COST MANAGEMENT IN SHIPBUILDING

Case Studies Software System "CostFact"

NSRP Joint Panel Meeting

Biloxi, Mississippi, USA
May 10, 2016
CostFact is the number one in maritime specialized costing software. It is developed in close cooperation with several of the world’s leading shipyards, which means that a number of best-practice methods have been incorporated into the system, covering all of a shipyard’s calculation demands.

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CostFact: Integration of all Cost Relevant Information
Case Study Blohm+Voss

Reliability of Cost Estimations
Blohm+Voss

- Shipbuilding, conversion and repair since 1877.
- Product range includes merchant vessels, passenger ships, yachts and naval ships.

Initial Situation:
- Need to create a great number of quotations in shortest amount of time.
- The uncertainty in cost estimates leads to economical risks which have to be quantified before quotation.
Several Facts Lead to Uncertainties in Cost Estimation

- Time pressure in quoting
- Project complexity
- Lack of information in early project stages
- Organizational separation of the included parties

Cost prognoses come along with uncertainty inevitably
Case Study Blohm+Voss

Reliability of **Bottom-Up** Cost Estimations
Bottom-Up Costing in the Work Breakdown Structure

∑ Entire Vessel: Total Material Cost and Labour Hours

∑ Group A: Total Material Cost and Labour Hours

- Material Cost Steel
- Labour hours Steel Work
- Material Cost Purchased System 4711
Bottom-Up Costing: Calculation View of CostFact
Risk Analysis in Bottom-Up Calculation: Identifying and Quantifying Concrete Cost Risks

2300 PROPULSION UNITS

15 Alignment

Description: Additional adjust device

Value: 5,000.00

Probability: 30%

Remarks:

Cost in case of occurrence:

- (Statistical) expected value: 1,500.00
- Standard Cost: 25,520.00
- 30,520.00
The Expected Values are Calculated and Summarized

Calculation and display of the resulting expected value.

Additional Options:
- Monte Carlo Simulation
- Listing all single risks for further analysis and treatment

Summarizing the expected values
Case Study Blohm+Voss

Reliability of **Top-Down** Cost Estimations
Top-Down Costing: From Functions to Costs

(See Haakon Shetelig: “Shipbuilding Cost Estimation – Parametric Approach”)

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Parametrical Cost Prediction

Incorporation of technical parameters for cost prognoses and project comparisons.

Previous Projects

Regression Analysis

Cost Forecast Current Project
Determining Cost Functions by Regression Analysis

Production cost and length over all of yachts built in the past

Regression Function

© COSTFACT GmbH | www.costfact.com | CostFact improves cost management.
Forecast Error in Top-Down Costing: Assessing the Reliability of Cost Functions

Assessing the reliability of cost functions:
- Ranges/Outliers
- Stability index
- Assessment based on expert knowledge
### Storing and Selecting Cost Norms

<table>
<thead>
<tr>
<th>Group</th>
<th>Parameter (x)</th>
<th>Unit (y)</th>
<th>Type</th>
<th>Function</th>
<th>Risk Class</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 HULL STRUCTURE, GENERAL</td>
<td>Length over all [m]</td>
<td>Steel [t]</td>
<td>Linear</td>
<td>y = 4 * 4 * x - 170</td>
<td>5 (±5%; SI &gt; 0.97 + Sample &gt; 11)</td>
<td>Valid for length between 75 and 120 meters</td>
</tr>
<tr>
<td>1100 HULL</td>
<td>Surrounded volume [m³]</td>
<td>Plates [m²]</td>
<td>Logarithmic</td>
<td>y = 10 * LN(x) + 5</td>
<td>3 (±15%; SI &gt; 0.95 + Sample &gt; 8)</td>
<td></td>
</tr>
<tr>
<td>6400 LIVING SPACES</td>
<td>Crew members [No.]</td>
<td>Standard cabins</td>
<td>Linear</td>
<td>y = 0.7 * x + 2</td>
<td>1 (±30%; SI &gt; 0.90 + Sample &gt; 5)</td>
<td></td>
</tr>
<tr>
<td>6310 PAINTING</td>
<td>Area waterline [m²]</td>
<td>Conservation [t]</td>
<td>Linear</td>
<td>y = 0.5 * x + 10</td>
<td>2 (±20%; SI &gt; 0.90 + Sample &gt; 8)</td>
<td></td>
</tr>
<tr>
<td>6310 PAINTING</td>
<td>Length over all [m]</td>
<td>Quantity of hours (plan, ...</td>
<td>Potential</td>
<td>y = 0.3433 * x - 2,2264</td>
<td>1 (±30%; SI &gt; 0.90 + Sample &gt; 5)</td>
<td>03.05.2015: Calculation result regression analysis (User: JSfE)</td>
</tr>
<tr>
<td>1100 HULL</td>
<td>Hull weight [t]</td>
<td>Steel work [h]</td>
<td>Linear</td>
<td>y = 140 * x + 200</td>
<td>3 (±15%; SI &gt; 0.95 + Sample &gt; 8)</td>
<td>150 labour hours steel work per ton steel</td>
</tr>
<tr>
<td>6310 PAINTING</td>
<td>Length over all [m]</td>
<td>Quantity of hours (plan, ...</td>
<td>Exponential</td>
<td>y = 5.5333 * 1.0671 ^ x</td>
<td>2 (±20%; SI &gt; 0.90 + Sample &gt; 8)</td>
<td>21.12.2015: Calculation result regression analysis (User: JSfE)</td>
</tr>
<tr>
<td>1000 HULL STRUCTURE, GENERAL</td>
<td>Hull weight [t]</td>
<td>Shrinking [h]</td>
<td>Linear</td>
<td>y = 65 * x + 1,000</td>
<td>1 (±30%; SI &gt; 0.90 + Sample &gt; 5)</td>
<td>Gültig bis Länge 120 m</td>
</tr>
<tr>
<td>1047 VIBRATIONS</td>
<td>Pipe motors [m]</td>
<td>Pipe weight [t]</td>
<td>Linear</td>
<td>y = 0.25 * x + 0</td>
<td>2 (±20%; SI &gt; 0.90 + Sample &gt; 8)</td>
<td></td>
</tr>
<tr>
<td>0200 PROPULSION PLANT, GENERAL</td>
<td>Propulsion power [kW]</td>
<td>Product cost (plen)</td>
<td>Exponential</td>
<td>y = 2.013 544 6218 * 1.0001 ^ x</td>
<td>5 (±5%; SI &gt; 0.97 + Sample &gt; 11)</td>
<td>08.04.2018: Calculation result regression analysis (User: JSfE)</td>
</tr>
<tr>
<td>1000 HULL STRUCTURE, GENERAL</td>
<td>Hull weight [t]</td>
<td>Steel work [h]</td>
<td>Linear</td>
<td>y = 130 * x + 200</td>
<td>2 (±20%; SI &gt; 0.90 + Sample &gt; 8)</td>
<td></td>
</tr>
<tr>
<td>2000 PROPULSION PLANT, GENERAL</td>
<td>Propulsion power [kW]</td>
<td>Product Cost (Budget)</td>
<td>Linear</td>
<td>y = 392,4965 * x + 771,696,7062</td>
<td>3 (±15%; SI &gt; 0.95 + Sample &gt; 8)</td>
<td>21.04.2016: Ergebnis Regressionsanalyse (Benutzer: JSfE)</td>
</tr>
</tbody>
</table>
Applying the Effect of Error Compensation

Individual forecasts with individual errors

Resulting overall forecast value

\[ f_{\text{overall}} = \sqrt{\frac{\sum_{i=1}^{n} (f_i \cdot y_i)^2}{y_{\text{overall}}^2}} \]

- \( f_{\text{overall}} \) = relative error of overall forecast value
- \( f_i \) = relative error of the individual forecast value
- \( y_{\text{overall}} \) = overall forecast value (sum of individual forecast values)
- \( y_i \) = individual forecast values

Resulting Error

\( +/- 5\% \)
Estimated Forecast Error

Production cost of selected object: 33,398,224
Resulting forecast error of selected object: 5.1%

Shares of Hardness Grades

- HG 3: 32%
- HG 2: 25%
- HG 4: 23%
- HG 1: 15%
- HG 5: 5%

HG 1: 30% Estimation, rough
HG 2: 20% Estimation, detail
HG 3: 15% Comparison project
HG 4: 5% Proposal (not binding)
HG 5: 0% Proposal (binding)

Refer to the cost of the components
Refer to the number of the components

<table>
<thead>
<tr>
<th>Group</th>
<th>ID</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1100</td>
<td>03</td>
<td>Low strength plates &lt; 7 mm</td>
<td>4,033.832</td>
</tr>
<tr>
<td>1100</td>
<td>08</td>
<td>Steel Castings</td>
<td>785.808</td>
</tr>
<tr>
<td>1100</td>
<td>05</td>
<td>HF - Plates</td>
<td>74.903</td>
</tr>
<tr>
<td>1100</td>
<td>09</td>
<td>Stem Tube</td>
<td>25.791</td>
</tr>
<tr>
<td>1100</td>
<td>11</td>
<td>Hull engineering</td>
<td>230.680</td>
</tr>
<tr>
<td>1100</td>
<td>06</td>
<td>NF - Profiles</td>
<td>232.047</td>
</tr>
<tr>
<td>1100</td>
<td>07</td>
<td>HF - Profiles</td>
<td>75.571</td>
</tr>
<tr>
<td>1100</td>
<td>13</td>
<td>Stock material</td>
<td>9.924</td>
</tr>
<tr>
<td>1100</td>
<td>12</td>
<td>Welding</td>
<td>163.800</td>
</tr>
<tr>
<td>1100</td>
<td>02</td>
<td>Goods issue Plates</td>
<td>52.658</td>
</tr>
<tr>
<td>1100</td>
<td>01</td>
<td>Stock Withdrawal Steel</td>
<td>21.834</td>
</tr>
<tr>
<td>1100</td>
<td>04</td>
<td>Low strength plates &gt; 10 mm</td>
<td>1,146.080</td>
</tr>
</tbody>
</table>
CASE STUDY Flensburger Shipbuilders
Optimizing the Total Cost of Ownership
Due to the high in-service costs and the long operating life of a ship, a cost management focusing the entire life cycle is particularly important.
Cost Impact of Design and Engineering on Ship's Life Cycle
Continuous cost planning and controlling accompanying the design and production process, up to the entire life cycle.
Flensburger Shipbuilders

→ Building of special ships like RoRo-Ferries, RoPax-Ferries and complex combat support vessels.

→ More than 700 ships up to 50,000 tdw. since 125 years; currently approx. 750 employees.

→ Initial Situation:
  - Participating in an advertisement for combat support vessels
  - Call for bids focuses very much on life cycle cost. Bidders are asked to develop proposals how to realize cost advantages, including alternative designs which deviate from the advertisement.
Design of a Basic and an Alternative Propulsion Version

Step 1: Design basic version

2-SCREW VESSEL

⇒ The technical demands of the advertisement are fulfilled exactly.

Step 2: Design alternative version

1-SCREW VESSEL
(including additional alternative design options)

⇒ Advantage:
Effects probably less production costs and in-service costs compared to the 2-screw vessel.

⇒ Disadvantage:
The fulfilment of the required functions falls a little behind of the 2-screw.
Input of Life Cycle Costs for Each Variant

![Life Cycle Cost: 2014-02 - Gas Tanker BN 21](image)

### Project basic data
- **In-service periods:** 11 years
- **Interest rate:** 8.50%

### Payments before in service
- **Purchase price on the basis of product cost and surcharge (year 0):** 65,558,348
- **Manual input purchase price:**
  - **Point in time:**
    - 2 years before start of service: 30,000,000
    - 1 year before start of service: 35,000,000
    - Cash value year 0: 67,550,000

### Payments year 1 to 10 (in-service)

<table>
<thead>
<tr>
<th>Payment</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
<th>Year 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>654,614</td>
<td>665,397</td>
<td>678,392</td>
<td>690,603</td>
<td>703,034</td>
<td>715,688</td>
<td>720,571</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>9,683,657</td>
<td>9,827,542</td>
<td>10,014,617</td>
<td>10,194,851</td>
<td>10,378,388</td>
<td>10,565,159</td>
<td>10,755,373</td>
</tr>
<tr>
<td>Lube Oil</td>
<td>779,629</td>
<td>795,662</td>
<td>807,948</td>
<td>822,491</td>
<td>837,296</td>
<td>852,367</td>
<td>867,710</td>
</tr>
<tr>
<td>Regular Maintenance</td>
<td>140,716</td>
<td>149,531</td>
<td>148,401</td>
<td>149,329</td>
<td>152,318</td>
<td>155,362</td>
<td>158,489</td>
</tr>
<tr>
<td>Sustaining Maintenance</td>
<td>150,000</td>
<td>1,350,000</td>
<td>150,000</td>
<td>150,000</td>
<td>150,000</td>
<td>150,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Investment</td>
<td>0</td>
<td>7,050,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Dockings</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Charter</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Classification Fees</td>
<td>0</td>
<td>150,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Insurance</td>
<td>435,706</td>
<td>443,549</td>
<td>451,532</td>
<td>459,660</td>
<td>467,934</td>
<td>476,357</td>
<td>484,931</td>
</tr>
</tbody>
</table>

### Payments year 11
- **Sale/scrap:** -30,000,000
- **Other costs:** 1,450,000

### Life Cycle Cost: 2014-02 - Gas Tanker BN 21
- **Cash Value:** 136,469,140
- **Annuity:** 20,798,048
Addressing Uncertainty

This analysis examines the effect on the actual cash value of the project if the actual fuel price increases are:

- lower than originally expected and
- higher than originally expected.
## Total Cost of Ownership: Scenario Analysis

### Scenarios analysis: Minimum and maximum of cash values

<table>
<thead>
<tr>
<th>Cash value:</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>688 - 1-SCREW</td>
<td>135,141,349</td>
<td>147,813,472</td>
</tr>
<tr>
<td>Annuit:</td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>688 - 1-SCREW</td>
<td>11,543,467</td>
<td>12,625,370</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cash value:</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>688 - 2-SCREW</td>
<td>164,265,887</td>
<td>163,954,467</td>
</tr>
<tr>
<td>Annuit:</td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>688 - 2-SCREW</td>
<td>14,031,195</td>
<td>14,517,100</td>
</tr>
</tbody>
</table>

- Schematic representation for confidentiality reasons -
Assess Alternative Variants and Select the Optimal Design

- 1-Screw
- 2-Screw

<table>
<thead>
<tr>
<th>Variant</th>
<th>Economical Value</th>
<th>Technical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Screw</td>
<td>85% (Costs 1-Screw / Costs 2-Screw)</td>
<td>100%</td>
</tr>
<tr>
<td>1-Screw</td>
<td>100%</td>
<td>69% (Scoring-Model)</td>
</tr>
</tbody>
</table>

Integrated assessment of compared alternatives

- Values < 100% fictional -