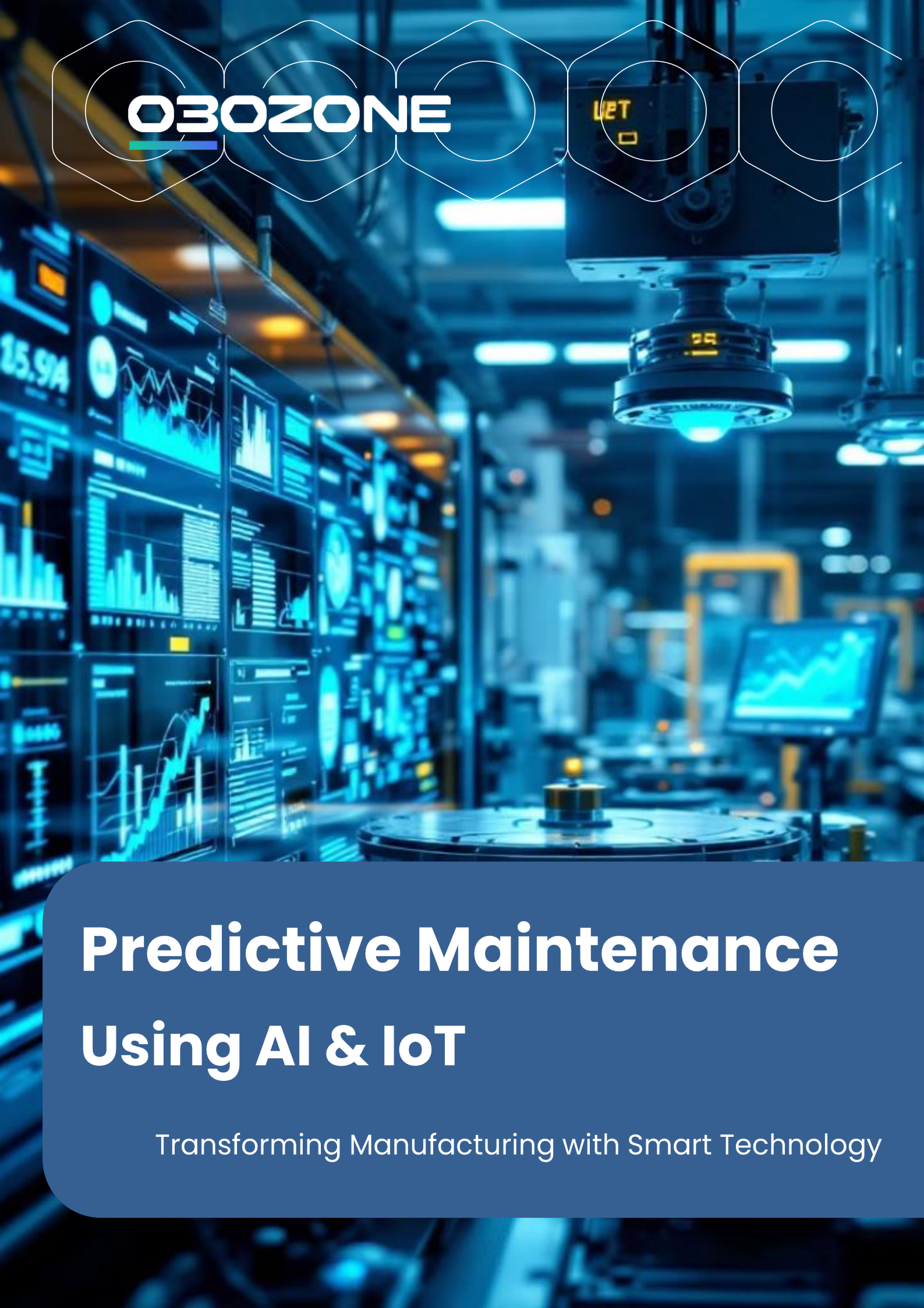


Predictive Maintenance Using AI & IoT

Transforming Manufacturing with Smart Technology

> “Deloitte research indicates that on average predictive maintenance increases productivity by 25%, reduces breakdowns by 70%, & lowers maintenance costs by 25%”

Deloitte Analytics on Predictive Maintenance

Why Predictive Maintenance?

In manufacturing, equipment maintenance strategies have evolved from reactive *“fix it after failure”* to preventive *“service at fixed intervals”* & now to predictive maintenance; a smarter, data-driven approach that prevents failure before it happens.

Predictive maintenance uses continuous monitoring & advanced analytics to determine when maintenance should be performed, based on the actual condition of equipment rather than a fixed schedule

Predictive maintenance **reduces downtime & costs** by servicing equipment only when needed. It **extends asset life, enhances safety, & improves product quality**. Companies adopting predictive maintenance consistently report a **strong ROI;** with many recovering implementation costs within the first year.

Data Collection

Collect real-time data from equipment sensors & systems

Apply Analytics

Analyze, Interpret, & Communicate data patterns

Use ML Models

Pre-trained models are tailored to certain assets in certain industries;

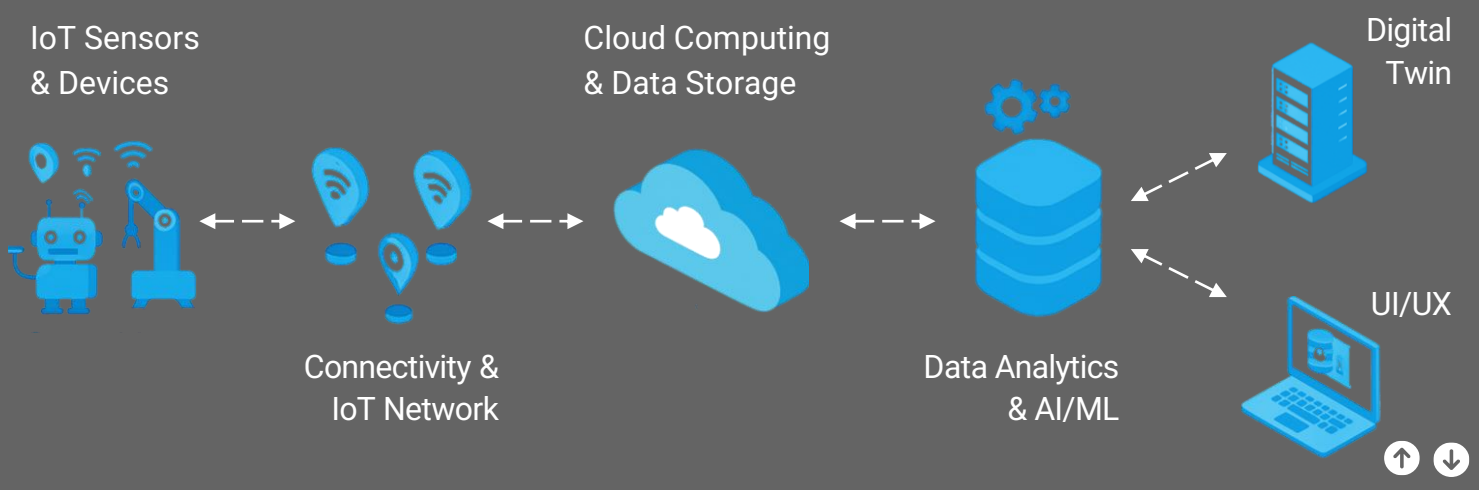
Next Best Action

Optimal actions to take in case of an (upcoming) failure

In essence, the machines “tell” us how they are feeling in real time, & maintenance is carried out just-in-time to prevent breakdown

Core Technologies Stack

	Role in Predictive Maintenance	Examples / Notes
IoT Sensors & Devices	Monitor equipment conditions in real time; collect data on vibration, temperature, etc.	Accelerometers, thermocouples, power meters attached to machines. Legacy machines can be retrofitted with sensor monitoring kits.
Connectivity & IoT Network	Transmit sensor data to central systems reliably & securely *(often in real time).*	IoT gateways & edge devices aggregate data. Ensures continuous data flow from factory to cloud.
Cloud Computing & Data Storage	Store large volumes of sensor data; provide scalable computing for analysis; enable remote access.	Cloud IoT platforms *(AWS, Azure, etc.),* time-series databases. Unified view of operations with high availability for real-time analytics.
Data Analytics & AI/ML	Analyze data to detect anomalies & predict failures; learn patterns from data.	ML models *(regression, classification, neural networks)* generate outputs such as assets health, failure probability, remaining useful life.
Digital Twin (*Simulation*)	*(Advanced / Optional)* Simulate the asset digitally to test scenarios & enhance predictions.	Virtual models of machines updated with real data. Helps in understanding complex failure modes & what-if analysis.
User Interface & Integration	Present insights & alerts to teams; integrate with workflow *(CMMS/EAM).*	Dashboards with equipment health visualization; mobile alerts to teams. Ensures predictions lead to timely action by humans or automated processes.



AI Techniques that Drive Predictive Maintenance

Anomaly Detection

Identify abnormal patterns or behaviors in data that deviate from the normal range.

Approach : Autoencoders, Isolation Forest, One-Class SVM, Z-score analysis.

Use Cases : Initial PdM phase when fault types are unknown or unlabeled.

Unsupervised Health Clustering

Group machine data into clusters (normal, degraded, or failure) using unlabeled data.

Approach : K-Means, DBSCAN, HDBSCAN, Hierarchical Clustering.

Use Cases : For exploratory analysis & pattern discovery in asset behavior.

Predictive Modeling with Labeled Data

Uses labeled historical data to predict failure or degradation in an asset.

Approach : Random Forest, XG Boost, SVM, CNN, Regression models.

Use Cases : To detect or classify known issues in advance using labeled fault data.

Remaining Useful Life (RUL) Estimation

Estimate time remaining before asset failure.

Approach : LSTM, GRU, Survival Analysis, Bayesian Regression.

Use Cases : For assets where downtime is costly & proactive planning for repairs or replacements is critical.

Multimodal Sensor Fusion

Enhance fault detection by integrating data from multiple sensors.

Approach : CNN + LSTM, Transformer models, PCA with ML.

Use Cases : Effective in environments with diverse sensors (vibration, thermal, current).

Prescriptive Maintenance

Goes beyond prediction, suggests the best corrective actions.

Approach : Decision Trees, Rule Engines, Policy-based Learning.

Use Cases : Automatically generate work orders dispatch tasks, or adjust parameters.

Digital Twin

Digital twin to simulate & predict asset behavior.

Approach : Hybrid models (Physics + ML), Simulation-fed ML.

Use Cases : For simulating “what-if” scenarios, root-cause analysis, & strategic planning.

Reinforcement Learning for Maintenance Optimization

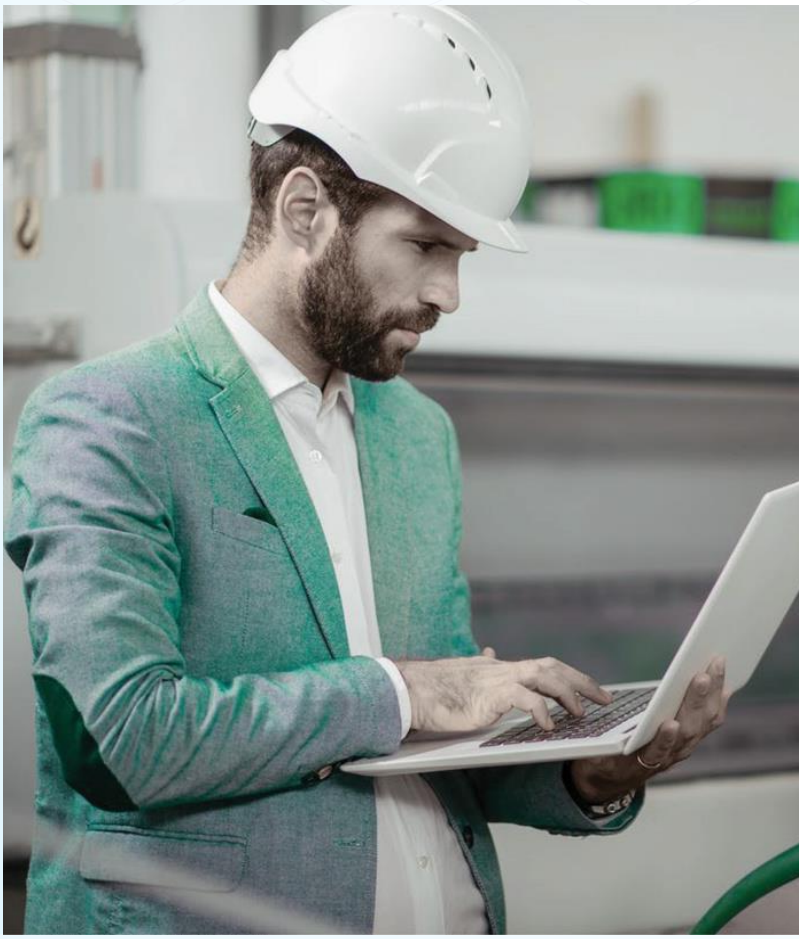
Learn best long-term maintenance strategies via trial & feedback.

Approach : Q-Learning, Deep Q-Networks (DQN), Policy Gradient Methods.

Use Cases : Advanced PdM systems for long-term strategy optimization is needed.

Implementation Roadmap

Implementing predictive maintenance requires more than just technology; it involves process updates & cultural change. A clear strategy helps maximize benefits while managing costs & integration. Below are key steps & best practices for a successful rollout :



Step 1 : Assess Current Maintenance Practices

Step 2 : Identify Priority Assets, Set Clear Objectives & KPIs

Step 3 : Select the Right Technologies & Solutions

Step 4 : Develop a Data Collection & Management Strategy

Step 5 : Build or Configure Predictive Models & Analytics

Step 6 : Integrate into Maintenance Processes & Train Staff

Step 7 : Address Challenges Proactively

Real World Impact of Predictive Maintenance

Industry: Industrial Consumer Packaging *(Folding Cartons)*

AI System Deployment :

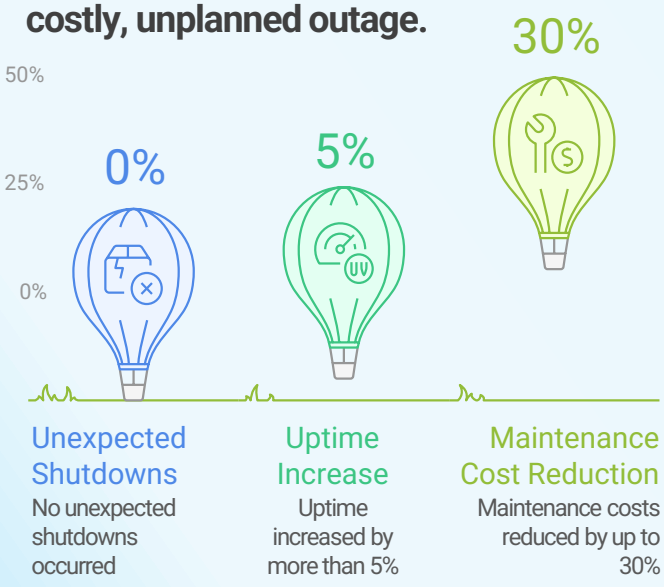
OFC implemented an O3OZONE's **AI-powered predictive maintenance system** to monitor critical equipment across the production floor. Sensors were installed to measure **temperature, pressure, current** etc. with real time data streamed.

Failure Pattern Detection :

ML models were trained on historical data to identify patterns & precursors that typically led to machine failure.

Proactive Intervention :

The system detected an anomaly in a **critical compressor unit**, predicting likely failure within weeks. Maintenance was performed during a planned shutdown, & the faulty part was replaced ; **avoiding a costly, unplanned outage.**



Industry: Rigid Plastic Packaging *(Injection Molding, Blow Molding)*

IoT + ML Implementation :

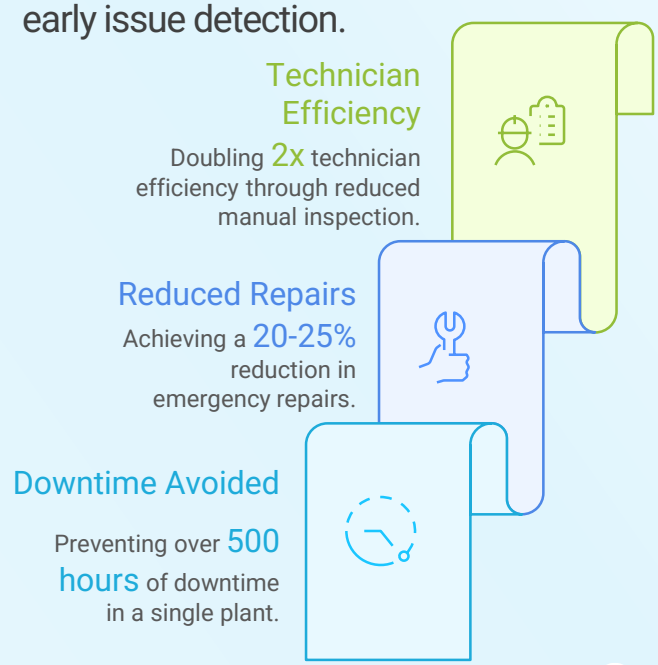
Wireless **vibration & temperature sensors** were installed on motors & pumps. Sensor data was transmitted to the cloud for O3OZONE's **machine learning-based anomaly detection.**

Early Fault Detection :

The system identified **abnormal vibrations** in a high-speed mixer motor, predicting a potential burnout. Maintenance was executed overnight, avoiding a **multi-shift outage**.

Downtime Reduction :

Across one site, **over 500 machine hours** of unplanned downtime were prevented during the initial deployment ; all due to early issue detection.



End-to-End Traceability Across Your Factory; Powered by O3OZONE

O3OZONE seamlessly integrates with your ERP system, enabling real-time data capture, analysis, & traceability across your entire manufacturing process. Built on globally recognized GS1 standards, it allows batch tracking at any stage, providing instant insights on machine, production, supplier details, & other critical data.

With advanced analytics, intelligent reporting tools, & AI-driven insights, O3OZONE transforms raw data into actionable intelligence. Manufacturers can detect trends, identify inefficiencies, prevent costly issues, & optimize performance in real-time.

By streamlining operations, enhancing regulatory compliance, & supporting predictive maintenance, O3OZONE empowers industries to drive efficiency, quality improvement, & sustainable growth.

Meet Regulatory Compliance

Many industries have strict traceability requirements & regulation, especially food & beverages, pharmaceuticals, & automotive. O3OZONE makes audits easier by collecting, processing, & analyzing traceability data & producing reports.

Improve Quality Control

Identify & address quality issues early for improved consistency. Integrating O3OZONE with your ERP for full traceability helps reduce waste & meet customer quality expectations.

Optimize Supply Chains

Reduce costs by optimizing your supply chain. Track products & components back to their origin to identify bottlenecks & inefficiencies. This leads to better inventory management, reduced lead times, & improved resource allocation.