Development of a modular production planning and control system for a company specialized in mechanical machining

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Abstract. Companies acting in the mechanical machining are heavily concentrating in optimising their performance and profitability in the actual days. Especially due to the globalizing apparent break down. Actual supply chain challenges are obliging suppliers and customers to shorten these. A high complexity parts machining company performance is dramatically influenced by the PPC efficiency. This article is bringing to the attention a real example, via presenting the strategy and actions implemented in the moment when the studied company encountered a critical moment of a "big times" increase in orders, being obliged to act with high speed and determination in order to reach the customer needs. decision system based on fuzzy sets was achieved through experimental research. Critical analysis of the existing PPC system highlighted the deficiencies that must be faced briefly. The defined action plan as well as it's implementation and the results achieved are presented in this article through the academic and analytical visor.

1. Introduction

This article presents the structure of the Production Planning and Control (PPC) system solution developed within a company to support a hybrid manufacturing environment. This approach enables the coexistence of high-volume serial production, small-batch manufacturing, and one-off products within a complex and technologically advanced industrial setting. Particular emphasis is placed on compliance with stringent quality requirements related to technical specifications and full traceability, which significantly influence the company's key performance indicators, namely Turnover (T.O.), First Time Quality (F.T.Q.), and Delivery Date (D.D.). [2].

The main production processes are preceded and intertwined with a variety of auxiliary and additional phases which, despite their designation, represent *sine qua non* conditions for the realization of production. [1]. As these phases, the following can be identified:

- Order receipt and analysis;
- Procurement, management, and preparation of raw materials;
- Make-or-Buy decision-making;
- Quality Gates, whose role is to ensure the conformity of the manufactured parts with the technical documentation on the basis of which they are produced;
- Fitting and packaging operations.

In order to improve the company situation in the global status, the PPC team developed a new PPC process based on its structuring into six autonomous yet interdependent zones, which are critical to the evolution of parts throughout the production process. [3].

Thus, following the CRM (Customer Relationship Management) process and the Make-or-Buy decision, order tracking begins at the moment of order receipt. This tracking is conducted through the raw material management process, with an agreed Service Level Agreement (SLA) defining a maximum reaction time of 14 days.

2. CRM - Customer Relationship Management

The CRM process involves the preliminary analysis of all major variables that act as input factors in the execution process of a part (subassembly or assembly). A received Purchase Order (PO) is entered into the ERP (Enterprise Resource Planning) [5] system and subsequently released, meaning that it formally begins its lifecycle within the company's database. From this point onward, the Contract Survey (CS) process is initiated.

Within the CS process, each participating department—namely Engineering, Technology, Procurement, Production, PPC, Logistics, and Senior Management—verifies its specific responsibilities related to the production of the part. Based on the results obtained, each department reports its status in the CS file and, implicitly, in the CRM file, indicating task completion (Yes/No). The timestamp corresponding to task completion is automatically assigned by a Macro module running in the background of the associated Excel file.

In order to prevent potential errors or unauthorized modifications to reporting timestamps, the Macro module disables any subsequent overwriting or correction of the automatically assigned data. As a result of the CS and CRM processes, the sales manager has access to all necessary information required to either confirm the delivery date (DD) requested by the customer in the Purchase Order or to propose an alternative delivery date. This revised date is communicated to and agreed upon with the customer and subsequently entered into the system as the official delivery date.

To control reaction times, ensure the execution of assigned tasks, and minimize the risk of omitting order lines during processing, the CRM file automatically imports all order lines from the ERP system. This mechanism enables real-time updates of the production schedule and effectively prevents omissions. The performance of the departments involved in the CS process is directly evaluated through the *Live Summary* page of the CRM file.

The CRM file follows a dedicated structure, as illustrated in Figure 2.

At top management level, CRM data are synthesized within the *Live Summary* page, which provides consolidated managerial information, as illustrated in Figure 1.

	A	B	C	D	E	F	G	H	I	J	K	V
1	11-Feb-25		TO DO							DONE		
2	Alert	Responsible	Total Lines	Lines in Delays	Percentage in time	SLA (days)	SLA Reference	Type of update	# of waiting confirmation	Percentage in time	average days of delay	average days to complete (all lines)
3	CS	Engineering	0	0	100%	3	OD	Manual	#	100%	3	0.6
4	NPI-CS	Eng/Q	30	5	83%	30	CS	Manual	#	96%	4428	23.0
5	KickOff-CS/NPI	Planning	62	0	100%	7	CS/NPI	Manual	#	92%	6	3.9
6	Production Order-KO	Planning	88	30	66%	7	KO	Manual	#	92%	13	6.9
7	RM - CS	Supply Chain	240	65	73%	7	CS	Manual	0	76%	5	4.5
8	SC - PO	Supply Chain	0	0	100%	7	PO	Manual	0	99%	3	0.9
9	Shelf Items - KO	Supply Chain	189	15	92%	14	KO	Manual	0	100%	3	2.8
10	Elmet-KO	Planning	0	0	100%	4	KO	Manual	#REF!	100%	0	0.0
12												

Figure 1. CRM Live Summary page.

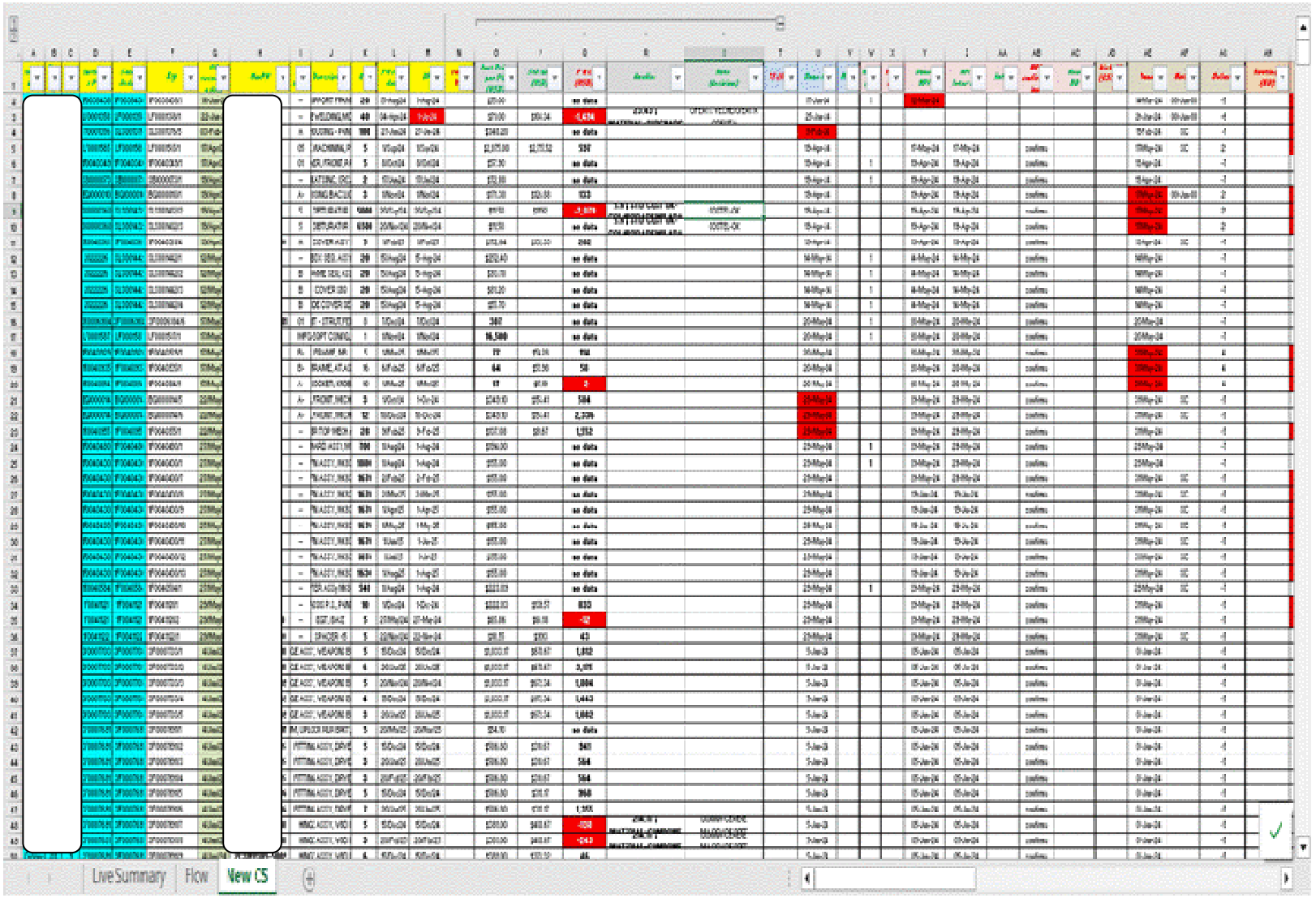

Figure 2. CRM page.

Explanation of the abbreviations used:

CS – Contract Survey: a process responsible for introducing order lines into the Enterprise Resource Planning (ERP) system, carried out under the responsibility of the Sales Manager.

NPI-CS – Contract Survey within the NPI (New Project Implementation) Department. This process evaluates the feasibility of parts or subassemblies and defines the execution technology through the development of the Production File.

Kick-Off NPI/CS: this stage involves the analysis of the company's internal capabilities and the resources required for the production of the ordered parts or subassemblies.

Production Order–KO: this process corresponds to the Make-or-Buy decision, based on internal capacity loading, as well as the capabilities and capacity loading of subcontractors.

RM-CS – Raw Material Contract Survey. This process addresses raw material from a logistics and procurement perspective, including quotation, purchasing decisions based on volume, price, and availability. If the raw material is available in the CAMON stock, it is planned accordingly in the RM file (see Figure 4.8).

SC-PO – Subcontractor Purchase Order: Following the Make-or-Buy decision, in the case of a Buy decision, subcontractor benchmarking is performed. This activity is managed by the Supply Chain Manager and results in the issuance of a Purchase Order (PO) to the subcontractor.

Shelf Items–KO At this stage, the Bill of Materials (BOM) is analyzed, typically represented in an exploded assembly drawing that includes all components of the subassembly.

The company–KO At this step, the PPC Department performs detailed production planning across all operations and establishes an estimated Delivery Date (DD),

3. The PPC New Logic

The logical interrelation between the various critical elements within the planning process, both at the macro level and at the subsequent operational level, while also taking into account the preliminary phase, can be observed in Figure 3.

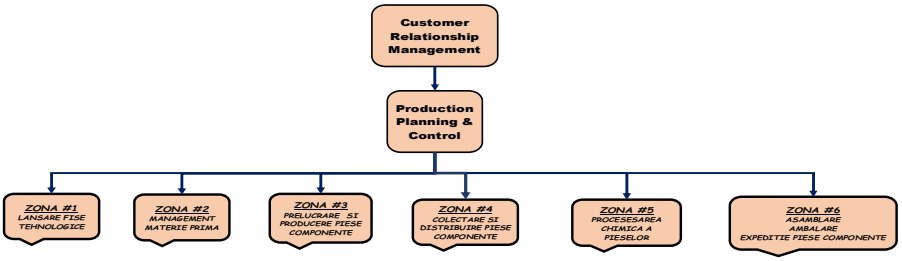

Figure 3. Logical relationship in PPC New.

The logical diagram of the newly developed planning process, based on a thorough analysis of changes within the production process as well as of the factors involved therein, is presented in Figure 4.

In principle, the new PPC process involves monitoring the production flow and the routing of parts through six critical/key points. These six points can be considered as six self-sufficient zones, each managed by a dedicated planner or planning team. Based on the PULL principle, their role is to release production orders according to priority and to perform re-planning within a maximum of 8 hours in the event of delays affecting the planned volumes. Planning is carried out based on the available man-hours or machine-hours, as well as on priority levels. In the case of special processes executed on automated production lines, the standardized volume assigned to each part number (p/n) determines the available capacity.

In order to achieve an intrinsic understanding of the PPC process, the following sections analyse each planning phase individually, through a detailed examination of the process flow and the presentation of the corresponding tracking files.

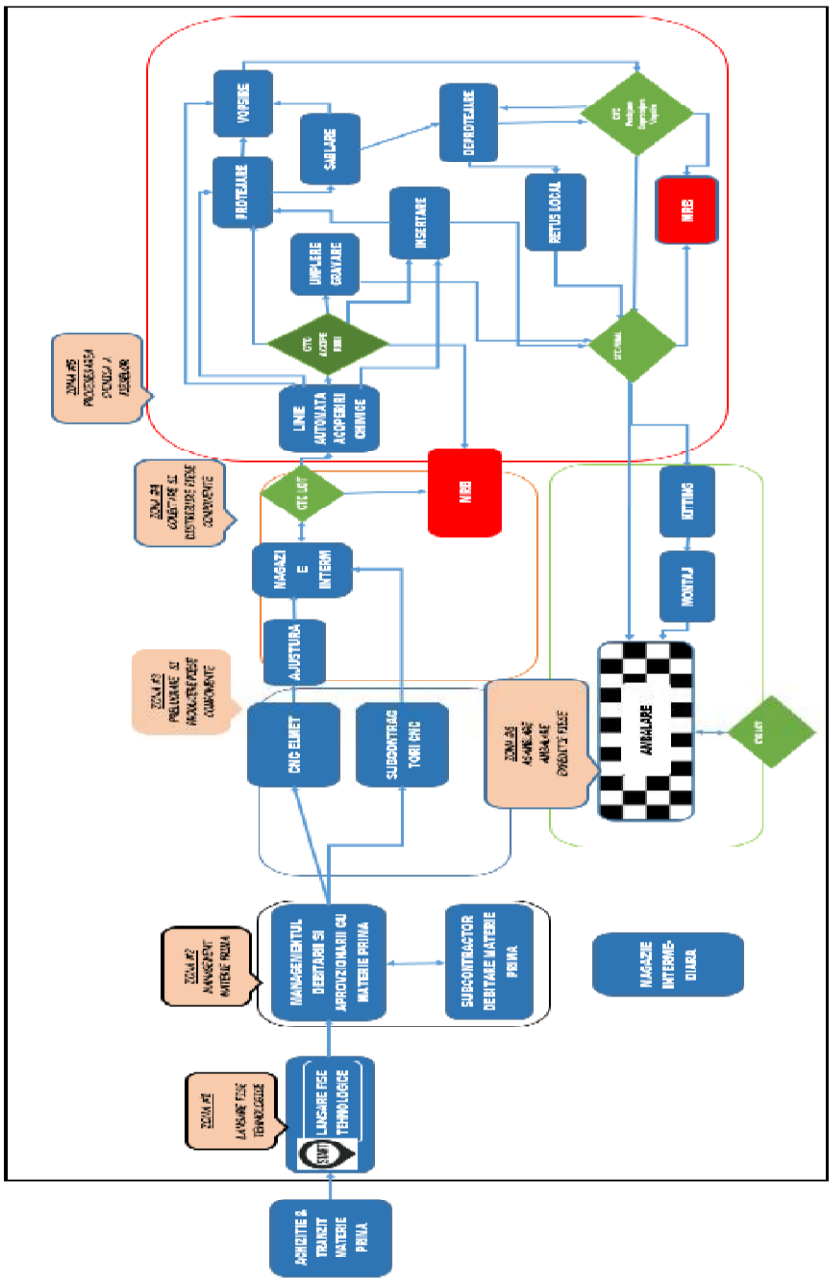

Figura 4. Logical Flowchart – PPC New.

3.1. Zone 1 + Zone 2. Technologic Routing + Raw Material Management.

The phase involving the release of technological routing sheets and raw material management represents the initial point of the production process. The corresponding connections and interactions can be observed in Figure 5.

In order to define and release a raw material order, the technological routing sheet (Production Sheet) is established by the Engineering Department. This document includes all technical, technological, logistical, quality, and traceability details required for the manufacturing of a product.

To ensure uninterrupted operation with minimal stoppages, raw material sufficient for the subsequent 168 hours must be available at the machine level.

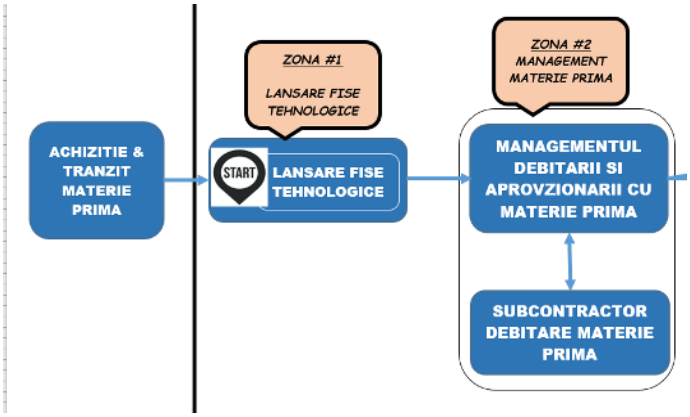

Figure 5.- Zone 1 and Zone 2 process flow.

Documents and material flow.

Figure 6 shows the material flow (physical flow) within the Cutting Department, while Figure 7 highlights the corresponding document flow for the same department.

The procured raw material is subject of both quantitative and qualitative inspection in accordance with the delivery documentation. Simultaneously, the raw material quality analyst verifies the chemical composition and mechanical parameters using a portable photo-spectrometer, as well as other equipment available in the laboratory.

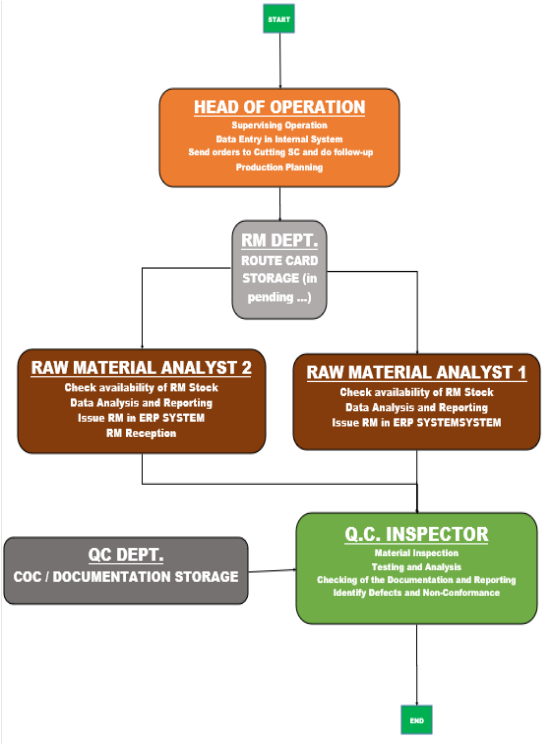

Figure 6. Documents logical flow.

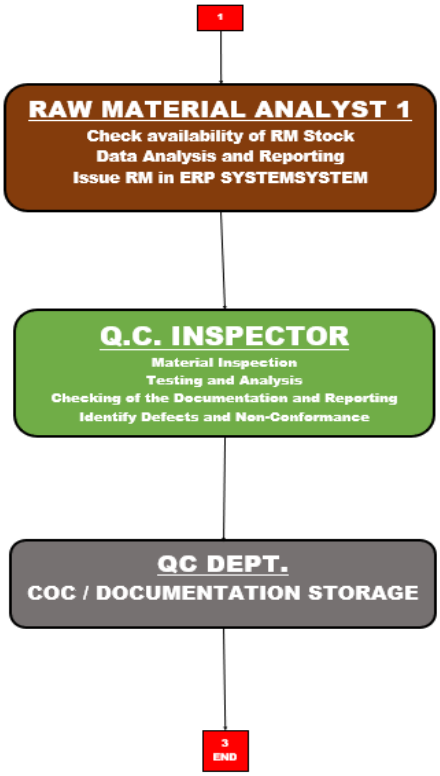

Figure 7. Raw Material flow.

Considering the high volume and wide variety of raw materials processed within a given time frame in the production processes, as well as the existing space constraints within the company, the activities related to raw material handling, warehousing, and cutting were subcontracted to a partner

company. This partner is also a raw material trader, thereby enabling the optimization of production space utilization with a focus on the company's core business. At the same time, in order to maintain objectivity and price competitiveness for raw materials procured through the aforementioned partner, a "First Refusal" option was included in the collaboration contract. Under this arrangement, the benefits of outsourced cutting and raw material management—services for which the company pays a fixed monthly fee to the partner company, hereinafter referred to as CAMON—are combined with procurement flexibility.

Raw Material follow up file

The file used for tracking orders from a raw material perspective is an Excel-based file employing macro commands, designed to support both planning and tracking of orders as well as the routing of raw materials up to the machine level. The format and structure of this file are illustrated in Figure 8, being structured in six zones, each structured using data extracted from the ERP system database. Core system data are exported through predefined transactions and subsequently used within the raw material tracking file.

Zone 1 – "Inventory" This zone contains information regarding the file line number and the date on which the line was introduced. The date is automatically assigned by Excel.

Zone 2 – "ITEM & RM INFORMATION" This zone includes data synchronized from the ERP export. These data are essential for the physical tracking of raw materials.

Zone 3 – "Batch & RM Dimensions" This zone includes the following information:

- Routing sheet operation date;
- Unique batch identification number of the raw material, used for traceability purposes;
- Semi-finished product dimensions (L × W × H);
- The planned date for raw material pickup from the subcontractor (hereinafter referred to as CAMON).

Zone 4 – "CAMON + Recipient Tracking" This section of the file is dedicated to monitoring CAMON's performance and the status of the ordered raw material.

Zone 5 – "HT Tracking" This zone tracks the evolution of the raw material through heat treatment, when required by the drawing.

Zone 6 – "Machine & Planned Week Information" This zone contains information related to the subsequent machining operations, namely the assigned machine and the week in which the operation is planned.

In the last column, entitled "Pt. Planner – To Be Checked", any relevant messages from the Raw Material (RM) Manager or the PPC Manager are entered and addressed to the warehouse responsible, *Ana*, with the purpose of accelerating or decelerating specific order lines.

In order to manage data originating from the system databases, functions such as VLOOKUP are employed, while data entry control is ensured through a macro command. This macro automatically generates the data entry timestamp, thereby facilitating user activity and, at the same time, ensuring the accuracy and reliability of the reported information.

Macro description.

The operating algorithm of the macro command can be described as follows. Within the "L:L" routine, whenever the values in the cells of column C are modified, the corresponding date on which the operation was performed is automatically populated in column B.

In the "U:U" subroutine, the selection made in the cells of column U updates the status of the raw material. The timestamp associated with this status update enables monitoring of the response speed for semi-finished material preparation by CAMON, as well as control of the moment when the material reaches the machine.

The "Error Handle" subroutine manages errors related to data entry in the two columns, including attempts to repeatedly enter data into the same cell. In any of these situations, a warning message is automatically displayed, indicating the occurrence of an invalid or duplicate data entry.

Thus, the possibility of introducing incorrect or duplicate values into the cells of columns C and U is eliminated. These columns are designed to ensure the proper progression of each order line through the process and to enable control of the processing time associated with each line.

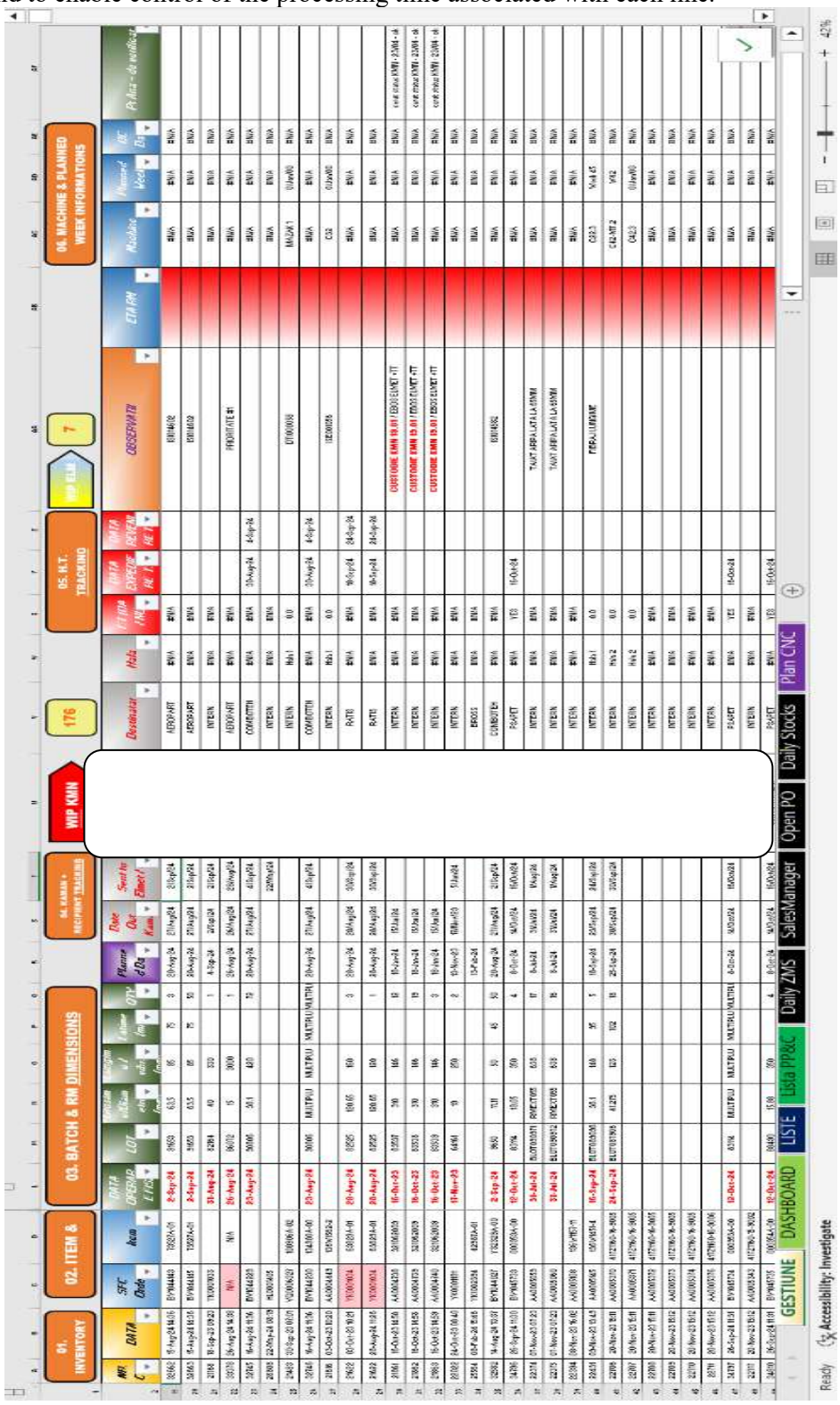

Figure 8. Raw Material Follow up sheet.

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Control of the Raw Material Management Process – Dashboard

In order to enable control over raw material preparation, as well as to monitor the processing rate at CAMON and the elapsed time between release from CAMON and arrival at the machine, a report entitled “Dashboard” (Figure 9 and 10) was developed, providing a concise overview of the main operational data.

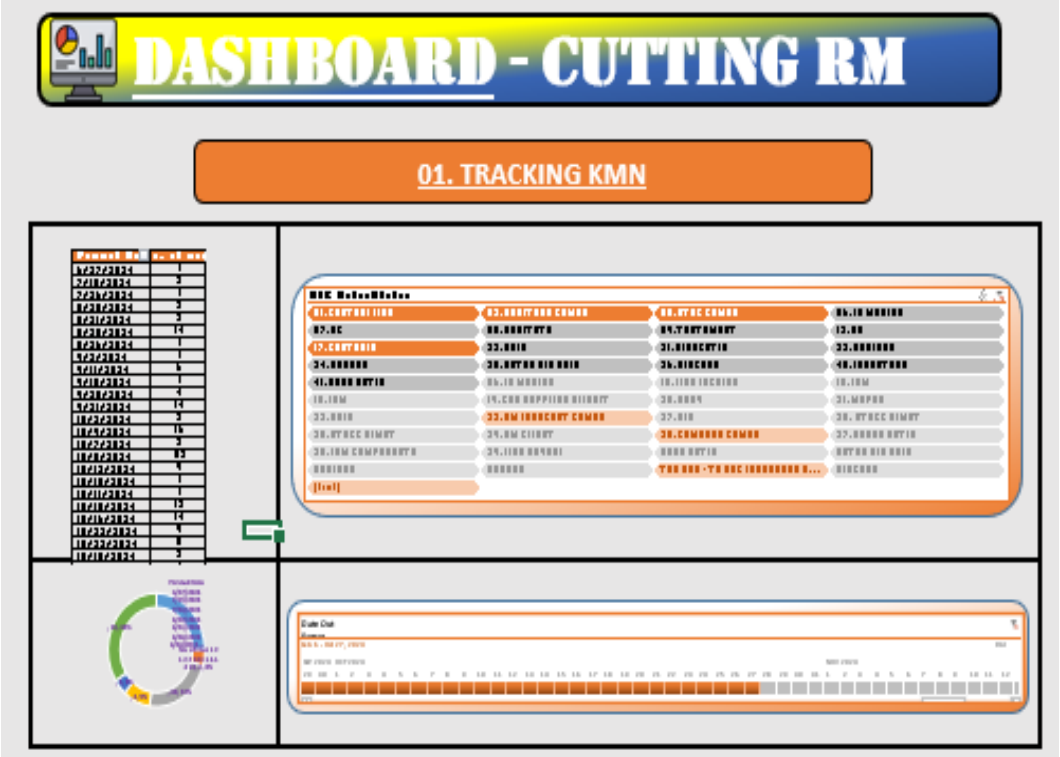

Figure 9. Dashboard Raw Material Follow up

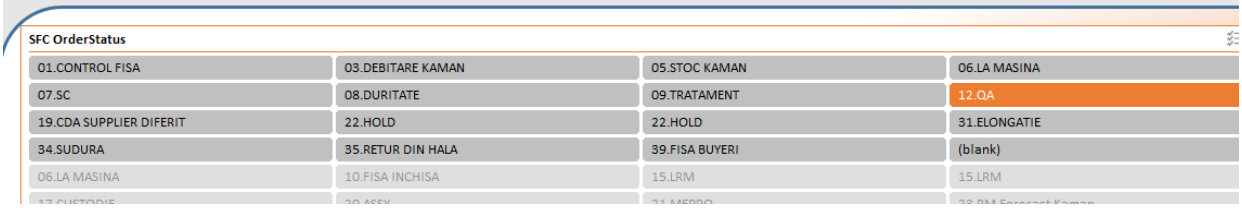

Figure 10. Process Station Workload Monitoring Area (Dashboard).

3.2. Zone 3 – CNC Machining of components.

The CNC machine fleet available within the company consists of a total of 40 machines, structured as follows:

- 24 milling machining centers with 4- and 5-axis capabilities;
- 15 turning machining centers with 4- and 5-axis capabilities, equipped with Gantry Loaders;
- 2 CNC sheet metal bending machines;
- 1 slotting machine.

In order to plan the available resources—namely, the available machine-hours—the following reference iterations are used:

- The total available machine-hours per month, calculated as 720 machine-hours, are considered for planning purposes using an effective OEE of 75%;
- Production on CNC machines is planned under a 24/7 operating schedule.

Description of the CNC Production Planning and Tracking File

In the following, the description continues with the Excel file used for planning activities within the machining shop floor, whose layout is illustrated in Figure 11.

Zone 1 – Item Information contains data synchronized from the ERP export.

These data are required to allow responsible personnel within the CNC machining department to make informed decisions regarding processing priorities, as well as to enable project managers to monitor the progress of the targeted part numbers and to push parts through the process.

Zone 2 – Raw Material (RM) specifies information related to raw materials. These data are imported from the raw material planning file presented in the previous chapter and are automatically updated, such that any changes are immediately reflected.

Zone 3 – CNC HOURS addresses machining time management. In the column *"TOTAL CNC HOURS – PLANNED"*, the total number of machine-hours required to process the planned batch of parts for the respective part number is defined. In the subsequent column, *"TOTAL CNC HOURS – ACTUAL"*, the actual number of machine-hours consumed to process the planned batch is recorded.

It is important to note that, in order to preserve objectivity in reporting—thus ensuring data quality and information availability—the company opted for the implementation of a Manufacturing Execution System (MES).

After the first year of MES utilization, a real OEE of 62% was recorded. Subsequently, following the implementation of the initial KAIZEN projects, this value increased to 75%**.**

Zone 4 – PROGRESS & STATUS INFORMATION is following the machining process developement in the CNC machining shop.

Zone 5 – CNC Programming Information. This zone addresses the availability of the software-related information required to execute the planned part.

Zone 6 – Machine Information. In this zone, the planner assigns the parts to be machined to the available and capable machines.

Zone 7 – Planned & Completed Week Information.

Zone 8 – Unnamed This zone contains important data entered for and by the planner, providing additional information necessary to ensure planning in accordance with the quarterly-defined strategy.

In the "Prod. Order Status" column, the order status is automatically updated based on the automatic export from the ERP system.

The "Intermediate WH" column cells are automatically populated from the ERP export for the reasons mentioned above, facilitating the use of the file and easing the planner's workload.

In the "Complexity of the Parts" column, parts are classified according to profile and technological complexity. In order to maximize added value within the company, management decided to manufacture

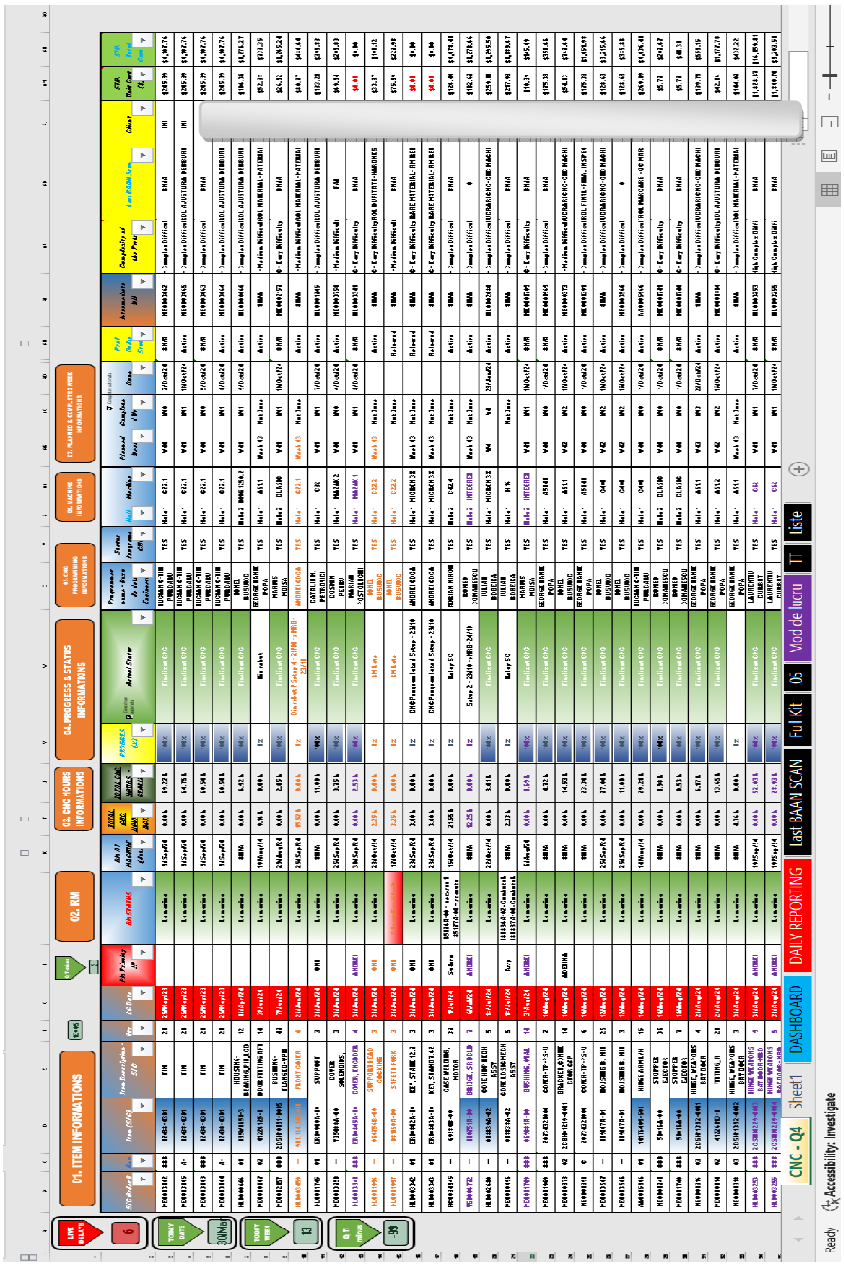

Figure 11. CNC Planning sheet.

the most complex parts in-house and to utilize the remaining available capacity with category C parts, limited to a maximum of 15%. The classification and an example of the distribution of CNC-machined parts internally at the company during the fourth quarter of 2023 are illustrated in Figure 14.

In the “Last Scan” column, the most recent order status is imported from the daily ERP system export.

The “Client” column contains information, extracted from the ERP system,

In the “Std. Unit Cost” and “Total Cost” columns, the unit selling price and the total batch-level selling value of the manufactured parts are specified.

Within the CNC machining planning and tracking file, on the left-hand side, several cells display critical information for the planner’s activity, as illustrated in Figure 12

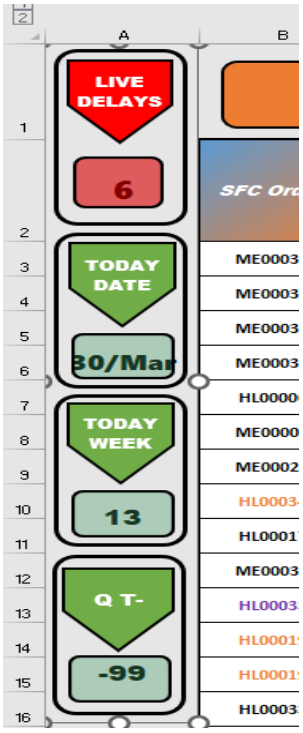

Figure 12 – Critical info cells

These cells summarize the planning date, the current calendar week, the number of delayed order lines, and the number of delayed parts. The objective is to achieve zero delayed order lines and zero delayed parts.

Zone 9 – Virtual Application Execution Button.

This "button", when activated (Figure 13), triggers a macro command running in the background, which generates the number of machine-hours required for the selected machine to produce the selected parts. As a result, an updated overview of machine loading is obtained, along with theoretical data (displayed in column AB), which are subsequently used for planning the next processing stages.

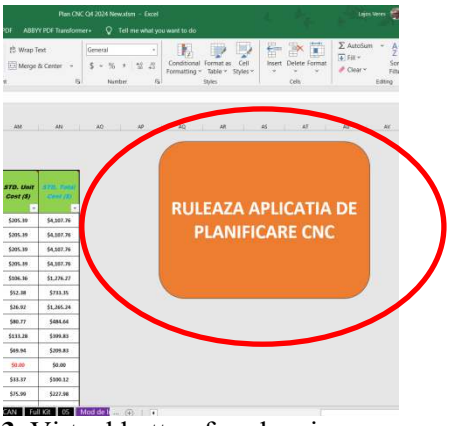

Figure 13. Virtual button for planning app running.

CNC Fleet Report Panel (CNC Fleet Dashboard)

The control and summary page for planning and monitoring activities within the machining department is structured into reports, each of which presents critical aspects relevant to planning.

The first report, provides a summary of continuous machine loading over a three-week horizon. The planner's objective is to load and balance the CNC machine fleet at 150 hours per machine, corresponding to 90% of the agreed nominal available capacity.

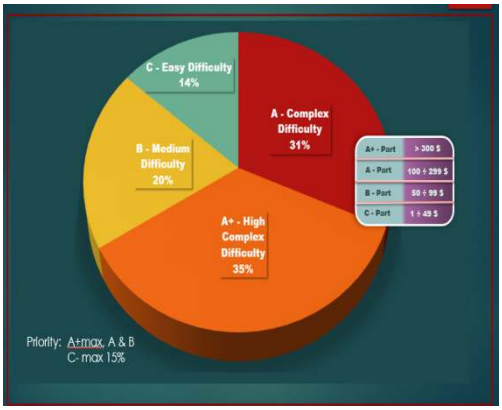

Figure 14. Parts classification upon complexity.

The second report is following the loading of the CNC machines at quarter level based on the following criteria:

- Full fleet loading;
- 5 axis milling CNC loading;
- Milling centers loading;
- 3 & 4 axis CNC Milling loading;
- 5 axis CNC Lathes loading;
- 3 axis CNC Lathes loading.

An other report presents the distribution of production value across the machine fleet at a quarterly level. This report supports the planner in balancing machine utilization in coordination with subcontractors and in scheduling planned maintenance activities.

The report presenting machine loading from the perspective of part category is also useful for the planner in aligning with the strategy for distributing workloads between internal production and external subcontracting.

OTD planning represents one of the critical KPIs monitored on a daily basis by top management. The report tracks the number of delayed order lines.

The maintenance planning status represents a critical input for rigorous production planning. Machine availability can be monitored through the report summarized on a quarterly and annual basis. [7] [8] [9]

Macro description.

The first macro used within this file is implemented as a routine entitled "General_Call_01"**.** The algorithm can be described as follows: upon entering the execution date in column AD, where the correctness of the date format is validated, the corresponding calendar week is automatically generated in column AC. Based on the presence of a reference value in column AB, the status "CNC Completed" is then filled in column W.

If the input value is not of the *Date* type, or if the other validated data are missing, an error message is generated. In order to ensure the correctness and immutability of execution data, once the completion date of the parts is entered, cells AC, AB, and W are locked against further editing.

The second macro command, whose routine is entitled "Finish Date", performs a load simulation based on the selected machine, the number of parts within the order, and the selected time horizon. As a result of this simulation, an execution date for the selected order line is determined.

At this stage, the planner may either accept the calculated results or intervene, having write access enabled. The planner can redirect the workload to a different machine, redistribute the load across multiple machines, modify the delivery date, or apply any combination of these actions.

3.3. Zone 4 – Components and parts regrouping and distribution (Intermediary Warehouse)

The management of activities and inventories at this stage—of paramount importance with respect to inventory turnover speed and the handling of orders in terms of time and volume—relies on a system similar to the Kanban approach. The following section describes the operation of the Intermediate Warehouse area. The flow of parts within the Intermediate Warehouse is illustrated in Figure 15.

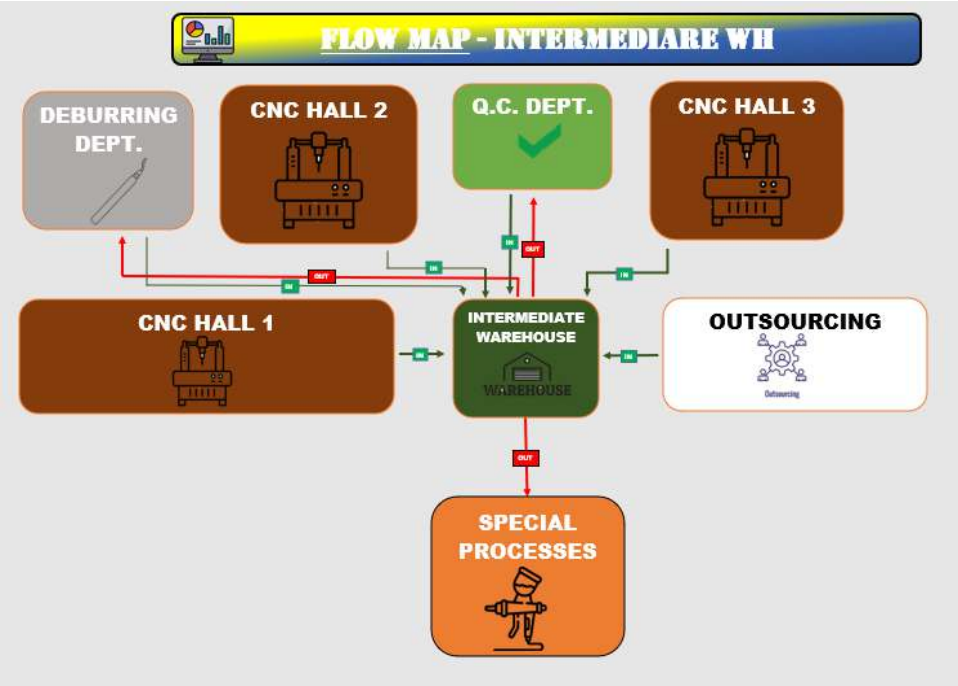

Figure 15. Parts flow in the Intermediary Warehouse.

This warehouse plays the role of distributing parts among the various departments, while simultaneously minimizing inter-operational inventories within production areas and maximizing part flow. Inter-operational quality control is performed within this warehouse, significantly increasing both the efficiency of the process and reducing the time required for this operation.

Description of the Intermediate Warehouse Tracking File.

The activity of the intermediate warehouse is managed through a dedicated file. The interface of this file is illustrated in Figure 16, being organized into six zones.

Zone 1 – Receiving Date This column records the date on which the parts are received into the intermediate warehouse. In order to prevent parts from remaining in this warehouse for excessively long periods, at the time the process was defined, a target was established for the maximum allowable aging of parts in the intermediate warehouse, set at T + 30 days. Consequently, the date of entry into the warehouse represents the starting point for measuring this process indicator (KPI – Key Performance Indicator).

Zone 2 – Item Information presents the specific data related to the parts received into the intermediate warehouse, as extracted from the ERP management system.

Zone 3 – Warehouse Information specifies the information required for the subsequent operation, namely the date on which the parts are released to the next processing stage.

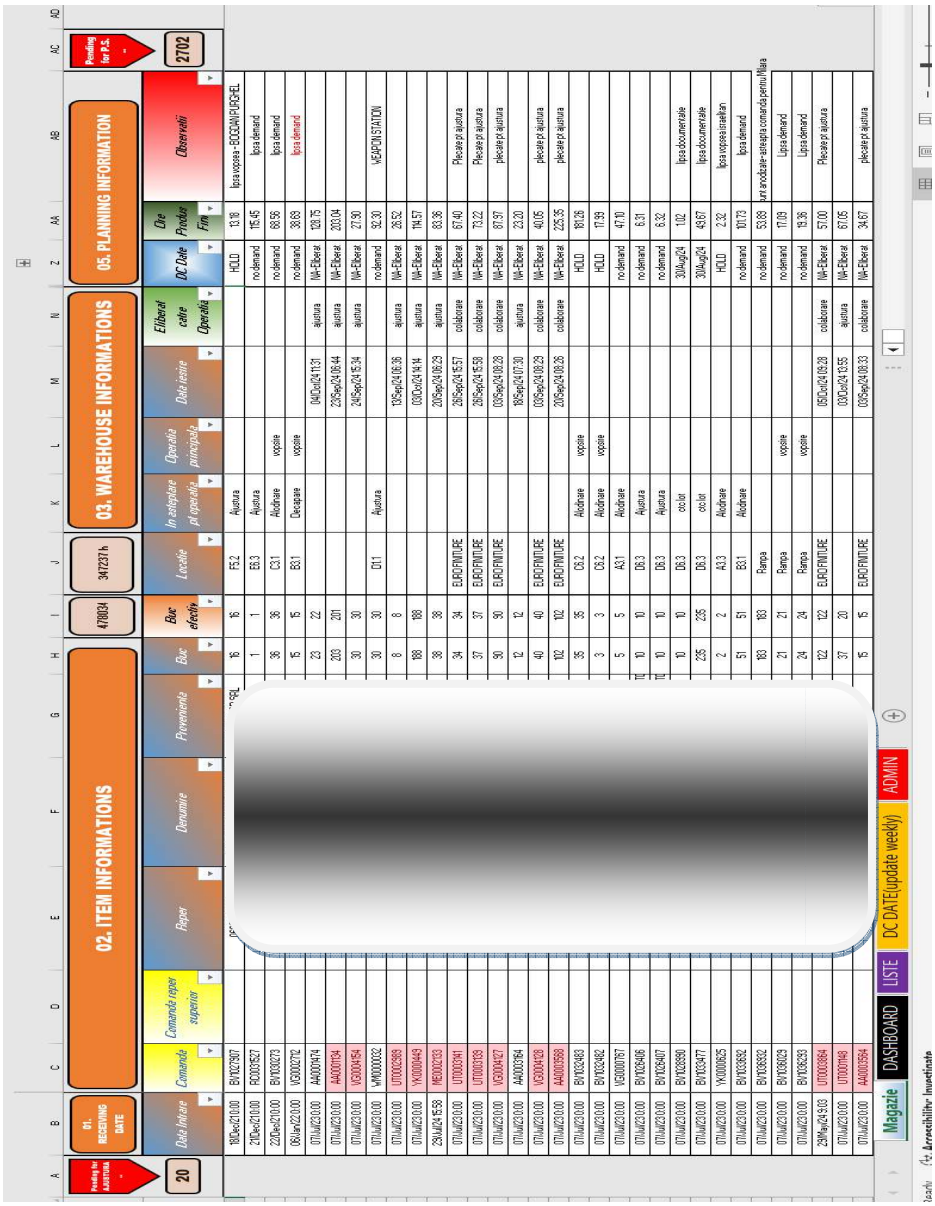

Figure 16. The Intermediate Warehouse Tracking File.

Zone 4 - In the "Release Date" column, the date on which the parts leave the Intermediate Warehouse for the previously specified operation is recorded. In cases where rework is required due to quality nonconformities identified during inspection, the **"**Released to Operation**"** column specifies either the name of the required operation or the name of the subcontractor to whom the work has been allocated.

Zone 5 – Planning Information contains data specific to the planner responsible for the Intermediate Warehouse, enabling the preparation and release of parts according to priority for subsequent production stages.

In the final column, "Remarks", the upstream or downstream planner, or the PPC manager, may enter observations regarding the progress of the parts or any other information relevant to the Intermediate Warehouse.[10]

Intermediate Warehouse Dashboard (Control Panel)

In order to control the activity within the Intermediate Warehouse, three predefined reports have been developed:

- Loading T+30 days;
- Total load of the Intermediary Warehouse;
- T+30 days total hours.

Macro's description.

In figure 17 there's showed the logical structure of the Macro's functioning.

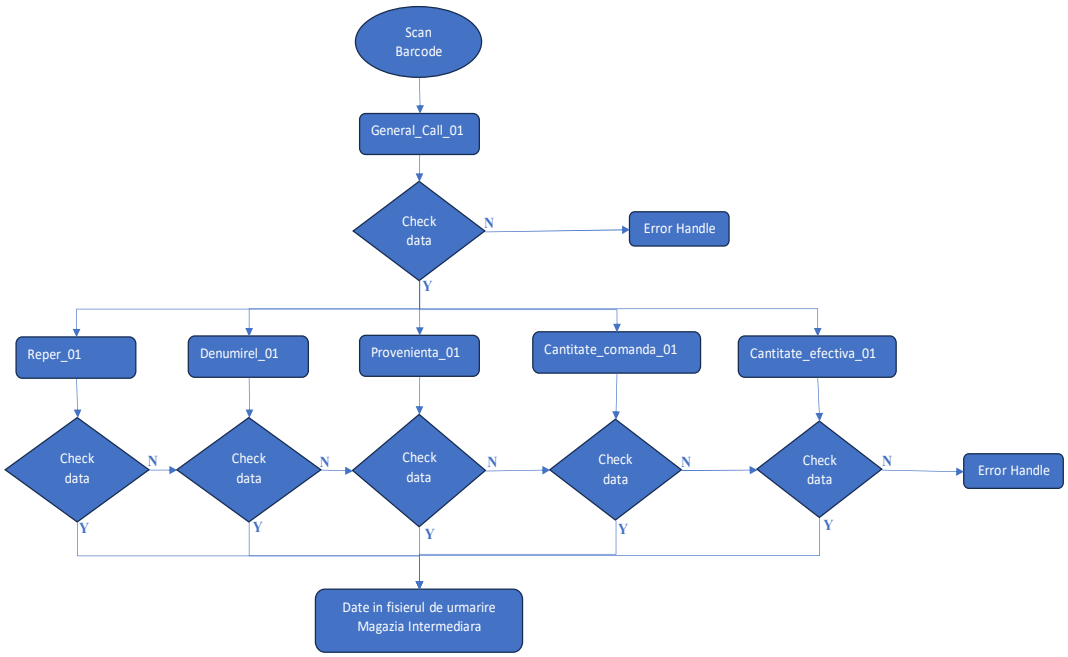

Figure 17. Logical structure of the Macro related to the Intermediate Warehouse.

The macro commands running in the background of the file consist of six routines and exhibit the following specific functionalities:

- "General_Call_01", which, upon scanning the barcode on the production routing sheet associated with each batch—thereby converting it into the production order number that is recorded in column C—automatically registers the scan timestamp (i.e., the receipt date and time) in column B, and subsequently calls the following subroutines:
- "Reper_01" This module is implemented as a function that searches for a specific value (Part Code) within an external file and populates the corresponding "Part" field in the Intermediate Warehouse tracking file. In the event that the value cannot be identified or retrieved, the function generates the error message "ERR".
- "Denumire_01" This module searches for the Part Name corresponding to the code identified by the "Denumire_01" module and copies it into the "Part Name" column of the Intermediate Warehouse tracking file.
- "Provenienta_01" The module in question searches the export report generated by the ERP management system to identify the origin of the part defined in the preceding modules and records the retrieved information in the "Origin" column of the Intermediate Warehouse tracking file.
- "Cantitate_Comanda_01" This module searches the export report from the ERP management system for the quantity released in the production order corresponding to the part identified in the

previous modules and records the retrieved information in the "Qty" column of the Intermediate Warehouse tracking file.

- "Cantitate_Efectiva_01" This module searches the export report from the ERP management system for the quantity received from subcontractors or from adjacent internal production departments corresponding to the part identified in the previous modules, and records the retrieved information in the "Actual Quantity" column of the Intermediate Warehouse tracking file.

This module calls the previously presented modules, ensures that the data are populated in the required cells, and handles any errors that may occur.

3.4. Zone 5 - Special Processes planning

The Special Processes within the company encompass all technological processes that add value to mechanically machined parts by protecting metallic surfaces—both ferrous and non-ferrous—and by ensuring the aesthetic and functional parameters required by customer drawings.

Parts Flow chart within Special Processes

The routing of parts through the special processes can be observed in the flow diagram extracted from the general the company process diagram, as illustrated in Figure 18.

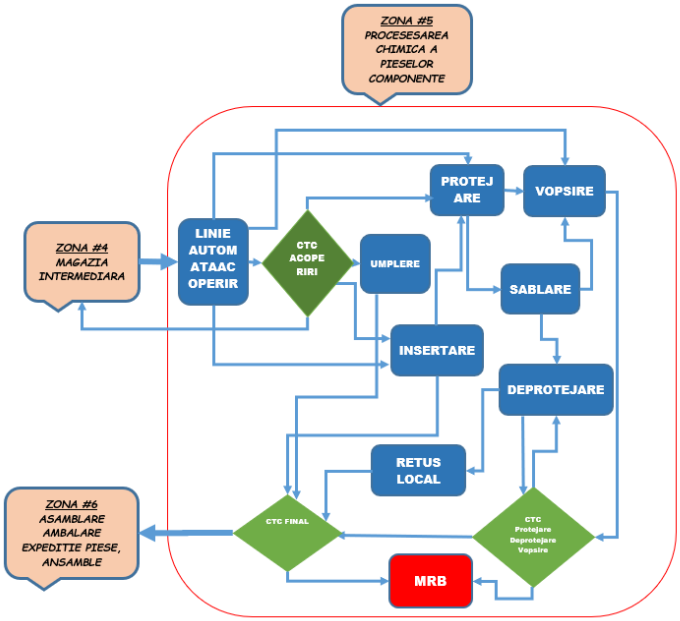

Figure 18. Flow chart of Special Processes.

Planning process at Special Processes.

Due to the high complexity and increased variability of the applied processes, combined with strict yet variable technological lead times, planning activities within this department are carried out by a dedicated planner for each special process. In addition, a planning board system is used, where each planner records the order lines to be executed, together with the standard time allocated to each operation and the priority level of the respective order line.

These planning board are filled on a daily basis for each working day of the week. In case of delays, the corresponding entries are highlighted at the top of the table using red ink.

Each planning table uses two color codes:

- Blue for standard order lines;
- Red for urgent or delayed order lines.

Based on the available, allocated, and/or required personnel for each working day, the planner specifies the number of productive hours that can be scheduled for that day.

3.5. Zone 6. Assembly, Kitting, Packing and Deliveries.

Within these departments, activities exhibit a high level of technological complexity, involving the use of specialized tools and fixtures, ATP (Acceptance and Testing Protocol) devices, as well as specialized packaging solutions.

Flow chart Assembly, Kitting, Packing and Deliveries.

The flow of parts, subassemblies, and assemblies through these departments is illustrated in Figure 20.

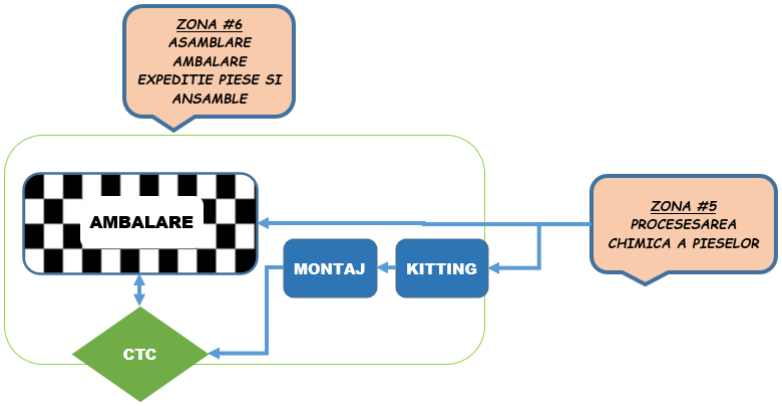

Figura 20. Flow chart for: Kitting-Assembly-Packaging.

Planning activities within these departments are carried out in a manner similar to that used in the Special Processes, by assigning a dedicated planner to each section. The planner schedules part-hours against delivery deadlines while allocating available personnel through rotation.

The planning table used in the Kitting, Assembly and Packaging area is illustrated in Figure 19.

4. Dashboard PPC-New

Control represents the phase of the management process through which performance is measured and, as a consequence, activities are adjusted. Control is not an objective in itself; rather, it constitutes a means for improving and regulating organizational activities [4] [6].

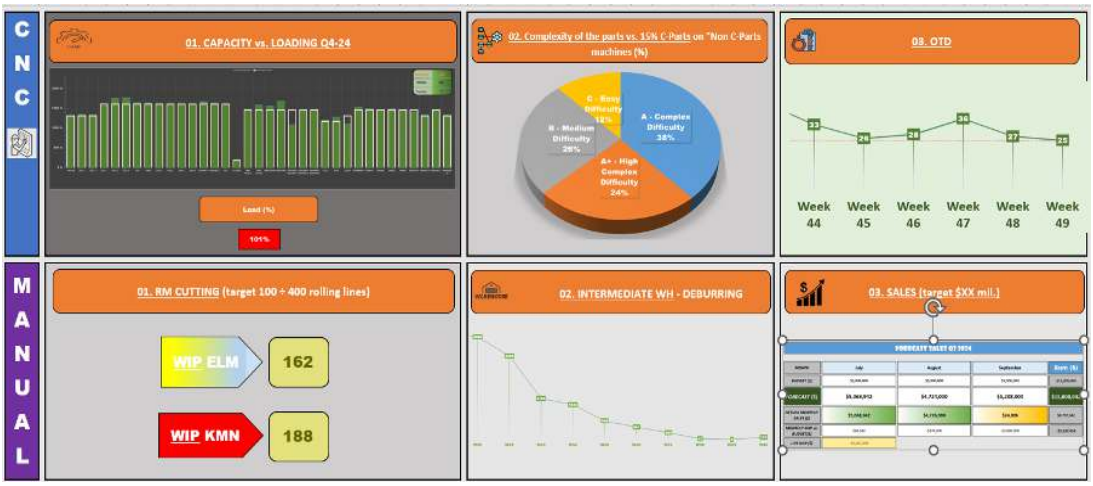

Figure 21. Dashboard PPC –New.

Within the company, the PPC department operates under a structured planning and control framework, employing modern monitoring methods. The KPIs defined as critical and, consequently, monitored by the company's top management are as follows:

- Machine loading (Loading vs. Capacity);
- Loading of Class C parts on non-Class C machines ≤ 15%;
- Raw material WIP limited to a maximum of 400 order lines;
- Delays versus the CNC machining plan ≤ 25 order lines;
- Number of deburred parts processed weekly (order lines with T + 30 days lead time);
- Sales plan performance.

These reports, which are reviewed on a weekly, monthly, and quarterly basis by top management, are illustrated in Figure 21.

5. Conclusions

In order to address the identified challenges, the company's management team developed the CRM module, designed to facilitate and enhance interdepartmental communication, thereby enabling a comprehensive analysis of the capacities and capabilities required and available to fulfill incoming customer orders.

Given that the productive and technological processes had reached a satisfactory level of maturity, the following strategic decisions were made:

- The implementation of a Manufacturing Execution System (MES) to ensure the availability of real-time data [11];
- The creation of autonomous planning zones within the company, each functioning as an independent "mini-factory" with the sole objective of delivering parts at the end of the process in accordance with the planned delivery date;
- The introduction, alongside the planning zones, of simple and transparent dashboards, accessible 24/7 to all employees, with the aim of increasing process accountability, and staff responsibility

Following the philosophy of the 19th-century industrial pioneer Henry Ford,Production planning was divided into six independent zones, for which dedicated planning, tracking, and escalation processes were developed, together with the definition of specific KPIs. Accordingly, the following zones were established:

- Technological Routing Release Zone;
- Raw Material Management Zone;
- CNC Machining Planning Zone for Components;
- Parts and Components Collection and Distribution Zone (Intermediate Warehouse);
- Special Processes Planning Zone;
- Assembly, Packaging, and Finished Products Shipping Zone.

Within the newly created autonomous zones, the following PPC modules were developed:

1. PPC Module – Technological Routing Release and Raw Material Management, with the following main KPIs:
    - Average procurement lead time of 3 months, excluding LLI (Long Lead-Time Items).
2. PPC Module – Raw Material Management, monitored through the following KPIs:
    - Maximum of 500 order lines (100the company+ 400 KMN) in WIP (Work in Process);
    - 24 hours for raw material preparation;
    - 1 hour transit time from CAMON to the machine.
3. PPC Module – CNC Planning Zone, monitored through the following KPIs:
    - 150 machine-hours loading per machine;
    - Minimum OTD (On-Time Delivery) of 95%;
    - 100% in-house execution for A+ and A parts (according to Figure 4.25);
    - Maximum of 15% category C parts executed in-house (according to Figure 4.25).
4. Intermediate Warehouse Module, monitored through the following KPIs:
    - Maximum of 3,000 hours in waiting status;
    - T + 30 days, with a maximum of 200 hours.

5. PPC processes within the Special Processes departments and their integration into the company's IoT framework;
6. PPC processes within Assembly and Packaging and their integration into the IoT framework

As numbers the results can be enounced as:

- Sales increase of 290%;
- Employee increase by 12%
- Productivity increase: 409%/FTE
- OEE increase by 21%

The principles underlying the development and implementation of the PPC-New system can be successfully applied in other industrial organizations. This work highlights the necessity for organizations to move beyond the development level associated with Industry 4.0 and to orient themselves toward the Industry 5.0 paradigm, which is characterized by a human-centric approach, increased resilience, and the promotion of sustainability.

Furthermore, achieving Industry 5.0 maturity opens the perspective for evolution toward Industry 6.0, characterized by the deeper integration of advanced technological, organizational, and societal concepts. The successful progression through these stages represents an essential condition for maintaining competitiveness and ensuring the long-term survival of organizations within the contemporary global market.

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