

USER MANUAL

CraftFlow Software

INTEGRATIVE PROJECT – 3rd SEMESTRE - LEI – ISEP – 2024/2025

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PREFACE

This User Manual was developed with the aim of supporting users in understanding and using the computerised solution created for production management in industrial facilities, **CraftFlow**. The application, developed as part of the **Integrating Project** of the third semester of **LEI - ISEP**, was designed to demonstrate the principles of planning, monitoring and controlling production in flexible industrial environments, adapted to different types of manufacturing.

The content presented here reflects good software development practices, including the use of agile methodologies and techniques such as **Test-Driven Development (TDD)**. In addition, the solution was created in a modular way, integrating different languages and technologies to ensure a robust and interoperable approach.

This document is designed to be accessible to all users of the system, regardless of their technical level. The structure of the manual ranges from basic installation and initial configuration instructions to detailed explanations of the system's functionalities and solutions to common problems.

The team responsible for developing this project hopes that this manual will serve as a clear and practical guide, promoting efficient and productive use of the application.

Porto, January 2025

Byte Masters: Second Coming

1. PRE – REQUISITES

To ensure that the application works correctly, the following pre - requisites are required:

1.1 OPERATING SYSTEM

The application has been developed to be compatible with **Windows**, **Linux** and **macOS**.

1.2 SOFTWARE DEPENDENCIES

- **Java Runtime Environment (JRE):** The application requires a way to execute `.jar` files. Make sure you have the **JRE** installed on your system.
 - Download the **JRE** from Oracle's official website: [Java SE Downloads](#).

1.3 SPECIFIC REQUIREMENTS PER OPERATING SYSTEM

- **Windows:**
 - Make sure that **Windows Subsystem for Linux (WSL)** is installed. Follow the steps described by Microsoft: [WSL Installation Guide](#).
- **Linux:**
 - Make sure that **gnome-terminal** is installed. To install, use the following command in the terminal:

```
sudo apt install gnome-terminal
```

- **macOS:**
 - The system already includes Terminal by default, but make sure the user has executed permissions for the **osascript** command. Use the following command in the terminal to check:

```
sudo chmod +x usr/bin/osascript
```

1.4 APPLICATION LOCALISATION

Make sure that the application runs directly in the folder where the software was installed or extracted. All the necessary files must be present in that directory.

1.5 EXECUTION PERMISSIONS

Make sure that the terminal has permissions to execute `.jar` files and other associated commands.

2. INSTALLATION

To install and configure the application correctly, follow the steps below:

2.1 UNZIP THE ZIP FILE

- Download the **sem3-pi-2024-g094.zip** file provided by the development team.
- Unzip the file into a directory of your choice. Make sure that the contents retain the original folder structure.

2.2 KEEP THE .JAR IN THE MAIN FOLDER

- The **CraftFlow.jar** file must remain in the main folder after unzipping. It is essential that this file is not moved to other locations, as the application depends on other files in the same folder to work properly.
- Any attempt to move the **.jar** file could cause errors when running the application.

2.3 ADDING NECESSARY FILES TO THE RESOURCES FOLDER

- For the application to work correctly, any additional files required must be placed in the folder: **sem3-pi-2024-g094\src\main\resources**.

All the files in this folder must be in **.csv** format. Make sure that the files comply with the formats expected by the application (described in the **Initial Configuration** and **Main Functionalities sections**).

2.4 CHECKING THE FOLDER STRUCTURE

After unzipping, the folder structure should look like this:

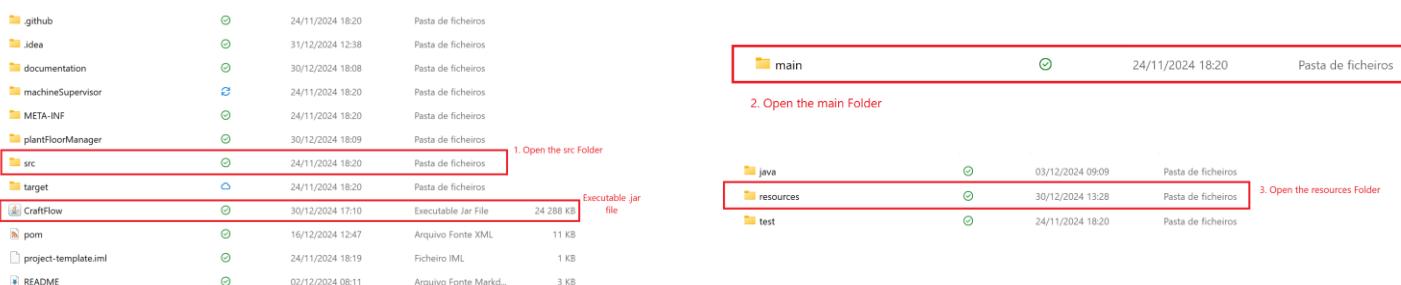


Figure 1 - Path for adding required .csv files and location of the .jar executable.

⚠ Notes:

- Do not edit or delete files in the main folder unless instructed to do so by the development team.
- If you encounter problems at this stage, check that the folder structure is correct and that the necessary files are in the right place.

3. INITIAL SETUP

In this section, we will explain how to navigate to the folder where the software is located and how to run it using the terminal. Please follow the steps according to your operating system.

3.1 OPEN THE TERMINAL

- **Windows:**

- Use the **Win + R** keyboard shortcut, type **cmd**, and press **Enter** to open the terminal.
- If using **WSL**, open **Ubuntu** or another installed distribution.

- **Linux:**

- Press **Ctrl + Alt + T** to open the terminal.

- **macOS:**

- Use **Spotlight (Cmd + Space)** and search for "**Terminal**".

3.2 NAVIGATE TO THE SOFTWARE FOLDER

In the terminal, use the **cd (change directory)** command to navigate to the folder where the software was extracted.

For example:

- **Windows:**

```
cd C:\Users\[your_username]\Downloads\sem3-pi-2024-g094
```

- **Linux/macOS:**

```
cd ~\Downloads\sem3-pi-2024-g094
```

3.3 RUN THE SOFTWARE

Once in the correct folder, run the **.jar** file with the appropriate command:

```
java -jar CraftFlow.jar
```

⚠️ Important Note: Ensure that the **.jar** file and all required files, such as **.csv** files, remain in the same folder. Any additional files required must be placed in the **src\main\resources** folder and must be in **.csv** format.

4. STEP-BY-STEP GUIDE TO THE APPLICATION

After completing the steps outlined in the previous sections, we now move on to an overview of how to navigate and use the **CraftFlow application**. Below is a detailed explanation of its Main Menu and the functionalities available in each section:

4.1 MAIN MENU

The initial menu provides access to five submenus, each tailored to specific functionalities:

- **Data Operations** - This section includes all simulators and their associated tools, allowing you to perform various data-related operations.
- **Database Management** - This section provides tools for working with the system's database. It includes **Functions and Triggers Demonstrations and Query Execution**.
- **Machine Monitoring and Control** - In this menu, you can operate and monitor various factory-floor machines. Additionally, it allows you to simulate machine operations using a **Raspberry Pi Pico**.
- **Search Glossary Terms** - This feature enables you to search through the application's glossary to better understand key terms relevant to your business and the software.
- **Help** - Access the comprehensive User Manual in **PDF** format for detailed guidance and support.

```
+-----+
|      C R A F T F L O W      |
+-----+
Welcome to your favourite Simulation Tool!
\ Initializing CraftFlow ...

--- Main Menu ---

1 - Data Operations
2 - Database Management
3 - Machine Monitoring and Control
4 - Search Glossary Terms
5 - Help
0 - Exit

Type your option: |
```

Figure 2 - Main Menu.

4.2 DATA OPERATIONS MENU

The Data Operations Menu is the first main menu of the application. Upon selecting it, a submenu with specific options will be displayed:

4.2.1 CHOOSE YOUR FILES SUBMENU

This submenu allows the user to select the files to be used in this section of the application. Three options are available:

- **Use Default Files:** Selects the default files created for client demonstrations.
- **Use Exported Files from the Database:** Selects files exported directly from the database.
- **Enter File Names Manually:** Allows the user to manually input the required file names.

! Note:

- Files must be in the resources folder.
- If files are in a subfolder, use the format subfolder/filename.csv.
- All files must have the .csv extension.

```
---- Choose Your Files ----

1 - Use Default Files
2 - Use Exported Files from the Database
3 - Enter File Names Manually
0 - Back

Type your option: |
```

Figure 3 - Choose Your Files Submenu.

4.2.2 CHOOSE SIMULATOR SUBMENU

In this submenu, users can choose between five different simulators:

1. **Simulation by Time**
2. **Simulation by Priority**
3. **Simulation by Structural Information (Production Tree)**
4. **Simulation by PERT/CPM**
5. **Simulation by Orders**

```
---- Choose Simulator ----

1 - Simulation by Time
2 - Simulation by Priority
3 - Simulation by Structural Information
4 - Simulation by PERT/CPM
5 - Simulation by Orders
0 - Exit

Type your option: |
```

Figure 4 - Choose Simulator Submenu.

4.2.2.1 SIMULATION BY TIME AND PRIORITY

Both simulators have identical menus, differing only in how the production order is determined.

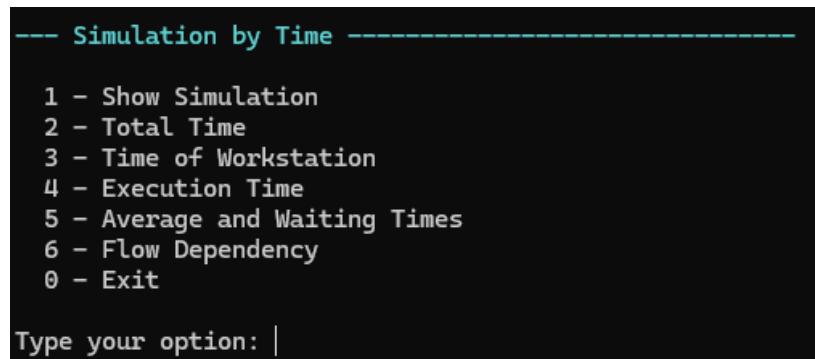


Figure 5 - Simulation by Time Submenu.

Available Options:

- **Show Simulation:** Enables viewing of the simulation for a single item or all items.
 - Figure 6: Main menu where the user selects the desired option.
 - Depending on the choice, the corresponding simulation will be displayed.

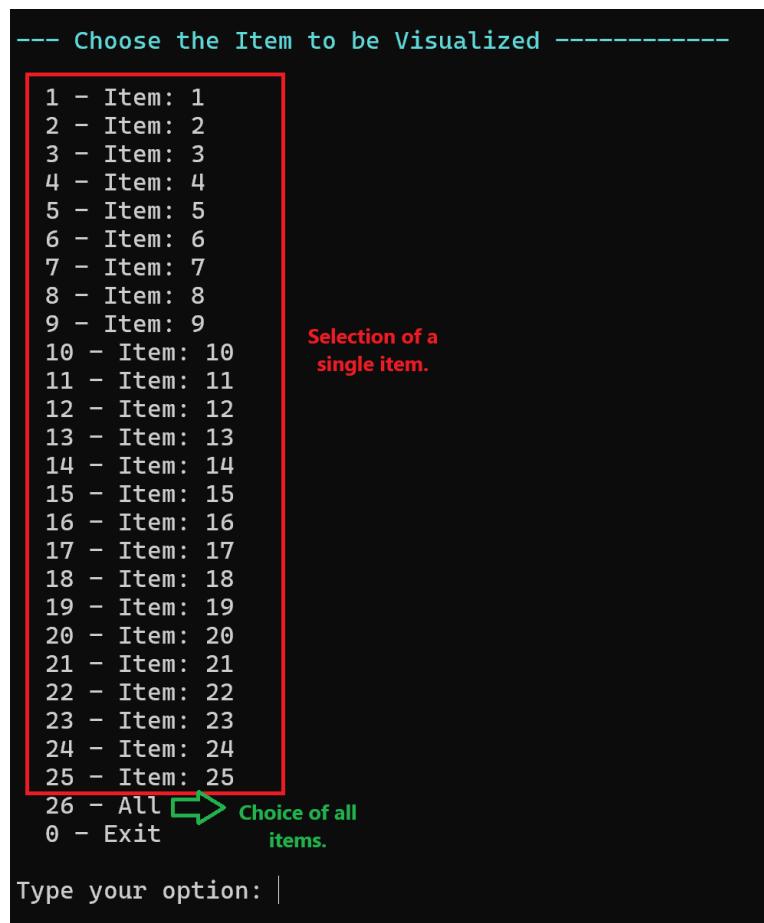


Figure 6 - File selection menu for the Simulation by Time and Priority.

```
--- Simulate Process by Time -------

Item: 17 - Quantity: 1
1 - Operation: CUT - Machine: ws11 - Priority: Normal - Item: 17 - Time: 21
2 - Operation: DRILL - Machine: ws22 - Priority: Normal - Item: 17 - Time: 26
3 - Operation: SCREW - Machine: ws31 - Priority: Normal - Item: 17 - Time: 50
4 - Operation: POLISH - Machine: ws44 - Priority: Normal - Item: 17 - Time: 76
5 - Operation: VARNISH - Machine: ws54 - Priority: Normal - Item: 17 - Time: 101
6 - Operation: PACK - Machine: ws62 - Priority: Normal - Item: 17 - Time: 162

Item: 25 - Quantity: 1
7 - Operation: CUT - Machine: ws13 - Priority: Normal - Item: 25 - Time: 25
8 - Operation: DRILL - Machine: ws21 - Priority: Normal - Item: 25 - Time: 36
9 - Operation: SCREW - Machine: ws32 - Priority: Normal - Item: 25 - Time: 74
10 - Operation: POLISH - Machine: ws41 - Priority: Normal - Item: 25 - Time: 77
11 - Operation: VARNISH - Machine: ws52 - Priority: Normal - Item: 25 - Time: 107
12 - Operation: PACK - Machine: ws61 - Priority: Normal - Item: 25 - Time: 195

Item: 15 - Quantity: 1
13 - Operation: CUT - Machine: ws12 - Priority: Normal - Item: 15 - Time: 25
14 - Operation: DRILL - Machine: ws22 - Priority: Normal - Item: 15 - Time: 26
15 - Operation: SCREW - Machine: ws31 - Priority: Normal - Item: 15 - Time: 50
16 - Operation: POLISH - Machine: ws43 - Priority: Normal - Item: 15 - Time: 81
17 - Operation: VARNISH - Machine: ws56 - Priority: Normal - Item: 15 - Time: 177
18 - Operation: PACK - Machine: ws62 - Priority: Normal - Item: 15 - Time: 162

Item: 11 - Quantity: 1
19 - Operation: CUT - Machine: ws11 - Priority: Low - Item: 11 - Time: 21
20 - Operation: DRILL - Machine: ws21 - Priority: Low - Item: 11 - Time: 36
21 - Operation: SCREW - Machine: ws32 - Priority: Low - Item: 11 - Time: 74
22 - Operation: POLISH - Machine: ws42 - Priority: Low - Item: 11 - Time: 84
23 - Operation: VARNISH - Machine: ws51 - Priority: Low - Item: 11 - Time: 316
24 - Operation: PACK - Machine: ws61 - Priority: Low - Item: 11 - Time: 195

Item: 6 - Quantity: 1
25 - Operation: CUT - Machine: ws13 - Priority: Normal - Item: 6 - Time: 25
26 - Operation: DRILL - Machine: ws22 - Priority: Normal - Item: 6 - Time: 26
27 - Operation: SCREW - Machine: ws31 - Priority: Normal - Item: 6 - Time: 50
28 - Operation: POLISH - Machine: ws44 - Priority: Normal - Item: 6 - Time: 76
29 - Operation: VARNISH - Machine: ws55 - Priority: Normal - Item: 6 - Time: 326
30 - Operation: PACK - Machine: ws62 - Priority: Normal - Item: 6 - Time: 162

--- Simulate Process by Time -------

Item: 2 - Quantity: 1
1 - Operation: CUT - Machine: ws13 - Priority: Low - Item: 2 - Time: 25
2 - Operation: POLISH - Machine: ws41 - Priority: Low - Item: 2 - Time: 77
3 - Operation: VARNISH - Machine: ws54 - Priority: Low - Item: 2 - Time: 101

Item: 2 - Quantity: 2
4 - Operation: CUT - Machine: ws11 - Priority: Normal - Item: 2 - Time: 21
5 - Operation: POLISH - Machine: ws42 - Priority: Normal - Item: 2 - Time: 84
6 - Operation: VARNISH - Machine: ws56 - Priority: Normal - Item: 2 - Time: 177

Item: 2 - Quantity: 3
7 - Operation: CUT - Machine: ws12 - Priority: Normal - Item: 2 - Time: 25
8 - Operation: POLISH - Machine: ws41 - Priority: Normal - Item: 2 - Time: 77
9 - Operation: VARNISH - Machine: ws55 - Priority: Normal - Item: 2 - Time: 326

Item: 2 - Quantity: 4
10 - Operation: CUT - Machine: ws11 - Priority: Normal - Item: 2 - Time: 21
11 - Operation: POLISH - Machine: ws42 - Priority: Normal - Item: 2 - Time: 84
12 - Operation: VARNISH - Machine: ws55 - Priority: Normal - Item: 2 - Time: 326

Item: 2 - Quantity: 5
13 - Operation: CUT - Machine: ws12 - Priority: Low - Item: 2 - Time: 25
14 - Operation: POLISH - Machine: ws41 - Priority: Low - Item: 2 - Time: 77
15 - Operation: VARNISH - Machine: ws54 - Priority: Low - Item: 2 - Time: 101

Item: 2 - Quantity: 6
16 - Operation: CUT - Machine: ws11 - Priority: Low - Item: 2 - Time: 21
17 - Operation: POLISH - Machine: ws41 - Priority: Low - Item: 2 - Time: 77
18 - Operation: VARNISH - Machine: ws55 - Priority: Low - Item: 2 - Time: 326

Item: 2 - Quantity: 7
19 - Operation: CUT - Machine: ws13 - Priority: Normal - Item: 2 - Time: 25
20 - Operation: POLISH - Machine: ws43 - Priority: Normal - Item: 2 - Time: 81
21 - Operation: VARNISH - Machine: ws52 - Priority: Normal - Item: 2 - Time: 107

Item: 2 - Quantity: 8
22 - Operation: CUT - Machine: ws11 - Priority: Normal - Item: 2 - Time: 21
23 - Operation: POLISH - Machine: ws42 - Priority: Normal - Item: 2 - Time: 84
24 - Operation: VARNISH - Machine: ws54 - Priority: Normal - Item: 2 - Time: 101
```

Figure 7 - Example of a Simulation for All Items and Item 2 respectively.

- Total Time:** Calculates the total production time.

- Figure 8: Shows the option to view the total time for all items (option 1) or a specific item (option 2).
- If option 2 is selected, a menu similar to Figure 6 will appear, but without the "All" option.

```
--- List Total Time -------

1 - List Total Time of All Items
2 - List Total Time of Specific Item
0 - Exit

Type your option: |
```

Figure 8 - List Total Time Menu.

--- Total Time for All Items -----	
Item	Total Time
12	404,00
24	445,00
20	634,00
24	397,00
20	407,00
24	620,00
24	481,00
24	609,00
20	666,00
24	634,00
24	474,00
3	421,00
24	469,00
3	418,00
24	606,00
3	440,00
16	402,00
16	646,00
16	360,00
16	441,00
16	594,00
8	623,00
8	638,00
8	370,00
8	448,00
8	626,00
8	594,00
8	470,00
8	630,00
8	601,00
5	208,00
5	427,00

--- Total Time for Item 3 -----	
Item	Total Time
3	421,00
3	418,00
3	440,00
3	279,00
3	427,00
3	209,00
3	203,00
3	213,00
3	413,00
3	216,00
3	451,00
3	418,00
3	203,00

Press '0' to go back: |

Figure 9 - Total Time for All Items and Item 3 respectively.

- **Time of Workstation:** This section displays the total working time of each workstation, providing the data in both seconds and percentage formats. The workstations are presented in ascending order based on their total working time.

Workstation	Total Time	Percentage
ws22	936	0.81 %
ws21	1260	1.09 %
ws31	1800	1.55 %
ws11	1827	1.58 %
ws12	2150	1.85 %
ws13	2175	1.88 %
ws32	2590	2.23 %
ws54	3838	3.31 %
ws52	4066	3.51 %
ws44	4940	4.26 %
ws41	5005	4.32 %
ws43	5265	4.54 %
ws42	5460	4.71 %
ws56	6726	5.80 %
ws51	12008	10.36 %
ws55	12388	10.69 %
ws53	12996	11.21 %
ws62	13932	12.02 %
ws61	16575	14.30 %

Press '0' to go back:

Figure 10 - Workstations by Ascending Order.

- **Execution Time:** When selecting this option, a menu will appear where you can choose whether you want to view the execution time for a specific operation (Option 1) or for all operations (Option 2).

```
--- List Execution Time ---
1 - List Execution Time of One Operation
2 - List Execution Time of All Operations
0 - Exit

Type your option: |
```

Figure 11 - List Execution Time Menu.

If you select Option 1, a second menu will appear where you can choose the operation you wish to analyse.

```
--- Choose the Operation to be visualized ---
1 - CUT
2 - DRILL
3 - SCREW
4 - POLISH
5 - VARNISH
6 - PACK
0 - Exit

Type your option: |
```

Figure 12 - Menu to choose Operation.

After navigating through the mentioned menus or selecting Option 2 in the first menu, the output will be displayed as shown in Figure 13.

```
--- Execution Times by Operation -------

Total time of the operation DRILL : 2196.0

Press '0' to go back: |
```



```
--- Execution Times by Operation -------

Total time of the operation POLISH : 20670.0
Total time of the operation CUT : 6152.0
Total time of the operation SCREW : 4390.0
Total time of the operation VARNISH : 52022.0
Total time of the operation PACK : 30507.0
Total time of the operation DRILL : 2196.0

Press '0' to go back: |
```

Figure 13 - Execution Time by Drill Operation and All Operations respectively.

- **Average and Waiting Times:** After selecting this option, you will be able to view the Average Execution Time and Average Waiting Time for each operation presented in a table.

--- Average Execution and Waiting Times for Each Operation -----		
Operation	Average Execution Time	Average Waiting Time
POLISH	79,50	198,93
CUT	23,66	59,07
SCREW	61,83	159,44
VARNISH	228,17	582,33
PACK	178,40	452,79
DRILL	30,93	79,24

```
Press '0' to go back: |
```

Figure 14 - Average Execution and Waiting Times for Each Operation.

- **Workstation Flow Dependency:** This section provides an overview of the dependencies between workstations in the production process. These dependencies are illustrated in Figure 15, which shows an example of how operations depend on each other.
 - Operation: Represents the workstation performing a specific operation (e.g., ws11).
 - Dependencies: Lists the workstations that the operation relies on, along with the number of tasks or items transferred between them. Each dependency is shown as a pair:
 - The first element is the dependent workstation (e.g., ws42).
 - The second element is the number of tasks/items processed or transferred (e.g., 16).

Example:

- In Figure 15, for ws11:

- It depends on ws42 for 16 tasks/items.
- Similarly, it depends on ws43 for 16 tasks/items.

This representation helps to visualize how workstations are interconnected and how tasks flow through the production process.

--- Workstation Flow Dependencies -----	
Operation	Dependencies
ws11	(ws42, 16), (ws43, 16), (ws44, 16), (ws41, 15), (ws21, 12), (ws22, 12)
ws13	(ws41, 16), (ws42, 16), (ws44, 16), (ws43, 15), (ws21, 12), (ws22, 12)
ws12	(ws41, 16), (ws42, 16), (ws43, 16), (ws44, 15), (ws22, 12), (ws21, 11)
ws41	(ws54, 12), (ws51, 11), (ws52, 11), (ws53, 11), (ws56, 9), (ws55, 7)
ws43	(ws56, 12), (ws54, 11), (ws55, 11), (ws51, 9), (ws52, 7), (ws53, 7)
ws42	(ws52, 15), (ws51, 13), (ws53, 9), (ws55, 9), (ws56, 6), (ws54, 4)
ws44	(ws53, 11), (ws54, 11), (ws55, 11), (ws56, 11), (ws51, 5), (ws52, 5), (ws13, 1)
ws22	(ws31, 36)
ws31	(ws43, 18), (ws44, 18)
ws21	(ws32, 35)
ws32	(ws41, 18), (ws42, 17)
ws56	(ws62, 20), (ws61, 12)
ws53	(ws61, 20), (ws62, 11)
ws54	(ws62, 21), (ws61, 7), (ws12, 1), (ws13, 1)
ws51	(ws61, 21), (ws62, 6), (ws12, 1)
ws52	(ws61, 18), (ws62, 8), (ws11, 1)
ws55	(ws62, 20), (ws61, 7)
ws62	(ws13, 4), (ws12, 3), (ws11, 1)
ws61	(ws12, 4), (ws11, 2)

Press '0' to go back: |

Figure 15 - Workstation Flow Dependency.

4.2.2.2 SIMULATION BY STRUCTURAL INFORMATION

In this section, production is simulated using a Production Tree. When this option is selected from the menu, a submenu is displayed, as shown in the figure below.

--- Simulation by Structural Information -----	
1	– Show Production Tree
2	– Search Materials and Operations
3	– Tracking Materials Quantities
4	– Quality Checks
5	– Update Material Quantities
6	– Total Quantity Materials and Operations
7	– Critical Path Operations
8	– Show Simulation
9	– Product Structure Graph
10	– Operation Structure Graph
0	– Exit

Type your option: |

Figure 16 - Simulation by Structural Information Submenu.

Available Options:

- Show Production:** When this option is selected, a menu will be displayed allowing you to choose the item for which you want to view the production tree.

```
--- Choose the Item to be Visualized -------

1 - Item: 1001 - bench leg w/hole
2 - Item: 1002 - bench leg w/bolt
3 - Item: 1003 - bench seat w/holes
4 - Item: 1004 - bench seat w/nut
5 - Item: 1005 - bolt M6
6 - Item: 1006 - finished bench
7 - Item: 1007 - nut M16
8 - Item: 1008 - polished bench leg
9 - Item: 1009 - polished bench seat
10 - Item: 1010 - raw bench
11 - Item: 1011 - raw bench leg
12 - Item: 1012 - raw bench seat
13 - Item: 1013 - threaded rod M16
14 - Item: 1014 - varnish
15 - Item: 1015 - wood 3cm
16 - Item: 1016 - wood pole 4cm
0 - Exit
```

Figure 17 - Menu to choose Item.

Once the item is selected, the corresponding Production Tree will be displayed. Each type of node is represented by a different color:

- Final Product:** Green
- Operation:** Red
- Component:** Blue
- Raw Material:** Yellow

This color-coding helps to quickly identify the role of each element within the production tree.

```
--- Production Tree -------

varnish bench (Quantity: 1) (Operation)
|__finished bench (Quantity: 1) (Product)
|__assemble bench (Quantity: 1) (Operation)
|__raw bench (Quantity: 1) (Component)
|__fix nut M16 21 (Quantity: 1) (Operation)
|__bench seat w/nut (Quantity: 1) (Component)
|__drill bench seat (Quantity: 1) (Operation)
|__bench seat w/holes (Quantity: 1) (Component)
|__polish bench seat (Quantity: 1) (Operation)
|__polished bench seat (Quantity: 1) (Component)
|__cut bench seat (Quantity: 1) (Operation)
|__raw bench seat (Quantity: 1) (Component)
|__wood 3cm (Quantity: 0,0576) (Raw Material)
|__nut M16 (Quantity: 4) (Raw Material)
|__bolt M6 (Quantity: 12) (Raw Material)
|__fix bolt M16 22 (Quantity: 4) (Operation)
|__bench leg w/bolt (Quantity: 1) (Component)
|__drill bench leg (Quantity: 1) (Operation)
|__bench leg w/hole (Quantity: 1) (Component)
|__polish bench leg (Quantity: 1) (Operation)
|__polished bench leg (Quantity: 1) (Component)
|__cut bench leg (Quantity: 1) (Operation)
|__raw bench leg (Quantity: 1) (Component)
|__wood pole 4cm (Quantity: 0,28) (Raw Material)
|__threaded rod M16 (Quantity: 1) (Raw Material)
|__varnish (Quantity: 0,125) (Raw Material)

Press '0' to go back: |
```

Figure 18 - Production Tree for Item 1006

- **Search Materials and Operations:** When this option is selected, a menu will appear allowing you to choose whether you want to search for a Material or an Operation.

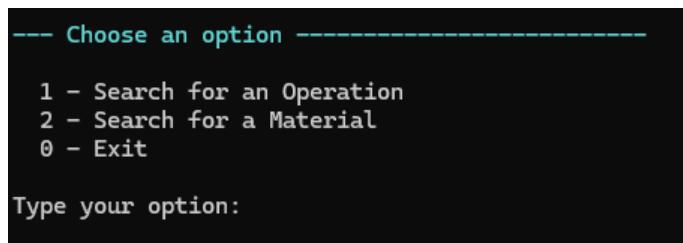


Figure 19 - Menu to choose between searching by Material or Operation in the Production Tree.

After selecting your preferred option, an additional menu will be displayed where you can specify whether to search by ID or by Name.

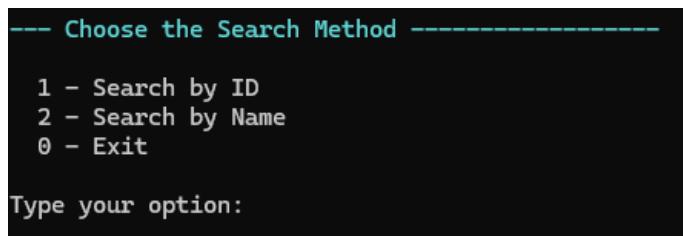


Figure 20 - Menu to choose the search method (ID or Name).

- **Option 1:** Search for an Operation

If you choose "Search for an Operation" (Option 1) and specify whether to search by ID or Name, the search results will be displayed in a format similar to the example below:

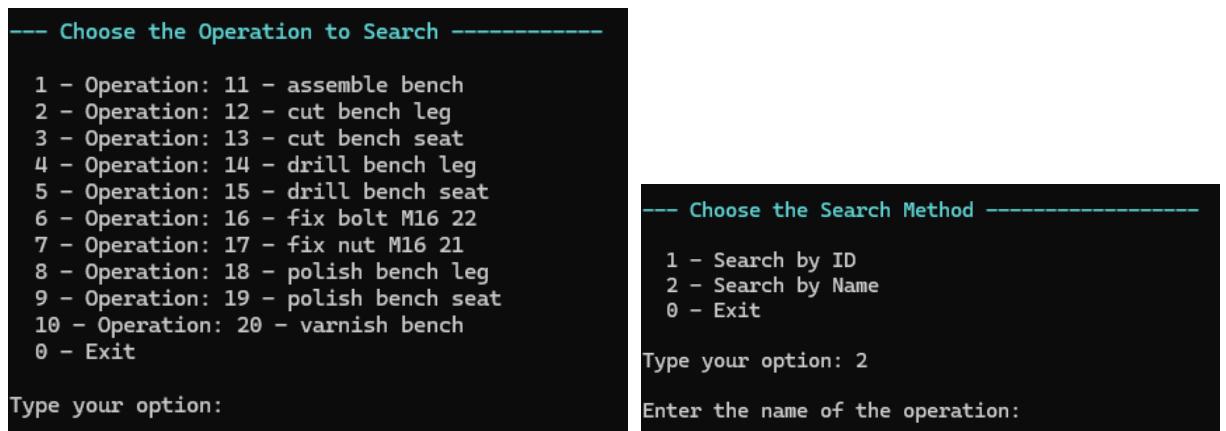


Figure 21 - Search for Operations by ID and by Name, respectively.

--- Operation Search Result ---		
Type	Description and Quantity	Parent Operation
Operation	assemble bench (Quantity: 1)	finished bench (Quantity: 1)

Figure 22 - Search for Operation 11 - assemble bench.

- **Option 2: Search for a Material**

If you choose "Search for a Material" (Option 2) and specify whether to search by ID or Name, the search results will be displayed in a format similar to the example below:

```

--- Choose the Material to Search -------

1 - Item: 1001 - bench leg w/hole
2 - Item: 1002 - bench leg w/bolt
3 - Item: 1003 - bench seat w/holes
4 - Item: 1004 - bench seat w/nut
5 - Item: 1005 - bolt M6
6 - Item: 1006 - finished bench
7 - Item: 1007 - nut M16
8 - Item: 1008 - polished bench leg
9 - Item: 1009 - polished bench seat
10 - Item: 1010 - raw bench
11 - Item: 1011 - raw bench leg
12 - Item: 1012 - raw bench seat
13 - Item: 1013 - threaded rod M16
14 - Item: 1014 - varnish
15 - Item: 1015 - wood 3cm
16 - Item: 1016 - wood pole 4cm
0 - Exit

Type your option:

--- Choose the Search Method -------

1 - Search by ID
2 - Search by Name
0 - Exit

Type your option: 2

Enter the name of the material:

```

Figure 23 - Search for Materials by ID and by Name, respectively.

--- Material Search Result ---		
Type	Description and Quantity	Parent Operation
Component	bench leg w/hole (Quantity: 1)	drill bench leg (Quantity: 1)

Figure 24 - Search for Material 1001 - bench leg w/hole.

- **Tracking Material Quantities:** When this option is selected, a menu will appear allowing you to choose whether to track the material quantities in ascending or descending order.

```

--- Choose the Option -------

1 - Show Material Quantities in Ascending Order
2 - Show Material Quantities in Descending Order
0 - Exit

Type your option: |

```

Figure 25 - Menu for choosing the order in which the tracking is displayed.

After making your selection, the material quantities will be displayed in a table, sorted in the chosen order.

--- Material Quantities in Ascending Order ---		--- Material Quantities in Descending Order ---	
Material	Quantity	Material	Quantity
wood 3cm	0,0576	bolt M6	12,0000
varnish	0,1250	nut M16	4,0000
wood pole 4cm	0,2800	threaded rod M16	1,0000
threaded rod M16	1,0000	raw bench seat	1,0000
raw bench seat	1,0000	raw bench leg	1,0000
raw bench leg	1,0000	raw bench	1,0000
raw bench	1,0000	polished bench leg	1,0000
polished bench leg	1,0000	finished bench	1,0000
finished bench	1,0000	bench seat w/nut	1,0000
bench seat w/nut	1,0000	bench seat w/holes	1,0000
bench seat w/holes	1,0000	bench leg w/bolt	1,0000
bench leg w/bolt	1,0000	bench leg w/hole	1,0000
bench leg w/hole	1,0000	polished bench seat	1,0000
polished bench seat	1,0000	wood pole 4cm	0,2800
nut M16	4,0000	varnish	0,1250
bolt M6	12,0000	wood 3cm	0,0576

Press '0' to go back:

Press '0' to go back:

Figure 26 - Material Quantities in Ascending and Descending Order, respectively.

- **Quality Checks:** This feature allows users to perform Quality Checks on operations during production. When selecting this option from the menu, you will be asked if you want the quality checks to be performed interactively or not.
 - **Interactive Quality Checks:**
If you choose to perform the quality checks interactively (by entering "Y" or "y"), the system will guide you through each quality check one at a time.

```
----- Quality Checks -----  

Do You Want to Perform Quality Checks Interactively? (Y/N): y  

Starting Interactive Quality Checks:  

Next Quality Check: fix bolt M16 22 [Priority: 2]  

Perform this quality check? (Y/N): y  

Performing Quality Check: fix bolt M16 22  

Do you want to continue with the next quality check? (Y/N): y  

Next Quality Check: drill bench leg [Priority: 3]  

Perform this quality check? (Y/N): n  

Skipping Quality Check: drill bench leg  

Do you want to continue with the next quality check? (Y/N): y  

Next Quality Check: drill bench seat [Priority: 3]  

Perform this quality check? (Y/N): y  

Performing Quality Check: drill bench seat  

Do you want to continue with the next quality check? (Y/N): y  

Next Quality Check: polish bench seat [Priority: 4]  

Perform this quality check? (Y/N): y  

Performing Quality Check: polish bench seat  

Do you want to continue with the next quality check? (Y/N): n  

Stopping Quality Checks.  

Press '0' to go back: |
```

Figure 27 - Interactive Quality Checks.

- The system displays the next quality check along with its priority.
- For each check, you are asked if you want to proceed (Y/N).
- You can stop the process at any time by entering "N" or "n".

- **Non-Interactive Quality Checks:**

If you choose not to perform the checks interactively (by entering "N" or "n"), the system will automatically process all the quality checks in order of priority, without requiring further input.

```
----- Quality Checks -----  
  
Do You Want to Perform Quality Checks Interactively? (Y/N):  
n  
  
Quality Checks in Order of Priority:  
  
Quality Check: polish bench leg [Priority: 4]  
Quality Check: cut bench leg [Priority: 5]  
Quality Check: cut bench seat [Priority: 5]  
  
Press '0' to go back:
```

Figure 28 - Non-Interactive Quality Checks.

- **Update Material Quantities:** When selecting this option, a menu will appear allowing you to update the quantity of a material (Option 1) and view the updated production tree (Option 2).

```
--- Update Material Quantities Menu ---  
  
1 - Update Material Quantity  
2 - Show Updated Production Tree  
0 - Exit  
  
Type your option:
```

Figure 29 - Update Material Quantities Menu.

- **Option 1: Update a Material Quantity**

If you choose Option 1, a menu will display all materials along with their current quantities. After selecting the material by entering its corresponding index, you can input the new quantity for that material.

```
---- Choose the Material to be Updated ----

1 - wood pole 4cm (Quantity: 0.28)
2 - wood 3cm (Quantity: 0.0576)
3 - varnish (Quantity: 0.125)
4 - threaded rod M16 (Quantity: 1.0)
5 - raw bench seat (Quantity: 1.0)
6 - raw bench leg (Quantity: 1.0)
7 - raw bench (Quantity: 1.0)
8 - polished bench leg (Quantity: 1.0)
9 - nut M16 (Quantity: 4.0)
10 - finished bench (Quantity: 1.0)
11 - bolt M6 (Quantity: 12.0)
12 - bench seat w/nut (Quantity: 1.0)
13 - bench seat w/holes (Quantity: 1.0)
14 - bench leg w/bolt (Quantity: 1.0)
15 - bench leg w/hole (Quantity: 1.0)
16 - polished bench seat (Quantity: 1.0)
0 - Exit

Type your option: 5

Enter the new quantity for raw bench seat: 25
Quantity updated successfully.

Press '0' to go back: |
```

Figure 30 - Menu with materials and their quantities.

- **Option 2: View Updated Production Tree**

If you choose Option 2, the updated production tree reflecting the changes in material quantities will be displayed.

```
--- Production Tree ----

varnish bench (Quantity: 1) (Operation)
|__finished bench (Quantity: 1) (Product)
|__assemble bench (Quantity: 1) (Operation)
|___raw bench (Quantity: 1) (Component)
|___fix nut M16 21 (Quantity: 1) (Operation)
|___bench seat w/nut (Quantity: 1) (Component)
|___drill bench seat (Quantity: 1) (Operation)
|___bench seat w/holes (Quantity: 1) (Component)
|___polish bench seat (Quantity: 1) (Operation)
|___polished bench seat (Quantity: 1) (Component)
|___cut bench seat (Quantity: 1) (Operation)
|___raw bench seat (Quantity: 25.000) (Component)
|___wood 3cm (Quantity: 1.440) (Raw Material)
|___nut M16 (Quantity: 4) (Raw Material)
|___bolt M6 (Quantity: 12) (Raw Material)
|__fix bolt M16 22 (Quantity: 4) (Operation)
|___bench leg w/bolt (Quantity: 1) (Component)
|___drill bench leg (Quantity: 1) (Operation)
|___bench leg w/hole (Quantity: 1) (Component)
|___polish bench leg (Quantity: 1) (Operation)
|___cut bench leg (Quantity: 1) (Operation)
|___raw bench leg (Quantity: 1) (Component)
|___wood pole 4cm (Quantity: 0.28) (Raw Material)
|__threaded rod M16 (Quantity: 1) (Raw Material)
|__varnish (Quantity: 0.125) (Raw Material)

Press '0' to go back:
```

Figure 31 - Production Tree updated with the new quantity.

- **Total Quantity Materials and Operations:** When selecting this option, a menu will appear allowing you to display tables with the quantities of materials, operations, or both. At the end of each table, the total quantity is also shown.

```
--- Total Quantity of Materials and Operations Menu ----

1 - Show Total Quantity of Materials
2 - Show Total Quantity of Operations
3 - Show Total Quantity of Materials and Operations
0 - Exit

Type your option:
```

Figure 32 - Total Quantity of Materials and Operations Menu.

- **Materials:** Displays a table with the quantities of all materials, followed by the total quantity.

--- Total Quantity of Materials ---	
Material	Quantity
bench leg w/hole	1,0000
raw bench seat	1,0000
polished bench leg	1,0000
bolt M6	12,0000
varnish	0,1250
bench seat w/nut	1,0000
threaded rod M16	1,0000
wood 3cm	0,0576
raw bench leg	1,0000
raw bench	1,0000
bench seat w/holes	1,0000
nut M16	4,0000
finished bench	1,0000
polished bench seat	1,0000
bench leg w/bolt	1,0000
wood pole 4cm	0,2800
<hr/>	
Total Material Quantity = 27.4626	
Press '0' to go back:	

Figure 33 - Total Quantity of Materials.

- **Operations:** Displays a table with the quantities of all operations, followed by the total quantity.

--- Total Quantity of Operations ---	
Operation	Quantity
drill bench seat	1,0000
fix nut M16 21	1,0000
cut bench seat	1,0000
polish bench leg	1,0000
fix bolt M16 22	4,0000
assemble bench	1,0000
polish bench seat	1,0000
drill bench leg	1,0000
cut bench leg	1,0000
varnish bench	1,0000
<hr/>	
Total Operation Quantity = 13	
Press '0' to go back:	

Figure 34 - Total Quantity of Operations.

- **Both:** Displays both tables, one for materials and one for operations, each followed by their respective total quantities.

This feature helps users quickly assess the quantities of materials and operations used in the production process, as well as their totals.

- **Critical Path Operations:** This section shows the operations on the **critical path** of the production process. These operations are essential and directly impact the total production time.

```
--- Critical Path Operations -------

cut bench seat (Quantity: 1) (Depth: 11)
cut bench leg (Quantity: 1) (Depth: 11)

Press '0' to go back:
```

Figure 35 - Critical Path Operations.

- **Operation Name:** The task being performed.
- **Quantity:** Number of items involved.
- **Depth:** The position of the operation in the production tree.
- **Show Simulation:** When this option is selected, the simulation is displayed according to the previously created Production Tree. The output format is similar to the Show Simulation feature in the Time and Priority simulators.

```
--- Simulation Of The Process Tree -------

Operation: cut bench leg
- Machine: ws11 - Item: raw bench leg - Time: 21 - Quantity: 1.0
- Machine: ws12 - Item: wood pole 4cm - Time: 25 - Quantity: 0.28

Operation: polish bench leg
- Machine: ws44 - Item: polished bench leg - Time: 76 - Quantity: 1.0

Operation: drill bench leg
- Machine: ws21 - Item: bench leg w/hole - Time: 36 - Quantity: 1.0

Operation: fix bolt M16 22
- Machine: ws31 - Item: bench leg w/bolt - Time: 50 - Quantity: 1.0
- Machine: ws31 - Item: threaded rod M16 - Time: 50 - Quantity: 1.0

Operation: cut bench seat
- Machine: ws13 - Item: raw bench seat - Time: 25 - Quantity: 1.0
- Machine: ws13 - Item: wood 3cm - Time: 25 - Quantity: 0.0576

Operation: polish bench seat
- Machine: ws43 - Item: polished bench seat - Time: 81 - Quantity: 1.0

Operation: drill bench seat
- Machine: ws22 - Item: bench seat w/holes - Time: 26 - Quantity: 1.0

Operation: fix nut M16 21
- Machine: ws32 - Item: bench seat w/nut - Time: 74 - Quantity: 1.0
- Machine: ws32 - Item: nut M16 - Time: 74 - Quantity: 4.0
- Machine: ws32 - Item: bolt M6 - Time: 74 - Quantity: 12.0

Operation: assemble bench
- Machine: ws62 - Item: raw bench - Time: 162 - Quantity: 1.0

Operation: varnish bench
- Machine: ws54 - Item: finished bench - Time: 101 - Quantity: 1.0
- Machine: ws52 - Item: varnish - Time: 107 - Quantity: 0.125

Press '0' to go back:
```

Figure 36 - Simulation of The Process Tree.

- **Product Structure Graph:** When the **Product Structure Graph** option is selected, a graph representing the **Bill of Materials (BOM)** for the **Main Product** of the Production Tree is both displayed in the browser and automatically downloaded as an **SVG file**. The file is saved in the following path:

`src\main\java\graphic_representation\output\product_structure_graph.svg`

The graph is color-coded to make it easier to identify different types of nodes:

- **Green** for the Main Product,
- **Blue** for Components,
- **Yellow** for Raw Materials.

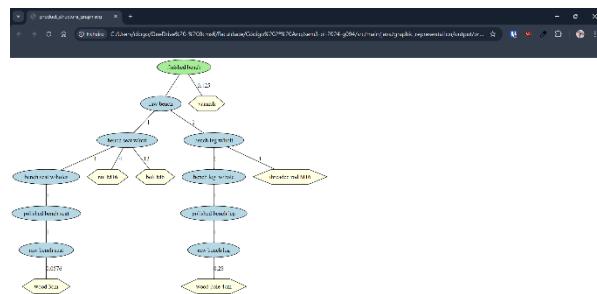


Figure 37 - Product Structure Graph in Google Chrome.

- **Operation Structure Graph:** When the **Operation Structure Graph** option is selected, a graph representing the **Bill of Operations (BOO)** for the **Main Product** of the Production Tree is both displayed in the browser and automatically downloaded as an **SVG file**. The file is saved in the following path:

`src\main\java\graphic_representation\output\operation_structure_graph.svg`

The graph is color-coded to make it easier to identify different types of nodes:

- **Red** for Operations,
- **Green** for the Main Product,
- **Blue** for Components,
- **Yellow** for Raw Materials.

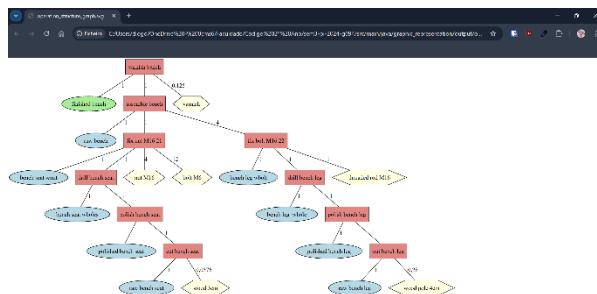


Figure 38 - Operation Structure Graph in Google Chrome.

4.2.2.3 SIMULATION BY PERT/CPM

The **PERT (Program Evaluation Review Technique)** and **CPM (Critical Path Method)** are project management tools used to analyse and represent the tasks involved in completing a project. These methods focus on identifying the critical path, which determines the shortest time needed to complete the set of interdependent activities.

When this option is selected, the application presents an initial menu with three options:

- **Use the Small File** – Loads a default file designed for demonstration purposes, containing a smaller and simpler dataset.
- **Use the Large File** – Loads another default file with a substantially larger and more complex dataset for advanced simulations.
- **Enter the File Name Manually** – Allows you to specify the name of the file. The file must be located in the **src/resources** folder.

For manually entered file names, include the file extension (**.csv**) and ensure the file adheres to the required format for PERT/CPM simulations.

```
--- Choose a File for the Activities ---
1. Use the Small File
2. Use the Large File
3. Enter the File Name Manually
0. Back

Type your option: |
```

Figure 39 - Menu to choose the file with the data for PERT/CPM.

After selecting one of the file options in the initial menu, the **Simulation by PERT/CPM Menu** is displayed. This menu contains various options to explore and analyse the simulation data.

```
--- Simulation by PERT/CPM ---
1 - Show PERT/CPM
2 - Detect Circular Dependencies
3 - Topological Sort of Project Activities
4 - Show Earliest and Latest Start and Finish Times
5 - Export Project Schedule to CSV
6 - Identify the Critical Path
7 - Identify Bottlenecks Activities in the Project Graph
8 - Simulate Project Delays and Their Impact
0 - Exit

Type your option:
```

Figure 40 - Simulation by PERT/CPM Menu.

Available Options:

- **Show PERT/CPM:** When this option is selected, the following steps occur:
 - A **textual representation of the graph** is displayed in the terminal, showing tasks, dependencies, and other related details.
 - A message confirms that the graph has been successfully generated, indicating its location: **src\main\java\projectManager\output\pert_cpm.svg**

- The user is then prompted with the question:
"Do you want to open the generated graph in the default browser? (Y/N)"
 - If the user types Y or y, Google Chrome is opened, displaying the PERT/CPM graph.



Figure 41 - PERT/CPM result, if the user wants to see it in the browser.

- If the user types N or n, the system ends this process. To exit, the user is instructed to type 0.

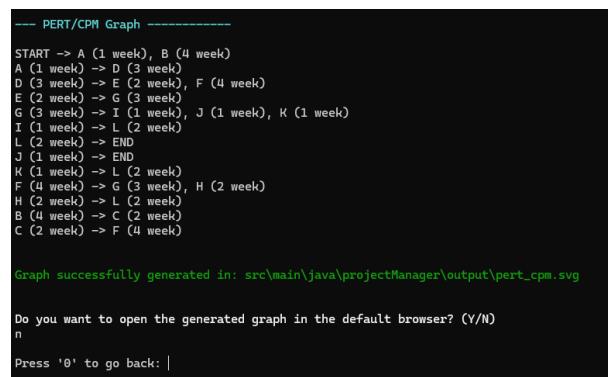


Figure 42 - PERT/CPM result, if the user doesn't want to see it in the browser.

This ensures the graph is both generated and accessible, providing flexibility for users to view it in a graphical interface or save it for later use.

- **Detect Circular Dependencies:** When this option is selected, the system checks for any circular dependencies within the PERT/CPM data. It simply displays whether or not circular dependencies exist.
 - If no circular dependencies are detected, a message confirming their absence will be displayed.

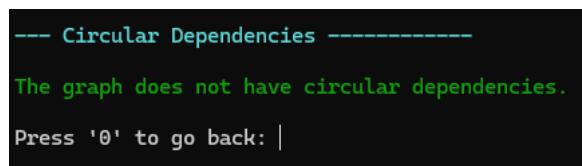


Figure 43 - There are no circular dependencies.

- If **circular dependencies** are found, the system will notify the user of their presence, indicating the issue needs to be resolved.

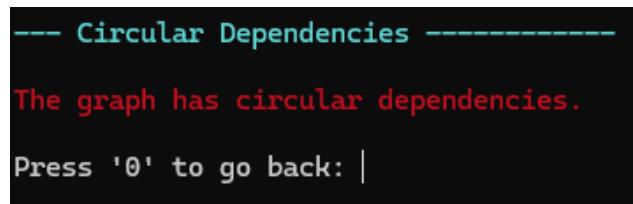


Figure 44 - There are circular dependencies.

This helps ensure the correctness of the project plan by verifying that no tasks are stuck in infinite loops or cyclic dependencies.

- **Topological Sort of Project Activities:** The **Topological Sort** is a method used to order tasks (or nodes) in a directed acyclic graph (DAG), ensuring that each task appears before any tasks that depend on it. This is especially useful for project scheduling, where tasks must be performed in a specific sequence due to their dependencies.

When this option is selected, the system performs a **topological sort** of the tasks based on their dependencies, displaying the result in a clear, ordered list.

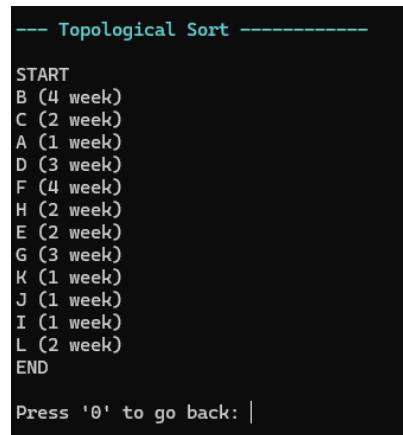


Figure 45 - Topological Sort.

This order ensures that all dependencies are respected, and tasks are completed in the correct sequence. Tasks that don't depend on any other tasks can be scheduled first, while tasks with dependencies are only scheduled once their predecessors have been completed.

- **Show Earliest and Latest Start and Finish Times:** When selecting this option, the system displays the **Earliest** and **Latest** possible start and finish times for each activity. This is crucial for project scheduling, as it helps determine the critical path and the slack time for each task.
 - **Earliest Start (ES):** The earliest time at which an activity can begin, considering all its dependencies.
 - **Latest Start (LS):** The latest time an activity can begin without delaying the project.

- **Earliest Finish (EF):** The earliest time the activity can be completed, calculated as **ES + duration**.
- **Latest Finish (LF):** The latest time the activity can be completed without affecting the overall schedule, calculated as **LS + duration**.

The menu will show all activities, and at the end, there is an option called **All**, which, when selected, displays the **Earliest** and **Latest** times for all activities at once.

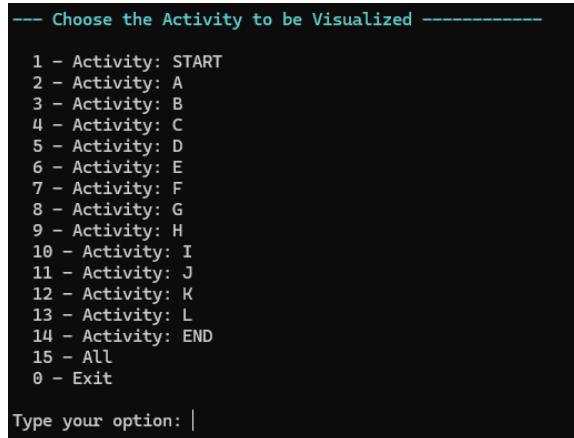


Figure 46 - Menu to choose the activity to see the times.

After the menu is shown, selecting a specific activity will display the detailed times for that activity. Selecting **All** will display the times for all activities in the project at once, offering a broad view of the schedule and how each task fits within the overall timeline.

```
--- Show Earliest Time and Latest Finish -------

--- Activity: START -----
ES: 0.0
LF: 0.0

--- Activity: A -----
ES: 0.0
LF: 3.0

--- Activity: B -----
ES: 0.0
LF: 4.0

--- Activity: C -----
ES: 4.0
LF: 6.0

--- Activity: D -----
ES: 1.0
LF: 6.0

--- Activity: E -----
ES: 4.0
LF: 10.0

--- Activity: F -----
ES: 6.0
LF: 10.0

--- Activity: G -----
ES: 10.0
LF: 13.0

--- Activity: H -----
ES: 10.0
LF: 14.0

--- Show Earliest Time and Latest Finish -------

--- Activity: Activity: C -----
ES: 4.0
LF: 6.0

Press '0' to go back: |
```

Figure 47 - Earliest Time and Latest Finish for all activities and for activity C, respectively.

- Export Project Schedule to CSV:** This option allows you to export the project schedule to a CSV file. The exported file follows this structure:

act_id;cost;duration;es;ls;ef;lf;prev_act_id1;...;prev_act_idN

Where:

- act_id:** The identifier of the activity.
- cost:** The cost of the activity.
- duration:** The duration of the activity.
- es:** The earliest start time for the activity.
- ls:** The latest start time for the activity.
- ef:** The earliest finish time for the activity.
- lf:** The latest finish time for the activity.
- prev_act_id1 to prev_act_idN:** The IDs of the predecessor activities (if any).

When the export is complete, a message is displayed confirming that the export was successful on path:

src\main\java\projectManager\output\schedule.csv

You will then be asked if you wish to open the file in the default application:

Do you want to open the generated CSV file in the default application? (Y/N)

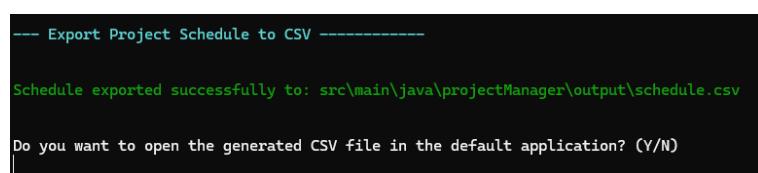


Figure 48 - Export Project Schedule to CSV.

- If you press **Y** or **y**, the CSV file will open in your default application (e.g., Excel).

act_id	cost	duration	es	ls	ef	lf	prev_act_id1	... prev_act_idN
2 A	30	1	0	2	1	3 START		
3 B	2500	4	0	0	4	4 START		
4 C	1250	2	4	4	6	6 B		
5 D	30	3	1	3	4	4 A		
6 E	30	2	4	8	6	10 D		
7 F	20	4	6	6	10	10 C, D		
8 G	20	3	10	10	13	13 E, F		
9 H	50	2	10	12	12	12 G		
10 I	30	1	13	13	14	14 G		
11 J	550	1	13	15	14	16 G		
12 K	750	1	13	13	14	14 G		
13 L	1500	2	14	14	16	16 H, I, K		
14								
15								
16								
17								
18								

Figure 49 - schedule.csv in Microsoft Excel.

- If you press **N** or **n**, the application will not open the file. Pressing **O** will allow you to return to the previous menu.
- **Identify the Critical Path:** The system identifies and displays the critical paths of the project, which represent the longest sequences of dependent tasks that determine the overall project duration.

```
--- Show Critical Paths -------

--- Critical Path 1 -----
START -> B -> C -> F -> G -> I -> L -> END

--- Critical Path 2 -----
START -> B -> C -> F -> G -> K -> L -> END

Press '0' to go back: |
```

Figure 50 - Critical Paths.

The critical paths are presented in the order of their sequence of tasks and dependencies. This feature provides the user with key insights into the project's critical paths, which are essential for understanding the project timeline and task dependencies.

- **Identify Bottlenecks Activities in the Project Graph:** When this option is selected, the system identifies and displays the bottleneck activities in the project, which are tasks that cause delays or limit the flow of the project due to their longer duration or dependencies.

```
--- Bottleneck Activities -----

F
G
L

Press '0' to go back: |
```

Figure 51 - Bottleneck Activities.

These activities are highlighted because they may require attention to avoid project delays. This feature helps users pinpoint critical activities that may hinder project progress, enabling better management and resource allocation to avoid delays.

- **Simulate Project Delays and Their Impact:** When this option is selected, a menu is displayed with all project activities, allowing the user to choose which activity they wish to delay. Additionally, there is an option to **Show New Start and Finish Times** to visualize the impact of these delays.

```
--- Choose an Activity to Add a Delay or Show Times-----
1 - Activity: START - START
2 - Activity: A - High level analysis
3 - Activity: B - Order Hardware platform
4 - Activity: C - Installation and commissioning of hardware
5 - Activity: D - Detailed analysis of core modules
6 - Activity: E - Detailed analysis of supporting modules
7 - Activity: F - Programming of core modules
8 - Activity: G - Programming of supporting modules
9 - Activity: H - Quality assurance of core modules
10 - Activity: I - Quality assurance of supporting modules
11 - Activity: J - Application Manual
12 - Activity: K - User Manual
13 - Activity: L - Core and supporting module training
14 - Activity: END - END
15 - Show New Start and Finish Times
0 - Exit

Type your option: |
```

Figure 52 - Menu to choose the activity for which to add a delay.

Upon selecting an activity, the user is prompted with the message:

“Enter delay duration for Activity X:”

(Where X is the selected activity.)

After entering the delay duration and pressing **Enter**, the system will ask if the user wants to add another delay:

“Do you want to add another delay? (Y/N)”

- If the user chooses **Y** or **y**, the menu is shown again to select another activity. If **N** or **n** is chosen, the system will display the updated critical paths and the new total project duration.

```
Type your option: 3
Enter delay duration for Activity B: 24
Delay added to activity B.

Do you want to add another delay? (Y/N)
y

--- Choose an Activity to Add a Delay or Show Times-----
1 - Activity: START - START
2 - Activity: A - High level analysis
3 - Activity: B - Order Hardware platform
4 - Activity: C - Installation and commissioning of hardware
5 - Activity: D - Detailed analysis of core modules
6 - Activity: E - Detailed analysis of supporting modules
7 - Activity: F - Programming of core modules
8 - Activity: G - Programming of supporting modules
9 - Activity: H - Quality assurance of core modules
10 - Activity: I - Quality assurance of supporting modules
11 - Activity: J - Application Manual
12 - Activity: K - User Manual
13 - Activity: L - Core and supporting module training
14 - Activity: END - END
15 - Show New Start and Finish Times
0 - Exit

Type your option: 4
Enter delay duration for Activity C: 23
Delay added to activity C.
```

Figure 53 - Adding the delay to activity B and C.

```

Do you want to add another delay? (Y/N)
n

--- Simulate Project Delays -------

Updated Critical Paths and Project Duration:

Path 1: START B C F G I L END
Path 2: START B C F G K L END

Total Project Duration: 63.0 weeks

Press '0' to go back: 0

```

Figure 54 - Updated Critical Paths and Project Duration.

Then, if the user selects the **Show New Start and Finish Times** option, the system will display the updated early start (ES) and late finish (LF) times for each activity based on the delays:

```

--- Show New Start and Finish Times -------

--- Activity: START -----
ES: 0.0
LF: 0.0

--- Activity: A -----
ES: 0.0
LF: 50.0

--- Activity: B -----
ES: 0.0
LF: 28.0

--- Activity: C -----
ES: 28.0
LF: 53.0

--- Activity: D -----
ES: 1.0
LF: 53.0

--- Activity: E -----
ES: 4.0
LF: 57.0

--- Activity: F -----
ES: 53.0
LF: 57.0

--- Activity: G -----
ES: 57.0
LF: 60.0

```

Figure 55 - New Start and Finish Times.

This option helps project managers simulate and understand the effect of delays on project timelines, providing insights into how these changes alter critical paths and the overall project duration.

4.3.3.4 SIMULATION BY ORDERS

In this section we are going to simulate the orders. When this option is selected from the menu, a submenu is displayed, as shown in the figure below.

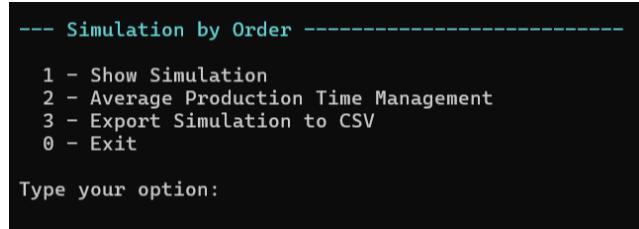


Figure 56 - Simulation by Order Menu.

Available options:

- **Show Simulation:** When this option is selected, all orders existing in the system are processed, and the user is presented with a menu to choose which order to visualize or to display all orders. Regardless of the selection, the program will simulate all orders in the system.

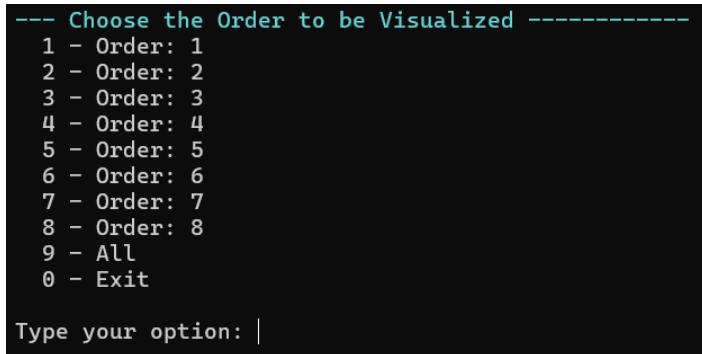


Figure 57 - Menu to choose the order(s) to be visualized.

Once an order is selected, the corresponding simulation will be displayed. Each order is visually represented by a distinct colour based on its priority:

- **High:** Red
- **Normal:** Yellow
- **Low:** Green

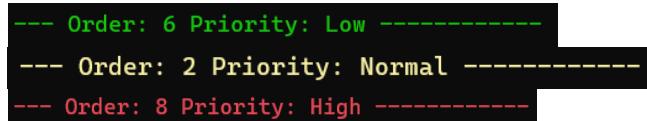


Figure 58 - Priorities and their colours.

The colour coding enhances clarity, making it easier to identify the priority level of each order immediately.

To further aid user comprehension, the simulation separates items clearly. Before simulating the production of each item, its name is displayed prominently. For every operation within the simulation, the required materials are also listed with their names, ensuring that users can follow the sequence of operations and understand which materials are involved at each step.

This organized representation allows users to monitor the production process efficiently while providing a visual and contextual understanding of each order's execution.

```
--- Order: 1 Priority: High -------

Item ID: AS12945S20

Operation: Lid pressing
1 - Machine: 9847 - Item: 200 mm lid pressed - Time: 22 - Quantity: 15.0
2 - Machine: 9855 - Item: 250 mm 1 mm stailess steel disc - Time: 25 - Quantity: 15.0
3 - Machine: 9847 - Item: Coo lube 2210XP - Time: 22 - Quantity: 75.0
4 - Machine: 9855 - Item: 200 mm lid pressed - Time: 25 - Quantity: 15.0
5 - Machine: 9847 - Item: 250 mm 1 mm stailess steel disc - Time: 22 - Quantity: 15.0
6 - Machine: 9855 - Item: 250 mm 1 mm stailess steel disc - Time: 25 - Quantity: 15.0
7 - Machine: 9847 - Item: Coo lube 2210XP - Time: 22 - Quantity: 75.0
8 - Machine: 9855 - Item: Coo lube 2210XP - Time: 25 - Quantity: 75.0

Operation: Lid finishing
9 - Machine: 5124 - Item: 200 mm lid pressed - Time: 15 - Quantity: 15.0
10 - Machine: 5124 - Item: 200 mm lid polished - Time: 15 - Quantity: 15.0
11 - Machine: 5124 - Item: 200 mm lid pressed - Time: 15 - Quantity: 15.0
12 - Machine: 5124 - Item: 200 mm lid polished - Time: 15 - Quantity: 15.0
```

Figure 59 - Example of how the orders are displayed.

- **Average Production Time Management:** When this option is selected, a menu displays all available products, allowing the user to select a specific product or all products (via the "All" option).

```
--- Choose the Product to be Visualized -----
1 - AS12945W22
2 - AS12945T22
3 - AS12945S22
4 - AS12946S22
5 - AS12947S22
6 - AS12945S20
7 - AS12946S20
8 - AS12947S20
9 - AS12945S17
10 - AS12945P17
11 - AS12945S48
12 - AS12945G48
13 - All
0 - Exit

Type your option: |
```

Figure 60 - Menu to choose a product to visualise your Average Time.

Once a selection is made, the program calculates and updates the average production time for the chosen product(s).

```
---- Average Production Time Management ----

#Product Average Time Update for Product: AS12946S048
Old Average Time: 0,00
New Average Time: 0,00

#Product Average Time Update for Product: AS12946SP17
Old Average Time: 0,00
New Average Time: 0,00

#Product Average Time Update for Product: AS12946SS17
Old Average Time: 0,00
New Average Time: 0,00

#Product Average Time Update for Product: AS12946SS17
Old Average Time: 0,00
New Average Time: 0,00

#Product Average Time Update for Product: AS12946SS28
Old Average Time: 0,00
New Average Time: 129,29

#Product Average Time Update for Product: AS12946SS22
Old Average Time: 0,00
New Average Time: 127,38

#Product Average Time Update for Product: AS12946SS48
Old Average Time: 0,00
New Average Time: 0,00

#Product Average Time Update for Product: AS12946ST22
Old Average Time: 0,00
New Average Time: 0,00

#Product Average Time Update for Product: AS12946W22
Old Average Time: 0,00
New Average Time: 0,00

#Product Average Time Update for Product: AS12946SS28
Old Average Time: 0,00
New Average Time: 55,69

#Product Average Time Update for Product: AS12946SS22
Old Average Time: 0,00
New Average Time: 57,66

#Product Average Time Update for Product: AS12946TS20
Old Average Time: 0,00
New Average Time: 55,00

#Product Average Time Update for Product: AS12947HS22
Old Average Time: 0,00
New Average Time: 92,48
```

---- Average Production Time Management -----

```
Product Average Time Update for Product: AS12946S20
Old Average Time: 0,00
New Average Time: 55,00
```

Figure 61 - Average Time for all products and for one product, respectively.

This feature provides users with a clear view of how the average production times have been updated for each product, allowing for efficient time management and tracking.

- Export Simulation To CSV:** When this option is selected, two texts will appear displaying the success or failure of exporting the simulation to two csv files, as well as showing the exported csv files in their own separate files.

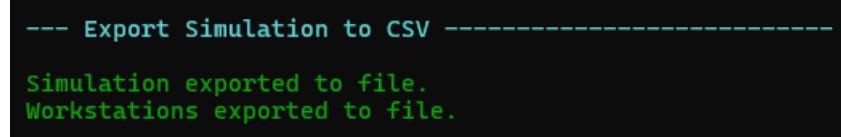


Figure 62 - Exported simulation and workstations to file with success.

Figure 63 - Workstations and Simulation files exported, respectively.

Both csv files are saved in:

machineSupervisor/ARQCP/SPRINT3/src/data

4.3 Database Management Menu

The Database Management Menu is the second main menu of the application. Upon selecting it, a submenu with specific options will be displayed:

4.3.1 Choose the Database Management Option

This submenu allows users to select the type of management operations they wish to perform. Three options are available:

- Project Overview and Operations:** This option provides access to functions for reviewing the existing system data, including:
 - Orders currently in the system.
 - Materials and workstations required for orders.
 - Supported operations available in the system.
- Product Registration and Customer Management:** This option enables users to perform the following:
 - Register new orders or deactivate a customer.
 - Register a new product or workstation.
 - Check the required items and operations for a product.

- Determine if the product requires all types of machines to complete its production.
- **Manage Operations and Materials:** This option emphasizes database security by ensuring that no actions compromising system integrity are allowed. Users can also:
 - List operations required for a product.
 - Verify if all necessary resources are available to start production.
 - Review and manage reserved materials.
 - Reserve materials if needed for production.

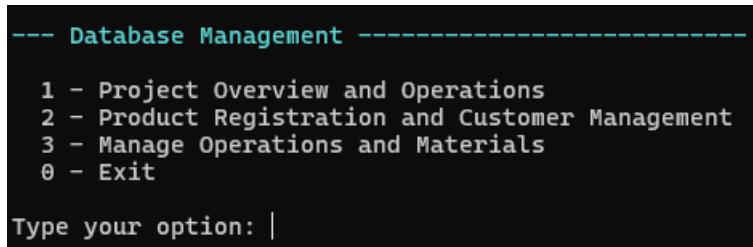


Figure 64 - Database Management main menu.

4.3.1.1 Project Overview and Operations Menu

As explained before this menu contains everything related to the project overall.

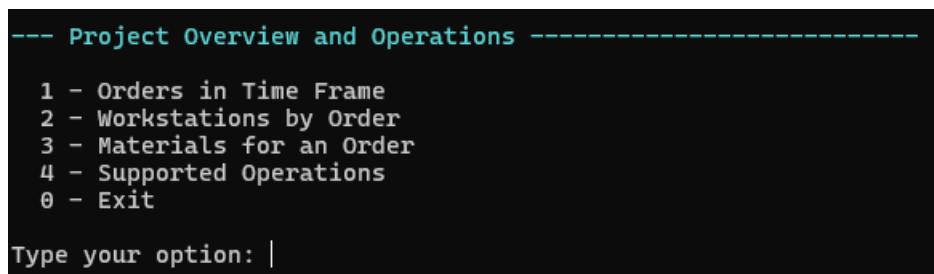


Figure 65 - Project Overview and Operations Menu

Available Options:

- **Orders in Time Frame:**

- The system prompts the user to input a start date and an end date in the format **DD-MM-YYYY** (e.g., 01-01-2025 for January 1, 2025).
- After that it will show a table with the costumer's name, the product name, the quantity and a delivery date.

--- Orders from 10-11-2019 to 20-12-2024 -----			
Customer Name	Product Name	Quantity	Delivery Date
Tudo para a casa, Lda	Pro 22 sl pot	5	2024-09-23
Sair de Cena	Pro 22 sl pot	10	2024-09-26
U Fleku	Pro 22 sl pot	10	2024-09-25
Tudo para a casa, Lda	Pro 22 sl pot	15	2024-09-25
Sair de Cena	Pro 22 sl pot	12	2024-09-25
Carvalho & Carvalho, Lda	Pro 22 sl pot	8	2024-09-26
Casa do Medo	Pro 22 sl pot	15	2024-09-26
Tudo para a casa, Lda	Pro 22 sl pot bottom	8	2024-09-23
U Fleku	Pro 22 sl pot bottom	6	2024-09-25
Casa do Medo	Pro 22 sl pot bottom	20	2024-09-26
Tudo para a casa, Lda	Pro 22 lid	10	2024-09-23
U Fleku	Pro 22 lid	7	2024-09-25
Casa do Medo	Pro 22 lid	8	2024-09-26
Casa do Medo	Pro 22 lid	10	2024-09-26
Tudo para a casa, Lda	Pro 28 sl pot	15	2024-09-23
U Fleku	Pro 28 sl pot	10	2024-09-25
Tudo para a casa, Lda	Pro 28 sl pot	20	2024-09-25
U Fleku	Pro 28 sl pot	15	2024-09-26
Casa do Medo	Pro 28 sl pot	5	2024-09-26
Sair de Cena	Pro 28 sl pot bottom	8	2024-09-26
Tudo para a casa, Lda	Pro 28 sl pot bottom	12	2024-09-25
U Fleku	Pro 28 sl pot bottom	10	2024-09-26
Sair de Cena	Pro 28 lid	7	2024-09-26
Casa do Medo	Pro 28 lid	10	2024-09-26
Tudo para a casa, Lda	Pro 17' 2l pot	8	2024-09-25
U Fleku	Pro 17' 2l pot	8	2024-09-26
Casa do Medo	Pro 17' 2l pot	8	2024-09-25
Sair de Cena	Pro 17' 2l sauce pan	20	2024-09-26
U Fleku	Pro 17' 2l sauce pan	16	2024-09-26

--- Date Range Selection -----			
Enter start date (DD-MM-YYYY) or 'stop' to return: 10-11-2019			
Enter end date (DD-MM-YYYY) or 'stop' to return: 20-12-2024			

Figure 66 - Data Range selection and Orders Table, respectively.

- Workstations by Order:**

- The system lets the user choose a Customer Order, to see which Workstation Types are being used by that Customer Order.

--- Choose the Customer Order to be Visualized ---

1 - Customer Order ID: 1
2 - Customer Order ID: 2
3 - Customer Order ID: 3
4 - Customer Order ID: 4
5 - Customer Order ID: 5
6 - Customer Order ID: 6
7 - Customer Order ID: 7
8 - Customer Order ID: 8
9 - Customer Order ID: 9
0 - Exit

Type your option: |

--- Workstation Types for Order ID 1 -----

Workstation Type ID	Workstation Type
K3675	Packaging
C5637	Border trimming
AH588	600t cold forging precision stamping press
S3271	Handle rivet
A4578	600t cold forging stamping press

Press '0' to go back: |

Figure 67 - Customer orders and the necessary workstation types for that Customer Order.

- Materials for an Order:**

- In this section the user is prompted choose a Production Order. By choosing one the user then will see all the product from that Production Order and their respective important information.

--- Choose the Production Order to be Visualized ---

1 - Production Order ID: 1001
2 - Production Order ID: 1002
3 - Production Order ID: 1003
4 - Production Order ID: 1004
5 - Production Order ID: 1005
6 - Production Order ID: 1006
7 - Production Order ID: 1007
8 - Production Order ID: 1008
0 - Exit

Type your option: |

--- Materials Required For Production Order ID 1001 ---

Product ID	Product Name	Part ID	Part Description	Quantity Required
AS12946522	Pro 20 3l pot	AS12946528	30 cm stainless steel lid	15
AS12946528	Pro 20 3l pot	AS12946528	31-28 cm stainless steel pot bottom	15
AS12946522	Pro 22 5l pot	AS12946522	23 cm stainless steel lid	5
AS12946522	Pro 22 5l pot	AS12946522	51-22 cm stainless steel pot bottom	5
AS12946522	Pro 22 5l pot bottom	PNGH56167	Coo lube 2210XP	50
AS12946522	Pro 22 5l pot bottom	PN1854A421	Rivet 6 mm	20
AS12946522	Pro 22 5l pot bottom	PN1854C21	Stainless steel handle model U6	10
AS12946522	Pro 22 5l pot bottom	IP12945A04	220 mm pot base final	5
AS12946522	Pro 22 5l pot bottom	IP12945A02	220 mm pot base phase 1	5
AS12946522	Pro 22 5l pot bottom	IP12945A03	220 mm pot base phase 2	5
AS12946522	Pro 22 5l pot bottom	IP12945A01	250 mm 5 mm stainless steel disc	5
AS12946522	Pro 22 5l pot bottom	PN5238HR50	300x300 mm 5 mm stainless steel sheet	5

Press '0' to go back: |

Figure 68 – Production Orders and the required materials.

- Supported Operations:**

- The Supported Operation displays all the operation inside the system

--- Supported Operations ---

Operation ID	Operation Type ID	Operation Description	Workstation Type ID	Workstation Type Description
100	5647	Disc cutting	AH578	600t cold forging stamping press
100	5647	Disc cutting	AH588	600t cold forging precision stamping press
101	5647	Disc cutting	AH578	600t cold forging stamping press
101	5647	Disc cutting	AH588	600t cold forging precision stamping press
102	5649	Initial pot base pressing	AH588	600t cold forging precision stamping press
103	5649	Initial pot base pressing	AH588	600t cold forging precision stamping press
112	5651	Final pot base pressing	AH588	600t cold forging precision stamping press
114	5653	Pot base finishing	C5637	Border trimming
115	5659	Pot handles riveting	S3271	Handle rivet
120	5647	Disc cutting	AH578	600t cold forging stamping press
120	5647	Disc cutting	AH588	600t cold forging precision stamping press
121	5655	Lid pressing	AH588	600t cold forging precision stamping press
122	5657	Lid finishing	C5637	Border trimming
123	5661	Lid handle screw	T3452	Assembly T1
124	5667	Lid testing	Q3677	Stainless steel polishing
139	5663	Pot test and packaging	AH575	Packaging
150	5647	Disc cutting	AH578	600t cold forging stamping press
150	5647	Disc cutting	AH588	600t cold forging precision stamping press
151	5649	Initial pot base pressing	AH588	600t cold forging precision stamping press
152	5651	Final pot base pressing	AH588	600t cold forging precision stamping press
153	5653	Pot base finishing	C5637	Border trimming
154	5659	Pot handles riveting	S3271	Handle rivet
160	5647	Disc cutting	AH578	600t cold forging stamping press
160	5647	Disc cutting	AH588	600t cold forging precision stamping press
161	5655	Lid pressing	AH588	600t cold forging precision stamping press
162	5657	Lid finishing	C5637	Border trimming
163	5661	Lid handle screw	T3452	Assembly T1
164	5667	Lid polishing	Q3547	Stainless steel polishing
170	5663	Pot test and packaging	K3675	Packaging
5001	5647	Disc cutting	AH578	600t cold forging stamping press
5001	5647	Disc cutting	AH588	600t cold forging precision stamping press
5002	5649	Initial pot base pressing	AH588	600t cold forging precision stamping press
5003	5651	Final pot base pressing	AH588	600t cold forging precision stamping press
5004	5653	Pot base finishing	C5637	Border trimming
5005	5655	Lid pressing	AH588	600t cold forging precision stamping press
5006	5657	Lid finishing	C5637	Border trimming
5007	5659	Pot handles riveting	S3271	Handle rivet
5008	5661	Lid handle screw	T3452	Assembly T1
5009	5663	Pot test and packaging	K3675	Packaging
5010	5665	Handle welding	D9123	Spot welding
5011	5667	Lid polishing	Q3547	Stainless steel polishing
5012	5669	Pot base polishing	Q3547	Stainless steel polishing
5014	5672	Packaging for large items	K3676	Packaging for large items

Press '0' to go back: |

Figure 69 - Supported operations in the system.

4.3.1.2 Product Registration and Customer Management

This menu contains most of the functionalities related to creating a new entry in the database and listing important information.

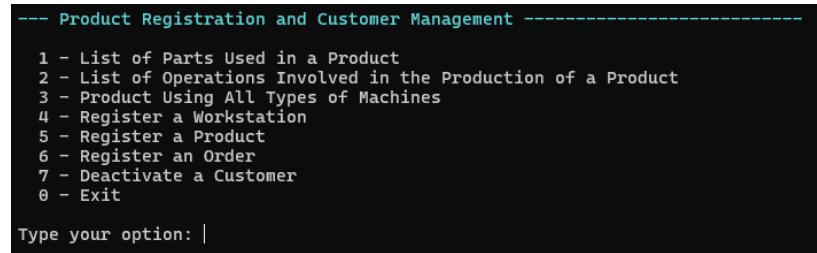


Figure 70 – Product Registration and Customer Management.

Available Options:

- **List of Parts Used in a Product:**

- This functionality of the system lets the user choose which product what product he wants to be listed and the lists the Product Parts, their respective IDs and some more relevant information

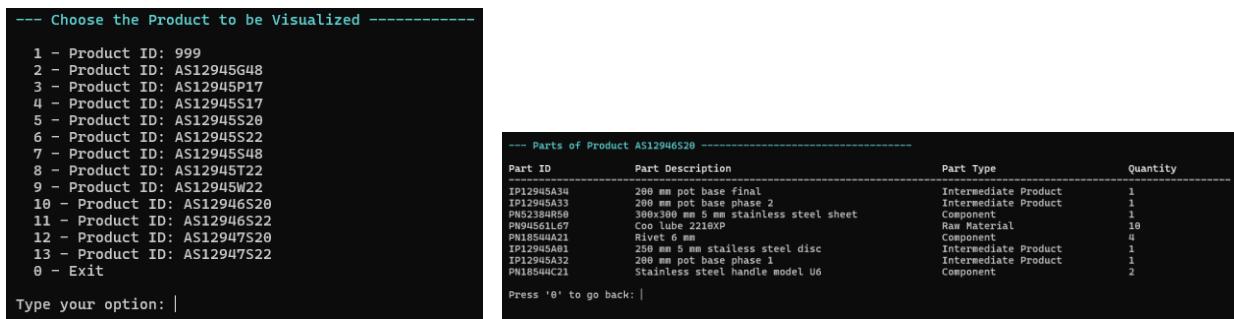


Figure 71 - Product List and the menu of parts.

- **List of Operations Involved in the Production of a Product:**

- This option displays the operation that are involved in a certain product selected by the user, as well as the input and output components of that same product.

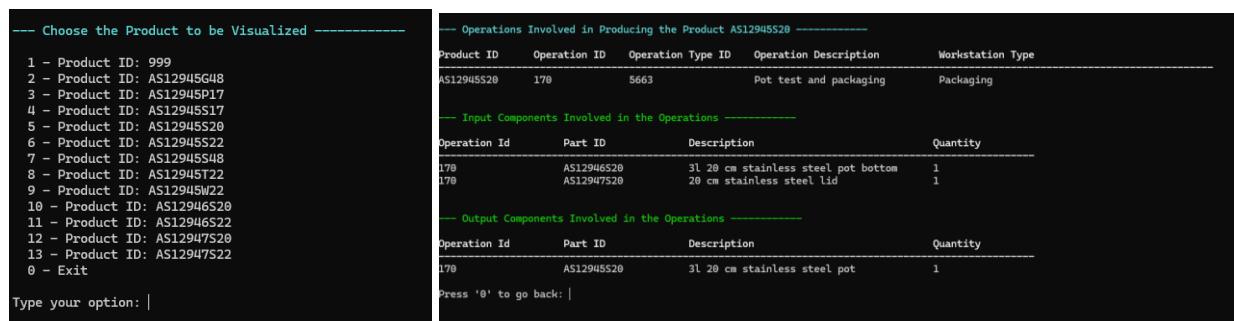


Figure 72 - Menu to choose the Product to show and table with the Operations involved in the Production of Product AS12946S20, respectively.

- **Products Using All Types of Machines:**

- This option displays all product that use all the Workstation Types.

```
--- Product Using All Types of Machines -------

Do you want to insert test data? (Y/N)
y

The test data has already been entered!
Skipping...

Product ID          Product Name
-----
AS12945W22          Washing Machine

Press '0' to go back: |
```

Figure 73 - Product Using All Types of Machines.

- **Register a Workstation:**

- The functionality to register a workstation lets the user create a workstation with the parameters that he wants.

```
--- Register a Workstation ----

Enter Workstation ID: 1
Enter Workstation Name: Test
Enter Workstation Description: Test Description
Enter Workstation Setup Time: 12
Enter Workstation Time: 13
Choose Plant Floor ID:
  1 - Plant Floor ID: 1
  2 - Plant Floor ID: 2
  3 - Plant Floor ID: 3
  0 - Exit
Type your option: 1
Choose Workstation Type ID:
  1 - Workstation Type ID: A4578
  2 - Workstation Type ID: A4588
  3 - Workstation Type ID: A4598
  4 - Workstation Type ID: C5637
  5 - Workstation Type ID: D9123
  6 - Workstation Type ID: G9273
  7 - Workstation Type ID: G9274
  8 - Workstation Type ID: K3675
  9 - Workstation Type ID: K3676
  10 - Workstation Type ID: Q3547
  11 - Workstation Type ID: Q5478
  12 - Workstation Type ID: S3271
  13 - Workstation Type ID: T3452
  0 - Exit
Type your option: 2
Enter Minimum Temperature: 12
Enter Maximum Temperature: 15
Enter Minimum Humidity: 2
Enter Maximum Humidity: 6
Workstation registered successfully.

Press '0' to go back: |
```

Figure 74 - Register a Workstation.

- **Register a Product:**

- To Register a Product, the user can choose all the parameters that make a product.

```
---- Register a Product ----
Enter Product ID: id1
Enter Product Name: Test
Enter Product Description: Test Description
Choose Factory Plant ID:
  1 - Factory Plant ID: 1
  2 - Factory Plant ID: 2
  3 - Factory Plant ID: 3
  0 - Exit
Type your option: 1
Enter Market Demand: 12
Enter Optimization: 12
Enter Production Cost: 12
Enter Flexibility: 12
Enter Production Average Time: 15
Choose Family ID:
  1 - Family ID: 125
  2 - Family ID: 130
  3 - Family ID: 132
  4 - Family ID: 145
  5 - Family ID: 146
  0 - Exit
Type your option: 1
Product registered successfully.

Press '0' to go back: |
```

Figure 75 - Register a Product.

- **Register an Order:**

- To Register an order the user needs to fill all the necessary parameters of an order, the system also gives a lot of option to customize that specific order.

```
---- Register Customer Order ----
Choose Customer ID:
  1 - Customer ID: 456
  2 - Customer ID: 785
  3 - Customer ID: 657
  4 - Customer ID: 348
  5 - Customer ID: 986
  0 - Exit
Type your option: 2
Enter Order Date (DD-MM-YYYY): 02-03-2024
Enter Delivery Date (DD-MM-YYYY): 04-04-2024
Enter Delivery Location: Porto
Choose a Product:
  1 - Product ID: 999
  2 - Product ID: AS12945G18
  3 - Product ID: AS12945P17
  4 - Product ID: AS12945S17
  5 - Product ID: AS12945S20
  6 - Product ID: AS12945S22
  7 - Product ID: AS12945S48
  8 - Product ID: AS12945T22
  9 - Product ID: AS12945W22
  10 - Product ID: AS12946S20
  11 - Product ID: AS12946S22
  12 - Product ID: AS12947S20
  13 - Product ID: AS12947S22
  14 - Product ID: id1
  0 - Exit
Type your option: 3
Enter Quantity: 12
Choose a Priority:
  1 - High
  2 - Low
  3 - Normal
  0 - Exit
Type your option: 2
Product ID AS12945P17 with quantity 12 and priority Low added successfully.

Do you want to add another product? (Y/N)
n

Order registered successfully. Order ID: 10

Press '0' to go back: |
```

Figure 76 - Register an Order.

- **Deactivate a Costumer:**
 - The user is prompted to select a costumer to deactivate. The costumer is deactivated if it has no pending orders.

```
--- Choose the Customer to be Visualized ---
1 - Customer ID: 456
2 - Customer ID: 785
3 - Customer ID: 657
4 - Customer ID: 348
5 - Customer ID: 906
6 - Customer ID: 907
0 - Exit

Type your option: 1
Error: Customer has pending or undelivered orders and cannot be deactivated.

Press '0' to go back: 0
```

```
--- Choose the Customer to be Visualized ---
1 - Customer ID: 456
2 - Customer ID: 785
3 - Customer ID: 657
4 - Customer ID: 348
5 - Customer ID: 906
6 - Customer ID: 907
0 - Exit

Type your option: 6
Customer successfully deactivated.

Press '0' to go back: |
```

Figure 77 - Customer deactivation unsuccessful and successful, respectively.

4.3.1.3 Manage Operations and Materials

```
--- Manage Operations and Materials ---
1 - Ensure Operation Time
2 - Avoid Circular References
3 - List Product Operations
4 - Check Stock for Orders
5 - Reserve Materials
6 - List Reserved Materials
0 - Exit

Type your option: |
```

Figure 78 - Manage Operations and Materials Menu.

Available Options:

- **Ensure Operation Time:**
 - The ensure Operation time makes sure that the database that the expected execution time of an operation is not greater than the maximum execution time of every workstation type.

```
--- Trigger Test UI: Ensure Operation Time ---
Step 1: Inserting test data...
Inserted Operation Type 1.
Inserted Workstation Type W1.
Workstation type 'W1' with a maximum execution time of 100 seconds was assigned to Operation Type 1 and added successfully.

Step 2: Running tests...
Test 1: Attempting to insert an operation with an expected estimated time of 90 seconds (within allowed limit).
Test 1 Passed: Insertion within limit.

Would you like to continue with the next test? (Y/N)
y

Test 2: Attempting to insert an operation with an expected estimated time of 200 seconds (exceeding allowed limit).
Test 2 Passed: Error raised for time limit.
Message: ORA-20001: Operation Execution Time Violation:
Expected Time: 200
Actual Time: 200
Compatible Workstation Types: W1
The operation's expected execution time exceeds the allowed maximum
allowed_max_execution_time=100, actual_time=200, error_code=100, error_message='ORA-20001: erro durante a execucao da trigger 'CRAFTF0R.CHECK_OPERATION_EXECUTION_TIME''.
https://docs.oracle.com/error-help/db/ora-20001/
```

```
Would you like to continue with the next test? (Y/N)
y

Test 3: Attempting to update the expected estimated time of Operation 1 to 20 seconds.
Test 3 Passed: Update within limit.

Would you like to continue with the next test? (Y/N)
y

Test 4: Attempting to update the expected estimated time of Operation 1 to 300 seconds (exceeding allowed limit).
Test 4 Failed: Error raised for time limit.
Message: ORA-20001: Operation Execution Time Violation:
Expected Time: 300
Actual Time: 300
Compatible Workstation Types: W1
The operation's expected execution time exceeds the allowed maximum
allowed_max_execution_time=100, actual_time=300, error_code=100, error_message='ORA-20001: erro durante a execucao da trigger 'CRAFTF0R.CHECK_OPERATION_EXECUTION_TIME''.
https://docs.oracle.com/error-help/db/ora-20001/
```

```
Step 3: Cleaning up test data...
Cleaned up Workstation_Type_Operation_Type.
Cleaned up Workstation_Type.
Cleaned up Operation_Type.
Cleaned up Operation_Type.

All steps completed successfully!
Press '0' to go back: |
```

Figure 79 - Tests for the Ensure Operation Time Trigger.

- **Avoid Circular Dependencies:**

- This functionality makes sure that the Bill of Operations doesn't have any circular dependencies to maintain the flow of operations.

The screenshot shows four terminal windows side-by-side, each displaying the output of a test script for the 'Avoid Circular References' trigger:

- Step 1: Inserting test data...**
Shows the insertion of intermediate products (IP123) and operations (101, 102) into the database.
- Test 1: Inserting a new input for Product TEST123 with Operation 101 and Part IP123.**
Shows a successful insertion with no circular reference.
- Test 2: Attempting to insert a new input for Product TEST123 with Operation 102 and Part TEST123.**
Shows a failure due to a circular reference error (ORA-20001).
- Test 3: Attempting to update the expected estimated time of Operation 1 to 20 seconds.**
Shows a successful update with no circular reference.
- Test 4: Attempting to update the expected estimated time of Operation 1 to 300 seconds (exceeding allowed limit).**
Shows a failure due to a circular reference error (ORA-20001).

Figure 80 - Tests for the Avoid Circular References Trigger.

- **List Product Operations:**

- The list Product Operation functionality is used to list all the operation of a certain product. The information displayed are the product Id, Operation Id, the operation Description, the execution time, the part type and the input and output parts.

The screenshot shows a terminal window displaying the operations for Product AS12945S20:

Product ID	Operation ID	Operation Description	Execution Time	Part Type	Input Components	Output Components
AS12945S20	170	Pot test and packaging		Packaging	AS12946520	AS12947520

Figure 81 - Operations of Product AS12945S20.

- **Check Stock for Orders:**

- This system functionality serves the purpose to list the orders for a specific customer order.

The screenshot shows a terminal window displaying the check stock for Order 4:

Part ID	Description	Total Required	Stock	Status
PN1854U4A21	Rivet 6 mm	48 unit	300 unit	Sufficient
PN5238UR56	300x300 mm 5 mm stainless steel sheet	12 unit	150 unit	Sufficient
PN94561L67	Coo lube 2210XP	128 ml	500 ml	Sufficient
PN1854UC21	Stainless steel handle model U6	24 unit	22 unit	Insufficient

Figure 82 - Check Stock for Order 4.

- **Reserve Materials:**

- The reserve material lets the user reserve materials for a specific customer order.

```
---- Choose the Customer Order to Reserve Materials ----
1 - Customer Order ID: 1
2 - Customer Order ID: 2
3 - Customer Order ID: 3
4 - Customer Order ID: 4
5 - Customer Order ID: 5
6 - Customer Order ID: 6
7 - Customer Order ID: 7
8 - Customer Order ID: 8
0 - Exit

Type your option: 4

Failed to reserve materials for Customer Order ID: 4 - Error: Insufficient stock for the order.

Press '0' to go back: |
```

Figure 83 - Failure to reserve stock for order 4.

- **List Reserved Materials:**

- This function displays all the reserved materials.

---- Reserved Materials -----				
Part ID	Description	Quantity	Unit	Supplier Details
PN1234WA21	Screw M6 35 mm	50	units	1 - TechSupplies Inc., 1 - TechSupplies Inc., 12298 -
PN1234WA21	Screw M6 35 mm	30	units	1 - TechSupplies Inc., 1 - TechSupplies Inc., 12298 -
PNS2384R10	300x300 mm 1 mm stainless steel sheet	25	units	3 - AluminiumCo, 3 - AluminiumCo
PNS2384R10	300x300 mm 1 mm stainless steel sheet	10	units	3 - AluminiumCo, 3 - AluminiumCo
PNS2384R50	300x300 mm 5 mm stainless steel sheet	200	mm ²	2 - MetalWorks Ltd., 2 - MetalWorks Ltd.

Figure 84 - Reserved Materials.

4.4 Search Glossary Terms Menu

This menu Option lets the user search for key words in the Glossary to retrieve their meaning.

---- Search Glossary Terms -----	
Enter a term or letter to search: boo	
Term	Definition
BOO	Acronym for "Bill of Operations"
Bill of Operations	A detailed list of the manufacturing steps or processes required to produce a product, including the sequence of operations and the prodPlanSimulator.resources involved.
Do you want to search for another term? (Y/N)	

Figure 85 - Search for 'boo' in the glossary.

4.5 Help Menu

The help option opens the User Manual in the default browser.

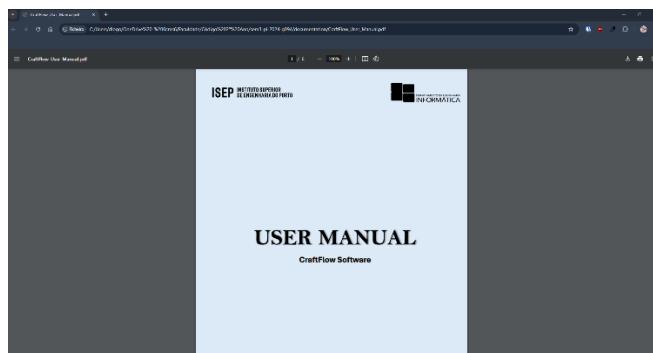


Figure 86 - User Manual in the Default Browser.

FAQ'S AND TROUBLESHOOTING

1. HOW CAN I CHECK IF THERE ARE ANY CIRCULAR DEPENDENCIES IN THE PROJECT?

Answer: After importing your activity data, you can validate the project graph for circular dependencies. The system will automatically analyse the activity dependencies and notify you if any cycles are detected.

2. WHAT IS TOPOLOGICAL SORTING, AND HOW CAN I PERFORM IT?

Answer: Topological sorting orders the project activities in a sequence that respects their dependencies (i.e., an activity cannot be executed before its predecessors). You can use this function to generate a valid execution sequence, which helps ensure that the project structure is sound.

3. HOW CAN I CALCULATE THE EARLIEST AND LATEST START/FINISH TIMES FOR ACTIVITIES?

Answer: Once the activity dependencies are validated, you can calculate the Earliest Start (ES), Latest Finish (LF), Earliest Finish (EF), and Latest Start (LS) times for each activity. The system will take dependencies into account and help identify the critical path, as well as slack for non-critical activities.

4. WHAT IS SLACK, AND HOW CAN I IDENTIFY NON-CRITICAL ACTIVITIES WITH SLACK?

Answer: Slack refers to the amount of time an activity can be delayed without affecting the project's overall completion date. The system calculates slack by analysing the difference between the Latest Finish (LF) and Earliest Finish (EF) for each activity. Non-critical activities will have slack, allowing for some flexibility in their scheduling.

5. HOW CAN I IDENTIFY THE CRITICAL PATH IN THE PROJECT?

Answer: The critical path consists of the activities that directly impact the project's overall duration. To identify the critical path, the system analyses all activities and their dependencies to find the sequence of activities with zero slack. These activities must be completed on time to avoid delaying the entire project. The system will display the total project duration and the activities on the critical path, along with their earliest and latest start/finish times.

6. WHAT ARE BOTTLENECK ACTIVITIES, AND HOW CAN I IDENTIFY THEM?

Answer: Bottleneck activities are tasks that have the highest number of dependent activities or that appear most frequently on different paths in the project. These activities can cause significant delays if they are postponed. The system can analyse the project graph and highlight bottleneck activities, helping you anticipate where delays might propagate.

7. HOW CAN I SIMULATE DELAYS IN ACTIVITIES AND ASSESS THEIR IMPACT ON THE PROJECT?

Answer: You can simulate delays by adjusting the duration of specific activities. The system will automatically recalculate the critical path, slack times, and total project duration, allowing you to assess how delays in one or more activities will affect the overall project schedule.

8. WHAT SHOULD I DO IF THE PROJECT GRAPH HAS INVALID DEPENDENCIES?

Answer: If the project graph contains invalid dependencies (e.g., circular dependencies or missing predecessors), the system will notify you. You will need to review the activity data and correct the dependencies before proceeding.

9. HOW DOES THE SYSTEM CALCULATE THE TOTAL PROJECT DURATION?

Answer: The total project duration is determined by identifying the longest path in the project graph (i.e., the critical path). The system sums the durations of all activities on this path to calculate the total time required to complete the project.

10. WHAT HAPPENS IF I ADD OR REMOVE ACTIVITIES AFTER THE PROJECT SCHEDULE IS CALCULATED?

Answer: If you add or remove activities, the project graph and all related calculations (e.g., start/finish times, critical path, slack) will be automatically updated to reflect the new structure. You can re-export the updated schedule if needed.

11. HOW DOES THE SYSTEM HANDLE DIFFERENT UNITS FOR COST AND DURATION?

Answer: The system allows you to specify units for both cost and duration (e.g., days, hours for duration; USD, EUR for cost). It will automatically account for these units during calculations. However, you should ensure that all activities use consistent units within the same project to avoid confusion.

12. HOW DO I CREATE A CSV FILE WITH THE SEQUENCE OF OPERATIONS PERFORMED BY A MACHINE?

Answer: You can generate a CSV file to log the sequence of operations for a specific machine. This file will contain a record of each operation, including timestamps and relevant parameters.

13. HOW CAN I MANAGE THE PLANT-FLOOR MACHINERY?

Answer: You can manage plant-floor machinery by performing the following actions:

- Add a Machine: You can add a new machine to the plant floor by inputting its configuration details, either manually or by importing a setup file.
- Remove a Machine: You can remove a machine from the plant floor, but only if it is not currently operating. If a machine is operational, you must stop it first before removing it.
- Read Machine Status: You can check the current status of any machine on the plant floor. This includes details such as operational status (ON, OP, OFF), current temperature and humidity levels.

14. HOW DO I ASSIGN AN OPERATION TO A MACHINE ON THE PLANT FLOOR?

Answer: To assign an operation to a machine, you must specify the machine's identifier and the operation details. The operation can be assigned through the user interface or by importing a list of instructions (e.g., from a text file). The system will then send the operation to the machine for execution. Ensure the machine is in a ready state before assigning an operation.

15. HOW CAN I DISPLAY THE STATE OF A MACHINE ON THE DEVICE?

Answer: When you manage a machine (e.g., start, stop, assign operation), the system will automatically display the current state of the machine on the device for 2 seconds. This display will include the machine's identifier, status (running/stopped), and any relevant operational parameters, providing a quick summary of the machine's state.

16. HOW DO I FEED THE SYSTEM WITH A LIST OF INSTRUCTIONS FOR A MACHINE?

Answer: You can provide a list of instructions through a text file. Each line in the file represents an instruction for a specific machine.

17. HOW WILL I BE NOTIFIED IF A MACHINE'S TEMPERATURE OR HUMIDITY LEVELS ARE OUTSIDE THE ALLOWABLE RANGE?

Answer: The system will monitor the temperature and humidity levels for each machine. If the machine's temperature or humidity exceeds the defined minimum or maximum thresholds, you will receive an automatic notification or alert. The alert will be displayed on the user interface.

18. HOW CAN I ENSURE THAT MACHINES ARE REMOVED SAFELY FROM THE PLANT FLOOR?

Answer: Machines can only be removed from the plant floor if they are not currently operating. If a machine is running, stop it first via the control interface. Once the machine has stopped and is in a safe state, you can proceed with its removal.

19. HOW CAN I RESERVE MATERIALS AND COMPONENTS FOR AN ORDER?

Answer: You can reserve materials and components for an order by recording the reservation in the database. However, the materials will not be automatically deducted from stock until the order is finalized. The reservation should only be created if the entire order can be fulfilled with the available stock. This ensures that partial reservations are avoided, which could cause issues later in production.

20. HOW DO I CHECK IF WE HAVE ENOUGH MATERIALS AND COMPONENTS IN STOCK TO FULFIL AN ORDER?

Answer: To determine if you have sufficient materials and components to fulfill an order, you can query the stock database. The query should check the available quantity of each material/component required for the order against the minimum stock levels. If any material is below the required quantity, the system should notify you that the order cannot be fulfilled with the current stock.

21. WHAT HAPPENS IF THERE ARE NOT ENOUGH MATERIALS IN STOCK TO FULFILL AN ORDER?

Answer: If there are not enough materials or components in stock to fulfill an order, the system will notify you that the order cannot be processed. In this case, you may need to place a new order for the necessary materials from suppliers or adjust the production schedule to accommodate the shortage.

22. HOW CAN I TRACK SUPPLIER DETAILS FOR RESERVED MATERIALS?

Answer: You can view the supplier details for each reserved material by querying the reservations table. Each reservation will include the supplier ID, allowing you to track which supplier is responsible for providing the reserved materials. This information is useful for managing supplier relationships and ensuring timely deliveries.

23. HOW DOES THE EXHAUST FAN OPERATE BASED ON THE TEMPERATURE SENSOR?

Answer: The exhaust fan will turn on when the temperature sensor detects a reading 5°C higher than the initial value. The fan operation follows this sequence:

1. Exhaust Fan: Turns on for 5 seconds.
2. Ventilation Fan: After the exhaust fan, the ventilation fan turns on for another 5 seconds.

This sequence ensures that the heat is first removed, and then cooler air is circulated.

24. HOW DOES THE VENTILATION FAN OPERATE BASED ON THE HUMIDITY SENSOR (USFA03)?

Answer: When the humidity sensor detects a reading 5% higher than the initial value, the fans will operate in the following sequence:

1. Ventilation Fan: Turns on for 10 seconds.
2. Exhaust Fan: After the ventilation fan, the exhaust fan turns on for another 10 seconds.

This sequence helps maintain the humidity levels by first circulating air and then removing excess moisture.

25. What happens if both the temperature and humidity sensors exceed their thresholds at the same time (USFA03)?

Answer: If both the temperature and humidity sensors register values that exceed their respective thresholds simultaneously, the system will follow the programmed fan sequence for each sensor trigger. Depending on the logic in place, the system might either:

- Execute the temperature sensor's fan sequence first, followed by the humidity sequence.