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DMAIC, Data-Driven Quality Strategy Applied

Improvement of Mechanical-Labor Operations and Organizational KPIs

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Acronyms

AA	Associate
AE	Automation Engineer
AM	Area Manager
ASQ	American Society for Quality
BL	Batch Limit
C15	Condition 15
CE	Customer Experience
CPM	Cells per Minute
CRISP-DM	Cross Industry Standard Process for Data Mining
DEA	Delivery Estimated Accuracy
DL	Defect Lane
DMADV	Design Measure Analyze Design Verify
DMAIC	Define Measure Analyze Improve Control
DOE	Design of Experiments
ECFT	European Central Flow Team
EOS	End of Shift
ES	Early Shift
FBA	Fulfillment by Amazon
FC	Fulfillment Center
HC	Headcount
IB	Inbound
I4.0	Industry 4.0
KPI	Key Performance Indicator
LP	Leadership Principle
LS	Late Shift
LSS	Lean Six-Sigma
MES	Manufacturing Execution System
MHE	Material handling equipment
MP	Multiple Packaging
MP1	Medium Packaging 1
NS	Night Shift
OB	Outbound
OEE	Overall Equipment Effectiveness
OM	Operations Manager
Ops	Operations
OSP	Operations & Sales Production Plan

PDD	Promised Delivery Date
POC	Point of Contact/Proof of Concept
POV	Point of View
PP	Packing Process
PS	Problem Solver
Q#	Quarter # (e.g., Q1: Quarter 1)
RME	Reliability and Maintenance Engineering
RP	Robotic Palletizer
SCADA	Supervisory Control and Data Acquisition
SLAM	Scan Label Apply Manifest
SME	Subject Matter Expert
SOM	Senior Operations Manager
SOS	Start of Shift
SPE	Senior Process Engineer
SRMET	Senior RME Technician
TH	Throughput
TL	Tote Limit
TST	Target Shipping Time
TUR	Total Units Required (Planned)
UPB	Units per Batch
UPH	Units per Hour
UPT	Units per Tote
VOC	Voice of Customer
VP1	Various Packaging 1
VP2	Various Packaging 2
VSM	Value Stream Mapping
WIP	Work in Progress
WK	Week

Introduction

Six Sigma is a systemic approach for problem solution projects, it uses statistical techniques to eliminate causes of defects in products, services, and processes, and reduce process variability, with the main purpose to improve performance and customer satisfaction. Six Sigma's DMAIC facilitates the breakdown of a problem-solving project and structures it sequentially in phases, aiding the user in defining a strategy to analyze and solve the problem at hand, thus, it is suitable for breaking down complex problems. Lean Manufacturing has been linked to Six Sigma in a myriad of research and applied by quality engineers in continuous improvement activities due to its vast collection of tools to reduce wastes in processes, hence optimizing processes and improving quality of products and services.

This report presents the application of the DMAIC methodology in a company in the e-commerce industry where it intends to solve a problem present in a fulfillment center affecting the outbound processes (packing and shipping of orders). A supportive process performed by a special machine, referred to as Tote Distributor, receives containers called totes with picked items from the inventory storage and distributes them into the different lines installed for packing and shipping. The Tote Distributor was having high levels of recirculation percentage, which indicates the number of defects in the process. Recirculation is the result of an attempt to distribute a tote but for one or a series of reasons, the machine was not able to perform the task. This elevated number of defects was causing several problems downstream, affecting the packing processes and reducing efficiency in the workflow and its management. It was necessary to first identify the root causes for the elevated recirculation percentage, since the causes were not clear. Then, assess the recirculation's impact over the outbound processes, and based on data-driven analysis propose and make trials of solutions and improvements to the operational and mechanical processes, and implement the actions that improve the mechanical performance and the efficiency of the outbound processes.

Moreover, due to the high level of digitalization, with automation and robotics present, the company can be qualified to have integrated Industry 4.0 in its logistics processes. Based on the interaction of these three factors: the objective to solve a complex problem, the setting in the e-commerce industry (for which there is a lack of scientific research of applied DMAIC projects), and its advancements in Industry 4.0, Six Sigma's DMAIC complemented with Lean Manufacturing tools for process optimization and enhanced with I4.0 analytics capabilities (like data-mining to generate information) is the quality strategy selected as fit for the action research project. The author intends to present how to apply these concepts and techniques in the setting of operational-mechanical processes in the e-commerce industry.

The report is organized as follows: section 1 presents the theory on the methodologies used for the project based on a literature review. Section 2 describes the company and the environment where the project was developed. The development of the project is presented in the section 3 called "Tote Distributor Recirculation Project", which is divided into sub-sections following the sequence of the DMAIC phases. DMAIC was used to structure and manage the project, creating a Gantt chart at the Define phase (3.1), which details the activities with the Lean tools that were to be implemented, the milestones, and the deliverables. The problem in hand is assessed in the Measure phase (3.2).

Lean Manufacturing tools were used for optimizing the system and the relevant processes to the project. Table 1 is a summary of the Lean tools used for each phase on DMAIC. Among the tools implemented is included the Data Collection, which is further detailed in the Data Collection Plan at the Analysis Phase (3.3). Data-mining and generating insights of the processes took a significant amount of time in the Analysis phase, as well as in each activity where it was needed. The improvements implemented are presented in sub-categories along with the analysis phases (3.4), and the Control phase (3.5) includes a summary of controls linked to the improvements. The section is finalized with conclusions (3.6) of the project.

Table 1 Summary of Lean tools used in each DMAIC phase

Phase	Description of phase	Tool Implemented
Define	The problem and the current state are described. The objectives of the project, its scope, and the project team are defined. The work methodology is explained and its integration in the project schedule is presented.	• Project Charter • Gantt Chart • Stakeholder Analysis
Measure	Data about the current state of the process is collected to explain the situation. Measure of the technical and operational performance.	• As_Is • Pareto Analysis • VSM • MUDA • Flowcharts • SIPOC • VOC
Analyze	From the results of the Measure phase, KPI's are established with objectives. Assess the root causes of the problem and quantify their impact with indicators. Evaluate possible solutions to the problems.	• Data Collection Plan • SPC • Data analysis • Visual Management (KPI Dashboard) • OEE
Improve	Based on the root causes, propose solutions, and test their effectiveness. Assess the trials with data collection and analysis, comparing the results with the main KPI's. Implement solutions that show optimization over the processes and have positive outcomes over the production.	• DOE • Ergonomics in workstation area • Action Plan
Control	Validate the achievement of the objectives. Implement control measures to ensure process effectiveness after improvements. Documentation of project and lessons learned.	• Standardized Operational Procedure (SOP) • Visual Management (Graphs for Monitoring and Control) • White Paper

The last section (section 4) presents conclusions of the implementation of the DMAIC strategy with Lean Manufacturing tools in the setting of operational-mechanical processes of the e-commerce company with I4.0. It includes reflections and lessons learned throughout the project, limitations encountered, and finishes with suggestions for future improvements and recommended applications of DMAIC in other areas of the company.

1. Background

The Six Sigma's problem-solving quality strategy DMAIC *(Define, Measure, Analyze, Improve, Control)* was revised in the literature, focusing on the outcomes of its practical applicability in the manufacturing and process industries where there is substantial scientific research. Six Sigma was first introduced at Motorola for problem solution projects, it uses statistical techniques to eliminate causes of defects in products, services, and processes, and reduce process variability, with the main purpose to improve performance and customer satisfaction. (Costa et al., 2019; Escobar et al., 2021; Ferreira et al., 2019; Gleeson et al., 2019; Jevgeni et al., 2015)

The DMAIC methodology allows the breaking down of a problem-solving task, to structure it sequentially in phases that can be finished to transition from one to the next, helping the user to define a strategy to analyze and solve the problem at hand, thus, allowing to break down complex problems. (Bußwolder, 2014; Costa et al., 2019; de Mast & Lokkerbol, 2012)

DMAIC has been selected as the suitable strategy and methodology for structuring the project and managing the solution of the problem at hand for its applicability with complex problems. De Mast & Lokkerbol discuss DMAIC compared to scientific theories in problem-solving and some of their conclusions that back up its suitability are the following:

- Despite being a generic framework for problem solving, DMAIC has evolved into a large number of domain-specific adaptations by researchers and practitioners. (De Mast & Lokkerbol, 2012) According to De Mast & Lokkerbol, DMAIC is subject to power/generality trade-off (conclusion 1), which states that *"the more task-specific a method, the more useful support it can provide for problems within its range, but the smaller the range of problems for which it is applicable"*, and adaptations of the methodology to task-specific projects overcomes this limitation.
- Due to its finding techniques in the Measure phase that help structure more complex systems and approach the problem based on data, DMAIC is suitable for solving semi-structured problems (or science research problem solving), for which it is not clear how the problem should be approach and the solving process includes the finding of objectives. (De Mast & Lokkerbol, 2012)
- De Mast & Lokkerbol compare DMAIC to Smith's nine generic sub-problem types (Smith, 1988) and state DMAIC incorporates all of them. *"The DMAIC model describes rather extensive problem solving processes, in which a problem is first understood in terms of symptoms (the Measure stage), and then, after diagnosis, in terms of causes (Analyze). The design of remedies is less than half of the procedure."* (de Mast & Lokkerbol, 2012)

  This statement supports DMAIC as an appropriate approach for the action research project at hand that presents a complex problem without a clear view of the causes and the course of action to be taken. Ruling out techniques like DMADV (Design, Measure, Analyze, Design, Verify) and Design for Six Sigma that are suitable for knowledge problems that not necessarily require the implementation of changes to processes and constant data collection during the lifetime of the project. Knowledge problems are even not considered proper DMAIC projects by ASQ due to their lack of improvement actions (*Six Sigma Black Belt Certification - Get CSSBB Certified | ASQ*, n.d.).

However, Deeb et al. discuss that some DMAIC projects fail in their implementation due to a lack of guidance and the need for skillful evaluation of milestones reached on each phase of the DMAIC project. (Deeb et al., 2018) These challenges can be overcome by planning a detailed execution plan and clearly defining the milestones of each phase to transition smoothly from one phase to the next one. (Deeb et al., 2018) Their proposed Six Sigma meta-model includes the introduction of the elements:

- **objectives** on each DMAIC phase, evaluating them through statistic and qualitative tools.
- **indicators** for the quantitative evaluation of **requirements,** if they are being fulfilled and the achievement of objectives.
- **deliverables,** feed by data collection, that allow the evaluation of fulfilled requirements.

The deliverables are outputs of each phase, they create knowledge (Deeb et al., 2018; Gleeson et al., 2019) and may become an input for the next phase of the improvement project, (Deeb et al., 2018) which shows the value of the continuous measure of data along the duration of the project. The framework proposed by Deeb et al. integrates to DMAIC two major concepts: Lean Manufacturing for its tools that can be used in activities that reduce wastes, and CRISP-DM for the practices on collection, processing, and analysis of data.

Lean Manufacturing has been linked to Six Sigma in a myriad of research due to its vast collection of tools to improve process quality. Based on the requirements, the quality engineer selects the appropriate tools to be implemented for objective satisfaction. Lean Manufacturing was developed for Toyota Production System (TPS) by Taiichi Ohno to eliminate wastes, hence improving quality of products and processes, improving efficiency and delivery times, and reducing costs. (Acero et al., 2019; Dias et al., 2019; P.-E. Dossou et al., 2022; Ferreira et al., 2019; Gleeson et al., 2019) Lean Manufacturing is appropriate for the improvement of processes in a lean and cost-effective way, finding opportunities without the need for big investments. (Cortes et al., 2016; Dias et al., 2019) Integrations to Six Sigma include frameworks and models like: Lean Six Sigma (LSS) (Cited by (Acero et al., 2019; Gleeson et al., 2019)) , iLeanDMAIC (Ferreira et al., 2019), and Lean & Six-Sigma Framework (LSSF) (Cortes et al., 2016). Their applications have been studied in different process industries and manufacturing settings (iron ore industry (Indrawati & Ridwansyah, 2015), military logistics (Acero et al., 2019), logistics flows and supply chain performance (P. E. Dossou & Nachidi, 2017; P.-E. Dossou et al., 2022), automotive components industry (Dias et al., 2019), apparel industry (Ocampo et al., 2017), electronics manufacturing for automotive industry (Bastos et al., 2021), cognitive engineering (Gleeson et al., 2019), SMEs (Deeb et al., 2018)). Dossou et al. even discusses its contribution to transformation of traditional industrial processes into Industry 4.0 (I4.0) and attempts to integrate Lean Manufacturing, Six Sigma's DMAIC, and I4.0. (P.-E. Dossou et al., 2022)

Digitalization has been a topic of interest in the reviewed works, and there is an increase in the reference to the term *Industry 4.0*. (Mehta et al., 2018; Werner-Lewandowska & Kosacka-Olejnik, 2018) Researchers have seek to incorporate data mining into Lean and Six Sigma's framework, for its contribution with data analysis that provide insights for the development of improvements on problem-solving and process optimization projects. (Chhor et al., 2022; Deeb et al., 2018; Hazen et al., 2014; Morlock & Boßlau, 2021) Digitalized processes in Industry 4.0 (I4.0) generate a big amount of structured data generated by machines and collected by sensors. This data may be used by actuators and model-based programs to control and optimize processes. (Mehta et al., 2018; Morlock & Boßlau, 2021) The use of the process information transformed from the raw data depends on the company's level of digitalization and its capability to combine data with process knowledge to then optimize the workflow. (Chirumalla, 2021; Mehta et al., 2018; Morlock & Boßlau, 2021) Industrial Big Data is in a *"brown field",* since digitalization is implemented in already existing systems and facilities, therefore, the solutions derived from Industrial Big Data must be in harmony with these information and control systems, plants, and equipment. (Morlock & Boßlau, 2021) Amazon generates a big amount of data in this way, which can be collected from different production supporting information systems like MES, SCADA software, existing visual dashboards, and PLC logs. The collection of real time data about the production system's performance allows a better analysis of the present problems, a strong support on the approaches for action, the monitoring and control of changes and improvements, and the assessment of the achievement of the project's objectives.

During the literature review, a lack of studies and applications of DMAIC in e-commerce and logistic processes was perceived. Supply chain management (SCM) was the nearest similar type of industry to e-commerce that presented documented scientific research. Moreover, Werner-Lewandowska & Kosacka-Olejnik modeled the *"Phases of logistics evolution and SCM"* in 6 phases, where e-commerce is part of phase 5 (P5 - with "21st century" as time period and is characterized by the use of Internet and globalization) and IoT and I4.0 in phase 6 (P6 - with an "Unknown future" time period and characterized by automation and robotics). Even if many production companies have achieved phase 6, it is still not widely spread globally, and the literature review exhibited a lack of research on companies in logistics and SCM settings at phase 6.

Furthermore, the documented material related to improvement of processes in the internal knowledge database of the company was reviewed. However, there was just one relevant outcome, a guideline of numbered steps to implement DMAIC projects to approach IT problems. Through observation in the shop floor, it was discerned that most of the improvements done in operational and technical processes followed an unofficial approach, where Points of Contact (POCs) for the project, the objective of the improvement project, and a project deadline were defined at the beginning, and in between there were recurring meetings to check on the attempts to solve the problems and achieve the objective of the project.

Based on the project's objective to solve a complex problem, the setting of the project (i.e., the characteristics of the company's environment, its advancements in Industry 4.0 and the field in e-commerce) and the review on the related work in scientific research, Six Sigma's DMAIC complemented with Lean Manufacturing tools for process optimization and enhanced with I4.0 capabilities (especially use of data-mining to generate information for the identification of causes and approach solutions) is the quality strategy selected as fit for the problem-solving process presented in the action research project. The author intends to present how to apply these concepts and techniques on operational-mechanical processes (collaborating labor work, automation, and robotics) in the e-commerce industry.

2. Company

Amazon is a multinational company with more than one million employees, operating in hundreds of cities for the e-commerce industry, as well as offering digital products and services like cloud computing. Among its fulfillment network of different types of facilities, Fulfillment Centers (FCs) are the warehouses where items from Fulfillment by Amazon sellers (FBA) are received and stored in inventory. (*Fulfillment by Amazon – FBA – Amazon*, n.d.) When customers purchase these items, associates (AAs) pick, pack, and ship the orders. (*Why Amazon Warehouses Are Called Fulfilment Centres*, 2019)

In Italy, several of these FCs work customer orders of 'sortable' and 'non-sortable' items, the former are items that can be handled (like toys and books) and the latter are items of bigger dimensions (like televisions). The action research project developed was on a sortable fulfillment center type, due to confidentiality requirements, it will be referred to as FC. Other fulfillment centers in different locations mentioned will be referred to as FC1 and FC2.

The FC's processes are grouped into three main areas of the Operations department, the Inbound (IB) area where items are received, Inventory Storage area where items are stored and from which are then picked, and Outbound area (OB) where items are packed and shipped. The project presented in this report focuses on the Outbound area, where its collaborators include associates (AAs), Leads, Flow Leads, Problem Solvers (PSs) Area Managers (AMs), Operations Managers (OMs), and Senior Operations Managers (SOMs). In parallel, the Reliability and Maintenance Engineering (RME) department works in a daily-basis manner alongside the Operations department to ensure the correct functionality of the machinery and material handling equipment (MHE) to ensure an efficient flow of products. RME and Operations work together on everyday activities as well as in agile teams formed for projects of mid- and long-term duration for operational improvement.

The Outbound area packs and ships the customers' orders in different lines divided by the classification of packages. The packages can contain multiple items or single items, and for the single items the packaging differs in dimensions categorization: small, medium, or large. Based on these two criteria, process lines are divided, of which the relevant ones to the project will be referred to as 'multiple packaging', 'single packaging', and 'medium packaging'. Furthermore, there are two special types of shipping processed in two different lines: the first one processes returns of items to the FBA sellers and the second one transfers items to other centers that need the inventory to comply with customers' orders. These two will be referred to as 'various packaging 1' and 'various packaging 2', respectively.

The items picked from the Inventory area arrive to the Outbound area to be packed, through a series of special machinery and MHEs that are installed and configured specially for the efficient internal transportation and distribution of the items to the corresponding lines. The items are transported in containers called totes, the totes are of standardized dimensions to facilitate their handling and transportation, designed to prioritize the AAs' safety and to ensure the functionality of them all around the FCs. Totes are distributed to the corresponding lines for packing by an automated machine referred to as 'Tote Distributor'. Through a series of sensors, PLC's, and logical-algorithm, the machine is connected to the company's Manufacturing Execution System (MES) to execute decisions in real-time. When the machine is not able to distribute the totes for one or a series of reasons, there is an extra line referred to as Defect Lane, where totes are received at the OB area and Problem Solvers (PSs) work on them. The project of this thesis is focused on the performance of the Tote Distributor and its impact on the operational processes in the OB area, considering the importance of the delivery of customer orders.

Additionally, at the OB area, three shifts in a day occur, called Early Shift (ES), Late Shift (LS), and Night Shift (NS). At the floor of the OB area there is a monitoring and control hub called Flow, where Flow Lead with the OM in shift manage the flow of the operation. At the hub, Senior RME Technicians (SRMET) are present monitoring and controlling the performance of machines, ensuring mechanical availability, and responding quickly to machine failures. The packing lines have assigned Leads an AMs on each shift, the former to coordinate the AAs' assignments and the latter to manage the operational production according to plan. The number of PSs on shift depends on the expected workload and operational plan, however, there must be a minimum of two PSs assigned to the shift in two key positions, at PSs helpdesk and at the Defect Lane.

The process of the Tote Distributor is the focus of this action research project, due to a high recirculation percentage present at the beginning of the project, lack of clarity about the causes of the elevated recirculation, and the several problems that recirculation causes downstream on the Outbound processes. The Defect Lane is of high relevance to the project because it is where periods of high recirculation can be perceived visually because of an increase in the line's buffer.

Furthermore, Amazon FCs are characterized by:

- Large number of different type of items
- Variable demand
- Supply managed according to different priority levels
- Need of equipment and supply readiness

These characteristics of the environment where the processes under study are set augments the complexity of the problem to solve, for which DMAIC is a suitable methodology.

3. Tote Distributor Recirculation Project

3.1 Define

3.1.1 Problem Statement

Tote Distributor Recirculation percentage (%) in FC has been on average 30% during Q3/Q4 of 2021 vs 15.1% of other FCs (+ 98% - Annex 1). This KPI has been a focus among the opportunities for improvement for the Outbound team, especially because it has a great impact on floor operations and its packing and shipping processes. The Tote Distributor is one of the main Inventory Storage/Outbound MHEs, as it transports all totes that infeed Outbound (Customer Experience Packaging /Various Packaging 2 /Various Packaging 1).

The recirculation of totes has an impact on the routing of the totes in all Outbound Packing Processes (PPs) lines due to the logical path of return to the Tote Distributor (this is explained further in 3.2.1). A portion of the recirculation percentage is assigned to the Defect Lane. The Defect Lane having an elevated number of arrivals or getting full of totes is just a symptom of the background problems that might be happening over the lines and the MHE, which cause the lanes getting full and have an elevated recirculation percentage in the Tote Distributor.

To improve the current performance of the KPI, first the root causes of the recirculation over the Tote Distributor must be identified, as well as outliers' events and the possible operational and mechanical problems. With this, propose solutions, test them, execute the improvements that have a positive impact, and finally make standardizations in the operational processes and mechanical settings that would prevent the recirculation percentage from reaching the high levels of the initial situation.

3.1.2 Current State at High Level

The correct function of the Tote Distributor is crucial to keep the flow coming from Inventory Storage into the OB area, ensuring operational productivity and compliance with Target Shipping Times (TST's) and Promised Delivery Date (PDD). For the expected days of high demand, it is required to have MHE working properly and aligned with the operational workforce to process the expected high volume of the peak seasons.

The main KPI's to monitor for the Tote Distributor Recirculation Project are:

1. Tote Distributor Recirculation %
2. DEA Pre-SLAM (Scan Label Apply Manifest), specifically the bucket "Late Slam". Also identified as "Late Slam Units" in the Quality IS.
3. Problem Solver's Productivity and Bucket C15 (Condition 15 are corrective actions performed by PS)

3.1.3 Goal and Business Impact

Main Objective

- Reduce the Tote Distributor Recirculation % KPI to its objective threshold (less than 5%), so the operational processes in Outbound perform more efficiently, by having a better control of the buffer over the lanes, improving Problem Solvers' productivity, and reducing the number of packages in bucket C15 worked by PSs.

Specific Objectives

- Identify the root causes for the elevated percentage of Tote Distributor Recirculation and quantify them in terms of occurrence and impact over OB operational processes.
- Based on data-driven analysis propose solutions and improvements to the operational and mechanical processes and design the experimentation of trials.
- Reduce the Tote Distributor Recirculation % KPI to its target value of less than 5% with process improvements designed to ensure mechanical performance and improve the operational processes in OB by July 2022.
- Increase the Problem Solver's productivity, by reducing the number of arrivals of totes to the Defect Lane caused by high recirculation in the Tote Distributor.

3.1.4 Scope

In Scope

- Outbound Area.
    - All its packing processes (Multiple Packaging 1/2, Single Packaging, Medium Packaging 1, Various Packaging 1, Various Packaging 2) and support team at Flow.
    - OB Problem Solver (specially PS at Defect Lane)
    - Defect Lane
- Partial extent to Inventory Storage
    - Picking process, more precisely, the action of pushing totes into conveyors for delivery to OB
    - Also, collaboration with OB Flow: Picking Rate, Headcount of Pickers AAs, and labor moves.
- Partial extent to Inbound (for the PPs that arrive to the Defect Lane that have been directly assigned and are owned by IB)
- RME, for the setting and control of MHE and machinery.

Out of Scope

- Kickout OB is not considered for the project, neither are Shipping Sorting and Shipping processes. The machinery of SLAM, Shipping Sorter, and Tray Sorters are not considered part of the project.
- IB is not considered for the project other than its direct travelling assignments to the Defect Lane.
- Inventory Storage stow processes are not part of the scope either.
- Problem Solver specific operation processes that don't affect the Defect Lane nor the collection of totes for packing.

3.1.5 Project Schedule

The project was developed in a 6-months period at the Operations Internship Program, starting from January 17th, 2022. After the Amazon Onboarding Experience, the project started on February 1st, 2022, and a Finish Date was established for July 7th, 2022 (based on the activities planned). The Internship was to finish on July 13th, 2022, allowing for an overall project slack time of 4 days (working days) in case of any delays. DMAIC was used to structure and manage the project, creating a Gantt chart (Annex 2), which details the activities with the Lean tools that were to be implemented, the milestones, the deliverables where findings and actual situation of the system were presented and compared with the project's KPIs. The milestones (Table 2) were reached after the deliverables were assessed and confirmed that they supported the achievement of the projects' objectives. The structure of the project and main activities are seen in Figure 1.

Table 2 Milestones of Tote Distributor Recirculation Project's Schedule

Milestones

Phase	Milestone Description	Deliverable	Assigned To	Due Date	Month
Define the Current Situation	Present Findings on Current Situation	Advancements Report	Astrid, Federico, RME	25/02/2022	**February**
	Update Schedule	Gantt Chart	Astrid	26/02/2022	
Measure (Data Collection)	Data Validation on Floor FC	Study Results	Astrid, AM	18/03/2022	**March**
Analysis	Present Findings of Analysis	Advancements Report	Astrid, Federico	14/04/2022	**April**
Improve - Proposals	Present POC	Advancements Report	Astrid, Federico	03/05/2022	**May**
Improve - Testing	Present DOE	Testing Program/Schedule	Astrid, Federico	10/05/2022	
	Present Testing Outcomes	Advancements Report	Astrid, Federico	20/05/2022	
Improve - New Process	Process Design	Process Procedure & Flowchart	Astrid	26/05/2022	
	Present New Process		Astrid, Federico	02/06/2022	**June**
	Execute New Process		Federico, AM	11/06/2022	
Control	Documentation	Final Thesis	Astrid	02/07/2022	**July**
	Lessons Learned	Amazon Wiki	Astrid	07/07/2022	
	Finish Internship			20/07/2022	

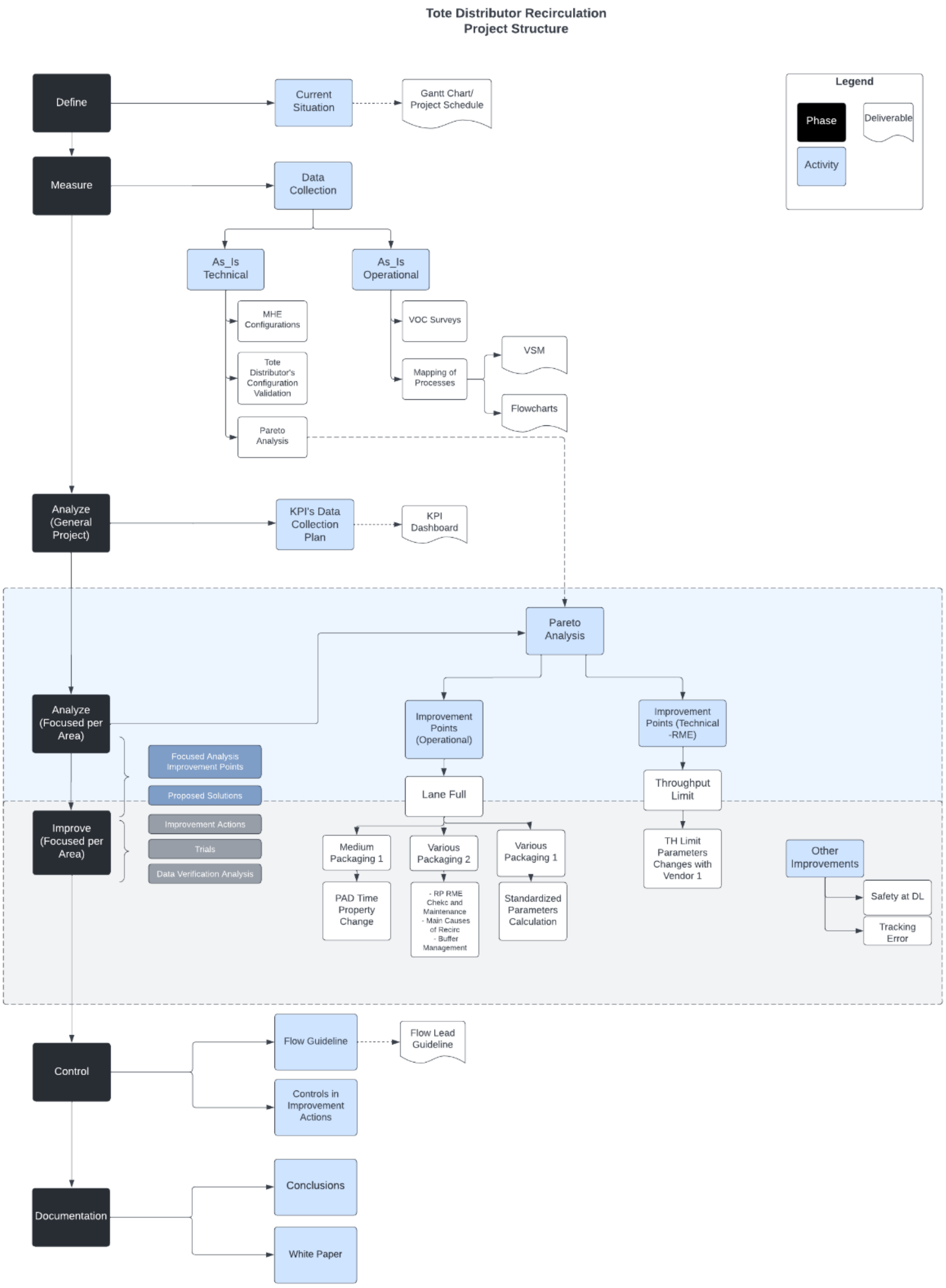


Figure 1 Project's Structure and Main Activities

3.1.6 Project Team

For the project to be implemented successfully throughout all its stages, a project team was defined, creating an agile cross-functional team. The main points of contact (POCs) for the development of the project were the team of Operations OB and RME (Table 3). For confidentiality purposes, the names of the team members are omitted.

Table 3 Project's Main POCs

Operations OB	RME Automation Engineers
1 OM 1 AM Flow Leads	1 Head of AE 3 Senior AE 1 Junior AE

The stakeholders are identified with the purpose of defining their interests and expectations, have a clear view of the possible conflicts that can emerge that could cause a risk to the project's progress. The Operations OB team includes SOMs, Operations Intern, AM, Leads, and AAs. The RME team includes AE's and SRMET's.

As the project schedule details the purpose of having a benchmarking with other two Fulfillment Centers (FC), FC2 and FC1, certain teams of these FCs are external stakeholders considered for the project. These two FCs were selected for benchmarking due to their similarities with FC, both are similar in machinery, MHE, and operations system and they are Sortable FC's. Besides, a crucial external stakeholder is the vendor of the Tote Distributor and MHE, referred to as "Vendor 1" (for confidentiality purposes).

Through benchmarking, knowledge will be transmitted between FCs of the same company. Programmed weekly meetings with the project team will allow the sharing of technical knowledge between team members as well as knowledge acquired from analysis and findings throughout the project.

3.1.7 Work Methodology

The methodology applied for the development of the project is DMAIC (Define, Measure, Analyze, Improve, Control). As defined by ASQ: *"DMAIC is a data-driven quality strategy used to improve processes. It is an integral part of a Six Sigma initiative, but in general can be implemented as a standalone quality improvement procedure or as part of other process improvement initiatives such as lean.*" (*DMAIC Process: Define, Measure, Analyze, Improve, Control | ASQ*, n.d.)

Based on this methodology, the project framework is scheduled and are defined the tools used for each phase of the project. In each phase of the project, data-analysis, and lean manufacturing tools and techniques are implemented.

All throughout the project Gemba Walk was practiced, which is defined by Lean Manufacturing as *"going to see the actual process, understand the work, ask questions, and learning from those who do the work."* (devteam, 2011) The project leader developed most of her work on the shop floor, where she could understand better the value steam and the problems.

3.2 Measure

An initial meeting was held with the project team, where the objectives of the project were presented, clarified the roles, and defined a recurring weekly meeting to report on advancements of the project and define actions. To define further the current situation at a detailed level in the mechanical processes, it was agreed with RME team to make a check on the settings and configurations of the machines and related MHE. Also, it was agreed to map the processes of OB that are connected to the functionality of the Tote Distributor to understand the value stream and the potential present problems.

3.2.1 As_Is (Technical)

Tote Distributor Functionality

The Tote Distributor has four in-feeders: two conveyors coming from Inventory Storage, one from the recirculation lane, and one from the Defect Lane returner. The totes are merged and are realigned in a single line (by the Merger) and then distributed to the OB lines (by the Tote Distributor). The totes that the Tote Distributor is not able to redirect to their corresponding lines due to reasons that will be called *defects*, are redirected to the Defect Lane line (View Figure 2, Figure 3, and Figure 4).

The recirculation percentage is calculated by the total of occurrences in which totes were unable to exit the Tote Distributor and were redirected to the recirculation lane versus the total occurrences of totes entering the Tote Distributor. The totes that are unable to be diverted to an OB line (including Defect Lane) are redirected to the recirculation line, counting for a recirculation occurrence. Equation (1) demonstrates how the Tote Distributor recirculation percentage (%) is calculated:

$$Tote\ Distributor\ Recirculation\ Percentage\ (\%) = \frac{Occurrences\ totes\ redirected\ to\ recirculation\ line}{Occurrences\ totes\ passing\ through\ tote\ distributor} \qquad (1)$$

The totes assigned directly to the Defect Lane are counted in the total totes that pass through the Tote Distributor (denominator in Equation (1)), but are **not** counted as a recirculation occurrence since it was not REdirected to the Defect Lane because of a defect in diverting to another line

After a tote has recirculated 3 times, it is redirected to the Defect Lane. The Defect Lane is the last line in OB physically, where the totes that recirculated a maximum number of three times or were directed intentionally to the Defect Lane arrive. It serves as a contingency outlet for peak moments of high volume WIP, when the WIP cannot be processed at the same arrival rate by the installed capacity, creating large queues in buffers. The Defect Lane can also be used on purpose for particular situations, i.e., assign the Defect Lane as a tote's direct destination. Typically, it is used by the Lead or Problem Solver to accelerate orders that are foreseen as late and will not arrive at their corresponding packing line on time to be processed for their corresponding Target Shipping Time (TSTs). This is a current process designed for solving these particular situations in which it exists the risk of non-compliance of the Promised Delivery Dates (PDDs) to customers.

The Defect Lane having an elevated number of arrivals or getting full of totes is just a symptom of the background problems that might be happening over the packing lines and the MHE, which cause the lanes getting full and have an elevated recirculation percentage in the Tote Distributor.

MHE OB Technical Rates Comparison

The configuration of the MHE is based on the FC's Machinery Layout blueprints. In Table 4, the "Nominal Capacity" designed in the layout are compared with the settings declared in OEE (RME's monitoring program) and the actual values in a specific day (2021.06.23) considered of distress workload in OB to confirm the correct functionality. It was confirmed that the settings were correct, allowing for a throughput even higher than the one expected from a 'Worst' Case Scenario. The throughput can be correctly handled by the MHE and these values prove that the current configuration is OK to work under normal conditions.

Table 4 MHE Configuration

			Nominal Capacity		Current Setting (SCADA)		Actual Values	2021.06.23
	Lines (RME Names)	Lines (Ops Names)	UPH (min)	UPH (max)	SCADA UPH (max exits)	SCADA UPH (max over lanes)	UPH (Exits)	UPH (Over lanes)
Tote Input Lines	AR Floor 2		2,046	3,000	3,000		1,665	
	AR Floor 3		2,046	3,000	3,000		1,578	
	Recirculation		462		3,000		824	
	SHV & KO		438	3,000	3,000		126	
Tote Merger	Tote Merge		4,638	10,560	10,560		4,124	
	Tote Distributor				9,462		3,579	
Tote Distributor to each line	Chu1	MP IS 20	90	600	10,000	600	89	99
	Chu2	VP1	162	1,200	10,000	1,200	161	187
	Chu3	MP IS 18-19	180	600	10,000	600	120	130
	Chu4	SP PACK 3	300	1,200	10,000	1,200	259	267
	Chu5	MP IS 16-17	180	600	10,000	600	197	220
	Chu6	SP PACK 2	300	1,200	10,000	1,200	252	272
	Chu7	MP IS 14-15	180	600	10,000	600	109	119
	Chu8	SP PACK 1	300	1,200	10,000	1,200	235	245
	Chu9	MP IS 12-13	180	600	10,000	600	203	227
	Chu10	MP IS 11	90	600	10,000	600	101	110
	Chu11	MP IS 10	90	600	10,000	600	92	98
	Chu12	SSP	228	1,200	10,000	1,200	217	228
	Chu13	MP IS 8-9	180	600	10,000	600	139	153
	Chu14	MP	228	1,200	10,000	1,200	390	421
	Chu15	MP IS 6-7	180	600	10,000	600	95	105
	Chu16	SM PACK 4	228	1,200	10,000	1,200	199	197
	Chu17	MP IS 4-5	180	600	10,000	600	154	169
	Chu18	MP IS 2-3	180	600	10,000	600	137	152
	Chu19	MP IS 1	90	600	10,000	600	89	102
	Chu20	VP2	468	1,200	10,000	4,680	255	258
	Chu21	Defect Lane (DL)	60	1,800	10,000	3,000	176	178
VP2	1. From the Tote Distributor		468	1,200	4,680		258	
	2. Conveyor		300	1,200	310		299	
	3. VP2 OB Scanner>Manual VP2		162	1,200	620		114/129/28/114	
	4. Conveyor		324	1,200	450		169	
	5. Dimensions Scanner	KO (VP2)	324	1,200	550		242	
	6. Palletizer				550		170	

Relevant Tote Distributor Configuration

Besides the MHE Throughput Configuration, certain conditions of the Tote Distributor logic are relevant to the situations under which totes recirculate and/or are redirected to the Defect Lane (DL). Table 5 summarizes these conditions for the Tote Distributor in FC. The defects of more relevance to the project are highlighted in the table.

Table 5 Command and Conditions of Tote Distributor

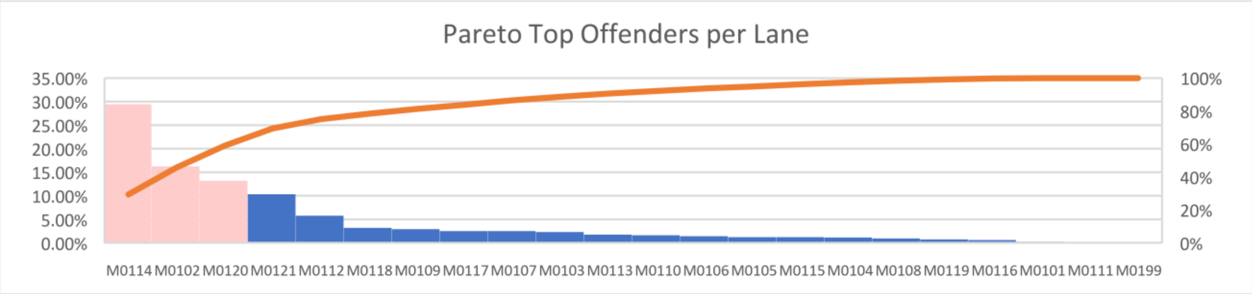
Description	Operation Type	Defect	Defect Classification
If 3 totes in line are assigned to the same chuting (exit), they are to be diverted into the assigned/directed line altogether.	SUCCESFUL DIVERT		
No more than 3 totes can be diverted at the same time to the same line. If more than 3 totes aligned must go to the same line, the excess (after first 3 totes) are redirected to the recirculation line.	SORT_RECIRC	SORT_THROUGHPUT_LIMIT	Load Balance Defect
If the lane assigned/directed is full, the tote(s) that were supposed to be diverted, are redirected to recirculation.	SORT_RECIRC	SORT_LANE_FULL	Ops Defect
After 3 recirculations, the tote is redirected to the Defect Lane (DL). Also called the *maximum number of recirculations* before totes being redirected to the Defect Lane.	SORT_ASSIGN_TO_KICKOUT	SORT_MAX_RECIRC	Ops Defect
If the Defect Lane (DL) is also full, the tote is redirected to the recirculation line.	SORT_RECIRC	SORT_LANE_FULL	Ops Defect
If the line destination of the tote was disabled virtually or is physically unavailable to receive totes, the tote is redirected to recirculation.	SORT_RECIRC	LANE_UNAVAILABLE	Ops Defect
Item diverted to kickout after being assigned to Defect Lane (DL) directly. *Several reasons for being assigned to Defect Lane (DL). *NO max. recirculation.	SORT_DIVERT_TO_KICKOUT	UNKNOWN	Directed Kickout
If the scanning cell identifies a misalignment, it signals to not attempt the diverting of the tote and redirect it to recirculation (for safety reasons).	SORT_RECIRC	SORT_FAILED_TO_DIVERT	MHE Defect
An error in the MHE. (Natural variability)	SORT_RECIRC	SORT_TRACKING_ERROR	MHE Defect
The bar code of the tote was not able to be read correctly. It is redirected to the Defect Lane (DL).	SORT_UNSCANNABLE	SORT_NO_READ	Scan Defect

Pareto Analysis of Historical Data

In parallel to the confirmation of these settings, a Pareto Analysis of the recirculation in the Tote Distributor was done to define two types of Top Offenders: Lane Top Offenders and Defects Top Offenders. The analysis was done based on Q3 & Q4 2021 data, taken from the Mechanical Visualization Web Application (Grafana).

The resulting Top Offenders per Lane (Graph 1) were:

- M0114 – Medium Packaging 1 (29%)
- M0102 – Various Packaging 1 (16%)
- M0120 – Various Packaging 2 (13%)

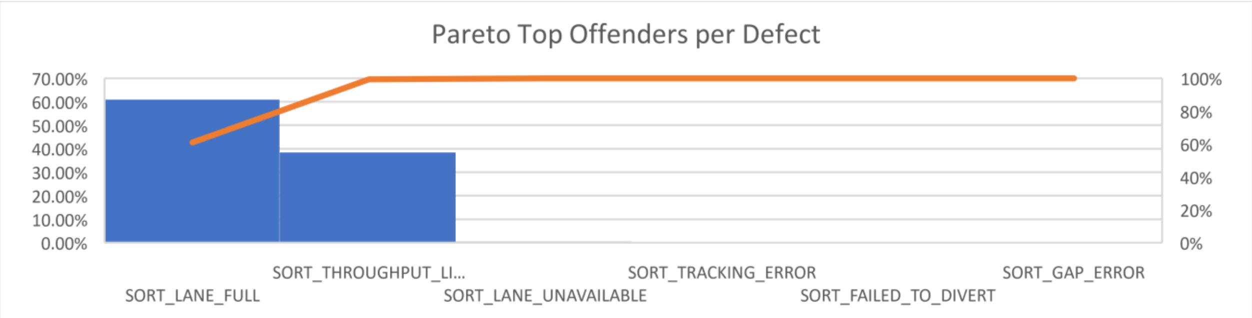


Graph 1 Pareto Top Offenders per Lane

And the resulting Top Offenders per Defect (Graph 2) were:

- Throughput Limit (38.10%)
- Lane Full (60.53%)

Lane Full is attributed as operational defect and Throughput Limit is attributed as technical defect.



Graph 2 Pareto Top Offenders per Defect

With the identification of these Top Offenders, in collaboration with the RME team, it was confirmed if the Tote Distributor Configurations described in Table 5 were working correctly. It was identified at the Defect Lane exit that the totes were being pushed by the Tote Distributor one at a time, instead of doing three pushes altogether, as it was expected to do by design for totes aligned together and assigned to the same destination. (Look at Figure 2, Figure 3, and Figure 4) After further investigation, it was identified that this phenomenon was happening for conveyors that lead to OB's induct and pack lanes. The next step was to confirm if this setting was the right one for the Tote Distributor of FC or if it was a setting that could be adjusted. This finding confirmed the results of the Pareto Analysis where Throughput Limit was a main defect that contributed to the high Tote Distributor recirculation.

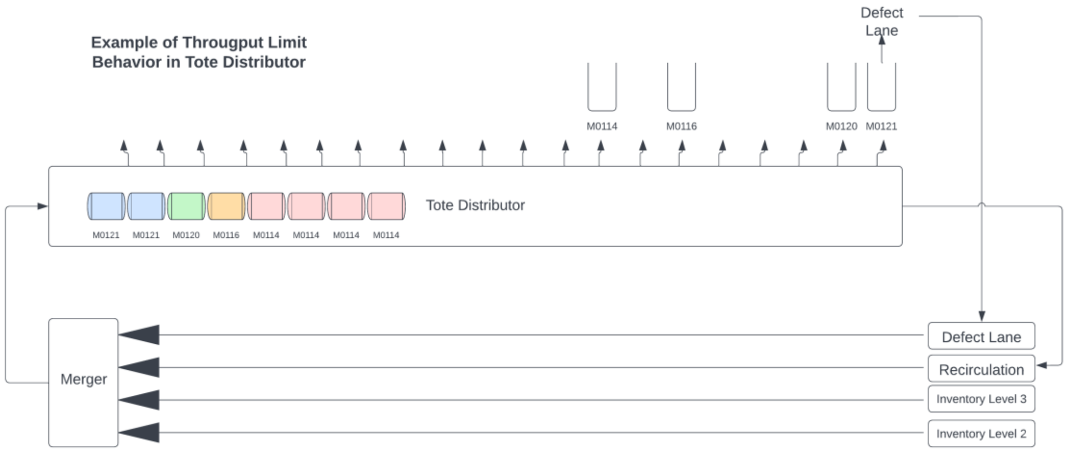


Figure 2 Diagram of TH Limit Behavior in Tote Distributor

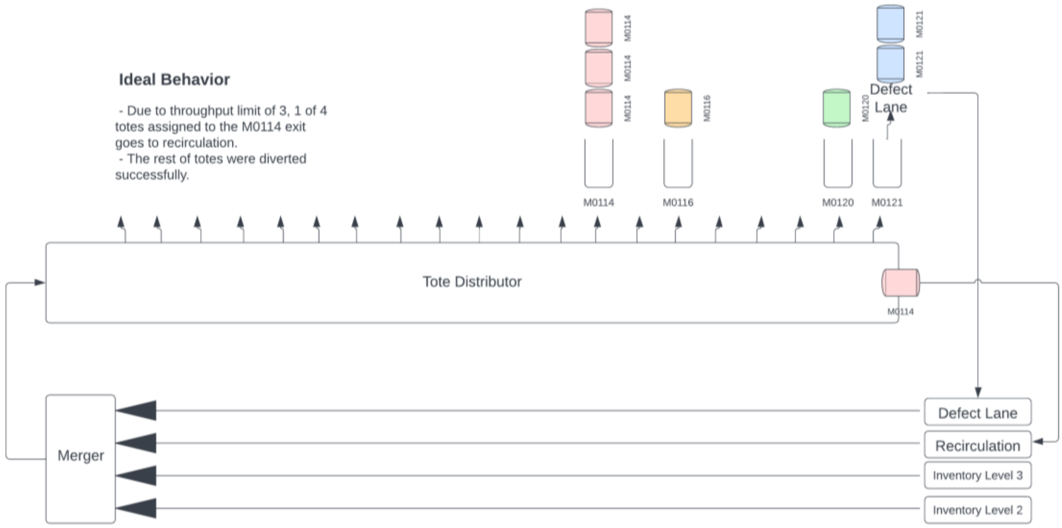


Figure 3 Diagram of Ideal Behavior - TH Limit in Tote Distributor

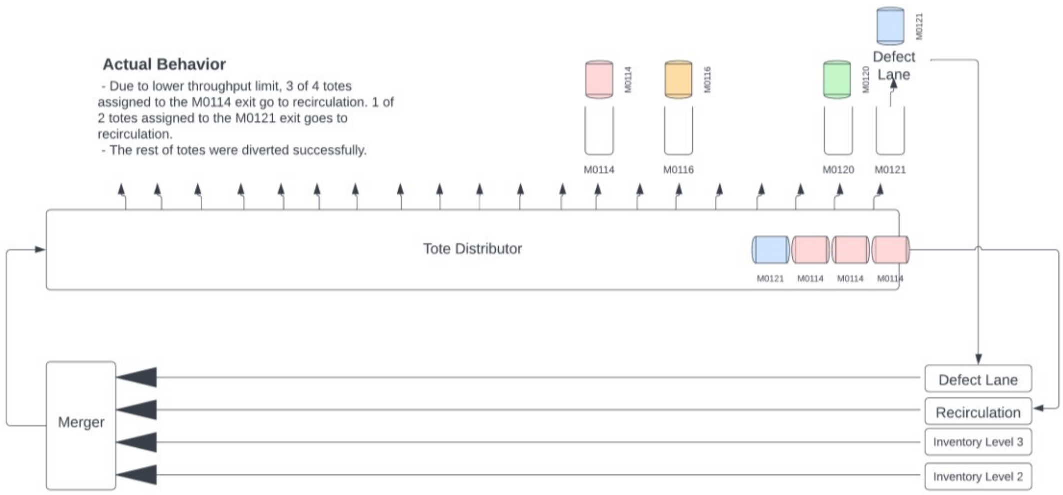


Figure 4 Diagram of Actual Behavior - TH Limit in Tote Distributor

3.2.2 As_Is (Operational)

On the operational side, before attempting to define root causes of the problem, it was needed to understand how the OB operational processes affect the recirculation in the Tote Distributor and to what extent. For this, a Value Stream Mapping (VSM) was constructed, the relevant processes were mapped out, taking as a main point of reference the Defect Lane and the actions taken at the Flow. The process mapping aids in understanding why totes recirculate and eventually arrive at the Defect Lane.

Additionally, to have the voice from the OB team about the possible problems that could be causing the high recirculation and even suggestions and ideas, it was done a Voice of the Customer (VOC) survey. The survey was done to the OB leadership team and to the RME Senior Technicians.

Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is a powerful tool to understand the current situation of a system and its processes. With the VSM it was possible to identify the non-added value activities and wastes (what qualifies as waste are the 7 types of Muda defined by Ohno: being *transportation, inventory, unnecessary movement, waiting, overproduction, overprocessing, defects)*. ("What Are the 7 Wastes in Lean?," n.d.) Figure 5 shows the VSM for the Medium Packaging 1 process, the rest of the processes' VSM were built as well and can be seen in Annex 3.

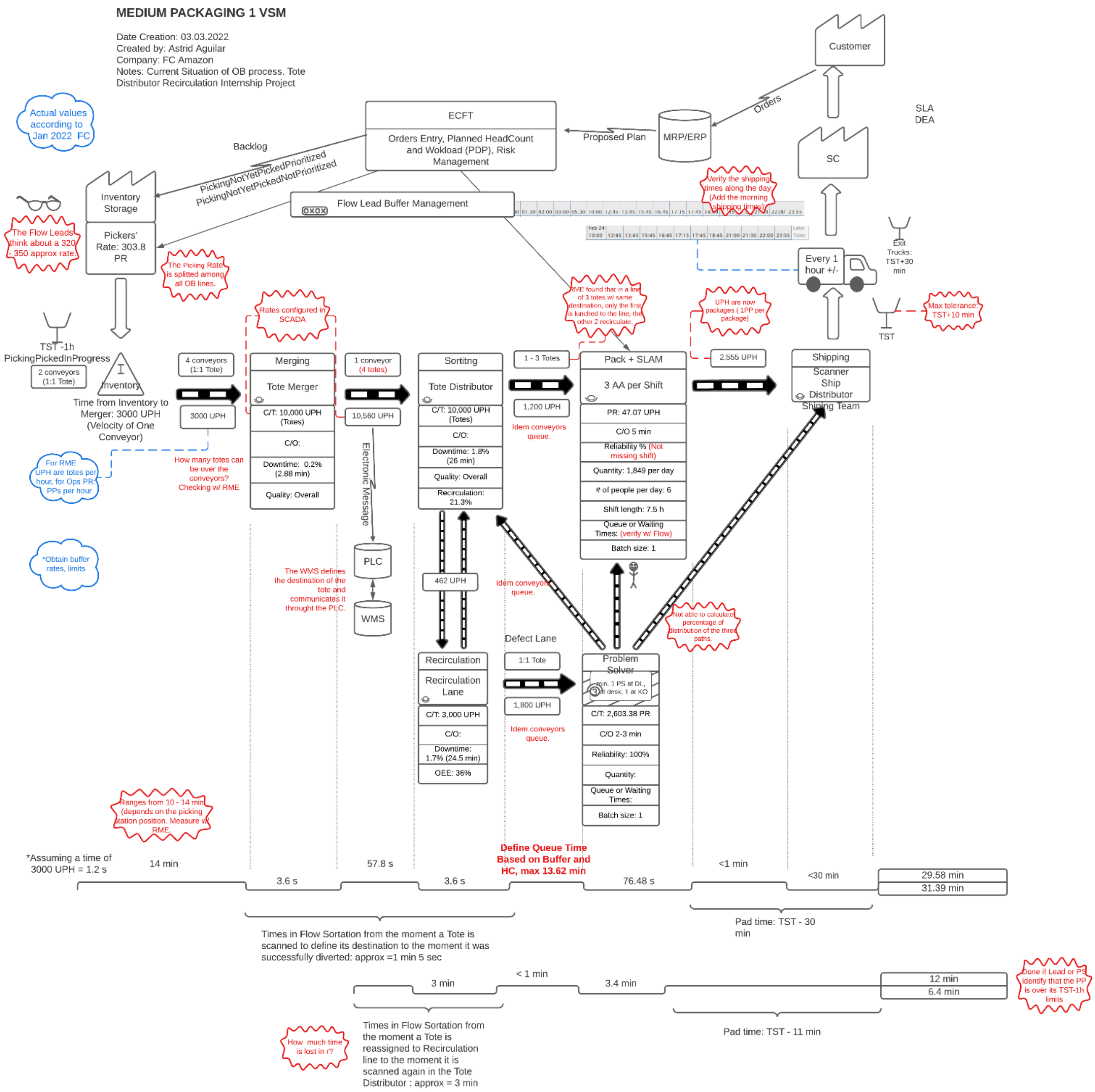


Figure 5 VSM of Medium Packaging 1 Process

From the VSM, it is concluded that the activity of recirculation does not add value, and each tote that goes into recirculation spends 3 additional minutes in the process to be distributed to the corresponding packing line (*transportation* waste). Additionally, for each tote that arrives to the Defect Lane, the Problem Solver spends 3.4 min processing it, to reintroduce the items to the processes and be packed and shipped on time.

The activities done by the PS at the Defect Lane due to *defects* in the distribution process cause other types of wastes, like *overprocessing* due to the extra activities that must be done to process the items, *waiting* and *inventory* due to the buffers created over the Defect Lane, *unnecessary movements* because PS must move from the Defect Lane for certain activities to process the items and reintroduce them in the workflow of Outbound to be shipped.

Flowcharts of Processes

The flowcharts map three processes:

1. The overall flow process of pieces picked from Inventory Storage, passing through the MHE and Tote Distributor, and eventually arriving at OB. (Figure 6)
2. The process of totes arriving at the Defect Lane and the process done by PS at the Defect Lane. This flowchart identifies the main reasons for arrival to the Defect Lane. (Figure 7)
3. The Flow Leads processes along the shift. (Figure 8)

The first flowchart (Figure 6) explains the source of totes, how they are processed in the Tote Distributor, when totes are successfully routed and when are unsuccessfully routed, and why totes arrive to the Defect Lane. A clear SIPOC framework (Supplier, Input, Process, Output, Customer):

- **Supplier**: Inventory Storage
- **Inputs**: totes and the system's commands (like the tote's assigned destination)
- **Process**: the sortation done by the Tote Distributor and transportation by the linked MHE
- **Outputs**: totes arriving over the lanes (including Defect Lane)
- **Customer**: Outbound

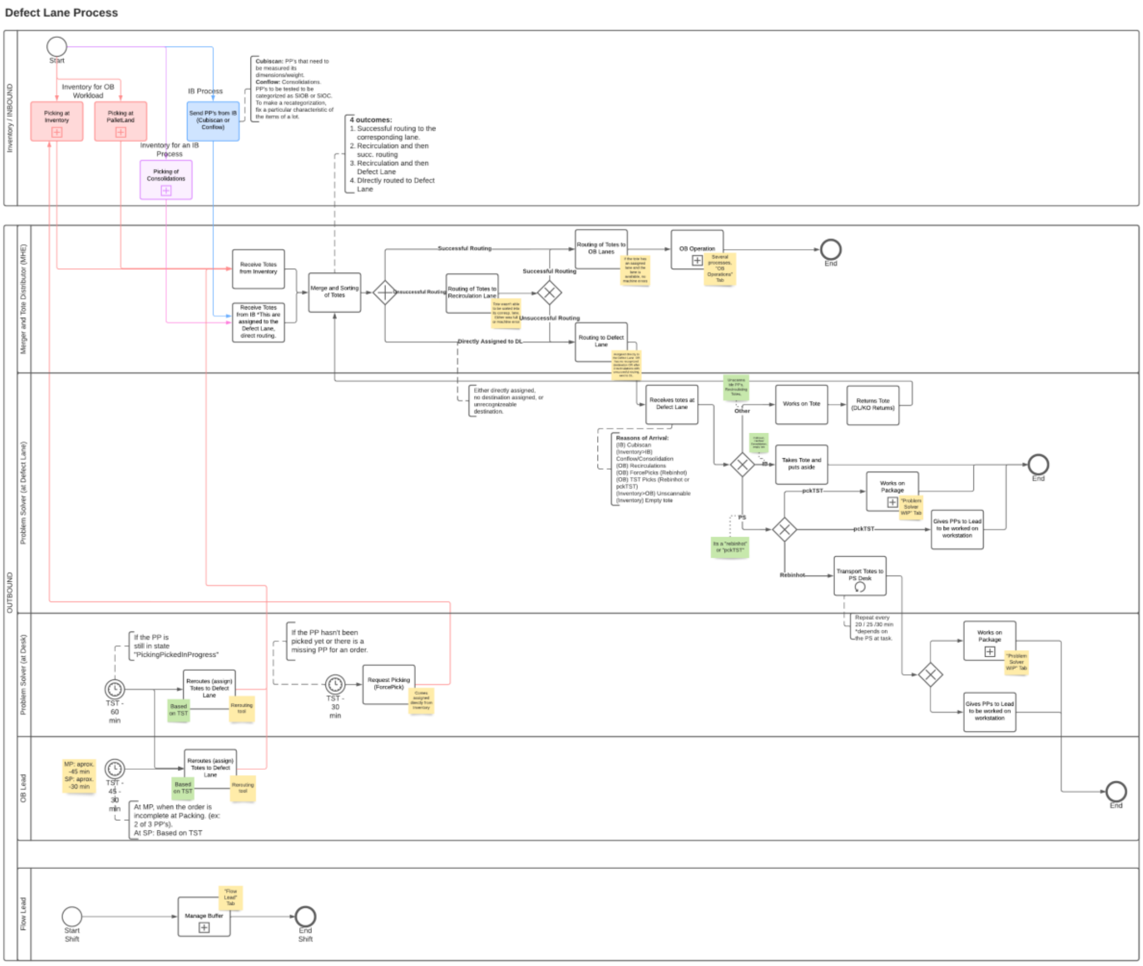


Figure 6 Flowchart of Defect Lane Process

In the second flowchart (Figure 7), it was identified the main reasons of arrival of totes to the Defect Lane, which are:

- **Recirculations**: After the max recirculation of 3 times, totes are redirected to the Defect Lane.
- **Unscannable**: Items that are not able to be scanned correctly in Inventory Storage are signaled by the picker and the systems directs it to the Defect Lane for that item be worked by a Problem Solver.
- **Empty Totes**: Totes that are pushed from Inventory Storage and have no items assigned to it.
- **Pick TST or pkTST**: Items that are required earlier in OB to be processed in the corresponding PP in time for the TST, based on PAD Time. These items are searched in the system by the Lead or PS and redirected to the Defect Lane to arrive earlier.
- **Rebinhot**: Items that are required by the PS to be picked with priority from Inventory Storage and redirected to the Defect Lane to be processed in time for TST.
- **Cubiscan/Conflow/Consolidations**: Consolidations done by IB, these items need to be picked from Inventory Storage and are sent to the first floor (IB and OB) through the Tote Distributor. At their arrival, they are downstacked by OB PS and processed by IB PS.

Only the recirculation occurrences add to the Tote Distributor Recirculation % calculation, the rest are not considered as recirculation occurrences as they are directly assigned to the Defect Lane in the system. For the project, the arrivals of most relevance are **"Recirculation", "Pick TST",** and **"Rebinhot".**

When a lane is full, the Lead or PS will redirect totes that contain pieces needed to complete order shipments on time for TST. From the system, they redirect these totes to the Defect Lane, so they are easier to retrieve. When items for TST (pkTST) arrive at the Defect Lane, the PS either processes it directly and then reintroduces the package to the process to be "SLAMmed" and/or Shipped or transports it to the corresponding line to the Lead that requested it. The processing and transportation of packages for TST done by PS is crucial to prevent Late Slams.

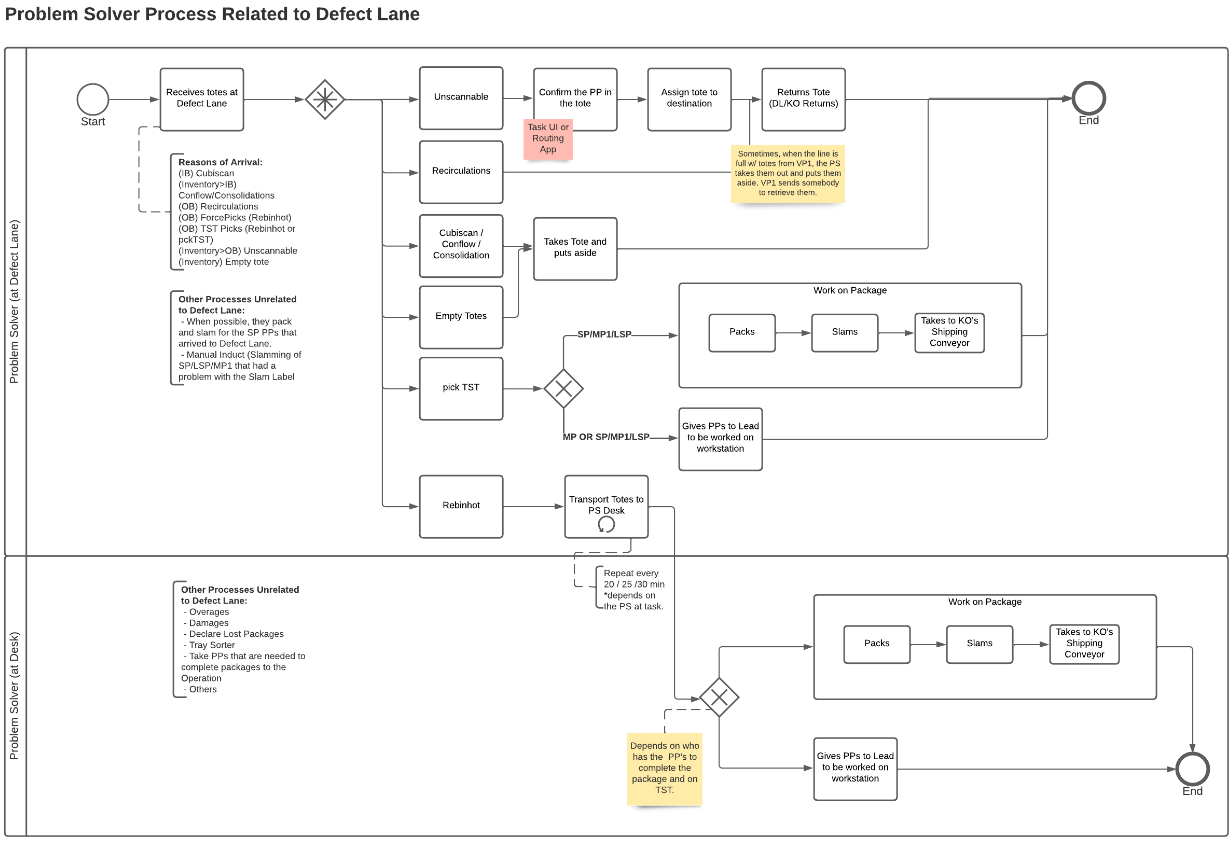


Figure 7 Flowchart of Problem Solver Process at Defect Lane

The third flowchart (Figure 8) pictures the Flow Lead processes in a linear way with some recurring activities. The Flow Lead's recurring activities can be done at different periods and several times along the shift. The activities of checking and approving plans have specific periods of execution during the shift, and this are detailed further in the Flow Lead Guideline developed further ahead in the project.

The main activities of the Flow Lead are:

- Check and Approve/Refuse OSP Plans
- Buffer Management
- Risk Management
- Coordination with RME

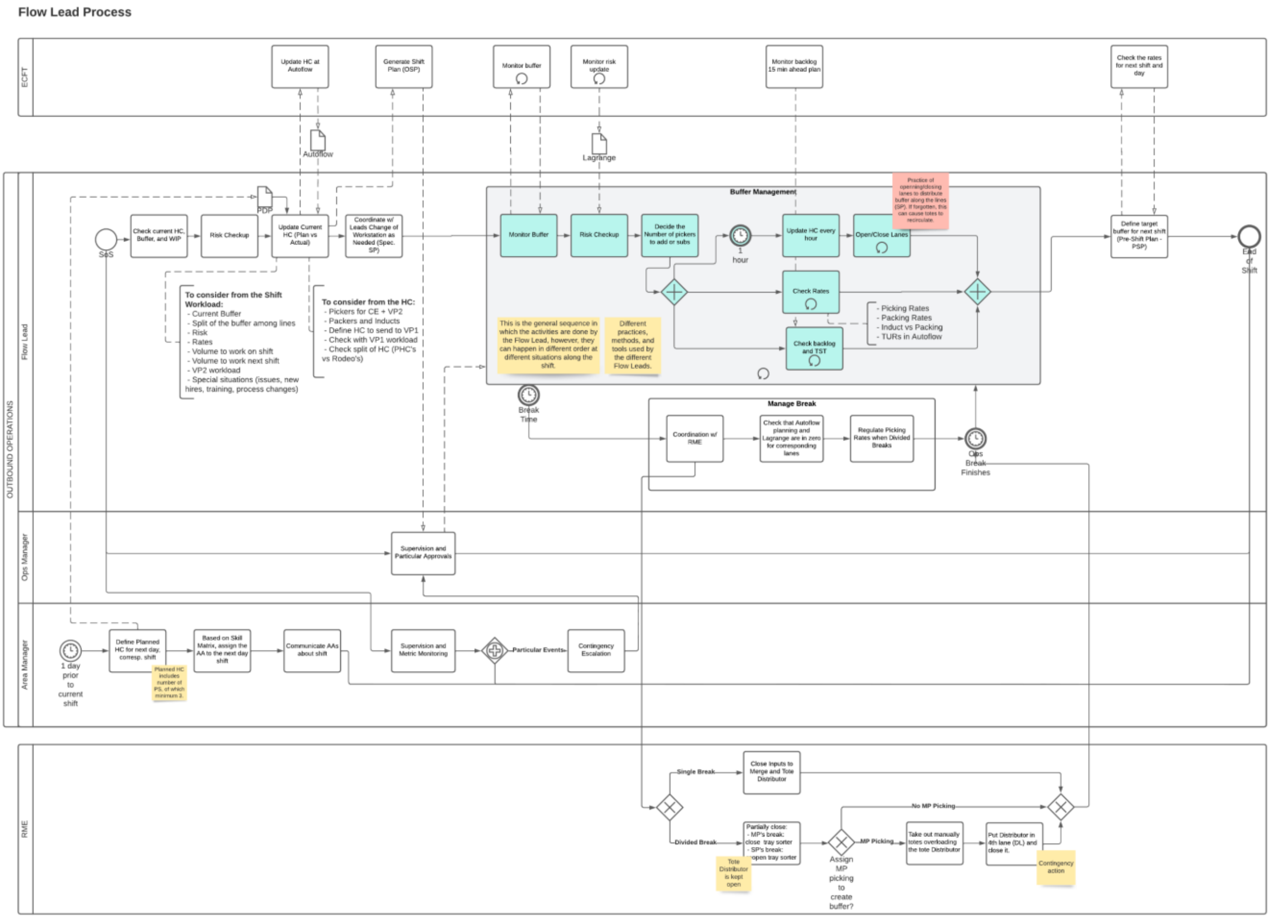


Figure 8 Flowchart of Flow Lead Processes

With the diagramming of the processes, it was possible to assess the processes' capability to meet operational-mechanical specifications, achieve KPI's and identify where improvements could be made. It was identified that the high recirculation in the Tote Distributor caused by **Lane Full** has a strong relationship with how the buffer is managed by the Flow Lead. The lanes get full depending on various characteristics: Headcount (HC) in packing and induct, rate of packers, rate of pickers, number of pickers, Total Units Required (TUR), specific events like mechanical issues, etc.

As explained, because of the dynamics of the shift, not all activities of the Flow Lead can be executed in a linear sequence. Also, each Flow Lead may use different tools to collect data and have similar but different ways of reasoning to arrive at the decision-making of the buffer management. Because of its dynamic nature it is a role that develops and changes routines constantly. It requires Flow Leads to have capabilities that allows them to be flexible, be fast decision-makers, and be right most of the time despite the uncertainty. With this and a VOC Survey done afterwards, it was proposed to build a guideline that would support Flow Leads in their everyday activities and decision-making. The purpose of the guide was to make a common source of information and give guidance in situations of uncertainty; as well as to support new Flow Leads in their training. To get a better understanding of the Flow Leads' POV and the OB team, it was made the VOC Survey.

VOC Survey

The survey was directed to the Flow Leads, AMs, OMs, PSs, and SRMETs. A summary of the results of the survey (Annex 4) reflects the next points:

- Main action taken by PS and OB team when high recirculation of Tote Distributor is to re-introduce the totes to the Tote Distributor. If the situation becomes critical, they downstack totes of the Various Packaging 2 and Various Packaging 1 processes at Defect Lane which are later retrieved.
- PS made suggestions on the redesign of the Defect Lane layout and remarked Safety issues related to the number of totes arriving to the Defect Lane, which were causing muscular fatigue due to repetitive moves (more on 3.4.5)
- The level of importance given to each activity by Flow Leads and the information needed.
- Proposed actions from OB:
  a. More communication with Various Packaging 2 and Various Packaging 1 teams.
  b. Improve buffer management at Flow.
  c. Lean management of the Medium Packaging 1 PP.
  d. Reduce time of logout or change of workstation by AAs.
- Proposed actions from RME:
  a. Balance the flow of totes to each line.
  b. Correctly coordinate when machines are left running for processing at Various Packaging 2 during breaks.

The proposed actions that resulted from the survey were selected to be included on the Improvement phase of the project, since they align to the results of the Pareto Analysis, where Various Packaging 2 and Medium Packaging 1 were two of the Top Offenders Lanes. Due to the outcomes of the VOC survey and the process mapping, it was decided upon creating a Flow Guideline that would support the Flow Lead (Section 3.5.1).

The survey also confirmed that improvements at the Various Packaging 2 and Medium Packaging 1 are needed to reduce the recirculation percentage, therefore, it was decided to dive deeper into these processes, as well as Various Packaging 1. By diving deep and understanding the root causes of the problems each process inflicts in the recirculation at the Tote Distributor, then proposals for improvements can be made and tested.

3.3 Analyze (General Project)

3.3.1 Data Collection

After the Measure Phase, a project's KPI Dashboard (Annex 5) was designed, to evaluate initial scenario, current scenario for project advancements, and final scenario with results of the project. This way, any improvement made was easier to monitor its impact on the main KPI's and in the achievement of the project's objectives.

KPI's

1. Tote Distributor Recirculation Percentage (%)
2. Recirculation Top Offenders
    a. Per Lane (%)
    b. Per Defect (%)
3. DEA
    a. Pre-SLAM, bucket:
        - Late Slam
4. Productivity and C15 Bucket of Problem Solver
    a. PS Productivity
    b. PS C15 Bucket

Additionally, it was monitored the "Arrivals at Defect Lane" in total and the number as a result of max. recirculation:

a. Total Arrivals to the Defect Lanes in a day
b. Max Recirculation Assigned to Defect Lane

The initial scenario is composed of Q3&Q4 2021, compared against a current scenario that starts from WK1 of Q1 2022. After some progress in the project, the current scenario is divided in two: WK1-WK13 and W14-WK23. The final scenario is composed of the last 3 weeks at the end of the project, WK24-WK26. The result of the overall internship project, closing on WK27, is just after Q2 2022 has ended and before the high demand week initiates. Figure 9 shows the timeline of the project and its scenarios.

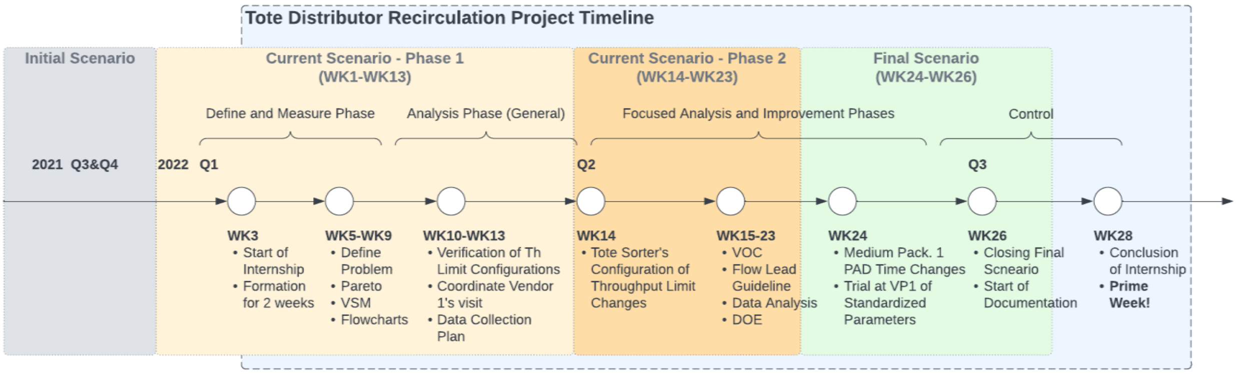


Figure 9 Project Timeline

Why these KPI's?

The KPI's are aligned to the main objective and the specific objectives.

- **KPI 1 and 2:** Diving deep into the Tote Distributor Recirculation % **(KPI 1)** and its Top Offenders Lanes and Defects **(KPI 2)**, it allowed to focus actions over the PPs where solving root causes would contribute the most to the overall recirculation % reduction; to have higher impact in less time.
- **KPI 3:** Moreover, there is a relation between the PSs productivity (which can be elevated in peak moments when the Defect Lane arrivals are constant) with the number of Late Slams Units **(KPI 3)**. High recirculation causing increase in Late Slam Units is not a causal relationship, but it is a situation that may happen altogether when lanes get full, making it more difficult to achieve SLAM in time for the Target Shipping Time (TST) over each lane and increasing the need for PS to work rebinhots, Force picks, or pickTST's **(C15 bucket – KPI 3).** In this scenario, the probabilities for totes arriving at the Defect Lane increases, increasing the labor of the PS.
- **KPI 4:** When a tote arrives to the Defect Lane, the MES records a defect called UNKNOWN classified under the Operation Type SORT_DIVERT_TO_KICKOUT. This defect gives an estimation of the number of totes that arrive to the Defect Lane, which elevates the workload of the Problem Solver at the Defect Lane. By quantifying the PSs workload caused by the recirculation it can be traced to how it affects the PSs productivity **(KPI 4)**.

  Since the recirculation provokes delays caused by Lane Full and overload of totes of different TSTs being mixed, then Leads and PS ask for Rebinhot picks. PS can also ask for FORCE picks, to be processed immediately by them. These corrective actions increase the number of Condition 15 (C15), all Rebinhot and Force Picks fall in this bucket, which is a condition attributed to PS. The C15 bucket with the PSs productivity rate makes up the Productivity of Problem Solver **(KPI 4).**

The source of information and data for measuring these KPI's are further detailed in Annex 6.

3.4 Analysis and Improve (Focused per Area)

After the results of the Measure phase and the General Analysis of the project, based on the results of the Pareto Analysis with the Top Offenders, the Analysis and Improve phases divide into focused activities per area: Operations and RME. The "Throughput Limit" is attributed to RME as a technical defect, and "Lane Full" is attributed to Operations. In this report, it is first approached the RME area with Throughput Limit, as it is a defect that affects the overall recirculation in the Tote Distributor and all lines. Then, the focus shifts to Operations, where Lane Full is approached by analyzing and improving individually the processes in each Top Offender Lane.

3.4.1 Analysis (Focused Technical - RME)

Throughput Limit

As described from the Technical As_Is, Throughput Limit was one of the main defects causing recirculation and it was due to a misconfiguration in the Tote Distributor. The defect attribution to recirculation was **38.10% at the initial situation (Q3&Q4 2021)** and this percentage increased along **Q1 2022, arriving to a 50.17% on WK1-WK13**. (Figure 10).

PROJECT KPI's DASHBOARD

1 Tote Distributor Recirc %

**Update Daily*

Q3 & Q4 2021	WK1-WK13 2022
30.01	20.51

2 Recirculation Top Offenders

**Update Weekly*

	2021 Q3 & Q4 2021			2022 WK1-WK13 2022		
Lane	% per Lane	**Defect**	% per Defect	Per Lane		Per Defect
MP1 (M0114)	29%	Lane Full	**62%**	**27%**	Lane Full	35.97%
		TH_Limit	**38%**	175786	TH_Limit	63.36%
VP2 (M0120)	13%	Lane Full	**67%**	**23%**	Lane Full	61.61%
		TH_Limit	**32%**	151199	TH_Limit	37.23%
VP1 (M0102)	16%	Lane Full	**61%**	**12%**	Lane Full	50.3%
		TH_Limit	**39%**	81345	TH_Limit	49.1%
		Lane Full	**60.53%**		Lane Full	**46.53%**
	Total (All Lanes)	TH_Limit	**38.10%**	Total (All Lanes)	TH_Limit	**50.17%**

Figure 10 Project's KPI Dashboard - Initial Situation of Tote Distributor Recirculation %

3.4.2 Improve (Focused Technical – RME)

Throughput Limit: MHE Settings Changes

When it was identified the misconfiguration of Throughput Limit at the Tote Distributor, it was confirmed with RME if this setting could be changed directly by RME department.

It was held an initial call with Vendor 1 to explain how the original design was for the Tote Distributor to make 3 *chutings* (pushes to exit) at once of totes together in a slack to the same destination (as explained in the Measure phase). If a slack of same destination had more than 3 totes together, the first 3 were to be sorted into the destination lane and the rest be redirected to the recirculation lane. However, it was identified by RME that the machine was sorting one at a time, sending everything else to recirculation. The design of 3 *chutings* is part of the parameters defined from the original machinery layout, which is based on the number of cells per minute (CPM) reading, which is converted to speed and slug length of the Tote Distributor and its takeaways (mechanical pushing devices). The throughputs settings of each lane confirmed during the As_Is Technical were capable of receiving the totes pushed at the supposed speed.

The Throughput Limit is a measure that depends on two factors: The takeaway's speed called Lane Speed (ft/min), and the length of the *chuting*, called Maximum Slug Length (in). The settings before Vendor 1's visit were:

- Lane Speed (ft/min): 159.0
- Max Slug Length (in): 30.0

After several calls with Vendor 1, it was confirmed that only Vendor 1 as the vendor is authorized to make such change in the Tote Distributor's settings. Therefore, it was coordinated in collaboration with RME, a visit from the vendor to verify the current behavior of the machine and explain the problem.

Vendor 1 Visit

On April 4th, 2022, the Vendor 1 Engineer visited the site, and after explaining the situation and checking and verifying the machine's settings, did the modifications on the system according to the calculations required to change the Throughput Limit (only known by Vendor 1, calculations are not to be known by Amazon).

The settings changed by Vendor 1 were:

- Lane Speed (ft/min): 179.0
- Max Slug Length (in): 59.1

The length was changed from 30 to 59.1 in (+29.1 in). The speed of the takeaway was changed from 159 to 179 ft/min (+20 ft/min). These parameters are changed based on a calculation, not decided randomly. The new configurations changed the Throughput Limit of *chutings* from 1 to 3 (when totes in slack are together), Annex 7 shows the settings before and after changes.

A trial was done at 15:45, marking eleven totes with red and white tape across, introducing them to the Tote Distributor through the DL altogether. When they arrived at the Merger, 9 totes in line went together to the Tote Distributor (slack shown in Annex 8). All these totes were assigned the Defect Lane as destination. When arriving to the M0121 (Defect Lane exit), the *chutings* done by the takeaway were {3Y – 1N – 1Y – 1N – 1Y – 2N}, i.e. {3 Diverted Successfully - 1 NOT diverted - 1 Diverted Successfully - 1 NOT diverted - 1 Diverted Successfully - 2 NOT diverted}. In total, 5 were diverted successfully to DL and the 4 NOT Diverted successfully to Defect Lane and were sent to recirculation.

As was expected from the changes, the takeaway did the first three altogether *chutings*, and then did 2 additional interval *chutings*, because the machine tries to maximize its performance. The inputs of Slug Length and Lane Speed are parameters that are not measured in number of totes, but for simplicity of this report, they are translated to the number of totes it is capable to chute until its Throughput Limit.

At the end of the trial, some remarks about the machine operation and its settings were clarified with Vendor 1 (Annex 9). Important to remark is that the settings for throughput limit of the Tote Distributor either to make more or less *chutings* should not be done, the machine has been designed in a way that it can handle different workloads. The Tote Distributor makes changes actively on its velocity according to the number of lines that are physically open (done by RME), even when lanes are virtually closed (done by Flow Lead); i.e., if they are more lines are open, the higher is the velocity and vice versa. Therefore, it is not necessary to do adjustments to the Tote Distributor settings before or during high demand seasons. After investigating with Vendor 1 Engineer why the settings were not adjusted correctly, it was found that the changes done to the Tote Distributor from the supposed design were done in August 2018 (over 3 years ago from the time of the project).

After the changes made by Vendor 1 Engineer, it was agreed to monitor the ongoing of the Tote Distributor and results of Throughput Limit as defect causing recirculation for the next week to confirm if the changes had a positive effect.

Results

Tote Distributor Recirculation %

According to Quality's IS, the day of the changes made, the Tote Distributor's recirculation % was **15.56%** (Figure 11 and Graph 3).

The [redacted] - **Tote** [redacted] **Recirc %** in [redacted] **2022-04-04** was **15.5558**

Description: Calculated as (Totes Recircing / Total Throughput Totes)

Threshold: Green: between 0.0 and 10.0 | Yellow: between 10.0 and 15.0 | Red: above 15.0

Comments:

[redacted]

[redacted] on April 5, 2022 at 4:37 AM — on Apr 5

Total totes affecting Recirc. during D-1: 4057

Issue: Main buckets causing Tote Sorter Recirc. due to lane full occurrences are:

Various Packaging 2
1) [redacted] with 2219 occurrences accounting for 54.7%
2) [redacted] with 915 occurrences accounting for 22.6%
Single Medium Packaging

The above buckets account for 77.3% of Tote Sorter Recirc.

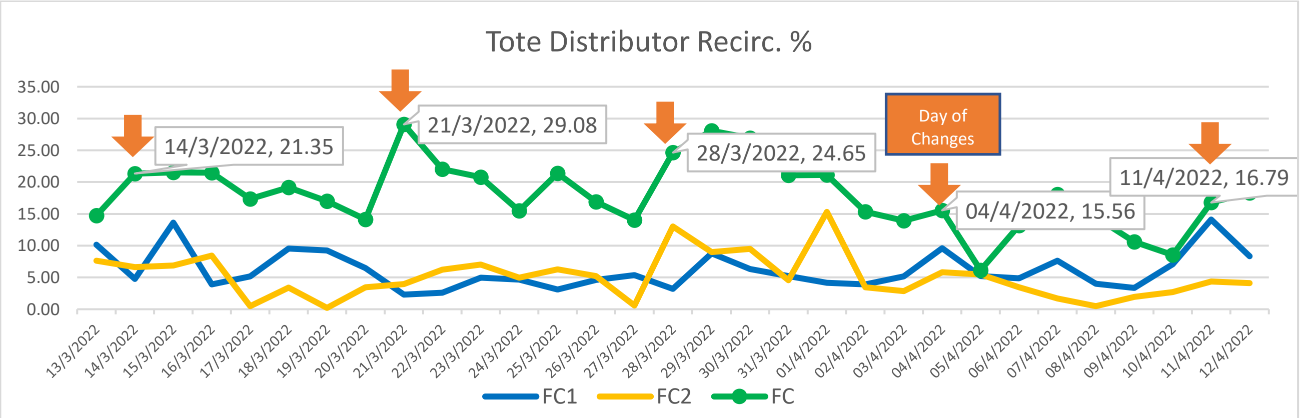
RC:
1&2) Mismatch between planned and real TUR. Issue caused unexpected volume of totes routed to the [redacted] and [redacted] lanes.
Single Medium Packaging — Various Packaging 2

Actions:
Various Packaging 2
a) Improve Flow team ability to manage [redacted] TUR on new guidelines flow related shared by Ops team.
b) Share guidelines among Ship teams for both Palletizer destinations management and Flow related topics with focus on buffer management.
c) Enhance Flow team ability to manage [redacted] TUR accuracy checking with EUCF
Single Medium Packaging

Owner: OB Oms

ETA: a-b-c) Done

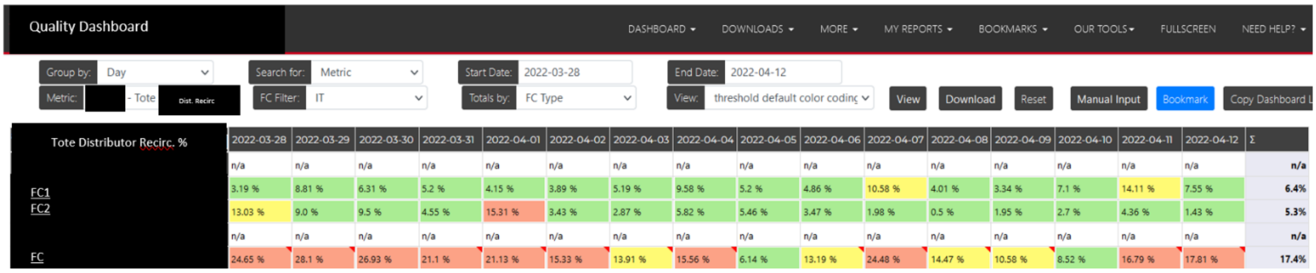
Figure 11 Quality's IS – Quality's IS Report in Tote Distributor Recirculation % KPI, 04.04.2022



Graph 3 Tote Distributor Recirculation % (2022.03.13 - 2022.04.12)

Marked in orange on Graph 3 are the recirculation values for Mondays of the previous 3 weeks plus the day on which changes were made (Monday, April 4th, 2022), and the next Monday, April 11th, 2022.

On WK 14 (2022.04.04 until 2022.04.10) **the average Tote Distributor Recirc % in FC** was **12.36%,** accounting for a reduction of **8.15%** from previous week's average of **20.51**% (WK1 to WK13: 2022.01.01 till 2022.04.03). For the first time, **Tote Distributor Recirculation %** presented green results in the Quality's IS Report on days when the values were as low as **6.14% on April 5th** (Figure 12).


Quality Dashboard
DASHBOARD ▾ DOWNLOADS ▾ MORE ▾ MY REPORTS ▾ BOOKMARKS ▾ OUR TOOLS ▾ FULLSCREEN NEED HELP? ▾
Group by: Day | Search for: Metric | Start Date: 2022-03-28 | End Date: 2022-04-12
Metric: [redacted] - Tote Dist. Recirc | FC Filter: IT | Totals by: FC Type | View: threshold default color coding
View | Download | Reset | Manual Input | Bookmark | Copy Dashboard L

Tote Distributor Recirc. %	2022-03-28	2022-03-29	2022-03-30	2022-03-31	2022-04-01	2022-04-02	2022-04-03	2022-04-04	2022-04-05	2022-04-06	2022-04-07	2022-04-08	2022-04-09	2022-04-10	2022-04-11	2022-04-12	Σ
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FC1	3.19 %	8.81 %	6.31 %	5.2 %	4.15 %	3.89 %	5.19 %	9.58 %	5.2 %	4.86 %	10.58 %	4.01 %	3.34 %	7.1 %	14.11 %	7.55 %	6.4%
FC2	13.03 %	9.0 %	9.5 %	4.55 %	15.31 %	3.43 %	2.87 %	5.82 %	5.46 %	3.47 %	1.98 %	0.5 %	1.95 %	2.7 %	4.36 %	1.43 %	5.3%
	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
FC	24.65 %	28.1 %	26.93 %	21.1 %	21.13 %	15.33 %	13.91 %	15.56 %	6.14 %	13.19 %	24.48 %	14.47 %	10.58 %	8.52 %	16.79 %	17.81 %	17.4%

Figure 12 Quality's IS - Quality's Report, Tote Distributor Recirc % KPI (2022.03.28 - 2022.04.12)

As predicted, the Top Offenders defects that caused recirculation: Lane Full and Throughput Limit, have changed their portion values of contribution on the overall recirculation percentage. **Throughput Limit** contribution percentage has been reduced from **50.17% to 8.11%, Delta: - 83.8%.** The Initial Situation is average from WK1 to WK13 (Q1 2022), before setting changes (Figure 13).

1 Tote Distributor Recirc %

**Update Daily*

WK1-WK13 2022	WK14	WK15 (DOW)
20.51	12.36	12.85

2.1 Recirculation Top Offenders

**Update Weekly*

Lane	(Before Changes) WK1-WK13 % per Lane	Defect	% per Defect	After Changes WK14 Per Lane	Defect	Per Defect	WK15 (DOW) Per Lane	Defect	Per Defect
MP1 (M0114)	27%	Lane Full	35.97%	24%	Lane Full	78.89%	20%	Lane Full	90.08%
	175786	TH_Limit	63.36%	8366	TH_Limit	20.76%	3598	TH_Limit	9.56%
VP2 (M0120)	23%	Lane Full	61.61%	32%	Lane Full	86.04%	51%	Lane Full	93.95%
	151199	TH_Limit	37.23%	11111	TH_Limit	12.20%	9162	TH_Limit	6.01%
VP1 (M0102)	12%	Lane Full	50.3%	4%	Lane Full	90.9%	1%	Lane Full	95.3%
	81345	TH_Limit	49.1%	1425	TH_Limit	8.4%	254	TH_Limit	3.9%
	Total (All Lanes)	Lane Full	46.53%	Total (All Lanes)	Lane Full	82.22%	Total (All Lanes)	Lane Full	91.13%
		TH_Limit	50.17%		TH_Limit	13.74%		TH_Limit	8.11%

Figure 13 Project's KPI Dashboard - Before and After MHE Changes

Productivity

Problem Solver's productivity was improved and the median of the C15 bucket dropped for the weeks after changes (WK14 and WK15) as shown in Figure 14 and Figure 15, from a **median of 93.32 to a median of 67.38**. **Delta: -27.8%.**

2021 Q3-Q4

OB Problem Solver	Q3	Q4
PS Volume	29,799,215.00	32,203,499.00
PS Labor Hours	13,010.19	15,940.75
PS Rate	2,290.45	2,020.20

C15 Problem Solve	Q3	Q4
Max	258.78	349.73
Min	19.50	3.00
Average	96.34	108.88
Median	91.59	104.32

2022 WK1-WK13 (Before Changes)

Q1	WK1-WK13	Q1 2021
27,086,639.00	26,091,430.00	30,110,741.10
10,340.28	9,967.25	11,612.89
2,619.53	2,617.72	2,592.87

Q1	WK1-WK13	Q1 2021
	242.79	398.12
	3.00	26.77
	90.93	126.97
	93.32	126.07

WK14-WK15 (After Changes)

Q2	WK14-WK26	Q2 2021
20,565,287.00	4,376,303.00	35,183,851.11
7,541.86	1,489.55	12,215.47
2,726.82	2,938.00	2,989.93

Q2	WK14-WK26	Q2 2021
	167.10	363.54
	16.20	0.49
	70.65	111.22
	67.38	106.5

Figure 14 KPI Dashboard – PS Productivity Before and After MHE Changes

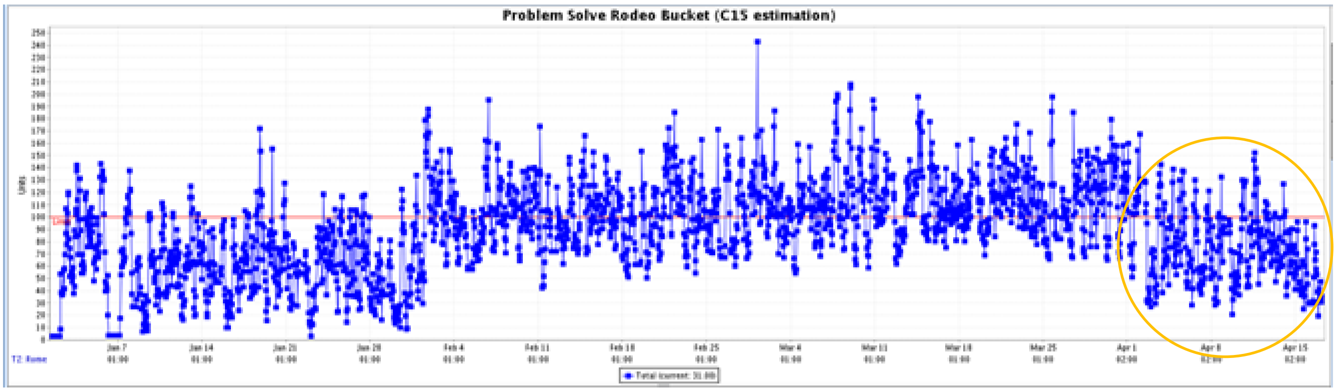


Figure 15 Problem Solver Rodeo Bucket C15 (WK1-WK15)

Comparing the productivity of OB among the week previous to changes, week of changes, and one week after changes (WK1-WK13 vs WK14-WK15), it has not been affected. There is an increase in the TPH to plan percentage by 5%, it is still over 100% (Figure 16).

2021 Q3-Q4

OB Productivity	Q3	Q4
Planned		
TPH	65.10	60.05
Actual		
TPH	67.85	61.12
% to Plan	104.23%	101.79%

2022 WK1-WK13 (After Changes)

Q1	WK1-WK13	Q1 2021
Planned		
72.32	69.93	
Actual		
67.36	74.23	
107.36%	106.14%	

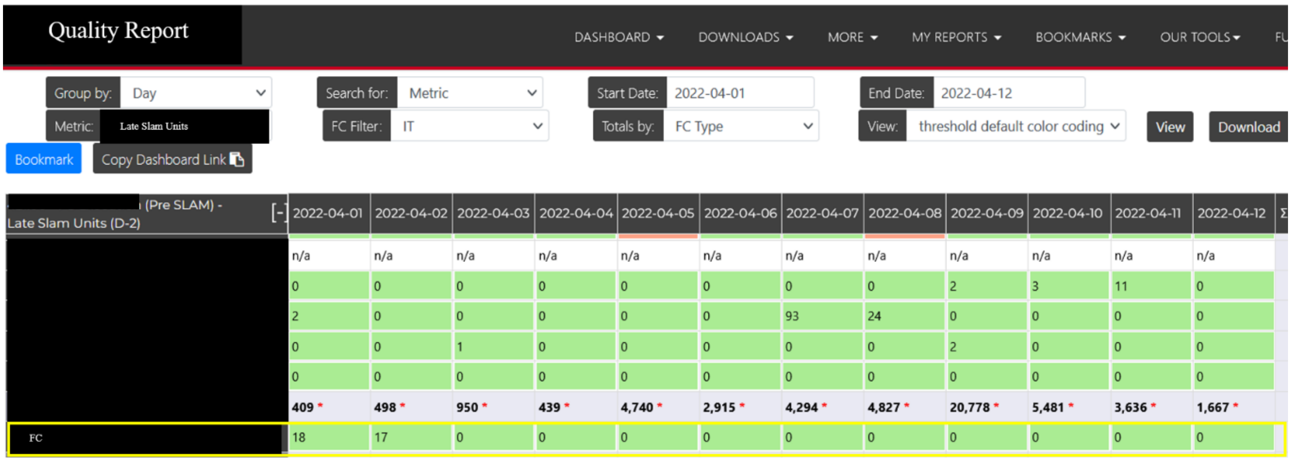
WK14-WK15 (After Changes)

Q2	WK14-WK26	Q2 2021
Planned		
72.97	72.62	
Actual		
73.09	81.13	
100.16%	111.73%	

Figure 16 KPI Dashboard - OB Productivity Before and After MHE Changes

DEA

The Pre-SLAM DEA has presented 0 Late Slam Units misses over Quality's IS Report after the changes done on Monday, April 4th, 2022 (Figure 17).



[redacted] (Pre SLAM) - Late Slam Units (D-2) [-]	2022-04-01	2022-04-02	2022-04-03	2022-04-04	2022-04-05	2022-04-06	2022-04-07	2022-04-08	2022-04-09	2022-04-10	2022-04-11	2022-04-12
[redacted]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	0	0	0	0	0	0	0	0	2	3	11	0
	2	0	0	0	0	0	93	24	0	0	0	0
	0	0	1	0	0	0	0	0	2	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
	409 *	498 *	950 *	439 *	4,740 *	2,915 *	4,294 *	4,827 *	20,778 *	5,481 *	3,636 *	1,667 *
FC [redacted]	18	17	0	0	0	0	0	0	0	0	0	0

Figure 17 Quality's IS – Quality's Report, KPI: (Pre-SLAM) "Late Slam Units" (2022.04.01 - 2022.04.12)

The results of the Throughput Limit improvement had a major impact in the overall recirculation of the Tote Distributor. Throughput Limit was no longer the Top Offender but was monitored constantly during the rest of the project. After this improvement, the focus shifted towards specific solutions per Top Offenders Lanes with the defect Lane Full in sight.

3.4.3 Analysis (Focused Operational)

Lane Full

After solving the Throughput Limit in the Tote Distributor, the focus for improvement shifted towards Lane Full defect. The approach to improve the defect was to take each Top Offender Lane individually to analyze root causes, propose solutions, and test them.

Recirculation Top Offenders Lanes

From the Pareto Analysis, it was defined the Top Offenders Lane for recirculation were:

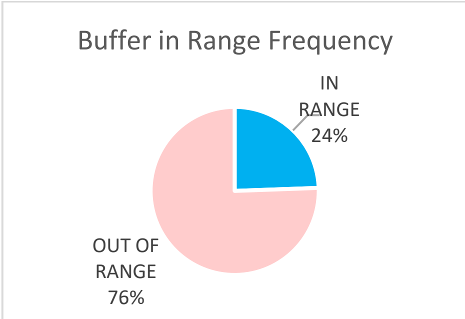
- M0114 – Medium Packaging 1 (29%)
- M0102 – Various Packaging 1 (16%)
- M0120 – Various Packaging 2 (13%)

To identify root causes, it is needed to analyze the Top Offenders Lanes (Various Packaging 2, Various Packaging 1, and Medium Packaging 1) individually and focus the attention on how those root causes can be solved in each lane to achieve an overall improvement in the recirculation percentage.

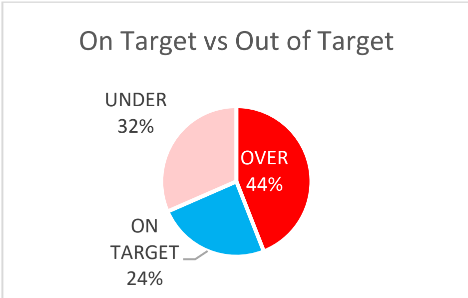
Medium Packaging 1

% of Buffer in Target

It was perceived at the Flow that the Medium Packaging 1 PP was the most sensitive to changes when managing the buffer, it usually oscillated over and under the buffer target. To quantify it, the percentages of the times the buffer were in target and out of target were taken daily, taking historical data of the previous day, in 5 minutes periods, and aggregating it to a data base of the Medium Packaging 1 buffer. For Q1 2022, Medium Packaging 1's average "buffer in range" frequency was 24% and average "out of range" frequency was 76% (Graph 4), of which 44% was "over" the limits and 32% "under" the limit (Graph 5).

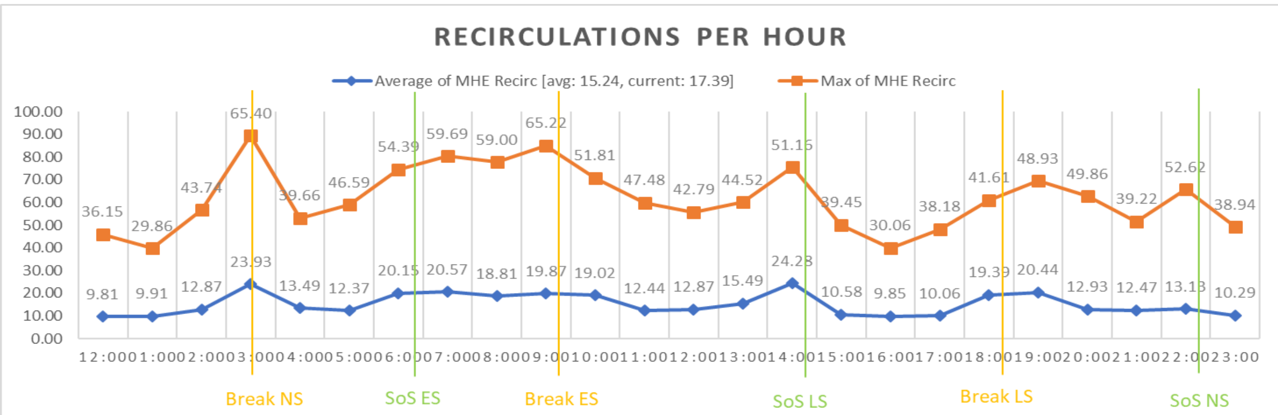


Graph 4 Buffer in Range Frequency (Q1 2022)



Graph 5 Buffer on Target vs Out of Target (Q1 2022)

Additionally, it was analyzed the most recurring recirculation periods along the shifts, and it was found that the recirculation is higher in changes of shifts and after breaks (Graph 6 and Figure 18). A reason for recirculation to increase at Start of Shift (SoS) is due to the practice at Flow to increase the buffer so that the next shift has enough WIP. This is a phenomenon most common at the SOS of the LS at 14:30, when there are more near TST's to comply, from 15:45 till 18:45 (Figure 16).



Graph 6 Recirculation per Hour

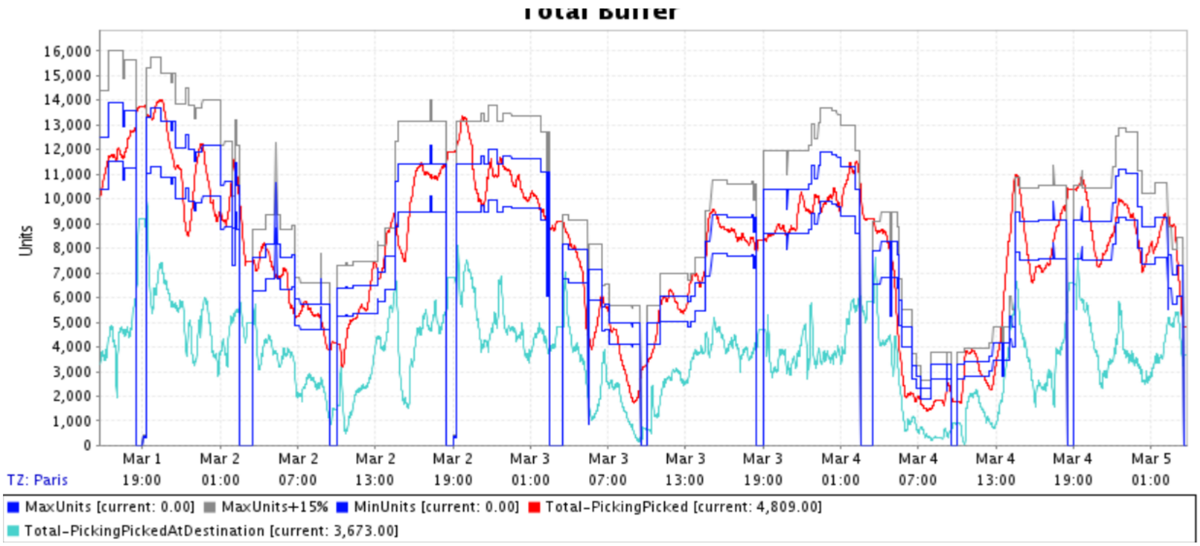


Figure 18 Total Buffer Example (2022.03.01 - 2022.03.05)

Figure 19 TST's in the LS

This phenomenon affects the most Medium Packaging 1, since it is a PP of low UPT, and it has been identified as a PP with a different Processing PAD Time (Picking) from the rest of the PPs. In the section 3.4.4, Medium Packaging 1 it is explained how this property affects differently the PP from the rest and why it was the focus for improving the PP's performance that would reduce the recirculation caused by its line.

<u>Various Packaging 2</u>

MHE and Robotic Palletizer Properties

Certain MHE Properties need to be evaluated and obtain metrics that will give a clearer look into the situation of the MHE components at Various Packaging 2. These metrics can be obtained from OEE (RME's monitoring tool). OEE measures Performance, Availability, and Quality percentages which allows to measure the OEE.

The Various Packaging 2 has a series of causes for which the Robot Palletizer gets stopped frequently and delays overall production for TST's. Through data analysis and observation of March 2022 values, it has been identified an average of **15.53% Downtime** of the Robot Palletizer due to recirculation at Palletizer, with totes being sent out to Recirculation Lane (Table 6). This contributes to the Robot Palletizer's **Starvation %, which is 47.36%.**

Table 6 MHE Properties (March 2022) - Various Packaging 2's Robot Palletizer and Induct

	Average of OEE	Average of Q (%)	Average of P (%)	Average of A (%)	Average of Production (%)	Average of Downtime (%)	Average of Starved (%)
Robot Tote Handler - Induct	24.41	73.60	46.42	77.46	34.52	22.54	35.61
Robot Tote Handler - Robot	27.40	99.57	33.20	84.46	27.53	**15.53**	**47.36**

Various Packaging 1

TUR's and BL's (Planned at SoS)

The Various Packaging 1 has several PPs with very different defined processes, properties, and volumes. Due to the variability of work, the calculation of TUR and Batch Limit (BL) at the SoS can be difficult, the Leads may have different ways of calculating them based on their experience at the Various Packaging 1, the HC available for work, and the PPs needed to be worked for the shift. The PPs to be opened with their TUR and BL (if applicable) are communicated to the Flow Lead who communicates it to the European Central Flow Team (ECFT) to be set in the PPs properties in the system.

A challenge is to get historical data of the TUR and BL defined by the Leads at the SoS. Also, it is a limitation that the Various Packaging 1's line is short, but currently it is not an option to make the conveyors longer.

3.4.4 Improve (Focused Operational)

Medium Packaging 1

Process PAD Time Effect Over Medium Packaging 1 at FC

Medium Packaging 1 was a volatile PP, very susceptible to changes for line balancing done as part of the buffer management by the Flow Lead. As explained before, the Medium Packaging 1 PP had a different Processing PAD Time from the rest of the PPs. By diving deep, it was found that Medium Packaging 1's PAD time was 4 hours whereas for the rest it was 3 hours. Each PP has its own properties configured, including this PAD time, so the company's MES and ERP software can assign picking efficiently. The PAD time can be different among PPs and depends on process, rates, mechanical characteristics, and more.

By diving deep, it was found that this difference in the property caused the changes done from Flow (for example: adding pickers) had an initial impact over Medium Packaging 1, before the rest of the PPs. Since Medium Packaging 1 had one hour more as PAD time, it prioritized the PP before the rest in the assignment of picking, following the rules of Chasing explained in Annex 10. Hence, it was more difficult for the Flow Lead to manage Medium Packaging 1 with respect to the rest of the PPs.

The line tended to full when changing shifts, specially from ES to LS (Annex 11). Because of the next TSTs after the SOS (SOS at 14:30 and next TSTs are 16:45, 17:15, 17:45, 18:45, 21:00 –Figure 20) and the Flow's practice to elevate the total buffer for next shift delivery, this line was the one that fill faster than the rest, causing recirculation in the Tote Distributor.

Medium Packaging 1

Planned	Total	Earlier Total	Range Total	Apr 8 10:00	12:00	12:4	13:45	16:45	17:15	17:45	18:45	21:00	21:30	22:00	23:55	Late Tota
Planned Subtotal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 20 TST LS for Medium Packaging 1

Because of this PP's "Process Padding Time", the picking became more aggressive when it was near the 4 hours before the TST, in this situation the TST of 18:45 picking turned more aggressive since 14:45, the one of 17:45 since 13:45 and so on. This effect of PAD time and chasing is better described in the diagrams in

Annex 10. There is no confirmed reason for why this PP had a different PAD time, but it was believed that it was configured as a default setting at the time the line was installed, which was the newest one with respect to the rest PPs.

An AM from ECFT was contacted to discuss the topic, who recommended to speak with a Senior Process Engineer at the ECFT. Discussing with this ECFT SPE, several doubts were clarified, and it was presented how other inputs of the system did not affect directly on the peaks phenomenon. This contact suggested to get the review from a Subject Matter Expert (SME) of Picking.

Before discussing further with the SME Picking, it was taken a sample by analyzing the phenomena on a random day of the week during the change from ES to LS, this was detailed in a report done to the SME Picking, which for confidentiality reasons cannot be shown. The analysis, reasoning, and proposal to make a trial by changing the PAD time from 4 hours to 3 hours was presented to the SME Picking. He agreed that the analysis was clear, correctly dived deep, and approved the changes for the trial. The changes were done on the 13.06.2022 (WK24).

Results

The changes on the Medium Packaging 1 PP to the property "Processing Padding Time" of Picking were done on 2022-06-13 4:42:52 PM (UTC+02:00) by the SME Picking. The changes were on Monday, June 13th, 2022, at the beginning of WK24, therefore, the parameters to measure before and after changes are based on this starting point. For the Design of Experiments (DOE), the **"before changes scenario"** is defined as WK23 and the scenario **"after changes scenario"** is defined as WK24.

The results were monitored over the next week after the changes, and were as follows (Table 7):

- Lower **Average Tote Distributor's Recirculation**, **7.56% lower** on WK24 vs WK23 and **9,013 less occurrences**.
- Lower volume of **recirculation contributed to Medium Packaging 1 PP**. (Maintained 15% of contribution but occurrences reduced: **from 5,040 occurrences to 3,860 occurrences. (Delta: -1,180, -23.4%**)
- The **productivity of Medium Packaging 1** was stable (WK23 with rate 217.16 UPH vs WK24 with **rate 226 UPH**)
- **Late slam units** were kept on check, with none been attributed to Medium Packaging 1 after the changes. *Late slam units were reduced during the time of the trial, but it cannot be attributed directly to the changes done over the PP's property.
- The buffer peaks remained the same**, buffer was 24%** in range for both scenarios.

Table 7 Summary of Results: Medium Packaging 1 Trial

	KPI	Specific KPI	WK23	WK24	WK Δ
1	Recirculation % Tote Distributor	%	18.83%	11.27%	-7.56%
		Occurrences	34,409	25,396	-9,013
2	Recirculation % Medium Packaging 1	%	15.0%	15.0%	0.00
		Occurrences	5,040	3,860	-1,180
3	Productivity	MP1 Packing Rate	217.16	226	9.25
		MP1 Packing Volume	109,277	159,004	49,726
		OB PS Rate	2,380.10	2,756.67	376.57
		C15 Median	68.31	74.75	6.44
4	DEA Pre-SLAM	Late Slam Units	287	59	-228.00
5	Buffer	In Range	24%	24%	0.00
		Out of Range	76%	76%	0.00

Despite of the recirculation % contribution of Medium Packaging 1 between both scenarios staying the same (15%), the number of occurrences of recirculation reduced by **1,180 (only Medium Packaging 1),** a **23.4%** reduction from previous week's occurrences.

The performance of the PP was monitored for the rest of the project's duration, for more detailed information and daily values, refer to the DOE (Annex 12).

Various Packaging 1

Parameters Standardization

The Various Packaging 1 area is usually opened when the production of CE is on target. Labor moves of AAs happen, and a Lead is assigned to the Various Packaging 1 to manage it while open. One of the main tasks to do when opening the VP1 processes, is defining the Total Units Required (Planned) (TUR) and Batch Limit (BL) per process. The Lead defines them and requires the Flow Lead to check them. Then Flow Lead requires the indicated values to be configured in the system by the ECFT's Process Control Specialists (PCS).

Engaging with several Leads and AM's, it was found out that the Leads have different ways of defining these values. The results depend on the know-how of the Lead, their experience in Various Packaging 1, and how they were trained in Various Packaging 1 processes.

The line of the Various Packaging 1 coming from the Tote Distributor is physically short, it has a physical capacity of approximately 53 totes (measured with RME). Due to the shortness of the Various Packaging 1's MHE, it gets full easily, especially when an elevated number of items are picked from Inventory Storage for the Various Packaging 1 processes. When the TUR and BL are too high or are configured in a non-optimal combination of values, the line will get full, and the totes start to recirculate (Figure 21).

Moreover, when looking at the picking volumes of the hour before full lane happens, the numbers elevate considerably. This is due to the configured TUR and BL, and the system's prioritization algorithm, which prioritizes CE over Various Packaging 1 processes. When CE is under control and the next pickings are for further TST's, the MES will make a sudden high-volume picking assignment to Various Packaging 1 processes if the TUR and BL are set very high.

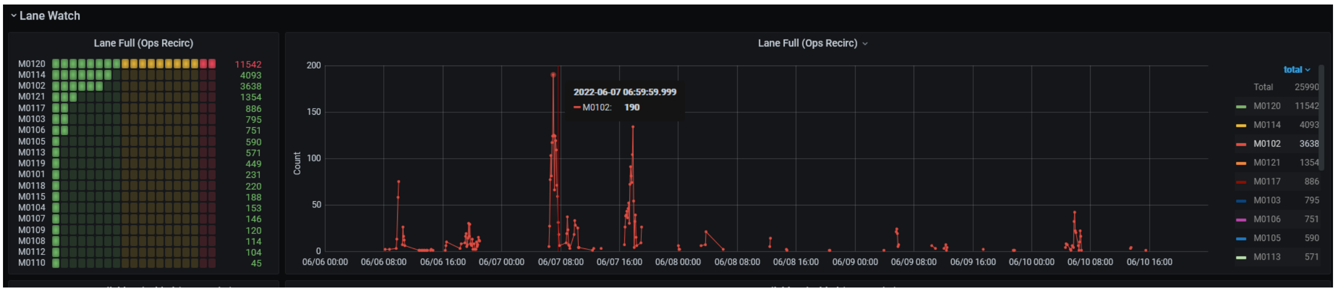


Figure 21 Lane Full in Various Packaging 1 (Grafana, 2022.06.02 – 2022.06.10)

Parameters Investigation and Definition

Major information was needed to understand how to start to define a standardized method to calculate TUR's and Batch Limits (BL) that would be functional to Various Packaging 1 - FC. Investigation included:

- Engaging with local Leads and AM's,
- Benchmarking with other sites (included having a call with an FC2's AM)
- Consulting ECFT PCS for materials they would recommend or could provide on Various Packaging 1 management from Flow's POV
- Internal knowledge database research.

The results of the overall investigation and analysis are explained by segmenting TUR, BL, and Tote Limit.

After doing benchmark with FC2, the AM suggested to check their Various Packaging 1 guidelines at the internal knowledge database that their team have built, where a method for defining TUR has been defined. Part of their practices were taken for the guidelines of how to open Various Packaging 1 and calculate the TUR. The steps to calculate the Various Packaging 1's parameters were defined and verified; these can be consulted in the Flow Lead Guidelines (Annex 17).

Resulting Standardized Parameters

Summarized, the parameters standardized are Equations (2), (3), and (4):

TUR: $$TUR\ required = (Target\ WIP - Current\ WIP) + (Pack\ Rate * HC) \quad (2)$$

Batch Limit: $$Batch\ Limit\ (BL) = \left(\frac{TUR}{UPB}\right) * Cycle\ Time \quad (3)$$

Tote Limit: $$Tote\ Limit\ = TUR\ * \ target\ WIP\ (in\ hours)\ * \ 150\%\ /\ UPT \quad (4)$$

*The 150% multiplier is somewhat arbitrary and is based on how much higher than the target you may get before having execution issues.

*UPB: Units per Batch. The values to calculate UPB are taken from PickingConsole (internal application), and it is calculated as, (Equation (5)):

$$UPB = \frac{Units\ in\ container}{Batch\ Count} \quad (5)$$

Tote Limit can also be calculated by using the mechanical capacity of the line, (Equation (6)):

$$Tote\ Limit = [mechanical\ capacity\ per\ line * number\ of\ lines\ in\ use] + [number\ of\ pickers * totes\ per\ picker] + approximate\ totes\ in\ transit \quad (6)$$

For Various Packaging 1 at FC* (Equation (7)):

$$Tote\ Limit = [53 * 1] + [40 * 2] + 56\ (estimated) = 149\ (estimated) \quad (7)$$

How this value was estimated:

- ***Mechanical capacity per line***: 53
  *Measured with RME the mechanical capacity for totes over the Various Packaging 1 line conveyor, resulting in 53 totes.
- ***Number of pickers:*** average of 40
- ***Totes per Picker*: 2**
  *Assuming 2 spaces for Various Packaging 1 totes at pick stations in Inventory Storage
- ***Approximate totes In Transit*: 56 totes**
  *Considering that it takes 11-14 min for totes to arrive from Inventory Storage to Tote Merger+Distributor and a wrangler can work in 15 seconds a tote in buffer, then the arrival to the lane is of 4 totes per minute, 56 totes in 14 min.

This calculation is just for the Tote Limit from the moment in which a picker starts working a tote for a Various Packaging 1 PP, until the totes arrive over the lane at Various Packaging 1. It **DOES NOT** include totes in buffer. To include totes in buffer, sum it to Equation (6) as follows (Equation (8)):

$$Tote\ Limit = [mechanical\ capacity\ per\ line * number\ of\ lines\ in\ use] + [number\ of\ pickers * totes\ per\ picker] + approximate\ totes\ in\ transit + [number\ of\ buffers * totes\ per\ buffer] \quad (8)$$

The first formula is used in Amazon North America, while the first one is used in Amazon Europe. It was decided to keep Europe's formula as the standard for measuring Tote Limit for Various Packaging 1 PPs at FC, but the second formula's result serves as a suggested threshold (cap) to not be surpassed for Tote Limit.

<u>*Testing and Verifying*</u>

To make it easier for Leads to make these calculations and to ensure every Lead follows the same process, an Excel file was created, with clear instructions of the data needed as inputs, the source of these data, and the results calculated automatically (Annex 13).

The use of the file and the calculation of the parameters as described were tested during WK24 to ensure that the results were feasible for productive work at the Various Packaging 1 and recirculation of totes arriving to the line was kept under control. The trial was done during the ES of WK24 and feedback was requested from each Lead that worked at Various Packaging 1 during the trial. The only deviation identified was occasional situations in which the buffer was being consumed more rapidly by the packers than the rate of arrival to the line. This was corrected by increasing the Target WIP which increased the TUR requested. If BL changed as well, it was requested its change to the Flow.

Results

The results were monitored over the next week after the changes, and were as follows (Table 8):

- Lower **Average Tote Distributor's Recirculation** by **6.91% lower** and **10,463 less occurrences** from WK23 to WK26.
- On the first week of trial (WK24), lower volume of **recirculation contributed from Various Packaging 1 PP**
    - **From 12% to 8% contribution, Delta: -4%,**
    - Occurrences reduced **from 4,105 occurrences to 2,049 occurrences. Delta: -2,056, -50%**
- By WK26 (vs WK23), the contribution increased by +1%, however, with less occurrences **(Delta: -10,463, -30%).**

Table 8 Summary of Results: Various Packaging 1 Trial

	KPI	Specific KPI	WK23	WK24	WK25	WK26	Δ WK23 vs WK26
1	Recirculation % Tote Distributor	%	18.83	11.27	15.99	11.92	-6.91
		Occurrences	34,409	25,396	38,113	23,946	-10,463
2	Recirculation % Various Packaging 1	%	12.0%	8.0%	8.7%	13.0%	+1%
		Occurrences	4105	2049	3307	3163	-942.00

The performance of the PP was monitored for the rest of the project's duration, for more detailed information and daily values, refer to the DOE (Annex 12).

3.4.5 Other Improvements

Tracking Error Defect

Tracking Error defect became a main concern as a share of the Technical Impact over the recirculation in the Tote Distributor, during the months of April-May 2022. The data from 08.05.2022 presents 508 occurrences (Figure 22) and attributed a 15.97% (Figure 23) to recirculation, among all attribution of both Operational and Technical defects.

Figure 22 Grafana Dashboard (08.05.2022)

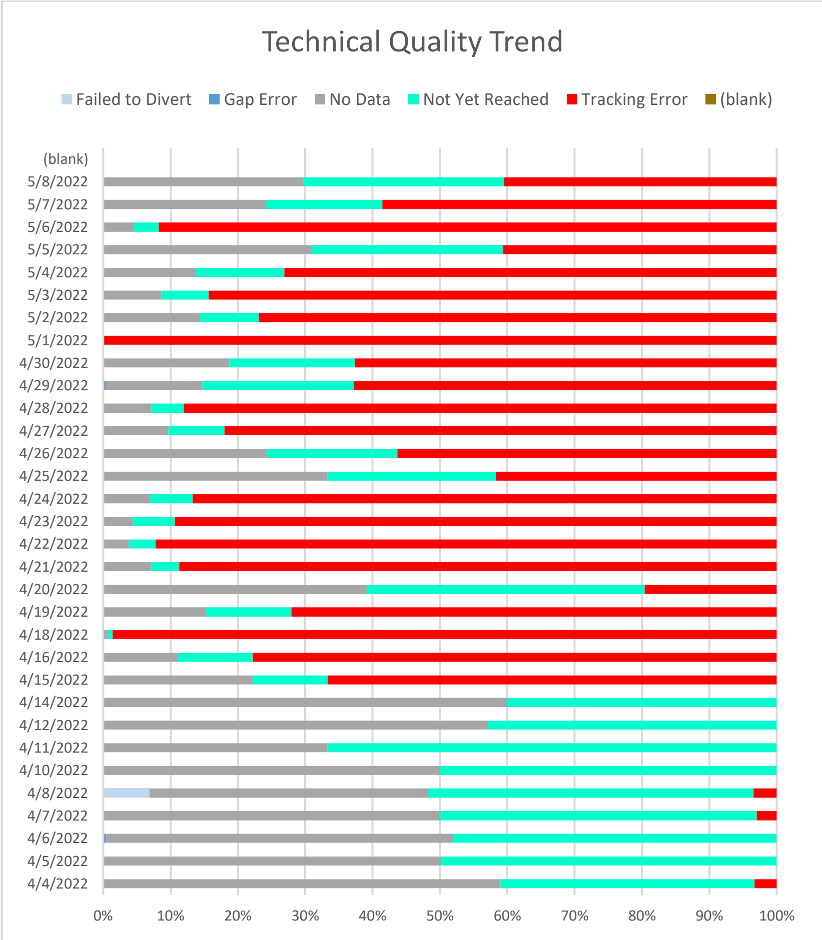
Efficiency - Split by causes

site	equipment	date: May 8, 2022 Gap Error	Failed Div	Lane Full	LNO	Lane Unav	No Data	Thr Lim	Track Err
FC	SHIP SORTER	3.38	0.05	83.21	12.86	0	0.51	0	0
	Tote Distributor	0	0	56.05	0	0.5	11.73	4.05	15.97
	TRAY SORTER	1.7	0.09	67.1	0	1.42	0.13	28.43	0.98

Figure 23 RME MHE Report - EU OBR Daily Insights (08.05.2022)

The data of 08.05.2022 of 508 occurrences was a concerning value, since it was **263% more than the median of the data from previous weeks (WK15-WK18, 15.04.2022-07.05.22).**

Tracking Error was monitored since April 25th, 2022, as a result of a faulting event of the Tote Distributor on April 21st, 2022 that caused a breakdown of 3 hours and impacted the processes of Operations Outbound. From data analysis, it was found that Tracking Error has appeared as a recurring defect since April 15th, 2022 (Graph 7). The possibility of it being an alert before the Tote Distributor faults has been discussed between Operations and RME team and was agreed to be monitored daily to identify recurrences, elevated values, and possible root causes.



Graph 7 Technical Quality Trend from 15.04.2022 to 08.05.2022

Analysis and Findings

When looking at the data of 08.05.2022 in detail, the Tracking Error was caused by repeating tote bar codes. A particular code: tsX00ce6u4q repeats 293 times on 08.05.2022. When searched in the PLC logs, that particular tote had recirculated 530 times and continued to recirculate at that moment (Figure 24).

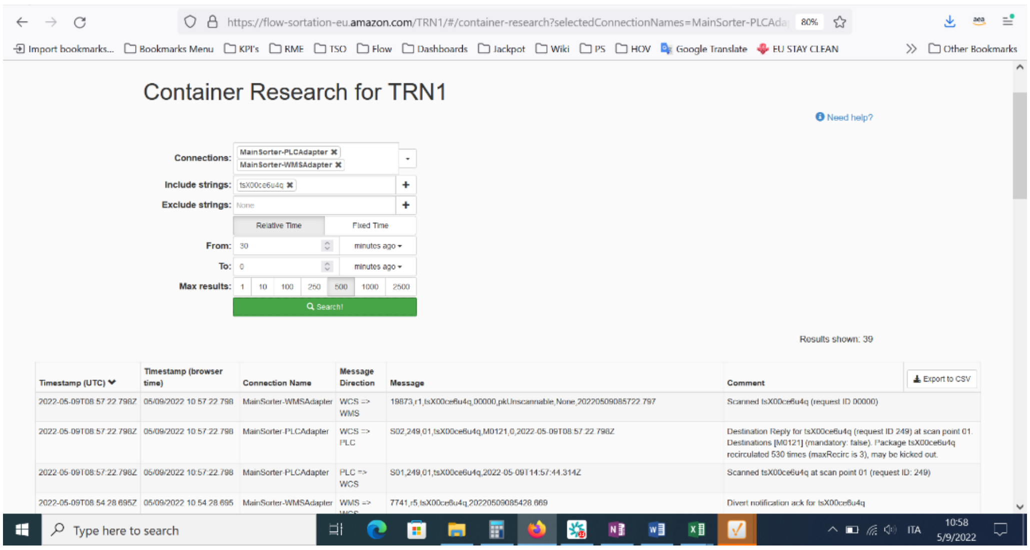


Figure 24 PLC logs - Search of tote barcode: tsX00ce6u4q

When a tote is scanned with a Tracking Error defect, the Tote Distributor does not divert the tote to its given destination and sends it to recirculation (M0199). If this is repeated and the tote recirculates 3 times, it is redirected to the Defect Lane (DL/M0121). However, it was happening that to be diverted to the Defect Lane, the photocell was also scanning the tote with Tracking Error, redirecting again the tote to the recirculation lane. This repeated itself infinitely until the tote was downstack manually by an RME Technician.

Taking a random sample of totes that has undergone through the process described, it was noticed that they had deformations in their surface. Either they had an *indentation* on the upper boards (either on the sides or the front/back), or they were bent from the sides (mostly an *inflated* type of deformation) (Annex 14). This is a physical problem of the totes that are also affecting the Robot Palletizer's quality of work at Various Packaging 2, when there are indentations on the front/back sides of the upper boarder of the totes, the RP lets them fall before it finished locating them on the respective space of the destination's pallet (Annex 15).

<u>*Actions Suggested*</u>

1. Downstack these totes and take them out of production.
2. Inspect photocells at the *chutings* (exits) where tracking error occurs, starting with the Defect Lane's *chuting* (M0121).
3. If necessary, adjust photocells in a way that they don't mark unnecessary Tracking Error defects but also is safe that the Tote Distributor will do a correct divert.
4. Related to Action 1, make a periodical "cleaning" of totes that have the defects on their surface that cause these problems.
5. The indentations on the sides are caused by the strapping machine when used with a high force and without covering the top (Annex 15). On Inventory Storage, share guidelines for the process of Pick to withdraw totes with indentations on the upper boarders and put them on the "dirty" pile of totes. Run the same guideline to the tote runners at Inventory Storage that receive the empty totes and feed them to the pick stations.

After further investigation on the Tracking Error, RME identified that out of 4 photocells that scan this defect, 2 were marking the most Tracking Error. The Tracking Error was being marked because of Length Changes in the vertical dimensions of the totes, not on the horizontal (Load Length – Figure 25). This meant that a space between the surface of the conveyor and the tote was being perceived by the photocell, however, this space does not affect the capability of the takeaway to push the tote to its corresponding exit. This meant that if the takeaway tried to push the tote to the exit, it would do it correctly without any safety issues. The RME AE Team agreed to make an adjustment to the photocell to increase the range of acceptance for Length Changes, so that less Tracking Error would be marked and the Tote Distributor be able to divert the tote to the corresponding assigned lane.

	SEQUENCE	SUBSYSTEM	TRACKING POINT	TRACKED LOADS	UNEXPECTED LOADS	LOST LOADS	EARLY LOADS	LATE LOADS	LENGTH CHANGES	MUZ ERRORS	FLAPS	AVERAGE LOAD LENGTH (IN)
	2.1	1Transport	001UD	635898	0	0	0	0	0	0	4301	20.9
	2.3	1Transport	002UD	635534	484	364	330	15	1893	0	22771	20.9
	3.3	1Sorter	003UD	635825	65	208	0	60	4145	82	15	21.4
	3.5	1Sorter	004UD	71130	34	27	16	8	12	13	71	21.4

Figure 25 Tracking Error - Photocells Logs

This is an easy modification in practice but delicate, therefore it is still being modified by RME since little changes already done have shown an improvement in accepting occurrences that used to be possible Tracking Errors and are successfully kicked out to the Defect Lane, but the variation has increased and with it the total number of totes that mark Tracking Error. After further detailed modifications to the photocell, Tracking Error must reduce its occurrences and with it its contribution to the Tote Distributor's recirculation percentage.

Defect Lane Layout (Safety Safe)

From the VOC Survey's results, suggestions from the PS to improve the workstation at the Defect Lane were raised. This is a quick win that has as main priority **the Safety of Amazon's AAs**.

Mainly, PSs requirements were:

- Adjust conveyor in a way that it is easier for PS to recirculate totes and prevent fatigue on shoulders when there are a high number of arrivals to the Defect Lane.
- Have 5S spaces for TST divided by lane.
- 5S for trays and u-boat (tote transportation equipment)
- More space for empty totes
- Space to downstack totes for Various Packaging 2/Various Packaging 1 during high recirculation events

The requirements were discussed with the PS to clarify their requests, these were discussed with AM and OM to have their suggestions and approval. Afterwards, it was confirmed with RME the technical aspects that needed to be changed over the conveyor and the workstation equipment, which was finally revised and approved by Safety.

The first aspect solved was the arrival of totes, with RME ensuring that the totes arrived correctly to the end of the line, to reduce PSs work that cause fatigue over the shoulders and back. For the changes, it was designed three propositions and executed on the one that complied not only with the requirements but also with Safety constraints and operational feasibility (Annex 16).

The conveyor's and photocells' mechanisms were adjusted to ensure totes arrive correctly to the end of the line, without forcing the AA to pull totes and create fatigue over their shoulders and back. Stands and 5S were defined for TST and Rebinhot differentiation, the workstation was unified into a single one where SLAM and pack can be done with easiness, and space for downstack was assigned for extreme cases of high recirculation that cause high number of arrivals to the Defect Lane. The comparison of the DL's layout and workstation before versus after can be seen in Figure 26, Figure 27, and Figure 28.

Before

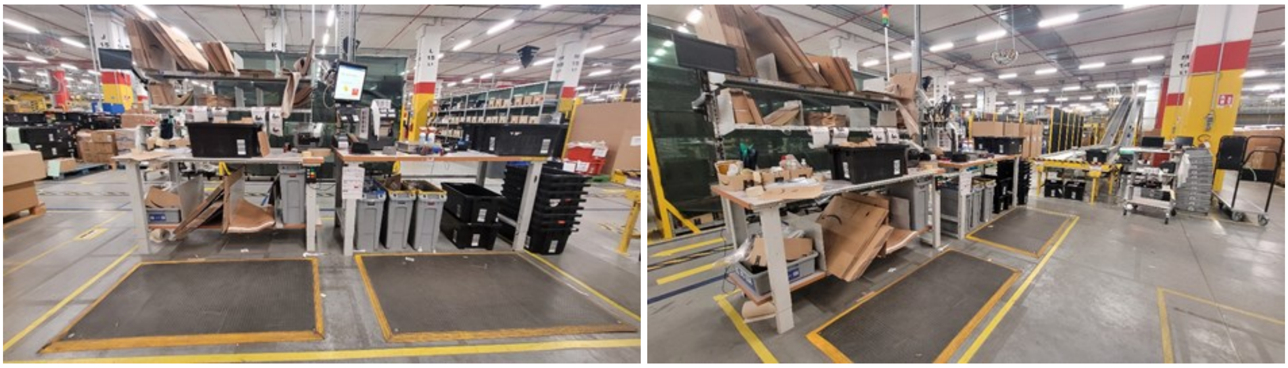


Figure 26 Layout and Workstation at Defect Lane Before

After

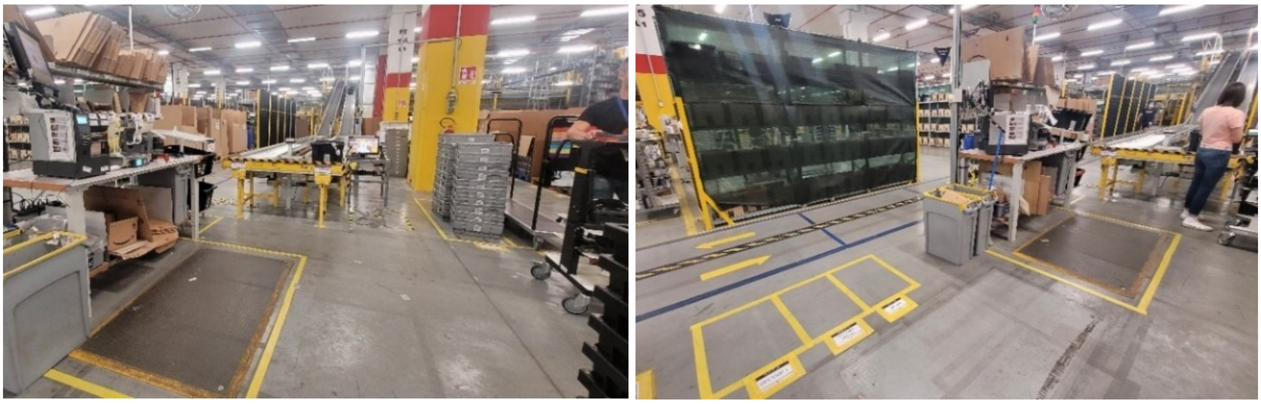


Figure 27 Layout and Workstation at Defect Lane After

Figure 28 Details of Workstation at Defect Lane After

3.5 Control

3.5.1 Flow Guideline

After mapping out the processes and doing the survey of the VOC from the OB team during the Measure phase, it was identified the need for a certain level of standardization in the functions of the Flow Lead. Flow is an interactive role that requires flexibility and fast adaptation from the Flow Lead, who must be able to multitask and maintain focus on the production targets of the shift. This type of role cannot be outlined in a step-by-step process; however, it needs all Flow Leads to have the same knowledge and clear concepts. Therefore, it was decided upon creating a guideline that would serve as a support to the Flow Lead, to be consulted whenever needed and be an easy-to-use material in hand.

To define the main functions to be described in the guideline, it was referenced the Flow Lead's process flowchart created as part of the As_Is during the Measure phase. The main functions of the Flow Lead are:

- Buffer managements
- Risk management
- Various Packaging 2 and Various Packaging 1 guidelines
- Charge and backlog split monitoring and control

Furthermore, through the VOC Survey it was identified the level of importance given by Flow Leads to the information used to plan the shift:

1. Headcount per Process Path (PP)
2. Total Actual Buffer
3. Actual Buffer per PP (in the system)
4. Risk Management
5. Backlog split per PP
6. Cumulated volume production and Total planned volume for the day
7. Physical actual buffer per PP
8. Various Packaging 2/Various Packaging 1 Volume to Produce
9. Actual TUR and Rates of Picking/Induct/Packing

Based on this list, the guideline was designed into detail for each point. Due to non-disclosure requirements, the guideline cannot be shown but at Annex 17 can be seen a sample of pages from the file. The guideline is composed of 31 pages with clear steps with pictures and graphics, brief explanations, and case studies that support the Flow Lead in the routines of everyday shifts.

The guideline was received positively by the Flow Leads and it was helpful in the training of new Flow Leads that were being prepared in the moment (3 new ones). The guideline has the purpose of being used in the future training and development of new Flow Leads and support the current ones.

3.5.2 Controls in Improvement Actions

All the actions of improvements taken during the project seek to be reliable and sustainable, i.e., that they would ensure improvement in the moment of their implementation and be consistent in time. How the actions taken control and ensure quality:

- **Throughput Limit:** The changes done in the configurations of the machine are permanent, unless until they are changed again directly by the Vendor after a request from Amazon and approval from the Vendor 1.
- **Medium Packaging 1 Pad Time:** The setting of 4-hour PAD time as a property of the Medium Packaging 1 PP is permanent, it does not change automatically, unless an OM or SOM requests the changes and an SME approves.
- **Various Packaging 1 Parameters Standardization:** Standardizing the calculations of the TUR and BL reduces variability in the WIP of the Various Packaging 1, reducing recirculation caused by Lane Full. This action is more dependable on the Lead's/PSs actual implementation of the calculations, they are not done automatically in a program. To increase the use of the standardized parameters, it was created the excel file that requires of the inputs from the Lead and calculates the TUR and BL values.
- **Tracking Error:** The adjustments in the photocell to reduce Tracking Error occurrences is stable, unless it is moved by an RME team member, either because of a maintenance or failure intervention.
- **Defect Lane Layout**: The modifications to the workstation are designed to ensure Safety of the team, unless it is changed in the future by an AM.
- **Flow Lead Guideline:** The guideline defines the steps a Flow Lead must follow for the different activities that are developed along the shift. The guideline was shared to all Flow Leads and created awareness to the team of its advantages and uses. It also serves as a guideline for new Flow Leads in training.

3.6 Project Conclusions

With DMAIC, implementing data-driven analysis, continuous collaboration with RME, the support from Operations OB team, and applying lean manufacturing techniques, the project's achievements (Figure 29) were:

- Successfully identified the causes for high recirculation, these being the **Top Offenders defects Throughput Limit and Lane Full**, and quantifying the **Top Offenders Lanes: Medium Packaging 1, Various Packaging 2, and Various Packaging 1.** By measuring the Top Offenders, it was clear where to make improvements with higher positive returns.
- The overall Tote Distributor's Recirculation % was **reduced from an average of 20.51% (WK1-WK13) to 13.6% (WK24-WK26), Delta - 33.61%.** For the first time in FC, Quality's IS Report showed green values in the Tote Distributor Recirculation % KPI, with **3.69% (19.06.2022)** being the lowest value in all 2022 (without considering Saturdays and Holidays). For comparison, on **2021 Q3 & Q4**, the Tote Distributor's recirculation % was of **30.01%** and the lowest value registered was of **16.39% (15.09.2021)** (without considering Saturdays and Holidays).
- Through the mechanical adjustments done with RME and Vendor 1, the initial Top Offender Defect, **Throughput Limit**, was **reduced from 50.17% to 8.38%** contribution to the overall Tote Distributor Recirculation %, **Delta: -83%.**
- The Medium Packaging 1 PP was regulated with the change of PAD time from 4 hours to 3 hours, **reducing by 3% the Medium Packaging 1's contribution (WK14-WK23 vs WK24-WK26).**
- Standardized the calculation of parameters at Various Packaging 1 has not just helped control the recirculation in the Tote Distributor, but also, it has allowed the Leads to manage the Various Packaging 1 according to the WIP and work planned for the shift. Initial trial **saved 2% in recirculation contribution from Various Packaging 1 (WK14-WK23 vs WK24-WK26).**

1 Tote Distributor Recirc %

*Update Daily

Target	Min
WK26	19/06/2022
< 5%	3.69

Q3 & Q4 2021	WK1-WK13 2022	Δ %	WK14-WK23 2022	Δ %	WK24-WK26	Δ %	Δ % TOTAL
30.01	20.51	-31.65%	13.93	-32.08%	13.62	-2.25%	-33.61%

2 Recirculation Top Offenders

*Update Weekly

Lane	2021 Q3 & Q4 2021 % per Lane	Defect	% per Defect	2022 WK1-WK13 2022 Per Lane		Per Defect	WK14-WK23 2022 Per Lane		Per Defect	WK24-WK26 Per Lane		Per Defect
MP1 (M0114)	29%	Lane Full	62%	27%	Lane Full	35.97%	17%	Lane Full	84.94%	14%	Lane Full	87.97%
		TH_Limit	38%	175786	TH_Limit	63.36%	45510	TH_Limit	13.61%	12086	TH_Limit	10.11%
VP2 (M0120)	13%	Lane Full	67%	23%	Lane Full	61.61%	35%	Lane Full	91.88%	45%	Lane Full	92.37%
		TH_Limit	32%	151199	TH_Limit	37.23%	96939	TH_Limit	7.24%	38477	TH_Limit	6.66%
VP1 (M0102)	16%	Lane Full	61%	12%	Lane Full	50.3%	12%	Lane Full	92.7%	10%	Lane Full	93.5%
		TH_Limit	39%	81345	TH_Limit	49.1%	32701	TH_Limit	6.1%	8303	TH_Limit	5.6%
	Total (All Lanes)	Lane Full	60.53%	Total (All Lanes)	Lane Full	46.53%	Total (All Lanes)	Lane Full	87.19%	Total (All Lanes)	Lane Full	84.42%
		TH_Limit	38.10%		TH_Limit	50.17%		TH_Limit	8.38%		TH_Limit	7.60%

Figure 29 KPI Dashboard. Tote Distributor Recirculation %, Final Situation

- Improved overall PS Productivity (Figure 30), from **2,617.72 UPH (WK1-WK13) to 2,874.67 UPH (Closing WK23).** Values of PS Productivity in last 3 weeks **(WK24-WK26)** are a little lower due to reinforcing training being done as preparation for the high demand week.

4 Productivity

*Daily / *Sour

	2021 Q3-Q4		2022 WK1-WK13			WK14-WK23			WK24-WK26
OB Problem Solver	**Q3**	**Q4**	**Q1**	**WK1-WK13**	**Q1 2021**	**Q2**	**WK14-WK23**	**Q2 2021**	**WK24-WK26**
PS Volume	29,799,215.00	32,203,499.00	27,086,639.00	26,091,430.00	30,110,741.10	24,268,790.00	18,691,693.00	35,183,851.11	5,577,097.00
PS Labor Hours	13,010.19	15,940.75	10,340.28	9,967.25	11,612.89	8,677.02	6,502.20	12,215.47	2,174.82
PS Rate	2,290.45	2,020.20	2,619.53	2,617.72	2,592.87	2,796.90	2,874.67	2,989.93	2,564.39

*Wee / *Sour

C15 Problem Solver	**Q3**	**Q4**	**Q1**	**WK1-WK13**	**Q1 2021**	**Q2**	**WK14-WK23**	**Q2 2021**	**WK24-WK26**
Max	258.78	349.73	242.79	242.79	398.12	218.00	218.00	363.54	171.63
Min	19.50	3.00	3.00	3.00	26.77	-5.88	-5.88	0.49	12.63
Average	96.34	108.88	90.93	90.93	126.97	64.94	62.11	111.22	69.03
Median	91.59	104.32	93.32	93.32	126.07	59.88	57.38	106.5	64.05

Figure 30 KPI Dashboard. PS Productivity, Final Situation

- It was achieved significant reduction in the C15 Bucket of Problem Solver (Figure 31), from a **median of daily C15 bucket of 93.32 (WK1-WK13) to 64.05 (WK24-WK25), Delta: -31%,** which represents workload of reactive actions to comply with TST, and has been kept under the limit.

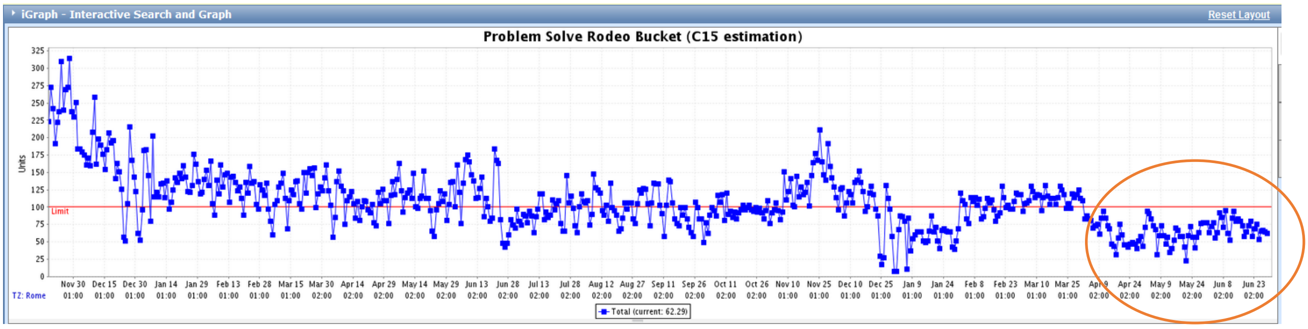


Figure 31 PS Bucket C15, Historical Data and Final Situation

- Late Slams for **Q2 2022 closed with 4,357 vs Q1 2022 of 1,334** (Figure 32). However, **2,060 late slams of Q2** are attributed to the shutdown of a PLC on site caused by an antenna failure caused by high winds of the storm on the night of May 23rd and dawn of May 24th, 2022.

3 DEA

*Update daily from EU Stay Clean - ICQA Report

	2021 Q3-Q4		2022 WK1-WK13			WK14-WK23			WK24-WK26
DEA Pre-SLAM	**Q3**	**Q4**	**Q1**	**WK1-WK13**	**Q1 2021**	**Q2**	**WK14-WK23**	**Q2 2021**	**WK24-WK26**
130.14 - Late SLAM Units	2,368	2,840	1,334	1,336	7393	4,357	4,033	2643	327

Figure 32 KPI Dashboard. DEA Late Slam Units, Final Situation

- It was possible to create a **Flow Guideline** to build homogeneous knowledge and know-how for all Flow Leads (both current and new ones in training), which allows for more consistent buffer management and rapid decision-making.
- Through proactive listening to PSs at Defect Lane and the applied VOC Survey, it was achieved a **Safety Safe** and applied the **Invent and Simplify LP**, by adjusting the Defect Lane's workstation in a way PS are able to do their work efficiently and maintaining safety at all times.

4. Conclusions

4.1 Discussion

The project presented needed a complex problem to be solved, categorized as so because of the interaction of many interrelated elements: setting in the e-commerce industry with real-time data arriving and changing constantly in short time, the company's Industry 4.0 infrastructure that generates a big amount of data that needs to be managed to generate insights on the processes, and the many causal effects that a decision can have on the whole system. DMAIC as a data-driven strategy was demonstrated to be a proper fit for the problem-solving of the Tote Distributor Recirculation project.

First, it was approached the definition of objectives, allowing for a clear view from start to end of the project. Proceeding with the identification of the root causes behind the problem, measuring and quantifying them. Once the causes were identified, it was possible to break down the complex problem and easily approach its improvement with a set of actions that were first tested and then implemented. The improvements done in the Tote Distributor Recirculation Project has reduced wastes in time and over processing, as well as improved mechanical performance. Contributed to the Operations OB performance in processing orders and shipments efficiently, generating higher margins, and ensuring excellent Customer Experience.

The achievements of the project were possible because of:

- The ability to structure and manage the problem-solving project with the DMAIC strategy, including in the planning schedule crucial elements like milestones, objectives and KPIs. This was achieved by building a Gantt chart of the project at the Define phase with the crucial elements included, which was used to monitor the project's progress throughout all its duration.
- The progress of the project was supported by the assessment of the objectives' achievement with data collected in real-time, with the practice of data mining and the analytical activities that let to discover the processes' information. A foundation on data reduced uncertainty and prevented equivocality in the management of the project. This was possible by defining the KPI Dashboard at the first stages of the project and using it during the lifespan of the project for the objectives' assessment and to compare the initial situation versus the current and final situations. The application of data-analysis tools (like Pareto) and statistical analysis (like defects quantitative computation) allowed the generation of insights for interpretation of the problems present in the system.
- Including Lean tools in the planning of the project and applying them allowed the author to propose and implement solutions in a fast-moving setting as it is e-commerce and the company's environment with I4.0 infrastructure, which can have advantages from the frugality of these tools and their favorable results. The tools applied were several, among which were included Flowcharts for process modeling and measure, Pareto for analysis, DOE for experimentation on improvements, and standardized operational procedures (like the Flow Guideline) for control.

The practical action research evidence that the use of a structured method to approach a complex problem facilitates the ability to:

- Decompose the problem into phases and define objectives and indicators of the project that would evaluate the accomplishment of each phase and transition through them smoothly, until accomplishing the overall main objective of the project and solving the problem at hand.
- The alignment of indicators with operational and strategical objectives that allowed the project team to keep a focus on the project and maintain interest of the different stakeholders involved to accomplish the project's objectives. The KPI Dashboard made possible the constant comparison of accomplishment of objectives with the defined metrics.
- Create mental models through the Measure and Analysis phases based on data and generating knowledge in a cyclic pattern, developing heuristic competence. Attached to this is the importance of sharing knowledge among the team members, creating synergy to explore out-of-the-box approaches for solving problems.
- Contemplate about solutions in a systematic way, proposing and implementing solutions that favored the processes in scope (Outbound processes) and safeguarding the advancement of the whole system without deteriorating other aspects of the system (other processes in the FC).

4.2 Reflections and Lessons Learned

The company has a set of Leadership Principles that all Associates are expected to apply in their work. (*Amazon's Global Career Site*, n.d.) These Leadership Principles serve as guidelines in every setting and management level of the company. To reflect on the lessons learned, the author associates the major advantages of the practical activities performed and her major contributions with the main Leadership Principles practiced all throughout the project.

Amazon provides abundant Big Data, which is a great opportunity for its Associates at all managerial levels to execute their work at their best with high standards. The project was highly data-driven, complementing it with rapport and trusting relationships with the Operations and RME team, the LPs of **Learn and Be Curious** with **Dive Deep** complemented each other. The information systems of the company facilitated a big amount of data, however, it was subject to the author's proactivity to search for information, seek for guidance from experts, and apply theoretical knowledge in her analytics so that she was able to derive information from this data. These were the main LPs that lead to the set of achievements described in the conclusions.

Moreover, there is no better person to know how to execute an activity than the one that does it every day, so having great relationships with the AAs in all levels, **Earning Trust**, was crucial to learn and identify opportunities for improvements. This was possible due to the Gemba Walks practiced during the whole duration of the project, providing the author with sources of knowledge from the Associates' know-how and the information systems available. Through these rapports, the author was able to develop at a practical level soft skills like communication, teamwork, and leadership.

The changes made over the line of Medium Packaging 1 PP was a challenge, since it was a problem that had no clear background and unknown to most of the team. Besides the **Diving Deep** done of the root cause, **Having Backbone; Disagree and Commit** was challenging, by reaching out to the right Subject Matter Experts and getting approval for the changes. However, persistence came from the certainty of being right on what was the problem and the solution to it, based on data analysis and developed knowledge through experience that allow to notice patterns and causal effects.

All improvement actions done did not require additional headcount nor additional expenses, applying the **Frugality** LP during the project's lifespan. Improvements were done with hard work, being resourceful, and a touch of creativity. Following reviewed recommendations from practitioners and researchers on how to use Lean tools for process optimization added value to these activities.

The overhead LP was **Customer Obsession**. The project was focused mainly on the OB area, the one that prepares, pack, and ships the customers' orders and makes sure that compliance in time and quality is achieved, to obtain and keep Customer Satisfaction and an Excellent Customer Experience. In detail, the final goal was to improve the operational-mechanical processes that would allow for a better performance of the OB area, contributing to the compliance of TSTs and PDDs so that packages arrive in time to the customers. The main KPIs of the project were aligned to this major Leadership Principle and corresponding strategical KPIs.

4.3 Limitations

During the weekly meetings with the team, several ideas and actions were proposed to improve the performance of the Tote Distributor and Outbound processes. However, not all of them were acted upon mostly due to the need to prioritize the actions that would generate major contributions to the project. Besides, some constraints were in the prioritization decisions, like:

- Actions that involved the action at other FCs were out of the scope of the project. FCs benchmarking helped to compare results and to obtain knowledge from experts and Area Managers in those locations, however, the reach to influence their operations were out of the scope.
- Time was an important constraint, since actions that could be done inside the duration of the project were encouraged. The ending of the project was matched with a period of expected high demand, so the improvements were expected before this period to be implemented and prove positive results.

When there was no available historical data, it was a challenge to measure and analyze the patterns of a process, like it was for the Various Packaging 1 process. Suggestions for these limitations and process are detailed in the next section.

The process of Various Packaging 2 is managed and operated by Associates with significant experience in the process and special technical knowledge about the variables that define the demand, production, and mechanical operation of the line. The tests and attempts of improvement in this process were limited to simpler actions that would not affect the daily production of the line. This process by the end of the project became the process of major contribution to the remaining recirculation in the Tote Distributor. In the next section, suggestions are made for the improvement of the process.

Additionally, geographic and temporal boundaries limit the knowledge exchange among teams inside the company. Lessons learned from solving similar problems are difficult to retrieve if they are not registered in the internal knowledge database. Likewise, it was a limitation when information from Subject Matter Experts was needed, and they were in different geographical locations. The level of digitalization of the company provided data available in software programs and cloud-based platforms, and sometimes it was necessary to understand from where, how, and when the data was retrieved and how it was processed by algorithms to be presented in these reports for identifying root causes. If this information was not in the internal knowledge database, it was difficult to reach out to the Subject Matter Experts.

4.4 Suggestions for Future Studies

Along the project, there were several actions suggested, some of them were not further pursued due to limitations (as described in the previous section) and others were not selected to go forward with them in the moment due to limitation of resources, including time. The most relevant actions that are suggested to move forward with after the end of the project are:

A) For the process Various Packaging 1, the calculations of significant parameters were standardized for the FC and tested with Leads and Area Managers at the process line. To ensure the parameters set by the Lead/AM favor the workflow, a set of graphics measuring the parameters for the efficient flow of buffer and WIP was suggested. It included:

- Units per Batch (UPB, needed to calculate Batch Limit)
- Units per Tote (UPT, needed to calculate UPB)
- Number of Totes (needed to calculate UPB and monitor Tote Limit)
- Current WIP (needed to calculate TUR)
- Total Units Required (TUR) at Various Packaging 1

These graphics should generate information from specific data and algorithms and be available in a visual dashboard visible to the Lead and Area Manager on shift at the Various Packing 1 process area to monitor and control the workflow.

B) Trials and different mechanical adjustments were done at the Various Packaging 2, however, there were no major improvements in the line's performance. A major maintenance has been done on the Robot Palletizer recently (June 2022) as part of its maintenance planning, and it has been ensured all its parts function correctly. A trial of staffing experienced AAs fixed on the line plus an additional AA in the headcount was done, but no major improvements were perceived. Since, by the end of the project it was the line with the highest contribution to the Tote Distributor's recirculation (47%), it is advisable to investigate deeper into the main problems and solve the issues, both from the Operational and Mechanical sides.

Additionally, this represents an opportunity for developing a project like the one described in this action research project. It is highly recommended that the use of simulations is explored for the *measure*, *analysis*, and *improve* phases, considering simulation software like Flexsim. Flexsim, and other similar software packages, can model a system/process, measure statistically the performance of the system/process and simulate discrete-events scenarios for the trial of improvements without the use of resources in the physical world. This allows the running and testing of several scenarios before making big changes or investments for the improvement of a process. Instead, there is a major effort on data collection, statistical analytics, and deriving conclusions and solutions from the model.

The author advises on the implementation of these propositions as well as the continuous improvement of the improved processes and the overall production system.

Furthermore, the author recommends the use of the DMAIC strategy reinforced with Lean Manufacturing tools and Industry 4.0 practices to approach other projects with similar characteristics of complexity for solving problems at industries enabled with digitalized processes.

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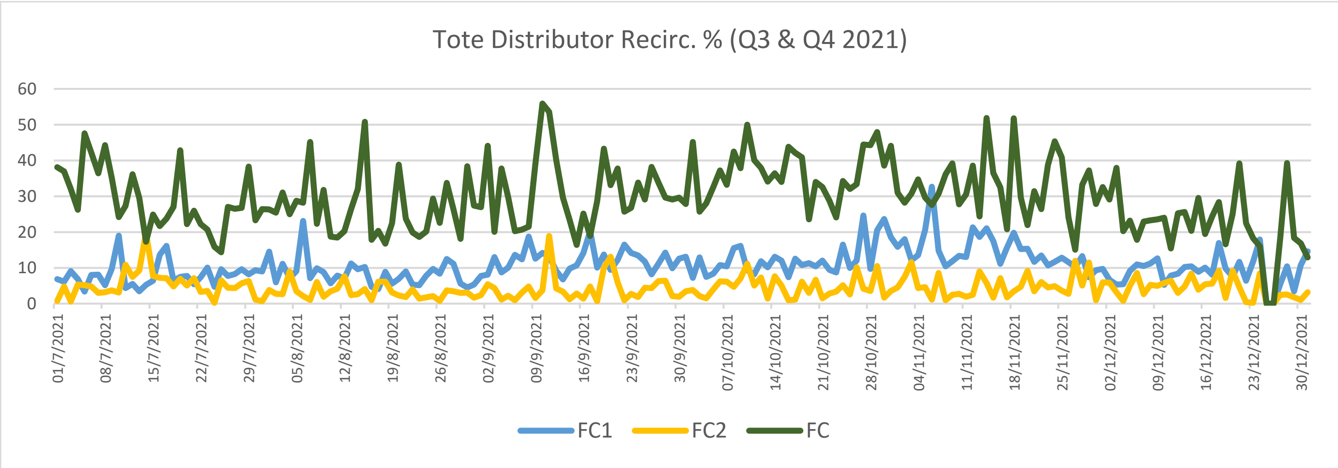
6. Annexes

6.1 Annexes: Define

Annex 1 Tote Distributor Recirculation %



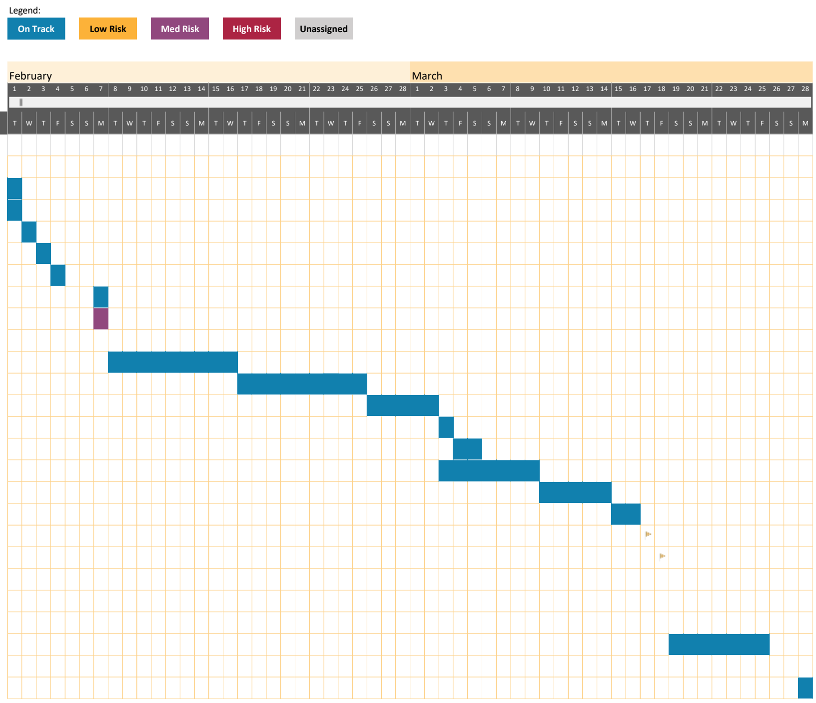
Annex 2 Gantt Chart

Tote Distributor Recirculation Percentage FC

Company Name Amazon
Project Lead Aguilar, Astrid (aastridc)
Project Champio Schiffini, Federico (schiffif)

Project Start Date: 01/02/2022
Scrolling Increment: 0

Milestone Description	Deliverable	Category	Assigned To	Progress	Start	Due Date	Duration	Calendar Days
						00/1/1900		
Scoping the Plan								
Define in scope and out scope		On Track	Astrid	100%	01/02/22	02/02/22	1	1
Problem Statement		On Track	Astrid, Federico	100%	01/02/22	02/02/22	1	1
Project Schedule	Gantt Chart	On Track	Astrid	100%	02/02/22	03/02/22	1	1
Project Team		On Track	Astrid	100%	03/02/22	04/02/22	1	1
Stakeholders Analysis	Stakeholders Analysis	On Track	Astrid	100%	04/02/22	05/02/22	1	1
Path to Green Statement		On Track	Astrid	100%	07/02/22	08/02/22	1	1
Work methodology	Advancements Report	Med Risk	Astrid	100%	07/02/22	08/02/22	1	1
Define the Current Situation								
Investigate on the Current State	As_Is	On Track	Astrid	100%	08/02/22	17/02/22	7	9
Design VSM (VSA)	VSM	On Track	Astrid	100%	17/02/22	26/02/22	9	9
Measure KPIs		On Track	Astrid, S&OP, ICQA	100%	26/02/22	03/03/22	5	5
Design KPIs Network	KPI's Network	On Track	Astrid, ICQA	100%	03/03/22	04/03/22	1	1
Benchmarking FC2 & FC1		On Track	Astrid, S&OP, OB FC2, OB FC1	100%	04/03/22	06/03/22	2	2
KPIs Dashboard Design	KPI's Dahboard	On Track	Astrid	100%	03/03/22	10/03/22	5	7
Measure KPIs on Floor		On Track	Astrid, AM	100%	10/03/22	15/03/22	3	5
Comparison Ideal vs Actual		On Track	Astrid	100%	15/03/22	17/03/22	2	2
Present Findings on Current Situation	Advancements Report	Milestone	Astrid, Federico, RME	100%	17/03/22	18/03/22	1	1
Update Schedule	Gantt Chart	Milestone	Astrid	100%	18/03/22	19/03/22	1	1
Measure (Data Collection)								
Design Data Collection Plan	Data Collection Plan	On Track	Astrid	100%	30/03/22	03/04/22	1	4
Meeting with FC Team to Update		On Track	Astrid, Federico, RME, S&OP	100%	03/04/22	04/04/22	1	1
Shadowing of Flow Lead		On Track	Astrid	100%	19/03/22	26/03/22	5	7
RME Data Collection		Med Risk	Astrid, RME	100%	28/03/22	02/04/22		
Pareto Analysis		On Track	Astrid	100%	28/03/22	30/03/22	2	2



Tote Distributor Recirculation Percentage FC

Company Name Amazon

Project Lead Aguilar, Astrid (aastridc)

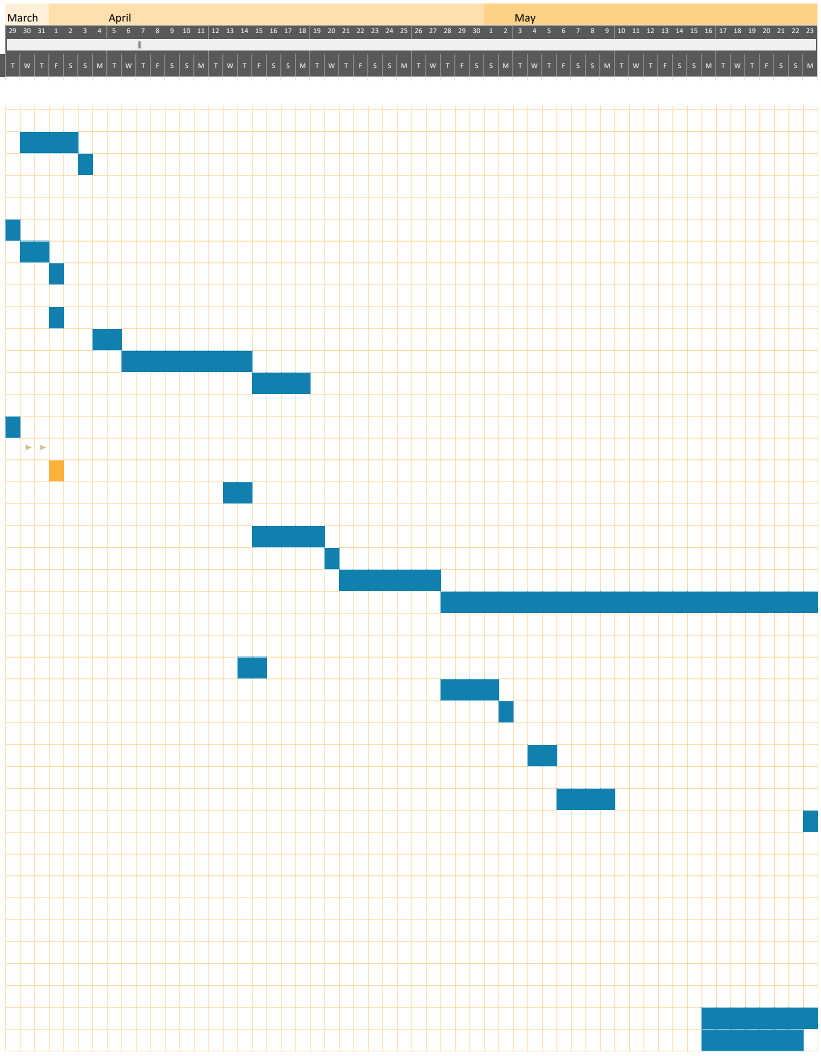
Project Champio Schiffini, Federico (schiffif)

Project Start Date: 01/02/2022

Scrolling Increment: 56

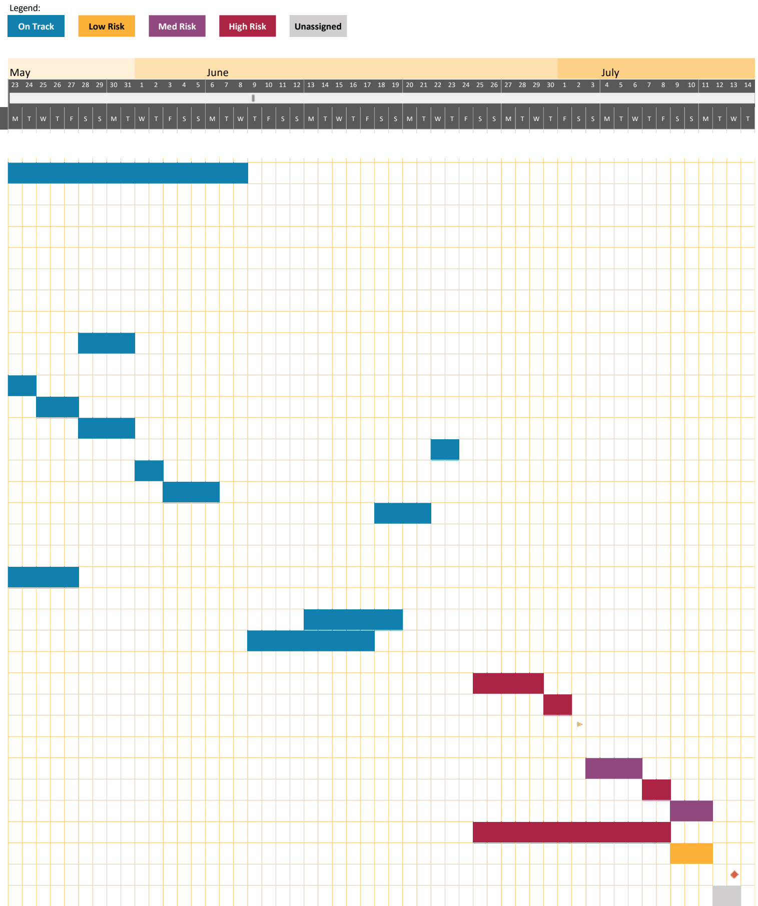
Legend: On Track | Low Risk | Med Risk | High Risk | Unassigned

Milestone Description	Deliverable	Category	Assigned To	Progress	Start	Due Date	Duration	Calendar Days
Update Schedule	Gantt Chart							
Measure (Data Collection)								
Design Data Collection Plan	Data Collection Plan	On Track	Astrid	100%	30/03/22	03/04/22	1	4
Meeting with FC Team to Update		On Track	Astrid, Federico, RME, S&OP	100%	03/04/22	04/04/22	1	1
Shadowing of Flow Lead		On Track	Astrid	100%	19/03/22	26/03/22	5	7
RME Data Collection		Med Risk	Astrid, RME	100%	28/03/22	02/04/22		
Pareto Analysis		On Track	Astrid	100%	28/03/22	30/03/22	2	2
Top Offenders		On Track	Astrid	100%	30/03/22	01/04/22	2	2
Decision of MHE Settings		On Track	Astrid, AM	100%	01/04/22	02/04/22	1	1
DEMATIC Visit		Med Risk	Astrid, S&OP	100%	01/04/22	19/04/22		
Preparation for Vendor Visit		On Track	Astrid	100%	01/04/22	02/04/22	1	1
Vendor Visit and Trials		On Track	Astrid, RME	100%	04/04/22	06/04/22	2	2
Monitoring of KPI's After Changes		On Track	Astrid	100%	06/04/22	15/04/22	7	9
Report of DEMATIC visit and	Report of Visit	On Track	Astrid, AM	100%	15/04/22	19/04/22	2	4
Design VoC Survey	Questionnaire (Electronic)	On Track	Astrid, AM	100%	11/03/22	25/03/22	10	14
Collect VoC (AA's Voice)		On Track	Astrid, ICQA	100%	25/03/22	30/03/22	5	5
VOC Summary Report	Questionnaire Summary	Milestone	Astrid, AM	100%	30/03/22	01/04/22	2	2
Revalidation (if needed)		Low Risk	Astrid	0%	01/04/22	02/04/22	1	1
Presentation of Findings	PPT	On Track	Astrid, Federico, GM	100%	13/04/22	15/04/22	2	2
VOC Results Actions		On Track	Astrid	100%	15/04/22	09/06/22		
Safety Suggestion DL		On Track	Astrid, Safety, RME	100%	15/04/22	20/04/22	3	5
for Feasibility of VP2 further study		On Track	Astrid, RME	100%	20/04/22	21/04/22	1	1
Defect Lane Area Re-Design	Proposals Designs	On Track	Astrid	100%	21/04/22	28/04/22	5	7
Flow Lead Guidelines	Flow Guideline	On Track	Astrid	100%	28/04/22	09/06/22	30	42
Analysis (Focused)								
Analysis of Lines	Analysis Plan	Med Risk	Astrid	100%	22/03/22	22/03/22		
VP2 Analysis		On Track	Astrid	100%	14/04/22	16/04/22	2	2
MP1 Analysis		On Track	Astrid	100%	28/04/22	02/05/22	2	4
VP1 Analysis		On Track	Astrid	100%	02/5/2022	03/5/2022	1	1
Define Trials and Analysis	Analysis Plan	Med Risk	Astrid	100%	04/05/22	01/06/22		
VP2 Trial Design		On Track	Astrid	100%	04/05/22	06/05/22	2	2
VP2 Post Trial Analysis		On Track	Astrid	100%	28/05/22	01/06/22	2	4
DL Trial Design		On Track	Astrid	100%	06/05/22	10/05/22	2	4
DL Post Trial Analysis		On Track	Astrid	100%	23/05/22	25/05/22	2	2
MP1 Dive Deep		On Track	Astrid	100%	25/05/22	28/05/22	3	3
MP1 Trial Design		On Track	Astrid	100%	28/05/22	01/06/22	2	4
MP1 Post Trial Analysis		On Track	Astrid	100%	22/06/22	24/06/22	2	2
VP1 Trial Design		On Track	Astrid	100%	01/06/22	03/06/22	2	2
VP1 Parameters Tetsing and		On Track	Astrid	100%	03/6/2022	07/6/2022	2	4
VP1 Post Trial Analysis		On Track	Astrid	100%	18/06/22	22/06/22	2	4
Improve - Testing								
Trials and Studies		Med Risk	Astrid	100%	16/05/22	20/06/22		
VP2 Trial		On Track	Astrid	100%	16/05/22	28/05/22	10	12
DL Trial		On Track	Astrid	100%	16/05/22	23/05/22	5	7



Tote Distributor Recirculation Percentage FC

Company Name: Amazon
Project Lead: Aguilar, Astrid (aastridc)
Project Champio: Schiffini, Federico (schiffif)
Project Start Date: 01/02/2022
Scrolling Increment: 111

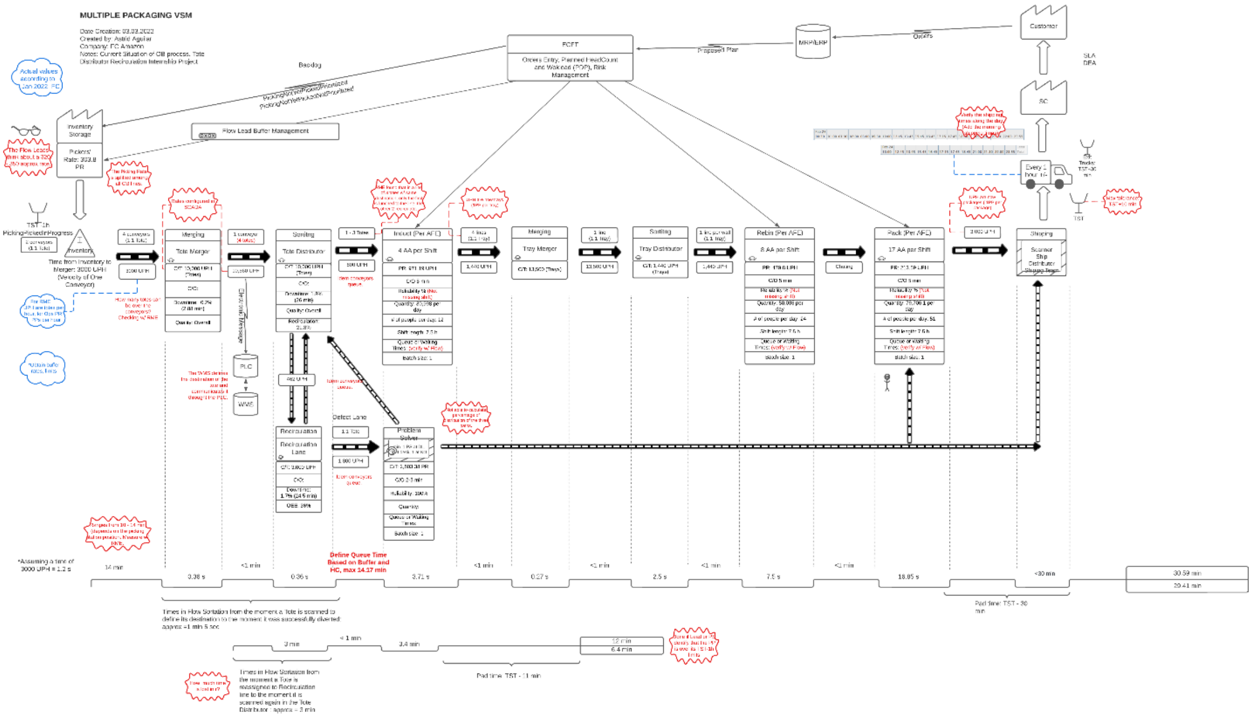


Milestone Description	Deliverable	Category	Assigned To	Progress	Start	Due Date	Duration	Calendar Days
Flow Lead Guidelines	Flow Guideline	On Track	Astrid	100%	28/04/22	09/06/22	30	42
Analysis (Focused)								
Analysis of Lines	Analysis Plan	Med Risk	Astrid	100%	22/03/22	22/03/22		
VP2 Analysis		On Track	Astrid	100%	14/04/22	16/04/22	2	2
MP1 Analysis		On Track	Astrid	100%	28/04/22	02/05/22	2	4
VP1 Analysis		On Track	Astrid	100%	02/5/2022	03/5/2022	1	1
Define Trials and Analysis	Analysis Plan	Med Risk	Astrid	100%	04/05/22	01/06/22		
VP2 Trial Design		On Track	Astrid	100%	04/05/22	06/05/22	2	2
VP2 Post Trial Analysis		On Track	Astrid	100%	28/05/22	01/06/22	2	4
DL Trial Design		On Track	Astrid	100%	06/05/22	10/05/22	2	4
DL Post Trial Analysis		On Track	Astrid	100%	23/05/22	25/05/22	2	2
MP1 Dive Deep		On Track	Astrid	100%	25/05/22	28/05/22	3	3
MP1 Trial Design		On Track	Astrid	100%	28/05/22	01/06/22	2	4
MP1 Post Trial Analysis		On Track	Astrid	100%	22/06/22	24/06/22	2	2
VP1 Trial Design		On Track	Astrid	100%	01/06/22	03/06/22	2	2
VP1 Parameters Tetsing and		On Track	Astrid	100%	03/6/2022	07/6/2022	2	4
VP1 Post Trial Analysis		On Track	Astrid	100%	18/06/22	22/06/22	2	4
Improve - Testing								
Trials and Studies		Med Risk	Astrid	100%	16/05/22	20/06/22		
VP2 Trial		On Track	Astrid	100%	16/05/22	28/05/22	10	12
DL Trial		On Track	Astrid	100%	16/05/22	23/05/22	5	7
MP1 Trial		On Track	Astrid	100%	13/06/22	20/06/22	5	7
VP1 Trial		On Track	Astrid	100%	09/06/22	18/06/22	7	9
Present Trials Results	PPT	Milestone	Astrid, Federico	100%	24/06/22	25/06/22	1	1
Design of Testing (DOE)	DOE	High Risk	Astrid	100%	25/06/22	30/06/22	3	5
Define SPC Needed		High Risk	Astrid, ICQA	100%	30/06/22	02/07/22	2	2
Execute New Process		Milestone	Federico, AM	100%	02/07/22	03/07/22	1	1
Control								
Result Validation		Med Risk	Astrid	100%	03/07/22	07/07/22	4	4
Conclusions and Presentations	Final Presentation	High Risk	Astrid, Federico, GM	100%	07/07/22	09/07/22	2	2
Evaluation of Overall Project	Final Report	Med Risk	Astrid	100%	09/07/22	12/07/22	1	3
Documentation	Final Thesis	High Risk	Astrid	100%	25/06/22	09/07/22	10	14
Lessons Learned	Amazon Wiki	Low Risk	Astrid	100%	09/07/22	12/07/22	1	3
Finish Internship		Goal	Astrid	100%	13/07/22	14/07/22	1	1
Project Slack					12/07/22	14/07/22		2

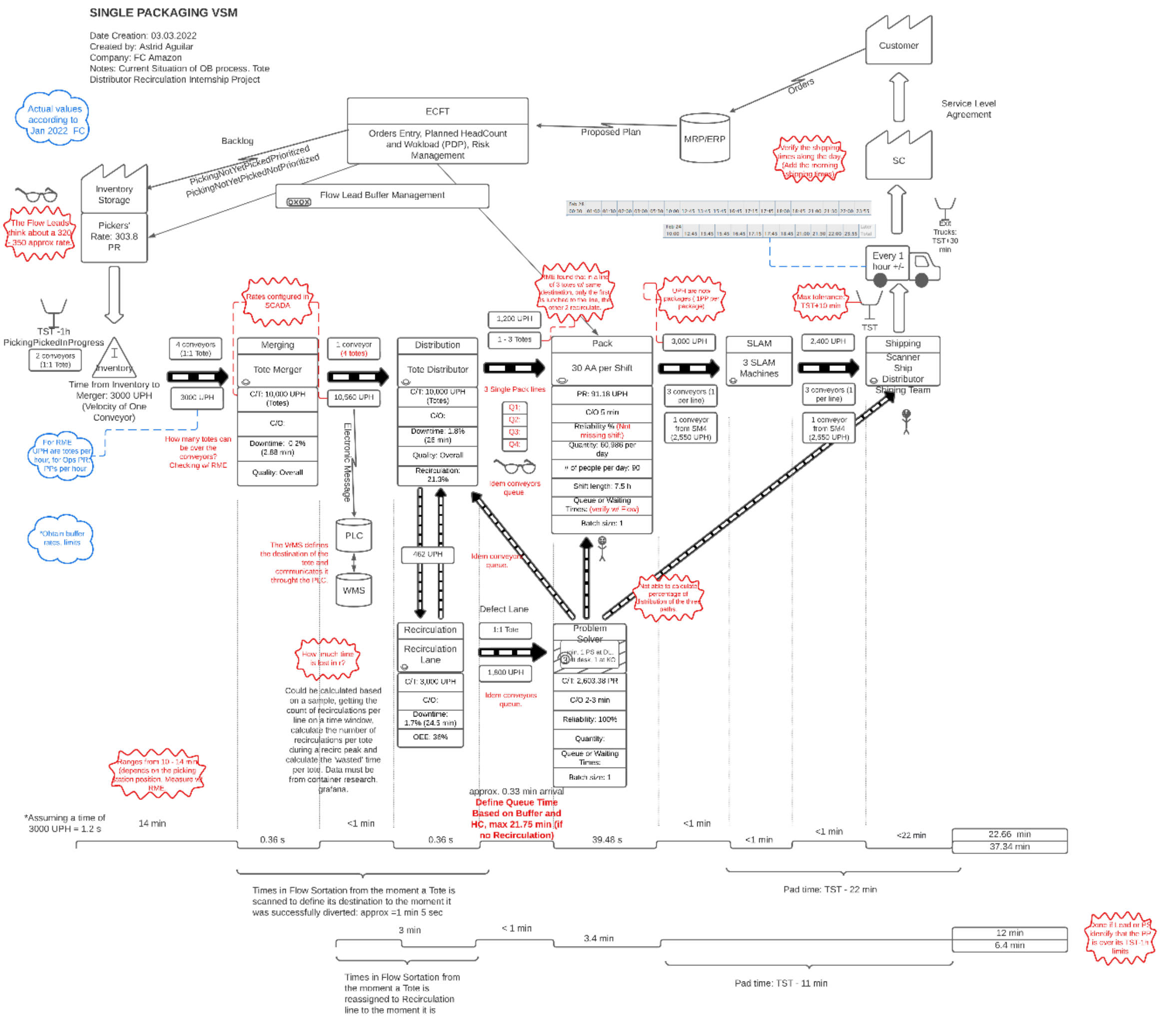
6.2 Annexes Measure

Annex 3 Processes' VSM

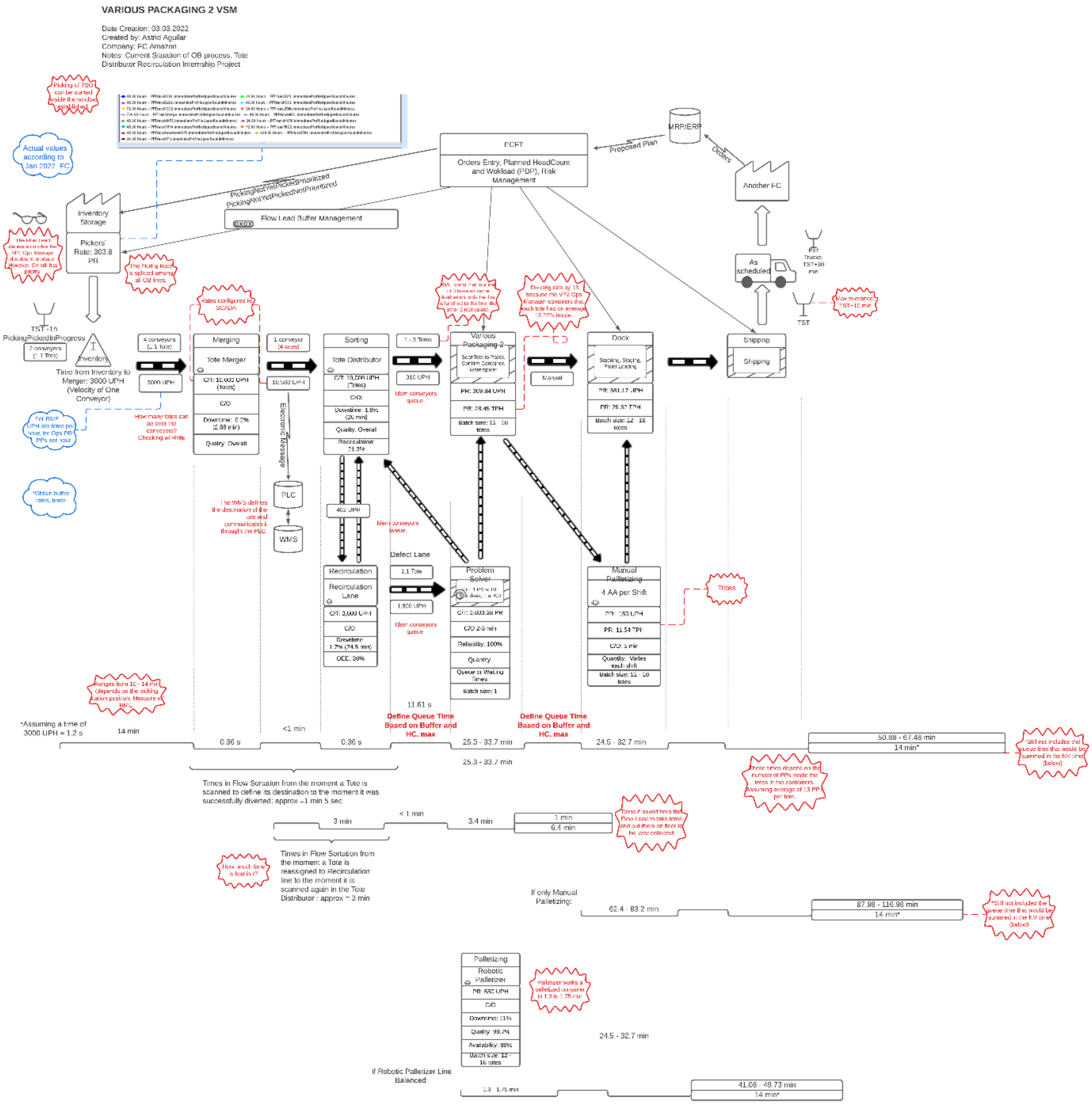
VSM of Multiple Packaging



VSM of Single Packaging



VSM of Various Packaging 2



Annex 4 VOC Survey Tabulated Answers

Outbound Problem Solvers Answers

ID	Start time	Completion time	Quale è la % del tempo che dedichi a ricircolare totes quando sei staffato al Jackpot?	Quando sei al Jackpot che altre attività fai?	Che azione(i) fai quando noti che il Jackpot inizia a riempirsi?	Lato RME, hai dei suggerimenti da dare per modificare le loro attività al fine di migliorare il ricircolo del Tote Sorter?	Hai dei suggerimenti che vorresti aggiungere per gestire meglio il Jackpot?	Ritieni che avere un altro PS staffato al Jackpot possa aiutare nella gestione delle tasks e favorire il ricircolo del Tote Sorter?
1	3/29/22 9:19:11	3/29/22 9:26:44	25% - 50%	al Jackpot il problem solver si occupa di smistare i tote prioritari sotto CPT girati dai lead di processo per velocizzarne la partenza, quelli di single in casi estremi vengono paccati dal solver stesso mentre per quelli dei processi di afe vengono lavorati obbligatoriamente uno per uno muovendo i pezzi nei tray. Oltre a questo il solver del jp ha il compito di mantenere pulito il manual induct lavorando i pacchi messi in ko dagli AAS.Ultima task il solver si occupa di portare gli hotpick al desk.	dipende dalle situazioni ma sicuramente viene avvisato il flow lead ed in base alle comunicazioni può essere fatta una qualsiasi delle altre opzioni sopracitate;	Lato RME uno dei problemi che impattano sul jp è dovuto al malfunzionamento del pallettizzatore, se non viene fatto ripartire per tempo si rischia di congestionare il jp rendendo difficoltosi i CPT	il jp è una task complicata perchè assorbe un solver tenendolo lontano dagli altri processi ed anche nelle giornate più tranquille è comunque una risorsa che il problem deve tenere in quella postazione	Sì
2	3/29/22 9:27:21	3/29/22 9:32:57	> 75%	Controllo dei pacchi al manual innduct, refill di scatole nella pack station, aiuto collect single no slam	Farli ricircolare;Comunicarlo al Flow Lead;	Frequente manutenzione	Creazione 5s per dividere i tote di cpt dei vari processi	Sì
3	3/29/22 10:29:39	3/29/22 10:36:57	50% - 75%	Manual induct e a volte gestione delle C13 con Vista	Comunicarlo al Flow Lead;Fare downstack dei totes dei Process Paths che lo richiedono;	no	le linee che a mio parere intasano di più sono il convayor del tso e del vr, eliminando questo sovraccarico, in una situazione difficile, quindi parlo di volumi alti basta un ps in piu al jp, altrimenti in condizioni normali un solver è sufficiente	Sì
4	3/29/22 15:03:37	3/29/22 15:07:26	50% - 75%	controllo tote di cpt con relativi move, controllo tote cpt single, gestione unscannable, collect di hp da portare al desk del PS, check sul manual induct e ovviamente ricircolo tote	Farli ricircolare;dipende dal flusso di tote;	non ne ho le competenze	spesso i tote di tranship intasano la linea, forse aumentare la linea del TSO da permettere di evitare troppo ricircolo potrebbe essere una idea	No
5	3/29/22 15:45:43	3/29/22 15:49:44	50% - 75%	Gestione manual induct, gestione tote di cpt (se di single-pack, se di afe move e flow sortation), ristickeraggio unscannable, gestione rebinhot.	Comunicarlo al Flow Lead;Farli ricircolare;	Non saprei		Sì
6	3/29/22 19:44:29	3/29/22 19:52:46	50% - 75%	Manual induct, paccare le priorita del SM/SNS e portarle al KO, portare a ogni wall di AFE i tray di cpt. Contrallare Rodeo generale per dare una mano al DESK. Eventualmente flagare le 1320.	Fare downstack dei totes dei Process Paths che lo richiedono;Farli ricircolare;Comunicarlo al Flow Lead;	.	un indiretto fisso per il JP, per i giorni di alto volume. Cosi il PS che sta al JP non si devo movere del JP.	No
7	3/30/22 14:41:42	3/30/22 14:44:29	5%	vista manual indact aging	Farli ricircolare;	no	no	No
8	3/30/22 14:41:44	3/30/22 14:46:03	50% - 75%	VISTA, MANUAL INDUCT, AGING	comunicare con il flow lead e prendere decisioni di conseguenza;	Inserire un controllo fisico dei codici a barre che identificano i totes. Spesso i tote che ricircolano hanno un codice non leggibile dalle fotocellule.	Riorganizzare l'area 5s per avere più spazio per i totes vuoti, per uboat e tray.	No
9	3/30/22 15:05:48	3/30/22 15:07:57	> 75%	manual induct	Farli ricircolare;Fare downstack dei totes dei Process Paths che lo richiedono;Comunicarlo al Flow Lead;	no		No
10	3/30/22 16:03:46	3/30/22 16:06:44	> 75%	Move nei tray per il cpt, ripatchare barcode illegibili, giro al manual induct per recuperare pacchi con lable accartocciate o assenti, togliere dalla linea tote inmumerevoli che scendono vuoti sia fisicamente che virtualmente, tote che scendono fisicamente pieni, ma virtualmente vuoti.	Comunicarlo al Flow Lead;Farli ricircolare;	Accorgersi immediatamente di eventuali problemi sui vari PP		No
11	3/31/22 15:40:55	3/31/22 15:46:22	50% - 75%	Controllare le c13 del Manual Induct . Lavorare i Tote problematici . Fare Aging del reparto OB	Farli ricircolare;Se il ricircolo è molto elevato e noto che sono sempre gli stessi Tote che scendono al Jackpot , comunico al Flow . In caso contrario ricorcolo normalmente;	no		No
12	3/31/22 16:28:42	3/31/22 16:33:05	50% - 75%	manual induct	Farli ricircolare;Fare downstack dei totes dei Process Paths che lo richiedono;Comunicarlo al Flow Lead;	.	non mandare tote cpt prima di un ora del cpt	No
13	3/31/22 17:40:03	3/31/22 18:14:42	25% - 50%	rielaborare le spedizioni che si raccolgono al manual induct, ship label (strappate o perse), ed a volte con k basso si è provato a fare PS sns	Comunicarlo al Flow Lead;dopo essersi confrontati con flow e lead del processo i tote possono essere messi a terra per poi essere ricircolati in un secondo momento;Fare downstack dei totes dei Process Paths che lo richiedono;Farli ricircolare;	no (per ultima domanda "staffati jp", nei momenti di picco, serve un'altra persona, altrimenti una persona è sufficiente)	avere un solo piano di lavoro, con pc, bilancia radio e e rastrelliera cartoni, per avere spazio al fine di creare 5s per ubot destinati ai CPT single e sns, ed avere un porta tote, come quello del cubiscan dove poggiare il tote degli hp	No
14	4/4/22 6:57:11	4/4/22 6:59:45	50% - 75%	pacchi manual induct	Farli ricircolare;	-		No

Outbound Area Managers Answers

ID	Start time	Completion time	Segnala la posizione in cui lavori in Operations OB. (Se sei un Lead che a volte lavora come Flow Lead, segnalare quela opzione).	Produttività	Qualità	AAs engagement	Customer Experience	Safety	Conoscendo la seguente informazione sulle linee Top Offenders del ricircolo del Tote Sorter: > SNS2 (28%) > TSO (13%) > VRET (10%) Quali sono secondo te le variabili che influiscono maggiormente?	Cosa può essere cambiato lato RME secondo te per migliorare il ricircolo del Tote Sorter?	Hai dei suggerimenti che vorresti aggiungere per gestire meglio il ricircolo del Tote Sorter?
1	3/28/22 10:16:39	3/28/22 10:19:29	Area Manager	2	1	3	4	5	Rates dei packers;CPT Risks;Gestione del buffer al Flow;	Allungare conveyor SNS-2	Miglior controllo di VRET e TSO
2	3/28/22 10:22:40	3/28/22 10:26:18	Area Manager	5	5	5	5	5	CPT Risks;Rates dei packers;Rates dei pickers;Gestione del buffer al Flow;	Autobilanciamento linee di single medium, Maggior utilizzo della super high velocity, Miglioramento nella gestione delle problematiche del pallettizer	Rendere L4 una linea ibrida. Nei periodi non di picco, in cui non serve lavorare SM su quella linea, sarebbe meglio lavorarci processi PCNS disabilitando la slam e disponendo zebra printers sulle pack stations.
3	3/28/22 11:41:25	3/28/22 11:44:36	Area Manager	5	5	5	5	5	Gestione del buffer al Flow;	Più velocità negli interventi e (su indicazione del flow team) support JB light per liberare le linee da buffer alto.	migliore gestione dei buffers
4	3/28/22 11:45:59	3/28/22 11:47:55	Area Manager	5	4	4	5	3	CPT Risks;Volume shift;Palletizer;	Contingency live	incrementare la velocità del sorter
6	3/28/22 13:48:13	3/28/22 13:49:02	Area Manager	5	3	4	4	3	Efficienza nello spostamento degli AAs;Gestione del buffer al Flow;	-	.
7	3/29/22 7:02:26	3/29/22 7:06:27	Area Manager	5	4	5	5	5	CPT Risks;Volume shift;Gestione del buffer al Flow;Apertura di molte linee di TSO contemporaneamente ;	provare a cambiare la regola del divert che al momento è 1/3	n/a
8	3/29/22 10:51:50	3/29/22 10:53:13	Area Manager	4	5	5	4	4	Rates dei packers;Gestione del buffer al Flow;	VELOCITA' TOTE SORTER, MAGGIORE UTILIZZO DELL'HIGH VELOCITY, MAGGIORE DIVE DEEP DI RME SU EVENTUALI PROBLEMATICHE	VELOCITA' TOTE SORTER, MAGGIORE UTILIZZO DELL'HIGH VELOCITY
9	3/29/22 18:50:21	3/29/22 18:52:37	Area Manager	5	5	5	5	5	Gestione del buffer al Flow;	una linea di ricircolo in più	aumentare la lunghezza della linea di vret o rallentare la velocità della linea di sns2
13	3/31/22 15:56:16	3/31/22 16:18:08	Area Manager	5	5	5	5	5	Efficienza nello spostamento degli AAs;Gestione del buffer al Flow;Volume shift;	Si potrebbe stabilire una procedura per cui RME, avvisa il Flow OB più frequentemente quando vede pieni del tote sorter o inizio di recirculation	La differenza la fa sicuramente una buona gestione del buffer lato flow, quindi bisogna aumentare il focus sui target buffers
15	4/1/22 15:25:50	4/1/22 15:55:21	Area Manager	5	5	5	5	5	Rates dei packers;Gestione del buffer al Flow;Volume shift;	Proattività di risposta ai problemi	no

Outbound Flow Leads Answers

ID	Start time	Completion time	Segnala la posizione in cui lavori in Operations OB. (Se sei un Lead che a volte lavora come Flow Lead, segnalare quela opzione).	Inoltre a Flow Lead, segnala il (i) PP(s) per i qualli lavori a OB. (Puoi selezionare più di un'opzione).	Quando al SoS, organizza in base al livello di importanza che dai alle seguenti informazioni per pianificare in anticipo il turno (dal più importante al meno importante).	Se c'è altra informazione che consideri al SoS oltre a quella sopra, per favore, menzionala.	Buffer per PP	Headcount per PP	TUR dei vari PPs	Volume di Produzione	Rates di Picking, Induct e Packing	Backlog split	CPT Volume	Risk Management	Tote Sorter recirculation	Buffer fisico per linea	Prior Day Plan (PDP)	Nello stabilizzare il buffer a SoS, quali consideri come fattori principali?	Quali sono le azioni che intraprendi quando si ha elevato ricircolo sul Tote Sorter?	Ci sono strumenti o informazioni che vorresti avere che ti permetterebbero di vedere le cose in maniera più chiara o per decidere con un giudizio più sicuro?	Ci sono informazioni sul tote sorter che vorresti capire meglio per gestire il buffer in modo che non aumenti il ricircolo?	Hai suggerimenti che OB potrebbe mettere in pratica per migliorare il ricircolo sul Tote Sorter?	Hai suggerimenti che RSP potrebbe mettere in pratica per migliorare il ricircolo sul Tote Sorter?	Hai suggerimenti che RME potrebbe mettere in pratica per migliorare il ricircolo sul Tote Sorter?
5	3/28/22 11:43:38	3/28/22 12:09:32	Flow Lead	SingleMedium ;SingleNoSlam1/2 ;AFE 1/2 ;	Headcount per PP;Buffer attuale per Process Path (PP);Buffer totale attuale ;Previsione di risk management;Volume prodotto fino ad allora e target totale per la giornata;TUR e Rates attuali di Picking/Induct/Packing ;Buffer fisico attuale per PP;Backlog split per PP;Volume a lavorare al TSO/VRET ;	manutenzioni programmate, chiusure di eventuali wall	Spesso	Spesso	Spesso	Spesso	Spesso	Occasionalmente	Spesso	Spesso	Occasionalmente	Spesso	Occasionalmente	Ritardo dei PCS nell' eseguire le azioni;	Controlli il buffer del PP che causa ricircolo; Aggiungere packers o aprire walls ;	numero effettivo dei pickers loggati	nessuna	nessuna	nessuna	nessuna
11	3/30/22 1:44:12	3/30/22 1:55:21	Flow Lead	SingleMedium ;SingleNoSlam1/2 ;	Headcount per PP;Buffer totale attuale ;Buffer attuale per Process Path (PP);Volume a lavorare al TSO/VRET ;Buffer fisico attuale per PP;Backlog split per PP;TUR e Rates attuali di Picking/Induct/Packing ;Volume prodotto fino ad allora e target totale per la giornata;Previsione di risk management;		Sempre	Sempre	Sempre	Sempre	Sempre	Spesso	Spesso	Sempre	Spesso	Sempre	Spesso	Labor moves;Ritardo nel ricevere le conte;	Controlli il buffer del PP che causa ricircolo;Communicarlo al Lead della linea ;Chiudere temporaneamente la linea interessata ;scaricare manualmente la linea interessata ;	qualsiasi strumento o informazione aggiuntiva sarebbe utile per agire al meglio	informazioni tecniche	non al momento	non al momento	non al momento
14	3/31/22 17:14:12	3/31/22 17:26:43	Flow Lead	SingleMedium ;SingleNoSlam1/2 ;AFE 1/2 ;VRET ;	Headcount per PP;Buffer totale attuale ;Buffer attuale per Process Path (PP);Buffer fisico attuale per PP;TUR e Rates attuali di Picking/Induct/Packing ;Previsione di risk management;Backlog split per PP;Volume a lavorare al TSO/VRET ;Volume prodotto fino ad allora e target totale per la giornata;		Sempre	Sempre	Sempre	Spesso	Sempre	Spesso	Spesso	Spesso	Spesso	Spesso	Occasionalmente	Labor moves;	le azioni da intraprendere cambiano in base all pp che ricircola;	pick rates più accurato e split dei picker per pp più facilmente monitorabile	quanti sono i tote max per ogni linea (accurato)	più comunicazione con vr e tso	non conosco bene i processi di rsp	poca esperienza per giudicare
16	4/3/22 14:51:39	4/3/22 15:25:49	Flow Lead	SingleMedium ;SingleNoSlam1/2 ;AFE 1/2 ;	Previsione di risk management;Backlog split per PP;Volume prodotto fino ad allora e target totale per la giornata;Buffer totale attuale ;Buffer attuale per Process Path (PP);TUR e Rates attuali di Picking/Induct/Packing ;Volume a lavorare al TSO/VRET ;Headcount per PP;Buffer fisico attuale per PP;		Sempre	Spesso	Sempre	Sempre	Sempre	Sempre	Sempre	Sempre	Sempre	Sempre	Spesso	Ritardo nel effettuare le operazioni da RME;Labor moves;Ritardo nel ricevere le conte;Ritardo dei PCS nell' eseguire le azioni;	Chiudere temporaneamente la linea interessata ;Communicarlo al Lead della linea ;Controlli il buffer del PP che causa ricircolo;Ridurre il numero di pickers; Aggiungere packers o aprire walls ;Azioni con il Problem Solver al Jackpot;	reputo Grafana un ottimo strumento , forse avere accesso alle telecamere di RME sul tote sorter potrebbe aiutare ad avere un'idea della effettiva presenza fisica dei tote sul sorter	ho già ricevuto tutte le informazioni di cui ho bisogno quando sono stato accompagnato da RME sul tote sorter , so che però non tutti i flow lead hanno avuto questa opportunità, io personalmente consiglierei a operation di schedulare sempre un tour sul tote sorter all'interno della formazione da flow lead.	evitare il più possibile spostamenti di HC senza comunicarli al flow e ridurre la durata di essi a massimo 10/15 minuti salvo eccezioni. Maggiore cominucazione tra ship e flow riguardo a problemi sul pallettizzatore	non conosco abbastanza il mondo RSP per poter dare un consiglio, ma in base alla mia esperienza RSP non può fare molto.	maggiore intraprendenza e maggior ownership nel risolvere i problemi soprattutto sul palletizer.

Operations Managers Answers

ID	Start time	Completion time	Segnala la posizione in cui lavori in Operations OB. (Se sei un Lead che a volte lavora come Flow Lead, segnalare quela opzione).	Produttività2	Qualità2	AAs engagement2	Customer Experience2	Safety2	Quante volte durante il turno controlli l'IGraph su ricircolo del Tote Sorter?	Hai dei suggerimenti per gestire meglio le manutenzioni con RME?	Hai dei suggerimenti per gestire meglio il ricircolo del Tote Sorter?	Quali sono i KPI operativi che secondo te sono influenzati maggiormente dal ricircolo del Tote Sorter?	Ci sono punti di miglioramento che vedi nella collaborazione con ECFT per ridurre il ricircolo del Tote Sorter?	A tuo parere, quali sono gli stakeholders che influenzano maggiormente il ricircolo del Tote Sorter
10	3/30/22 1:22:22	3/30/22 1:38:05	Operations Manager	3	3	5	4	5	1 - 10 volte	Ottimizzazione dei fermi macchina in maniera da ridurre impatto sulla capacità di OB. Es. fare contemporaneamente Slam 1 e IS 15 per fermare AFE 1/2 solo una volta e non in due giorni separati	1) Risolvere problema Throughput limit con RME 2) Aumentare focus dei PS staffati al JP, troppo spesso l'andon blu è acceso e quindi il sistema registra la fullness solo perchè loro non ricircolano 3) Controllare con RME se ci sia qualche altro parametro da verificare come il Throughput Limit	Cycle Time ;OB Productivity ;DEA;SLA;	In linea di massima no, corretta comunicazione per una migliore gestione dei buffers	OB
12	3/31/22 10:07:07	3/31/22 10:08:52	Operations Manager	4	3	3	5	4	1 - 10 volte	Migliorare comunicazione preventiva	Avere solver formati 100% del tempo al tote jackpot	SLA;DEA;Cycle Time ;	Gestione lean dei buffer dei process path con UPT più bassa (SNS2)	OB

RME Answers

ID	Start time	Completion time	Quali azioni intraprendi in relazione al tote sorter?	Controlli la disattivazione/attivazione del tote sorter durante le pause di Ops?	Quando Operations fa la pausa unica, quando CHIUDI il tote sorter? (senza che il TSO stia lavorando)	Quando Operations fa la pausa unica, quando APRI il tote sorter?	Hai suggerimenti per Outbound per gestire meglio il Tote Sorter e quindi diminuire il ricircolo?	Secondo il tuo parere, ci sono variabili dipendenti da RSP che influiscono sul ricircolo del tote sorter? Se sì, quali?	Potrebbe essere fatta qualche azione a livello manutentivo per migliorare il ricircolo sul Tote Sorter? Se sì, quali?	A tuo parere, quali sono le azioni ulteriori che potrebbero ridurre il ricircolo del Tote Sorter?
1	3/28/22 10:21:33	3/28/22 10:31:01	Controllo durante la pausa ;Prevenire il gridlock del tote sorter;Tirare fuori totes quando alcune linee sono piene ;Tirare fuori totes solo quando la linea di recirculation si sta riempiendo ;Monitorare i suoi valori di performance (Throughput, Disponibilità, OEE, ecc.);	Sì	Dopo che Ops ha iniziato la pausa	Allo stesso tempo che Ops ritorna dalla pausa	bilanciare correttamente il processo di pick con i vari processi di OB + non far ricircolare TOTE a caso dal jackpot	sicuramente il numero e l'efficienza dei picker oltre che la gestione del processo di pick	check del read rate degli scanner e delle fotocellule di pieno	creare zone di buffer dopo che i tote vengono divertati sui processi
2	3/28/22 11:59:09	3/28/22 12:04:38	Prevenire il gridlock del tote sorter;Monitorare i suoi valori di performance (Throughput, Disponibilità, OEE, ecc.);	Sì	Prima che Ops inizii la pausa	Successivamente al rientro di Ops dalla pausa	Se durante la pausa si lavora al TSO bisogna calcolare i tote in transit per tempo. es: TOTE in transit 300, TOTE per TSO 30/50. Gli altri manderanno inevitabilmente l'impianto in gridlock		NO.	Non lasciare un unico processo in ACTIVE durante la pausa. TSO + AFE oppure TSO + SM/SNS. SOLO TSO non è sufficiente
3	3/28/22 20:58:45	3/28/22 21:05:20	Prevenire il gridlock del tote sorter;Monitorare i suoi valori di performance (Throughput, Disponibilità, OEE, ecc.);	Sì	Al stesso tempo che Ops inizia la pausa	Allo stesso tempo che Ops ritorna dalla pausa	numero di tote a destinazione e numero di packer devono essere proporzionati meglio			
4	3/28/22 23:16:09	3/28/22 23:28:10	Monitorare i suoi valori di performance (Throughput, Disponibilità, OEE, ecc.);Controllo durante la pausa ;Prevenire il gridlock del tote sorter;	Sì	Al stesso tempo che Ops inizia la pausa	Allo stesso tempo che Ops ritorna dalla pausa	per ora no			
5	3/29/22 10:57:43	3/29/22 11:00:13	Controllo durante la pausa ;Prevenire il gridlock del tote sorter;Tirare fuori totes quando alcune linee sono piene ;Tirare fuori totes solo quando la linea di recirculation si sta riempiendo ;Monitorare i suoi valori di performance (Throughput, Disponibilità, OEE, ecc.);	Sì	Prima che Ops inizii la pausa	Successivamente al rientro di Ops dalla pausa	Far lavorare bene la gente al KO	Molte volte tengono dei Tote su stanziati, fanno aumentare il transit ma non il ricircolo	aumentare l'area di scarico allungato i conveyor.	Far lavorare meglio il Problem, spesso ricircolano perché il KO è full.
6	3/31/22 12:54:38	3/31/22 13:40:38	Prevenire il gridlock del tote sorter;Monitorare i suoi valori di performance (Throughput, Disponibilità, OEE, ecc.);Controllo durante la pausa ;	Sì	Al stesso tempo che Ops inizia la pausa	Allo stesso tempo che Ops ritorna dalla pausa	Bilanciare bene i flussi delle single (pack o manual) con quelli destinati alle induct, in modo che il merge possa essere chiuso con quanto più possibili Takeaway	andrebbe calcolato meglio la differenza di flusso tra le vaire tipologie di linee (velocità dei processi)	A livello tecnico nulla da eccepire	La soluzione credo di averla, ne possiamo parlare a voce
7	4/1/22 15:55:19	4/1/22 16:02:30	Prevenire il gridlock del tote sorter;Controllo durante la pausa ;Monitorare i suoi valori di performance (Throughput, Disponibilità, OEE, ecc.);Tirare fuori totes solo quando la linea di recirculation si sta riempiendo ;	Sì	Prima che Ops inizii la pausa	Successivamente al rientro di Ops dalla pausa	Controllare il numero di tote destinati a ciascuna linea se è idoneo o meno alla capacità della linea.		A mio parere, no.	Maggiore attenzione del flow lead, spesso con scarsa esperienza.
8	4/3/22 0:41:43	4/3/22 0:45:24	Controllo durante la pausa ;Prevenire il gridlock del tote sorter;Monitorare i suoi valori di performance (Throughput, Disponibilità, OEE, ecc.);	Sì	Prima che Ops inizii la pausa	Successivamente al rientro di Ops dalla pausa	evitare di utilizzare i wall vicini ,quando possibile.	indirizzamento corretto dei wall		

6.3 Annexes Analyze (General Project)

Annex 5 KPI Dashboard

PROJECT KPI's DASHBOARD

1 Tote Distributor Recirc %

Update Daily

Q3 & Q4 2021	WK1-WK13 2022	Δ %	WK14-WK23 2022	Δ %	WK24-WK26	Δ %
30.01	20.51	-31.65%	13.93	-32.08%	13.62	-2.25%

2 Recirculation Top Offenders

Update Weekly

2021 – Q3 & Q4 2021 | 2022 – WK1-WK13 2022 | WK14-WK23 2022 | WK24-WK26

Lane	% per Lane	Defect	% per Defect	Per Lane (WK1-WK13 2022)	Defect	Per Defect	Per Lane (WK14-WK23 2022)	Defect	Per Defect	Per Lane (WK24-WK26)	Defect	Per Defect
MP1 (M0114)	29%	Lane Full	62%	27%	Lane Full	35.97%	17%	Lane Full	84.94%	14%	Lane Full	87.97%
		TH_Limit	38%	175786	TH_Limit	63.36%	45510	TH_Limit	13.61%	12086	TH_Limit	10.11%
VP2 (M0120)	13%	Lane Full	67%	23%	Lane Full	61.61%	35%	Lane Full	91.88%	45%	Lane Full	92.37%
		TH_Limit	32%	151199	TH_Limit	37.23%	96939	TH_Limit	7.24%	38477	TH_Limit	6.66%
VP1 (M0102)	16%	Lane Full	61%	12%	Lane Full	50.3%	12%	Lane Full	92.7%	10%	Lane Full	93.5%
		TH_Limit	39%	81345	TH_Limit	49.1%	32701	TH_Limit	6.1%	8303	TH_Limit	5.6%
	Total (All Lanes)	Lane Full	60.53%	Total (All Lanes)	Lane Full	46.53%	Total (All Lanes)	Lane Full	87.19%	Total (All Lanes)	Lane Full	84.42%
		TH_Limit	38.10%		TH_Limit	50.17%		TH_Limit	8.38%		TH_Limit	7.60%

3 DEA

Update weekly from PerfectMile

2021 – Q3-Q4 | 2022 – WK1-WK13 | WK14-WK23 | WK24-WK26

DEA Pre-SLAM	Q3	Q4	Q1	WK1-WK13	Q1 2021	Q2	WK14-WK23	Q2 2021	WK24-WK26
FC Execution - Pre-SLAM (bps)	6	5	4		6	4		10	
FC Execution - Pre-SLAM	17,929	14,999	10,347	11,543	20,340	9,361	7,146	34,506	1,945

Pre-SLAM Buckets	Q3	Q4	Q1	WK1-WK13	Q1 2021	Q2	WK14-WK23	Q2 2021	WK24-WK26
Miss./Dam. Inventory (bps)	3	2	2		1	2		2	
Miss./Dam. Inventory (misses)	7,410	4,955	4,573	2,566	3611	4,737	3,453	5424	1,119
Late Slam (bps)	0	0	0		1	1		0	
Late Slam (misses)	994	880	413	426	4706	1,588	1,486	948	86

Update daily from Quality Report

DEA Pre-SLAM	Q3	Q4	Q1	WK1-WK13	Q1 2021	Q2	WK14-WK23	Q2 2021	WK24-WK26
421.00 - Late SLAM Units	916	824	384	419	4429	1,458	1,345	940	79

Update weekly from PerfectMile

2021 – Q3-Q4 | 2022 – WK1-WK13 | WK14-WK23 | WK24-WK26

DEA Post SLAM	Q3	Q4	Q1	WK1-WK13	Q1 2021	Q2	WK14-WK23	Q2 2021	WK24-WK26
FC Execution - Post-SLAM (bps)	5	8	4		7	8		6	
FC Execution - Post-SLAM	15,587	25,089	11,517	11,543	25,743	17,999	13,124	20,286	4,357

Post-SLAM Buckets	Q3	Q4	Q1	WK1-WK13	Q1 2021	Q2	WK14-WK23	Q2 2021	WK24-WK26
FC Rolled Freight (bps)	1	4	1		2	2		1	
FC Rolled Freight (misses)	3,899	10,710	2,488	2,566	5587	5,164	4,489	2,784	578
VPM (bps)	3	3	2		4	3		4	
VPM (misses)	8,267	8,626	5,197	5,247	13774	7,947	5,532	12,584	2,141

4 Productivity

2021 – Q3-Q4 | 2022 – WK1-WK13 | WK14-WK23 | WK24-WK26

*Daily

*Sour

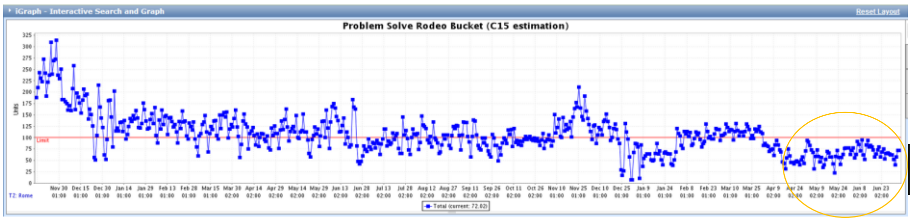
OB Problem Solver	Q3	Q4	Q1	WK1-WK13	Q1 2021	Q2	WK14-WK23	Q2 2021	WK24-WK26
PS Volume	29,799,215.00	32,203,499.00	27,086,639.00	26,091,430.00	30,110,741.10	24,268,790.00	18,691,693.00	35,183,851.11	5,577,097.00
PS Labor Hours	13,010.19	15,940.75	10,340.28	9,967.25	11,612.89	8,677.02	6,502.20	12,215.47	2,174.82
PS Rate	2,290.45	2,020.20	2,619.53	2,617.72	2,592.87	2,796.90	2,874.67	2,989.93	2,564.39

*Wee

*Sour

C15 Problem Solver	Q3	Q4	Q1	WK1-WK13	Q1 2021	Q2	WK14-WK23	Q2 2021	WK24-WK26
Max	258.78	349.73	242.79	242.79	398.12	218.00	218.00	363.54	171.63
Min	19.50	3.00	3.00	3.00	26.77	-5.88	-5.88	0.49	12.63
Average	96.34	108.88	90.93	90.93	126.97	64.94	62.11	111.22	69.03
Median	91.59	104.32	93.32	93.32	126.07	59.88	57.38	106.5	64.05

***600 Days ago, daily values (06.07.2022)**



After mechanical changes over the tote Distributor were done.

Annex 6 Sources of Information for Data Collection

KPI 1: Tote Distributor Recirculation Percentage (%)

Source: **Quality's IS - ICQA Report**. KPI "823.00 - Tote Distributor Recirc %"

KPI 2: Recirculation Top Offenders

Source: Pareto Analysis done by obtaining Operational and Technical defects of the MHE related to the Tote Distributor (chutings/exits). **Raw Data from Grafana.**

Data taken weekly (Sun-Sat) to have a sufficient sample size and consider the multiple situations that can occur in a "normal" working week. From the defects reported in Grafana, the ones of interest are "LANE_FULL" (Ops defect) and "THROUGHPUT_LIMIT" (Technical defect).

KPI 3: DEA

Source: Two sources, PerfectMile and Quality's IS – ICQA Report.

PerfectMile. The general DEA Post-SLAM and buckets of interest values are obtained from PerfectMile, values from the previous week. It is done on a post mortem basis given that the DEA values update constantly for the 4 consecutive days. Still after a week later, it is recommended to double check the DEA of two previous weeks to confirm if the values have changed.

In number of misses and in BPS (Basis points), a common unit of measure **for interest rates and other percentages in finance.** One basis point is equal to 1/100th of 1%.

$$0.01\% = 1 \text{ basis point}$$

Bps is calculated as follows:

$$bps = \frac{errors}{opportunities} * 10{,}000 = \frac{DEA\ Misses}{DEA\ Volume * Scan\ Rate} * 10{,}000$$

The BPS values give a better understanding of the impact of the DEA bucket than the number of misses which can be higher or lower for each FC with a different impact because of the FC's throughput (production) volume.

The DEA Pre-SLAM values for the Late Slam bucket are taken from Quality's IS - ICQA Report. KPI **"130.14 Late Slam Units"** and those are measured in number of units missed, not BPS.

KPI 4: Productivity

Source: **PPR** for OB PS Volumes and Rates and OB Productivity. The PSs C15 Bucket is taken from the graph of MonitorPortal that can be found at the FC's iGraph. To measure differences in scenarios without being affected by outliers, it is calculated the median of the scenario's time frames.

Additional KPI: Arrivals at Defect Lane (Occurrences)

Source: **Grafana**. Obtaining the number of Occurrences and Unique Barcodes for the defects "UNKNOWN" and "SORT_MAX_RECIRC"

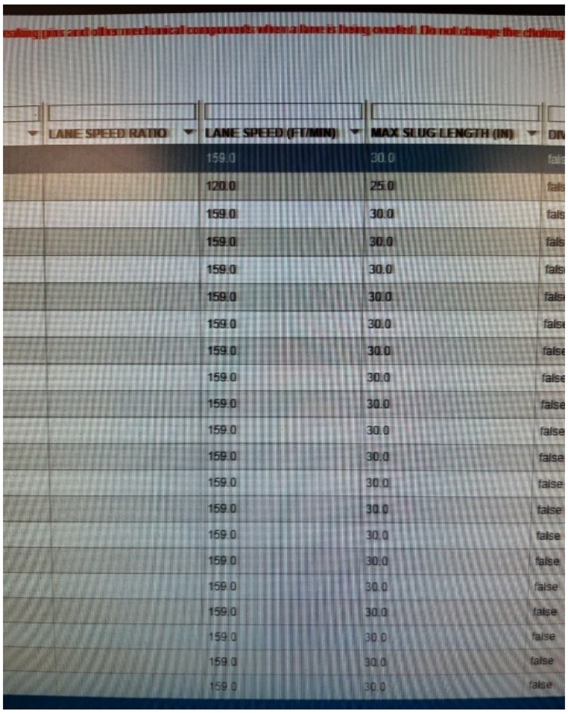
a. Max Recirculation Assigned to Defect Lane (# of Totes)
Taking both total occurrences and Unique Barcodes

b. Arrivals to the Defect Lane (# of Totes)
The total occurrences of UNDLWN

6.4 Annexes Improve (Focused per Area - RME)

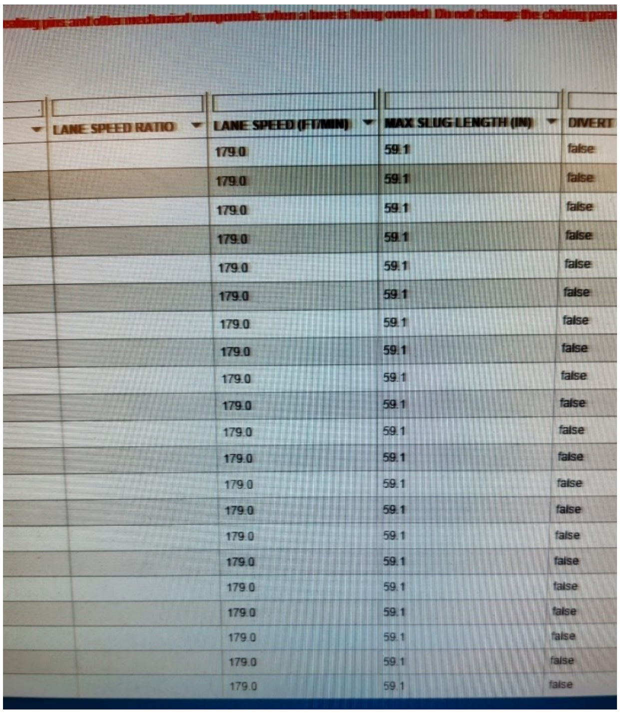
Annex 7 Tote Distributor's Settings Before and After Changes

Before Changes



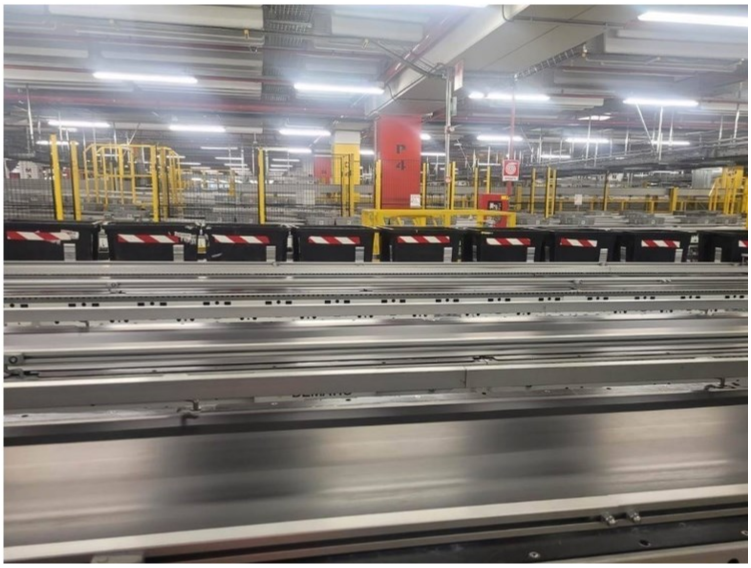
LANE SPEED RATIO	LANE SPEED (FT/MIN)	MAX SLUG LENGTH (IN)
	159.0	30.0
	120.0	25.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0
	159.0	30.0

After Changes



LANE SPEED RATIO	LANE SPEED (FT/MIN)	MAX SLUG LENGTH (IN)	DIVERT
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false
	179.0	59.1	false

Annex 8 Slack of Totes for Trial after TH Limit Configurations Changes



Annex 9 Questions done to Vendor 1

1. What are the settings done from the last peak season?

   The last time that the settings were changed was on August 2018.

2. How every period are the settings changed?

   They are not supposed to be changed. Only Vendor 1 (vendor) is authorized to do these changes.

3. What settings can be done by RME that are possible without needing setting done by Vendor 1?

   Amazon can change only the TPM according to the number of exits to the lanes open.

4. In peak seasons, what are suggestions from Vendor 1 to handle higher load?

   None, the settings are to be kept as they are. They are not supposed to be changed in peak season because they have been designed to undergo this period as well. *More on additional notes

5. UPH of chutings shown on OEE?

   They are to be modified by Amazon RME. They don't tell anything different from the rest of the sites, the correct visualization of the conveyors velocity or capacity is to be the ones after the chutings. The Vendor 1 Schematic map is a correct source of information.

6. The length of the conveyors to the lines are being measured, do they have the values already?

   Still WIP.

7. If TH limit can be changed, can the UPH of the MHE be changed (either higher or lower) after changes done of TH?

   They go hand in hand, the parameters to change are the velocities of the takeaways and the size of the Throughput Limit (how long). The length was changed from 30 to 59.1 in (29.1 in). The speed of the takeaway was changed from 159 to 179 ft/min (+20 ft/min).

   These parameters are changed based on a calculation, not decided randomly. The formula for calculations are known just by Vendor 1, not to be known by Amazon.

8. In case of MHE errors increase dramatically as a consequence of TH Limit setting change, what is the procedure to follow? Contingency plan?

   There is a possibility that the Tech defects will increase/decrease after changes. (*Validate by how much and if the change is a big impact)

9. If TH cannot be changed currently, what are other options?

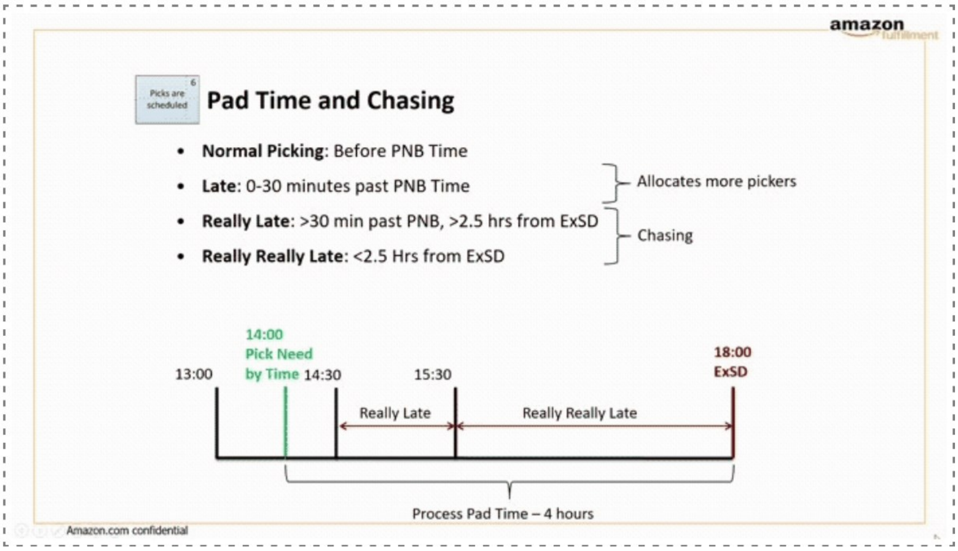
   We'll see.

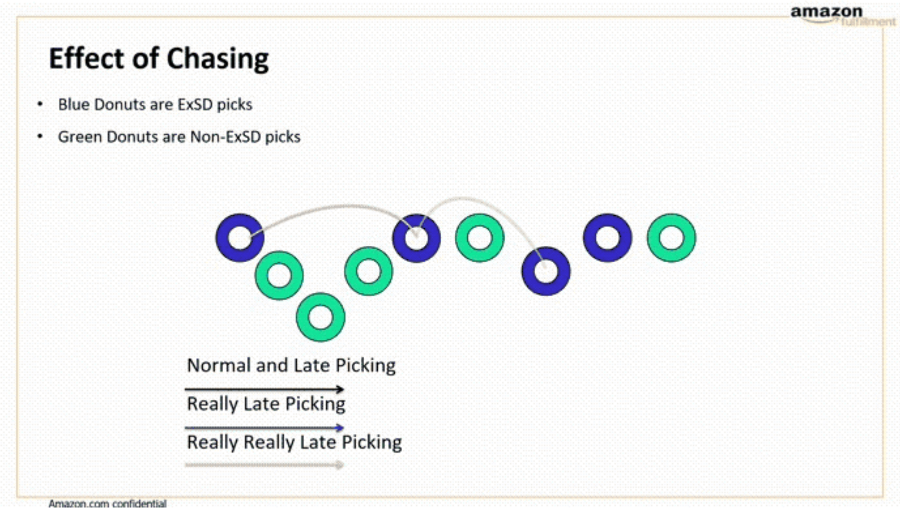
***Additional Notes:**

The Tote Distributor makes changes actively on its velocity according to the number of lines that are physically open (RME), i.e. when lanes are virtually closed (in Flow Sortation routes - done by Flow Lead) they must also be closed by RME. Otherwise, the Tote Distributor considers that line as well for its velocity. (More lines are open, the higher is the velocity and vice versa. This is why it is not necessary to do adjustments to the Tote Distributor settings before or during peak season).

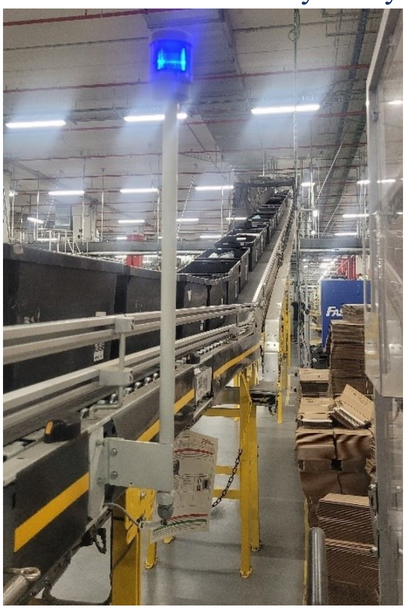
6.5 Annexes Improve (Focused per Area - Operations)

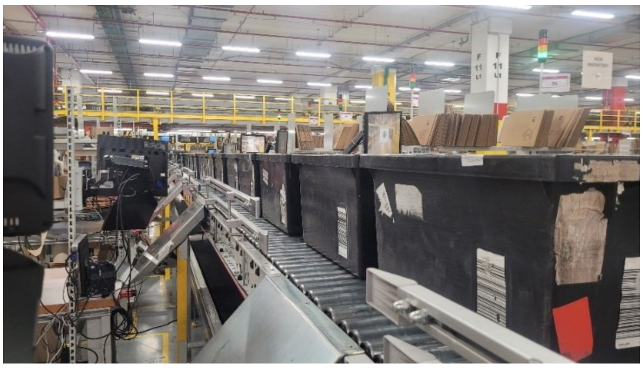
Annex 10 PAD Time and Chasing





Annex 11 Lane Full Physically





Annex 12 Trials DOE (Medium Packaging 1 and Various Packaging 1)

Medium Packaging 1

DESIGN OF EXPERIMENTS (DOE) - MP1

Date of Experiment 13.06.2022 - 19.06.2022
Date of Analysis 20.06.2022

0 Summary

	KPI	Specific KPI	WK23	WK24	WK Δ
1	Recirculation % Tote Distributor	%	18.83	11	-7.56
		Occurrences	34,409	25,396	-9013
2	Recirculation % MP1	%	15.0%	15.0%	0.00
		Occurrences	5040	3860	-1180
3	Productivity	Pack MP1 Rate	217.16	226	9.25
		Pack MP1 Volume	109,277	159,004	49727
		Pack OB PS Rate	2,380.10	2,756.67	376.57
		Pack OB PS Volume			0.00
		C15 Median	68.31	74.75	6.44
4	DEA Pre-SLAM	Late Slam Units	287	59	-228.00
5	Buffer	In Range	24%	24%	0.00
		Out of Range	76%	76%	0.00

1 Recirculation % Tote Distributor

Recirculation % on Tote Distributor

Q3 & Q4 2021	WK1-WK13 2022	WK14-WK23	WK24
30.01	20.51	13.93	11.27

Normal Work

	WK23	Mon 06/6/2022	Tue 07/6/2022	Wed 08/6/2022	Thu 09/6/2022	Fri 10/6/2022	Sat 11/6/2022	Sun 12/6/2022
Recirc %	18.83	18.40	15.64	18.05	21.76	25.46	24.45	8.06
Occurrences	34,409	6,809	6,293	7,450	5,166	4,658	2,557	1,476

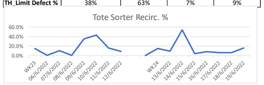
MP1 Trial

	WK24	Mon 13/6/2022	Tue 14/6/2022	Wed 15/6/2022	Thu 16/6/2022	Fri 17/6/2022	Sat 18/6/2022	Sun 19/6/2022	WK Δ
Recirc %	11.27	24.47	10.58	14.55	18.72	6.77	3.40	0.40	-7.56
Occurrences	25,396	10,258	4,149	3,679	4,436	1,903	520	451	-9013.00

2 Recirculation % MP1

Recirculation % MP1 (M0114)

	Q3 & Q4 2021	WK1-WK13 2022	WK14-WK23	WK24
Contribution % of L	29%	27%	13%	15%
Occurrences		175,786	20,500	3,860
Lane Full Defect %	62%	36%	91%	90%
TH_Limit Defect %	38%	63%	7%	9%



WK23

	WK23	06/6/2022	07/6/2022	08/6/2022	09/6/2022	10/6/2022	11/6/2022	12/6/2022
Lane	% Lane							
MP1 (M0114)	15.0%	0.4%	10.0%	0.6%	35%	43%	16%	9%
	5040	30	608	43	1822	1994	417	126
Defect	% per Defect							
Lane Full	89%	23%	88%	40%	92%	93%	77%	58%
TH_Limit	10%	73%	12%	47%	8%	7%	21%	35%

Total Diverted	38,087
% Recirculated	13.2%

WK24

	WK24	13/6/2022	14/6/2022	15/6/2022	16/6/2022	17/6/2022	18/6/2022	19/6/2022	WK Δ
Lane	% Lane								
MP1 (M0114)	15.0%	9.0%	54.0%	4.0%	8%	6%	6%	16%	0.00
	3860	904	2238	147	354	105	29	73	-1180.00
Defect	% per Defect								WK Δ
Lane Full	88%	92%	94%	74%	77%	41%	21%	23%	-0.01
TH_Limit	10%	7%	6%	74%	21%	41%	55%	70%	0.00

Total Diverted	39,670
% Recirculated	9.7%

3 Productivity

Productivity Pack MP1

	Q3 & Q4 2021	WK1-WK13	WK14-WK23	WK24
MP1 Pack Rate		210.40	229.68	229.81

WK23

	WK23	06/6/2022	07/6/2022	08/6/2022	09/6/2022	10/6/2022	11/6/2022	12/6/2022
MP1 Pack Rate	217.16	211.86	192.32	222.53	212.00	219.64	219.01	236.44
MP1 Pack Volume	109,277	24,619	1,094	23,053	1,821	22,351	15,928	25,272

WK24

	WK24	13/6/2022	14/6/2022	15/6/2022	16/6/2022	17/6/2022	18/6/2022	19/6/2022	WK Δ
MP1 Pack Rate	226	228.45	218.59	225.78	230.87	229.40	215.33	260.29	9.25
MP1 Pack Volume	159,004	27,584	22,665	21,344	27,433	22,747	11,959	26,438	49,726.94

Productivity OB Problem Solver

	Q3 & Q4 2021	WK1-WK13	WK14-WK23	WK24
OB Problem Solver Rate	2,141.65	2,617.72	2,723.86	2,756.67
OB Problem Solver Volume	62,002,714	26,091,430	18,691,693	1,873,594

WK23

	WK23	06/6/2022	07/6/2022	08/6/2022	09/6/2022	10/6/2022	11/6/2022	12/6/2022
OB Problem Solver Rate	2,380.10	2,299.61	2,244.27	2,258.02	2,457.06	2,415.68	2,980.40	3,075.18
OB Problem Solver Volume	1,865,308	305,696	329,354	277,441	285,670	270,093	162,609	274,870

WK24

	WK24	13/6/2022	14/6/2022	15/6/2022	16/6/2022	17/6/2022	18/6/2022	19/6/2022	WK Δ
OB Problem Solver Rate	2,756.67	2,794.77	2,493.29	2,789.48	2,759.09	2,586.08	3,122.00	2,649.34	376.57
OB Problem Solver Volume	1,873,594	322,602	294,259	265,164	296,008	275,831	144,860	270,336	8,286

C15				
Max	349.73	242.79	218.00	171.63
Min	3.00	3.00	-5.88	17.25
Average		90.93	62.11	77.54
Median		93.32	57.38	74.75

C15	WK23
Max	218.00
Min	12.38
Average	74.68
Median	68.31

C15	WK24	WK Δ
Max	171.63	-46.38
Min	17.25	4.88
Average	77.54	2.86
Median	74.75	6.44

4 Late Slams

**Late Slams registered in EU Stay Clean Report as "ICQA 130.14 Late Slam Units"*

	Q3 & Q4 2021	WK1-WK13	WK14-WK23	WK24
ICQA 130.14 Late Slam Units		1,374	3,995	72

WK23

	WK23	06/6/2022	07/6/2022	08/6/2022	09/6/2022	10/6/2022	11/6/2022	12/6/2022
ICQA 130.14 Late Slam Units	287	8	1	11	261	6	-	-

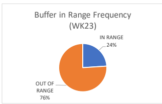
WK24

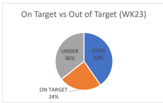
	WK24	13/6/2022	14/6/2022	15/6/2022	16/6/2022	17/6/2022	18/6/2022	19/6/2022	WK Δ
ICQA 130.14 Late Slam Units	59	11	10	-	-	37	-	1	-228.00

5 Buffer

WK23

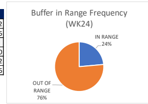
Buffer in Range	
IN RANGE	422
OUT OF RANGE	1338
OVER	710
ON TARGET	422
UNDER	628

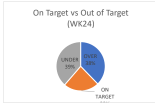




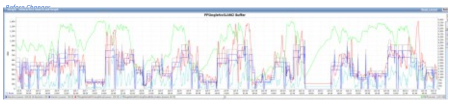
WK24

Buffer in Range	
IN RANGE	412
OUT OF RANGE	1336
OVER	660
ON TARGET	412
UNDER	676

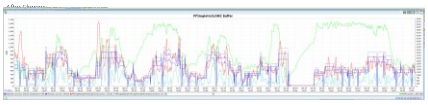




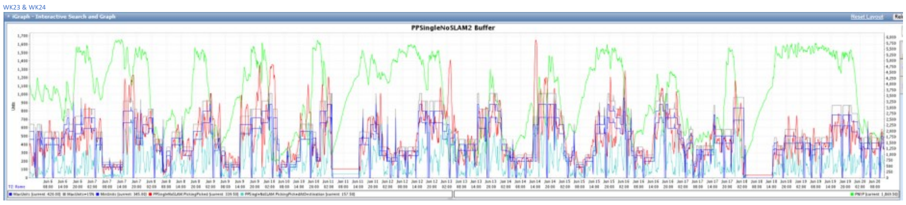
Before Change



After Change



WK23 & WK24



Various Packaging 1

DESIGN OF EXPERIMENTS (DOE) - VP1

0 Summary

	KPI	Specific KPI	WK23	WK24	WK25	WK26	Δ WK23 vs WK26
1	Recirculation % Tote Distributor	%	18.83	11.27	15.99	11.92	-6.91
		Occurrences	34,409	25,396	38,113	23,946	-10463.00
2	Recirculation % VP1	%	12.0%	8.0%	8.7%	13.0%	1%
		Occurrences	4105	2049	3307	3163	-942.00
3	DEA Pre-SLAM	Late Slam Units	287	59			-287.00
5							

-30%

1 Recirculation % Tote Distributor

Recirculation % on Tote Distributor

Q3 & Q4 2021	WK1-WK13 2022	WK14-WK23	WK24	
30.01	20.51	13.93	11.27	

Normal Work

	WK23	Mon 06/6/2022	Tue 07/6/2022	Wed 08/6/2022	Thu 09/6/2022	Fri 10/6/2022	Sat 11/6/2022	Sun 12/6/2022
Recirc %	18.83	18.40	15.64	18.05	21.76	25.46	24.45	8.06
Occurrences	34,409	6,809	6,293	7,450	5,166	4,658	2,557	1,476

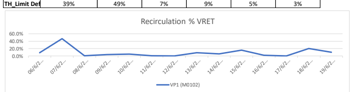
VP1 Trial

	WK24	Mon 13/6/2022	Tue 14/6/2022	Wed 15/6/2022	Thu 16/6/2022	Fri 17/6/2022	Sat 18/6/2022	Sun 19/6/2022	WK Δ
Recirc %	11.27	24.47	10.58	14.55	18.72	6.77	3.40	0.40	-7.56
Occurrences	25,396	10,258	4,149	3,679	4,436	1,903	520	451	-9013.00

2 Recirculation % VP1

Recirculation % VP1

	Q3 & Q4 2021	WK1-WK13 2022	WK14-WK23	WK24	WK25	WK26
Contribution	16%	12%	14%	8%	9%	13%
Occurrences		6,257	2,319	2,049	3,307	3,163
Lane Full Def	61%	50%	91%	90%	94%	95%
TH_Limit Def	39%	49%	7%	9%	5%	3%



WK23

	WK23	06/6/2022	07/6/2022	08/6/2022	09/6/2022	10/6/2022	11/6/2022	12/6/2022
Lane	% Lane							
VP1 (M0102)	12.0%	9.0%	47.0%	1.0%	4%	5%	1%	-
	4105	581	2964	70	184	231	25	-
Defect	% per Defect							
Lane Full	89%	89%	92%	91%	58%	100%	-	-
TH_Limit	9%	9%	7%	7%	42%	0%	-	-

WK24

	WK24	13/6/2022	14/6/2022	15/6/2022	16/6/2022	17/6/2022	18/6/2022	19/6/2022	WK Δ
Lane	% Lane								
VP1 (M0102)	8.0%	9.0%	6.0%	16.0%	2%	0%	20%	10%	-4%
	2049	951	248	605	88	9	104	44	-2056.00
Defect	% per Defect								WK Δ
Lane Full	90%	93%	81%	87%	98%	100%	89%	98%	0.02
TH_Limit	9%	6%	17%	12%	2%	0%	11%	2%	0.00

Annex 13 Various Packaging 1 Calculations

VP1 - Flow Values

Process Path 1 PPFracsDamageLTL

TUR Required

Formula: $TUR\ required = (Target\ Wip - Current\ WIP) + (Pack\ Rate * HC)$

Target WIP	2,000	items	*How much you want to keep in WIP
Current WIP (RebinBuffered+Pi	511	items	
RebinBuffered	406	items	*Get it from RODEO
PickingPicked	105	items	*Get it from RODEO
Pack Rate of PP	250	UPH	*Standard for the PP (Consult AM)
Headcount	4	AA's	*

TUR Required	2489
TUR Required (rounded)	2500

Batch Limit (BL)

Formula: $Batch\ Limit\ (BL) = (TUR/UPB) * Cycle\ Time$

UPB	0.20		
Units Per Container	20	Items	*Get it from Picking-Console or calculate it with "=totes*UPT"
Batch Count	99	Batches	*Get it from Picking-Console

*If updated actual Cycle Time available, use that one. Otherwise, can be calculated as:

$$Cycle\ Time = \frac{UPB}{PRA}$$

Cycle Time (Actual)		hours	
Cycle Time (Calculated)	0.001	hours	
PRA	200	UPH	*Get it from Picking-Console

Batch Limit	12.50	*A good BL for FC is between 6-4 per PP. Try this BL and control TL.

Tote Limit

Formula: $Tote\ Limit\ = TUR\ *\ target\ WIP\ (in\ ore)\ *\ 150\%\ /\ UPT$

UPT	4	Items	*Get it from Picking-Console
Number of Totes	5	Totes	*Get it from Picking-Console
Target WIP (hours)	2	hours	*From the Target WIP, divide by the capacity (Rate*Packers)

Tote Limit	1875	Totes	*This includes totes RebinBuffered and PickingPicked.
Tote Limit (rounded)	1900	Totes	

Adjusted Values

*If the calculated values surpass limits, adjust by distributing appropriately among lines or decide to open less PP.

TUR	
BL	
TL	

Process Path 2

TUR Required

Formula: $TUR\ required = (Target\ Wip - Current\ WIP) + (Pack\ Rate * HC)$

Target WIP		items	*How much you want to keep in WIP
Current WIP (RebinBuffered+Pi	0	items	
RebinBuffered		items	*Get it from RODEO
PickingPicked		items	*Get it from RODEO
Pack Rate of PP		UPH	*Standard for the PP (Consult AM)
Headcount		AA's	

TUR Required	0
TUR Required (rounded)	0

Batch Limit (BL)

Formula: $Batch\ Limit\ (BL) = (TUR/UPB) * Cycle\ Time$

UPB	#DIV/0!		
Units Per Container	0	Items	*Get it from Picking-Console or calculate it with totes*UPT
Batch Count		Batches	*Get it from Picking-Console

*If updated actual Cycle Time available, use that one. Otherwise, can be calculated as:

$$Cycle\ Time = \frac{UPB}{PRA}$$

Cycle Time (Actual)		hours	
Cycle Time (Calculated)	#DIV/0!	hours	
PRA	340	UPH	*Get it from Picking-Console

Batch Limit		*A good BL for FC is between 6-4 per PP.

Tote Limit

Formula: $Tote\ Limit\ = TUR\ *\ target\ WIP\ (in\ ore)\ *\ 150\%\ /\ UPT$

UPT		Items	*Get it from Picking-Console
Number of Totes		Totes	*Get it from Picking-Console
Target WIP (hours)	#DIV/0!	hours	*From the Target WIP, divide by the capacity (Rate*Packers)

Tote Limit		Totes	*This includes totes RebinBuffered and PickingPicked.
Tote Limit (rounded)		Totes	

Adjusted Values

*If the calculated values surpass limits, adjust by distributing appropriately among lines or decide to open less PP.

TUR	
BL	
TL	

Total Values and Limits for VP1

Threshold Overall VP1 TUR	9500		*Proposed Maximum, based on capacity.
Current VP1 TUR	2500		Calculated Values OK
Adjusted VP1 TUR			

Overall VP1 Batch Limit	20	Batches	*Based on physical capacity.
Current VP1 Batch Limit	12.50		Calculated Values OK
Adjusted VP1 Batch Limit			

Overall VP1 Tote Limit	1277	Totes	*Estimated Totes, based on physical capacity.
Current VP1 Tote Limit	1900		Adjust!
Adjusted VP1 Tote Limit	0		OK

149 TL
68 Buffers
16 Totes per buffer
1088
56
168
1405

Summary

	Process Path	TUR	BL	TL
PP1	PPFracsDamageLTL	2500	12.5	0
PP2	0	0	0	0
PP3	0	0	0	0
PP4	0	0	0	0

6.6 Annexes Other Improvements

Annex 14 Deformations in Totes causing Tracking Error

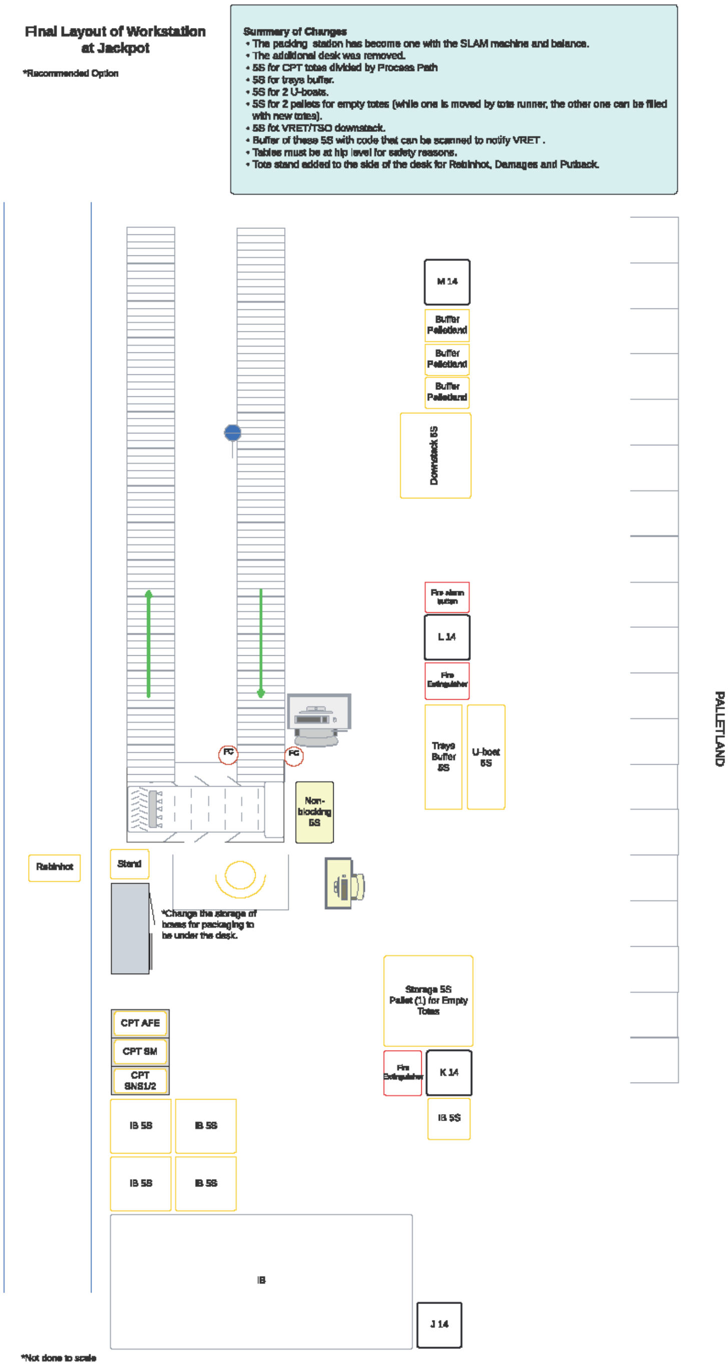
Downstack from Tote Distributor and recirculation

Annex 15 Totes with Indentations in Various Packaging 2

Fallen Totes from Robot Palletizer

Inbound strapped container of totes

Annex 16 Final Defect Lane Layout



Annex 17 Flow Lead Guideline

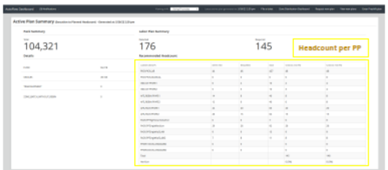


Figura 2 Autoflow - Headcount

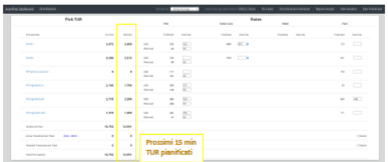


Figura 3 Autoflow - TUR Pianificata

- Controlla il buffer per PP e segui le istruzioni nella sezione "Buffer Attuale per Process Path (PP)".
- Per richiedere aggiungere/levare pickers, devi tenere presente la TUR già pianificata per i prossimi 15 minuti.

$$TUR\ richiesta\ (1\ ora) = (WIP\ target - WIP\ attuale) + Capacità\ di\ Packing$$

- ➤ *Tempo per matchare il buffer target*: [ore]
- ➤ *WIP Target*: [unità]
- ➤ *WIP Attuale*: [unità]
- ➤ *Capacità di Packing*: [UPH]

- Per ottenere i valori per il calcolo:
  - WIP Attuale = **WorkInProgress** in RODEO.
    (Si, includono PickingPicked + Inducted + Sorted + Packing + Scanned + Problem Solving)

https://tiny.amazon.com/thdrjrqs/rodeamazTRN1ExSD

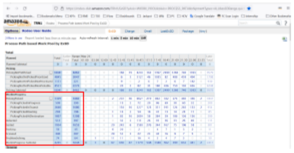


Figura 4 RODEO - Prossimi CPT per CE

  - WIP Target = Dimensione del Buffer (in unità) che vuoi essere raggiunto
  - Capacità di Packing:

$$Capacità\ di\ Packing\ per\ Ora = Headcount\ Pack * UPH$$

- Quanti Pickers sarebbero necessari da aggiungere/levare per raggiungere il target?

$$Numero\ di\ Pickers = \frac{TUR}{Picking\ Rate\ Average\ (PRA)}$$

- Flow Lead può monitorare il numero complessivo di raccoglitori attivi in Picking-Console. Per vedere i pickers assegnati a ogni PP, guarda i pickers attivi per PP visualizzati in un elenco nella pagina Picking-Console o in Roboscout (maggiori informazioni nella sezione **"Picking Rate per Process Path"**)
- Inoltre, se si prevede fare picking per CE + TSO, calcolare la Capacità di Picking richiesta come:

$$CE + TSO\ Target:$$
$$Capacità\ di\ Picking\ Richiesta = Capacità\ di\ Packing + Transshipment\ Target$$

Note:

- Il **Picking Rate Average (PRA)** è il rate standard di picking per PP. NON è picking rate attuale
- Le capacità sono misurate come **Units per Hour (UPH)**. È il numero di articoli che possono essere lavorati (pick, pack, ecc.) dagli AA in un'ora
- Gli obiettivi pianificati sono misurati come **Target Unit Rate (TUR)**. Imposta il numero di unità pianificate per picking all'ora a livello di Process Path. Non è quanto stai piccando attualmente, ma è il tuo target, per evitare mismatch, devi controllare che la TUR sia allineata con la Total Pick Capacity (effettivamente quanto stai piccando)
  https://tiny.amazon.com/bnqh2y99/iGraph

- Le regolazioni TUR sposteranno gradualmente i pickers da un process path all'altro. Non modificare le TUR e aspettarsi che le modifiche avvengano all'istante dato che il sistema favorisce uno spostamento graduale di pickers tra processi
- Buffer Attuale per Process Path (PP)
- Controlla l'HC del PP specifico
  - Headcount "Detected" su Autoflow vs Headcount "Required/Planned"
  - Farsi confermare HC dal Lead per ogni PP
- Controlla il packing rate degli ultimi 30 minuti del PP specifico, questo è il Packing Rate Attuale. (Sezione Rates per Induct, Rebin e Pack per Multis (AFE) e Rates per Pack Singles)
- Confrontare il Packing Rate Attuale vs il Packing Rate su AutoFlow. Controlla "Predicted Pack Rate" e se c'è un Override Pack Rate. L'Override è troppo alto o troppo basso rispetto alla Packing Rate Attuale? Chiedi a ECFT di ristabilire il Pack Rate all'attuale
- Verifica se ci sono problemi meccanici. I totes/trays non arrivano alla linea? Verifica se sono presenti avvisi di jam o altri blocchi su OEE (Sezione Controllo dei performance meccanici su OEE)
- Confermare con RME in caso di problemi meccanici, chiedere il loro supporto (Apri il ticket se necessario e condividilo con ECFT. Link: https://w.amazon.com/bin/view/TRN1_RME/TRN1_Trouble_Tickets)

- Controlla il buffer totale. È oltre/sotto la limitazione superiore/inferiore? Guarda le istruzioni per la sezione Buffer Totale Attuale

Note:

- AutoFlow calcola la TUR e l'aggiorna ogni 15 minuti necessari per ogni Process Path in base all'HC, Pick Rates e buffers
- Autoflow prende in considerazione le limitazioni delle dimensioni del buffer (Buffer Size Limits) per sapere quante unità devono essere elaborate all'ora per evitare di sovraccaricare o ridurre eccessivamente il buffer.

$$HC * Min\ Size\ Limits = Limitazione\ Minima\ del\ Buffer$$
$$HC * Average\ Limits = Target\ Buffer$$
$$HC * Max\ Size\ Limits = Limitazione\ Massima\ del\ Buffer$$

- Le limitazioni di dimensione minima/massima del buffer sono definite da OM/AM in base a review settimanali con ECFT in base ad andamento rates ed altre variabili specifiche che possono influenzarli (e.g. modifiche meccaniche su una linea) (Buffer Size Limits).

Figura 5 Outbound WIP Buffer Size Limits

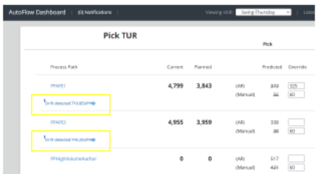
1.3 Overrides

- I rates dei PP devono essere rivalutati almeno ogni 30 minuti in Autoflow e confrontati in PPR con i Rates Attuali per assicurarsi che non siano disallineati
- Gli Overrides dovrebbero essere evitati il più possibile, ma possono essere utilizzati se le performance sono al di fuori delle seguenti soglie:
  - Pack/Pick: +/- 20%
  - Induct: +/- 20%
  - Eventi sulle MHE (Material Handling Equipment) o di Severity che portano a disruption nella gestione del buffer
- Per eventi sulle MHE (Material Handling Equipment) o di Severity2, Overrides possono essere usati per ripristinare il buffer con il suo valore target

1.4 Drifts

- Autoflow esaminerà gli ultimi periodi di tempo in un quarto d'ora e tenterà di rilevare se i buffer post picking (induct per AFE, pack per Singles) si sono esauriti o sono cresciuti costantemente più del previsto. Se Autoflow rileva questo drift dai valori previsti, nei piani di Autoflow verrà utilizzati il drift rilevato in modo che i buffer si regolino di conseguenza
- **Esempio**: supponiamo che Autoflow abbia impostato la stessa TUR per AFE1 per un paio di periodi di tempo, ma gli inducts di AFE1 stano lavorando più lentamente della Induct Rate su Autoflow. Quindi, il

buffer di AFE1 aumenterà più del previsto per i primi due periodi di tempo. Autoflow rileverà quindi un drift positivo nel buffer di AFE1. Ad esempio, Autoflow potrebbe rilevare un drift di +720 UPH in AFE1 (vedere la Figura 6). Questo numero verrà visualizzato nella colonna TUR della dashboard di AutoFlow



- **Filtrate:**
  - Metrics: pick_rate
  - Series: process_path
  - x-axis: hour(time)
- I risultati sono una tabella con i Picking Rates per ora del tempo filtrato e per Process Path attivo in quel tempo.

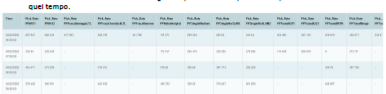


Figura 8 Roboscout - Riporto di Picking TUR per Ora e PP

- Per controllare la TUR, usa lo stesso riporto ma devi filtrare Metrics: **total_picked_unit**

1.5.2 Rates per Induct, Rebin e Pack per Multis (AFE)