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Relocation of Manufacturing Lines - A Structured Approach for Success

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Abstract: ***This paper presents a comprehensive approach to relocating and consolidating manufacturing lines and process equipment between plants efficiently and methodically. As global trends shift manufacturing operations from one region to another, the traditional AS IS Lift and Shift method often falls short in optimizing the manufacturing process. The proposed approach emphasizes redesigning and improving manufacturing processes to eliminate waste and enhance efficiency using advanced technologies combined with lean principles. This method promises significant benefits, including reduced lead times, improved quality, and lower manufacturing costs. The process is broken down into three main workstreams: Industrial and Manufacturing Engineering Planning, Production Control and Logistics Engineering Planning, and Program Management Support. Each workstream comprises detailed phases and steps that ensure a seamless transition. The paper highlights the importance of redesigning manufacturing processes, detailing decommissioning coordination at the origin plant, integrating and testing manufacturing processes at the target plant, and providing ongoing support during the manufacturing build and launch phase. Additionally, it underscores the need for meticulous logistics planning and robust program management to manage stakeholders, delivery, change, and risks effectively. Future work will explore integrating augmented, virtual, and mixed reality technologies to enhance planning, execution, and validation processes for even smoother transitions.***

Keywords: Industrial engineering, Manufacturing engineering, Logistics Engineering, Program Management, Material Handling Equipment, Process flow, Standard Operating Procedures, Work Instruction, Simulation, Risk Management.

1. Introduction

This paper outlines a systematic approach for relocating manufacturing lines or consolidating process equipment from one plant to another in a timely and process-oriented manner. There is a growing trend happening globally where manufacturing operations are moved from one region to another, and typically the method followed is "AS IS Lift and Shift", but the most optimal one is to aim at optimizing the manufacturing design to eliminate waste and improve the line/ manufacturing process in its new location. Doing the same using advanced technologies, in conjunction with traditional, lean principles, can provide enormous value in terms of lead time reduction, improvement in quality, and overall reduction of manufacturing cost by eliminating waste. The process of relocating manufacturing lines and process equipment is very complex, and it becomes even more complicated when the aim is to consolidate and improve existing assembly /manufacturing processes to achieve efficiencies in the new setup. The approach's scope involves three significant work streams: Industrial and Manufacturing Engineering Planning Support, Production Control and Logistics Engineering Planning Support, and Program Management Support. Each workstream has detailed sub-steps that need alignment and execution to achieve a seamless relocation. The document provides a detailed illustration of the sub-steps involved, which include manufacturing process redesign, manufacturing process detailing, decommissioning coordination at the mother plant, and manufacturing integration and tryouts/runoffs at the target plant.

2. Methodology

To move the manufacturing lines, three significant streams need to work simultaneously and in parallel:

- Stream 1 - Industrial and Manufacturing Engineering Planning
- Stream 2 - Production Control and Logistics Engineering Planning
- Stream 3 - Program Management

2.1 Stream1- Industrial and Manufacturing

Industrial and Manufacturing, Engineering Planning support, involves a systematic approach and can be distributed into four phases.

1) Manufacturing Process Re-design
2) Manufacturing Process Detailing & Decommissioning Coordination
3) Manufacturing Integration and Try-outs/Runoffs
4) Manufacturing Build and Launch Support

The diagram below showcases the phases involved and the high-level activities that must be performed.

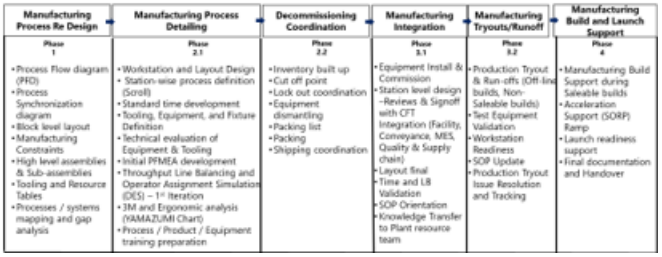


Figure 1: Industrial and Manufacturing Engineering Planning Support

2.1.1 Phase1-ManufacturingProcess Redesign

The diagram below showcases the steps involved in the manufacturing process redesign.

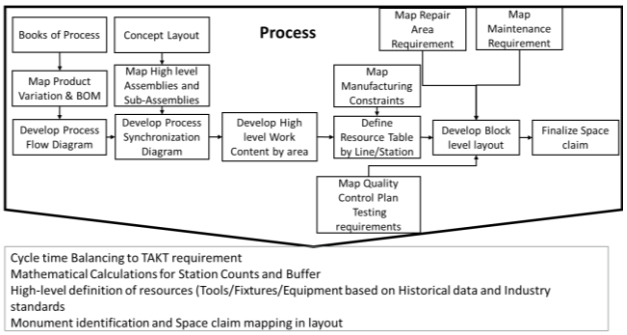


Figure 2: Systematic Process for Manufacturing Process Design

Manufacturing process redesign involves studying the Existing Process and Layout of the plant from where the equipment is planned to be moved. Study Future Space availability, Constraints, and Layout at the target plant. Create a Process flow and Synchronization Diagram for the manufacturing processes to be relocated and define high-level assemblies and sub-assemblies to be manufactured, followed by block-level future state Layout option development (with space claim) for each product and process.

2.1.2Phase2.1-ManufacturingProcess Detailing

The below flowchart showcases the different steps that are required to be followed to detail the manufacturing process,

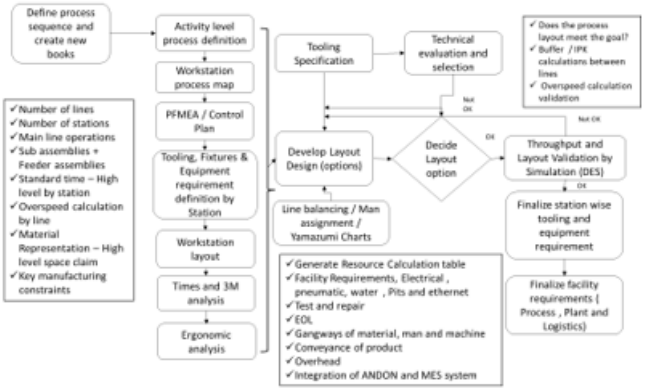


Figure 3: Systematic Layout Mapping of Manufacturing Process

The Major activities involved are as follows,

- Create a detailed workstation layout for each work cell/assembly line.
- Detail process definition by each cell/station/line for processes getting impacted/relocated.
- Develop Standard time for new processes.
- Define new Tooling, Equipment, and Fixture requirements.
- Evaluate new Equipment and tooling as per requirement.
- Develop Initial PFMEA for new / modified processes.
- Perform revised line balancing and define man-assignment based on process change/modification, define operator requirement.
- Design Layout
- Run Throughput Simulation (DES) – 1st Iteration for output validation.
- Perform 3M (Mura, Muri, Muda) and Ergonomic analysis (YAMAZUMI Chart) for new processes.
- Perform revised line balancing and define man-assignment based on process change/modification, define operator requirement.
- Identify improvement opportunities in the existing/new process and layout.
- Run Throughput Simulation (DES) – Iterations for output validation as required. Repeat the process till output is achieved and then finalize the process and layout.
- Prepare training document for Process/ Product/ Equipment changes.

Layout development is a very complex process and below process helps in designing and selecting an optimum layout

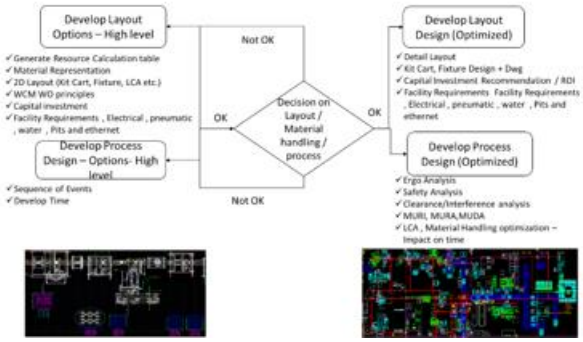


Figure 4: Detailed Layout Design

2.1.3 Phase2.2- Decommissioning Coordination at the Mother Plant

Before starting the decommissioning process, the first step is to evaluate the current inventory levels to determine what needs to be built up for the decommissioning process. Develop a plan to acquire or produce the necessary materials and supplies required for the decommissioning activities. Monitor and manage inventory levels to ensure that adequate stock is available when needed.

Decommissioning coordination involves planning and managing shutting down equipment, facilities, or entire operations. Identify stakeholders involved or impacted by the decommissioning process and establish communication channels. Form a cross-functional team with representatives from relevant departments (e.g., finance, Controller, operations, maintenance, environmental health, and safety) to coordinate decommissioning activities.

Develop and implement a comprehensive lockout/tagout procedure to ensure the safety of personnel during equipment shutdown. Develop a detailed plan for dismantling equipment, including sequencing and resource allocation. Implement safety measures to protect personnel and equipment during dismantling activities. Carry out equipment dismantling according to the established plan, following manufacturer guidelines and safety protocols. Create a comprehensive list of all components and parts to be packed for transportation. Clearly label each item on the packing list to ensure accurate inventory tracking and destination identification. Coordinate shipping schedules to ensure timely delivery of packed items to their respective destinations.

2.1.4 Phase3.1&3.2-Manufacturing Integration and Try-outs / Runoffs at the Target Plant

- Review the station-level design with representatives from various departments, including Facility, Conveyance, MES (Manufacturing Execution System), Quality, and Supply Chain.
- Assess the integration of the equipment with existing systems and processes to identify any potential conflicts or issues.
- Obtain signoff from the cross-functional team to confirm agreement on the station design and integration plan.
- Finalize the layout of the equipment within the production facility, considering factors such as workflow efficiency, space utilization, and safety.
- Seek approval from relevant stakeholders, including plant management and operations teams, for the finalized layout design.
- Carry out the physical installation of equipment according to manufacturer specifications and safety guidelines.
- Connect the equipment to power sources, utilities, and other necessary infrastructure.
- Conduct preliminary tests to ensure that the equipment is functioning properly and safely before commissioning.
- Develop comprehensive standard operating procedures (SOPs) for operating, cleaning, and maintaining the equipment.
- Conduct orientation sessions to familiarize operators and maintenance staff with the SOPs, emphasizing safety protocols, troubleshooting procedures, and best practices.
- Implement training programs to transfer knowledge and skills related to equipment operation, maintenance, and troubleshooting to the plant resource team.
- Provide hands-on training opportunities for plant personnel to practice operating and maintaining the equipment under supervision.
- Ensure that relevant documentation, including manuals, guides, and training materials, is accessible to the plant resource team for reference and ongoing learning.

Managing production tryouts and run-offs involves several key steps to ensure the smooth transition from equipment installation to full-scale production.

Production Tryout & Run-offs (Off-line builds, non-saleable builds)

Off-line Builds: Conduct trial production runs using the newly installed equipment without impacting regular production schedules. These off-line builds allow for testing equipment functionality and process optimization.

Non-Saleable Builds: During tryouts, produce non-saleable or prototype products to evaluate quality, identify potential issues, and make necessary adjustments before full-scale production.

Test Equipment Validation

Equipment Testing: Validate the performance and accuracy of test equipment used to evaluate product quality during production tryouts.

Calibration: Ensure that test equipment is properly calibrated according to industry standards and specifications.

Verification: Verify that test equipment functions correctly and provides reliable data for quality assessment and process control.

Workstation Readiness

Setup and Preparation: Ensure that workstations are set up and ready for production tryouts, including the availability of tools, materials, and personnel.

Safety Measures: Implement safety protocols and precautions to protect workers and equipment during production tryouts.

Quality Assurance: Confirm that workstations meet quality standards and are capable of producing products that meet specifications.

Standard Operating Procedure (SOP) Update

Review Existing SOPs: Review and update standard operating procedures (SOPs) based on insights gained during production tryouts and run-offs.

Revisions: Incorporate any changes or improvements identified during the tryout process into SOPs to ensure consistency and compliance with best practices.

Training: Communicate updated SOPs to relevant personnel and provide training as needed to ensure understanding and adherence to revised procedures

Production Tryout Issue Resolution and Tracking

Issue Identification: Identify and document any issues or challenges encountered during production tryouts, including equipment malfunctions, process inefficiencies, or quality concerns.

Root Cause Analysis: Conduct root cause analysis to determine the underlying reasons for issues and develop corrective actions.

Tracking and Monitoring: Implement a system for tracking and monitoring the resolution of tryout issues, including assigning responsibility, setting deadlines, and documenting outcomes. These documents can be station readiness dashboards, Station/assembly area-wise issue and resolution trackers, tooling masters, etc.

Continuous Improvement: Use insights gained from issue resolution to drive continuous improvement efforts and refine processes and procedures to optimize production performance.

2.1.5 Phase4-Manufacturing Build and Launch Support

Supporting manufacturing build and launch involves providing assistance and resources to ensure smooth production and successful market entry of a product. Below are the main activities involved during the Launch support phase.

- Launch readiness support.
- Manufacturing Build Support during Saleable builds – Providing adequate resources.
- Acceleration Support during Ramp-up – Resources Support
- Final documentation and Handover

By providing comprehensive support throughout the manufacturing build and launch process, organizations can optimize production efficiency, ensure product quality, and maximize the success of new product introductions in the market.

3. Stream2-LogisticsEngineering Planning Support

Logistics Engineering Planning support involves a systematic

approach. It involves designing, optimizing, and managing logistics processes and can be divided into four phases.

1) Logistics Process Re-design
2) Logistics Process Detailing and Decommissioning Coordination
3) Manufacturing Integration and Tryouts/Runoffs
4) Manufacturing Build and Launch Support

The diagram below showcases the phases and high-level activities that must be performed.

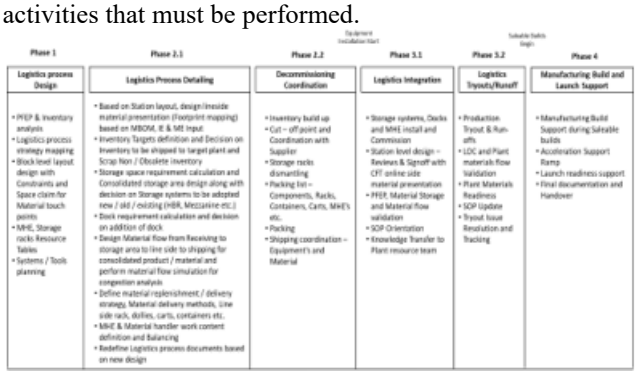


Figure 5: Phases of Logistics Engineering Planning and Support

3.1 Phase 1 – Logistics Process Re-Design

The flow diagram below depicts the steps involved in the redesign of the logistics process.

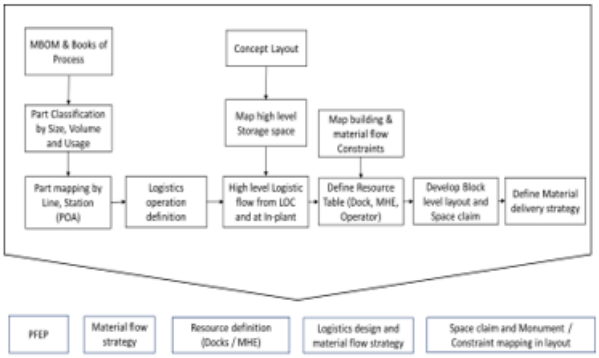


Figure 6: Systematic Process for Plant Material Process Design

- Study Existing PFEP information (PFEP data, Inventory, Storage space calculation, Storage systems/methods, Racks, and Type of product packaging) and Layout (Warehouse, Storage, Dock, Receiving and Shipping area, etc.) of the Mother Plant
- Study Future Space availability, Constraints, and Layout at the Target Plant
- Study Target Plant PFEP information and Material flow.
- Define high-level Logistics process design and strategy.
- High-level computation of Dock requirement, MHE, Storage racks, Space requirement, and Material handlers
- Block level material storage layout and material flow design with constraints and Space claim for Warehouse, Storage systems/racking, Dock locations, Staging area, and Kitting / Staging area.
- Layout evaluation and decision matrix for layout and storage strategy selection
- Map Systems and Processes between both plants and identify gaps.

3.2 Phase 2 - Logistics Process Detailing

The flow diagram below depicts the steps involved in the logistics process detailing.

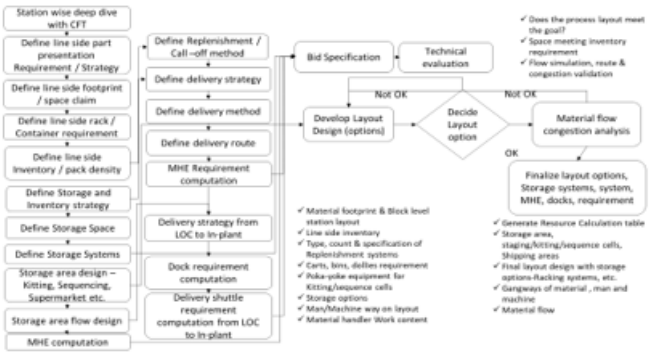
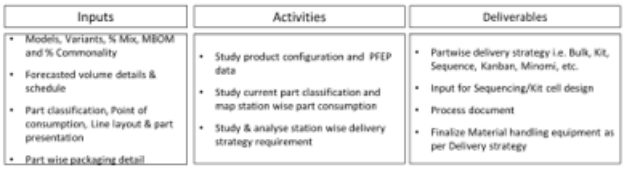


Figure 7: Systematic Layout Mapping of Logistics Operation Center

- Design lineside material presentation (Footprint mapping) based on Station layout, MBOM, IE & ME Input
- Define Inventory Targets, decide on Inventory to be shipped to the Target Plant, and Scrap Non- / Obsolete inventory at the Mother Plant before transfer.
- Storage space requirement calculation and Consolidated (combined) storage area design, along with the decision on Storage systems to be adopted, Figure 9. Material Cell-Off Process Design
- new/old / existing (HBR, Mezzanine, etc.) at Target Plant
- Dock requirement calculation based on the number of inbound and outbound shipments and decision on adding docks, if any
- Design Material flow from Receiving to the storage area to line side to shipping for consolidated (Combined) product/material and perform material flow simulation for congestion analysis.
- Define material replenishment/delivery strategy, Material delivery methods, Line side rack, dollies, carts, containers, etc., for the process and layout changes.
- MHE & Material handler work content definition and balancing for process and layout changes.
- Redefine Logistics process documents based on new Logistics design



Material delivery strategy development

Figure 8: Material Delivery Strategy Development

Material Call-off process design

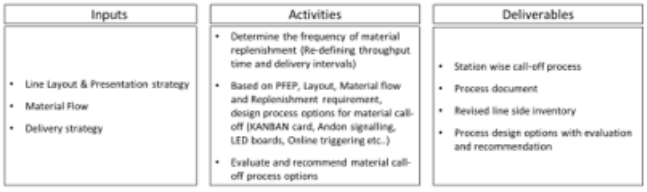


Figure 9: Material Cell-Off Process Design

Dock to Dock Material Flow Map & Material Classification Analysis

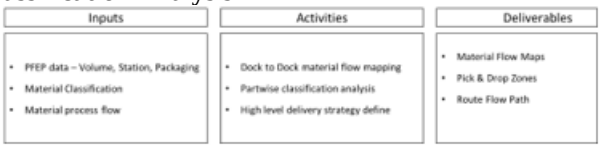


Figure 10: Material flow map and classification analysis

Layout and Storage Design - Storage Space Calculation

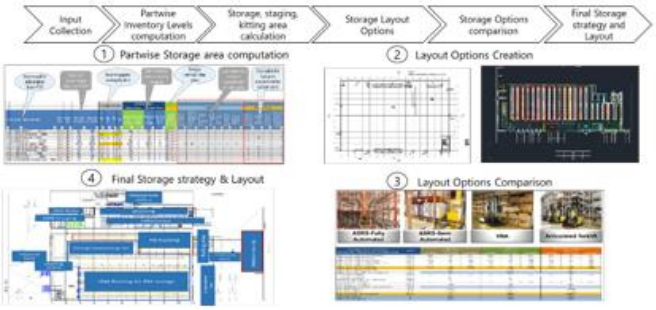


Figure 11: Storage Space Calculation

Dock Requirement Analysis & Operational Process Design

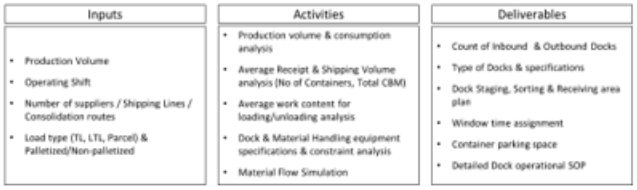


Figure 12: Dock Requirement Analysis & Operational Process Design

Requirement computation for Indirect Manpower and Shuttle for Material Supply (LOC to Plant)

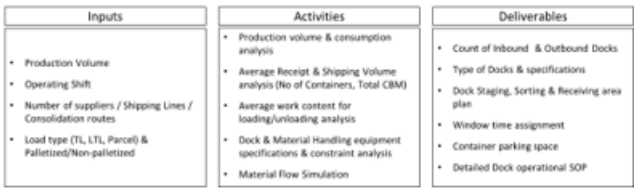


Figure 13: Requirement Computation for Indirect Manpower and Shuttle for Material Supply (LOC to Plant)

3.3 Decommissioning Coordination at Mother Plant

•Develop phase-wise decommissioning and relocation plan.
•Work with the production team to build Inventory without impacting customer delivery – define Inventory buffer storage area, Packaging, and Rack requirements.
•Decide the cut-off point/breakpoint for each product/process/equipment with the supplier and coordinate material delivery/transfer.
•Coordinate with Storage racks dismantling team as per plan (Sequential activities)
•Coordinate with the Logistics team for Packing and shipping of Components, Racks, Containers, Carts, and MHEs and define loading/unloading/handling of equipment and Materia during transit.

3.4 Logistics Integration and Manufacturing Tryouts / Runoffs

- Coordinate with the integration team for the installation and commissioning of Storage systems, Docks, and MHE
- Review station design and line side material presentation and sign off from Integration team – Facility, Conveyance, MES, Quality, Logistics team.
- Develop final layout with minor changes/modifications based on station review and sign-off.
- Validation of PFEP process, Material Storage, Material flow, and Layout for combined processes
- Workstation readiness for each product and process
- SOP (Standard Operating Procedures) / Work Instruction update.
- SOP orientation to operators based on process and layout change.
- Production Tryout & Run-offs (Off-line builds, non-Saleable builds)
- Production Tryout Issue Resolution and Tracking
- Knowledge Transfer to the Plant resource team

3.5 Manufacturing Build and Launch Support

- Manufacturing Build Support during Saleable builds
- Acceleration Support Ramp
- Launch readiness support.
- Final documentation and Handover

4. Stream3-Program Management Support

Program management typically encompasses several key areas to ensure successful project execution and achievement of objectives. Here's an overview of the four main areas within the program management stream.

- Stakeholder Management
- Delivery Management
- Change Management
- Risk Management

The below diagram showcases the main activities involved in program management.

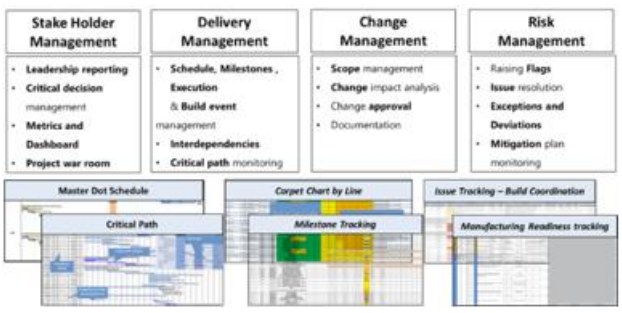


Figure 14: Program Management Pillars

Stake Holder Management
Stakeholder management is a crucial aspect of program management that involves identifying, engaging, and satisfying the needs of various stakeholders. Program managers can effectively engage stakeholders, align program activities with stakeholder expectations, and drive program success by integrating stakeholder management practices into leadership reporting, critical decision management, metrics and dashboards, and project war rooms.

Delivery Management
Delivery management encompasses the planning, executing, and monitoring program activities to ensure timely achievement of objectives. By effectively managing schedules, milestones, execution, build events, interdependencies, and critical path activities, program managers can optimize program delivery, minimize delays, and ensure the successful achievement of program objectives.

Change Management
Change management is essential for effectively managing alterations to project scope, ensuring that changes are carefully evaluated, approved, and documented. By integrating change management practices with scope management, change impact
analysis, change approval, and documentation, project managers can effectively manage changes to project scope while minimizing disruptions and maintaining project alignment with organizational objectives

Risk Management
Risk management involves identifying, assessing, and mitigating risks that could impact project objectives. Project managers can minimize the likelihood and impact of adverse events on project success by actively managing risks, raising flags, resolving issues, addressing exceptions and deviations, and monitoring mitigation plans. This proactive approach helps ensure that projects stay on track and achieve their objectives within established constraints.

5. Conclusion & Future Work

The relocation and consolidation of manufacturing lines to a new facility is a challenging and complex task. However, it can be seamlessly achieved with the above-mentioned three streams and by adopting a step-by-step approach and close monitoring through strong project management. Future work will analyze how we can adopt technologies like AR / VR / MR to aid in the planning, execution, and installation of manufacturing lines, with the goal of virtually validating the complete plan before we break the ground for installation and move.

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