MANUFACTURING STRATEGIES FOR NORWEGIAN SHIPBUILDING

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OUTLINE

• Introduction: Manufacturing strategy
• Product, market, and business characteristics
• Product-process matrix
• Strategies with different CODPs (IGLO-MP)
• Degree of vertical integration (MODNET)
• Models for ship production in Norway (SUSPRO)
• Conclusions and further work
DEVELOPMENT OF MANUFACTURING STRATEGY

Product/market

Performance objectives
- Cost
- Quality
- Lead time
- Delivery precision
- Flexibility

Decision areas
- Vertical integration
- Organizational structure and control
- Facilities, resources and capacities
- Process technology
- Sourcing and distribution
- Production planning and control
- Human resources and capabilities

Competitors
Suppliers
Customers
Complementors

National and international industry rules and regulations
National work system and culture
Economic and socio-demographic environment
Technology and innovation

(Based on Hill 2000 and the Platts-Gregory procedure 1990)
PRODUCT/MARKET CHARACTERISTICS

Shipbuilding in general

- Large, heavy, expensive products with a long life
- Large product variety (customization), relatively low volumes
- Uncertain, fluctuating demand with frequent changes
- Many components and complex bills-of-material
- Increasing environmental and life-cycle requirements

Norwegian shipbuilding

- At an international level primarily competitive in the offshore sector
- Equipment/technology-intensive (rather than steel or accommodation)
- Deep product structure
- High level of customization, innovation, and specialization
- High level of change orders
NORWEGIAN BUSINESS ENVIRONMENT

- Vital tradition for innovating and manufacturing customized, technologically advanced products
- Highly educated and skilled work force
- Flat, flexible, and informal organizational structure
- High level of worker autonomy
- Dedicated and experienced seamanship

- High-cost country
- Main market moving away from Europe
- Increasing global competition
- Lack of resources
PRODUCT-PROCESS MATRIX

(Hayes and Wheelwright 1979)
PROJECT-BASED MANUFACTURING

General

• Integrated design/engineering, procurement, construction
• High-variety, low volume production
• Long lead times
• Requirements to flexibility and responsiveness
• Variety of processes types

Shipbuilding-specific

• Highly technical and complicated
• Many skilled trades and contractors working under the control of a primary contractor.
• International
• Many yards competing for a fairly limited amount of work
CUSTOMER ORDER DECOUPLING POINT

Adapted from Olhager (2003)
CUSTOMER ORDER DECOUPLING POINT

Based on Hayes & Wheelwright (1984), and Olhager & Wikner (2000)
CODP IN SHIPBUILDING

CODP

Procurement

Commissioning

Production & Assembly

Engineering

Contract design

Basic & functional design

Concept design

Planning & coordination

Contract signing

Start of production

Launching and start of on-board activities

Delivery

After-Sale Period

Milestones

(Semini et al., 2014)
CODP IN SHIPBUILDING

Customized design

- CODP
- Concept design
- Planning & coordination
- Engineering
- Production & Assembly
- Commissioning
- After-Sale Period
- Contract design
- Basic & functional design

Standardized design

- CODP
- Planning & coordination
- Engineering
- Production & Assembly
- Commissioning
- Supply chain development & procurement
- Contract design
- Basic & functional design
- Market research & concept design

(Semini et al., 2014)
# Linking Strategies to Product/Market

<table>
<thead>
<tr>
<th>Product/market attributes</th>
<th>Customized design strategy</th>
<th>Standardized design strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost/Price</td>
<td>Higher</td>
<td>The more ships produced, the lower the unit cost and price</td>
</tr>
<tr>
<td>Lead time</td>
<td>Longer</td>
<td>Shorter (if production can start quickly)</td>
</tr>
<tr>
<td>Delivery precision</td>
<td>More difficult to achieve</td>
<td>Easier to achieve</td>
</tr>
<tr>
<td>Level of customization</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Variety</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Modularity and standardization</td>
<td>Desirable, but difficult to achieve</td>
<td>A must</td>
</tr>
<tr>
<td>Accommodation of change orders</td>
<td>Part of the value offered to the customer</td>
<td>Must be kept low</td>
</tr>
<tr>
<td>Number of components</td>
<td>Very high</td>
<td>High</td>
</tr>
<tr>
<td>Minimum volume requirements</td>
<td>One or two</td>
<td>Typically three or more</td>
</tr>
<tr>
<td>Order qualifiers</td>
<td>Quality, lead time, on-time delivery, price</td>
<td>Quality, lead time, on-time delivery</td>
</tr>
<tr>
<td>Order winners</td>
<td>Flexibility and customization, product design/features</td>
<td>Price, product design/features</td>
</tr>
</tbody>
</table>

(Semini et al., 2014)
DEGREE OF VERTICAL INTEGRATION (MODNET)

(Mudambi, 2008)
## DEGREE OF VERTICAL INTEGRATION (MODNET)

### Project management

**Today's Norwegian yards**

- **In-house activities**
  - Design, project management, logistics
  - Design, outfitting, project management
- **Comp. advantage**
  - Systems integration; coordination of internal and external processes
  - Systems integration; coordination of internal and external processes
- **Purchasing**
  - Yard capacity and building expertise
  - Hull, modules, systems, components

**The complete shipyard**

- **In-house activities**
  - Design, project management, logistics
  - Design, hull production, outfitting, project management
- **Comp. advantage**
  - Systems integration; coordination of internal and external processes
  - Process knowledge; integration of internal processes
- **Purchasing**
  - Yard capacity and building expertise
  - Materials and simple systems

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Based on Longva et al. (2007) and Hicks (2000)
In literature, the term **manufacturing strategy** usually refers to physical production and assembly.

Description of how the company currently carries out its ship production activities.

- Important input for design process

The **build strategy** is the application of a manufacturing strategy to a particular contract (Bruce & Garrard, 1999).

- Build strategy elements: What, how, when, where and with what resources?
SHIPBUILDING – HISTORICAL OVERVIEW

• «Piece by piece from the ground up»
• Riveting for joining steelplates and parts
• Work concentrated around shipway and outfit pier

(Storch et al., 1995)
Adaption of prefabrication of weldments away from shipways
Development of high-technology steel cutting and welding
Work stations defined and Group Technology applied
The shipways became assembly areas, rather than fabrication areas
Layout change, from job-shop to flow based
Specialization of facilities, tools, worker skills
SHIPBUILDING – HISTORICAL OVERVIEW

- Larger & more specialized ship types
- Modifying existing yards
- Series production & flow line techniques
- High technology introduced in steel fabrication and transport & lifting
- Further advances in modular construction
- Pre-outfitting introduced

(Storch et al., 1995)
SHIPBUILDING – HISTORICAL OVERVIEW

- Collapsing demand, bankrupting shipyards heavily invested in mechanization and large-scale production
- Shipyards with earlier focus on management prevail
  ➔ enter the success of LEAN Production
Basic goal: cost reduction via elimination of unnecessary operations, waiting time, and inventories

(Liker & Lamb, 2000)
LEAN SHIPBUILDING

1. Identify value
2. Map the value stream
3. Create flow
4. Establish pull
5. Seek perfection

(Liker & Lamb, 2000)
1965-1995: Japanese shipbuilders improved their productivity by 150%.
How?
• Perfecting structural block construction approach
• Developing advanced and zone outfitting
• Applying lean principles

Others are following

(Liker & Lamb, 2000)
<table>
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<tr>
<th>Method</th>
<th>Description</th>
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<tbody>
<tr>
<td>Group technology</td>
<td>Exploit the similarities of intermediate products to gain production economies of scale for non-standard products</td>
</tr>
<tr>
<td>Standardization</td>
<td>Standardized materials, components and modules give economies of scale and increased efficiency, reduced variability and easier planning</td>
</tr>
<tr>
<td>Modular construction</td>
<td>Based on modular design, allows effective production of complete modules by smaller, more competitive businesses.</td>
</tr>
<tr>
<td>Zone construction</td>
<td>When the blocks are assembled, use zones as a reference for materials and part lists, drawings, plans, schedules, follow up, and documentation.</td>
</tr>
<tr>
<td>Structural prefabrication, block construction</td>
<td>Producing parts of the steel structure outside the berth/dock. Units, 2D blocks, 3D blocks, grand/mega/ring blocks. Blocks of increasing size. Parallel construction of blocks.</td>
</tr>
<tr>
<td>Pre-outfitting (pre-erection outfitting, early outfitting, pre-erection system installation)</td>
<td>Installation of ship system components prior to final assembly of the primary structure. On-unit and on-block outfitting.</td>
</tr>
</tbody>
</table>
Pre-Outfitting

Advantages

- Improved work access and working positions
- Shorter distances for workers, materials, and equipment
- Reduced HSE risk
- Reduced need for installation, use, and removal of temporary product support services
- Work in controlled environment, with possibility for roof and other infrastructure
- Faster, less expensive, better quality control
- Automation (cost savings and HSE improvements (exposure to chemicals etc.))
- Less sequence dependency among jobs
- No need for damages on complete work
- Increased opportunity for parallel work

Drawbacks

- Increased inventory carrying cost (Cost of capital, risk of damage, etc.)
- Potential obstacles for later access
- Sections/blocks heavier
- Reduced opportunity for concurrent engineering

(Based on Hagen, 2014)
MODERN SHIPBUILDING – PROCESS OVERVIEW

(Norwegian University of Science and Technology)

- Prefabrication (supports, modules, pipes)
  - Raw material reception & preparation
  - Marking, cutting & conditioning of steel plates & profiles
    - Fabrication of 2D blocks
    - Fabrication of 3D blocks
      - Assembly of grand blocks / pre-erection
      - Erection & outfitting
    - Launching
  - Finishing & outfitting
  - Commissioning & trials
    - Delivery
  - Pre-outfitting
    - Blasting & painting/coating
    - Transport & handling (supports all processes)
    - Dimensional control & inspection (supports all processes)

(Andritsos & Perez-Prat, 2000)
Marking, cutting & conditioning of steel plates and profiles

- **Marking**
  - Powder marking, Inkjet marking, Plasma arc marking, Laser marking

- **Cutting**
  - Shears, Roller shears, water jet cutting, Thermal cutting(Oxy-Fuel cutting, Plasma-cutting, Laser cutting)

(Andritsos & Perez-Prat, 2000)
Fabrication of 2D blocks

- **Typical equipment**
  - Roller bed, Clamping, Butt-welding gantry, Panel turning/turnover arrangement, Stiffener pallet, Mobile Grinding, Mobile stiffener gantry, Fillet-welding gantry, Mobile web gantry, Web welding gantry, Lift-off transportation station

- **Types of panel lines**
  - Mini panel line, Normal flat panel line, Double bottom line, Curved panel line, Girder building line

MODERN SHIPBUILDING – PROCESS OVERVIEW

(Andritsos & Perez-Prat, 2000)
Fabrication of 3D blocks

- Assembly of flat panels, 2D sub-blocks and curved blocks
- Build strategy designed so as to make the welding in best possible position, but also maintain possibilities of efficient block outfitting
- Steel and outfitting work are parallel activities in the assembly
- When properly planned, a major part of the outfitting can be performed in the workshop

Erection & Outfitting

- Blocks are joined together in the dock and seated on the dock. They are arranged according to hull form or docking plan and then welded.
- Welding is by far the most important technology applied:
  - The weight of the metal deposited by welding in a ship can easily be as much as 3 to 4% of the total steel weight, and the cost of the welding consumable per kg deposited can be more than 10 times the cost of the same weight in steel.
- Erection of prefabrications (supports, modules, pipes)

(Andritsos & Perez-Prat, 2000)
Conclusions and further work

• We have presented different strategies for shipbuilding and linked them to product/market characteristics

• We are currently defining three models for Norwegian shipbuilding based on different degrees of domestic hull production.

• The overall purpose is to develop knowledge and theory about shipbuilding of relevance for Norway and other high-cost countries

• Further work (in SUSPRO):
  
  T1 Market Prediction
  T2 Best practice business processes
  T3 Network configuration and Collaboration
  T4 Effective Manufacturing of ships and equipment
  T5 Decision support for sustainable ship life cycle management (Supporting T1-T4)


