ERICK WAMBUGU
PLP: AI FOR SOFTWARE ENGINEERING
WEEK8 : AI AGENTS Q2

Smart Manufacturing Implementation at Auto Parts Inc.

The challenges faced by Auto Parts Inc: > 15% defect rate, unpredictable downtime, high labor costs, and customization demands) can be strategically addressed by implementing a **Multi-Agent System (MAS)** focusing on **Predictive Maintenance**, **Quality Assurance**, and **Workflow Automation**.

1. AI Agent Implementation Strategy

We propose a three-agent system built on an **Industrial IoT (IIoT) data platform** that integrates sensor data (vibration, temperature, pressure), MES (Manufacturing Execution System) logs, and ERP (Enterprise Resource Planning) order data.

1. Predictive Maintenance Agent (PMA)

- **Role:** Address **unpredictable machine downtime**.
- **Functionality:** A **Model-Based Agent** that continuously analyzes real-time sensor data. It uses Machine Learning models (e.g., LSTM for time-series forecasting) to predict **Remaining Useful Life (RUL)** for critical components (e.g., CNC spindle bearings, press tooling).
- **Action:** Triggers a maintenance work order in the MES only when a failure probability threshold (e.g., >70%) is crossed, allowing maintenance to be scheduled during planned breaks.

2. Quality Assurance Agent (QAA)

- **Role:** Address the **15% defect rate**.
- **Functionality:** A **Reflex Agent** augmented with **Computer Vision (CV)**. High-speed cameras capture images of precision components post-machining. The agent compares the live image features (texture, dimensions, surface finish) against the digital twin specification.
- **Action: Real-time adjustment:** If a deviation trend is detected, the QAA immediately sends feedback to the **Production Optimization Agent** to adjust machine parameters (e.g., feed rate, coolant flow) before the part becomes a full defect. It tags the part for automatic rejection if the defect is confirmed.

3. Production Optimization Agent (POA)

- **Role:** Address **rising labor costs** and **customization demands**.
- **Functionality:** A **Goal-Based Utility Agent** that manages the master production schedule. It ingests customer order data, material availability (from ERP), and capacity information (from MES). It uses a utility function to maximize throughput while minimizing changeover time.

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- **Action: Dynamic Scheduling:** Automatically generates the optimal production sequence for customized orders and autonomously assigns tasks to available assets, directly fulfilling the customer demand for customization and faster delivery without human scheduling intervention.

2. Expected ROI and Implementation Timeline

The strategy will be implemented in three phases over a 9-12 month period.

Quantitative ROI & Timeline

Metric	Baseline	Target (Year 1)	% Improvement	Timeline Focus
Defect Rate	15%	7.5%	approx 50%	QAA Pilot (Months 1-4)
Unplanned Downtime	X hours/month	X/2 hours/month	approx 50%	PMA Pilot (Months 1-4)
Maintenance Cost	Y	Y-20%	20%	PMA Scaling (Months 5-9)
Labor Cost/Part	Z	Z-15%	15%	POA Scaling (Months 5-9)

- **Financial ROI:** By reducing the 15% defect rate and 50% of unplanned downtime, Auto Parts Inc. is expected to achieve a **positive ROI within 12-18 months**, driven primarily by reduced scrap costs, increased asset utilization, and lower labor-intensive inspection/scheduling overhead.2

Qualitative Benefits

- **Workforce Augmentation:** Shifts skilled workers from reactive (fixing breakdowns, manually inspecting) to **proactive roles** (analyzing agent recommendations, complex tool servicing), improving job satisfaction and retention.
- **Business Agility:** The POA allows the company to rapidly adapt to *lot size one* manufacturing and demand spikes, providing a key competitive advantage in the customized parts market.
- **Data Foundation:** Creates a structured, clean data pipeline essential for future Industry 4.0 initiatives (e.g., Digital Twin creation).

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3. Potential Risks and Mitigation Strategies

Risk Category	**Potential Risk**	**Mitigation Strategy**
Technical	**Data Silos/Quality:** Inability to integrate legacy equipment sensor data, leading to incomplete model training.	**Middle ware/IIoT Platform:** Implement an **edge computing layer** (e.g., Azure IoT Edge) to normalize data from old PLCs and new sensors. Start the pilots only on machines with confirmed data quality.
Organizational	**Worker Resistance:** Fear of job replacement, leading to sabotage or under-utilization of the system.	**Human-Agent Symbiosis Training:** Re-frame the project as **Augmentation**, not replacement. Train machine operators to use the QAA and PMA alerts as decision-support tools. Implement a **"HITL" (Human-in-the-Loop)** governance structure where the operator must confirm PMA's work order.
Ethical	**Bias in Quality:** CV models are trained on biased data (e.g., only "good" parts from a single production shift), causing the QAA to disproportionately reject good parts produced under different conditions.	**Model Diversity & Auditing:** Train the QAA using data spanning all production shifts, materials, and operators. Implement **explain-ability (XAI)** to allow human supervisors to audit the *reason* for a rejection.

4. Simulation Link

[Append Simulation Link Here]