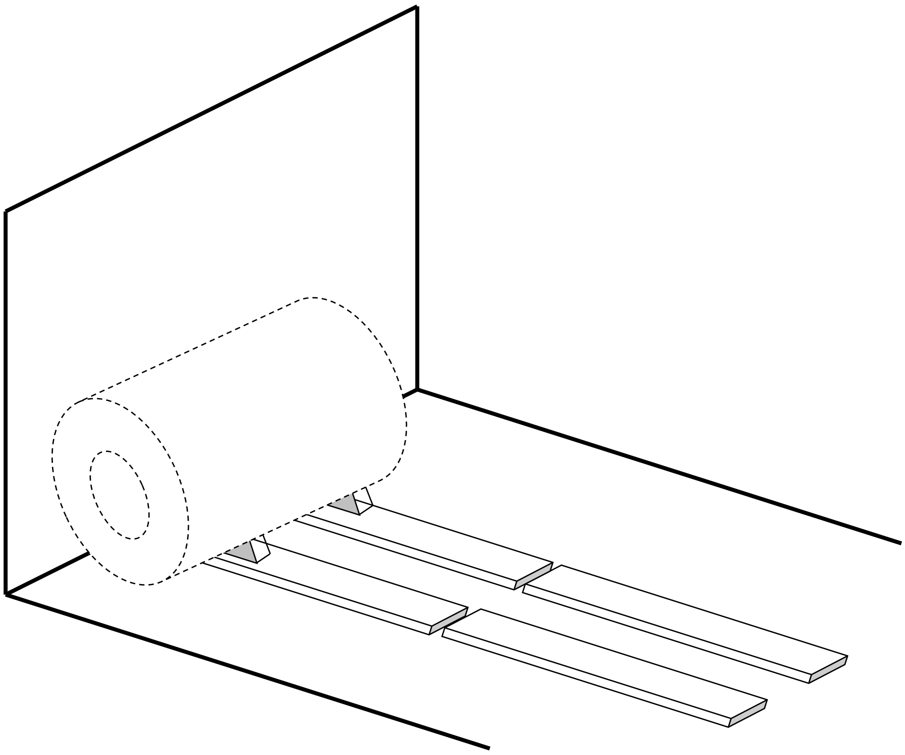


Figure 9 Position of wood on tank top

2.3.2 Tier set up

The two top-layers will be secured together; this means that in the top-layer the coils are lashed to the coils in the layer below. When the coils have to be placed 3-high the bottom-layer will not be lashed to the next layer on top of it.

The heaviest coils will be stowed in the lower layer of the rows.

It is general use to keep a distance between rows of about 10 -15 cm in order to keep space to attach the lashings, for using braided wire-slings and to avoid damage when lifting or using forklifts.

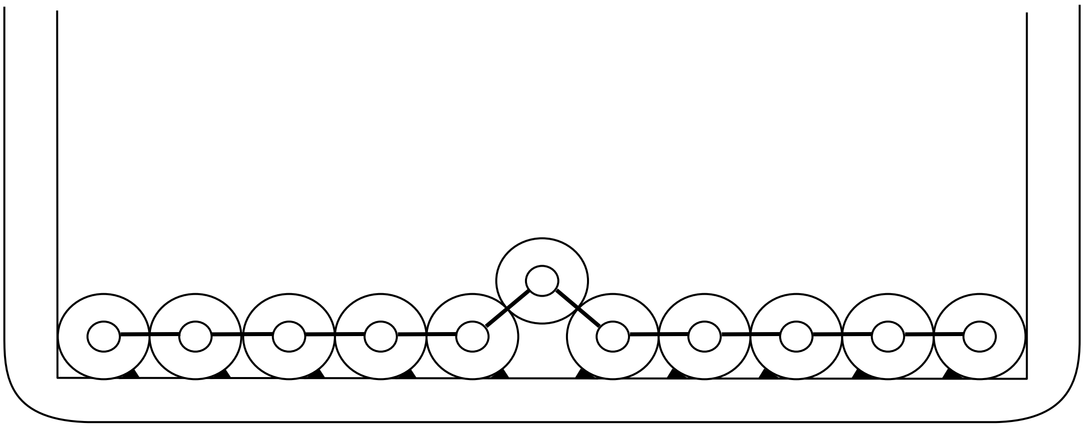


Figure 10 Stowage 1-high begin- and end row

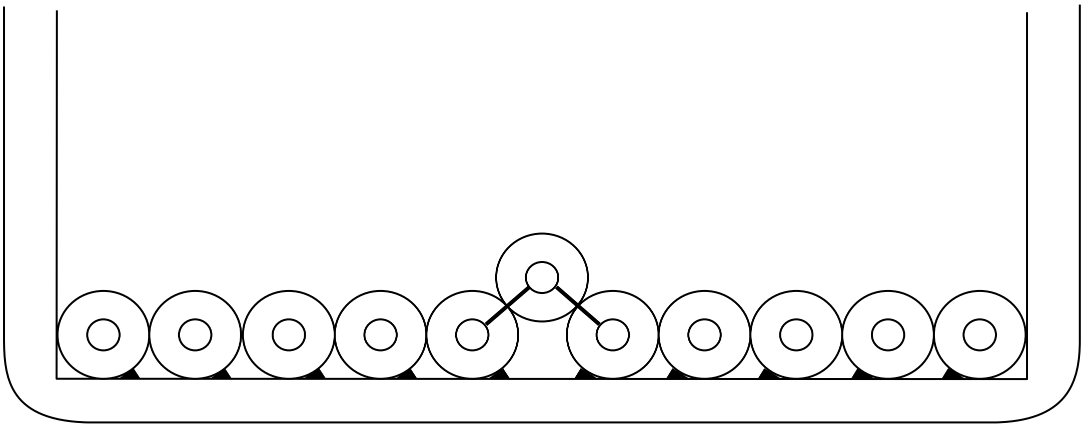


Figure 11 Stowage 1-high between begin- and end row

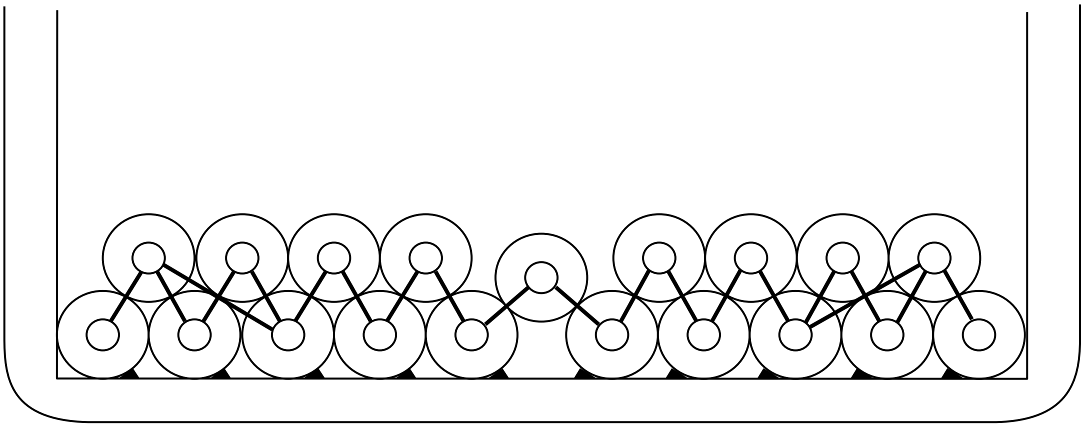


Figure 12 Stowage 2-high

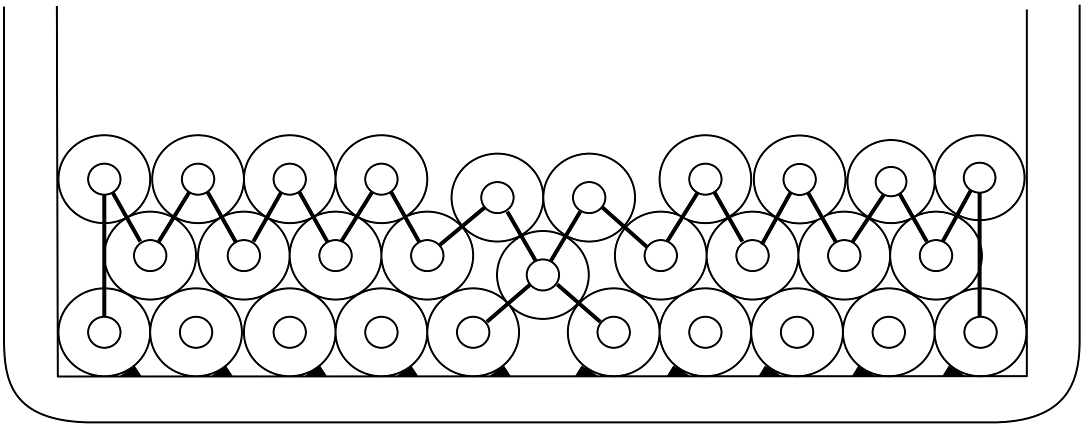


Figure 13 Stowage 3-high

2.4 Locking coils

Locking coils secure the tier by pressing the other coils of the tier to the side. The depth of the locking coil is important to keep the tier together. With two locking coils in one tier the depth should be as equal as possible.

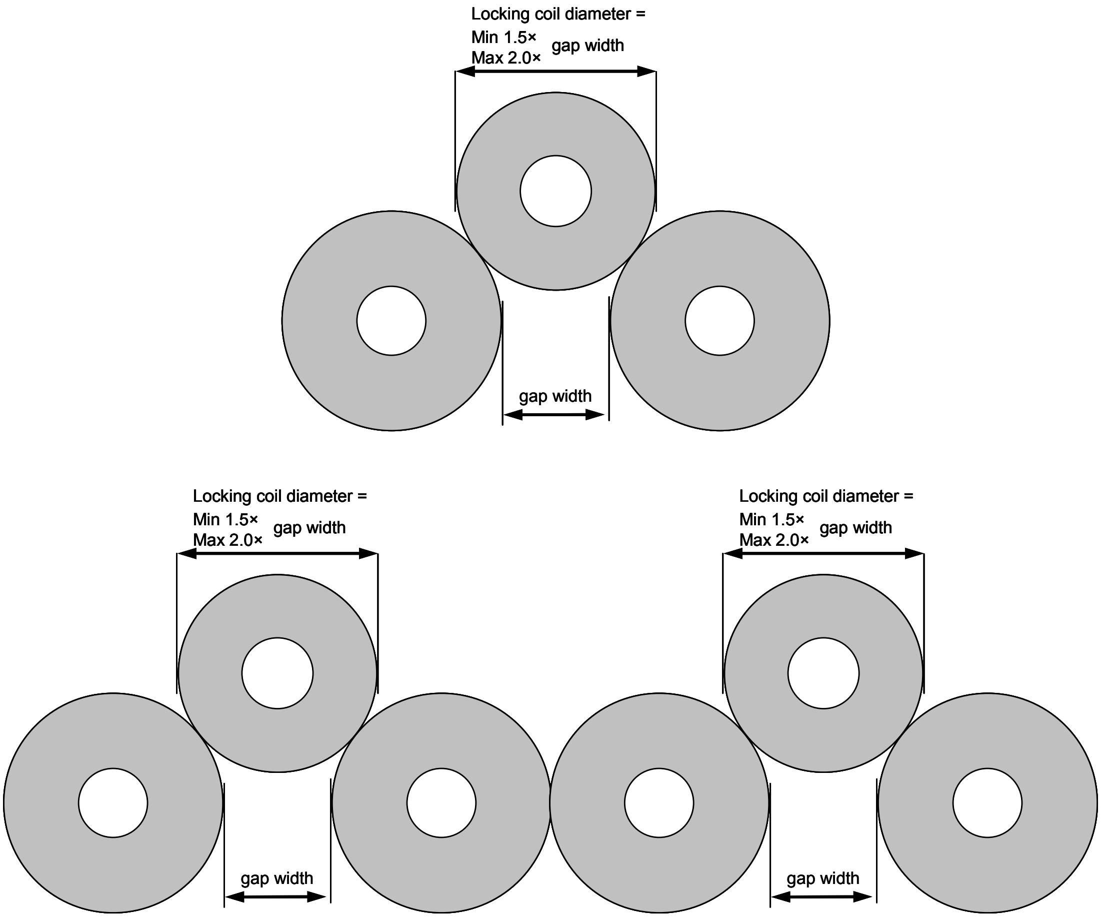


Figure 14 Locking coil examples

F

Certificate Tata Steel Loading Manual

This appendix shows the certificate Tata Steel IJmuiden received on April 8, 2004, from the Dutch Ministry of Transport, Public Works and Water Management. It states the stowage method of Tata Steel IJmuiden is conform the International Maritime Organisation regulations as shown in Appendix D.

Ministerie van Verkeer en Waterstaat

Date
8 April 2004
Number
DGG/V-04/002333/VL
Subject
Letter of Acceptance

LETTER OF ACCEPTANCE

This is to certify that the undersigned, Competent Marine Authority of the Netherlands:

1. has accepted the method for safe stowage and securing of coiled sheet steel coils on seagoing vessels as described in Corus Services *Logistic & Transport*, Stevedoring Department brochure "**Stowage and Securing on seagoing vessels**", dated 01-01-2004. The method is in compliance with International Maritime Organization (IMO) publication "Code of Safe Practice for Stowage and securing of Cargo, 2003 Edition, Annex 6 – *Safe stowage and securing of coiled sheet steel*.

2. is stating that the a.m. brochure is in compliance with MSC/Circ. 745 - *GUIDELINES FOR THE PREPARATION OF THE CARGO SECURING MANUAL* – 13 June 1996, especially regarding to paragraph 2.2 – **Specification for portable cargo securing devices**, regulation 2.2.1.

The validity of this letter of acceptance expires when the method of securing will be altered.

issued at The Hague, The Netherlands, April 08, 2004

DIRECTOR-GENERAL FOR FREIGHT TRANSPORT
on behalf,
senior policy adviser Cargo and Risk Management Division,

S. Hassing

DIRECTORAAT GENERAAL GOEDERENVERVOER

TO:
Corus Services *Logistics & Transport*
Stevedoring Department
Division : LT havens Bureau Operations (1F02)
P.O. Box 10000
1970 CA IJMUIDEN
The Netherlands

G

Analytical Hierarchy Process

This appendix contains the pairwise comparison of criteria and alternatives by four individuals for the purpose of a Multi Criteria Analysis, determining the preferred solution. Per individual, one form is used for collecting the comparisons. The frist three tables collect the pairwise comparisons for the solution criteria. The last three tables compare the alternative solutions per pair regarding the four criteria.

G.1. Ranking by E. Lute

What do you consider more important?

	-2	-1	0	1	2	
Effectiveness					X	**Safety**
Effectiveness				X		**Costs**
Effectiveness			X			**Practicality**

What do you consider more important?

	-2	-1	0	1	2	
Safety	X					**Costs**
Safety	X					**Practicality**

What do you consider more important?

	-2	-1	0	1	2	
Cost		X				**Practicality**

Which solution would you prefer w.r.t. the criteria?

Distribute Weight — Vertical Stowage

	-2	-1	0	1	2	
Effectiveness DW	X					VS
Safety DW				X		VS
Costs DW	X					VS
Practicality DW	X					VS

Which solution would you prefer w.r.t. the criteria?

Distribute Weight — Cradle/Casette

	-2	-1	0	1	2	
Effectiveness DW					X	CC
Safety DW					X	CC
Costs DW	X					CC
Practicality DW			X			CC

Which solution would you prefer w.r.t. the criteria?

Vertical Stowage — Cradle/Casette

	-2	-1	0	1	2	
Effectiveness VS					X	CC
Safety VS					X	CC
Costs VS	X		~~X~~		~~X~~	CC
Practicality VS				X		CC

G.2. Ranking by S. Borsje

What do you consider more important?

	-2	-1	0	1	2	
Effectiveness					X	Safety
Effectiveness				X		Costs
Effectiveness				X		Practicality

What do you consider more important?

	-2	-1	0	1	2	
Safety		X				Costs
Safety		X				Practicality

What do you consider more important?

	-2	-1	0	1	2	
Cost		X				Practicality

Which solution would you prefer w.r.t. the criteria?

Distribute Weight — Vertical Stowage

	-2	-1	0	1	2	
Effectiveness DW					X	VS
Safety DW					X	VS
Costs DW				X		VS
Practicality DW		X				VS

Which solution would you prefer w.r.t. the criteria?

Distribute Weight — Cradle/Casette

	-2	-1	0	1	2	
Effectiveness DW					X	CC
Safety DW					X	CC
Costs DW	X					CC
Practicality DW		X				CC

Which solution would you prefer w.r.t. the criteria?

Vertical Stowage — Cradle/Casette

	-2	-1	0	1	2	
Effectiveness VS				X		CC
Safety VS				X		CC
Costs VS	X					CC
Practicality VS		X				CC

G.3. Ranking by W. Kloosterman

What do you consider more important?

	-2	-1	0	1	2	
Effectiveness					X	**Safety**
Effectiveness			X			**Costs**
Effectiveness				X		**Practicality**

What do you consider more important?

	-2	-1	0	1	2	
Safety	X					**Costs**
Safety	X					**Practicality**

What do you consider more important?

	-2	-1	0	1	2	
Cost				X		**Practicality**

/hich solution would you prefer w.r.t. the criteri

Distribute Weight — Vertical Stowage

	-2	-1	0	1	2	
Effectiveness DW			X			VS
Safety DW			X			VS
Costs DW		X		X		VS
Practicality DW	X					VS

/hich solution would you prefer w.r.t. the criteri

Distribute Weight — Cradle/Casette

	-2	-1	0	1	2	
Effectiveness DW					X	CC
Safety DW				X		CC
Costs DW	X					CC
Practicality DW	X					CC

/hich solution would you prefer w.r.t. the criteri

Vertical Stowage — Cradle/Casette

	-2	-1	0	1	2	
Effectiveness VS					X	CC
Safety VS					X	CC
Costs VS	X					CC
Practicality VS	X					CC

G.4. Ranking by J. Kabel

What do you consider more important?

	-2	-1	0	1	2	
Effectiveness					X	Safety
Effectiveness				X		Costs
Effectiveness		X				Practicality

What do you consider more important?

	-2	-1	0	1	2	
Safety	X					Costs
Safety	X					Practicality

What do you consider more important?

	-2	-1	0	1	2	
Cost		X				Practicality

/hich solution would you prefer w.r.t. the criteri

Distribute Weight — Vertical Stowage

	-2	-1	0	1	2	
Effectiveness DW			X			VS
Safety DW	X					VS
Costs DW	X					VS
Practicality DW	X					VS

/hich solution would you prefer w.r.t. the criteri

Distribute Weight — Cradle/Casette

	-2	-1	0	1	2	
Effectiveness DW				X		CC
Safety DW			X			CC
Costs DW				X		CC
Practicality DW	X					CC

/hich solution would you prefer w.r.t. the criteri

Vertical Stowage — Cradle/Casette

	-2	-1	0	1	2	
Effectiveness VS					X	CC
Safety VS				X		CC
Costs VS				X		CC
Practicality VS					X	CC

H

Field Notes: Port of Antwerp

This appendix contains the field notes of the visit to the Port of Antwerp at Friday morning April 20, 2018. During this day, two Port Captains showed the harbour and explained different aspects of and the processes behind the stowage activities.

- The steel coil terminal at the port of Antwerp is devoted to loading steel products in the forms of plates, slabs, ETTS coils, horizontal coils or other special shaped steel.
- All loaded cargo will be shipped to America, no other destinations.
- Cargo is supplied to the terminal by different customers, primarily Thyssenkrupp, Arcelor Mittal and Tata Steel IJmuiden.
- Approx. 80% of the cargo is located at the terminal before the ship is berthed.
- The terminal features two transit halls to store coils, one roofed field and large open areas to store wet materials
- There are distinct work teams for stevedoring the ship, and discharging the supplied coils by train or truck.
- Since the terminal functions as a hub and has only the focus to load the bulk carriers, it has a strong focus on increasing its throughput.
- The throughput is not measured per hour, but the average throughput of a work team shift is 200 coils. With a shift duration of 6,75 hours, we can calculate a throughput average of 29,6 coils per hour.
- Besides the topstowage requirements imposed by the customer, the terminal labels any coil with a plate thickness less than 0.5 cm as topstowage. Not often is the number of topstowage coils problematic for the coil allocation.
- The average coil weight depends strongly on the ships' destination. To Veracruz, the estimated average coil weight is around 21 tons. The east coast however is supplied with less heavy coils, approx. 12-13 tons per coil.
- Damage at coils is mainly cause by rough handling of the coils.
- The stacking height is determined by the weight of the coils in combination with the loading manual of the ship. Often this manual has a maximum stacking height of 2 coils with a weight of 25 tons. So only coils weighing less as 17 ton, are aloud to stack 3 rows high. The terminal in Antwerp always obeys the loading manual, preventing discussions with the caption.
- Prior to starting the loading activities, the captain is handed the stevedoring manual, explaining the dunnage and lashing method of the stevedoors.

- More dunnage and lashing is used in comparison with Tata Steel IJmuiden. Additional crossed lashing is applied, as shown in Figure H.1 and the multiple lines of dunnage are shown in Figure 8.1
- The total height of the loaded cargo can vary significantly due to the stacking height difference per tier.
- There are multiple work teams deployed in one ship. Two stevedoring teams and one team applying the lashing (steel bands) consisting of only three workers. Above each team is a foreman deployed, determining the allocation of the coils. The three foremans report to the harbour team leader.
- During allocating coils under the hatch in the sided of the hold, no gooseneck equipment is used. Coils are allocated as closely as possible by the forklift, and next the coils are pushed by the hydrolic force of the thorn to the side. A wooden plank is used between the coil and the thorn to avoid damage to the coil. No second coil will be loaded on top of coils allocated by this method, since this allocation would be too difficult.
- Discharge harbours will drag the coils allocated under the hatch in the sides, out of their place by the quay crane. The Port Captain of the Antwerp terminal indicates the damage induced by this handling is acceptable.

Figure H.1: Stevedoors applying crossed lashing over coils

Research Paper

Application of the Deweyan Inquiry on the stowage approval difficulties at Tata Steel IJmuiden

J.J. Oudshoorn
Delft University of Technology

May 2018

Abstract

Right before the actual loading of a ship at the quay of steel production company Tata Steel IJmuiden starts, the ship management has to agree upon the stowage plan containing the stowage method and order. However, the company experienced the stowage plan approval was more often accompanied by complex discussion with the ship management. This is expected to cause delays which result in extra costs and severe plannings disruption at the harbor. A data analysis is executed to find several trends influencing the stowage difficulties regarding product types, information availability, ship compliance and regulation restrictions. Furthermore, the current system is analysed theoretically and practically (case studies) and the power of the stevedoring department is mapped to find solution boundaries. A multi criteria analysis combined with thorough understanding of consequences showed that distributing the cargo weight over the tanktop would prevent a quay discussion.

Keywords: Deweyen Inquiry, steel coil, stowage, Naturalistic Inquiry, en nog een paar meer om te vullen

1 Introduction

Tata Steel IJmuiden is a steel production site with their own stevedoring department (S&W) which is responsible for loading ships with finished products, the steel coils, to the customers. Before starting the loading procedure, S&W plans the cargo in the ship with a stowage plan which determines the weight distribution over the different holds and the arrangement of coils per hold. Since the ship management has responsibility over its ship and the cargo during the voyage, it has to approve agree upon the stowage plan. Lately, Tata Steel IJmuiden experiences more often discussions at the quay with the ship management about the stowage method. This is likely to result in additional costs and causes disruption in the planning.

Besides appointing the rising problem, S&W also indicated several probable causes. However, no distinct origin or bottlenecks of the problem are acknowledge. Therefore the fist step of the research is a in depth problem analysis and the first research characteristic is determined: the indistinction of the problem.

Moreover, the problem arose in a practical environment, namely during the actual performance of stevedoring activities at the quay of Tata Steel IJmuiden.

2 Method

To ensure the research approach and methodology match with the content of the research, two main characteristics of the problem situation are distinguished; the practical environment in which the problem arose and the indistinction of the problem. In this research, the Deweyan Inquiry provides a theoretical framework to incorporate practice and theory in defining the problem and its constituent factors. Together with its focus on a holistic approach, it is perceived suitable to cope with the two problem characteristics [3].

Further explanation on the Deweyan Inquiry is found is Section 2.1.

2.1 Deweyan Inquiry

The Deweyan Inquiry (DI) was first introduced in 1938 by John Dewey, an American philosopher, psychologist and pedagogue. His recognition for the need of a pragmatic method for scientific purposes with an equal focus on theory and practice resulted in an inquiry theory shown in Figure 1 and defined as follows:

> "Inquiry is the controlled or directed transformation of an indeterminate situation into one that is as determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole. [1]"

The DI consists of six steps [3] visualised in Figure 1 and explained as follows:

1. Doubtful Situation: It starts with the recognition that 'something' in the course of events 'somehow' violated the expectations. This first step is deciding that a situation requires inquiry.
2. Institution of the Problem: This step frames 'what' will be attended to in the inquiry, the potential constituents of the doubtful situation are addressed. Such frame must have its foundations in practice and theory.
3. Determination of the Problem Solution: This step concerns the controlling reconstruction of the existing situation to gain deeper understanding of the problem and give reference to possible solutions.
4. Reasoning: In this step the different problem solution combinations that are expected to solve the constituent factors are reasoned out with an if-then approach.
5. Experiment: In this step the optimal solution form the previous step will be tested against reality; do the problem solution actually have the expected effect?
6. Warranted Assertion: This step concludes if the situation is improved.

2.2 Indistinct Problem

To ensure a firm and correct base for the research and cope with the indistinct problem, a thorough analysis with clear constituents of the problem situation should be clarified. Applied in this research, it results in a focus on the first steps of the Deweyan inquiry on (1.) the Doubtful Situation, (2.) the Institution of the Problem and (3.) the Determination of the Problem Solution.

2.3 Practical environment

Since the discussion at the quay is raised in a practical environment (as also required for the first step of the DI), the research approach should be practice-oriented to increase the probability of a realistic outcome and effective solution to the problem. As shown in 1, the DI shows practice is constantly involved in (2.) the Institution of the Problem. To incorporate practice in step 2, case studies will be executed.

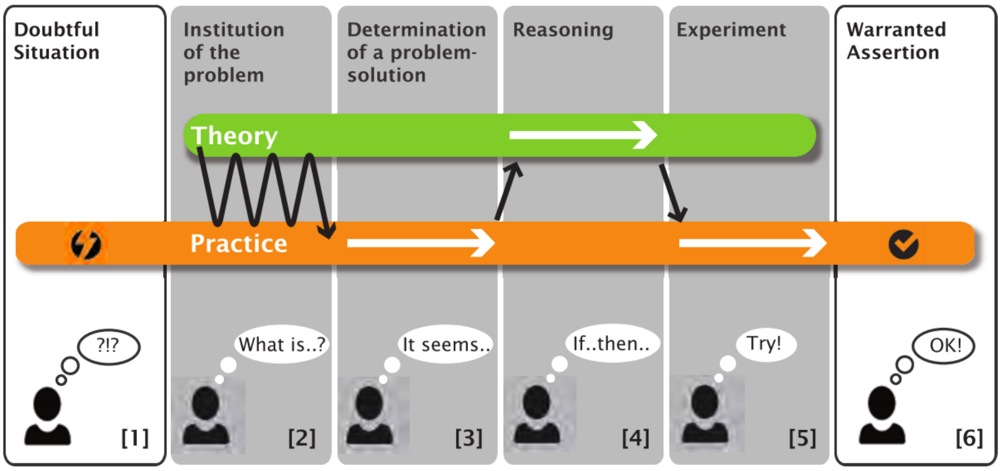


Figure 1: Overview of the Deweyan Inquiry

2.4 Application to the Problem

Now the different steps of the DI are clear, their application to the problem situation is up to the interpretation of the researcher. Per step, the implementation is explained:

Doubtful Situation As determined by the DI, the Doubtful Situation rises from the practical environment solely. Therefore, in the application to this problem, the problem environment is derived from the involved products, activities and financial aspects of the steel coil stevedoring process. Deciding that the situation required inquiry is based on a Failure Mode and Effect Analysis (FMEA), mapping its potential failure modes and corresponding probability and severity.

Institution of the Problem The basis of the institution of the problem are found in practice and theory. In this research a parallel analysis is executed on the probable causes with corresponding trend (indicated by S&W, shown in Figure 3), and the current system description.

For the **probable cause analysis**, the trends of the factors are analysed; determining which constituent to the problem is changing and how does this affect the problem situation. Data in the form of interviews, Literature or quantitative data of the company is not quantified towards a definite outlook, but are only reviewed to gain an indication. A the theoretical approach of the **current system description** is established by analysing how the current processes and method should be executed. The practical current system description is established by executing multiple **case studies**.

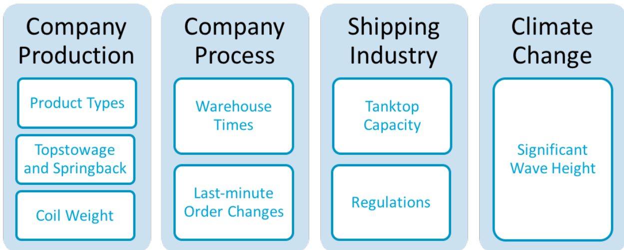


Figure 3: Probable Causes indicated by S&W

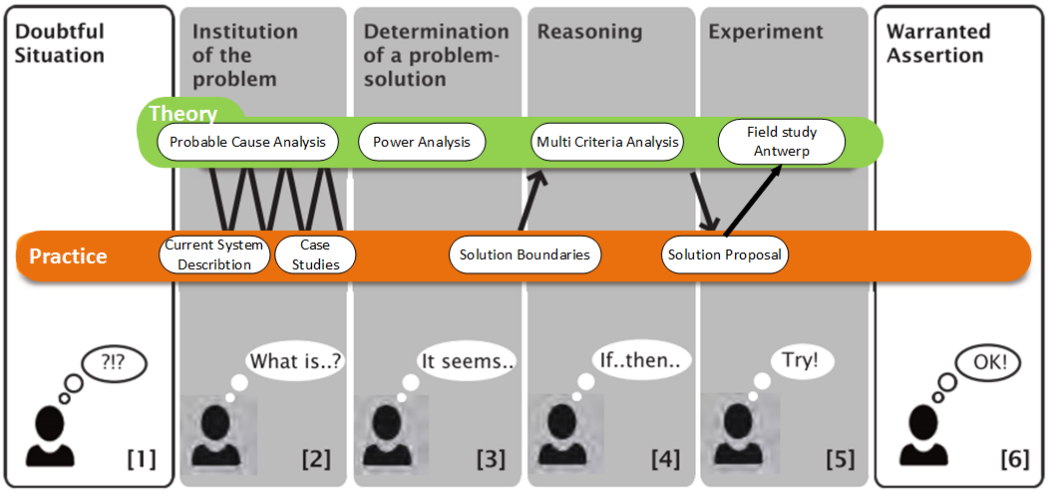


Figure 2: Application of the Deweyan Inquiry; the research design

Determination of a Problem Solution To give reference to possible solutions, boundaries to the solutions are sought by studying the area of influence of S&W. A theoretical framework for this **power analysis** is found in Literature and then applied to practice. Therefore, although not determined by the DI, the solution boundaries are based on theory and practice as well.

Reasoning By logical reasoning, multiple solutions ideas are evaluated and dismissed based on the solution boundaries resulting in three remaining solution proposals. These proposals are theoretically examined on several criteria by means of a **multi-criteria-analysis**, resulting in one optimal solution. This solution is then reasoned out and evaluated.

Experiment In this step, the optimal solution found in previous step is tested against reality. However, since validating and thus executing an experiment, was too costly and not within the scope of the research, the optimal solution is only verified. This is done by means of a **field study** of a similar environment; the steel coil terminal of Antwerp. Moreover, a **simulation** by means of calculation is executed to test the effects of solution against a controlled reconstruction of the existing situation and so enable verification.

Warranted Assertion The validity of the research is tested against Egons' (et al. [2]) defined terms for validating qualitative naturalistic inquiry: Credibility, Transferability, Dependability and Confirmability. With this research being a problem solving inquiry, conclusions directly also from the recommendations towards the problem owner; Tata Steel IJmuiden. So practical recommendations (regarding solving the problem) are included in the conclusions. However, scientific recommendations, regarding the research method and validity, are concluded separately, in the so called "research limitations". These latter are especially of interest for the conclusions of this paper.

3 Results

Results of above explained and applied methodology are described per DI step.

3.1 Doubtful Situation

The FMEA showed the financial consequences for S&W are marginally and acceptable while the planning and transport flow disruptions are critical and can have severe impacts.

Due to the significant physical difference of plates and vertically oriented coils compared to horizontal coils, the problem situation from this research does not occur with these cargo types and therefore are left out of scope. Since the coasters and inland ships transport less coils per shipment, the order changes and type of products on board have little influence on the loading procedure. Moreover, the ship management of these ships is less strict on the lashing and securing of the cargo, since the coils are often not stacked and weather has less influence on ship movements. Therefore, quay discussions at coasters or inland ships are rare and left out of this research scope.

At Tata Steel IJmuiden, shipping activities are secondary and supportive to production activities and therefore seen as not influencable. Furthermore, with the stevedoring and chartering costs of roughly €4,- and €35,- per tons respectively, problem solution should be sought without influencing the economical position of or restriction to the Chartering department.

3.2 Institution of the Problem

Probable Cause Analysis (PCA) From analysing (by means of qualitative data, interviews or literature research) the trends of factors (Figure 3) influencing the problem situation resulted in the following statements:

- More further finished zinc-coils are exported which are often not allowed to carry another coil on top and thus an increase in topstowage coils is expected.
- Due to the growing safety awareness, more coil handling and allocation restrictions (in the ship with respect to its construction) are imposed.
- Tata steel has already induced processes to increase the maximum coil weight to 38,5 ton.
- The importance of provided information will grow due to more imposed restrictions and focus on Just-in-Time delivery.

Current System Description (CSD) The cross case analysis (comparing the current system description and the two conducted case studies, resulted in the following statements:

- Chartering, Outbound Planning and S&W (departments) has to approve a ship before it is chartered. Only familiar ships (as in case study 1) do not require these approvals. Moreover, S&W has minor influence on the ship nomination; despite warnings from the shipping company (in case study 2), S&W did not have the power to refuse the ship.
- Applying more dunnage w.r.t. the standard amount is seen as less problematic as distribution the weight of the cargo more evenly over the tanktop (utilizing all tanktop area while stacking coils only 2 instead of 3 high). Both cases showed this adjustment ensured an agreement on the stowage plan by the ship management. This adjustment did not result in demurrage (large planning disruptions), contradictory to the expectations as found in the FMEA of the Doubtful Situation.

Combining the results of the PCA and the CSD, following research findings are concluded:

- Suitability of ships: restrictions on coil handling (for product quality) and allocation (imposed by the ship management) decreases S&W's stowage flexibility, and due to their little influence on the ship nomination, the suitability of ships is decreasing.
- Late Availability of Information: the decreasing stowage flexibility of S&W increases their dependency on cargo information provided by Outbound Planning which is, due to a focus on Just-in-Time delivery, not expected to expedite.
- Less Stacking and More Dunnage: the increased restrictions results in less flexibility in stowing height and more dunnage is requested by the ship management resulting in incompatibility of the current stowage method.

3.3 Determination of a Problem Solution

Internally, when looking at uncertainties, S&W is mainly dependent on Outbound Planning and the Chartering department. S&W only grants power due to its irreplaceability and immediacy when warehouses tend to overflow during harbours malfunctioning. However, since S&W has no central position in the companies workflow, the magnitude of influence with respect to these departments is low.

Externally, due to the lack of legitimate rights and responsibilities and without being able to exert pressure on counter parties, S&W only has power based on cooperative incentive of the counter party.

3.4 Reasoning

Due to the high *costs* per transported tons for chartering a ship compared with the stevedoring costs, adjustments in disadvantage for the chartering department are eliminated from the solution alternatives.

Due to the *deficient influence* of S&W on external parties and aspects (the ship management and regulations), the ship loading manuals and thus the ship managements' demands cannot be changed by S&W and is therefore dismissed as solution direction.

Due to the *uncertain results* of persuading the ship management with referent power or adjusting IT-system communication (implementing "the Smart Steel Factory project"), these solution directions are uncertain and therefore not seen as a sound solution.

Due to *company wide strategies* and optimisations, S&W cannot adjust production output to their preference. Therefore ensuring lighter coil and less springback and topstowage is not seen as feasible solution.

These dismissals have left S&W with two solution directions within their area of influence, fitting company wide strategy and with self-influencable outcomes: adjusting the current, or adapting another stowage method. Three solutions proposals are found in similar shipping industries: stowing the coil vertically (rotating coils 90°, VS), applying cradle cassettes (coil gutters, CC) and distributing the weight of the cargo evenly over the tanktop (not leaving forklift manoeuvrability area empty, DW). All three proposals are ranked by a Multi Criteria Analysis on Effectiveness, Safety, Costs and Practicality (Figure 4)

	Effectiveness	Safety	Costs	Practicallity	Priority
Criteria PV:	0,14	0,72	0,09	0,06	Ranking
DW	0,13	0,08	0,70	0,74	**0,18**
VS	0,07	0,14	0,25	0,19	**0,15**
CC	0,79	0,77	0,05	0,08	**0,67**

Figure 4: Results of the Multi Criteria Analysis

Although the application of cradle cassettes scored highest in the multi-criteria-analysis, due to its large practical challenges, high investment costs and difficult logistical management of returning the cradle cassettes, the solution is perceived as not viable on the sort term. Therefore the proposed solution is distributing the cargo weight

3.5 Experiment

During a **field study** at the Port of Antwerp, where the weight is distributed on default, it is verified no discussions with the ship management occurs. Therefore, it can be stated the problem will be solved by applying weight distribution on default. Moreover, by generating more upper (top) locations for coils, the increased topstowage coils is dealt with either. **Calculations** show this causes a higher hold capacity in number of coils and a similar throughput (Table 1).

Table 1: Capacity and throughput of Current System (CS) and Distributed Weight (DW)

	CS	**DW**
Coil capacity [#]	150	209
Tonnes capacity [ton]	3750	5225
Topstowage capacity [#]	36	99
Total Duration [hours]	11,54	16,74
Average throughput [coil/hour]	13,00	12,49

3.6 Warranted Assertion

It is recommended for Tata Steel IJmuiden to distribute the cargo weight over the tanktop area and so decreasing the burden on the tanktop. However, it is also recommended for Tata Steel IJmuiden to executed further research on two topics. First, to validate the conclusions on insignificant plannings and costs consequences and the frequency of the discussion, it is recommended to collect more data to establish more grounded conclusions on the magnitude of the problem. Secondly, the already initiated "Smart Steel Factory" project aiming to align the different IT-systems should be benefit from. To do so, proper and close management of the implementation is required to improve the communication and provide earlier information in the stowage process.

4 Discussion

Trend Analysis The Probable Cause Analysis consisted mainly on qualitative data gathering and analysis in order to find trends complicating the stevedoring process and method. The data found on different topics are only used as an indication of future trends. For example; the increasing amount of zinc-coils are not translated towards and exact expected amount of zinc coils in the future, but only an indication in terms of *increase* or *decrease* is generated. For a more precise analysis and future outlook, proper significance analysis is required. The same holds for other trends indicated in the probable cause analysis.

Case Studies To analyse the practical side of the problem two case studies are conducted. Although initially the cases were selected based on the magnitude of the problem and the discussion around horizontal, the main bottleneck was finding enough data for executing a case study. Therefore only 2 case studies could be performed and thus conclusions regarding the practical current system description are only based on two case studies, which is too little to ensure a certain representation of reality.

Multi Criteria Analysis The Multi Criteria Analysis is based on the input of only four individuals. Although the MCA, its criteria and solution alternatives were explain to the individuals, their interpretation of the criteria and operation of the solution alternatives differed significant. To cope with these deviations in interpretation, it is recommended to:

1. Define the criteria and solution alternatives more strict
2. Explain the criteria and solution alternatives (with their
3. Consult more than four individuals to capture and take the mean of the remaining deviations, expected to be caused by actual understanding and resulting opinion of the consultant and thus resulting in a realistic representation of the perceptions of the participants of the MCA.

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