Analysis of estimations, quotations and actual costs related to dry-docking

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Preface

This thesis and research is inspired by real projects with concerns to dry-docking. The thesis could not have been completed without access to necessary information about such projects. I would give a special thanks to Wilhelmsen Ship Management in Malaysia and especially Head of Dockings & Special Projects Mr. Sanjiv Rastogi for his time and effort for help and supervising. You helped with information, knowledge and real data.

I also would like to acknowledge Head of department at Maritime Studies Hive, Lars Christian Iversen for constructive discussions and supervising in Norway. You have provided me with knowledge from your background within new buildings that has been helpful on the way, not to mention the completion phase of the thesis.

Contents

Abstract

Six vehicle carriers/car carriers, one LPG and one bulk have been studied and analyzed closely after completing work in dry-dock with regards to estimations, quotations and actual costs. The ships are operated by Wilhelmsen Ship Management (WSM) which belongs in category of management companies that compete on an arena with high rivalry. Dry-docking is essential for all sailing ships and includes a number of different jobs which need to be completed. Costs are important in order to be competitive in this business.

The analyses reveal some severe differences in realized costs compared with the estimates and the quoted costs for the specific ships studied in this research. Estimations, quotations and invoices are three important factors for finding trends and deficiencies that may give indications for what to focus on, in order to achieve cost reductions.

Introduction

Dry-docking of ships is important because of compliance with class and regulations which is necessary in order to sail with goods. The budget is often hard to accomplish because of missing quotations, which makes the realized costs unpredictable and uncertain. The problem is usually solved by know-how and own experience from ship operations. When the ship has completed the visit the realized costs can often be higher than estimated.

There are several companies that provide management services to the shipping segment. They vary in size, segment and location. Larger companies usually arrange their different companies as a “group”, where smaller companies are located under the same umbrella. Companies can for instance own ships while another company in the group can provide ship management services, either to them self, others or both.

Some major ship management companies operating in Norway are:

- Fred Olsen
- OSM Ship Management
- VSM Ship Management
- Wallem Ship management Norway
- Wilson Ship Management

Some companies are specialized niche companies that offer a specific service in small scope to a ship owner, such as crewing of ships.

Analyses in the thesis are based on quantitative data from actual dry-dockings combined with the analysis of the process.

WSM has the management for a fleet of 52 ships (by summer 2012). The ships differ in age, from new buildings to almost 30 years old ships. The ships also have different purposes, but most of them belong to the category vehicle carriers/ car carriers.

Customers of Wilhelmsen Ship Management are ship-owners who find it more convenient to hand over the management role to WSM. They can handle the day-to-day operation of the vessels, but also schedule dry dockings, modifications, new installations and other special projects.

This master thesis is a collaboration between the writer (Karl Fredrik Hansen) and Wilhelmsen Ship Management (WSM). The relationship began in summer 2012, where I was an intern. The company had, when starting this thesis, no dedicated tools for analyses of dry-docking of ships, showing trends, performance or indications for improvement. I started gathering data from estimations, quotations and actual costs and set them into a system for further analyses.

My collaboration with WSM has been done in two steps and embrace information of individual ships and owners which has been scrutinized in this research. First, this has been a part where I have tried to provide WSM with helpful assistance for use in the future dockings, showing them trends, useful tables and information in order to do necessary steps to improve and, or achieve better margins in the future by highlighting important areas. The second part has been to apply this work into the work with master thesis and letting the reader know about the procedures, dockings and the SFI-system before they can see the results.

Searches have been made on internet and internal databases for master theses regarding similar topics without any results. There is no other research completed on this particular issue with regards to small projects ($300,000-700,000) in terms of the amount of costs for jobs completed in dry-dock. It has therefore been time consuming to achieve an overview, create systematization and find the small part of relevant literature used in the research. Research may have been difficult to complete and publish because of secrecy and code of conduct for the different companies. Internal analyses may have been made for different ship owners, but not published for public audience. It is confidential information that is kept between two, or three parties, for instance ship owner, yard and a ship management company. Most of the literature used is based on project risk management, together with digital documents.

Description of research problem

The preparation for dry docking starts months in advanced and involves the ship`s staff, ship owner, yards and perhaps a ship management company. A process begins and a budget based on estimates starts to take form. This is founded on what kind of work the ship has to complete in yard. It is decisive for the budgeting process to collect quotations from yards to see what expenses to expect.

Theories:
Analyses of quotations, estimations and expenses for several ships that have completed work in dry-dock can reveal information about the quality of the whole process where different actors are involved with own estimates. Ship yard and the respective ship management company will have own assumptions and background for estimating. Analyses will provide information about where deviations are present and the general costs for docking.

Hypothesis:
The work on this thesis has been based on the hypothesis that dry-docking for ships often contains large deviations between estimates, quoted price from yard and realized costs, based on the final invoice. One of the aims with this thesis is to prove whether data from the investigated projects can back up such hypothesis

Research question:
The first research question for this thesis is to identify the significant gaps that create deviations with concerns to estimations, quotations and realized costs in dry-dock projects.

Research question 2:
The second research question for this thesis is to bring to attention what changes can be made in order to improve the budgeting process.

- It would be to the satisfaction of the author if a ship management company could use such suggestions for improvements in order to be more cost efficient related to future yard visits.

Methodology:

The work completed is based on quantitative analyses of raw data. The raw data has been collected from different formats, mainly from excel sheets and then implemented and systemized in the new sheet. The data collected were primarily estimations completed by a vessel manager, quotations performed by ship yard, and the realized costs. These numbers were given in USD and Singapore dollars, and have later been converted to one standard currency (USD) for use in the research. This was done in order to compare the different ships on the same basis and to synchronize results to graphs and table used.

An important part of the work has been to systemize all estimations, quotations and realized costs related to the different jobs completed in dry-dock. Estimations, which are developed by an estimator, typically a vessel manager who performs his/her evaluations on what work that need to be completed, in terms of costs.

Quotations are done in the similar way, but from the yards` point of view and on the basis of what kind of jobs that were requested for quotation by the ship management company. Realized costs are the final cost for that particular piece of work. These costs are summarized by the ship yard and sent as an invoice to the ship owner or the management company.

The information used as raw data for this thesis has been collected from different spread sheets, either in excel or in paper form. A new sheet was then created and built with three columns, one for estimations, quotations and realized costs. Each row is dedicated with an identity-number, accordingly to the system for classification of technical and economic ship information (SFI Group System). The SFI-system consists of eight main categories. One particular concern for this research has been to identify where the gaps are located based on the SFI-system and on the level of main group only. The reason for not going in further details for the particular jobs are the comprehensive and complex coding of jobs. The coding is so specific that it would not be possible to compare the ships.

The sheet made has proved to be very helpful in the way it provides and displays different sets of information. This information is relevant not only for this thesis, but also for application by WSM.

Fig. 1 is a schematic picture of how the different raw data has been implemented in one systematic excel sheet.

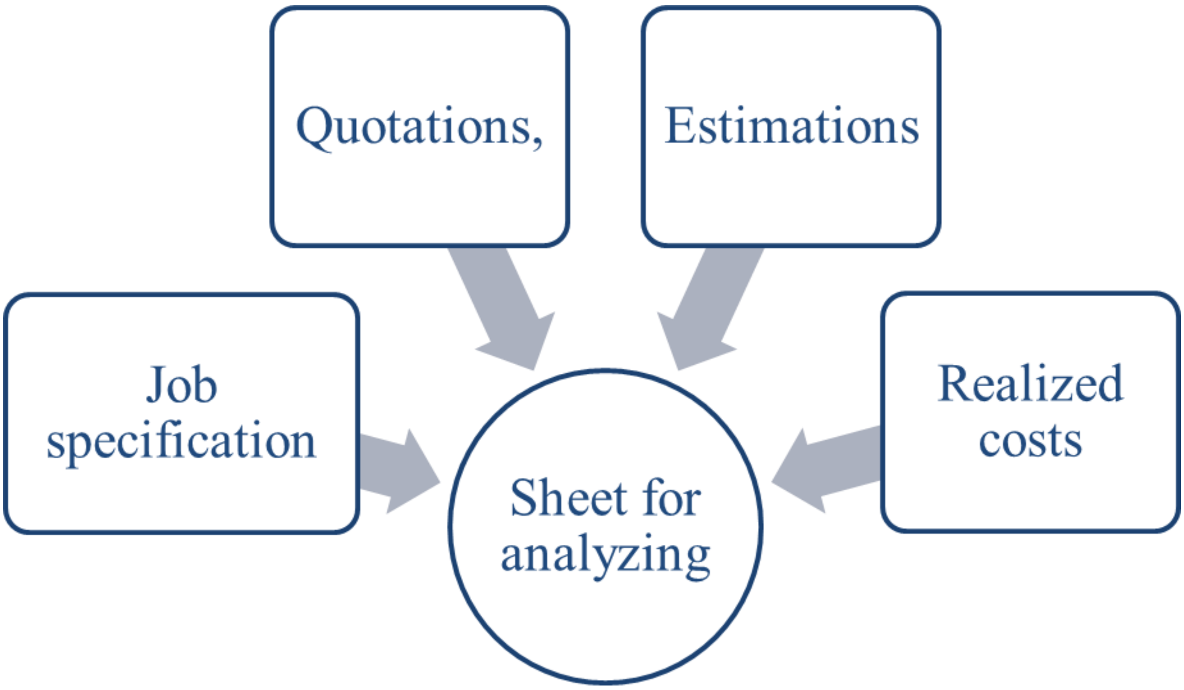


Fig. 1

The excel sheet is built with several features, or formulas which gives a broad scope of numbers, which again has been the main source for the analyses and arguments given in the thesis. It can be an important tool and help to obtain information for different use.

Emphasis has been given to put the basic numbers together and systemize it in a proper way, in order to get an overall view. The sheet is built line for line and all the jobs, estimations, quotations and realized costs are punched manually into the sheet.

Fig. 2 shows an example of how jobs and numbers have been implemented in the excel sheet

Vessel name:	
Yard name:	
Date of entry:	
Date of sailing:	

		Objectives	Amount	%	Column1		
		Total number of jobs in Specification	4.00				
		Total number of jobs including Specification and additional jobs	4.00				
		Number of jobs without yard quotation	1.00	25%	6	4	<10000
		Number of additional jobs	-	0%		ADDITIONAL JOBS	>0
		No. of invoiced items	3.00				
4	yard quote	Yard lumpsum quotation	#REF!	#REF!			
4	VM estimate	VM estimation of yard cost	#REF!	#REF!			
3.00	Total specs	Total value of invoice	#REF!	#REF!			
		Overall total of value in difference between Yard and VM	#REF!	#REF!			
		Overall total of value in difference between Invoice and VM	#REF!	#REF!			
		Overall total of value in difference between Invoice and yard quotation	#REF!	#REF!			
		Overall total of jobs with specs	4.00	100%		specification jobs	
		Overall total of additional jobs	-	0%		Cancelled jobs	
#VALUE!		Overall total of value of additional jobs	-	#REF!		% cancelled jobs	
		Total of incomplete input from yard		0%		No. of Yard quotes	
		Total of incomplete input by VM	0	0%		No. of VM estimates	
		VM estimate of cancelled jobs with no invoice value	-	#REF!			
1		Cancelled jobs with no invoice value	1	25.00%		Additional jobs	
		Jobs with invoice value less than 10.000	3.00	100%		% additional jobs	
		Jobs withinvoice value more than 10.000	0	0%			
		TOTAL	3	75%		total invoiced jobs	

Activity	Job ID	Job Description	Yard Quotation	VM estimate	Invoice	VM-Invoice	Yard-Invoice
SHIP GENERAL	100-SERIES	EXAMPLE: Sludge - and bilge removal	400.00	600.00	950.00	58%	138%
SHIP GENERAL	100-SERIES	EXAMPLE: Mooring trials	1,400.00	1,600.00		No Invoice Value	No Invoice Value
SHIP GENERAL	100-SERIES	EXAMPLE: Supply of ballast water	1,200.00	2,000.00	2,050.00	2%	71%
SHIP GENERAL	100-SERIES	EXAMPLE: Staging	0.00	3,500.00	9,000.00	157%	No Yard Quotation
HULL							
HULL							
HULL							
HULL							
EQUIPMENT FOR CARGO							
EQUIPMENT FOR CARGO							
EQUIPMENT FOR CARGO							
EQUIPMENT FOR CARGO							
SHIP EQUIPMENT							
SHIP EQUIPMENT							
SHIP EQUIPMENT							
SHIP EQUIPMENT							
EQUIPMENT FOR CREW AND PASSENGERS							
EQUIPMENT FOR CREW AND PASSENGERS							
EQUIPMENT FOR CREW AND PASSENGERS							
EQUIPMENT FOR CREW AND PASSENGERS							
MACHINERY MAIN COMPONENTS							
MACHINERY MAIN COMPONENTS							
MACHINERY MAIN COMPONENTS							
MACHINERY MAIN COMPONENTS							
SYSTEM FOR MACHINERY MAIN COMPONENTS							
SYSTEM FOR MACHINERY MAIN COMPONENTS							
SYSTEM FOR MACHINERY MAIN COMPONENTS							
SYSTEM FOR MACHINERY MAIN COMPONENTS							
SHIP COMMON SYSTEM							
SHIP COMMON SYSTEM							
SHIP COMMON SYSTEM							
SHIP COMMON SYSTEM							
ADDITIONAL JOBS							
ADDITIONAL JOBS							
ADDITIONAL JOBS							
ADDITIONAL JOBS							

Fig. 2

Please find all the individual analyses attached in appendix I.

From left: Activity indicates where the jobs have been completed according to the SFI-system. Job series are numbered from 100-series to 800-series and is related to the activities completed in dry-dock. The different jobs are placed in their respective main group. For example: Ship General will tell what category the job is placed under while identity-number will be the exact location or item.

Job description is a short description of the job or item. Yard quotation shows what the yard quoted for a particular job. VM estimate (Vessel Manager) is estimates developed by the individual vessel manager, who has been the principle of the estimations for the specific ship. Invoice display the realized cost associated with the particular job completed.

The analyses are based on real data from eight ships, categorized as ship 1 to 8. All the information in the sheet will give an analysis for the individual ship after work in dry-dock.

In this way the cost data for the ships can then be compared, and the data can be analysed to give an overview over patterns found in each ship, especially total costs for main groups with concerns to estimations, quotations and invoice. The output comprises a wide range of information. The comparing-process is therefore easier in terms of gathering all data for each ship into one single sheet.

Looking into the three factors; estimations, quotations and actual costs will reveal more information than only looking into two of them. It will be natural to include estimations from management into the analyses in order to see if there are significant gaps between the invoice and the estimate, which can support future improvements, in order to better the budgeting process.

When the data is systemized in this way the deviations are easy to find with regards to what kind of jobs show a significant gap between quotations from yard and actual costs.

Population:
The population used in the research consisted of eight ships where Wilh Wilhelmsen represents the ship owner. Age varies in the population and 6/8 ships are vehicle carriers.

Sampling:
The sampling comprises ships that have been docked in the past three years. The sample contains eight out of 52 ships in WSM´s fleet.

Sampling method:
Method used in this research is convenience sampling, which is a technique where subjects can be selected primarily due to accessibility and proximity to the data used for research. This method is used for the reason that the entire fleet of vessels cannot be examined and the size of the sample is limited. Convenience sampling is suitable to use in this research because of already collected data from an internship in Wilhelmsen Ship Management and because it is inexpensive.

Sampling size:
A general rule in quantitative research is to use the largest sample possible, which in this case are eight ships. Despite the small population in amount of ships (52) in the fleet, the sample of eight ships could give indications of similar trends for rest of the fleet.

1. Theory part

1.1 Rules and regulations for dry-docking

The life cycle for ships contains several dry dockings. Figure 3 below shows a schematic figure of scheduled dockings according to the DNV rules for classification of ships Pt.7 of Ch.1 Sec.5 A500.

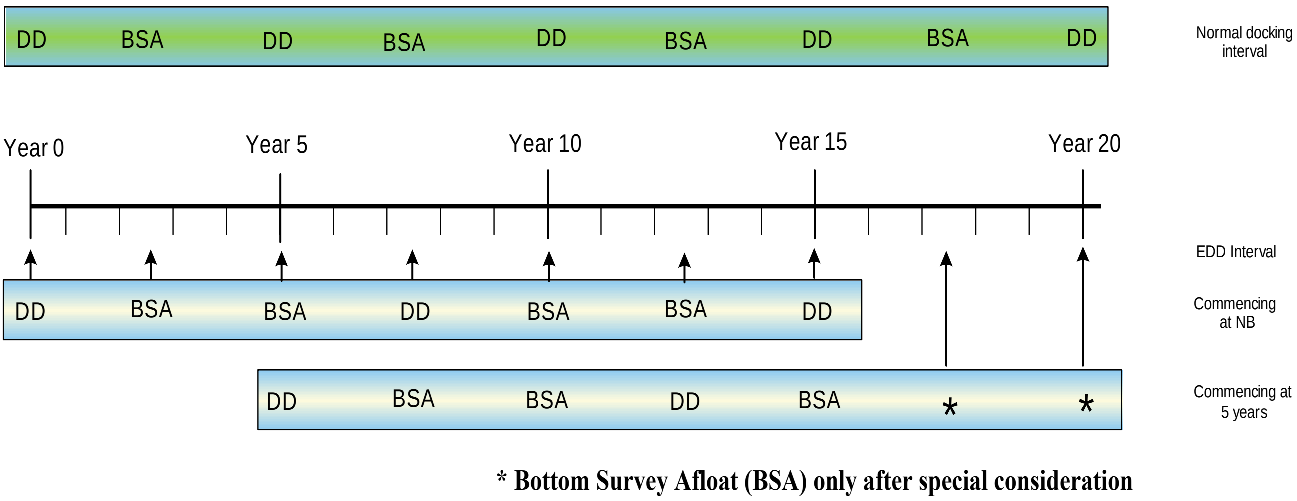


Fig. 3

Figure 3 reprinted from Det Norske Veritas, 2012. "Assessment of Ships and Managers for the Acceptance of Extended Interval between Bottom Surveys in Dry-Dock" No. 72.2. Retrieved from: https://exchange.dnv.com/publishing/cn/CN72-2.pdf

Bottom Survey Afloat (BSA) is carried out while the ship is in floating condition, either by harbour, anchored condition or wet dock. While undergoing a BSA the internal examination of; hull painting, adjacent structure and required thickness measurements find place. The coating condition in double bottom and double side water ballast tanks shall be inspected.

A plan for the BSA shall be submitted to DNV in advance of the survey and shall include the following posts:

- Scheduled time and location for survey.
- Name of approved diving company.
- Means for cleaning the hull below waterline.
- Means of access for examination of sea and sanitary valves and, when applicable, arrangement for complete examination (`opening up`) of box coolers, sea and sanitary valves.
- Results of inspections by the Owner's personnel of double bottom/double side ballast tanks (during the last 3 years) with reference to structural deterioration in general, leakages in tank boundaries and piping and condition of the protective coating.
- Conditions for internal examination of double bottom/double side ballast tanks (e.g., information regarding tank cleaning, gas freeing, ventilation, lighting, etc.).

(Det Norske Veritas, 2012)

SOLAS (Safety of life at sea) states in their convention (*SOLAS-74/78 Ch.1, regulation 10*) that every ship should be dry-docked for inspection of the hull under sea line and essential parts that are in service under water at least twice every five years (ref. Fig. 3). Time lapse between the dockings should not exceed three years. An in-water survey can be conducted instead of a complete dry- docking if, and only if special provisions have been made during the construction of the ship (Dokkum, 2011).

It is ship owners' responsibility to carry out periodically dockings and follow-up on deficiencies if such happens. If the survey reveals any damage or other conditions that acquire close attention and quick response the surveyor may require the ship docked as soon as possible, in order to carry out any necessary repairs.

According to Dokkum (2011) repairs due to damage below the water line can in most cases be related to:

- Collision with objects or other ships
- Groundings
- Lack of maintenance
- Propeller-shaft seal leakage
- Damage on rudder

Selling a vessel is a big transaction, which includes a great amount of money. In most cases a buyer of a ship will have a survey carried out before such transaction takes place.

1.2 SFI

Ship Research Institute of Norway or (SFI), which is a short term for Skipsteknisk Forskningsinstitutt came out with a reseach in 1972. The research led to a SFI-grouping system, making it possible for the different enterprices to get controll over their ship operations by tying together different activities, such as purchasing, accounting, maintenance, technical reports and so on (SFI Group System, 2001).

This system contributes to several advantages in different areas like: communication, co-operation, cost control, cost comparison, quality control, computerisation, development, education and training, and standardisation.

The grouping-system is today used by many companies within the shipping industry, including management companies, yards and suppliers. The system is recognized as providing a systematic coverage of the various systems, equipment and other aspects on ships and off-shore.

The system breakes the ship into functions letting the different parties understand each other when it comes to an area (main groups) of work, also to be as specific as possible by using detail codes. It is, however, a possibility for the enterprice to make their own special codes on induvidual basis related to budget controll, accounting, etc, in order to achieve a total cost control of ship operations.

Fig. 4 shows a scetch of how the SFI-grouping work in practice.

Fig. 4 (Source: Karl Fredrik Hansen, based on SFI ref. ASO 9004, par. 5.1)

Fig. 4 has the purpose of showing the different activities and enterprices that are taking advantage of the SFI system by using a standardization for numbering as common communication between the different stakeholders involved.
The standardization from SFI-numbering system ties engineering and related cost together in a systematic way.

Specifications are in most cases related to different Group System levels.

- First the specification is outlined on the basis of Main Group level
- Functional requirements are attached
- Solutions are added to Sub-Group level
- Selection of components are determined on Detail Code level.

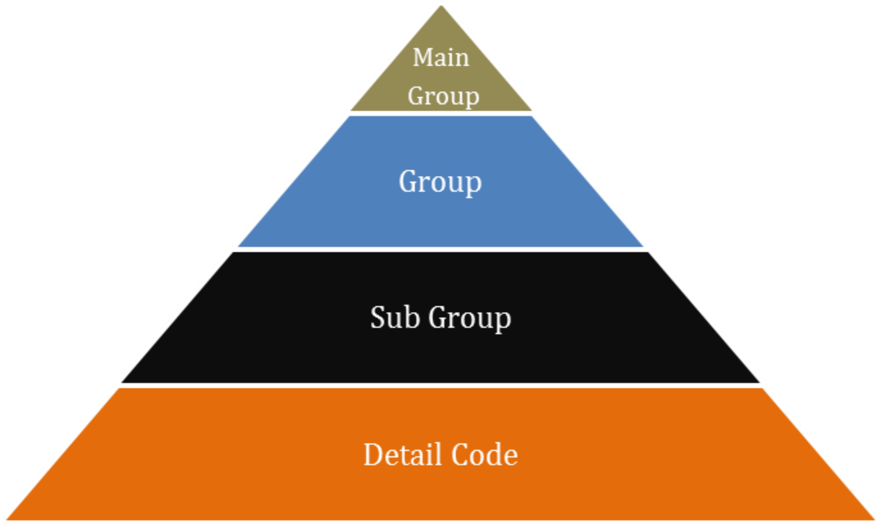


Fig. 5

The system is based on 8 categories

1. Ship General
2. Hull
3. Equipment for Cargo
4. Ship Equipment
5. Equipment for Crew and Passengers
6. Machinery Main Components
7. System for Machinery Main Components
8. Ship Common System

Fig. 6 Shows An example of chategorizing

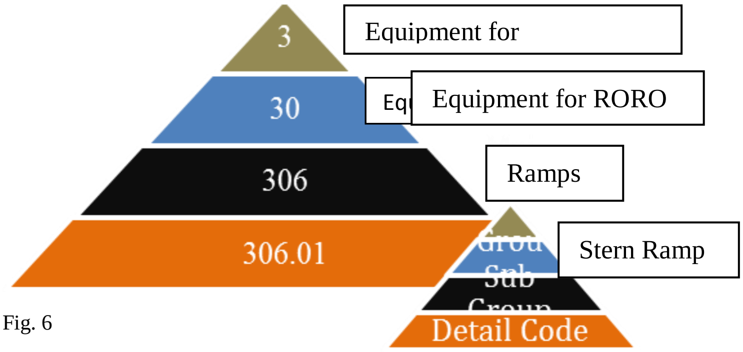
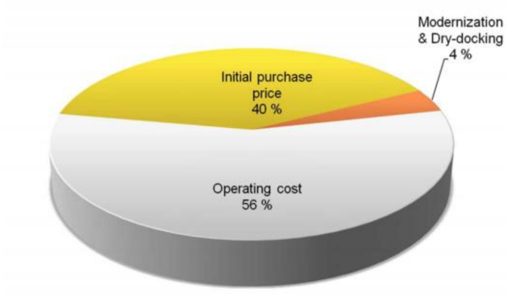


Fig. 6

(SFI Group System, 2001)

2. Dry-docking



Example of 30 years cost of ownership for a typical RoRo vessel, excluding fuel oil costs and capital costs

Fig. 7 (Source: Wilhelmsen Ship Management)

Fig. 7 shows shares of costs associated with a ro/ro vessel over a period of 30 years. The costs do not include fuel oil and capital costs. Dry-docking and modernization of a ship represent a relatively small part of the costs related to its life. Initial purchase is the price for the ship and operating costs are for instance crewing, charts, spare parts, harbour fees, pilot fees and cost connected to the operations on board. Dry-docking of ships is, however an expenditure for the owner and involve more cost than the docking itself. A ship out of service means no profit for transport of commodities. Nonetheless incidental costs related to dry-docking contribute to a significant overall cost for the owner. A solid grasp of the budgeting process is therefore necessary in terms of being competitive in the market.

Operating costs is more in focus for ship owners, since the 40 % represent a non-reimbursable cost, the influence of having those costs reduced is not present. Operational costs can be more influenced and affected by choices made, which means reducing costs to the operation, without breaking any rules and regulations.

Certain operational reductions will have an impact on the dry-docking costs. Quality of spare parts and lack of maintenance may be sources to increased costs in dry-dock. It may be an economically profit one year, and an increased cost in dry-dock the year after due to negligence. Having extra days in dry-dock means a significant loss of profit since the ship is out of service. Renewal and replacement are two important things that is expensive to complete in dry-dock, and extra commissioning and margins are being added.

2.1 Analysis of the docking process

The different actors operating in a ship management market are practicing the internal process for dry-docking differently. Key elements are however present in every internal decision making process for all companies. Fig. 8 is a sketched example for how the internal process may be held with concern to dry-docking.

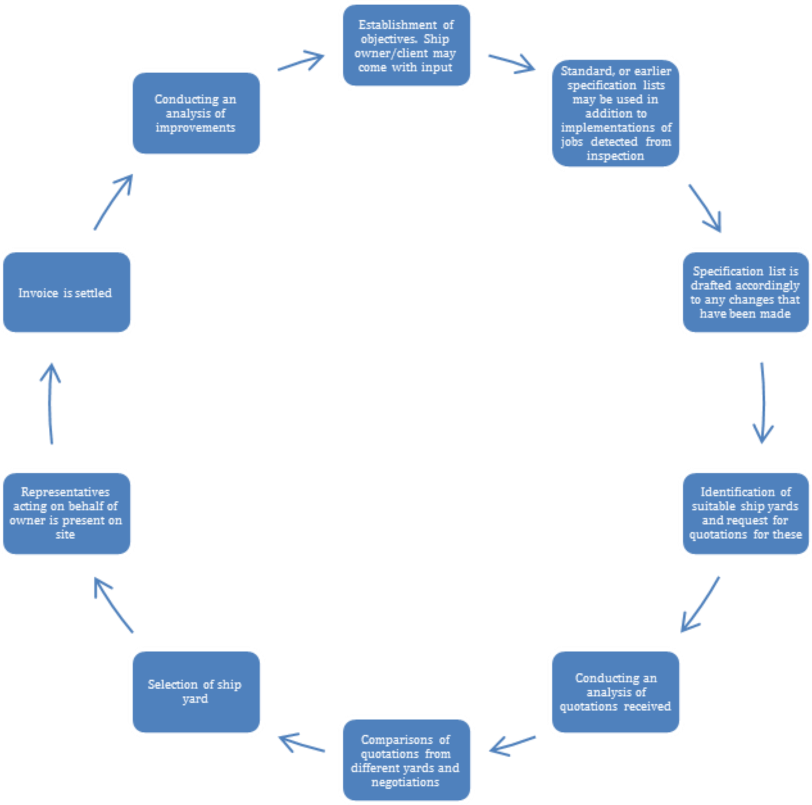


Fig. 8

Establishment of objectives is a mapping process where necessary jobs are identified and documented with photos and notes for further use. Some jobs are completed on interval basis and can be directly copied to the new spec list. New jobs and standard jobs are put in to order before sending out a request for quotations from different yards.

When quotations are received a selection process begins based on price, quality and reputation on the specific yard. The yard that meets the management`s requirements assigns the contract award for the specific ship.

Representatives will be placed on site during the whole yard stay, making sure quality and jobs are completed to the agreed specifications. Invoice is settled on the basis of what has been completed, including additional jobs, but also feedback from the representatives, who may report possible deficiencies and lead to a potential discount.

2.2 Five essential steps in the dry-docking process

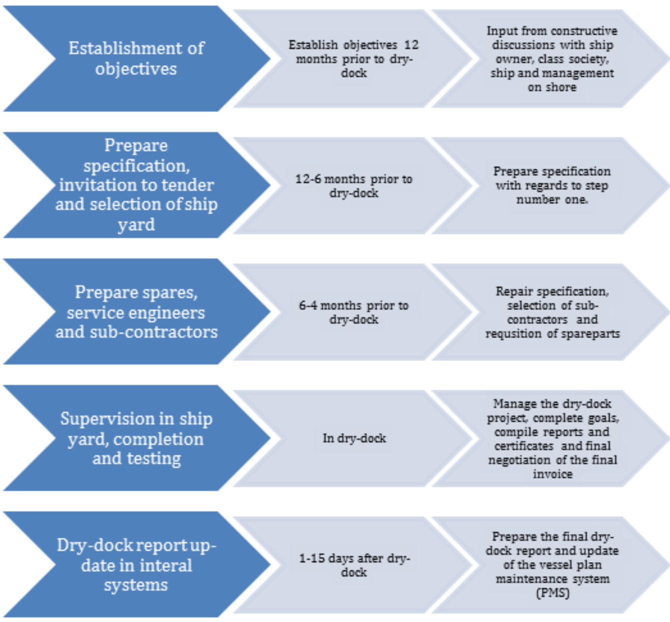


Fig. 9

Establishment of objectives is a coordination and team work between the ship's staff, management and owner, who can come with suggestions and special requests. The company starts to prepare a spec list where especially surveys and ship staff has a central role to map the necessary scope of work that needs to be completed in dry-dock.

All work is tagged in Main-Groups, Sub-Groups and Detail codes for use in the specification list sent to ship yard. Necessary spare parts and special work has to be determined prior to docking and may include special deliveries from sub-contractors.

Fig. 9 displays the essential steps that find place prior, under and after a dry-docking. The whole process contains several milestones which need to be completed before reaching the final goal - a successful docking.

2.3 The preparation for dry docking

The preparation begins months in advance. All jobs and repairs are listed and sent to the yard for quotations/tendering. This list has to describe what kind of jobs that have to be completed, what kind of materials to be used, where it is located and what kind of suppliers they will use in case of changing/repairs of rotating equipment, machinery or other equipment that are specially manufactured.

The sheets for jobs/equipment/requirements are sent in advance so the yard can quote for a price for every job that has to be completed, adding up the costs for the entire dry-docking of the ship. At the same time the list is sent, the ship management company undertakes own estimations, based on experience. They will present an "estimated" price to the ship owner. This is what the expected costs, or realized costs are estimated to be when the final invoice is to be settled between the management that acts on behalf of the owner and the yard. Discounts are normally discussed, negotiated and given on the premises of how often that particular yard has been chosen, or circumstances that may have occurred in yard e.g. deviation in quality, spare parts or materials.

Once the list with specifications is quoted for by the different yards the management will compare these estimations/quotations up against each other. The yard that quotes the lowest price compared to the estimations is usually the one getting the contract award. Management companies often use several yards for dry-dockings and a "ranking" is not unusual to use, which makes the decision easier and more reliable.

2.4 Internal ship procedures

Before the ship enters dock a brief survey finds place on board the vessel. Internal and external surveys are carried out, documented and reported by the ships' staff, usually the chief engineer who has a broad overview of the mechanical systems on board. A list is made and includes all necessary upgrades or jobs that need to be completed in dry-dock.

The list is then sent on shore to the ship owner, or the management, which is entitled and responsible for the ship operations. This list makes the base of what is estimated, quoted and what work that will be completed in dry-dock.

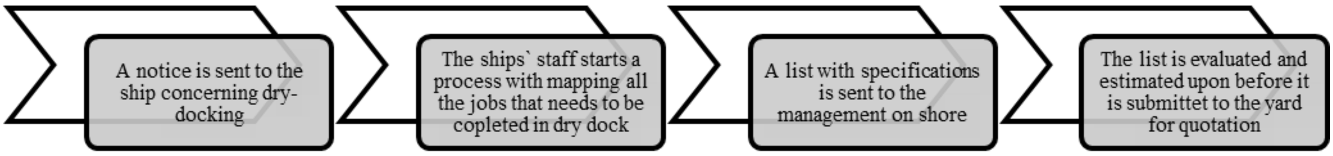


Fig. 10

3. Results

Some facts:

Eight ships, which are vehicle carriers, LPG and dry bulk are analysed with respect to raw data from estimations, quotations and realized costs. Ships' age vary, from relatively new to old and the sample examined has an average age of 11, 25 years. A total of 1019 jobs were sent on specification to yard for quotations and 323 additional jobs were completed in yard, and were not among the originally scheduled jobs sent on specification.

Ship	Age	Type
1	4	Vehicle Carrier
2	3	Vehicle Carrier
3	14	Vehicle Carrier
4	5	LPG
5	13	Vehicle Carrier
6	14	Vehicle Carrier
7	26	Vehicle Carrier
8	11	Bulk

Fig. 11

3.1 Key figures for the analysed ships

Activities	Ship 1	Ship 2	Ship 3	Ship 4	Ship 5	Ship 6	Ship 7	Ship 8
Jobs on specification	114	73	187	128	191	135	130	191
Cancelled jobs	42	20	61	52	62	65	52	56
Cancelled jobs in %	37 %	27 %	33 %	41 %	32 %	48 %	40 %	29 %
Number of yard quotes	74	61	74	82	56	37	71	125
Number of VM estimates	86	73	106	122	126	94	106	178
Additional Jobs	23	2	13	29	15	57	170	14
Additional jobs in %	20 %	2,7 %	7 %	23 %	8 %	42 %	131 %	7 %
Yard								
Total invoiced jobs	87	55	126	103	144	127	240	135
Yard quotation	$275 862	$ 263 470	$ 146 853	$349 600	$349 726	$ 38 556	$ 157 771	$ 214 163
acceptable quotations	26	28	15	26	8	8	14	30
exact quotation	19	10	14	19	5	6	11	24
quotations between 75-125%	7	29	6	14	3	5	8	32
Over 125% overspending	24	6	32	24	31	10	37	46
Under 75% underspending	7	10	4	7	1	3	5	14
VM estimations								
Acceptable estimations	36	29	18	32	17	18	29	124
Exact estimations	19	12	10	19	2	9	3	29
Estimations between 75-125%	13	17	11	13	15	9	26	13
Over 25% overspending	27	10	36	27	40	13	9	27
Under 25% underspending	15	11	11	13	14	9	28	15
Estimated value	**$337 433**	**$294 332**	**$ 294 998**	**$638 575**	**$269 000**	**$260 790**	**$ 536 000**	**$ 437 529**
Quotated value	**$275 862**	**$263 470**	**$ 146 853**	**$349 600**	**$ 89 984**	**$ 38 556**	**$ 157 771**	**$ 214 163**
Invoice value	**$285 000**	**$219 194**	**$ 403 876**	**$507 111**	**$467 078**	**$207 681**	**$ 762 611**	**$ 387 541**

Fig. 12

Figures have been built up from single lines, where name of jobs, quotations, estimations and invoices has been inserted manually. Key figures (fig. 12) shows all the accounted activities in an overall perspective, but is worked up from the very beginning.

What is interesting to see is the main numbers in the bottom where the total estimations, quotations and invoice value are shown. Jobs which were not scheduled are also shown in the sheet and are determined as additional jobs. These jobs were not included in the original budget since they were completed after the budgeting process. Several jobs scheduled are cancelled for a number of reasons and appear as cancelled jobs. Even additional jobs may be cancelled if the supervisor on site or suggestions by owner comes to the conclusion, that it is cheaper or feasible to do the repair on board, while sailing. This implies that the ship can continue to sail, be in operation and generate earnings.

3.2 Data for each ship

Fig. 13 -20 is single-analysis of the ships investigated in terms of invoices, quotations and estimations and are categorized according to the SFI-numbering system.

Ship 1

Ship number 1 had a small, insignificant deviation in terms of quotations from yard and the actual costs. The overall docking cost for this ship was $285,000 USD and had a quotation from yard on $275,862 USD. The final invoice was less than estimated and included 23 additional jobs. There were 42 cancelled jobs, which contributed in limiting the final invoice. Quotations were only two out of eight lower than the realized costs for the categories. This is an extraordinary successful docking process and shows a remarkable quoting-process where the yard hit a 97% success rate of the final invoice. The relationship between yard quotes and estimates are also good, hence 74 quotes and 86 estimates from the spec list sent.

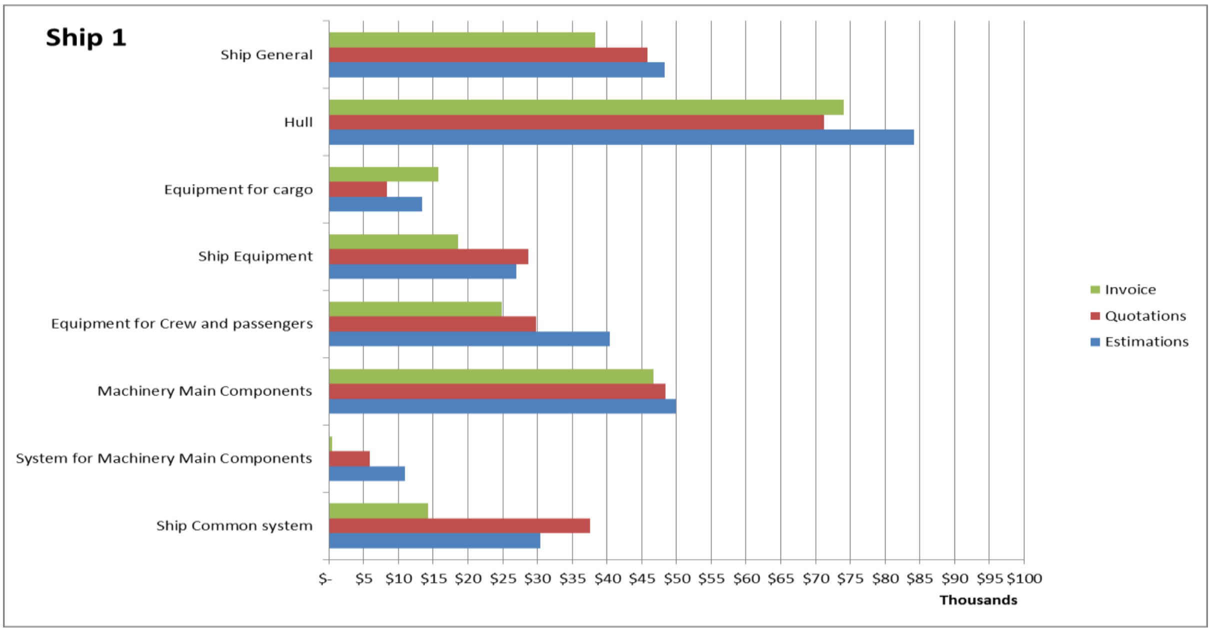


Fig. 13

Ship 2

This ship does only show a little more than $10,000 in deviation in the cateogry System for Machinery Main Components between the quoted value and invoice. Only two additional jobs were completed in this dry-dock period and contained twenty cancelled jobs, and is the reason for a higher quotations in the groups. The final invoice ended on $219,194 USD and can be placed in the lower range of what an average dry-dock cost. It had also the lowest number of jobs completed in dry-dock, and a final invoice of only 55 jobs.

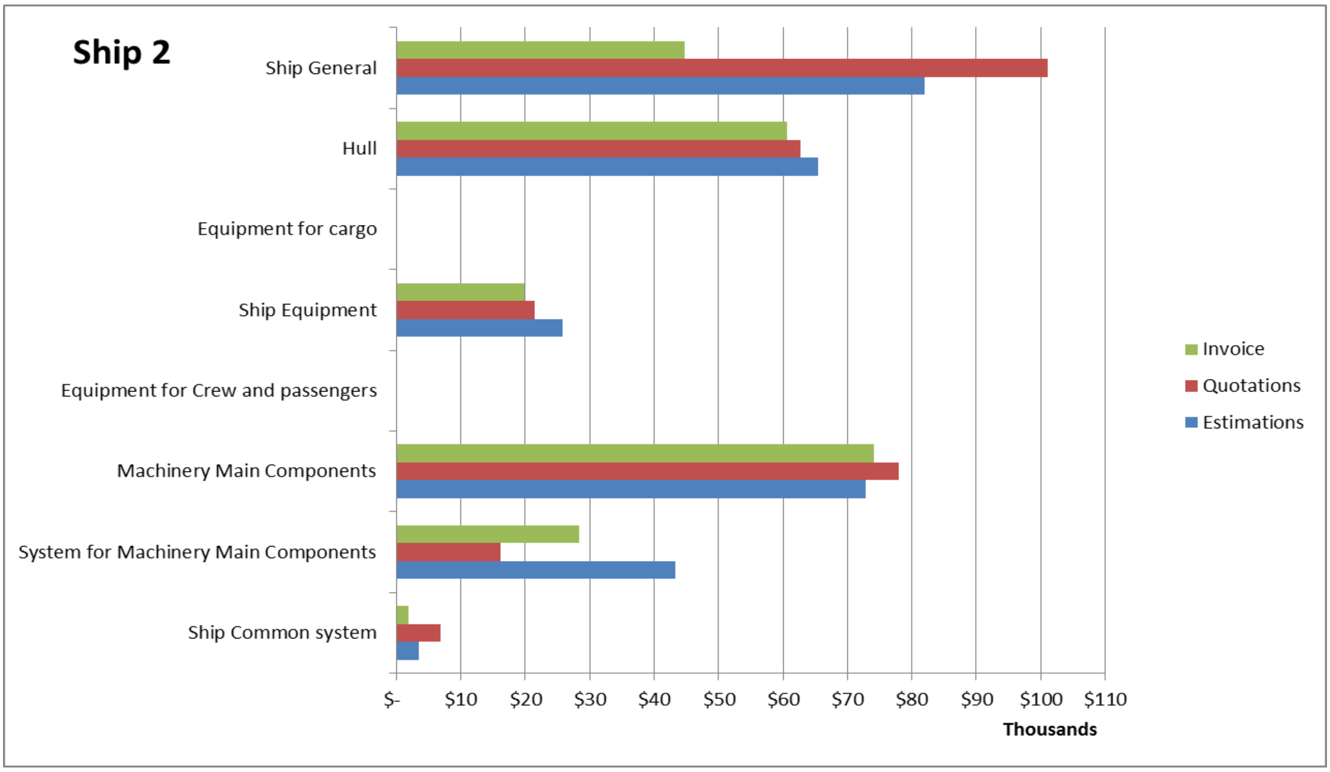


Fig. 14

Ship 3

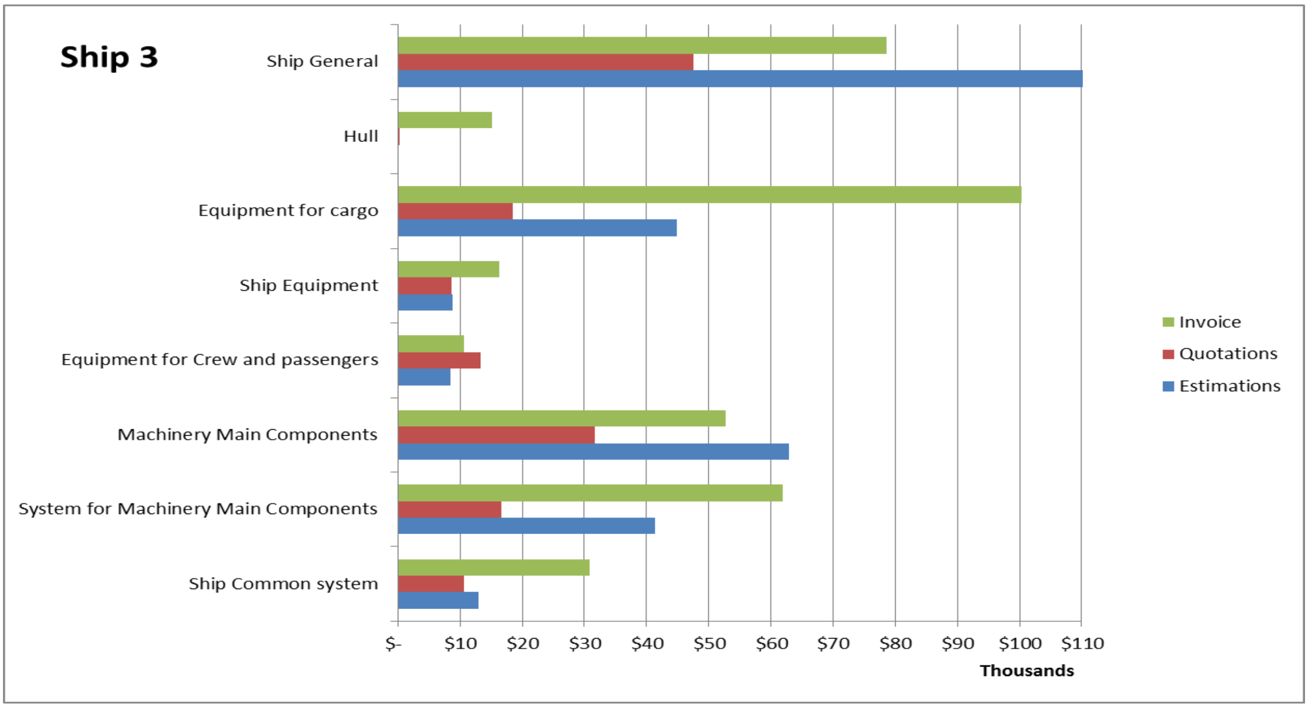


Fig. 15

As can be seen from fig. 15 this ship had a great spread and gaps between quoted value and realized costs. Seven out of eight categories contained an under-quoted value of jobs. The greatest gap is in Equipment for Cargo, where the difference was approximately $80,000 USD. The overall quoted value was far from the actual cost, which was $403,876 in this particular case. This made a gap of $257,023 in total. This docking had 61 cancelled jobs and 7% additional jobs in addition to the spec. Estimated costs were also beyond the actual cost with an estimation of $294,998 for the whole docking.

Ship 4

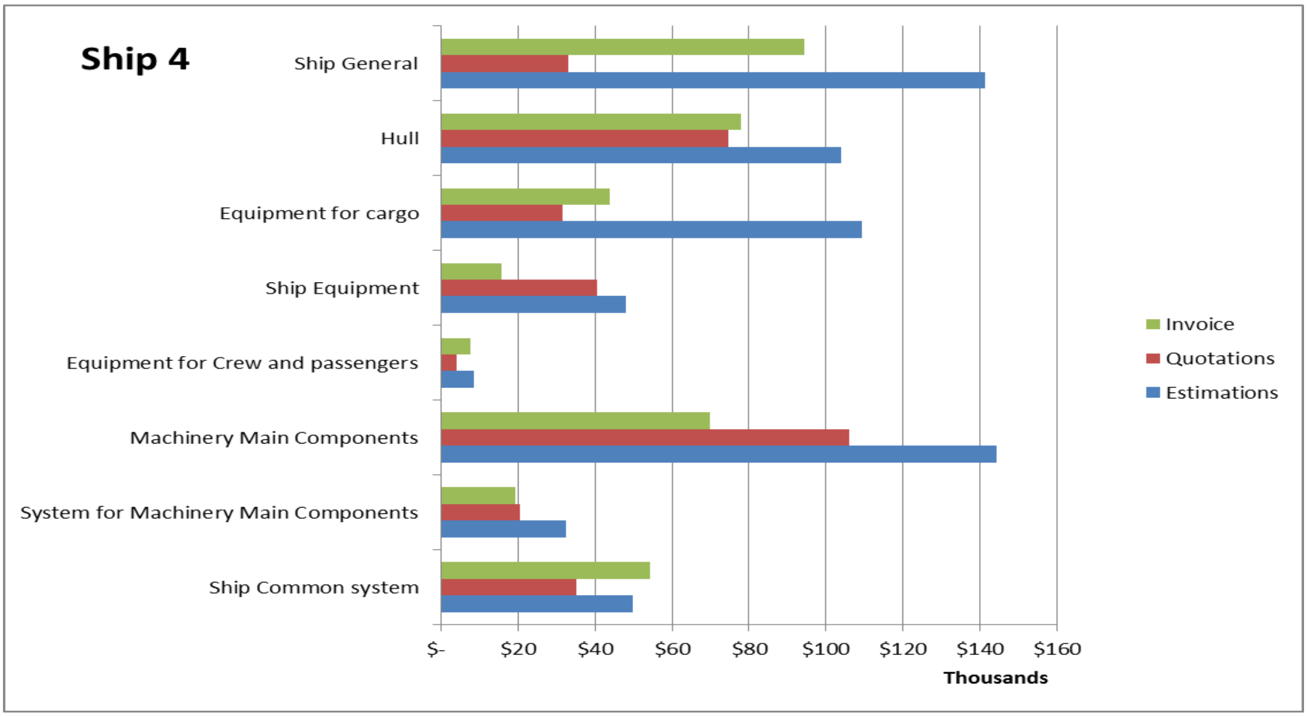


Fig. 16

Ship 4 contains variance in quality of quotations, which ranged from severe gaps to approximately the same realized costs as quoted. Great deviations are shown in category Ship General. This main group had a miss-quotation of approximately $55,000 USD. Five out of eight groups had a higher invoice than quoted. The quality also varies in the estimation phase, where estimations are estimated with a much higher value than invoice and contain gaps as much as $70,000 from the actual costs in category Machinery Main Components. This LPG carrier had the second largest invoice of all the ships analysed with its respective invoice of $507,111 USD. This was approximately $100,000 above the average docking costs.

Ship 5

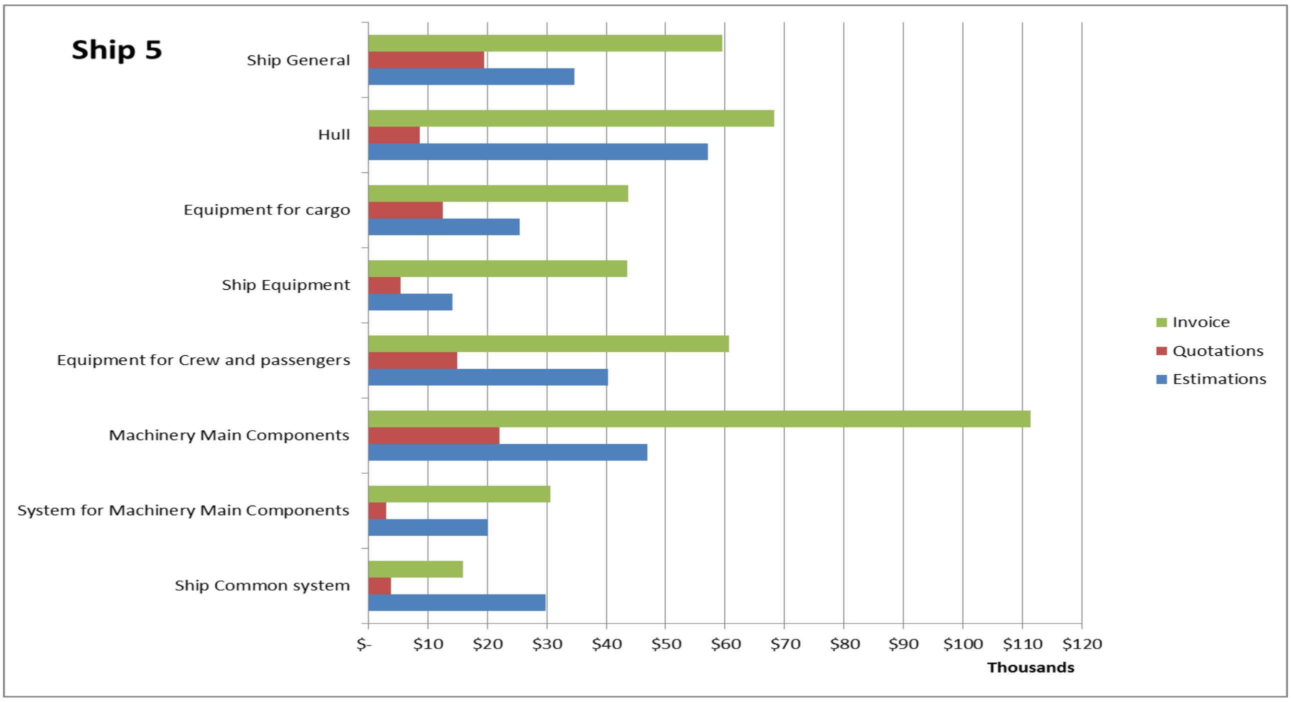


Fig. 17

Ship 5 was poorly quoted by yard and entailed only 19% of the actual costs. Estimations were also deviating from realized costs with significant discrepancy from the overall invoice. Machinery main components was the group that had unexpected high costs and was neither estimated nor quoted for near the final actual cost. Estimation in this group was $70,000 USD below the actual costs, while quotation was approximately $85,000 USD below actual cost.

Ship 6

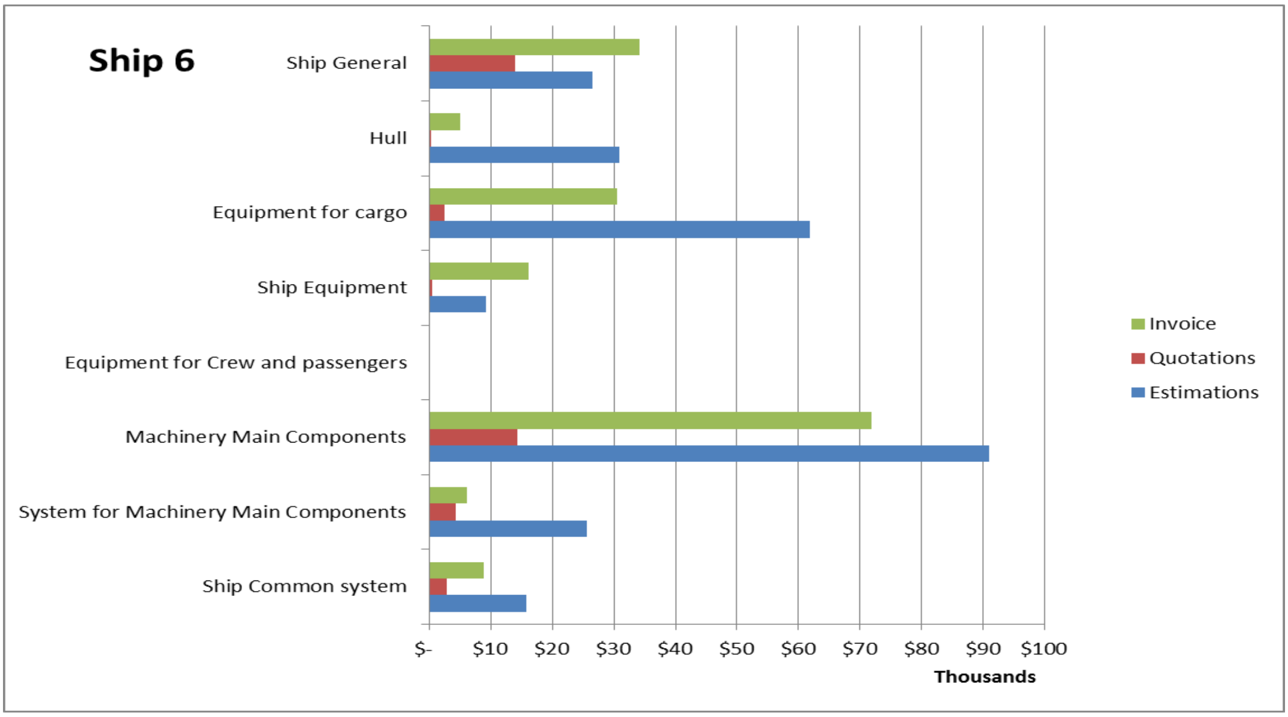


Fig. 18

Ship 6 had the poorest amount of quotations of all the ships analysed. The yard could only quote for 18, 5% of the total invoice, and were under-quoting for all the groups. The group Machinery Main Components was also in this case the outstanding group that had a significant gap. The total cost for this particular docking was $207,681 and had a poor quotation of only $38,556 for the whole project.

Ship 7

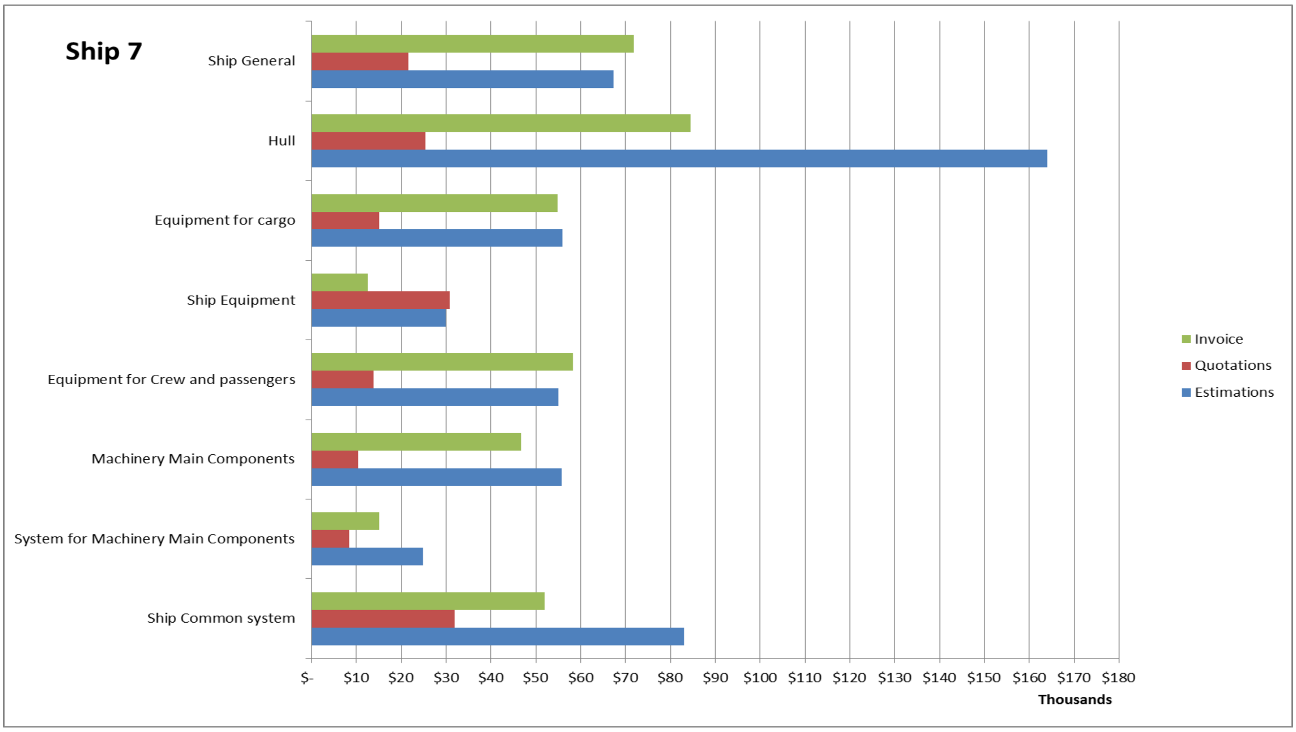


Fig. 19

Seven out of eight groups had a significant gap between realized costs and quoted cost. The yard could barely quote for 20% of the final invoice. Group that excel in deviation is Hull, also when it comes to estimations from Vessel Managers. Ship number 7 was the oldest ship analysed and had also the highest invoice of all the ships investigated. Despite the value of invoice, the estimations were good in seven out of the eight categories. Hull was also the area where estimations were significantly different from the invoice.

Ship 8

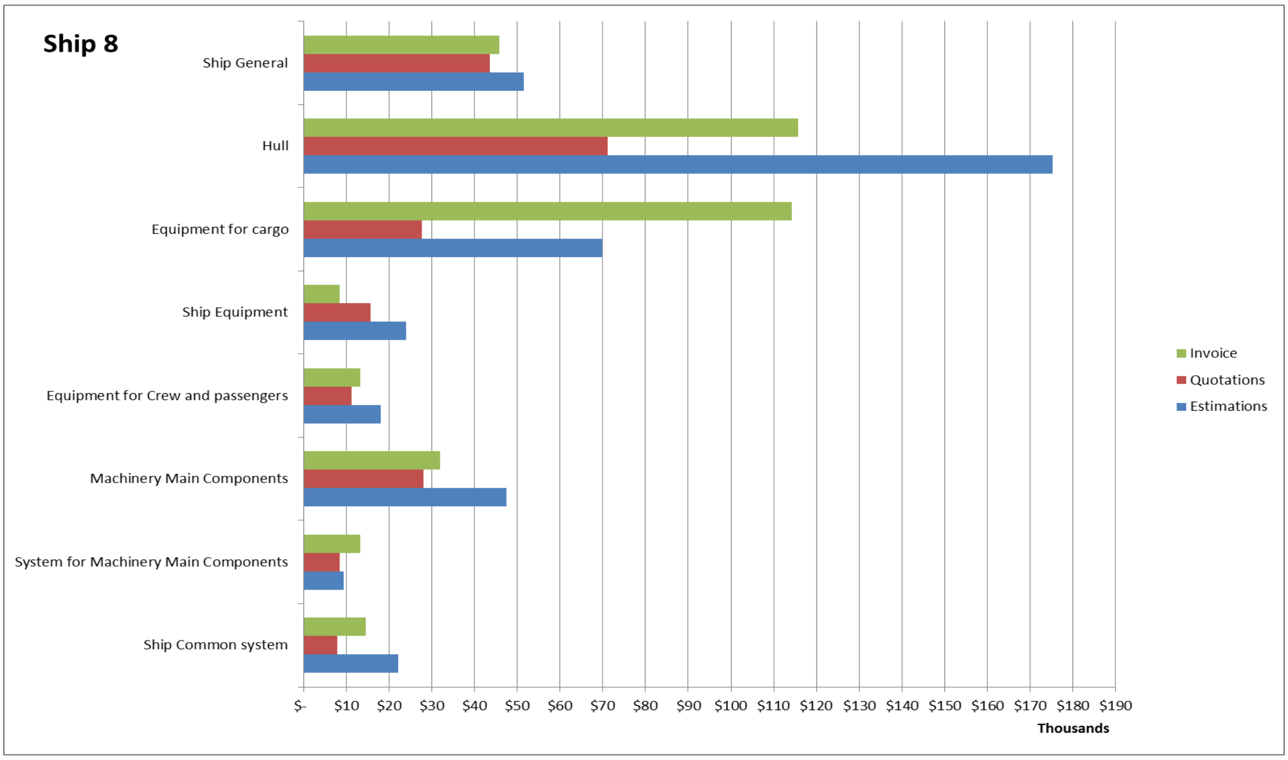


Fig. 20

This dry-docking had a quoted cost of $214,163 while the actual cost ended up on $387,541, which makes the quoted value be 55% of the total invoice. Groups that were having gaps are in this case Equipment for Cargo and Hull. Equipment for Cargo was under-quoted with more than $80,000 USD. Estimation upon the group Hull had an overestimation of approximately $60,000 USD. This vessel was a bulk carrier and the overall costs did not stand out significantly different from vehicle carriers, except that group Equipment for Cargo had the highest invoice of the ships analysed. The ship had a total invoice below the average docking cost for the ships analysed.

3.3 Comparison of data

What can be seen from these analyses is that realized costs (invoice) and quotations varies between the different ships, and in two segments the deviations are great, namely within mechanical and hull segment. Four of the eight ships had these two categories as the significant areas of gaps with deviations as high as approximately $90,000 in the worst case (Ship 5, Appendix 1). It is clear that individual ships have a different prioritization in terms of having work completed in different locations on board. The most frequent estimations are completed in the segment for Hull.

Hull is the segment that has the greatest amount of costs related to dry-docking with an average cost of $42,874 USD per docking and is probably the reason for the amount of estimations related to the category. In the opposite side, equipment for crew and passengers are having the lowest cost with an average of $34, 630 USD per docking. This type of category is related to life saving appliances, lifeboats and equipment/items related to crew area, for instance doors for cabins.

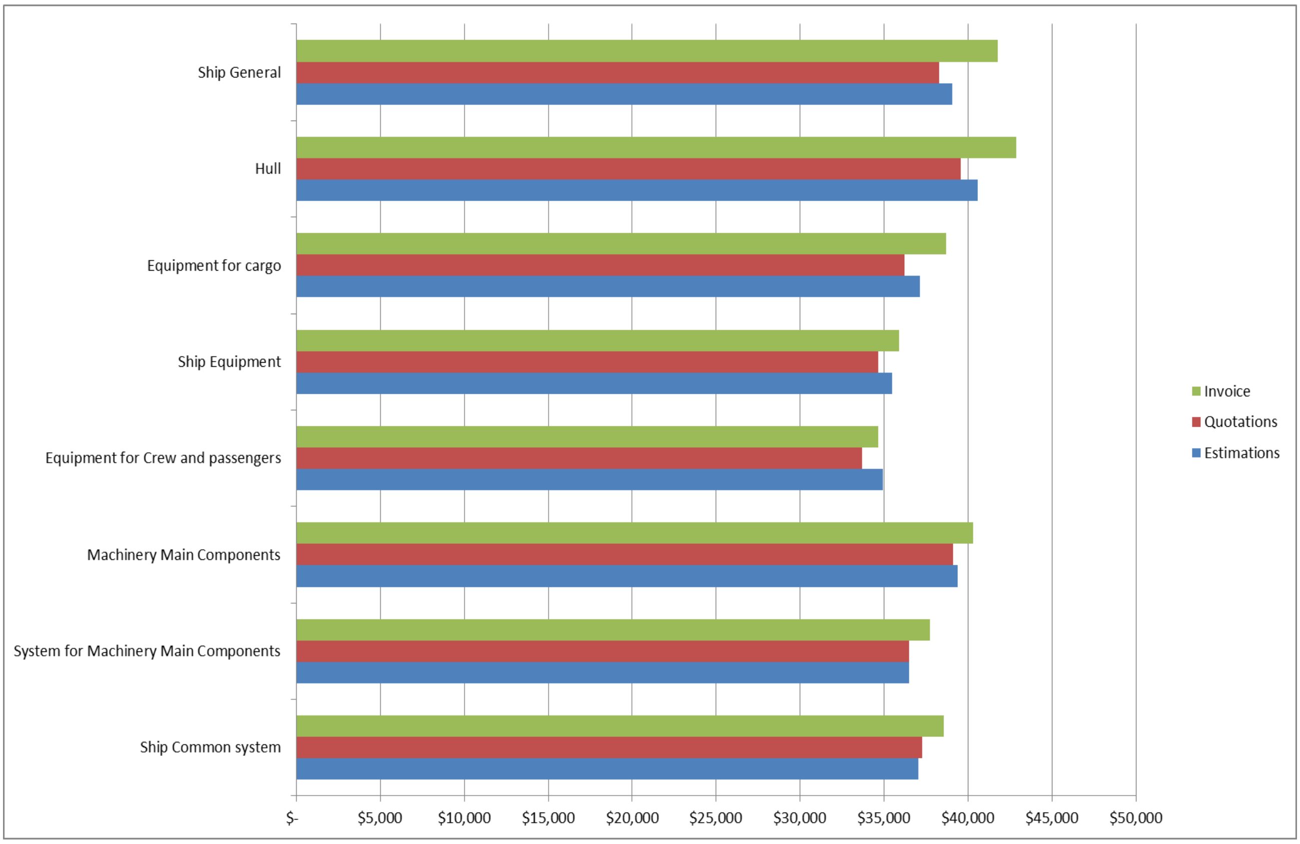


Fig. 21

Figure 21 displays the different figures in average and does not look very poorly, seen from an overall view, but significant differences are seen when looking into the individual ship.

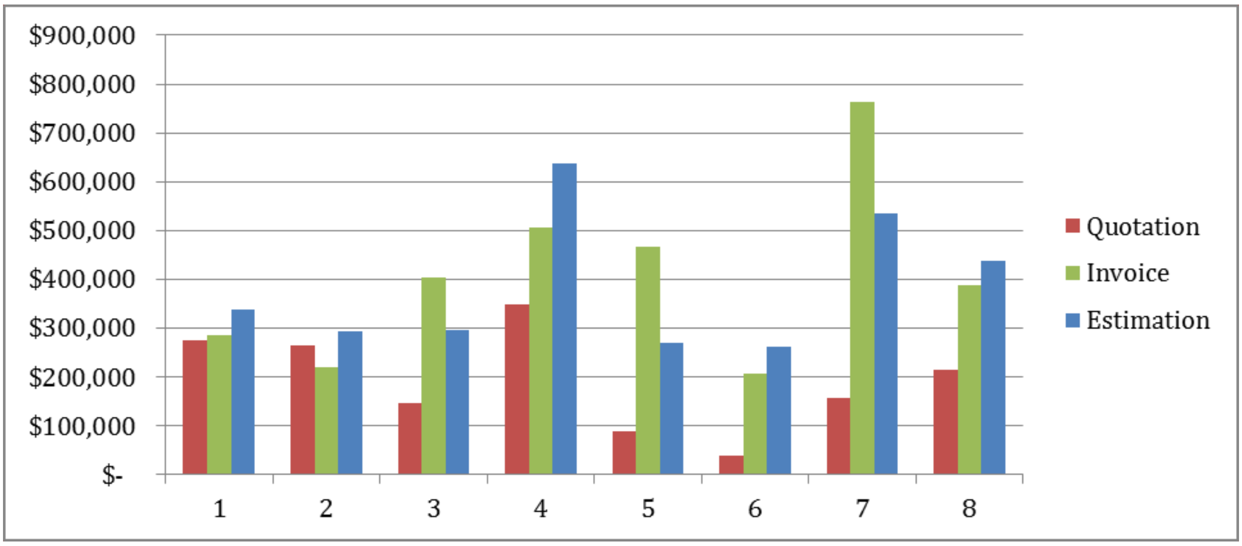


Fig. 22

The graph above shows quotations, invoice and estimations in USD for each individual ship, ranged 1-8. Red bars indicate the actual cost for the docking. As shown, seven out of eight ships were having a significant higher invoice than quoted from yard. The difference or the gap between invoice and quotations from individual projects seems to exceed the limit for what is reasonable. Quotations are far away from the actual costs.

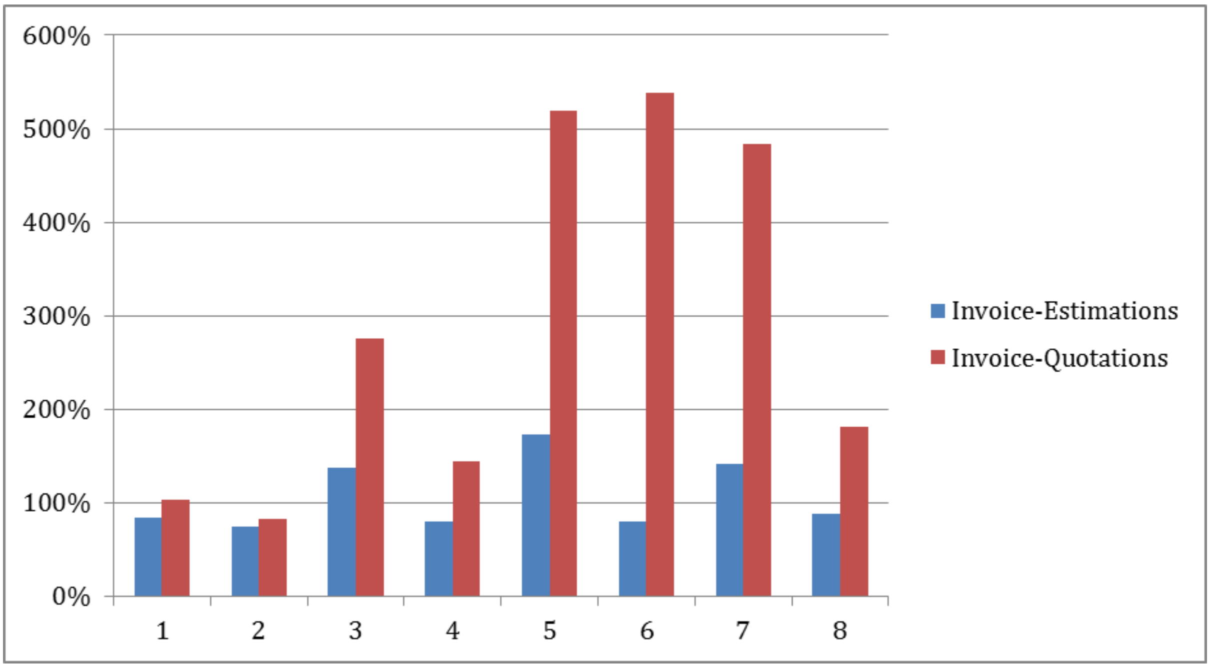


Fig. 23 (Source: Karl Fredrik Skorge Hansen)

Graph above displays actual cost related to the estimate and quotations in per cent. 100% will indicate an ideal relation between estimated and final invoice, for blue bar, which means how close the final invoice was to the estimate. Red bar indicates the relationship between quotations and invoice. Accuracy of the quotations is given in percentages, so red bars above 100% will display a higher invoice than quoted. Three out of the eight ships had a higher invoice than estimated. Ship number 8 shows the ideal relation between actual and estimated cost with 89% of estimated value of the final invoice. Looking at red bars we see 6/8 ships had a higher invoice than quoted.

The difference in USD can be seen above, and leaves no doubt about under-quoting. Average difference is 198,805 $, meaning the gap between the final invoice and quoted tender is significantly higher than the estimations done in advanced compared to the invoice.

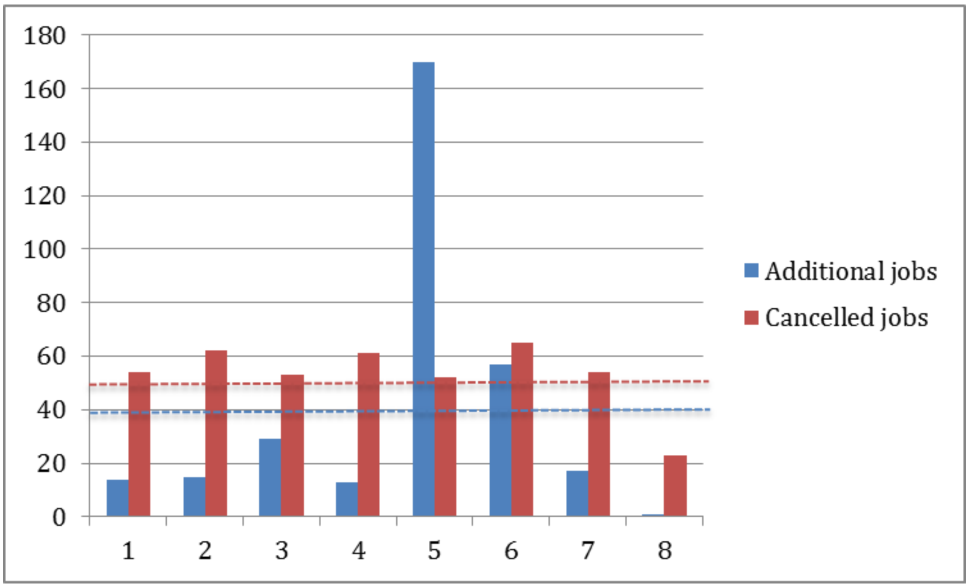


Fig. 24 (Source: Karl Fredrik Skorge Hansen)

Fig. 24 shows number of additional and cancelled jobs on each ship for the fleet analysed. The dotted line is the average for the sample. Cancelled jobs are present in relation to all ships analysed. This occurs for different reasons, for instance that the estimated scope of work was overestimated, with more jobs than necessary. Additional jobs are also present in all the dry-dockings analysed and is the kind of jobs that cost more than ordinary scheduled jobs.

Jobs that are not reported before the ship enters dry-dock will have an increased cost, in terms of an additional job. An approximate estimate for an additional job is $2000 USD, but will depend on the location and scope. Decreasing additional jobs will not always decrease the total invoice.

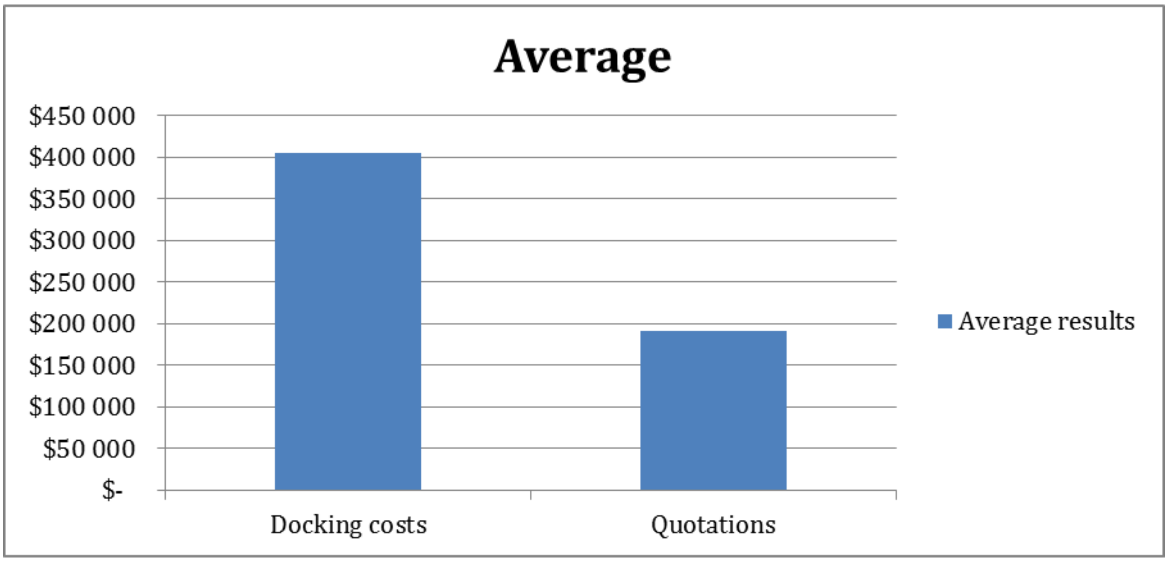


Fig. 25

An average cost for visits in dry-dock is estimated to $405,000 USD and quotations received from yard are estimated to approximately $192,000 USD, which turns out to be 47% of the final invoice, on average basis. This is caused by poor feedback from the yard in amount of jobs quoted for and the cost for individual jobs. The average estimations for all the ships are $383,000, which makes a much better view of the final costs (94, 5%), in an overall perspective, but variance between the individual ships are present.

Invoiced jobs with more than 5000$ in deviation from quotation	
100-Series	**Ship general**
Ship marking	
Dry docking costs (10,000$<)	
Supply of cooling water	
Supply of electrical power	
Supply of electrical power	
Sludge tank	
200-Series	**Hull**
Hull painting (10,000$<)	
Cleat housing renewal	
300-Series	**Equipment for cargo**
Reification compressor room plate	
Ramp Sheaves (10,000$<)	
Ramp wire (10,000$<)	
Grab bucket detachable attachment (10,000$<)	
Grab load testing (10,000$<)	
Grab LO tanks and renewal of hoses (10,000$<)	
Stern ramp and side ramp	
400-Series	**Ship equipment**
Stern ramp wire	
Side ramp wire	
Hydraulic pipe renewal (10,000$<)	
Installation of grey water tank (10,000$<)	
Anchor brake	
Chain locker modification	
500-Series	**Equipment for crew and passengers**
Main engine air cooler	
Renewal of accommodation doors	
Freezer room ceiling and internal repairs	
Car hold blowers	
600-Series	**Machinery main components**
Air condition plant repair	
Oil water separator service	
Main engine repair	
Piston crown	
Aux engine governor overhaul	
Aux boiler	
700- Series	**System for machinery main components**
Boiler fan motor overhaul	
Central cooler	
Main seawater inlet line, after valve	
800-Series	**Ship common system**
Installation of bridge watch keeper (10,000$)	

Fig. 26

Fig. 26 summarizes all the great deviations from the sample analysed. This table show jobs that turned out to be $5000 USD or more in realized costs than quoted. Analyses show that the realized costs in relation to what was quoted for are greatest in the category Equipment for Cargo. Five out of seven jobs had a significant deviation in quotation, with more than $10,000 USD in difference from what the final invoice was.

Main-Group 3, Equipment for Cargo includes systems for the vessel`s cargo, for instance loading/discharging systems, cargo winches and hatches.

Some of the estimations and quotations for docking in general is made on separate lines in the spec list, instead of including all jobs linked to the entering and the exit of dry-dock and present them as one cost. This may cause severe variance in numbers of quoted jobs.

The most significant costs related to dry docking projects are docking cost, sand blasting, painting and steel renewal. Docking costs includes all of the services that are necessary for the ship to enter, stay and exit the dry dock. Some of the important services provided from the yard are:

- Tug assistance
- Pilot assistance
- Gangway connection to the ship
- Filling water into the dry dock
- Supply of electrical power from shore
- Supply of cooling water

Docking costs represent approximately $50,000 USD of the final invoice for ships that are entering the dry dock.

4. Discussion

4.1 Part 1 – Summary of results

Eight ships have been analysed, with quantitative data from more than one thousand jobs and 300 additional jobs completed in dry-dock. This data has been closely analysed with concerns to estimations, quotations and realized costs.

Significant gaps were found in relation between quotations made from yard and final realized costs. The utmost gaps were found in the category Equipment for Cargo and consisted of several overruns of costs in individual jobs, with respect to quoted jobs and final costs. This category contained seven jobs where each job was having a deviation with more than $5,000 in extra cost from the quoted value. Five out of these seven jobs had more than $10,000 in extra cost compared to the quoted value.

Study shows an average docking cost of $405,000 USD per docking and an average quotation of $192,000 USD per docking. Quotations are carried out poorly by the individual yard with concerns to number of jobs - and the price quoted, and makes the quotations achieve only 47% in average of the complete docking costs.

4.2 Part 2 – Data and results

Quantitative data could not be compared to any other research or reports, which proved as non-existent when the research started. Small parts of literature were used in the theory part where dry-docking is described, but was not a determining factor to support the hypothesis.

The quantitative data analysed did clarify and supported the hypothesis, at the same time point out where the gaps were located. Yards show tendency of not quoting for the complete spec list which is sent from the management company, which naturally lead to a gap between the final invoice and quoted cost for the respective dry-docking. Lack of quotations and significant miscalculations by ship yard related to dry-docking lead to elements of uncertainties around estimations completed by the ship management. The use of know-how and experience in the past creates estimations based on assumptions, and could be seen from the individual jobs that were plotted into the analytical sheet. Where jobs were inserted and no quotations were received led to an approximate figure inserted by the estimator, but the actual costs turned out to be in some cases considerably different.

Five out of eight ships had a higher overall estimation than what the actual invoice turned out to be, which emphasizes the lack of basis for estimations. The ships investigated, did however, indicate an overall average of higher invoices than estimations in seven out of eight SFI categories. This is caused by few, but significant gaps between estimations and invoice in certain ships, which makes the average for all ships to be higher than the individual ones seen separately. This suggests that even if the estimations are revised up, the invoice turns out to be different from that seen from a group perspective and is mostly present in the categories Ship General and Hull.

Great variance with concerns to quotations and estimations were present in all the ships analysed and they differ from each other with concern to location of work completed in dry-dock. Hull and Machinery are standing out with higher invoice than other categories, and are the segments where costs are higher in general. Three out of eight ships had the mechanical area as the highest cost represented in the invoice, and three ships had hull as the highest cost. Significantly gaps between quotations and realized costs were also present in these groups, where 2/3 ships showed great deviations between quoted price and actual cost.

A great amount of jobs were cancelled in dry-dock and were never completed. A common reason for this is because surveys are carried out close to the entering date, which can reveal jobs that are not necessary to complete in dry-dock. Several additional jobs are however completed in dry-dock, which bound extra costs to the invoice.

The process has more or less been solved by know-how and experience in the past for the individual estimators, and has not been efficient or accurate enough in the way of handling the different data. One important issue, which can be related to project risk management, is the way of handling the uncertainties. By managing the variability the uncertainty will decrease. The variability may be handled by easy steps, such as systematization of data, which let the estimator, be in control of what kind of costs and estimations that have been made in the past. Simple software, which includes these data, will have an impact on future estimates and do it more accurately. This contribution will however relay on the effort from the yard, which also need to be included. Implementing the yards` quotations in similar way will contribute to display the deviations better, receive more quotations and find the yard that has approximately the same estimate. The yard should also be compared to other yards with this particular group in mind because this states something about experience on that particular type of ship.

A common IT-platform where jobs on specification in relation to dry-dockings can be inserted by management and accessed by yard for quotations may enhance the relationship between quotations and actual costs at the same time bring more knowledge around costs to the estimator. The yard should be given the same opportunity to participate in the process by having access to software where they can fill in quotations. Better documentation of the jobs, which are sent to the yard with notes and photos, may help to get a more complete tendering back in terms of number of jobs quoted for.

Spec lists should also be in focus in terms of being a common template where both the management company and ship yard can utilize the SFI-system better by using descriptions, photos and notes attached to the individual job which need to be completed in dry-dock.

Using different lists, which is of different quality (terms, statements and wording), can have an impact of how the parties understand each other. The terms of agreement have to be a mutual agreement based on clearly defined terms. Objectives arranged in the particular project will be easier to manage or survey (Green, 2001 as cited in Champman & Ward, 2011).

4.3 Part 3 - Limitations

The missing literature and research on the topic made some boundaries, but at the same time the opportunity to enlighten deviations in the process around dry-docking. The measurements and calculations may consist of small human errors because of the collecting process, where data needed to be taken from different spread sheets, both digital and in paper form, in order to implement it into one single sheet. The input into these spread sheets are completed by many people in different positions, either in the ship management or in ship yard. It has also been practiced differently with concerns to input of figures, where USD and Singapore dollars have been used in estimations, quotations and invoices interchangeably. A standardization of currency is an important procedure in order to achieve a correct and complete analysis.

Re-estimations hence to surveys done are more practiced now than when the ships were analysed. Some indications were found in relation to re-estimations, but were only valid for one or two ships, and on vague basis. Re-estimations are done if special surveys reveal unnecessary or additional work related to certain jobs and is therefore adjusted to the scope.

Analysis of a larger fleet with solely focus on one specific type of vessel may change the results of this research, and may show different costs for the respective group analysed. This sample may, however give an indication of dry-docking costs, estimations and quotations if different ships are in the same fleet. Validity for the gaps and deviations found in this research concerning the budgeting process will be strongly valid in other ship types investigated in the future. There are no reasons to believe that estimators with the same basis of information, no matter ship type, shall estimate more accurate or receive more quotations from yard than the investigated vessels in this research.

5. Conclusion

Significant deviations in the budgeting part of the dry-docking process are found with concerns to quotations from shipyard, estimations and actual costs. Category Equipment for Cargo should be prioritized, based on this research, as one main group to pay particular attention to, in terms of being where quotations from individual jobs have been standing out from other groups. Estimations analysed show a frequent overestimation above what the actual invoice turn out to be. Bettering the budgeting process in terms of being more accurate will be determined by systematization and practice of historical data from dry-docking.

Using such data from dry-docking in the past as a database where all specifications, estimations, quotations and actual costs can be stored may turn the subjective estimations more towards an objective approach. The uncertainties around budgeting process will be minimized to the point that real costs can be used as basis and therefore more certain than subjective estimations based on experience.

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Table of figures and tables