

# Parametric Cost Estimation at Azimut Yachts

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## Abstract

Mega yacht builder Azimut Benetti is the biggest private group in the luxury boating sector. As the business unit Azimut Yachts is engaged in serial production, the design of a new yacht always means a long-ranging cost determination. In order to predict the cost of new designs, Azimut uses cost estimation relationships (CERs). These formulas are calculated based on technical parameters and labor hours respectively material cost of historical projects. This paper describes the estimation process using the cost management software 'CostFact'. The process includes assessing the usability of available data, deriving the CERs, evaluating their reliability and finally incorporating the results in the calculation of the project.

## 1. Initial Situation

Cost prognoses play an important role in the design of yachts: During the project start no sufficient information is available for detailed cost calculation. Nevertheless, a cost estimation must be generated quickly and accurately. Predicting costs is also necessary for comparing the actual design with cost targets. When doing so and a prospective cost overrun can be foreseen, design options have to be evaluated and the costs of each option have to be estimated. The information that can be used for cost prognoses depends on the current project phase, Fig.1. As shown in the picture, past projects can be used in all phases for cost predicting. This is done by similarity calculation which means that for one thing the technical data of the historical project and the cost that occurred during its production are examined and for another thing the similarities respectively differences between the project from the past and the current project are analyzed.

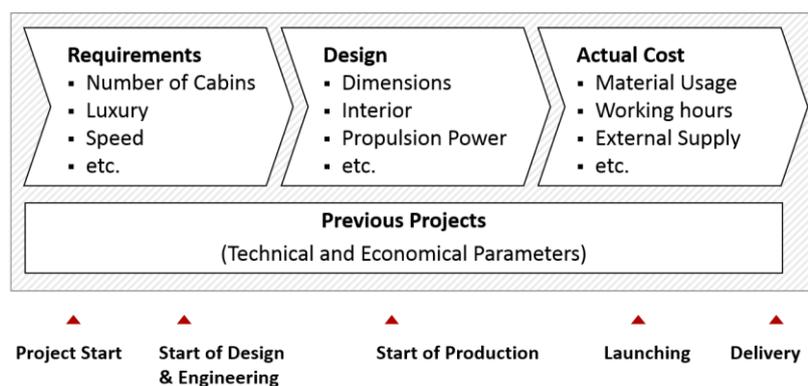


Fig.1: Information for cost prognoses according to project phase

## 2. Current Approaches of Parametric Cost Estimation

While analytical cost planning is primarily based on the assessment of components that generate costs, parametric cost planning can also refer to the functions fulfilled by component systems. Analytical and parametrical cost planning can be combined when planning the costs of a ship: Parametric cost planning is used especially in the early project phases for cost estimations of (main) building groups when detailed information about the components to be used as cost predictors is not yet available. As the project progresses and the available information increases, parametric cost prognosis can successively be replaced by analytical planning at more detailed levels to improve precision.

In parametric cost planning, the costs of previously built objects are compared with their technical attributes to ascertain if there is correlation between the costs and the attributes. A very simple and

common method in ship and yacht building is the use of cost indexes like welding hours per ton steel mass. After deriving the indexes from historical projects, the costs of a new object are predicted by multiplying the selected parameter by the corresponding index. At present, the use of weight as cost driving parameter dominates the scene of parametric cost estimation in shipbuilding, *Shetelig (2013)*. The clear advantage of cost indexes is their very simple use, both for deriving them from previous projects and applying them in new cost forecasts. However, this method assumes that the costs are directly proportional to the selected parameter. Such a linear cost progression is usually not the reality. Furthermore, the use of a mean value provides no insight as to how the costs of the reference object are distributed, meaning there is no indication that the cost prognosis is reliable.

A method that combines the advantages of cost indexes with a field of application that is not limited to linear correlation and also gives information on the reliability of a new cost estimation, is the regression analysis. Similar to cost indexes, this parametric procedure can be used to identify and describe the functional relation between an object's costs and its technical features, but the resulting formula can also refer to a non-linear relationship between cost and technical parameter. Furthermore, information can be gained on the reliability of cost prognoses, which base on the created formula.

Fig.2 presents a fictional example of a non-linear regression analysis where the propulsion power is the variable that affects the cost of the propulsion plant. The regression function is derived from seven already built yachts. The resulting function can be used to predict the cost of a new propulsion plant, based on the required propulsion power.

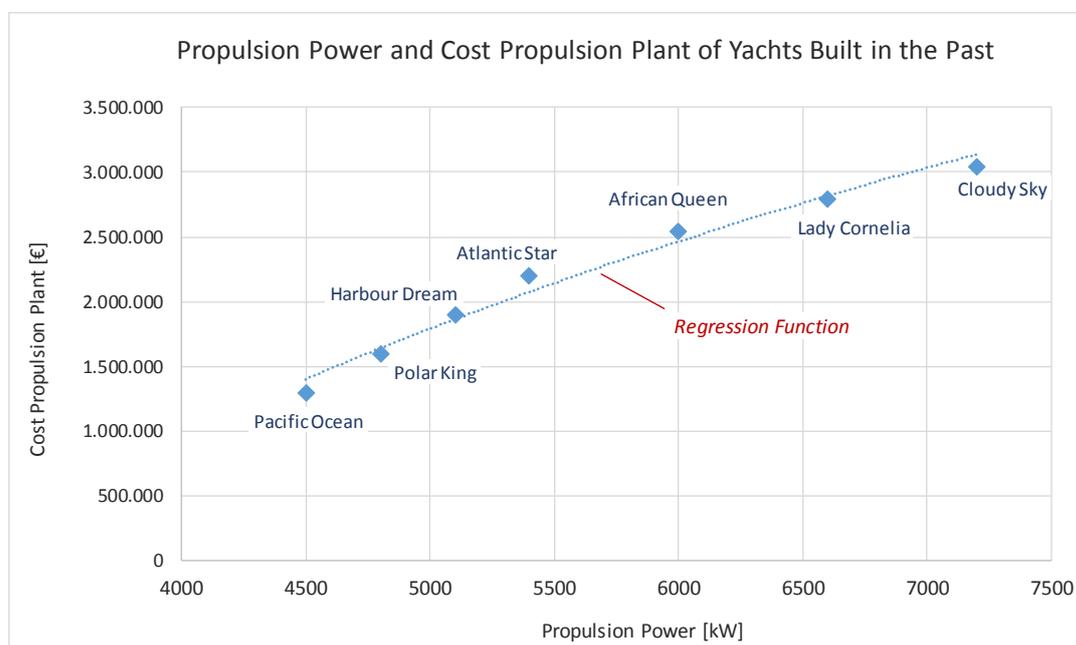


Fig.2: Regression analysis for the cost of propulsion plants

The execution of a regression analysis is carried out in the following steps, *Fischer and Holbach (2011)*:

1. The technical and economic data from previous projects have to be collected. Furthermore, cost data have to be updated if necessary, due to price increases or other changes.
2. The feature of the calculation object that will be used as cost determining parameter (“Propulsion Power” in the depicted example) must be defined. It is usually identified by a logical estimation of which element has the main effect on cost.
3. The regression function is generated. In general, the regression function is set up in such a way that the difference between the calculated costs and the actual costs is as small as possible.
4. The regression function is evaluated to assess the reliability of a cost prognosis generated by this function.

## 2. Software Support in Practice by CostFact

The software system "CostFact" was developed especially for the maritime sector. It supports cost management throughout all shipbuilding phases, beginning with the early phases of design and engineering, to the calculation accompanying the production and finally, to the analysis of already concluded projects. When setting up a calculation in CostFact, costs from alternative information sources can be integrated, such as:

- Unit rates
- Supplier proposals
- Previous projects
- Cost norms based on technical attributes

These different cost sources can be combined within a calculation. Typically, the utilization moves from parametric calculation with norms over cost import from previous projects to the direct input of costs or proposals from suppliers. This article focus the parametric approach.

CostFact contains an own module for parametric cost estimation. Compared to conventional calculation with spreadsheets, a main advantage of this module is the capability to integrate existing calculations by import from different sources like Excel-Files or ERP system automatically and to provide a uniform platform for the administration of all information required for parametric cost estimation. By this, such estimates can be carried out very efficiently.

### 2. CostFact Application by Yacht Builder "Azimut Yachts"

Using an example from real life, the procedure of setting up a calculation based on parametric relations is described in the following. The regarded shipyard performing the cost estimation is Azimut Yachts from Italy. Founded in 1969 for the chartering of sailing boats, Azimut quickly expanded its operations and began to design new yachts. With the acquisition of Benetti in 1985, Azimut became able to construct and produce its own yachts, defining new style and industry standards that revolutionized the boat building industry. In the course of implementing CostFact, Azimut Yachts' specific product breakdown structure was imported into the system. Furthermore, CostFact was populated with some representative projects from the past by importing these calculations from spreadsheet files.

After this general preparatory work was done, the actual parametric specific work started with the definition of the technical attributes which should be provided for use (see the left side of the window shown in Fig.3 with example "Propulsion Power").

In the next step, the elements of the product breakdown structure were assigned to the various technical parameters by selecting them from the list on the right. This designation is based on a technical and economic relationship between the attributes and the structure element (group). In other words, if the characteristic changes, the costs of the group assigned to it would also change. The example shown defines that a change of "Propulsion power" will lead to a cost change of group "YT0501 TRASMISSIONE" (transmission) and all of its subordinated groups.

Finally, for each project from the past the characteristic values of the different parameters were entered. Based on this data and information, a regression analysis was carried out. Fig.4 shows the corresponding window (some values are hidden for confidentiality). The added numbers refer to the description in the following. To begin the analysis, the user first selects the group to be calculated from the dropdown list (1, YT0705 Elettrodomestici in this example). After the selection, the attribute(s) dedicated to this group are displayed in the next list (2). The user selects the attribute that will most likely exert the strongest influence on cost respectively that is already available for the new project (here: Superficie/Surface  $L_{max} \times B_{max}$ ).

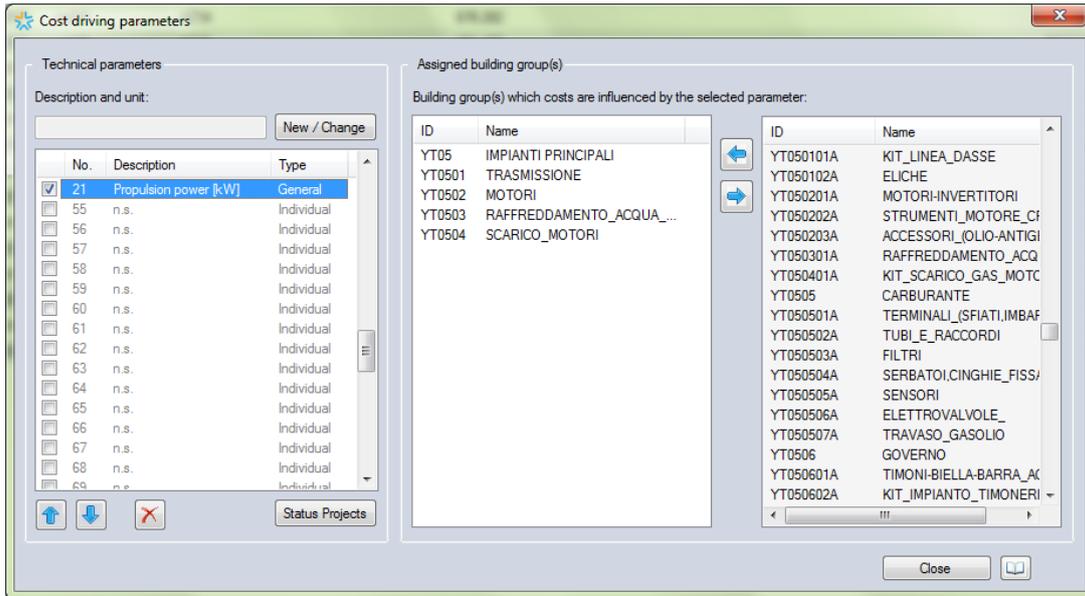


Fig.3: Assigning groups to parameters

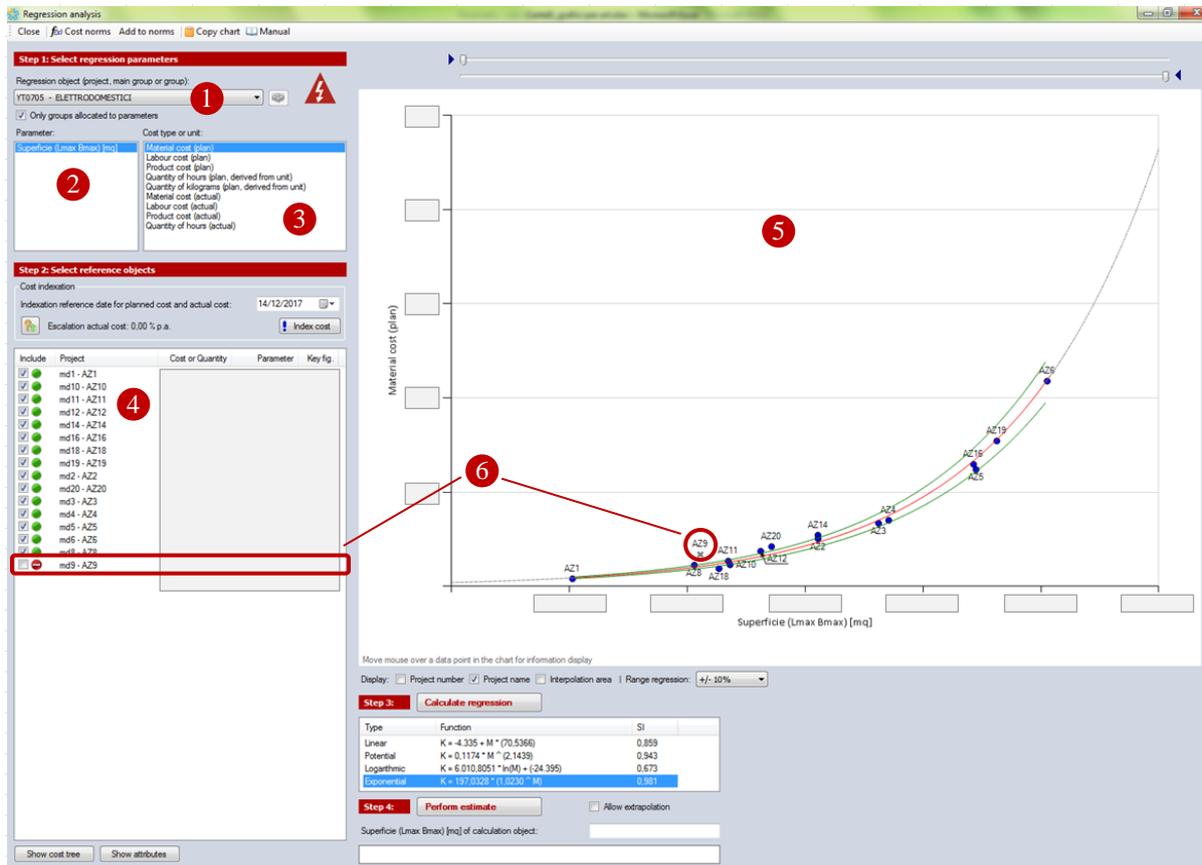


Fig.4: Regression analysis (values hidden for confidentiality)

Using the next list (3), the object to be analyzed is selected (Material Cost). Once these regression parameters have been defined, CostFact lists all projects in which the cost for the selected group has already been calculated and where the key data is available (4). In addition to the tabular presentation, the reference objects are also displayed in the scatter diagram on the right of the form (5). This visualization enables the user to quickly ascertain whether there is a correlation between the selected objects.

Optionally, the regression function can be weighted by excluding reference objects with inadequate similarity from the reference pool. In the current case (fictional example), the project “AZ9” (6) was identified to be an exception since its characteristics are different from the others projects and therefore untypical for the intended analysis. So, it was deselected in the list.

Finally, the user decides whether or not the costs should be indexed to a defined date. In this case CostFact escalates the costs of each project, based on a) the selected reference date, b) the respective date of the historical project and c) index values which are administered in CostFact centrally, specific for each cost class and calendar year.

In the next step, the regression function is calculated. CostFact uses the “least squares method”. In this method, the optimal adjustment of the regression function has been reached when differences between the sum of the squares of the actual values and those of the model values are as small as possible. CostFact includes four different regression models that are often used in practical situations (linear, potential, exponential and logarithmic). The so called “stability index” (displayed in column “SI”) measures the percentage of variance from the actual costs that can be explained by the regression. CostFact suggests the function with the highest stability index but the user is free to select the regression type they believe will best reflect the actual correlation. In the depicted example the chosen function is the exponential one, saying that the material cost can be calculated based on the technical parameter as:

$$\text{Material cost} = 197,0328 \times 1,0230^{\text{Superficie Lmax*Bmax}}$$

If the regression module is used for an ad hoc cost estimation, the user can already make a cost prognosis for the new object in the same window (“Add to norms” in the menu bar). However, in the example described here it is intended to incorporate the function into the calculation. Therefore, the user adds the derived cost function to the “Norm Pool” what makes it available for application within further projects’ calculations.

The current challenge is a cost prediction in the scope of a tender calculation at a very early stage with only few specification information and the need to generate the estimate very quickly. Against this background the user decides to calculate Material cost YT0705 Elettrodomestici based on the parameter “Superficie Lmax x Bmax” of the new project and the derived norm. To apply the function in the calculation, the user selects the object to be calculated and pulls up the window shown in Fig.5.

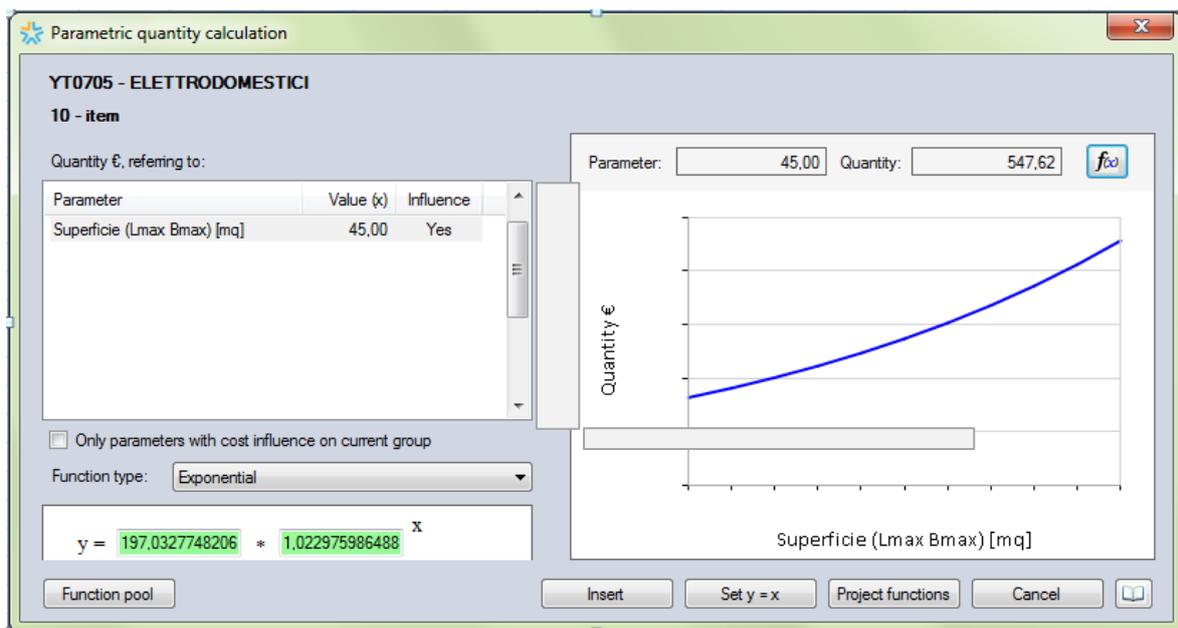


Fig.5: Input of parametric function (values hidden for confidentiality)

Besides the option to enter a project specific new function, this form provides access to the norm pool in order to select a stored function. In the displayed example the function that was previously derived by the regression analysis was chosen. The technical parameter of the new project (Surface Lmax x Bmax with 45 m<sup>2</sup> in the example) was already entered in the central project administration. The preview on the right side of the window shows the resulting number of material cost (548 €). After confirming, the complete function is implemented into the calculation.

The result is shown in the project calculation view that is depicted in Fig.6 (together with other cost inputs): Displaying the product breakdown structure on the left side and the cost data on the right, this view can show the complete calculation – from the single items at the final level of the tree view, via the subordinated and main building groups with sub totals, through to the costs of the complete project on the top level.

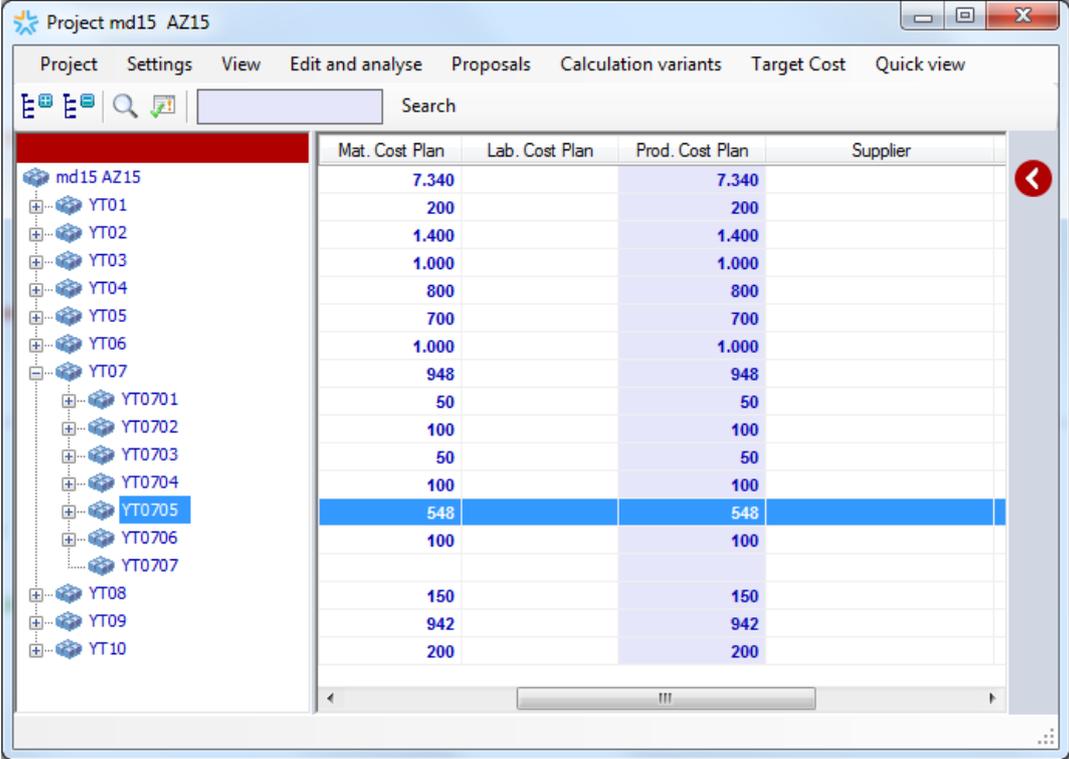


Fig.6: Calculation view of completed project (excerpt, fictional)

When a change of the technical attributes takes place, the complete costs can be recalculated self-acting. This is particularly helpful in the first phase with many design modifications. In principle, the complete (rough) calculation can be set up by those parametric functions. By reusing the resulting structure for new projects, it will be sufficient to enter the ship’s current attributes and the proposal calculation is created automatically, based on the defined dependences.

**References**

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