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

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1. Introduction

Introduction

High international competitiveness

→ **Need to manufacture**

→
- **Shortest delivery term**
- **Lower cost**
- **High level of quality**

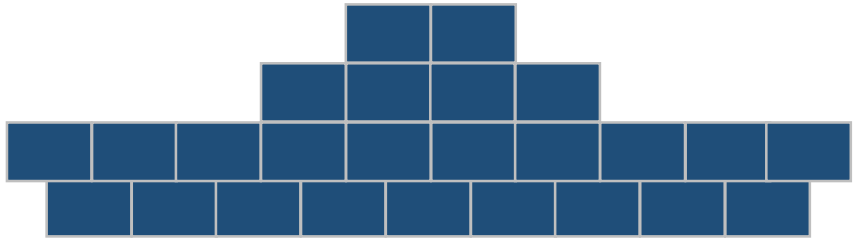
Complexity of shipbuilding process

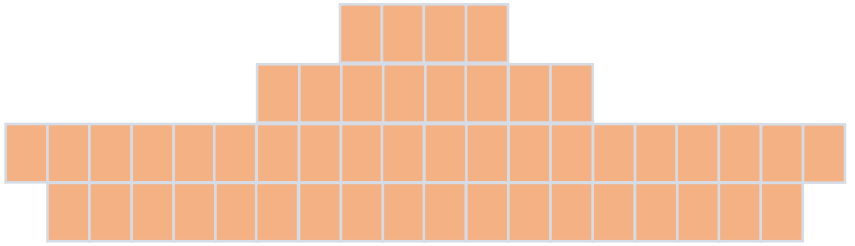
- **Diversity and # of elements**
- **Product (Frigate)** →
  - **Unique (not serialized)**
  - **High added value**
  - **Long construction period**
- **Non lineal process** →
  - **Complex coordination between stages / workshops**

2. Simulation Model

Model development

Frigate → 25 Blocks → 50 Sub-blocks





Input Data → Simulation Model → Results

- Excel interface for input data
- Connected with Extendsim

- Developed in ExtendSim
- Easy integration with SAP

- Results tables
- Gantt Chats

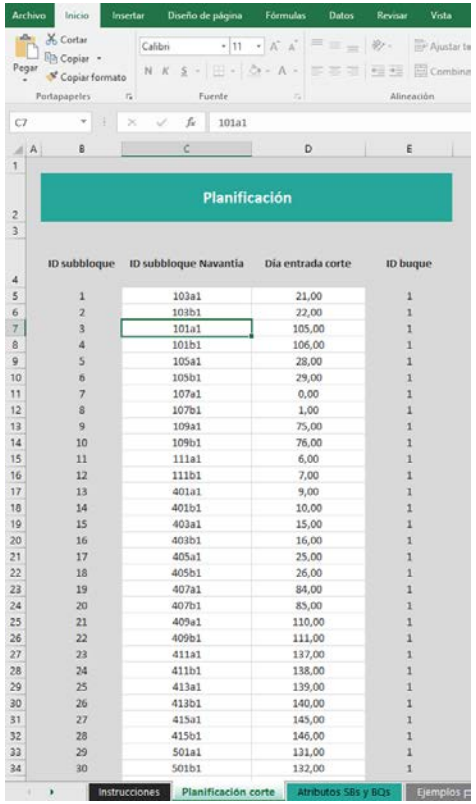
Model development

- 5 sub-blocks typology

Main sub-blocks attributes		
Typology	# Web frames	# Beams
Weight	# Longitudinal girders	# Spare parts (webs)
# Straight panels	# Transverse girders	# Profiles (webs)
# Shell panels	# Double bottom girders	# Spare parts (panels)
# Longitudinal profiles	# Bulkheads	# Profiles (panels)

Model development

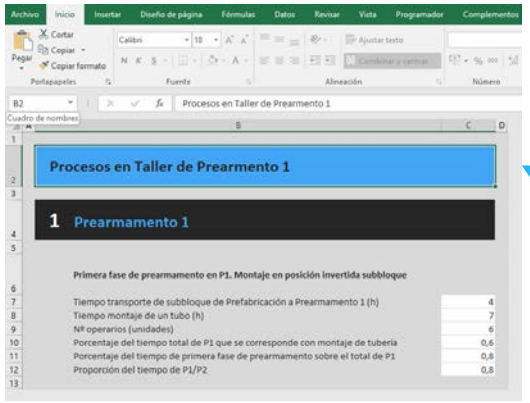
- Input sequence

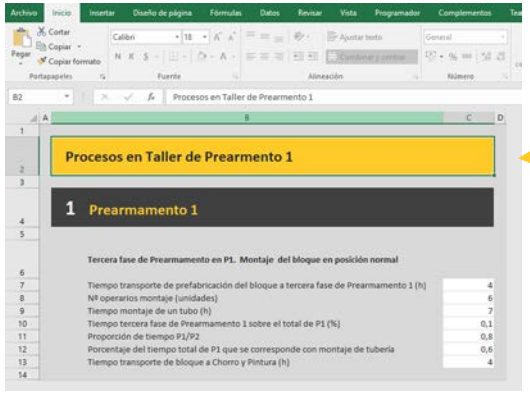


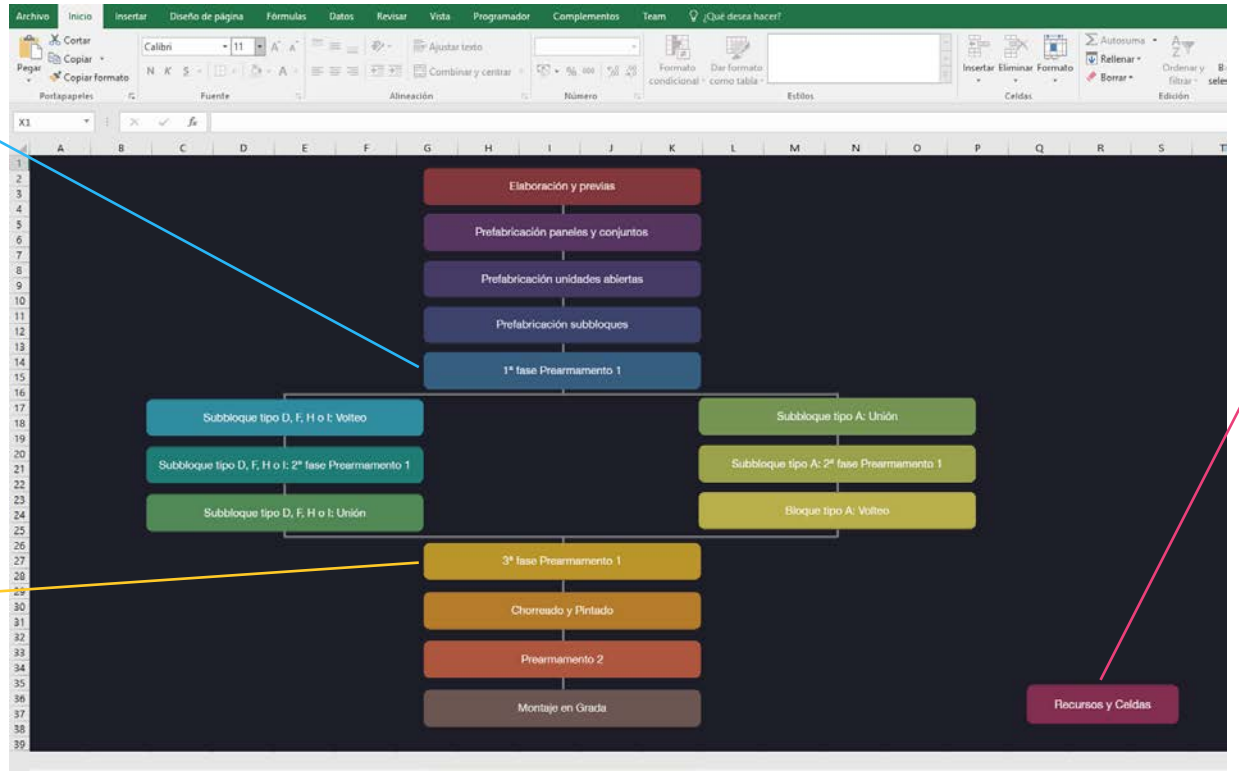
- Disaggregation process

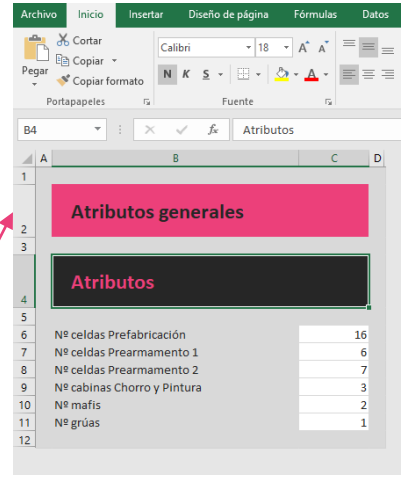
Main data analyzed
Sheets cutting lengths
Welding lengths
Sheets thicknesses
Transport lot sizes
Profiles dimensions
Sheets dimensions

Model development

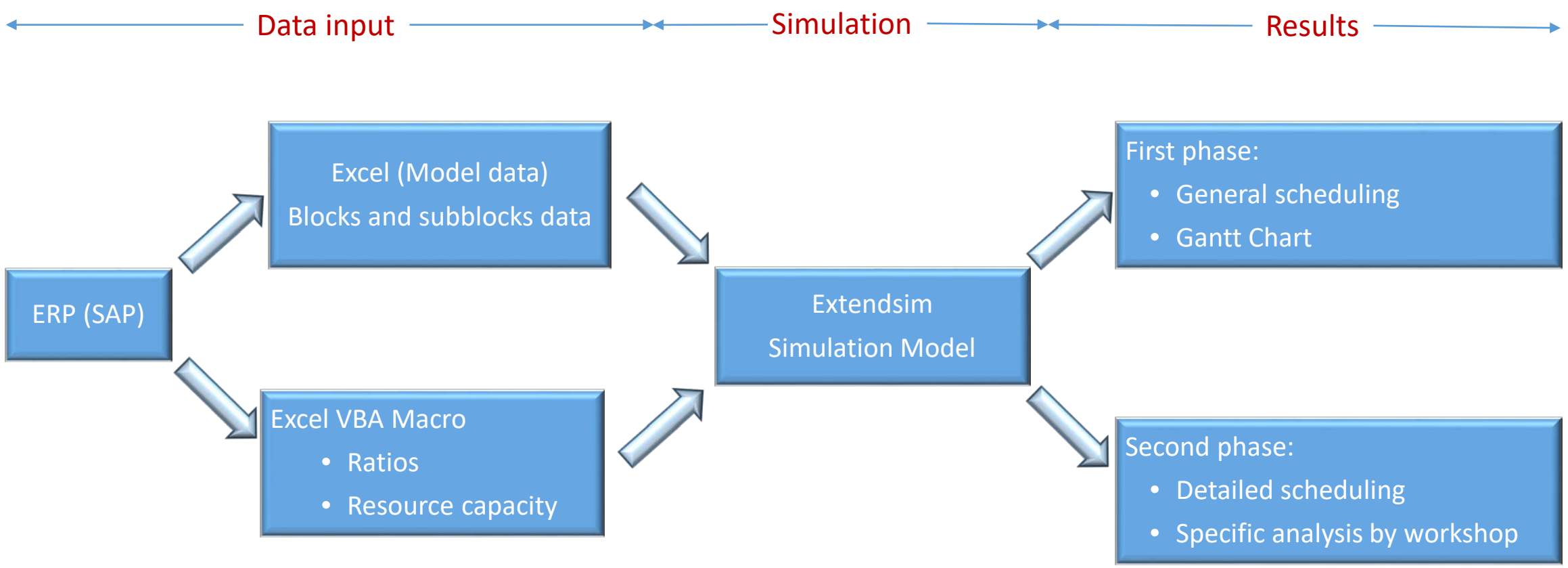




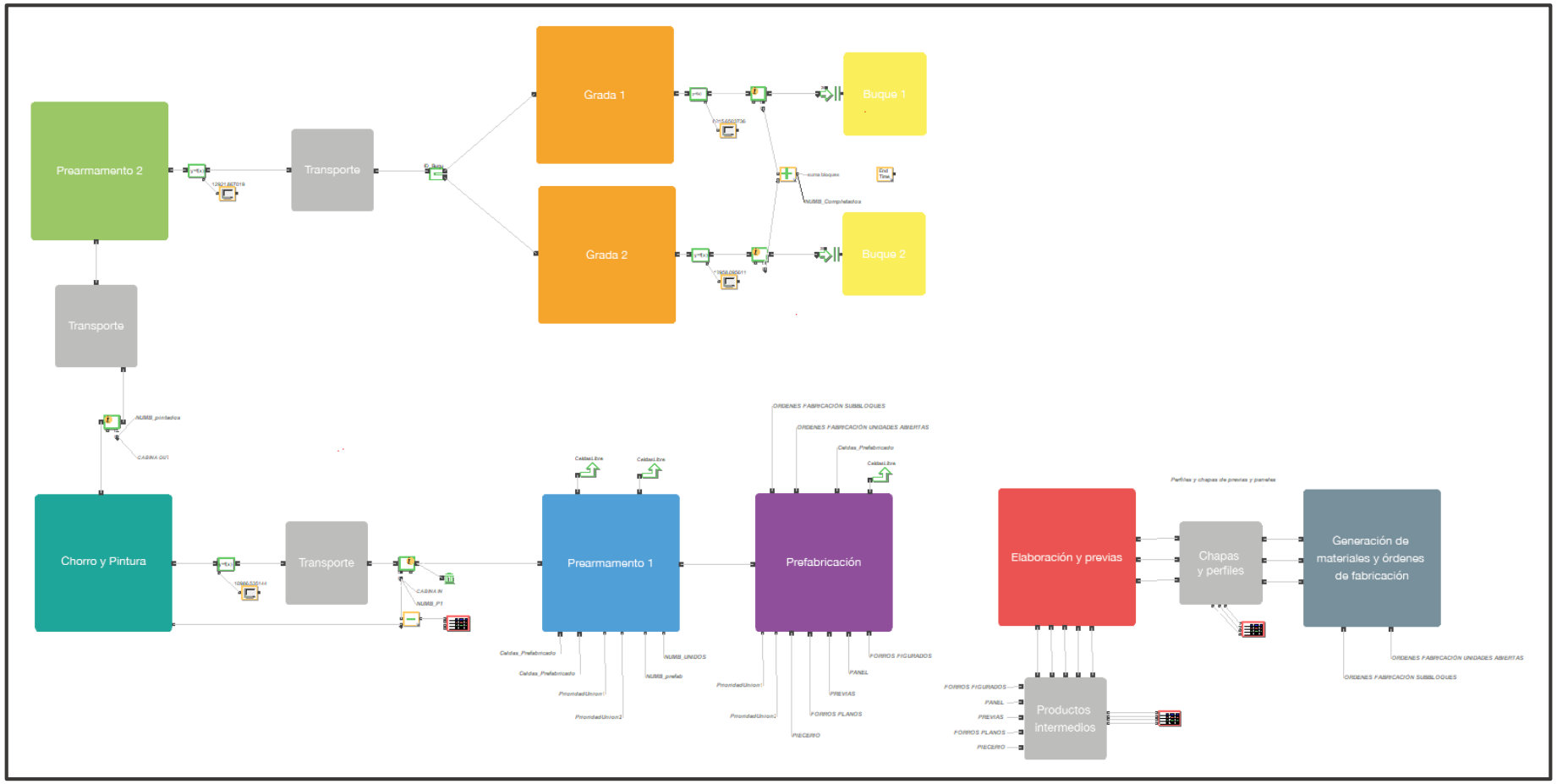




Simulation process



Model & Hierarchical blocks



4. Experimentation and Results

Experimentation and results

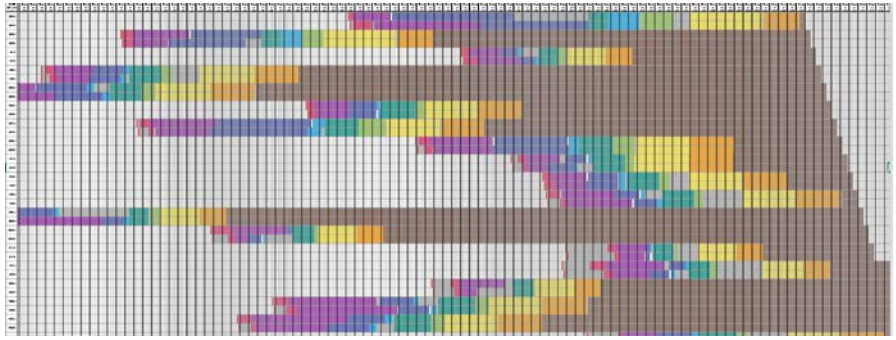
Exp. 1 – Improved production scheduling

- 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

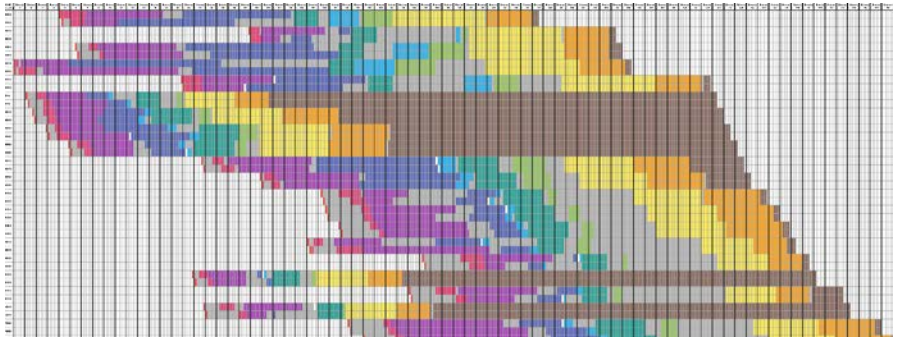
Exp. 1 – Improved production scheduling

Real ship scheduling



- Long manufacturing times
- Unbalanced resources.
- Long waiting times.

Improved ship scheduling



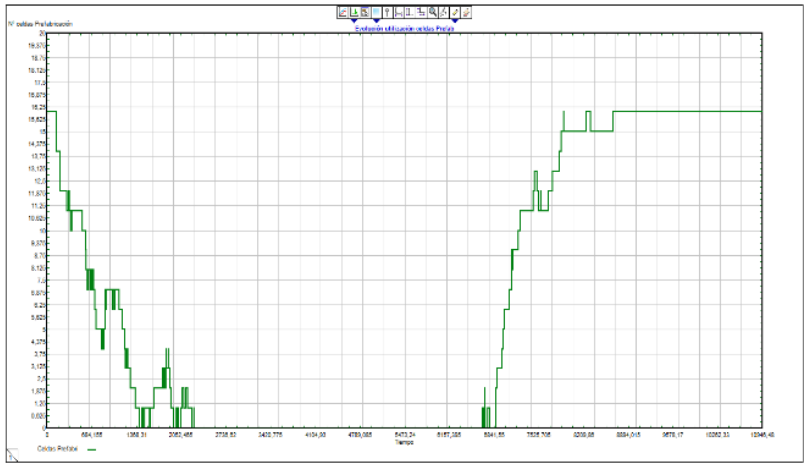
- 30% makespan reduction.
- Balanced resources.
- Buffers reduced

Experimentation and results

Exp. 1 – Improved production scheduling

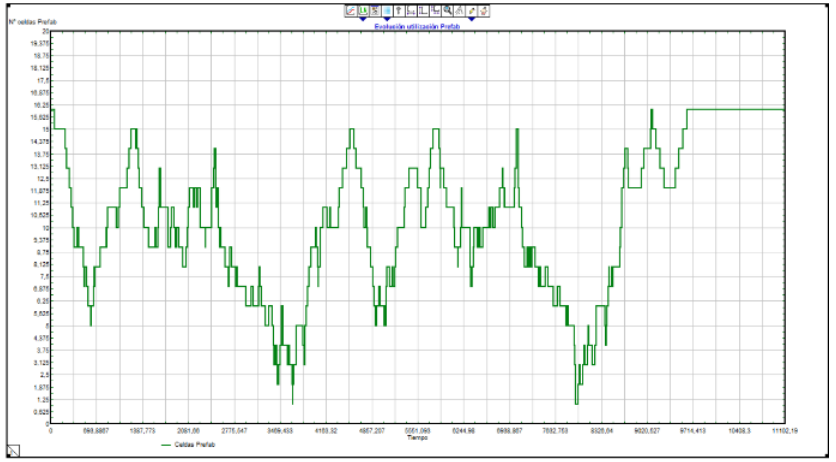
Available bays in Subassembly workshop.

Real ship sequence



- Less balanced utilization rate

Improved ship sequence



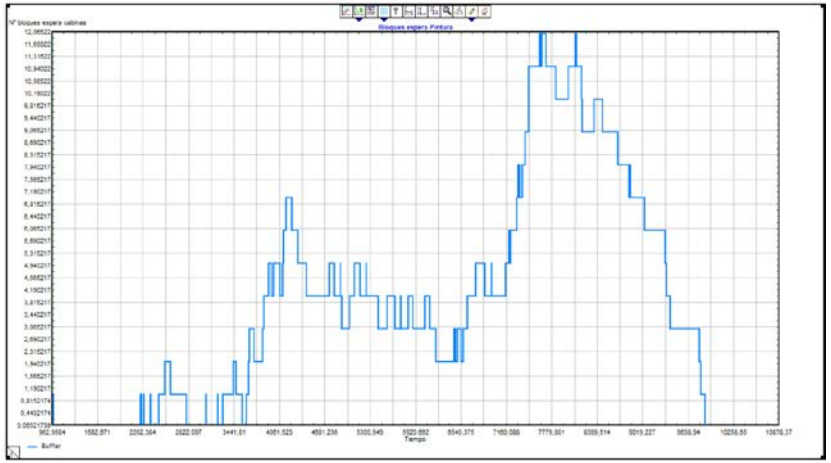
- More balanced utilization rate

Experimentation and results

Exp. 1 – Improved production scheduling

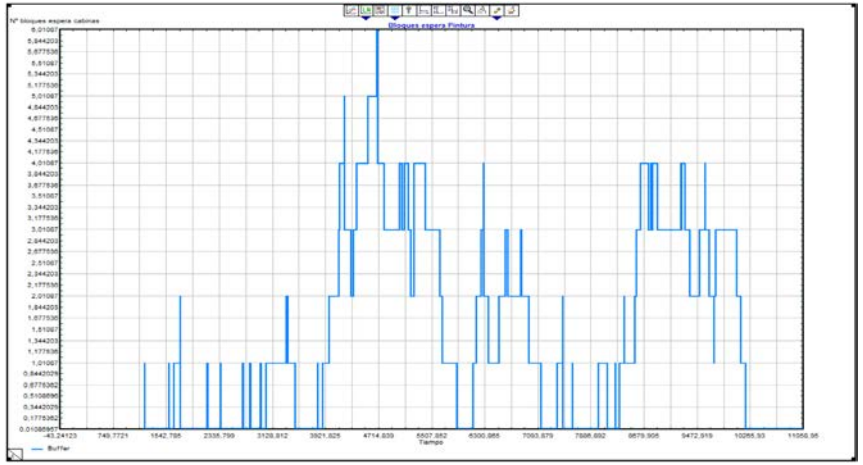
Buffer of blocks waiting for painting process

Real ship sequence



- 12 blocks in buffer
- Long waiting times

Improved ship sequence

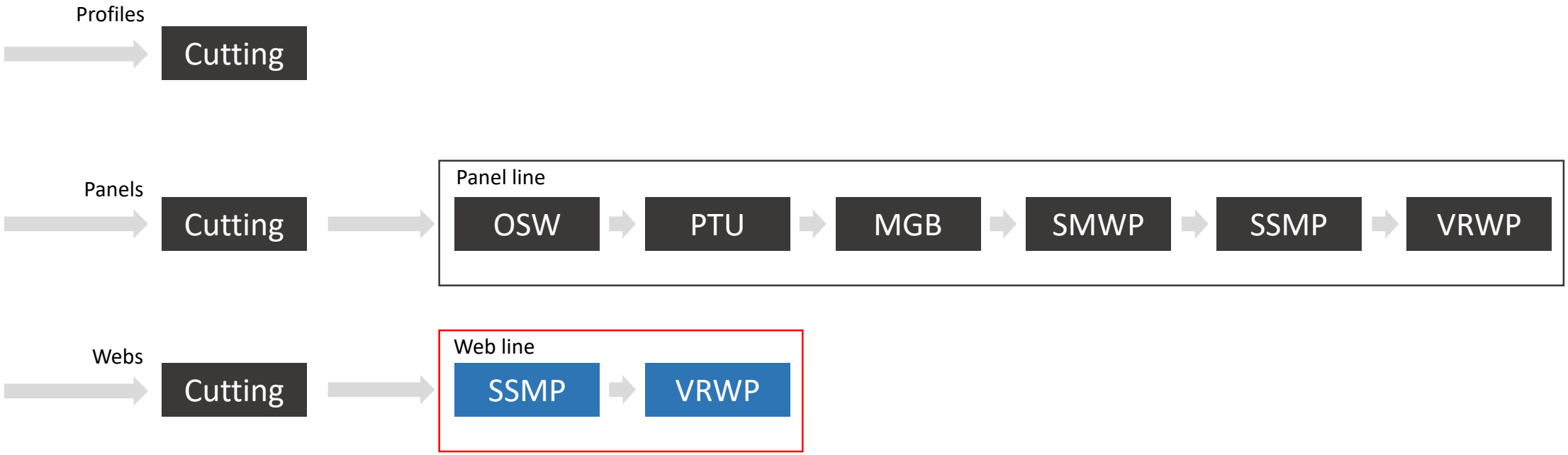


- 6 blocks in buffer
- Short waiting times

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



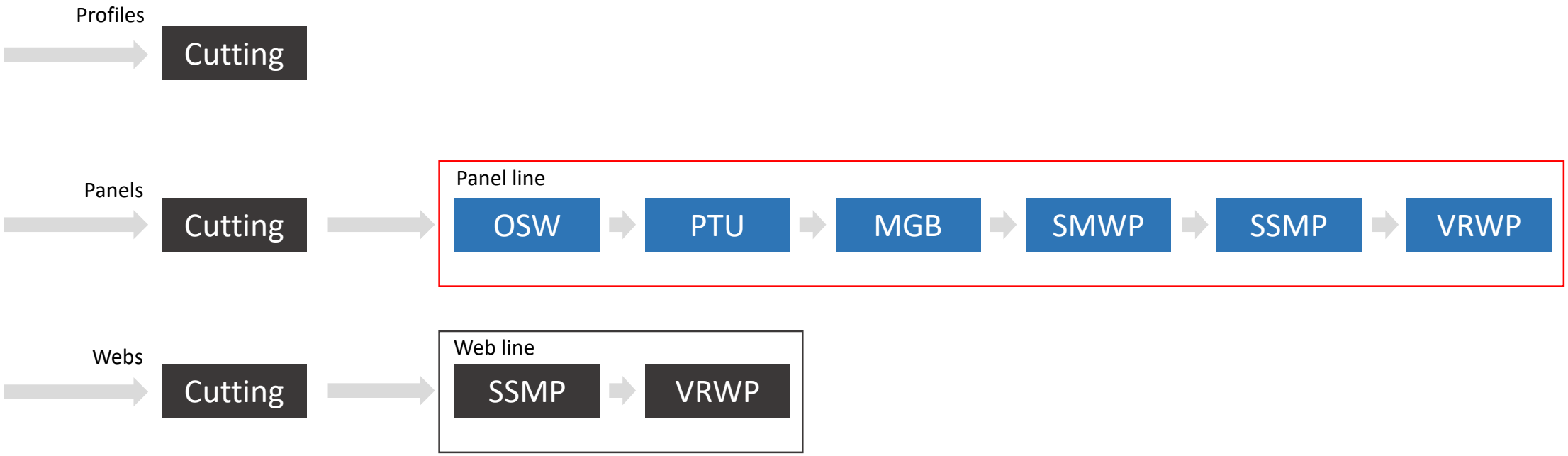
Experimentation and results

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.

Shifts	Mounting stations	Welding stations	Maximum capacity (95% CI) (panels/week)	Maximum capacity (95% CI) (blocks/week)
1	1	1	2.598 ± 0.015	0.411 ± 0.002
	1	2	2.756 ± 0.014	0.436 ± 0.002
	2	2	4.646 ± 0.042	0.735 ± 0.007
	2	4	4.759 ± 0.042	0.753 ± 0.007
	2	1	3.686 ± 0.026	0.583 ± 0.004
2	1	1	5.138 ± 0.060	0.813 ± 0.010
	1	2	5.487 ± 0.044	0.868 ± 0.007
	2	2	9.340 ± 0.110	1.478 ± 0.017
	2	4	9.550 ± 0.066	1.511 ± 0.010
	2	1	7.365 ± 0.053	1.165 ± 0.008

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.

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Thanks for your attention