



Manufacturing Downtime Analysis & Forecasting

Track: DEPI_ Data Analysis

Team Lead : Yousef Sameh

**Team Members: Yousef Sameh Mohamed | Ahmed Mohamed Ahmed saad |
Ahmed hossm Eldien Salah | Sayed Shabaan Sayed | Mohamed Rashwan Ali |
Sahdy Ehab Elsayd**

1. Project Planning

1- Project Description

This project focuses on analyzing manufacturing downtime data to understand why machines stop, how frequently downtime occurs, and how it affects production output.

The analysis will include identifying major downtime patterns, estimating their impact on production, and preparing simple predictive insights that support planning and decision-making.

The final deliverables will include an interactive dashboard (Power BI), structured CSV summary files, and well-documented notebooks that can help the plant improve productivity and reduce losses.

2- Project Goals

- Identify the main causes and recurring patterns behind machine downtime.
 - Quantify the impact of downtime on production (e.g., lost batches or reduced performance).
 - Produce simple next-day downtime predictions to support planning.
 - Provide machine-level insights that highlight high-risk equipment.
 - Deliver clear, actionable recommendations based on the analysis.
 - Provide reproducible documentation, organized outputs, and a Power BI dashboard.
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3- Project Scope

In Scope:

- Data preparation (ingestion, cleaning, validation).
- Exploratory data analysis (KPI extraction, visual summaries).
- Predictive insights (time-based forecasts + machine-level indicators).
- High-level recommendation logic.
- Dashboard creation (Power BI).

- Documentation and final presentation.

Out of Scope :

- Real-time data streaming.
 - Direct integration with factory hardware or sensors.
 - Automated maintenance scheduling systems.
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4- Functional Requirements (Summary)

- FR1: Calculate daily and machine-level downtime totals.
 - FR2: Identify root causes or patterns associated with downtime.
 - FR3: Provide simple next-day downtime estimates.
 - FR4: Estimate the production impact (lost batches / reduced output).
 - FR5: Prepare clean CSV outputs for dashboard integration.
 - FR6: Generate actionable recommendations per machine.
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5- Non-Functional Requirements

- Performance: Capable of handling medium-sized datasets efficiently.
 - Usability: Dashboard must offer intuitive filtering (machine, date, shift).
 - Reproducibility: Documented steps & a clear folder structure.
 - Security: No personal data included; only machine and sensor records.
 - Extensibility: Should support adding more machines or additional data fields later.
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6- High-Level Timeline

- Data cleaning & preprocessing
- Exploratory analysis & KPI extraction
- Predictive insights (forecasting + machine-level analysis)
- Recommendation logic

- Days 9–10: Dashboard development & polishing
 - After completion: Final documentation & presentation
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2. Stakeholder Analysis

Stakeholder	Role	Their Interest	How the Project Helps
Production Manager	Decision Maker	Reduce downtime, maintain targets	Provides forecasts & insights for planning
Maintenance Team	Technical Operators	Detect issues earlier	Highlights high-risk machines and recurring issues
Plant Planner	Scheduler	Plan batches & workforce	Links downtime to production impact
Data Team	Analysts	Clean and structured data	Receives organized outputs and reproducible notebooks
DEPI Instructors	Evaluators	Project completeness	Documentation, deliverables, and dashboard

3. Data Understanding

1- Dataset Overview

The dataset includes:

- Date
 - Machine information
 - Line/department information
 - Multiple operational sensor readings (temperature, pressure, vibration, speed, torque, voltage, etc.)
 - A downtime indicator describing whether a machine was operating normally or experiencing a failure
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2- Initial Data Assessment

- Date formatting needs normalization.
 - Machine and sensor data appear consistent but require standard cleaning.
 - The downtime indicator is usable for classification and event tracking.
 - Some descriptive fields may be missing (e.g: exact downtime duration), so part of the work will involve deriving practical KPIs from the available data.
 - Additional fields (e.g: inferred downtime reason) can be created later to support recommendations.
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4. Feature Preparation

- Convert date fields and create time-based features.
 - Standardize numerical fields and remove anomalies.
 - Handle missing values appropriately.
 - Create daily-level summary tables (per machine & overall).
 - Prepare simplified categorical fields to support insights.
 - Generate a high-level “Reason for Downtime” field using observable patterns in sensor readings.
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5. Predictive Insights (General Plan)

1- Time-Based Insights (Forecasting)

- Build daily summaries of downtime and detect patterns over time.
- Produce simple next-day downtime forecasts to support short-term planning.
- Evaluate accuracy and store outputs in CSV format for dashboard use.

2- Machine-Level Insights

- Generate per-machine risk indicators based on recent behavior and sensor trends.
- Highlight machines requiring attention or maintenance checks.

- Store outputs in structured CSVs.

3- Production Impact Estimation

- Estimate how downtime trends influence daily production.
 - Translate forecasts into expected batch counts or production losses.
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6. Recommendation System

Rule-Based Recommendations

- Provide clear actions based on repeated patterns or high-risk machine behavior.
 - Examples include scheduling maintenance checks, reducing assigned workload, or monitoring specific sensor patterns.
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7. Tools & Technologies

- SQL – for handling and querying structured data.
 - Python – mainly for preprocessing, analysis, forecasting, and preparing outputs.
 - Python Libraries: pandas, Matplotlib, scikit-learn.
 - Jupyter Notebook – for documenting and running the analysis workflow.
 - Tableau / Power BI – for building the visualization dashboard.
 - Excel / CSV – for data export and basic handling.
 - Presentation Tools – for preparing the final report and slides.
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8. Final Deliverables

- Cleaned dataset
- Summary CSVs (daily downtime, production impact, predictions, recommendations)
- notebooks (cleaning, EDA, insights, dashboard exports)

- Power BI dashboard file
- Documentation PDF & presentation slides
- README with run instructions