Kul-24.4130
Shipyard engineering

Lecture 6-1: Outfitting
Lecture in course contents

- Introduction
- Outfitting
- Production planning
- Shipbuilding process and shipyard productivity
- Design process and materials management
- Hull production
Objectives, contents and literature

• Learning objective:
  – Understand the main factors that affect the outfitting production
  – Can create a product hierarchy of outfitting
  – Can determine the appropriate sub-assemblies for outfitting production

• Contents:
  – Product hierarchy for outfitting
    • Construction method – Productization - Work breakdown structure - product hierarchy
  – Stages of outfitting production
    • Workshops - block outfitting - area outfitting

• Literature
  – Ship production, Storch et al., SNAME
Starting point for Productization

What factors have an effect?
System-based Work Breakdown Structure

System-based construction method
- The ship is seen to be composed of systems
  - E.g. hull, propulsion, air conditioning, cabins
- The hull is constructed first almost completed
- Number of professional groups make their own sub-system on board at same time
- challenges:
  - All unfinished until the end (Readiness %?)
  - Fighting between professional groups and labor leaders
  - Drawings based on systems
Area-based Work Breakdown Structure

Area-based construction method

- The ship is constructed area by area
- Area supervisor is a key
  - Multi-professional skills are required
- System aspects are suffered
  - Construction is fragmented
  - Responsible for commissioning and operation is not clear
- Training and exact definition for responsibilities are necessary
Area and system interaction

• The ship may include
  – System, which serves only one area
  – System, which serves one or a few areas. Part of system can be located outside the area (for example, air conditioning aggregate)
  – System that runs through the area without serving it
  – System, which is located on the border of area

• Alternative solutions for design
  – Avoid system, which runs through the area without serving it
  – Minimizing the disturbing effects (routing, space reservations)
  – Utilization of product hierarchy ("Installation box")
Product, what is it?

- A part of the ship
- Any work package (working place)
- The product has a content and definition
- It is always associated with the input and output (interfaces)
- Examples:

  Hull production
  - Ship
  - Aft ship
  - Block

  Outfitting production
  - Area or space
  - Cabin
  - Separator module
Productization

• Target of productization
  – Dividing of the ship into the sub parts, which can be manufactured by the yard or someone else as cheaply as possible

• Criteria for productization
  – It should be appropriate for the yard's activities; steel construction in most cases the common factor
  – Manufacturing constraints (recourse and time)
Productization

- Technical aspects on the basis of ship project
  - System-area matrix
  - Passing through system
- Suppliers and sub-contractors
  - Supply, competition
- Design process
  - Agreement in the various design stages
- Production control
- Transport technology
Ship product hierarchy

Ship
  └── GA
     ├── Kansi 1
     │     ├── Mehiistötilat
     │     └── Baari
     ├── Kansi 2
     │     └── Hyttiakueet
     └── Kansi 3
         ├── Yleiset tilat
         │     └── Ravintola
         └── Kansi 4
             ├── Catering-tilat
             │     └── Sisäänuloaula
             ├── Pesutilat
             └── Varastot
                 ├── Kellut
                 └── LVI-järjestelmät
                     └── Sähköjärjestelmät
  └── Zones
     ├── Palo-osasto 1
     │     └── VT-osasto 1
     ├── Palo-osasto 2
     │     └── VT-osasto 2
     └── Palo-osasto 3
         └── VT-osasto 3
  └── Hull
      ├── Suurlohko 1
      │     └── Lohko 1
      └── Suurlohko 2
          └── Lohko 2
      └── Suurlohko 3
          └── Lohko 3
      └── LVI-järjestelmät
          └── Sähköjärjestelmät
  └── System
      ├── Sähköjärjestelmät
      │     └── Sähkön tuotto
      └── Koneistojärjestelmät
          └── Hallintajärjestelmät
Ship product hierarchy

Ship – General arrangement
Ship product hierarchy

Ship – Zone, Hull, Systems
Product hierarchy for the restaurant roof

Kansi xx

- Ravintola NN
- Sähköjärjestelmät
  - IV järjestelmät
  - LV järjestelmät
Product hierarchy for the restaurant roof

- Kattovuoraus
  - Tyyppi 1
  - Tyyppi 2
  - Tyyppi 3
  - Paloeristys
    - Eriste
    - Kiinnitys
    - Päälystys
  - Lämpöeristys
  - Aänieristys
- Valaistus
  - Yleisvalaistus
  - Show-valaistus
  - Valaisin
  - Kannakkeet
- Äänentoisto
  - Yleisääni
  - Show-ääni
  - Kauhitin
  - Kannakkeet
- Palohälytys
  - Anturi
- Tulolima
  - IV-elin
  - Anturi
  - Kannakkeet
- Poistolima
  - IV-elin
  - Kannakkeet
- Ikkunapuhallus
  - IV-elin
  - Kannakkeet

- Peruskoolaus
  - Apukoolaus
  - Kannakkeet
  - Pintamateriaali
Product hierarchy for the restaurant roof
Product hierarchy for outfitting

- Basic elements
  - Device such as a pump or electric central
  - Equipment such as suction filter, sensor or switch
  - The raw material such as pipe or steel rod (6m)
- Prefabricated
  - The lowest level of assembly manufactured from raw materials based on the ship-related drawings
  - Rectangular channel, platform, pipe support
- Assembly
  - Modules, which are installed into blocks or areas of the ship
  - Consist of devices, equipment, raw materials, prefabrications, and sub-assemblies
  - Pipe package, container, aggregate, machine module
  - Sofa, bar desk, wall or roof element, cabin, deckhouse of cargo ship
Product hierarchy for outfitting

- **Basic elements**
  - Device such as a pump or electric central
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- **Assembly**
  - Modules, which are installed into blocks or areas of the ship
  - Consist of devices, equipment, raw materials, prefabrications, and sub-assemblies
  - Pipe package, tank, aggregate, machine module
  - Sofa, bar desk, wall or roof element, cabin, deckhouse of cargo ship
Machine unit (aggregate) - Example
Product hierarchy for outfitting

Pre-fabrication
Product hierarchy for outfitting

Block
• In perfect case, the internally fully equipped assembly unit
• Block-boundary outfitting connects the fully outfitted blocks to each other using raw materials and fitting part

Area
• In practice the assemblies, prefabrications, equipment, devices, and raw materials are installed on board
Class room assignment

Crew cabin area

1. Identify the factors affecting the productization
   – Area versus system
   – Etc...

2. Specify the product hierarchy
   – Basic elements
   – Prefabrications
   – Assemblies

Aalto University
School of Engineering
Stages of outfitting production

• Workshops
  – Basic elements
  – Prefabrications

• Block outfitting
  – Basic elements
  – Prefabrications
  – Assemblies

• Ship and area outfitting
  – Basic elements
  – Prefabrications
  – Assemblies
Workshops

• Traditional workshops at the shipyard
  – Machine workshop
  – Pipe workshop
  – Module workshop
  – Heavy plate workshop
  – Sheet metal workshop
  – Wood workshop
  – Electrical workshop
  – Rigging workshop

• Workshops today in co-operation with suppliers
  – Subcontractor for contract products
    • Subcontractor has specialized workshops for their products
    • Shipyard has had only basic equipment and workers
    • Co-operation is based on annual contracts
  – Shipyard workshops support the installation work
    • Installers operates
    • Close to the working place
    • Fitting pars (e.g. special pipe parts)
  – Extension of equipment delivery
    • Deliveries includes workshop work
Block outfitting - motivation and savings

- In shipbuilding, the amount of installation work is decreased when the work is transferred to an earlier production stage.
- This decrease can be roughly estimated as follows:

<table>
<thead>
<tr>
<th>Production stage</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine unit construction</td>
<td>1.0</td>
</tr>
<tr>
<td>Module construction</td>
<td>1.2</td>
</tr>
<tr>
<td>Panel block outfitting</td>
<td>1.5</td>
</tr>
<tr>
<td>Block outfitting</td>
<td>2.0</td>
</tr>
<tr>
<td>Area outfitting</td>
<td>4.0</td>
</tr>
</tbody>
</table>
Advantage of block outfitting

- **Good working environment**
  - Opportunity to maximize the downhand installation
  - Workshop conditions: warm, lighting, ventilation
  - Easier transportation of the material and tools to the work site (closeness and openness)

- **Other benefits**
  - Lesser need for repair painting
  - Reduction of the scaffold and other supporting work
  - Better balancing of outfitting work
  - Small disturbances due to other workers
Disadvantages of block outfitting

- Production of block is started earlier
- Design for outfitting is started earlier (increase)
- Block size restrict the outfitting design
- Block division and block size is affected by outfitting aspect
- Increased block weight affects the transport
- Accuracy requirements for the block installation is higher than that of the onboard installation
- Risk for the broken equipment is increase
- Labor and material costs are committed earlier
Stage of block outfitting

- Parts manufacturing (OVA)
  - During the manufacturing of sub-assembly, e.g. windows installation
- Before the painting to sub-block (EMO)
  - During the manufacturing of panel block (Block is located top to down)
- After the painting to sub-block (JMO)
  - Installations into the pre-painted blocks (A separate production step)
- Before the painting (EM)
  - During the manufacturing of grand block (Block is located right side up)
- After the painting (JM)
  - Installations into the painted grand block (A separate production step)
  - Production step between the block production and hull erection

(Abbreviation used in Helsinki shipyard)