StowMan\textsuperscript{s}s
Efficient stowage planning for higher cargo intake
A CASE STUDY

Innovation for shipping
Preface

This document is to give third-party readers insight into the technical and commercial benefits of StowMan[s], the most recent extension of the StowMan system for voyage container stowage planning. StowMan[s] is an optimizer for semi-automatic stowage planning and a decision support tool developed and distributed by INTERSCHALT maritime systems AG.

While stowage planners are convinced that StowMan[s] will ease their work, INTERSCHALT wanted a direct, as well as a quantitative comparison of StowMan[s] with other tools available on the market. Thus INTERSCHALT initiated a case study. Under controlled conditions experienced stowage planners compared tools with different functionalities in different stowage scenarios. These were as close as possible to real-world conditions and allowed one to measure KPIs.

This paper describes the case study based on real data and performed as a voyage simulation. Experienced stowage planners ran the simulation independently – using all features of StowMan[s] on the one hand and a subset of functionality typical for ordinary tools on the other. By comparing these two stowing procedures and their results, the test proves the superior performance of StowMan[s].

All information provided in this publication is meant to be informative only. All project-specific issues shall be arranged separately and therefore any information given in this publication shall not be used as part of agreement or contract.

Schenefeld, November 2015

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Dear reader,

In times of low freight rates and sustained intense competition, ship owners / operators are aiming to find more effective ways to utilize their fleets.

In keeping with our motto “Innovation for shipping” INTERSCHALT develops effective software solutions that bridge the gaps in efficiency, as in the case of stowage planning.

It takes a good stowage planner several hours to create a cargo plan for each leg of a voyage. Schedules are tight, leaving no additional time for optimization.

Imagine a software solution that not only assisted the planner in this job in just 30 seconds but also provided liner operators tangible economic advantages.

This software has now become reality: In a quantum leap forward for the shipping industry, StowMan(s) introduces a new method of rotation stowage planning.

StowMan(s) contains an algorithm that eliminates the need for the time-consuming task of placing containers manually, with an optimization engine that reduces planning time significantly and allows one to create multiple plans according to different strategic approaches.

The planner simply chooses the optimal plan in order to improve the vessel’s utilization.

Thanks to StowMan(s), creating the perfect stowage plan becomes a manageable task. In particular, if using StowMan(s) brings about a quantifiable economic impact we would like to prove it with this case study.

We hope you enjoy reading this initial StowMan(s) case study for the liner shipping industry.

Robert Gärtner
CEO

Foreword
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Case Study: StowMan
Executive Summary
Stowage planning is at the heart of container vessel operations. The quality of these operations affects the performance of a voyage significantly. However, stowage planning is highly complex and requires a great deal of manual labor, which can be tedious and time-consuming.

For this reason, INTERSCHALT teamed up with Optivation Aps, a Copenhagen-based company recognized by the liner shipping industry for its leading expertise in optimization algorithms for automated container ship stowage planning based on a decade of research at the Decision Optimization Lab, IT University of Copenhagen. Together we developed an optimizer function called StowMan[s] that runs alongside the existing StowMan planning tool to significantly reduce planning time by enabling the planner to run stow scenarios in seconds as opposed to hours.

Reducing planning time was the key motivation for the development of StowMan[s].

StowMan[s] offers a decision support tool to secure this kind of optimization and all the resulting benefits.

To avoid any misunderstandings, we would like to highlight here that StowMan[s] is NOT an automatic stowage tool. It is rather a decision support tool to support the vessel planner in his/her daily work by providing an 80/20 solution that requires additional fine tuning by the planner.

In order to quantify the performance gains from using StowMan[s], INTERSCHALT performed a case study in which the results of stowage planning based on StowMan[s] have been compared with a standard planning tool.

The test was done under realistic conditions (19,000 TEU vessel, real loadlist, real port rotation with real restrictions) and executed by experienced stowage planners who planned this vessel in this service for the first time. The evaluation of the planning results was done by an additional planning expert.

Before conducting the case study, the test evaluation criteria were determined. These comprised among other parameters the following:

1. Reduction of planning time / number of plans undertaken in a specific time period
2. Number of plans undertaken in a specific time period
3. Compliance with mandatory hydrostatic regulations
4. Reduction of port stay time
5. Reduction of restows
6. Increase of vessel utilization (i.e., increase in cargo intake measured by reduced dead space under deck)

While there are generally quantitative and qualitative measures to evaluate a stowage plan, the study focused strictly on quantifiable metrics:

» to increase utilization / company revenues and
» to reduce operational costs.
Clearly, the above metrics are not comprehensive and one can certainly think of other qualitative and commercial benefits, such as reduced communication costs, more flexibility in planning, and so forth.

As a general outcome of the case study, we can state that the StowMan\(^{(s)}\) optimizer functionality had a positive impact on all of the above criteria as we outline below:

[1] **Significant reduction of planning time**

StowMan\(^{(s)}\) reduced planning time significantly by an average of 30% – 50% while at the same time delivering more alternatives to the planner instead of a single solution. We anticipate that who are familiar with the service and the vessel would achieve additional savings of planning time.

In addition, the planner using StowMan\(^{(s)}\) not only needed less time but created five times the number of different stowage plan solutions.

Based on the feedback from our customers, we see this as the most valuable advantage of StowMan\(^{(s)}\) as the planner is now able to make use of the time saved to perform the duties of a ship manager.

He can liaise with the cargo flow management department to acquire more containers, focus on the quality aspects of the stowage (see below), and react flexibly to changed external parameters; or he can simply manage more vessels at the same time and increase his own productivity.

[2] **19 % less dead space under deck**

A key aspect of cargo planning is to increase vessel utilization. Although it is difficult to measure and compare two different stowage plans, we computed the increase in cargo intake by the reduced amount of dead space under deck.

On average, StowMan\(^{(s)}\) reduced the dead space by 19% during the case study. Multiplied by the number of port calls, rotations, vessels and freight rate, we see the potential for a very high increase in revenue in this area. In combination with the reduced planning time already mentioned, we see this as the most compelling commercial benefit when evaluating StowMan\(^{(s)}\).

[3] **Reduction of port stay time**

StowMan\(^{(s)}\) takes the reduction in the duration of port stays into consideration by improving the crane split according to the pro forma crane intensity. As the terms of terminal contracts vary significantly, port stays often depend on other external factors e.g., tide restrictions, we have not quantified this criterion. However, we can say that StowMan\(^{(s)}\) fulfilled the given pro forma crane split in all cases.
StowMan\textsuperscript{(k)} helps the planner to optimize restows. Depending on the planners’ preferences they can reduce the number of restows or make better use of them to improve other criteria.

By being linked to the MACS3 loading computer, StowMan\textsuperscript{(k)} simultaneously complies with all mandatory hydrostatic regulations set by classification societies to provide stowage plans. StowMan\textsuperscript{(k)} provides a seaworthy stowage plan within seconds.

As a sign of its uniqueness, this case study proves that StowMan\textsuperscript{(k)} manages the complex container configuration of all relevant stowage criteria for one vessel in terms of cargo and ship stability e.g., lashing, DG, GM, trim, as well as economical criteria all in one. To date there is no other stowage planning software on the market comparable to StowMan\textsuperscript{(k)}. 

\begin{itemize}
\item [4] Lowering restows by 54% 
\item [5] Seaworthy stowage plan within seconds 
\item [6] Increase in complex container configurations
\end{itemize}
The study showed an increase of 75,000 USD per vessel on this voyage.

Based on 1 departure of 11 vessels per week in this service would result in an increase of 3.9 million USD per year for this service. Results can be achieved of an increase in utilization of 1.3%.
About the process and planning tools on the market
However, the reality of stowage coordination is much more complex than this implies. Imagine a giant puzzle with as many as 20,000 pieces that needs to be solved. The difference between stowage and a puzzle is that there is not one single solution to stowage but many. Stowage is a 20,000-piece puzzle – with no single solution.

There is no ‘one size fits all’ solution.

There are numerous combinations that can be applied to solve the puzzle, and none of them can be described as truly correct or incorrect. Every scenario has some positive aspects as well as potential for optimization, often depending on what the stowage planner aims to do with this particular stow.

The other thing to consider is that this is a never-ending puzzle in that it does not even really have an end result, just steps along the way. Very rarely do container ships completely discharge and then reload. Usually they operate in a continuous loop of port calls. At every port, some containers will be discharged, and some more will be loaded.

Due to the dynamic nature of container shipping operations, there is no ‘one size fits all’ solution to stowage. Every service – often every port and/or vessel – has different requirements and restrictions that affect the stowage. What works well for one particular stow might not work at all for another.

The optimum way to look at stowage is to break it down into its individual components. There are quite clear rules for each specific aspect of stowage, such as hazardous cargo segregation, and it is then up to the stowage planner to look at the stowage he or she is currently dealing with and then apply the solutions that work in that particular instance.

It is rather like a ‘stowage toolbox’. Not every tool will fit every problem, but there is a solution to everything. Ultimately, if nothing in the toolbox works, then it’s necessary to restow the containers. It comes at a cost but it is always there as a backup.

What should be remembered about stowage is that virtually every decision that the stowage planner makes comes down to a tradeoff or compromise. If I make this decision, what effect will that have elsewhere? Often, good stowage is about coming up with the solution that has the least negative effect on something else.
Often, good stowage is about coming up with the solution that has the least negative effect on something else.

What makes stowage even more complex is that the coordinator often has to work with a combination of real-time data, forecast information and experience. As shipping is very dynamic, this information tends to change on short notice, which makes it even more challenging.

**Multi-Leg Planning |** Stowage for a single port cannot be viewed in isolation. An individual stowage instruction is just a snapshot of a vessel at a particular point in time and does not give any context to the evolution of the stowage. Each stowage has an impact on future ports in the rotation and is itself, a product of decisions taken earlier in the port rotation. For example, increasing the crane intensity in one port can result in a reduction in crane intensity in a later port.

**Planning with Average Weights vs. Specific Weights |** The most basic and probably also most common method of stowage planning is to plan with average weights – that is, by using consolidated load figures from a separate Excel sheet, for example, that shows the loading figures in a summarized format according to port of discharge and container type/size, which may or may not also include weight groups for further reference.

This summary is also referred to as a consolidated container booking forecast (CBF). The CBF is based on individual lines loadlists or CBF summaries received from agents respectively partner lines.

Using average weights gives an idea of the different weight of each port of discharge but lacks individual container weights and might therefore be misleading if used as the sole source of information, especially when trying to evaluate if stackweights are violated.

Also, stability and trim can only be evaluated very roughly with all bays loaded for one port of discharge when calculated at the same average weights.

At any rate, as many commercial stowage software solutions cannot even accommodate electronic loadlists, many shipping lines are forced to plan using average weights by default.
Considering Vessel Stability and Other Forces | Another obstacle that could prevent the planner from evaluating the exact impact of his or her stowage plan is that most stowage software has no class-approved or no exact calculations of, for example, the stability, trim and lashing forces.

The planners are limited by the calculation methods and lashing rules available in that particular software and the vessel profile information that was available and included by the manufacturer, which might not be complete unless the vessel is using the same software as the approved onboard loading computer.

This might lead to the planner being shown limited and incorrect information in his or her stowing software, thereby resulting in incorrect assessments and inefficient planning decisions. In turn this could require additional time to re-check the information displayed in the stowage software.

This could result in the stowage plan being repeatedly sent to the vessel for reviewing by the crew which leads to a time-consuming email exchange. The vessels crew usually only advises what values, i.e. lashing forces, stackweight etc., are exceeded as per the onboard loading computer from the initial stowage plan. After making changes the planner has to check again whether his plan is now acceptable or not and will again have to contact the vessel until all issues are settled.

As another solution for this problem some shipping lines have the vessels onboard software available in their planning centres additional to the software used for the stowage planning.

After having completely worked through the loading instructions the planner would load that file in the onboard software and cross-check it. If he needs to make amendments, he has to note them down and go back to his stowage planning software and change the plan – again limited to what he sees there.

Once changes to the bayplan have been completed, he would then have to load the updated file again on the onboard loading software to cross-check it again and repeat the process until all the problems have been solved.

Although still an extra step compared to actually planning with exactly the same software that is installed on board, this is at least a quicker means of sorting out issues in the stowage plan than exchanging emails with the vessel/terminal, especially as the planner does not depend on the response time of the vessel/terminal. ☞
Stowage planning with planning tools available on the market is tedious because of the repetitive work between the planning tool and loading computer.

Stowage planning with StowMan eases the planning since all functions are under one umbrella. Repeated work between planning tools is reduced.

Fig. 1

Fig. 2
Fig. 3
Stowage planning process with StowMan\[s\] including the optimizer shortens the planning time significantly.

Tool StowMan and the loading computer Seacos MACS3 is automatic. However, the task of creating the bayplan for rotation remains a manual one.
### 2.2 Planning with StowMan

However the most effective way to avoid all those steps is to use the on-board loading computer software already for the stowage planning.

With a 70% worldwide coverage of Seacos MACS3 by INTERSCHALT in terms of onboard loading software on container vessels the obvious choice for the stowage planning software is StowMan, based on MACS3 and thus able to give exactly the same calculations and results as seen onboard in the MACS3 system. The use of software operating with the same data and performing the same calculation the planner does not have to cross-check his results in another software or with the vessel.

This software can process loadlists with specific real container weights which gives the planner a big advantage compared to the planning with average weights: he can plan and evaluate the results of his planning far more accurately in all important fields to be observed such as stability, trim, stackweight and lashing forces.

The use of software operating with the same data and performing the same calculation the planner does not have to cross-check his results in another software or with the vessel.

Another advantage of planning with real loadlists is that it gives the opportunity to have all additional special cargo information such as dangerous goods, reefer or out of gauge cargo included in the loadlist avoiding time-killing and possibly defective manual input of this data like when planning with average weights and no electronic data for special cargo.

As a matter of course StowMan provides these advanced abilities to process loadlists, even of various kinds and formats.

Manual planning is tedious work | Whether planning with average weights or with loadlists and in addition to the previously mentioned cross-checking process with the vessel, a large part of the stowage planning in terms of time actually involves manually moving the containers from the loadlists into the designated positions.

Usually the planner has the general stowage arrangement for the ports already in his mind when starting to move containers / marking the loading positions. This general stowage arrangement he made considering the cargo mix received on the CBF in regards to the amount of containers to be loaded for each port of discharge, the mix of 20’, 40’, highcubes, 45’, special cargo and considering heavy, light or empty containers etc.

Whether or not the general stowage arrangement is a viable plan will only reveal itself once the planner has decided on where all or nearly all containers should be placed. It is not until then that all values for stability, trim, lashing, etc. can be known, once again assuming that all available data is accurate.

Therefore the planner might only become aware after several hours of tedious container moving / marking or even worse after re-checking in the onboard software or with the vessel by email that his assumed solution is not working out, having spent a lot of time altogether or partly in vain. Usually being under time pressure such situations may result in rather quick amendments that might not represent the optimum overall loading plan and accordingly create further disadvantages including less utilization capabilities as the voyage of the vessel goes on. ✎
2.3 Unique Benefits of StowMan[s]

Launched in September 2014, StowMan[s] is an optimized version of StowMan. The software is based on the latest optimization technology and provides cargo planners with loadlists within **30 seconds**. These loadlists are calculated by the optimizer based on all known rules and data and the preferences of the planner. The planner can change the preferences and re-run the optimizer. Out of all plans generated by the optimizer he can make his choice and, if needed, make corrections. Typically the final plan will be ready after 1-2 hours – compared to 4-6 hours with common planning tools and manual inputs.

**Planners view on the Optimizer** | While being able to use loadlists in StowMan is an advantage compared to planning with average weights, having loadlists plus the optimizer brings planning to a whole new level. This additional tool replaces nearly all of the tedious work such as moving containers from the loadlist to the bayplan by calculating suggestions for stowage plan arrangements for all the cargo within approx. 30 seconds, based on the planner’s guidance and objectives.

These stowage arrangement proposals made by the optimizer can be checked in a preview window referred to as a “solution pool” which also includes major stability data and may also be loaded to the bayplan views for more detailed checking. This means that unlike in the manual stowage process where the planner might need hours before he can check stability, trim and overall layout, he can re-check all the items immediately after this calculation time of 30 seconds, and decide whether or not this is the right method.

**The optimizer performs the tedious tasks in a matter of around 30 seconds.**

The planner may re-run the optimizer and change the objectives as often as he wishes in order to get different stowage proposals and compare them with each other. On top of the objective settings the planner may also e.g. define areas to be loaded for a specific port or block off areas either for certain ports or completely. The “solution pool” will keep all different proposals and enables the planner to switch back and forth within the different stowage proposals of the optimizer. This means that he can always refer back to an earlier proposal.

After he has decided on the most favorable stowage arrangement, he would then load it to the bayplan view and finalize the stowage including fine-tuning if necessary.

By using the available planning time rather for finding the best solution with the optimizer than for moving all the containers manually from the loadlist to the bayplan the planner can focus on his initial job of finding the best stowage layout and accordingly improving the quality of the stowage arrangement. This is exactly what we will prove with this case study.
2.4 Commercial Planning Tools

The market is dominated by six planning tools with a total market share of more than 90%. Besides their basic functionality of generating loadlists for placing containers on the vessel these tools perform additional calculations.

**Fig. 4**

<table>
<thead>
<tr>
<th>Company</th>
<th>Stowage Software</th>
<th>HQ</th>
<th>Market launch</th>
<th>Vessel profiles</th>
<th>Market Share</th>
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<td></td>
<td></td>
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<tr>
<td>Total Soft Bank</td>
<td>CASP</td>
<td>KR</td>
<td>1991</td>
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<td>NAVIS / XVELA</td>
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<td>INTERSCHALT</td>
<td>StowMan[1]</td>
<td>DE</td>
<td>2014</td>
<td>c.7,500</td>
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<td>Müller + Blanck</td>
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<td>DE</td>
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<td>AMT</td>
<td>SimpleStow</td>
<td>CA</td>
<td>2006</td>
<td>c.1200</td>
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<td>Opus Stowage</td>
<td>KR</td>
<td>2011</td>
<td>N/A</td>
<td>&lt;5%</td>
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The comparison shows that StowMan is the only tool on the market that supports the planners with functionality for all the planning demands listed above. As StowMan is “knowledgeable” of most of the rules that a planner has to keep in mind while preparing the stowage plan, the next logical step in the development of the product was a decision support function for semi-automatic planning – this is the optimizer within StowMan.

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### Software Features and Modules

<table>
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<th>Multi-leg</th>
<th>Loading software</th>
<th>Lashing</th>
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3

Case Scenario

Under controlled and realistic conditions
Case Scenario

3.1 The Procedure

In this case study we will prove the unique performance of StowMan[s]. As such cases cannot be performed in the real vessel operation of shipping lines without disturbing their business or without losing data from the stowage planning, it was necessary to map the real stowage planning in an isolated lab environment.

We carry out the following measures to make sure that the case translates back to the real world:

» All data concerning services, vessels, loadlists etc. are from a real, historic voyage of a vessel.

» The case procedure, e.g. the rules of the case, are described well and and reflect real planning. In addition, control activities have been carried out in order to ensure that the procedure is closely followed.

» The planners have been instructed about the vessel and the service in general, e.g. their basic knowledge is similar to that of the real planners.

» They plan port by port, getting the loadlist from the referee, an independent person, just when they start the planning for that port. The referee takes care that the planners do not exchange information.

» The definition of the criteria to compare the two plans are established in accordance with those that are used by planners as to make a “good” stowage plan.

Case Setup: System

The case study uses StowMan[s] in two settings:

Manual Planning: the positive features of the software, e.g. integrated hydrostatic checks, draft, trim, lashing calculations have all been switched off.

When a planner wants to check hydrostatics and lashing, he has to take his plan to another loading computer system, where he gets the result but cannot correct his plan.

This setting is called manual planning.

StowMan[s] Planning: the functions integrated in the software, e.g. the optimizer, hydrostatic and lashing calculation are all in use.

No time limits, no use of additional systems. This setting is called optimizer planning.
Case Setup: Data

Before starting a test run, a vessel’s voyage within a service has to be selected, and all the data required has to be collected and edited for the test. This work is done by planners not actively running this case study.

The required data are:

- The vessel profile for StowMan®
- Data file describing the arrival state of a vessel (cargo, ballast, bunker etc.)
- The service description with data for all ports of the rotation, e.g. max draft, no. of cranes and crane speed, port time, restow costs, company rules.
- The loadlists
- A forecast sheet for giving the planners some indications about typical cargo on the service without providing all details of the loadlists.
- Instructions about trim, maximum planning time (depending on the tool).
- These data are handed over to the planners performing the test. They have to confirm that the preparation is complete.

Case Setup: Team

To compare two different tools three planners are required:

Two planners to run the test and a third planner to act as a referee.

The referee has to ensure that both planners get exactly the same data. He takes care that they do not exchange any information. He collects the stowage plans and other results port by port, confirms the time taken for the planning and hands out the next loadfile.

The data collected in the test run will allow a re-run of the test. The planners have to comment their activities and decisions during the test in an electronic log.
Case Setup

at a glance

Fig. 5
The setup for the comparison of two stowage tools

TOOL

» StowMan\(^{(s)}\) with a semi-automatic decision tool optimizer

» Manual planning tool without integrated hydrostatic checks, draft, trim, lashing calculations

DATA

» Vessel profile

» Arrival state of vessel

» Service description including load forecast

» Loading per port

» Definition of target criteria

TEAM

» One planner for manual planning

» One planner for StowMan\(^{(s)}\) planning

» One planner as referee
3.2 The Planners

The cases are performed by a pool of stowage planners with more than 40 years of experience in planning at various shipping lines together. They make sure that the planning is done according to best practice of the industry and the results apply to real vessel planning.

**Thomas Bebbington**
Tom is head of Stowage Planning (Systems Deployment & Support), IS SEACOS ASIA maritime systems, an INTERSCHALT subsidiary.

Expert in the field of container terminal productivity improvements through innovative stowage coordination and vessel operations solutions. Over 15 years of experience in the container shipping industry both at sea and ashore with major players in the liner market.

He has sailed on container vessels up to 2nd Officer before moving ashore and into stowage planning. He has ten years experience of stowage coordination plus consulting on a number of high profile stowage and container terminal projects with Maersk Line.

He is co-author in three papers on stowage optimization with Prof. Rune Møller Jensen, IT University of Denmark.

**André Martin Nielsen**
André is stowage planner at INTERSCHALT maritime systems AG, Schenefeld, Germany.

Total 15 years of shipping experience from booking desk to boarding agent and stowage planner. He gained his experience as a planner while employed at China Shipping (Europe) Holding, Hamburg, from 2008 to 2015. In that time he planned vessels from TEU 1,250 to TEU 19,100 on services in Europe, Far and Middle East, Mediterranean, US Gulf. He is power user for CASP and StowMan for planning. For stability calculation he used Lashmate, MACS3, TSB Supercargo and Miranda.

His biggest planning achievement is the CSCL PACIFIC OCEAN, at that time the second-biggest container vessel in the world.

**Jes Tom Regner**
Jes is stowage planner at INTERSCHALT maritime systems AG in Schenefeld, Germany.

Jes has been working in the maritime industry for more than 20 years: he worked as a stowage coordinator/planner for eleven years at Hanjin Shipping European headquarters in Hamburg, before for four years as a waterclerk at Hanjin Shipping, handled all size of vessels both as planner and agent.

**Kian Hao Tan**
Kian Hao is stowage planner at IS SEACOS ASIA maritime systems in Singapore.

He started as an operations executive in Port of Singapore, managing the daily operations of the terminal. Later he worked on the stowage planning for the terminal.

After two years at PSA, he left for APL (American President Lines) and worked for one year on ship profiles for Powerstow stowage program.

Kian Hao Tan has a Bachelor Degree in Mechanical Engineering from the National University of Singapore (NUS).
3.3 Case Criteria

The following case study criteria (figure 6) was discussed between the planners involved in the case study. They described the goals, i.e. how the criteria should be applied, how they are measured within the test and how the (non)-fulfillment of the goals is rated.

Fig. 6
All criteria at a glance

Summary of case study criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial</strong></td>
<td></td>
</tr>
<tr>
<td>planning time</td>
<td>shortest</td>
</tr>
<tr>
<td>completed within max. hours</td>
<td>must</td>
</tr>
<tr>
<td>no. of new stowage attempts</td>
<td>n/a</td>
</tr>
<tr>
<td>crane intensity</td>
<td>yes</td>
</tr>
<tr>
<td>deadspace under deck</td>
<td>fewest</td>
</tr>
<tr>
<td>containers not loaded</td>
<td>fewest</td>
</tr>
<tr>
<td>restows</td>
<td>fewest + cheapest</td>
</tr>
<tr>
<td>Suez tier</td>
<td>minimum tiers</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td></td>
</tr>
<tr>
<td>lashing errors</td>
<td>within max. allowed + least errors</td>
</tr>
<tr>
<td>line of sight</td>
<td>no IMO violation</td>
</tr>
<tr>
<td>DG conflicts</td>
<td>none</td>
</tr>
<tr>
<td><strong>Stability</strong></td>
<td></td>
</tr>
<tr>
<td>GM</td>
<td>target value and within limits</td>
</tr>
<tr>
<td>BM</td>
<td>within max. allowed</td>
</tr>
<tr>
<td>SF</td>
<td>within max. allowed</td>
</tr>
<tr>
<td>TM</td>
<td>within max. allowed</td>
</tr>
<tr>
<td>draft acceptable</td>
<td>within limits</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
</tr>
<tr>
<td>trim target within coastal trip</td>
<td>closest to fixed trim target</td>
</tr>
<tr>
<td>trim target final port</td>
<td>closest to fixed trim target</td>
</tr>
<tr>
<td>ballast water</td>
<td>minimum</td>
</tr>
</tbody>
</table>
It is common sense that the quality of a stowage plan can be judged by these requirements.

In practice it is not possible to create a plan that would fully meet all the criteria at the same time. While some parameters like stability have to be within limits, the planner has to manage the trade-off between the others. All deviations from the optimum value have a penalty.

For many criteria we can give an estimate in USD. The better the plan the smaller is the overall deviation from the optimum state.

The planners who run the case study and the referees who control the execution are informed and agree on these rules.

<table>
<thead>
<tr>
<th>Measuring method / tool</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>referee</td>
<td>separate rating</td>
</tr>
<tr>
<td>referee</td>
<td>must</td>
</tr>
<tr>
<td>referee</td>
<td>none (for information only)</td>
</tr>
<tr>
<td>tool [measured ci]</td>
<td>USD/hour time in port/terminal</td>
</tr>
<tr>
<td>deadspace count</td>
<td>typ. freight rate to convert empty to USD</td>
</tr>
<tr>
<td>pier/ search loadlist</td>
<td>typ. freight rate to convert to USD</td>
</tr>
<tr>
<td>tool</td>
<td>USD-based on cost per restow</td>
</tr>
<tr>
<td>Suez canal charges</td>
<td>USD</td>
</tr>
<tr>
<td>tool [cond. check/ lash forces]</td>
<td>must</td>
</tr>
<tr>
<td>tool [cond. check/ visibility]</td>
<td>must</td>
</tr>
<tr>
<td>tool [cond. check/ DG]</td>
<td>must</td>
</tr>
<tr>
<td>tool [stab. results tab]</td>
<td>must</td>
</tr>
<tr>
<td>tool [status panel]</td>
<td>must</td>
</tr>
<tr>
<td>tool [status panel]</td>
<td>must</td>
</tr>
<tr>
<td>tool [status panel]</td>
<td>must</td>
</tr>
<tr>
<td>tool [status panel]</td>
<td>must</td>
</tr>
<tr>
<td>tool [stab. results tab]</td>
<td>must</td>
</tr>
<tr>
<td>tool [status panel]</td>
<td>separate rating</td>
</tr>
<tr>
<td>tool [status panel]</td>
<td>1.5% per 1m increased bunker costs, max. 3%</td>
</tr>
<tr>
<td>tool</td>
<td>separate rating</td>
</tr>
</tbody>
</table>
1. Financial Criteria

Planning time

Why is the planning time a factor when choosing a stowage tool? The reduced time for creating a stowage plan can have many positive effects:

» **Postponing the deadline** | The planner can postpone the deadline/cargo cut off which gives him the possibility to gather more cargo for the vessel.

» **Last minute changes** | The planner can make last minute changes or totally replan the vessel in situations where cargo will break away and thereby ensure that the next port will not have any effect on these changes.

» **Checking alternative stowages** | The planner has the possibility to create more plans to check alternatives for the planning and to analyze his possibility in the next ports.

» **Preplanning the voyage** | The planner can preplan the whole voyage and inform the cargoflow department if any space is left or if the vessel should make an AD HOC call in order to fully use all spaces onboard.

Overall more time equals more quality and possibilities.

In our case, the planners have to finish their plans within a time limit (depending on the service). The StowMan\(^{[a]}\) optimizer can generate many plans automatically within minutes, as suggestions/starting points for the planner, who has to select the “best one” and do some final work. The planner using the optimizer gets half the amount of time that the manual planner has to complete his work.

Number of new stowage attempts

Number of different stowage layouts for the whole cargo compared before finalizing the stowage

When planning manually, there is usually not enough time to make several different loading plans and compare the consequences for the stability, draft, trim etc. in order to find the very best cargo arrangement.

**Manual planning** | Due to this the planner can only assume the final loading plan result and whether it is workable / beneficial or not. If his assumptions are not right he might have to change his loading plan half way or re-start completely, in the worst case spending a lot of time to actually bring on the screen, moving container by container, what he already has in his mind as a stowage plan.

He might even find out after time consuming planning of 90% of the cargo that he actually can’t load everything and get further in time pressure to finish his stowage plan with the terminal waiting for the load instruction. However, time pressure could have a bad effect on the quality of the loading plan.

**Optimizer planning** | With StowMan\(^{[a]}\) the planner has the option to generate and check different loading plans of the same cargo and instantly check and compare the consequences for the stability, draft, trim etc.

Instead of the tedious and time-consuming work to move each and every container in the bayplan the planner can concentrate on finding the very best cargo arrangement and finalize that one with his full attention.

The number of stowage attempts should show the additional options available through StowMan\(^{[a]}\) compared to the manual planner and put it in relation to the time needed to finish the plan.
Crane Intensity is also a good indicator of how many cranes it makes sense to deploy on the vessel.

For example, if the stowage plan has a CI of four, a terminal can deploy any number of cranes up to four. If they deploy more cranes than the CI, the vessel will not sail any earlier because the port stay is still determined by that one crane with the most amount of work.

Therefore in this test set up the objective given was to supply the required CI and penalize in case it was underachieved. That way it should be ensured that reaching the required CI in all ports instead of partly over and partly underachieving is maintained.

Pro forma Cranes | This is the number of cranes that have to be deployed on this particular vessel/service in order for the ship to sail on time. This is initially derived by the liner operator informing the terminal how many moves they expect each week and how long the vessel may remain on the berth. From this, the terminal can work out the BMPH (berth moves per hour – total number of moves that can be done on the ship in one hour). The terminal also knows how fast each of their cranes operate on average, this is called GMPH (gross moves per hour). Once they have the required BMPH, they can inform the line how many cranes they should/can deploy. Once both parties sign this off, this is now referred to as the pro forma CI.

Penalties | If, for whatever reason, the vessel stays on the berth longer than the agreed pro forma time, costs start mounting. The port fees increase, the vessel’s diesel generators run longer. The vessel will need to go faster in order to reach the next port on schedule. To account for these increased operational costs, we add a penalty of USD 5,000 if the vessel exceeds the pro forma berth time, remaining alongside and working. This is what we have used in the calculations.

**Crane Intensity**

Crane Intensity (CI) is a calculation performed during the planning process to evaluate how many cranes should be deployed on a vessel when it is being loaded and discharged in a port.

- **Longest crane**: crane with longest working time.
- **Total working time on the vessel/working time of the longest crane** = Crane Intensity

Terminal cranes have a minimum separation distance needed between them. Therefore it is not possible to work two adjacent 40ft bays on the vessel simultaneously. This means that the longest crane is the one which is working two adjacent 40ft bays and will take longer than the other cranes.

Sometimes quick planning might be necessary due to time constraints and therefore not too many different stowage options might be checked while in other situations it would be beneficial to use the available time to the full extent to compare many loading plan options and thoroughly check for the very best arrangement.
**Dead space under deck**

**Unused space under deck** | A good stowage plan uses the available space on board most efficiently in order to have minimum slots remaining unused under deck in regards to the available cargo mix.

Ensuring to keep lost slots under deck to the minimum will enable the planer to increase the vessels overall utilization and as such becomes a vital argument in an economic sense.

To minimize unused slots under deck the planner has to consider both the stack weights and the stack height under deck and the mix of container types to be loaded for that specific port / bay.

A decent arrangement of highcube and standard height containers in the individual stacks matching the vessels specifications as well as an intelligent combination of the out of gauge units can lead to tremendous space savings.

**In our case the planners have to minimize the dead space, especially on the long legs. The number of lost TEUs in the final port is calculated by the tool, the loss is then rated by typical freight rates.**

**Containers not loaded**

As a matter of course transporting all intended containers is the main purpose of container shipping lines as such.

Any full container not loaded might lead to customer service failure in means of not shipping on the vessel intended by the customer and / or not fulfilling the agreed delivery time to final destination as well as potentially additional costs at the port of loading for storage, re-nomination fee for next vessel etc.

Any empty container not loaded might lead to storage charges, necessity to re-route or lease additional empty containers at costs or even reject full cargo at port of loading if the before mentioned is no option. An excellent stowage plan arrangement ensures to maximize the space available for loading at each port within stability and lashing force limits while keeping as many options as possible for future cargo to be loaded and as such stay flexible to cover future loadings for any port of discharge and any cargo mix.

An indicator to measure in how far this is the case is to count how many containers were actually left behind.

In our test these containers will be calculated with the loss of the freight rate.
Restows

The number of containers to be shifted by crane from their original position on board is called restows.

To shift containers results in both scenarios in extra crane moves and therefore additional operation time as well as extra costs as the terminal will usually charge each restow. Restow costs will lead to a direct increase of operational costs while on top additional operation time might delay the vessels departure and therefore indirectly also increase fuel costs as to having to proceed to the next port at a higher speed causing higher fuel consumption. There are four main reasons for making restows:

- Change of destination (COD) of a container after it has been already loaded
- Space issues at present port of loading
- Stability / lashing force issues
- Minimize Suez Canal fee related to tiers loaded on deck

For this test setting restows related to CODs do not apply as no destinations are changed. Space related restows include for example using temporary positions on top of earlier port of discharge ports that require the containers on top to be removed at a later port in order to discharge the cargo below.

Another example would be to shift containers already loaded in previous port(s) in order to use the space in this bay for other port of discharge cargo and move the containers already loaded to other positions.

Stability / lashing force related restows might become necessary in order to keep the vessel within its allowed limits which may change along the voyage with changing the overall draft and stability situation due to constantly loading and unloading.

A part of the Suez Canal fees are related to the number of tiers loaded on deck. This means that less tiers loaded on deck will result in fewer Suez Canal fees and therefore save operational costs. If there are only few containers loaded in the last tier at e.g. the last port in a region and there is still other space available in lower tiers it might be cheaper to restow some containers compared to the additional Suez Canal tier surcharge. In general, some restows might be unavoidable due to the constraints faced at the port of loading or even benefit the overall situation by e.g. allowing to finally load more containers overall.

Other restows might result from wrong decisions taken in earlier ports and this is where the planner’s utmost attention is necessary to focus on preventing to create such situations by all means with a good loading arrangement. Creating minimum restows is therefore one of the major goals for a good stowage plan and in terms of saving costs.

In the event restows have to be considered, the planner has to carefully evaluate for each situation if the time and costs involved for making restows is of advantage or not for the overall situation, e.g. compare the additional costs and time to the benefit of being able to load additional containers.

In the case study restows are charged with the average terminal fee for the geographical region.
2. Safety Criteria

Lashing errors

When we speak about lashing errors we should understand what lashing is and how this is done. Lashing is done via the lashing bridges which enable the vessel to fix lashing bars to containers higher up the stack which is not possible on older vessels that are not equipped with lashing bridges.

The result of this ability to secure the bottom of the 4th tier (or 5th tier on vessels with three tier high lashing bridges) is that the lashing forces are reduced, thus allowing tiers of containers to be stowed higher on deck than was previously possible. If the lashing forces are not 100% or below, the vessel is normally not allowed to continue its voyage due to safety reasons. Therefore this information is crucial for the planner in order to create a workable plan.

In the case study the planners are advised to stay within the allowed lashing forces for all containers.

Suez Tiers

When loading a service that is passing through the Suez Canal it needs to be observed to load only the minimum tiers on deck necessary as the Suez Canal fee includes a variable surcharge according to the tiers of containers actually loaded on deck.

This surcharge depending on the size and the tier may result in additional costs of approx. USD 10,000 to 30,000 per tier (different tiers have different surcharge).

The ability of planners and slot controllers to foresee the number of tiers needed, and arrange loadings up to that level while minimizing the deadspace under deck can make a huge difference in the Suez canal costs and as such help to keep operational costs at a minimum and ensure a profitable voyage.

In this case the surcharge for additional tiers will be compared between the plans.
**Line of sight (LoS)**

The line of sight means the visibility from the navigation bridge, in short terms the vessel view. The SOLAS (International Convention for the Safety of Life at Sea) line of sight rules state that:

**The view of the sea surface from the bridge shall not be obscured by more than two ship lengths, or 500m, whichever is less.**

These rules were written at a time when vessels were much smaller than today. For the majority of vessels that are stowed on the Asia – Europe trade today, the 500m rule applies.

The Line of Sight can be seen in the vessel stability program. Below is an illustration of how much loss in utilization there is when the rules are applied.

For the planner this is a very important factor in order to have as many containers as possible onboard but also to follow the rule as the vessel is not allowed to sail if this is not fulfilled.

**In the case study the LoS rules have to be fulfilled for a valid plan.**

---

**Fig. 7**

LoS rule applied to a container vessel

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Visibility</th>
<th>Panama full 399.7m</th>
<th>Panama 2000 500.0m</th>
<th>Panama ballast 599.5m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not in accordance</td>
<td>454.4m</td>
<td>(not OK)</td>
<td>(OK)</td>
<td>(OK)</td>
</tr>
</tbody>
</table>
Dangerous Goods Conflicts

Dangerous goods (DG) also referred to as hazardous containers are not limited to specific types of containers.

All hazardous cargo is covered by the IMDG code in terms of what can be loaded into containers, what class it is and the UN Number for each individual commodity.

The Storck guide also covers the segregation requirements needed onboard the vessel to ensure that commodities that are not compatible do not get loaded without the required separation.

The planners consider the general guidelines for the stowage of hazardous containers from the shipping lines perspective:

- No hazardous cargo to be stowed in bay 01 and 02
- No hazardous cargo to be stowed in the outermost row on deck in any bay, except fumigated units
- No hazardous cargo to be stowed in stacks outside the hatchcover which are liable to be damaged by seawater from below
- No hazardous cargo to be stowed in first tier positions that rest on two different hatchcovers
- Hazardous cargo may be loaded underdeck as per the vessels document of compliance and company in-house rules

From a more general perspective, when possible, the hazardous containers can be stowed on the port and starboard side of the vessel (as depicted). Doing this in each bay with hazardous cargo will minimize the amount of segregation problems when the vessel is being stowed.

All above named rules are normally done manually by the planner and due to this fact the shipping industry has seen some accidents on sea. Therefore is it very important for the planner to have a good tool which will support him and warn him if there are any problems.

In our case the planners count the number of violations to DG rules for each stowage plan. The goal is to have no violations – otherwise it would not be a valid plan.
3. Stability

Four main forces need to be within the permitted ranges for the vessel to be allowed to sail. The planner must keep with these criteria and within these limits when arranging the cargo:

- GM – metacentric of height
- BM – bending moments
- SF – shearing forces
- TM – torsion moments

The acceptable values are defined individually for each vessel by the classification society based on the ship’s drawings and further ship documents provided by the shipyard. On top there are only certain trim and draft combinations allowed.

Accordingly these criteria are a must to be fulfilled and are the limits in which the planner is allowed to act and to arrange the cargo.
4. Efficiency

Optimum Trim

Trim is the position of the vessel forward/bow (front) or aft/stern (back) part or even keel. The optimum trim influences the fuel oil consumption which has an impact on the economic as well as environmental outcome.

In order to reach the optimum trim of the vessel per loaded cargo, it is necessary to be considered during stowage.

Too much aft trim will increase the friction on the vessel caused by the stern being in the water. This will increase fuel consumption.

When there is too much trim forward, the rudder and propeller may not be sufficiently submerged. Particularly at low speeds, it will be difficult to control the vessel.

Trim target coastal

The trim target for the coastal voyage is most important for ports with draft (depth) restriction. For such cases it is important the vessel has "even keel", this means even in the water, good example is the Hamburg Port.

Fig. 8
Too much weight aft. Picture Credit: Thomas Bebbington
Trim target final port

As mentioned in above texts a trim with too much to the forward part can be a problem if not sufficiently submerged. Particularly at low speeds, it will be difficult to control the vessel. But if the vessel is submerged to ideal draft with the right trim the vessel will save fuel cost due to better efficiency of the propeller and engine.

These two points are very important for the planner especially how he has reached them. The ideal plan is this done by cargo. The second option is to use ballast water.

In the case study the planner has a trim target for the long leg (final port RTM). As a typical value from trim efficiency calculations, a 1.5% penalty on the fuel consumption per 1m of trim deviation will be applied.

Fig. 9
Too much weight forward. Picture Credit: Thomas Bebbington
**Ballast water**

The vessel will always carry water in order to fix the stability of the vessel. Some ballast water tanks are located all over the vessel as per the picture (page 44 & 45).

Furthermore the vessel has heeling tanks which are used to stabilize the vessel during discharging and loading but can also be used to even out smaller differences of the cargo load onboard starboard- and portside (right/left). Ballast water has an ambivalent effect on the overall condition and performance of the vessel.

On the one hand it helps to stabilize the vessel when the cargo is not able to give the vessel the required condition in order to sail or give 100% performance to the vessel. On the other hand every ton ballast onboard is tons which could have been used to load paying cargo or which influences the fuel oil consumption and therefore the environmental impact.

**Reducing the intake of ballast water to open space/tons to paying cargo is one of the main targets for increasing efficiency, which is the strategic approach.**

In the case study the ballast water intake for both plans will be compared direct.
Fig. 10 – Ballast water usage in stowman.

The top is a longitudinal cross-section of the vessel with moments and ballast tanks, the bottom one shows the tanks in a top view.
Case Study: StowMan
[4] Case Execution

Service, Case and Results
4.1 The Service: Asia-Europe Service

The Asia Europe services are the number one service from Europe to Far East for the majority of the liner operators.

The service has a high ranking position for the organization and is normally used to introduce the newest of the newly built large vessels such as the 19,000 TEU vessel used in this case study.

Service Information | The service we used is a weekly service. It is designed for a 77-day round trip. The service is operated with eleven vessels of comparable sizes.

East Bound (EB) Voyage – Europe to Asia Port Rotation:
Felixstowe GBFXT ➔ Rotterdam NLRTM ➔ Hamburg GEHAM ➔ Zeebrugge BEZEE ➔ Rotterdam NLRTM ➔ Port Kelang MYPKG

The challenges for EB stowage is the huge amount of empties to last POD Ningbo which needs to be loaded the first port of loading (POL) Felixstowe where the storage cost are normally very high.

The double call of Rotterdam is executed in order to bring these big vessels to Hamburg. The Hamburg call is very important due to the high value of WB and EB cargo.

The problem of the Hamburg call is the draft restriction which for these vessel types is 12.5m by normal water level so in times with a lot of cargo it is very important to trim the vessel by cargo. The Zeebrugge call is known for its very heavy cargo with an average weight of 26 tons per TEU. The last call at Rotterdam defines the overall difficult cargo mix of the service with very heavy containers and empties, especially POD Port Kelang with mostly heavy cargo and nearly no empties.

West Bound (WB) Voyage – Asia to Europe Port Rotation:
Port Kelang MYPKG ➔ Yantian CNYTN ➔ Qingdao CNTAO ➔ Shanghai CNSHA ➔ Ningbo CNNGB ➔ Yantian CNYTN ➔ Singapore SGSIN ➔ Port Kelang MYPKG ➔ Felixstowe GBFXT

One of the challenges of the WB stowage is having a vessel which is able to leave Port Kelang on the 1st call without any loadings. On the WB stowage there is a double call at Port Kelang and Yantian which will generate coastal cargo. The cargo mix from Far East is much more suitable for the fully loaded vessel design as the average cargo weight is much less than on the EB stowage.
4.2 The Case: Asia-Europe Service

Voyage

For the case study the EB voyage was chosen because this is the more challenging set of port calls. There is a much more complex cargo mix to deal with, including high volumes of empty containers in the early ports, high volumes of very heavy containers (particularly 20ft units) in the later ports, hazardous cargo, reefer container and out of gauge units.

<table>
<thead>
<tr>
<th>Build</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall length</td>
<td>400.0m</td>
</tr>
<tr>
<td>Overall beam</td>
<td>58.6m</td>
</tr>
<tr>
<td>Maximum draught</td>
<td>16.0m</td>
</tr>
<tr>
<td>Deadweight</td>
<td>187,673 tons</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>25.1 knots</td>
</tr>
<tr>
<td>Maximum capacity</td>
<td>19,000 TEU</td>
</tr>
<tr>
<td>Reefer containers</td>
<td>1,000 TEU</td>
</tr>
</tbody>
</table>

Port Rotation:
Felixstowe GBFXT ▶ Rotterdam NLRTM ▶ Hamburg GEHAM ▶ Zeebrugge BEZEE ▶ Rotterdam NLRTM ▶ MYPKG Port Kelang

Fig. 12
Pro forma description

<table>
<thead>
<tr>
<th>Port rotation</th>
<th>GBFXT</th>
<th>NLRTM</th>
<th>DEHAM</th>
<th>BEZEE</th>
<th>NLRTM</th>
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<td>Pro forma moves</td>
<td>6,000</td>
<td>3,500</td>
<td>5,500</td>
<td>3,000</td>
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<td>Pro forma crane intensity</td>
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<td>4-5</td>
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<td>136</td>
<td>146</td>
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<td>133</td>
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<td>Berthing side (P/S)</td>
<td>PORT</td>
<td>PORT</td>
<td>PORT</td>
<td>STB</td>
<td>PORT</td>
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<tr>
<td>Crane outreach (Row)</td>
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<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
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<tr>
<td>Crane separation (bet. bays able to work)</td>
<td>40</td>
<td>40</td>
<td>40</td>
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<tr>
<td>Max draft alongside (m)</td>
<td>17</td>
<td>16</td>
<td>13.5</td>
<td>15.5</td>
<td>16</td>
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<td>Max HC on deck</td>
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<td>Min draft alongside (m)</td>
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<td>13</td>
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<td>Max. departure draft (m)</td>
<td>17</td>
<td>16</td>
<td>12.5</td>
<td>15.5</td>
<td>16</td>
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</table>
1st port FXT
6,691 TEU discharge
With 17,028 TEU the vessel arrives fully loaded
6,691 TEU immediately discharged at FXT
ROB after discharge are 10,337 TEU, with ZEE, HAM and RTM as POD
Dead space under deck with this cargo is 195 TEU
The trim is 1.64 m aft with 15,717.3 mt ballast

1st call RTM
3,804 TEU discharge only

3rd port HAM
5,871 TEU discharge
4,763 TEU load
Draft and high restrictions; Setup for leaving Europe in terms of optimum trim ballast water restows

4th port ZEE
3,388 TEU load
662 TEU discharge

2nd call RTM
3,917 TEU load, no discharge
Very high no. of very heavy 20’ containers

Arrival state of the vessel at 1st port FXT

- With 17,028 TEU the vessel arrives fully loaded
- 6,691 TEU immediately discharged at FXT
- ROB after discharge are 10,337 TEU, with ZEE, HAM and RTM as POD
- Dead space under deck with this cargo is 195 TEU
- The trim is 1.64 m aft with 15,717.3 mt ballast

Load lists
Numbers & Challenges
Fig. 13 – Loadlist overview
At this point the test run with manual planning and optimizer planning starts. The planning starts with FXT. This port is especially important to lay the groundwork for the correct crane split in Asia since the intention is to load the highest number of TEU out of all four loading ports.

Not only planning for FXT, the planners need to consider the next port RTM as it is purely a discharge call, with a total of 3,804 TEU discharged. If the planner overlooks the RTM call, he may have to incur restows or add additional but unnecessary ballast water to maintain the seaworthiness of the ship, in order to get to HAM. Thus, this is essentially a stow built for two ports.

With the following two ports, HAM and ZEE, special attention will have to be paid to the terminal restrictions. Both ports have only cranes that can work up to eight HC high, with HAM having another restriction in the form of draft restriction at 12.5m departure draft.

Therefore, it is important to check for these constraints at RTM port, since the cranes here are taller and can make changes to the containers at the top tier, in order for operations in those two ports to proceed.

HAM has close to 3,000 loading boxes and 3,500 discharging boxes, making it the busiest port in this eastbound voyage.

With BEZEE, second-last port of this service, there is heavy DG loading for CNTAO, MYPKG and CNSHA, totalling around 200 DG cargo. For the last port of the rotation RTM, the potential challenge faced by the planner will be that the boxes to be loaded are the heaviest among all four ports at 10.9 tons per TEU, with a significant proportion of laden containers compared to earlier ports.

Prior knowledge of this is critical to prepare empty bays for such heavy boxes, reducing the potential to incur huge lashing errors and thus poor utilization of the vessel’s capacity.

The summary of all moves in total between Felixstowe and Rotterdam, i.e. those planned in this case study, is shown in figure 14. A total of 16,791 TEU of cargo is added to the vessel, with all of them belonging to Asia. No coastal cargo is added in this leg of the service.

### Fig. 14
Summary of the service loads/discharges/discharges in the Asia-Europe service case

<table>
<thead>
<tr>
<th>Summary</th>
<th>Cntr</th>
<th>Total20</th>
<th>Total40</th>
<th>TEU</th>
<th>Weight</th>
<th>Full20</th>
<th>Full40</th>
<th>Full Weight</th>
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<td>GBFTX (ROB)</td>
<td>6.137</td>
<td>1.937</td>
<td>4.186</td>
<td>10.337</td>
<td>88.085</td>
<td>1.937</td>
<td>4.146</td>
<td>87.903</td>
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<td>-6.137</td>
<td>-1.937</td>
<td>-4.186</td>
<td>-10.337</td>
<td>-88.085</td>
<td>-1.937</td>
<td>-4.146</td>
<td>-87.903</td>
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<tr>
<td>NLRTM (ROB)</td>
<td>10.072</td>
<td>3.353</td>
<td>6.613</td>
<td>16.791</td>
<td>155.803</td>
<td>1.802</td>
<td>3.511</td>
<td>139.940</td>
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</table>
4.3 Results & Conclusions

The eastbound voyage, stowing the European ports was chosen primarily because this is the more challenging set of port calls. There is a much more complex cargo mix to deal with, including high volumes of empty containers in the early ports, high volumes of very heavy containers (particularly 20ft units) in the later ports, hazardous cargo, reefer container and out of gauge units.

The voyage was almost completely full on departure. The intention was to showcase the ability of StowMan[s] to handle even the most complex services and cargo mixes. Both planners running the scenarios have approximately the same experience.

This complex cargo mix also made it possible to demonstrate that even with such a challenging set of stowages, StowMan[s] still allows the planner to exceed the capabilities of manual planning and produce a better end result.

Due to the complex nature of these stowages, the main focus points for both planners in order to increase financial efficiency were as follows.

1. Planning Time Using StowMan[s]

The planner can run an average of five simulations of the stowage for each port call. With multiple solutions to choose from, the planner is able to evaluate the different options and then decide which is best for the targets he is trying to achieve.

In contrast it was only possible to complete the manual plan once (with minor adjustments) and still remain within the time limit allowed. Planning with StowMan[s] took 31% less time overall than with the manual plan, to result in a saving of USD 500, calculated at USD 3.125 a minute.

2. Reducing lost space and thus loading more cargo

As the StowMan[s] planner was able to run multiple scenarios, there was time for him to focus on the different strategic approaches. The manual planner had to spend much more time working with individual containers to try and get the correct mix of containers underdeck in order to maximize the space available.

Since StowMan[s] is able to deal with these time-consuming and tedious tasks within a matter of seconds, the result was that by the time the vessel reached Rotterdam, StowMan[s] had 350 TEU of lost space (dead space) under deck against the manual plan that had 426 TEU calculated at USD 200 per TEU.

This is a difference of 19%, which meant that in the final port, the manual planner had to roll 135 containers charged at USD 300 per TEU, whereas the StowMan[s] planner was able to load all the containers onboard. This is a 1.3% increase in vessel utilization.
Because StowMan enabled the vessel capacities to be used much better for each of the stowages in the earlier ports, it had the upper hand when it came to the final restow counts.

Overall, the StowMan final plan had 52 restows in Rotterdam and 233 in Port Klang, charged at USD 150 in Europe and USD 125 in Asia. This is a decrease of 55% compared to the manual plan with 223 restows in Rotterdam and 393 in Port Klang to account for the empty containers that overstow the Port Klang full cargo to be discharged.

Both the StowMan and manual stowages managed to achieve the pro forma crane intensities (CI) in all ports with the exception of the final port. The manual plan achieved a CI of 4.8 and the StowMan plan achieved 3.6.

Despite the lower crane intensity, the pro forma number of cranes was based on a move count of 4,000 units. In reality, the move count was only 2,400 units.

This means that both vessels would be able to sail within the pro forma berthing window and neither would have needed to increase speed to remain on schedule and arrive at the Suez Canal in time for the pre-booked transit, although StowMan required one extra shift in RTM at USD 5,000 per shift.

Since neither vessel needed to speed up, there was no corresponding increase in fuel consumption.
Final Conclusions

A comparison of the costs for the stowages and their quality shows a big difference, with StowMan\textsuperscript{s} having a clear edge. For the main focus points 1-4, StowMan\textsuperscript{s} is far superior to manual planning, even when the manual stow is done by an equally experienced planner.

The main focus points show that StowMan\textsuperscript{s} is clearly superior to manual planning.

Point number 5 was least important for both planners. Had it been higher up on the priority list, StowMan\textsuperscript{s} could easily have handled it. The nature of stowage is that one has to make trade-offs or compromises to achieve a bigger gain elsewhere.

StowMan\textsuperscript{s} planning resulted in an increase of USD 74,794 on only one voyage.

When contrasting the trim and ballast in the manual plan to the fact that the planner had to leave 133 empty containers behind, the StowMan\textsuperscript{s} planner made better choices earlier on. This gave the upper hand to StowMan\textsuperscript{s} and resulted in savings of USD 74,794 on only one voyage.

The increase of 3.9 million USD is an extrapolation based on one departure of 11 vessels in service from Europe to Asia every week.
## Fig. 15
Results of Asia-Europe service – case at a glance

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Manual planning</th>
<th>StowMan[i] planning</th>
<th>Manual planning results in USD</th>
<th>StowMan[i] planning results in USD</th>
<th>Deviation in percent</th>
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<td>Number of new stowage attempts</td>
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<td>Dead space under deck</td>
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<td>Restows</td>
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<td>52 cntrs in Europe, 233 cntrs in PKG</td>
<td>82,575</td>
<td>36,925</td>
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<td>Suez tier</td>
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<td>Increased results, one trip eastbound</td>
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<td>INCREASE OF THE RESULTS, 52 trips eastbound / year with 11 vessels</td>
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Logbook
**Case Study:** StowMan

**Loadlist**

**Fig. L 1:** Asia-Europe service loadlists Part 1  
Felixstowe – Rotterdam – Hamburg – Zeebrugge – Rotterdam

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## Case Study: StowMan

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Felixstowe – Rotterdam – Hamburg – Zeebrugge – Rotterdam | Summary

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<th>OOG40</th>
<th>HC20</th>
<th>HC40</th>
<th>St20</th>
<th>St40</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBFXT (ROB)</td>
<td>6137</td>
<td>1937</td>
<td>4186</td>
<td>10337</td>
<td>88085</td>
<td>1937</td>
<td>4146</td>
<td>87903</td>
<td>0</td>
<td>40</td>
<td>182</td>
<td>6</td>
<td>65</td>
<td>14</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>11</td>
<td>3146</td>
<td>1926</td>
<td>1040</td>
<td>14</td>
</tr>
</tbody>
</table>

| Load 10072 | 3353 | 6613   | 16719   | 155803| 1802 | 3511   | 139940 | 1551863  | 7    | 120 | 214      | 63    | 4     | 14    | 0     | 5169  | 3353 | 1444 | 106 |


| NURTM (ROB) 10072 | 3353 | 6613   | 16719   | 155803| 1802 | 3511   | 139940 | 1551863  | 7    | 120 | 214      | 63    | 4     | 14    | 0     | 5169  | 3353 | 1444 | 106 |

| NURTM (ROB) 10072 | 3353 | 6613   | 16719   | 155803| 1802 | 3511   | 139940 | 1551863  | 7    | 120 | 214      | 63    | 4     | 14    | 0     | 5169  | 3353 | 1444 | 106 |
Case Study: StowMan

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Fig. L 3: Port 1 – FXT | Manual planning
Fig. L 4: Port 1 – FXT | StowMan[S] planning
LOG BOOK FXT

LOG BOOK FXT

GBFXT SPECIFICS | Forecasted to load the highest number of TEU out of all four loading ports, FXT is especially important to lay the groundwork for the correct crane split in Asia, by focusing on bigger Asia ports like MYPKG and CNNGB. In addition, planners will have to consider that next port RTM is a pure discharge port, so this is essentially a stow built for two ports.

<table>
<thead>
<tr>
<th>MANUAL PLANNING</th>
<th>StowMan\textsuperscript{[c]} PLANNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning time</td>
<td>2 hours</td>
</tr>
<tr>
<td>Attempts</td>
<td>1</td>
</tr>
<tr>
<td>Containers not loaded</td>
<td>0</td>
</tr>
</tbody>
</table>

Focus was to work on bringing the GM down to enable higher tiers to be loaded in later ports

Loaded the MTY units under the MYPKG cargo to reduce the restow in MYPKG but also to help in bringing down the GM

9,000mt of ballast added manually to counteract shear force issues on the aft end of the vessel

In hindsight, I would have loaded one tier less of MYPKG cargo on deck as this had to be restowed later in order to load MTY units on top

Virtually no time lost in moving from the StowMan Planning system to MACS3 for checking stability and lashing since this is the way I have always been planning in the past

7 runs/stowages made with one which perfectly match my requirements. Very small changes were made by me manually

Only 4 corrections/restows needed for lashing forces caused by the Far East stowage

Optimizer added about 2,000 tons of ballast water to get vessel even keel

The consideration of the discharge call in RTM was already taken into account by optimizer settings that the planner did

Comment to Figs L3 + L4: Port 1 – FXT | Comparison
LOG BOOK RTM (wb)

**NLRTM SPECIFICS** | A discharge only call, with a total of 3,804 TEU discharged. Much of the work should have already been done while planning for FXT. This port is also the last port to consider the lower crane height requirement in the next two ports – HAM and ZEE. Any bays / stacks that are too high for HAM and ZEE cranes will have to be changed here. There also needs to be monitoring of the allowable draft limits for HAM.

<table>
<thead>
<tr>
<th>MANUAL PLANNING</th>
<th>StowMan(^{(s)}) PLANNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning time</td>
<td>5 mins</td>
</tr>
<tr>
<td>Attempts</td>
<td>1</td>
</tr>
<tr>
<td>Containers not loaded</td>
<td>0</td>
</tr>
</tbody>
</table>

- Discharge call only
- Ballast was unchanged and vessel sailed at even keel
- About 3,000 tons of ballast water was discharged by the optimizer to get even keel
- One restow made caused by Far East stowage

**Comment to Figs L5 + L6: Port 2 – RTM (wb)**

**LOG BOOK RTM (wb)**

**NLRTM SPECIFICS** | A discharge only call, with a total of 3,804 TEU discharged. Much of the work should have already been done while planning for FXT. This port is also the last port to consider the lower crane height requirement in the next two ports – HAM and ZEE. Any bays / stacks that are too high for HAM and ZEE cranes will have to be changed here. There also needs to be monitoring of the allowable draft limits for HAM.

<table>
<thead>
<tr>
<th>MANUAL PLANNING</th>
<th>StowMan(^{(s)}) PLANNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning time</td>
<td>5 mins</td>
</tr>
<tr>
<td>Attempts</td>
<td>1</td>
</tr>
<tr>
<td>Containers not loaded</td>
<td>0</td>
</tr>
</tbody>
</table>

- Discharge call only
- Ballast was unchanged and vessel sailed at even keel
- About 3,000 tons of ballast water was discharged by the optimizer to get even keel
- One restow made caused by Far East stowage

**Comment to Figs L5 + L6: Port 2 – RTM (wb)**
Bayplans

Fig. L 5: Port 2 – RTM (wb) | Manual planning
Fig. L 6: Port 2 - RTM (wb) | StowMan planning
Bayplans

**Fig. L 7:** Port 3 – HAM | Manual planning
Fig. L 8: Port 3 – HAM StowMan planning
With 3,000 containers to be loaded and 3,500 to be discharged, Hamburg is the port with the highest number of moves on the eastbound voyage. The planners need to take note of the crane height limit of max. eight HC and the departure draft of 12.5m. With about 10,000 TEU the vessel is half loaded when leaving Hamburg.

**DEHAM SPECIFICS**

Concentration on loading the forward and aft ends of the vessel to leave space in the center to load the very heavy units that will come in the next two ports.

Ballast ex DEHAM was 21,577mt but this was just to solve the bending moment issues. This will solve itself in the next ports as it will be loaded the heavy 20fts.

Again, not much time lost checking stability and lashings.

6 runs/stowages made; very small changes were made manually.

**MANUAL PLANNING**

<table>
<thead>
<tr>
<th>Planning time</th>
<th>1 hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempts</td>
<td>1</td>
</tr>
<tr>
<td>Containers not loaded</td>
<td>0</td>
</tr>
</tbody>
</table>

**StowMan[s] PLANNING**

<table>
<thead>
<tr>
<th>Planning time</th>
<th>1.5 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempts</td>
<td>6</td>
</tr>
<tr>
<td>Containers not loaded</td>
<td>0</td>
</tr>
</tbody>
</table>

**20,000mt**

less ballast needed for StowMan[s] to reach target for Hamburg port

1 vs. 1.5 hours

1 vs. 6 attempts

Comment to Figs L 7 + L 8: Port 3 – HAM | Comparison
**BEZEE SPECIFICS** | For the second last port of this service with 3,400 TEU to be loaded and 660 TEU discharged. There is heavy DG loading for CNTAO, MYPKG and CNSHA, totaling around 250 TEU. Like DEHAM, BEZEE also has crane height restriction which needs to be taken care of.

<table>
<thead>
<tr>
<th>MANUAL PLANNING</th>
<th>StowMan[^{(a)}] PLANNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning time</td>
<td>1 hour</td>
</tr>
<tr>
<td>Attempts</td>
<td>1</td>
</tr>
<tr>
<td>Containers not loaded</td>
<td>0</td>
</tr>
</tbody>
</table>

- High numbers of heavy 20ft units in this port that ended up in the bottom of the vessel which did not help in keeping the GM down but there was no alternative realistic option.
- Ballast onboard was slightly less at 20,184mt as the weight started to be loaded in the center of the vessel.
- Without the optimizer, it was more challenging and time consuming to reduce the dead space under deck, 360 TEU lose.
- 2 runs/ stowages made.
- Stowage made by the optimizer hit spot on.

- No restow done.
- Vessel sailed with even keel with additional 7,000 tons of ballast.
- Dead space on departure was only 195 TEU.

**Comment to Figs L 9 + L 10:** Port 4 – ZEE | Comparison

\[^{(a)}\] the time required for StowMan\[^{(a)}\] to complete the stowage

\[^{(a)}\] the dead space used by StowMan\[^{(a)}\] on departure

\[^{(a)}\] 1 vs. 0.5 hours

\[^{(a)}\] 1 vs. 2 attempts

\[^{(a)}\] 123
Bayplans

**Fig. L 9: Port 4 – ZEE | Manual planning**
Case Study StowMan

Bayplans

Fig. L11: Port 5 – RTM (eb) | Manual planning
Case Study StowMan

Fig. L 12: Port 5 – RTM (eb) | StowMan planning
At the last port before the eastbound voyage another 3,900 TEU have to be loaded. On the loadlist are many heavy 20’cntrs, surprisingly also about 100 reefer (while previous POLS only had a few). The vessel will leave RTM with a load of 16,800 TEU, which means that it is practically fully loaded. The consequences of any wrong decision taken in the previous ports will be shown in this port.

NLRTM was by far the most challenging stowage in terms of balancing getting the cargo onboard and reducing the restows.

Decision to roll some of the MTY containers because the cost of leaving them behind

If the dead space had been better kept to a minimum earlier, it would probably have been possible to load more of the MTY units

Final ballast was reduced to only 1,809mt and the trim –1.97m by the bow (optimal trim achieved with minimum ballast)

75 lashing errors had to be resolved before finishing the stowage

Despite the rolling of MTY containers this is an acceptable stowage

179 restows in Rotterdam, 393 restows in Port Klang

Total load 16,522 TEU

10 runs / stowages were made with the optimizer and some manually work, a combination of the result from the optimizer and some manual work

Loading all cargo with minimum of restows

Trim off by 1 meter due huge amount of 20 heavy box to all destinations and only aft ship free for loading

The overall plan is good as the optimizer helped to reduce dead space, load all cargo, a minimum of restows and an acceptable departure condition

The vessel is also able to sail from PKG without any loadings with little adjustment to the ballast

46 restows made due to lashing errors only, 233 restows in Port Klang

Total load 16,791 TEU

75%

fewer restows done in the optimizer stowage

1,6%

higher vessel utilization when using the optimizer

4 vs. 2 hours

1 vs. 10 attempts
Comment to Figs L 11 + L 12:
Port 5 – RTM (eb) | Comparison
If you wish to benefit from the advantages of StowMan®,
don’t hesitate to contact us!

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