ACTION PLAN FOR RESTRUCTURING THE TECHNOLOGY OF A MEDIUM SIZED SHIPYARD

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## Project requirements
### Table of contents

<table>
<thead>
<tr>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project requirements</td>
</tr>
<tr>
<td>Analysis of functional and spatial structures</td>
</tr>
<tr>
<td>Results of the concept phase</td>
</tr>
<tr>
<td>Solution 1: Accuracy Control</td>
</tr>
<tr>
<td>Solution 2: Part fabrication</td>
</tr>
<tr>
<td>Solution 3: Panel fabrication</td>
</tr>
<tr>
<td>Solution 4: Outfitting</td>
</tr>
<tr>
<td>Solution 5: Section assembly</td>
</tr>
<tr>
<td>Solution 6: Ring and final assembly</td>
</tr>
<tr>
<td>Solution 7: Organisation</td>
</tr>
<tr>
<td>Solution 8: Design requirements</td>
</tr>
<tr>
<td>Final layout</td>
</tr>
<tr>
<td>Roadmap of implementation</td>
</tr>
<tr>
<td>Productivity analysis</td>
</tr>
</tbody>
</table>
Project requirements
Definition of achievable project results

→ The minimum aim for is to produce 4 ships per year in one shift
## Project requirements

### Applied methods

<table>
<thead>
<tr>
<th>Analysis Fields</th>
<th>Description</th>
<th>Applied method for the analysing phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Simulation</td>
</tr>
<tr>
<td>1</td>
<td>Analysis applying lean principles</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Analysis bottlenecks / improvable processes</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Analysis crane capacity and technology</td>
<td>x</td>
</tr>
<tr>
<td>4</td>
<td>Analysis communication and information flow</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Analysis core competencies</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Analysis Micro Panel Line</td>
<td>x</td>
</tr>
<tr>
<td>7</td>
<td>Analysis organization of work</td>
<td>x</td>
</tr>
<tr>
<td>8</td>
<td>Analysis outfitting performance</td>
<td>x</td>
</tr>
<tr>
<td>9</td>
<td>Analysis of payment methods</td>
<td>x</td>
</tr>
<tr>
<td>10</td>
<td>Analysis process orientation</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Analysis second slipway</td>
<td>x</td>
</tr>
<tr>
<td>12</td>
<td>Analysis spatial structures and flow</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Analysis welding speed and quality</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Analysis of new outfitting place</td>
<td></td>
</tr>
</tbody>
</table>

14 analysis fields will be analysed with the methods:

- Shop floor simulation
- Input-output relation
  - Benchmark
  - Planning Table
- Value stream
- Questionnaire
Analysis of functional and spatial structures

Agenda

- Project requirements
- Analysis of functional and spatial structures
- Results of the concept phase
  - Solution 1: Accuracy Control
  - Solution 2: Part fabrication
  - Solution 3: Panel fabrication
  - Solution 4: Outfitting
  - Solution 5: Section assembly
  - Solution 6: Ring and final assembly
  - Solution 7: Organisation
  - Solution 8: Design requirements
- Final layout
- Roadmap of implementation
- Productivity analysis
Analysis of functional and spatial structures
Introduction: Steel throughput per ship II

- The steel throughput for one ship is approx. 10646 tons based on the reference sections
- This value does match with the questionnaire

→Our model of reference section is sufficient for further investigations
Analysis of functional and spatial structures
Simulation: Introduction into the shipyards simulation model

Method for simulation and optimisation of the production in the shipyard especially for the valuation of special concepts
Analysis of functional and spatial structures
Simulation: Introduction *prerequisites of the different workshops*

**Steel cutting and bending**
- simulating with 3 shifts (pure working time)
- plate cutting
  - consists of 3 parallel workstations
  - buffer for plates is 10 sections
  - crane for the transportation of plates from buffer to panel assembly
- profile cutting
  - 1 workstation (representing the cutting robots)
- plate bending
  - 1 workstation (including all plate bending facilities from the shipyard)
- profile bending
  - only relevant for one reference section → has an low overall influence on simulation time → currently not included in the model
Analysis of functional and spatial structures
Simulation: Introduction *prerequisites of the different workshops*

**panel assembly**
- consists of 5 serial workstations representing the 5 stages of assembly
- every station needs 1/5 of the assembly duration (1/5 of 32h)
- profile portal tests if profiles from profile cutting are ready and available
- simulating with 2 shifts (pure working time)

**section assembly**
- maximum of sections which can be assembled parallel: 30
- average space requirement per section: 216m² (calculated from the section fabrication table)
- simulating with 1 shift (pure working time)
- curved sections and micro-panels are currently included in the section assembly with the simulation model
Analysis of functional and spatial structures

Simulation: Introduction *prerequisites of the different workshops*

**slipway**
- maximum of sections which can be assembled parallel: 2
- sections are allocated to section buffer 1 (starboard) or section buffer 2 (port) according to their weight:
  - up to 50t → section buffer 2 is used
  - up to 85t → section buffer 1 (port) OR workspace2 (starboard) is used
  - up to 100t → only section buffer 1 is used

- simulating with 1 shift (pure working time)
Analysis of functional and spatial structures
Simulation: Introduction *simulation flow model*

- parts from plate or profile cutting are transported to panel assembly or section assembly; plates that have to be bended are send to plate bending
- in the panel assembly plates and profiles are assembled to panels
- in the section assembly the fabricated plates and panels are assembled to sections

sections with reference section: 422, 1121, 4261, 3224, 2124, 3243

sections with reference section: 3212, 3254
Analysis of functional and spatial structures
Simulation: Introduction *prerequisites of the production data of sections*

**general prerequisites**
- simulating with 170 sections
- sections 4581 to 4584 are only handled as one section with reference section number 422
- section 3413 with a weight of 190t is spitted into two sections (3413 and 3414)
- section 1161 is spitted into three sections (1161, 1162 and 1163)
- order of production according to order of sections is based on information of assembly tree of the ship no. 315

**steel cutting and bending**
- the simulation is section oriented:
  - all parts of one section (profiles and panels) are summarized to three working packages (profile cutting, plate cutting, plate bending)
  - → three parts to simulate the assembly duration in cutting and bending in simulation model

**panel assembly**
- assembling of two parts coming from plate and profile cutting

**section assembly**
- assembling of third part (from plate bending) with panels coming from panel assembly
Analysis of functional and spatial structures

Simulation: Analyse the bottlenecks

Simulation of the execution time for each shop in consideration of one berth

Conclusion:

→ Duration time on the berth is 130 days → This matches with the project schedule of the shipyard

→ Bottleneck in the steel fabrication is the plate and profile fabrication → they determine the panel and the section assembly processes

→ The cranes on berth are another bottleneck, especially the 100 t crane
Analysis of functional and spatial structures
Input-output relations: steel input and output

Scrap
- 1422.7 t plate
- 212.6 t profile

Stockyard
- 10674.8 t plate
- 1606.5 t profile

Outbound fab.
- 1500 t plate

Profile fab.
- 1393.9 t

Plate fab.
- 7752.1 t

Panel line (T1 – T5)
- 2713.7 t plate
- 688.7 t profile

Section assembly (PH)
- 5346.6 t plate
- 905.3 t profile

Micro panel
- ?

Section assembly (F)
- 7399.5 t plate
- 1377.4 t profile

Section assembly (F1)
- 3316.7 t plate
- 592.0 t profile

Hull erection (slipway)
- 9252.1 t plate
- 1393.9 t profile
## Analysis of functional and spatial structures

### Input-output relations: Demands on the capacity

Estimation on capacity demands for each workshop due to the aimed output of the shipyard

### 1 ship

<table>
<thead>
<tr>
<th>workplaces</th>
<th>1121</th>
<th>2124</th>
<th>3212</th>
<th>3224</th>
<th>3243</th>
<th>3254</th>
<th>4261</th>
<th>422</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate fabrication</td>
<td>0</td>
<td>159,924</td>
<td>566,5256</td>
<td>3376,59</td>
<td>1692,096</td>
<td>1796,79</td>
<td>1220,492</td>
<td>154,468</td>
</tr>
<tr>
<td>Profile fabrication</td>
<td>0</td>
<td>5,464</td>
<td>86,752</td>
<td>557,718</td>
<td>302,036</td>
<td>0</td>
<td>349,496</td>
<td>40,26</td>
</tr>
<tr>
<td>hull erection</td>
<td>0</td>
<td>165,388</td>
<td>653,2776</td>
<td>3934,31</td>
<td>1994,132</td>
<td>1796,79</td>
<td>1569,988</td>
<td>194,728</td>
</tr>
</tbody>
</table>

2.2 ships (per anno)

<table>
<thead>
<tr>
<th>workplaces</th>
<th>1121</th>
<th>2124</th>
<th>3212</th>
<th>3224</th>
<th>3243</th>
<th>3254</th>
<th>4261</th>
<th>422</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate fabrication</td>
<td>351,833</td>
<td>1246,356</td>
<td>7428,5</td>
<td>3722,611</td>
<td>3952,94</td>
<td>2685,082</td>
<td>339,83</td>
<td>627,436</td>
</tr>
<tr>
<td>Profile fabrication</td>
<td>12,0208</td>
<td>190,8544</td>
<td>1226,98</td>
<td>664,4792</td>
<td>0</td>
<td>768,8912</td>
<td>88,572</td>
<td>114,717</td>
</tr>
<tr>
<td>hull erection</td>
<td>363,854</td>
<td>1437,211</td>
<td>8655,48</td>
<td>4387,09</td>
<td>3952,94</td>
<td>3453,974</td>
<td>428,402</td>
<td>742,152</td>
</tr>
</tbody>
</table>

2.5 ships (per anno)

<table>
<thead>
<tr>
<th>workplaces</th>
<th>1121</th>
<th>2124</th>
<th>3212</th>
<th>3224</th>
<th>3243</th>
<th>3254</th>
<th>4261</th>
<th>422</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate fabrication</td>
<td>399,81</td>
<td>1416,314</td>
<td>8441,48</td>
<td>4230,24</td>
<td>4491,98</td>
<td>3051,23</td>
<td>386,17</td>
<td>712,995</td>
</tr>
<tr>
<td>Profile fabrication</td>
<td>13,66</td>
<td>216,88</td>
<td>1394,3</td>
<td>755,09</td>
<td>0</td>
<td>873,74</td>
<td>100,65</td>
<td>130,36</td>
</tr>
<tr>
<td>hull erection</td>
<td>413,47</td>
<td>1633,194</td>
<td>9835,77</td>
<td>4985,33</td>
<td>4491,98</td>
<td>3924,97</td>
<td>486,82</td>
<td>843,355</td>
</tr>
</tbody>
</table>

4 ships (per anno)

<table>
<thead>
<tr>
<th>workplaces</th>
<th>1121</th>
<th>2124</th>
<th>3212</th>
<th>3224</th>
<th>3243</th>
<th>3254</th>
<th>4261</th>
<th>422</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate fabrication</td>
<td>639,696</td>
<td>2266,102</td>
<td>13506,4</td>
<td>6768,384</td>
<td>7187,16</td>
<td>4881,968</td>
<td>617,872</td>
<td>1140,79</td>
</tr>
<tr>
<td>Profile fabrication</td>
<td>21,856</td>
<td>347,008</td>
<td>2230,87</td>
<td>1208,144</td>
<td>0</td>
<td>1397,384</td>
<td>161,04</td>
<td>208,576</td>
</tr>
<tr>
<td>hull erection</td>
<td>661,552</td>
<td>2613,11</td>
<td>15737,2</td>
<td>7976,528</td>
<td>7187,16</td>
<td>6279,952</td>
<td>778,912</td>
<td>1349,37</td>
</tr>
</tbody>
</table>

→ The demand of capacities in consideration of 4 ships per year shows that the shipyard has to manufacture a steel throughput of approx. 37.008 t plates and 5.575 t profiles.
Analysis of functional and spatial structures
Input-output relations: Analysis of the bottlenecks *berth cranes 2*

Balancing the capacity

The cranes have to meet the following capacity demands:

<table>
<thead>
<tr>
<th>Ships per year</th>
<th>Work hours on berth</th>
<th>Other utilisation</th>
<th>Overall work time</th>
<th>Utilisation ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>starboard h/year</td>
<td>portside h/year</td>
<td>starboard h/year</td>
<td>portside h/year</td>
</tr>
<tr>
<td>1</td>
<td>57</td>
<td>310</td>
<td>668</td>
<td>620</td>
</tr>
<tr>
<td>2,2</td>
<td>125</td>
<td>682</td>
<td>1469</td>
<td>1834</td>
</tr>
<tr>
<td>2,5</td>
<td>142</td>
<td>775</td>
<td>1669</td>
<td>2084</td>
</tr>
<tr>
<td>4</td>
<td>227</td>
<td>1240</td>
<td>2671</td>
<td>3335</td>
</tr>
</tbody>
</table>

For an annual production of 2,5 ships the portside-crane just exceeds its capacity limit.
The aimed production of 4 ships per year exceeds the portside-cranes capacity for more than 70% and the starboard-cranes capacity approx. 40%.
Analysis of functional and spatial structures
Value stream: Analysis
Analysis of functional and spatial structures
Value stream: Analysis – *material flow and process orientation*

**Problems due to function-orientation:**

- Big inventory buffers → long lead times
- Imbalances in the timing of operations are hidden → bottlenecks are hidden
- Feedback from later operations to earlier operations is delayed → when a defect is discovered it is not clear when or why it was produced
- Low motivation for improvement → problems are not eliminated
- Extra handling is necessary → e.g. for sorting
- Extra floor space is needed → blocked ways of transportation
- Extra inventory costs money → chance to raise money for necessary investments
Analysis of functional and spatial structures
Value stream: Analysis – 5S and continuous improvement

• There is no accountability for orderliness and cleanliness
• There are no standards how the production area and the workplaces have to look like
• Obviously the responsibilities are not clearly defined (worker or maintenance)
• Waste and scrap disposal is badly organized, no defined places for dustbins and scrap containers

→ result: additional steering and work expenditure and very messy production area

• No standard process for handling improvement suggestions
• No responsible person to assess, decide and control the implementation of improvement suggestions
• Same situation for simplification of design (design for manufacturing)

→ result: many problems are obvious but nobody feels responsible for their elimination
### Analysis of functional and spatial structures

**Overall results 1**

<table>
<thead>
<tr>
<th>Analysis Fields</th>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analysis applying lean principles</td>
<td>1. Push principles applied on the shipyard increasing the inventory buffers and the duration time</td>
</tr>
<tr>
<td>2</td>
<td>Analysis bottlenecks / improvable processes</td>
<td>1. A bottleneck is the crane capacity of the steel fabrication and the 100t crane on the berth -&gt; new transport or positioning systems</td>
</tr>
</tbody>
</table>
| 3               | Analysis crane capacity and technology     | 1. The crane in plate and profile fabrication can handle 25000t this means approx. 2.5 ships  
|                 |                                            | 2. The crane on the berth could handle approx. 2.5 ships                                                                               |
| 4               | Analysis communication and information flow | 1. On the shipyard does not exist any information system. The applied CAD or CAM systems do not work together                        |
| 5               | Analysis core competencies                | 1. Analysis is not done -> Brodotorgir has to define the scope of the analysis                                                           |
| 6               | Analysis Micro Panel Line                 | 1. Detailed analysis is not done -> Currently no investment into a Micro Panel Line is recommended by Fraunhofer                     |
| 7               | Analysis organization of work             | 1. Ratio white collar to blue collar is to high -> white collars could handle the workload of 4 ships  
|                 |                                            | 2. Following the lean principles                                                                                                         |
## Analysis of functional and spatial structures

### Overall results 2

<table>
<thead>
<tr>
<th>Analysis Fields</th>
<th>Description</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Analysis outfitting performance</td>
<td>1. Outfitting performance should be improved -&gt; pipe outfitting</td>
</tr>
<tr>
<td>9</td>
<td>Analysis of payment methods</td>
<td>1. Payment methods (especially for subcontractors) is improvable -&gt; budgeting</td>
</tr>
<tr>
<td>10</td>
<td>Analysis process orientation</td>
<td>1. All processes are functional oriented. The processes are not arranged according the material flow</td>
</tr>
<tr>
<td>11</td>
<td>Analysis second slipway</td>
<td>1. Capacity of the first berth is able to produce 4 ships</td>
</tr>
<tr>
<td>12</td>
<td>Analysis spatial structures and flow</td>
<td>1. The structure of spatial and the material flow are developed due to different steps of accommodation to the modernization of workshops. A workflow in one direction is not possible</td>
</tr>
</tbody>
</table>
| 13              | Analysis welding speed and quality               | 1. Quality assurance should be improved -&gt; establish existing measurement system  
2. Mechanic welding systems should be established in section assembly -&gt; investment in technology |
| 14              | Analysis of new outfitting place                 | 1. To improve the capability of the outfitting workshops up to an international standard a new outfitting workshops with new facilities is necessary. 2. Unusual outfitting tasks should be outsourced (Pipe fabrication, ventilation, electrician) |
# Results of the concept phase

## Agenda

- Project requirements
- Analysis of functional and spatial structures
- **Results of the concept phase**
  - Solution 1: Accuracy Control
  - Solution 2: Part fabrication
  - Solution 3: Panel fabrication
  - Solution 4: Outfitting
  - Solution 5: Section assembly
  - Solution 6: Ring and final assembly
  - Solution 7: Organisation
  - Solution 8: Design requirements
- Final layout
- Roadmap of implementation
- Productivity analysis
Results of the concept phase
Introduction

**Analysis fields**
1. Analysis applying Lean principles
2. Analysis bottlenecks
3. Analysis crane capacity and technology
4. Analysis information and communication flow
5. Analysis core competencies
6. Analysis Micro Panel Line
7. Analysis of new outfitting place
8. Analysis organization of work
9. Analysis outfitting performance
10. Analysis of payment methods
11. Analysis process orientation
12. Analysis second berth
13. Analysis spatial structures and flow
14. Analysis welding speed quality

The analysis fields have been analysed with the applied methods simulation, input-output relation, value stream, planning table, benchmark and questionnaire.

**Concept fields**

<table>
<thead>
<tr>
<th>short</th>
<th>middle</th>
<th>long</th>
<th>term year</th>
</tr>
</thead>
<tbody>
<tr>
<td>'07</td>
<td>'08</td>
<td>´10</td>
<td></td>
</tr>
</tbody>
</table>

- Concepts for accuracy control
- Concepts for part fabrication
- Concepts for panel fabrication
- Concepts for pipe outfitting
- Concepts for section assembly
- Concepts for ring & final assembly
- Concepts for organisation
- Concepts for design requirements
## Results of the concept phase
### Overview of the solutions

<table>
<thead>
<tr>
<th>Solution 1</th>
<th>Short term concepts 2007</th>
<th>Mid term concepts 2008-2009</th>
<th>Long term concepts &gt;2010</th>
</tr>
</thead>
</table>
| Accuracy control and shrinkage management | • Implementation of measurement tasks and techniques  
• Development of accuracy control / production | • Introduction of mechanised welding (BUGO-Mat)  
• Implementation of shrinkage management |  |
| Solution 2 | Part fabrication | • Retrofitting the plate bending facility  
• Production maintenance | • Investments in new cutting building  
• Relocation of plate and profile fabrication | • Upgrade profile bending |
| Panel fabrication | • Improve the egg box integration (Process design)  
• Implementation of open section assembly on the panel line | • Relocation of the panel line  
• Introducing a mechanised micro panel fabrication | • Upgrading the flat panel fabrication |
| Solution 4 | Outfitting | • Implementation of new design principles and modern pipe connections  
• Increasing final documentation of pre-outfitting (Simultaneous Engineering) | • Subcontracting pipe fabrication  
• Relocation and elimination of outfitting workshops  
• New 35t crane |  |
## Results of the concept phase

### Overview of the solutions

<table>
<thead>
<tr>
<th>Solution 5</th>
<th>Short term concepts 2007</th>
<th>Mid term concepts 2008-2009</th>
<th>Long term concepts &gt;2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section assembly</td>
<td>Reorganisation of the areas</td>
<td></td>
<td>Closed section assembly building with a 160t crane</td>
</tr>
<tr>
<td>Solution 6</td>
<td>Ring and final assembly</td>
<td>New 160t crane</td>
<td>Installation of a transportation and positioning system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enlarge the launching berth</td>
<td>Introducing ring section assembly</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improve the ring section pre-outfitting</td>
</tr>
<tr>
<td>Solution 7</td>
<td>Organisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Implementation of steady collection procedures of production times for ERP, PPC and Simulation</td>
<td>Change the payment method for subcontractors</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solution 8</td>
<td>Design requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standardisation (Design for manufacturing; Design for assembly; Simultaneous Engineering)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Solution 1: Accuracy Control

### Agenda

- **Project requirements**
- **Analysis of functional and spatial structures**
- **Results of the concept phase**
  - Solution 1: Accuracy Control
  - Solution 2: Part fabrication
  - Solution 3: Panel fabrication
  - Solution 4: Outfitting
  - Solution 5: Section assembly
  - Solution 6: Ring and final assembly
  - Solution 7: Organisation
  - Solution 8: Design requirements
- **Final layout**
- **Roadmap of implementation**
- **Productivity analysis**
Solution 1
Parts of accuracy control

- Quality control
- Measurement systems
- Shrinkage management
- Mechanized welding
Solution 1
Quality control: Necessity of a quality control group – types of rework

A plenty of reworks happens in the shipbuilding manufacturing process. The largest part of them can be reduced or canceled through the implementation of accuracy control.

<table>
<thead>
<tr>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Unfixing welding beam and displacing</td>
</tr>
<tr>
<td>B</td>
<td>Cutting of material or edge deposit welding</td>
</tr>
<tr>
<td>C</td>
<td>Material cutting / deposit; difficult in curved areas</td>
</tr>
<tr>
<td>D</td>
<td>Alignment and rework</td>
</tr>
<tr>
<td>E</td>
<td>Warming up</td>
</tr>
<tr>
<td>F</td>
<td>Mechanical force alignment</td>
</tr>
<tr>
<td>G</td>
<td>Thermal straightening</td>
</tr>
</tbody>
</table>
Solution 1
Quality control: Necessity of a quality control group – costs of rework

In modern shipyards the implementation of accuracy control saves up to 22% of the production costs by reducing the necessary reworks.

⇒ The achievable results could be higher for the shipyard
Solution 1
Quality control: Road map of implementation

**Educational Phase**
- Preselection process of qualified workers (10 members)
- Start workshop for the QC – group (visit of a modern shipyard) to motivate the team
- Basic training course with the 3D - Totalstation

**Application Phase**
- Applied training with the 3D – Totalstation in the production process
- Execute measurements and analyze and evaluate the state of the quality in the production process
- Selection of the core QC – group (5 members)
- Start of the implementation of the accuracy control in the shipyard
Solution 2 + 3: Part and panel fabrication

Agenda

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  - Solution 8: Design requirements
- Final layout
- Roadmap of implementation
- Productivity analysis
Solution 2 + 3
New concept

• Relocation of the part fabrication
  - Warehouse
  - Cutting workshop
  - Bending workshop

• Relocation of the panel fabrication
  - Micro panel fabrication
  - Flat panel fabrication
  - Closed section assembly

→ Building a new part and panel fabrication building under the following requirements:
  • Ongoing production
  • Minimal investments
  • Optimised material flow
  • Future orientation for further increase beyond the proposed scheme
Solution 2 + 3
New concept: Procedure 1
Solution 2 + 3
New concept: Procedure 2
Solution 2 + 3
New concept: Procedure3
Solution 2 + 3
New concept: Procedure 4
Solution 2 + 3
Roadmap of implementation

1. Relocate the steel stock
   a. Pull down the old warehouse
   b. Level the ground
   c. Relocate the crane to the new steel stock
   d. Relocate the steel warehouse steel to its new place
2. Relocate the pre-conservation
   a. Construct a new building for the pre-conservation
   b. Move the pre-conservation
   c. Demolition of old pre-conservation-building
3. Build part 1 of the new steel fabrication building
4. Move plasma-cutting, profile-cutting and profile-bending
5. Build part 2 of the new steel fabrication building
6. Relocate the panel line
7. Integrate the micro panel line
8. Upgrade the panel line for the 4th and 5th workplace
Solution 4: Outfitting

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Solution 4
Sub-contracting pipe fabrication

• The core competence of the shipyard is the development and installation of pipe systems
• The preparation of pipes can be done more efficiently by special pipe manufactures
  - Cutting, bending and flanging the pipes by subcontractors
• Therefore the preparation of pipes should be outsourced to reduce costs as a middle term solution
• The free workers will be relocated to the pre-outfitting of sections and rings to decrease the duration time of pre-outfitting
• Warehouse for the pipes on 600m²
  - Buffering the pipes on stackable pallets
  - Delivering the pipes JIT (small stock)

→ the shipyard is responsible for the assembly of the pipe traces and the preparation of adjusting pipes
Solution 4
Relocation and elimination of outfitting processes

- Along with the concentration on the core competencies the number of outfitting workshops has to be reduced
  - The halls and buildings are no longer necessary for the outfitting
- Corresponding to the strategic plan of the shipyard to install a new ship repair division, these buildings and the workers should be a part of the new repair division
  - This will decrease the numbers of workers and areas for the shipbuilding division and decrease the productivity
  - Foreman's of the shipyard could found a company with the help of the shipyard to decrease the outfitting processes at the shipyard
- A Benchmark has shown that a comparable shipyard will require approx. 6000 m² for all outfitting workshops including warehouse
Solution 4
Area allocation for outfitting 2

• For all other workshops 3300m² of the warehouse are allocated
  - 2300m² as warehouse (with balconies to transport the outfitting components directly from the warehouse to the ship)
  - Approx. 1000m² for preparation

→ The available area for outfitting at the shipyard exceeds the benchmarked shipyard
**Solution 5: Section assembly**

**Agenda**

<table>
<thead>
<tr>
<th>Project requirements</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>Final layout</td>
</tr>
<tr>
<td>Roadmap of implementation</td>
</tr>
<tr>
<td>Productivity analysis</td>
</tr>
</tbody>
</table>
Solution 5
Calculation of section assembly areas - Current state of the art

<table>
<thead>
<tr>
<th>Present Brodo Trogir</th>
<th>length [m]</th>
<th>width [m]</th>
<th>floorspace [m²]</th>
<th>working hours [h/d]</th>
<th>weighted floorspace</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>47</td>
<td>15</td>
<td>705</td>
<td>10</td>
<td>294</td>
</tr>
<tr>
<td>D</td>
<td>56</td>
<td>24</td>
<td>1344</td>
<td>10</td>
<td>560</td>
</tr>
<tr>
<td>D</td>
<td>13</td>
<td>10</td>
<td>130</td>
<td>10</td>
<td>54</td>
</tr>
<tr>
<td>F</td>
<td>155</td>
<td>15</td>
<td>2325</td>
<td>10</td>
<td>969</td>
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<tr>
<td>F1</td>
<td>41</td>
<td>19</td>
<td>779</td>
<td>10</td>
<td>325</td>
</tr>
<tr>
<td>P</td>
<td>186</td>
<td>26</td>
<td>4836</td>
<td>10</td>
<td>2015</td>
</tr>
<tr>
<td>PH</td>
<td>120</td>
<td>16</td>
<td>1920</td>
<td>10</td>
<td>800</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td></td>
<td>5016 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>steel throughput</td>
<td></td>
<td></td>
<td>45000 t/a</td>
<td></td>
<td>8.97 t/a*m²</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>floorspace steel throughput</th>
<th>24</th>
<th>24800 m²</th>
<th>100000 t/a</th>
<th>4.03 t/a*m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>400</td>
<td>62</td>
<td>24600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- the shipyard could assemble sections for 2,5 - 3 ships maximum in reference to the current production (1 shift)
- The section assembly area is a bottleneck in the middle term solution
**Solution 5**
Calculation of section assembly areas—Future scenario with closed assembly

<table>
<thead>
<tr>
<th>Area</th>
<th>length [m]</th>
<th>width [m]</th>
<th>floorspace [m²]</th>
<th>workinghours [h/d]</th>
<th>weighted floorspace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed section building</td>
<td>40</td>
<td>13</td>
<td>520</td>
<td>24</td>
<td>520</td>
</tr>
<tr>
<td>Section assembly hall</td>
<td>155</td>
<td>33</td>
<td>5115</td>
<td>24</td>
<td>5115</td>
</tr>
<tr>
<td>Modul assembly hall</td>
<td>56</td>
<td>32</td>
<td>1792</td>
<td>24</td>
<td>1792</td>
</tr>
<tr>
<td>Berth</td>
<td>160</td>
<td>32</td>
<td>5120</td>
<td>10</td>
<td>2133</td>
</tr>
<tr>
<td><strong>Total floorspace</strong></td>
<td></td>
<td></td>
<td><strong>9560 m²</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Steel throughput</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benchmark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total floorspace</td>
<td>400</td>
<td>62</td>
<td>24800</td>
<td>24</td>
<td>24800 m²</td>
</tr>
<tr>
<td>Steel throughput</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100000 t/a</td>
</tr>
</tbody>
</table>

| factor                        | 117 %      |

→ the shipyard can produce sections for > 5 ships/year in consideration of the closed section assembly area (3 shifts) plus the berth in one shift

→ Erection of an additional building for section / module assembly is necessary as a long term solution
Solution 5
Layout

Module assembly: 56x32m 1800m²

Section assembly
Solution 6: Ring and final assembly

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Solution 6
Production during the launching berth enlargement 2

Variant: pyramid assembly
- Stern ship assembly
- Parallel pyramidal erection
  - Identification of the starting point of assembly (erection level, distance,..) could easily be measured
- Advantages: parallel erection of three areas of the ship and decrease of the duration time
  ➔ Using the tandem assembly method
Solution 6
Variant 1: Assembly of two ships parallel 1
Solution 6
Variant 1a: Assembly of two ships parallel with ring assembly 1
Solution 6
 Variant 2: Ring assembly procedure

- The stern ship will be produced on the ring assembly areas (launching berth 2) and after the finished production the stern ship will be transported immediately to the final assembly area (launching berth 1).

- The rings will be produced by a sequenced production on the ring assembly areas (launching berth 2) due to the assembly sequence on the final assembly area (launching berth 1). Afterwards they will be assembled in a defined order to the stern ship on the final assembly area (launching berth 1).
Solution 6

Variant 2: Ring assembly

• The launching berth 1 is the final assembly area
• The launching berth 2 is ring section assembly area
• The launching berth 2 consist of:
  - 4 middle ship ring assembly workplaces
  - 1 stern ship workplace
• The tanker of the shipyard consist of 6 middle ship rings plus 1 stern ship plus 1 bow ship
• The transport from the ring assembly area (launching berth 2) to the final assembly area (launching berth 1) is possible via 5 switches
  - 1 switch is allocated for the stern ship
  - 4 switch are allocated for the middle ship rings
• The transport and the positioning of the rings on the final assembly area (launching berth 1) is done by a transport and positioning system
  - Setting the stern ship
  - Positioning the rings to the stern ship
Solution 6
Variant 2: Transport procedure 1
Solution 6
Variant 2: Transport procedure 2
Solution 6
Variant 2: Estimation of the required duration and execution time 3

- The figures base on the know-how of Fraunhofer, literature and research projects of shipbuilding industry
- The closed manufacturing on the shipyard leads to a productivity growth of 20% in case of a climate independent fabrication.
- The implementation of mechanized welding leads to a longer working time of the welding torches
  - productivity growth up to 25% is possible
- Using a mechanized process the amount of required workers will be reduced.
  - The free workers will be replaced in a second and a third shift.
  - The new shifts leads to a productivity growth of 60% for the second shift and 40% for the third shift
Solution 6
Transport and positioning system 1

The keel block pillar could change its moving direction.

The external wheels are pivoted moveable and can be lifted and lowered.

A integrated cylinder can lift the keel block pillar for the new positioning of the wheels → 90° rotation of the wheels on point

map ...: keel block pillar
1 module; 2 external stamps; 3 wheel sets for ride along and across; 4 cross
Solution 7: Organisation

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Solution 7
Implementation of shop floor simulation: PPC vs. Simulation

- Tool for shop floor simulation
- Tool for work space allocation

Functions of ERP/PPC-Systems (Example ERP_{LN}, SAP)

- Sales
- Financial accounting
- Materials logistics
- Controlling
- Asset management
- Project management
- Office & Communication
- Solution for industry sector
- Production planning and control
- Quality management
- Maintenance management
- Human resources management

Shop floor simulation
Solution 7
Implementation of shop floor simulation: Future scenario

Backend-database-management system
(Oracle, Informix, SQL-Server, …)

• production order
• task schedule, workflow, part list
• value of production resources
• availability of production resources
• requirement of space, weight, manpower
• …

CAD-System

PPC-System

Project Management System

Shop floor planning tool

Simulation system
Solution 8: Design requirements

Agenda

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Results of the concept phase

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| Solution 8: Design requirements |

| Final layout |
| Roadmap of implementation |
| Productivity analysis |
Solution 8
Design requirements

The main part of costs for manufacturing and assembly is committed during the design phase!
Solution 8
Standardisation - Design for manufacturing

- Several style guides are the result of the different manufacturing processes
- During the design process of parts these style guides must be allowed
- Examples:

<table>
<thead>
<tr>
<th>Aim</th>
<th>Wrong</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitable for drilling</td>
<td>![Wrong Image]</td>
<td>![Right Image]</td>
</tr>
<tr>
<td>Suitable for cast parts</td>
<td>![Wrong Image]</td>
<td>![Right Image]</td>
</tr>
<tr>
<td>Escape for tools</td>
<td>![Wrong Image]</td>
<td>![Right Image]</td>
</tr>
<tr>
<td>Avoidance of too much chipping</td>
<td>![Wrong Image]</td>
<td>![Right Image]</td>
</tr>
</tbody>
</table>
**Final layout**

**Agenda**

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  - Solution 8: Design requirements
- **Final layout**
- **Productivity analysis**
Final layout
Overview
Productivity analysis

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Final layout

Productivity analysis
Productivity analysis
Additional notes

• The investments in the micro panel line and in the upgrade of the panel line are required due to the limited capacities of the panel and section assembly area → without the investment the shipyard will require a large area for micro panel assembly and open section assembly because of
  - Production in shifts is not possible
  - Outside welding depends on the climate conditions
  - Mechanised welding will achieve a productivity growth of approx. 25%
  - Increased output to 5 ships

• The total output can be increased to 6 ships in consideration of having the full process under control
  - Section can be produced outside → additional area is required
  - Rings can be erected with a higher input of workers → organised production planning is required
  - Duration for fitting the rings can be reduced with a higher input of workers → organised production planning is required

→ The targeted aim of the shipyard to produce 4 ships is realisable