Shipyard 4.0: The Ferrol Navantia Shipyard Model for Planning in Shipbuilding

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1. Introduction
2. Simulation Model
3. Experimentation and Results
4. Conclusions
1. Introduction
Introduction

High international competitiveness

• Shortest delivery term
• Lower cost
• High level of quality

Need to manufacture

Complexity of shipbuilding process

Diversity and # of elements

• Unique (not serialized)
• High added value
• Long construction period

Product (Frigate)

Non lineal process

• Complex coordination between stages / workshops
2. Simulation Model
Model development

Frigate → 25 Blocks → 50 Sub-blocks

- Developed in ExtendSim
- Easy integration with SAP
- Excel interface for input data
- Connected with ExtendSim
- Results tables
- Gantt Chats
Model development

- 5 sub-blocks typology

<table>
<thead>
<tr>
<th>Main sub-blocks attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typology</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td># Web frames</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td># Longitudinal girders</td>
</tr>
<tr>
<td># Straight panels</td>
</tr>
<tr>
<td># Shell panels</td>
</tr>
<tr>
<td># Longitudinal profiles</td>
</tr>
</tbody>
</table>
Model development

- Input sequence

- Disaggregation process

Main data analyzed

- Sheets cutting lengths
- Welding lengths
- Sheets thicknesses
- Transport lot sizes
- Profiles dimensions
- Sheets dimensions
Model development
Simulation process

- **ERP (SAP)**
  - Excel (Model data)
  - Blocks and subblocks data

- **Excel VBA Macro**
  - Ratios
  - Resource capacity

- **Extendedsim**
  - Simulation Model

First phase:
- General scheduling
- Gantt Chart

Second phase:
- Detailed scheduling
- Specific analysis by workshop
Model & Hierarchical blocks
4. Experimentation and Results
Experimentation and results

Exp. 1 – Improved production scheduling

• Aggregate planning at early stages of the project
• Objective: to find an improved production scheduling.
  • From first stage: first workshop
  • To last stage: arrival at the slipway
• Considerations:
  • Blocks assembly sequence in the slipway is fixed and predefined
  • Hard planning work
    • Big differences between blocks in dimensions, shape, structural conditions, etc.
    • Non linear process
    • Early stages of the project, when detailed technical data are unavailable
Experimentation and results

Exp. 1 – Improved production scheduling

- Improved ship scheduling

Real ship scheduling
- Long manufacturing times
- Unbalanced resources.
- Long waiting times.

Improved ship scheduling
- 30% makespan reduction.
- Balanced resources.
- Buffers reduced
Experimentation and results

Exp. 1 – Improved production scheduling

Available bays in Subassembly workshop.

Real ship sequence

Improved ship sequence

• Less balanced utilization rate

• More balanced utilization rate
Experimentation and results
Exp. 1 – Improved production scheduling

Buffer of blocks waiting for painting process

Real ship sequence

- 12 blocks in buffer
- Long waiting times

Improved ship sequence

- 6 blocks in buffer
- Short waiting times
Experimentation and results

Exp. 2 – Analysis of the Cutting & Welding workshop

- Very important: 1st stage of the process
- All other stages need that all parts arrive as soon as possible
Experimentation and results

Exp. 2 – Analysis of the Cutting & Welding workshop

• **Level**: detailed.

• **Objective**: Analyze the workshop to detect the limiting resources and select the most appropriate actions to improve its utilization rate and thus reduce the workshop's makespan.

• **Results**:
  - The welding station (VRWP) of the web line is the bottleneck of the workshop.
  - Utilization rate mounting station (SSMP): 29%
  - Utilization rate welding station: 97.2%

• **Actions**:
  - Increase of the capacity of the welding station in the web line would increase the overall capacity of the workshop, reducing the makespan of this workshop by 50%.
Experimentation and results
Exp. 3 – Panel line: maximum capacity analysis
Experimentation and results

Exp. 3 – Panel line: maximum capacity analysis

• **Level**: detailed.

• **Objective**: Determine the maximum capacity of the panel line (Cutting & Welding workshop).

• **Experiment**:
  • The line is saturated, generating all part and components of 2 frigates at start time.
  • Different scenarios are generated, changing the number of Mounting and Welding stations and the shifts number.
Experimentation and results

Exp. 3 – Panel line: maximum capacity analysis

- **Results**: The best scenario is the one with 2 Mounting and 2 Welding stations.

- # shifts: depend on the capacity needed to meet the milestones agreed with the client and the associated costs.

<table>
<thead>
<tr>
<th>Shifts</th>
<th>Mounting stations</th>
<th>Welding stations</th>
<th>Maximum capacity (95% CI) (panels/week)</th>
<th>Maximum capacity (95% CI) (blocks/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2.598 ± 0.015</td>
<td>0.411 ± 0.002</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2.756 ± 0.014</td>
<td>0.436 ± 0.002</td>
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<tr>
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<td>2</td>
<td>2</td>
<td>4.646 ± 0.042</td>
<td>0.735 ± 0.007</td>
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<tr>
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<td>2</td>
<td>4</td>
<td>4.759 ± 0.042</td>
<td>0.753 ± 0.007</td>
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<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3.686 ± 0.026</td>
<td>0.583 ± 0.004</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
<td>5.138 ± 0.060</td>
<td>0.813 ± 0.010</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5.487 ± 0.044</td>
<td>0.868 ± 0.007</td>
</tr>
<tr>
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<td>2</td>
<td>2</td>
<td>9.340 ± 0.110</td>
<td>1.478 ± 0.017</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
<td>9.550 ± 0.066</td>
<td>1.511 ± 0.010</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
<td>7.365 ± 0.053</td>
<td>1.165 ± 0.008</td>
</tr>
</tbody>
</table>
5. Conclusions and Future Research
**Conclusions (a)**

- A multilevel simulation model for a shipyard has been proposed and validated.

- Two level: aggregate (first stage of the project) and detailed (when project has started).

- Software used: Extendsim. Right now: is a **3D model using Flexsim**.

- 3 experiments

- **Experiment 1**: aggregate level. Useful at the beginning when little information in available. The modeled obtains an “improved scheduling” *reducing the makespan by 30% with a balanced use of resources*. 
Conclusions (b)

- **Experiments 2 and 3**: detailed level. Aiming at a detailed analysis of first workshop of the shipyard: the Cutting and Welding workshop.

- Experiment 2 allows to characterize the bottlenecks and how the capacity of this workshop affects the makespan.

- Experiment 3 allows to determine the maximum capacity of the panel line (Cutting & Welding workshop) and find the best alternative to fulfill the milestones of the client.

- The model will be implemented in the Navantia military shipyard (Ferrol, Spain).
Conclusions (c)

• Probably: the first complete virtual shipyard with all its workshops.

• The model allows to check many scenarios and all “building strategies”.

• The model will be implemented in the Navantia military shipyard (Ferrol, Spain).

• Many results has already been implemented.

• This virtual shipyard is a competitive advantage of Navantia for doing business with its clients.
Future Research

- Develop scheduling heuristics in order to get an “optimized” schedule that minimizes the total makespan.

- Get detailed 3D models of each of the workshops of the shipyard.

- Optimize the shipyard layout using simulation.
Thanks for your attention