Software Requirements Specification

for

Predictive Maintenance Automation System

Version 1.0

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1. Introduction

1.1 Purpose

The purpose of this document is to specify the software requirements for the **Predictive Maintenance Automation System (PMAS)**. This system is designed to proactively monitor the health of industrial assets and predict potential failures before they occur by leveraging historical and real-time operational data.

This SRS document serves as a reference for:

- System developers
- Project stakeholders
- Academic evaluators
- Future maintainers and researchers

The document defines the system's scope, functional and non-functional requirements, system features, constraints, and quality attributes in a structured and unambiguous manner.

1.2 Scope

The Predictive Maintenance Automation System (PMAS) aims to reduce unplanned downtime and maintenance costs by enabling condition-based and predictive maintenance strategies for industrial equipment.

In this project, the system will be **implemented and validated for manufacturing and industrial machines**, using sensor data like temperature, vibration, RPM/load, and runtime hours.

The system will:

- ingest periodic sensor readings (simulated or dataset-driven),
- assess machine health,
- detect anomalies / predict failure risk,
- automatically generate alerts and maintenance tickets,
- provide dashboards and maintenance history.

The architecture will be modular and extensible, allowing future expansion to other domains such as **aviation (aircraft engines)** and **electric vehicles (battery packs and motors)** with domain-specific datasets and feature mappings.

1.3 Definitions, Acronyms and Abbreviations

Term	Meaning
PMAS	Predictive Maintenance Automation System
Admin	Maintenance manager/system administrator
Technician	Maintenance worker assigned to tickets
Sensor Data	Machine readings like temperature, vibration, runtime
Alert	Warning event generated by system
Ticket	Maintenance work order generated for a machine

2. Overall Description

2.1 Product Perspective

The Predictive Maintenance Automation System is a **standalone, data-driven decision support system** that integrates with existing industrial monitoring infrastructure.

It operates as a layered system consisting of:

- Data acquisition layer (sensor and log data)
- Data processing and feature extraction layer
- Machine learning–based prediction layer
- Visualization and alerting layer

The system does not replace existing control systems but complements them by providing predictive insights and maintenance intelligence.

2.2 Product Functions

Major functions of PMAS include:

- User authentication and role management
- Add/edit/delete machines
- Collection and ingestion of historical and real-time sensor data
- Data preprocessing, normalization, and feature extraction
- Detection of abnormal operating conditions
- Prediction of potential component failures
- Estimation of remaining useful life (RUL) of components
- Generation of maintenance alerts, tickets and recommendations
- Visualization of system health and trends through dashboards
- Storage and retrieval of maintenance logs and predictions

2.3 User Classes and Characteristics

User Class	Description	Technical Expertise
Maintenance Engineers	Monitor asset health and perform maintenance actions	Medium
Operations Managers	Analyze downtime trends and maintenance efficiency	Low–Medium
Data Scientists	Train, evaluate, and improve predictive models	High
System Administrators	Manage system configuration and access control	High

2.4 Operating Environment

The system is expected to operate in the following environment:

- **Backend:** Python-based analytics and ML pipelines
- **Frontend:** Web-based dashboard (browser accessible)
- **Database:** Relational or time-series databases
- **Deployment:** On-premise servers or cloud platforms
- **Supported OS:** Linux, Windows
- **Hardware:** Industrial servers capable of handling sensor streams

2.5 Design and Implementation Constraints

- Availability and quality of sensor data
- Industry-specific regulatory and compliance requirements (especially aviation)
- Computational constraints for real-time inference
- Data privacy and access restrictions
- Model explainability requirements for safety-critical domains
- Limited real-time IoT integration in academic environment

2.6 Assumptions and Dependencies

- Users have internet/local network access
- Sensor data format is consistent (CSV/API payload)
- Email notification requires SMTP configuration
- Model/rules depend on provided data quality

3. System Features

3.1 Functional Requirements

FR-1: The system shall allow users to register/login.

FR-2: The system shall support role-based access control (Admin/Technician).

FR-3: The system shall allow Admin to register a machine with:

- Machine ID
- Machine name/type
- Location/department
- Installation date
- Maintenance interval (in days/hours)

FR-4: The system shall allow Admin to update machine details.

FR-5: The system shall collect and store sensor data from monitored assets.

FR-6: The system shall preprocess raw data by handling missing values, noise, and outliers.

FR-7: The system shall extract relevant features for health assessment and prediction.

FR-8: The system shall detect anomalies in operational behaviour.

FR-9: The system shall predict potential failures of components.

FR-10: The system shall automatically create a maintenance ticket when machine status is Critical.

FR-11: The system shall allow Admin to manually create a ticket for a machine.

FR-12: The system shall estimate the remaining useful life (RUL) of critical components.

FR-13: The system shall generate alerts when risk thresholds are exceeded.

FR-14: The system shall provide dashboards for visualizing asset health and trends.

FR-15: The system shall log predictions, alerts, and maintenance actions.

3.2 Use Cases

Use Case 1: Health Monitoring
The system ingests sensor readings (temperature, vibration, RPM/pressure), predicts failure risk, and automatically generates alerts and maintenance tickets when abnormal patterns are detected.

Use Case 2: Maintenance Ticket Automation
When a machine crosses a risk threshold, the system automatically creates a maintenance ticket, assigns it to a technician, and notifies relevant stakeholders.

Use Case 3: Maintenance History & Reporting
Admin views machine health trends, past alerts, and maintenance actions to understand recurring failures and plan preventive maintenance.

4. Other Non-Functional Requirements

4.1 Performance Requirements

- The system shall process incoming sensor data with minimal latency.
- Predictions shall be generated within acceptable time limits for operational use.
- The system shall support scalable data ingestion for multiple assets.

4.2 Security Requirements

- User authentication and role-based access control shall be enforced.
- Sensitive operational data shall be protected against unauthorized access.
- Secure communication protocols shall be used for data transfer.
- Audit logs shall be maintained for system activities.

4.3 Quality Attributes

- **Reliability:** The system must operate continuously with high availability.
- **Scalability:** The system should support increasing number of assets and data volume.
- **Maintainability:** Modular design to allow easy updates and enhancements.
- **Usability:** Clear dashboards and alerts for non-technical users.
- **Explainability:** Predictions should be interpretable, especially in safety-critical domains.