Application of the Montecarlo method for the validation of the budget of a suezmax type ship

Aplicación del método de Montecarlo para la validación del presupuesto de un buque tipo Suezmax

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Abstract

As the name suggests, the budget for the construction of a ship, in this case a Suezmax, means to specifically pre-suppose in economic terms, the activities and movements to carry out during the construction of said ship. The importance of this essential phase of the construction process lie one hand in budgeting a competitive price in the market, but without causing economic losses for the shipyard, in order to make a profit for the company. This study proposes the use of the Monte Carlo method to obtain a greater reliability in the valuation of the Suezmax vessel; in this case, the triangular method will be used, which starting point is based on results obtained from previous research and from which the most likely, most pessimistic and most optimistic ship budget is obtained in order to later perform a simulation.

For the realization of said simulation the ship is divided into different items, that will be assigned an optimistic and pessimist percentage based on a likely budget, according to the degree of trust of the shipyard in said concept. The final scope will be the calculation of the management reserve used to rectify any unforeseen item(s) in the construction of the ship.

Key words: Monte Carlo Method, Project Management, Budget, Shipbuilding, Suezmax.

Resumen

Tal y como dice su nombre, el presupuesto de un buque, en este caso un Suezmax, es justamente pre-suponer en materia económica, las actividades y movimientos a realizar durante la construcción de dicho buque. La importancia de esta fase esencial del proceso de construcción radica por un lado en presupuestar un precio competitivo en el mercado, pero sin que llegue a causar pérdidas económicas para el astillero, de manera que se busque un beneficio para la empresa. En este estudio se utilizará el método de Montecarlo para conseguir mayor fiabilidad en la tasación del buque Suezmax; en este caso, se empleará el método triangular cuyo punto de partida se basa en resultados obtenidos en investigaciones anteriores y del que se obtiene el presupuesto del buque más probable, el más pesimista y el más optimista para posteriormente realizar una simulación. Para la realización de dicha simulación se divide el buque en diferentes ítems, a los que se les asignará un porcentaje optimista y pesimista determinado en base a un presupuesto probable, según el grado de confianza del astillero en dicho concepto.
El alcance final será el cálculo de la reserva de gestión que se emplea para subsanar cualquier imprevisto en la construcción del buque.

Palabras claves: Método de Montecarlo, Gestión de Proyecto, Presupuesto, Construcción Naval, Suezmax.

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Introduction

Suezmax are classified as shuttle tankers with special construction, and are used transport different kinds of liquid fuels with its dimensions optimized for crossing through the Suez Canal, therefore avoiding the route through South Africa, shortening the journey and saving time on the way. This type of vessel has a transport capacity of between 0.9 and 1.2 million barrels of crude oil, with its highest demand being on the west coast of Africa for shipments to the Caribbean, the East coast of the United States or the North of Europe and the Black Sea.

Therefore, one of the biggest risks involved in the construction of a vessel with these characteristics is to obtain a final cost, because its new construction price can oscillate between 52 million € and 94 million €. The fact that the end value fluctuates, because a reliable method has not been followed, can result in a project with losses for the shipyard, either because it does not have the ability to complete the project with the estimated budget or because the final value of the ship is not competitive.

To mitigate this problem, the most current project management studies, such as those carried out by the Project Management Institute PMI[1] or by the International Project Management Association (IPMA)[2], propose the use of the Monte Carlo method to estimate the project management margin. This method has been verified not only in the field of project management, but also in other knowledge areas of engineering[3], Therefore, this method is considered to be valid for the estimation of uncertainties.

Purpose

The scope of this article is to calculate the management reserve (which is a budget item for contingencies) for a Suezmax-type vessel using the Monte Carlo probability method as a tool to obtain a greater level of reliability in the appraisal of the real value of the ship.

Definition of the method

The Monte Carlo method is a non-deterministic or numerical statistic method based on the simulation of random variables, which allows both physics and mathematical problems to be solved[4].

For this particular case the triangular method is used[5], which is based on the results of budgets obtained through the breakdowns that were reflected in Table 1; it is necessary to define 3 stages to break down the concept of the ship's budget: the most likely, the most pessimistic and the most optimistic.

Methodology

Once the 3 cases have been obtained, the Monte Carlo method will be used through a simulation.
The calculation of the budget is based on the breakdown of the ship into different parts, using as a basis the nomenclature of the technical manuals employed in the US Navy[6], which differs from that of a civilian ship simply by eliminating item 700, which corresponds to weapon systems as a Suezmax ship, as a civilian ship, does not have this item. Although this budget breakdown is for military vessels, its application to merchant ships is completely valid, as it contemplates the full scope of the project, serving as a cost concepts structure.[7]

The percentages of the optimistic and pessimistic margins are shown in Table 2, which have been obtained from the PMBOK[8] Guide on the basics of project management.

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[8] A Guide of the Project Management Body of Knowledge (PMBOK Guide) Sixth Edition, 2018

Table 1. Breakdown of the concept

100	Hull structure
200	Propelling plant
300	Power Plant
400	Communications and control
500	Ancillary services
600	Equipment and enabling
800	Technical Services
900	Support for the ship during construction
---	Staff dedicated to the work

Table 2. Percentages of optimistic and pessimistic margins

	Optimistic	**Pessimistic**
Low confidence	175%	75%
Medium confidence	125%	90%
High confidence	110%	95%
Overlap	0	0

The simulation is based on a shipyard located in western Europe taking into account the capacity and degree of knowledge that a shipyard with these characteristics has to carry out the tasks of each part, being able to adjust the margins in each item, as shown in Table 3. These percentages refer to the increase or decrease with respect to the base budget or the most likely budget.

Based on the percentages that have been assigned through the PMBOK reference, and that have been reflected in the methodology, are shown in Table 4, which reflects either the base budget or most likely budget, as well as the budgets that are calculated by applying the coefficients set out in Table 3.

From where can be observed that the highest physical construction cost of the ship would be in the hull structure (approximately 25%), which requires greater clarity when organizing the project. On the other hand, support for the ship during construction covers different aspects and that present great uncertainty, such as launching, control of weights, logistical and management support, scaffolds and beds, tests, etc. which imply a high likely budget and therefore present a greater impact on the margins.

The use of Staff only for the work would cover approximately 50% of the percentage of the total budget due mainly to the number and cost of the labour that a project of this magnitude requires.

The reference values of Table 4 are obtained through a breakdown of each of the items cited, using the formulas[9] that express each concept and multiplying them by a unit price.

Using the percentages displayed in Table 3, the value of the likely budget is closer to the optimistic budget (about 11%) than to the pessimistic budget (34%) and it can be concluded that the weighting reflected in the method is conservative.

[9] Albariño-Castro, R. Azpiroz Azpiroz, J. Meizoso Fernandez, M. Basic merchant ship project. 1997. Page 135 -141.

Table 3. Percentages of margins broken down into concepts

	Pessimistic	**Optimistic**
100 - HULL STRUCTURE	110%	95%
200 - PROPELLING PLANT	110%	95%
300 - POWER PLANT	110%	95%
400 - COMMUNICATIONS AND CONTROL	175%	75%
500 - ANCILLARY SERVICES	125%	90%
600 - EQUIPMENT AND ENABLING	125%	90%
800 - TECHNICAL SERVICES	175%	75%
900 - SHIP SUPPORT DURING CONSTRUCTION	175%	75%
STAFF DEDICATED TO THE WORK	125%	90%

Table 4. Pessimistic, Probable, optimistic budget in each concept

	Pessimistic	Likely	Optimistic
100 - HULL STRUCTURE	€22,148,775	€20,135,250	€19,128,487
200 - PROPELLING PLANT	€5,528,828	€5,026,207	€4,774,897
300 - POWER PLANT	€1,460,873	€1,328,066	€1,261,663
400 - COMMUNICATIONS AND CONTROL	€262,500	€150,000	€112,500
500 - ANCILLARY SERVICES	€2,249,412	€1,799,529	€1,619,576
600 - EQUIPMENT AND ENABLING	€436,837	€349,469	€314,522
800 - TECHNICAL SERVICES	€2,358,738	€1,347,850	€1,010,888
900 - SHIP SUPPORT DURING CONSTRUCTION	€9,434,953	€5,391,402	€4,043,551
STAFF DEDICATED TO THE WORK	€48,255,000	€38,604,000	€34,743,600
TOTAL COST OF CONSTRUCTION OF THE SERIES	**€92,135,915**	**€74,131,774**	**€67,009,685**

Results

Once the triangular Monte Carlo method is programmed, a number of "dice throws" or iterations are selected to perform the calculations. In this case, 10,000 iterations have been chosen, an amount that does not produce a surcharge in the numerical calculation but that it is enough to obtain a relevant result. It has been verified that the method converges from 2,000 iterations onwards, although the calculation process of 10,000 iterations does not imply an appreciable overcost in the simulation, which is why it has been considered the most suitable for performing the calculations.

In Fig. 2, the triangular distribution of the Monte Carlo method is observed and therefore it can be deduced that the likely budget will be where there is a greater number of iterations (approximately 76 million €) corresponding to the upper point of the triangle, and the optimistic and pessimistic budgets (Table 4) correspond to the lower end points of the graph. The red line of the graph shows the cumulative percentage of the probability that the project has in having said cost, or a lower one.

Regarding the management reserve shown in Fig. 2 it is observed that the value is adequate for the project to be competitive in different offers, without

Fig. 1. Result of the analysis of the Monte Carlo triangular distribution

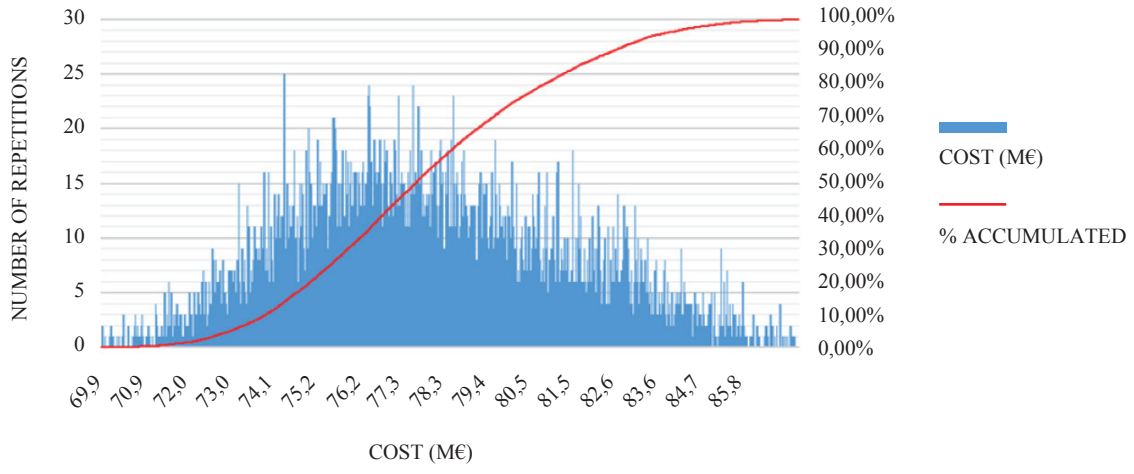
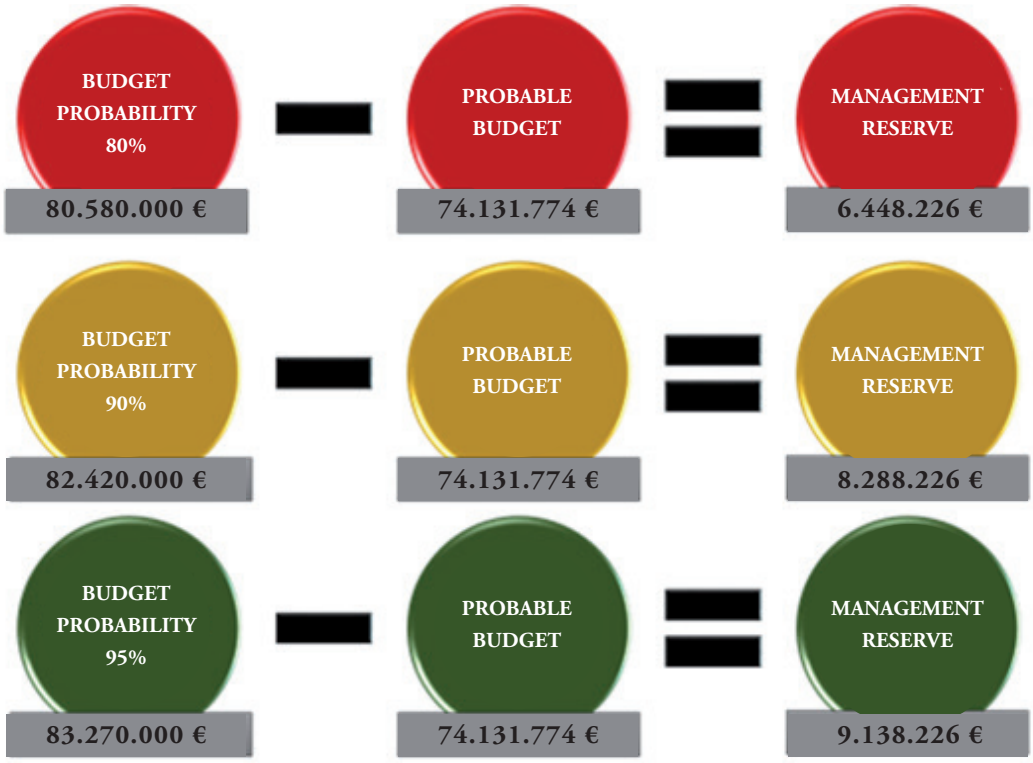


Table 5. Budgets based on the analysis of Monte Carlo

RESULTS	M €	PROBABILITY	DEVIATION
OPTIMISTIC BUDGET	67.01	< 0.10%	
PROBABLE BUDGET	74.13	12.2%	
PESSIMISTIC BUDGET	92.14	100%	
BUDGET PROBABILITY OF 80%	80.58	80%	8.7%
BUDGET PROBABILITY OF 90%	82.42	90%	11.2%
BUDGET PROBABILITY OF 95%	83.27	95%	12.3%
BUDGET PROBABILITY OF 100%	88.39	100%	19.2%

Fig. 2. Management Reserve Procurement scheme



the risk of possible losses for the company, with corresponding values between 8% and 10% of the ship's base budgets in the different probabilities.

Conclusions

In the table of results on budgets based on the Monte Carlo analysis (Table 5) the probability that budgets could have (optimistic, likely and pessimistic) are obtained directly through the breakdown of the different items (Table 4).

With the Monte Carlo method it is possible to know the probability of achieving a budget of 80% and 95% of certainity, depending on whether the company takes a conservative (95%) or risky (80%) strategy; the value of 100% probability would not be a determining value because it usually corresponds to a random iteration corresponding to said amount of money.

With respect to the results obtained in the management reserve, a margin of 6.5 million € has been achieved which corresponds to an 8.7%

deviation from the budget. This would be the decision of 80% probability, being the riskiest of the three. If one wants to be more conservative the same would be done with 90% or 95%, in which it would obtain a management reserve of 9 million € and 14 million € respectively that is equivalent to 11.2% and 12.3% of budget deviation.

All the results obtained by applying the methodology set out in this investigation are aimed at providing more information to the shipyard's management, thus facilitating senior management decision-making.

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