Universal foundation concept
A SCM approach to industrialization
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**Abstract**

Supply Chain Management (SCM) is a driving factor in the development of new technology and the vision of industrialization, series/mass production and installation of foundations for offshore wind farms. As the sites are getting larger in the future wind farm developments, and in most cases more complicated in a geotechnical and logistic sense, it is a must to find more feasible ways to configure standard structures and procedures into unique foundations for each wind turbine position using the philosophy of systematic mass customization and to optimize the supply chain with a focus on the industrialization process.

**Background**

The innovative foundation concept, inspired of the well know offshore technology suction anchors, was initiated by a research program in a joint venture formed by Marcon, Bladt Industries, MBD and Aalborg University. As it is a new concept, a design procedure had to be developed based on laboratory test and certified by DNV. The full scale foundation for the Vestas V90 3 MW turbine was built in Frederikshavn and transported to, and installed in the semidry test site in October 2002.

**Technology**

**Main objectives in the development of the concept**

- Cost reduction, reduction of steel consumption, rational production, smaller installation equipment, reduction of load regime.
- Risk management, availability of vessels, weather window, seabed condition.
- Going from "one off" to industrialized product, optimized design at each position, parameter driven design, standardized construction elements, standardized installation procedures.

**Development**

**Development approach**

- Industrialized product development

**Project development to development projects**

- Focus on total supply chain
- Coordinated R&D in each link of the supply chain
- Active use of feedback

**Technology transfer**

- Is not only using a product in a different location
- It is adapting technology to new physical environment
- It is adapting the organization culture
- It is adapting the knowledge and education

**Organization**

The database is containing description of principles, methods, procedures, structures stipulation the operation parameters and cost estimates for each element.

The database is also updated with operation project experiences to ensure an efficient feed-back to be used in future projects.

The product configuration system is a program defining the application range for each structure and procedure and the rules for combining the different elements to cover the entire wind farm. The system contains a decision support facility with the ability to estimate the involved cost-risk in the different project phases.

The documentation facility is based on standard output formats for each of the project phases, feasibility study, conceptual design, tender design, detail design, construction documentation and "as built" documentation.

**UFC / SCM facilitator**

The implementation of the concept is conducted by a facilitator organization with access to the IP-rights of the bucket concept and in close cooperation with the project developer/owner of the wind farm project. The functions of the facilitator are to the ensure that the technology, methodologies, and procedures is optimized throughout the entire supply chain as well as ensure that the contact relations between the different stakeholder is managed to utilize the full potential of the concept.

<table>
<thead>
<tr>
<th><strong>UFC / SCM Facilitator</strong></th>
<th>Configuration / Contract Consultant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project development</strong></td>
<td>Fabrication, Transport, Installation, Operation</td>
</tr>
<tr>
<td><strong>Procedure</strong></td>
<td>Document / Material Flow, Design / Methodologies / Procedures / Feedback</td>
</tr>
</tbody>
</table>

**UNIVERSAL FOUNDATION CONCEPT – A SCM APPROACH TO INDUSTRIALIZATION**

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(1) MBD Offshore Power A/S, (2) Aalborg University, Denmark.

**Table 1: Foundation comparison**

<table>
<thead>
<tr>
<th>Component</th>
<th>Shaft</th>
<th>Lid</th>
<th>Skirt</th>
<th>Total</th>
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</thead>
<tbody>
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<td>195</td>
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<td>210</td>
<td>987</td>
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<td>1317</td>
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<tr>
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<td>987</td>
</tr>
<tr>
<td>6MW</td>
<td>623</td>
<td>159</td>
<td>283</td>
<td>1317</td>
</tr>
</tbody>
</table>

**Figure 1: UFC System**

- **UFC** is a concurrent process, adding new experiences and processes to a database, used by a configuration methodology to produce the required documentation in each step of the wind farm projects focusing on:
  - The optimal foundation for each turbine position
  - Design is parameter driven
  - Structure based on scaleable modules and elements
  - Production based on series or mass production
  - Installation in widest possible weather window
  - Installation based on common available transport and installation vessels

**Figure 2: Foundation dimensions**

- **Similar to lower production**: Based on variation in depth in cylindrical lower part
- **Welded of cut plates 20-40 mm**: Suitable for mass production of elements
- **Two different designs**

**Figure 3: UFC system**

- **Database**: Principles, methods, procedures, experiences
- **Configurator**: Standard output, feasibility studies, conceptual design, tender design, detail design, component documentation, change documentation
- **Standard output**: Site data, database, configurator, standards, material flow, design / methodologies / procedures / feedback

**Figure 4: Foundation dimensions**

- **A**: Gravitation platform
- **B**: Bucket foundation
- **C**: Mono pile