Business case of the unmanned vessel

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E-guided vessels: The 'autonomous' ship
Agenda

- Introduction
- Methodology of analysis
- Cost of the unmanned autonomous ship
- Business case scenarios
Successful introduction of innovative technologies depends on:

- Technical feasibility
- Regulatory compliance
- Proven safety
- Economic viability
Trade-off Between Increased Capital Costs and Reduced Crew Costs

Crew size development of ocean going ships

Principal correlation of crew size and new building cost

Source: Fraunhofer CML
Agenda

- Introduction
- **Methodology of analysis**
- Cost of the unmanned autonomous ship
- Business case scenarios
Scope of Analysis

Innovations in waterborne transport

Unmanned ship
- Reduced crew
- New ship designs
- Improved safety

Intelligent ship
- Optimized (weather) routing
- Onboard energy efficiency management
- Voyage performance management
- Condition monitoring and management

Efficient ship
- Hull form optimization
- Energy-saving devices
- Machinery technology

Source: Fraunhofer CML
If cost over lifetime of unmanned autonomous bulker is lower than cost of conventional bulker it will generate a higher free cash flow.

Source: Stopford 2009
Methodology of Analysis

1. Cost model of conv. bulker:
   1. Capital Cost
   2. Operational Cost
   3. Voyage Cost

2. Identify differences
   a. Identify differences
   b. Model & calculate effects

3. Cost model of MUNIN bulker:
   1. Capital Cost
   2. Operational Cost
   3. Voyage Cost

4. Calculate Net Present Value of cost over lifetime
   Compare Cost-NPV under different scenarios
   If Cost-NPV of MUNIN bulker is lower than Cost-NPV of conventional bulker
   \( \rightarrow \) unmanned autonomous ship is favorable

Source: Fraunhofer CML
Agenda

- Introduction
- Methodology of analysis
- **Cost of the unmanned autonomous ship**
- Business case scenarios
Operating Cost – Changes for the MUNIN Bulker

Operating cost conventional bulker

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Cost</td>
<td></td>
</tr>
<tr>
<td>Crew Cost</td>
<td>45%</td>
</tr>
<tr>
<td>Stores &amp; Consumables</td>
<td>14%</td>
</tr>
<tr>
<td>Maint. &amp; Repair</td>
<td>13%</td>
</tr>
<tr>
<td>Insurance</td>
<td>15%</td>
</tr>
<tr>
<td>General Costs</td>
<td>13%</td>
</tr>
</tbody>
</table>

Source: Fraunhofer CML
Unmanned Ship Requires Land Based Services

Crew is shifted from ship to shore

On board crew related cost is reduced

Additional cost for land based services:
1. Shore control center
   • Personnel cost
   • Equipment, rent, etc.
2. Maintenance crews in port

Source: Fraunhofer CML
Voyage Cost and Fuel Price

- Impossible to predict how fuel prices develop in future
- Necessary to predict how fuel prices develop in future
- Approach based on forecast for crude oil prices (IEA World Energy Outlook)

<table>
<thead>
<tr>
<th>Crude Oil [USD/barrel]</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDO</td>
<td>119.5</td>
<td>121.9</td>
<td>123.6</td>
<td>125</td>
</tr>
</tbody>
</table>

- Oil price is converted into fuel prices (HFO/MDO) based on past ratio

Source: IEA World Energy Outlook 2012, Fraunhofer CML
Voyage Cost – Changes for the MUNIN Bulker

Voyage cost conventional bulker

<table>
<thead>
<tr>
<th>Component</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voyage cost</td>
<td></td>
</tr>
<tr>
<td>Fuel propulsion</td>
<td>-69%</td>
</tr>
<tr>
<td>Fuel e-power</td>
<td>-14%</td>
</tr>
<tr>
<td>Port cost</td>
<td>-17%</td>
</tr>
</tbody>
</table>

Source: Fraunhofer CML
Efficiency Gains Related to Unmanned Ship Design Considered in Analysis

1. Light Ship Weight (no deckhouse) → Reduced fuel consumption
2. Air resistance (no deckhouse) → Reduced fuel consumption
3. Hotel systems (no crew living on board) → Reduced fuel consumption
4. Twin skeg / two engines design → Additional fuel efficiency gains possible

Source: Fraunhofer CML
New Building Price of Panamax Bulk Carriers

Development of bulker new building prices
in USD

- New building price volatile in recent past
- Average new building price for panamax bulker over past 12 years was 34mUSD
- Capital cost of conventional bulker assumed to be 34mUSD

Source: EquityGate Advisors 2013, Fraunhofer CML
Changes in New Building Cost for Unmanned Ship Design

1. No deckhouse (reduced material & production cost)
2. No hotel (air conditioning, heating, ventilation, etc.)
3. Autonomous ship technology (advances sensor module, deep-sea navigation system, etc.)
4. Redundancy of technical systems (communication, e-system, etc.)
5. Propulsion: twin skeg & two engines

Source: Fraunhofer CML
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- Introduction
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- **Business case scenarios**
Base Scenario

Scenario description:

- Fuel price: med.
- New building: 110%
- Main fuel type: HFO
- Considers effects of
  - Reduced crew
  - Improved ship efficiency

MUNIN compared to a conventional bulker
Expected present value over lifetime

- Higher newbuilding cost: -3.4 mUSD
- Crew cost: +10.4 mUSD
- Land based services: -2.5 mUSD
- Better fuel efficiency: +5.4 mUSD
- MUNIN: +9.9 mUSD

Source: Fraunhofer CML
Impact of Fuel Cost on Base Scenario

Scenario description:
- Fuel price: high/med./low
- New building: 110%
- Main fuel type: HFO
- Considers effects of
  - Reduced crew
  - Improved ship efficiency

Advantageousness of MUNIN bulker for different fuel price scenarios

<table>
<thead>
<tr>
<th>Oil price [USD/barrel]</th>
<th>Expected PV [mUSD]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>5</td>
</tr>
<tr>
<td>Medium</td>
<td>10</td>
</tr>
<tr>
<td>High</td>
<td>15</td>
</tr>
</tbody>
</table>
MDO Scenario

Scenario description:
- Fuel price: med.
- New building: 110%
- Main fuel type: MDO
- Considers effects of:
  - Reduced crew
  - Improved ship efficiency

MUNIN vs conventional bulker
Expected present value of savings over lifetime

<table>
<thead>
<tr>
<th>Category</th>
<th>Savings (mUSD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher newbuilding cost</td>
<td>-3,4</td>
</tr>
<tr>
<td>Crew cost</td>
<td>+10,4</td>
</tr>
<tr>
<td>Land based services</td>
<td>-2,5</td>
</tr>
<tr>
<td>MDO as fuel</td>
<td>-19,4</td>
</tr>
<tr>
<td>MUNIN</td>
<td>-14,9</td>
</tr>
</tbody>
</table>

Source: Fraunhofer CML
Scenario description:

- Fuel price: med.
- New building: 110%
- Main fuel type: MDO on MUNIN & conv. bulker
- Considers effects of
  - Reduced crew
  - Improved ship efficiency

MUNIN vs conventional bulker
Expected present value of savings over lifetime

- Higher newbuilding cost: -3.4 mUSD
- Crew cost: +10.4 mUSD
- Land based services: -2.5 mUSD
- Better fuel efficiency: +7.0 mUSD
- MUNIN: +11.5 mUSD

Source: Fraunhofer CML
Scenario Reduced Crew Only

Scenario description:
- Fuel price: med.
- New building: 110%
- Main fuel type: HFO
- Considers effects of
  - Reduced crew
  - Improved ship efficiency

MUNIN vs conventional bulker
Expected present value of savings over lifetime

- Higher newbuilding cost: -3.4 mUSD
- Crew cost: +10.4 mUSD
- Land based services: -2.5 mUSD
- Additional port call cost: -3.2 mUSD
- MUNIN: +1.3 mUSD

Source: Fraunhofer CML
Best Case Scenario

Scenario description:
- Fuel price: high
- New building: 80%
- Main fuel type: MDO on MUNIN & conv. bulker
- Considers effects of
  - Reduced crew
  - Improved ship efficiency
  - No onboard control team

MUNIN vs conventional bulker
Expected present value of savings over lifetime

- Lower new building cost: +6.8 mUSD
- Crew cost: +10.4 mUSD
- Land based services: -2.5 mUSD
- Better fuel efficiency: +14.3 mUSD
- MUNIN: +29.0 mUSD

Source: Fraunhofer CML