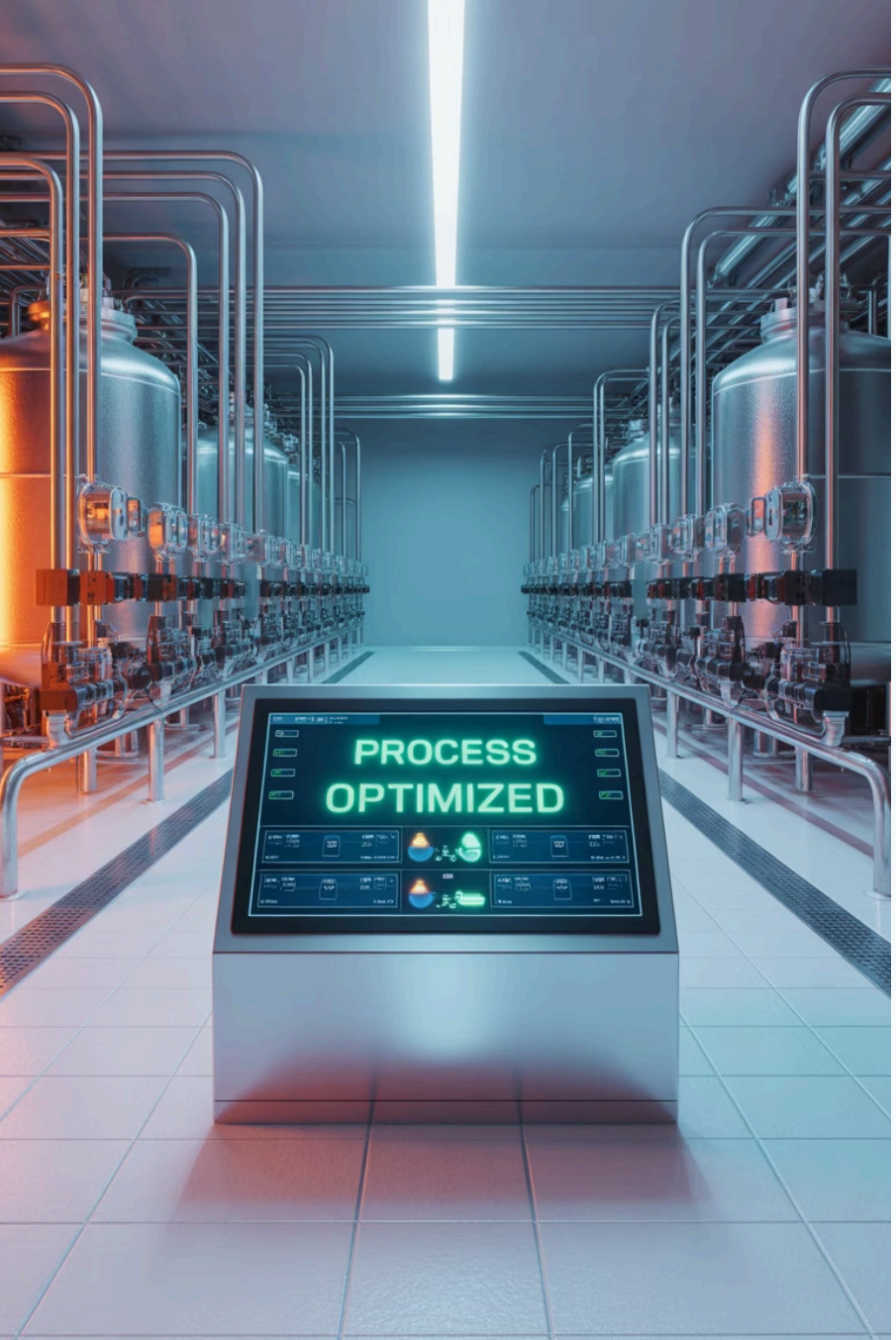


Predictive Maintenance in Chemical Engineering: A Data Science & BI Integration

Transforming equipment reliability through advanced analytics and intelligent monitoring systems.

J by Jemael Nzihou

Project Overview

Objective

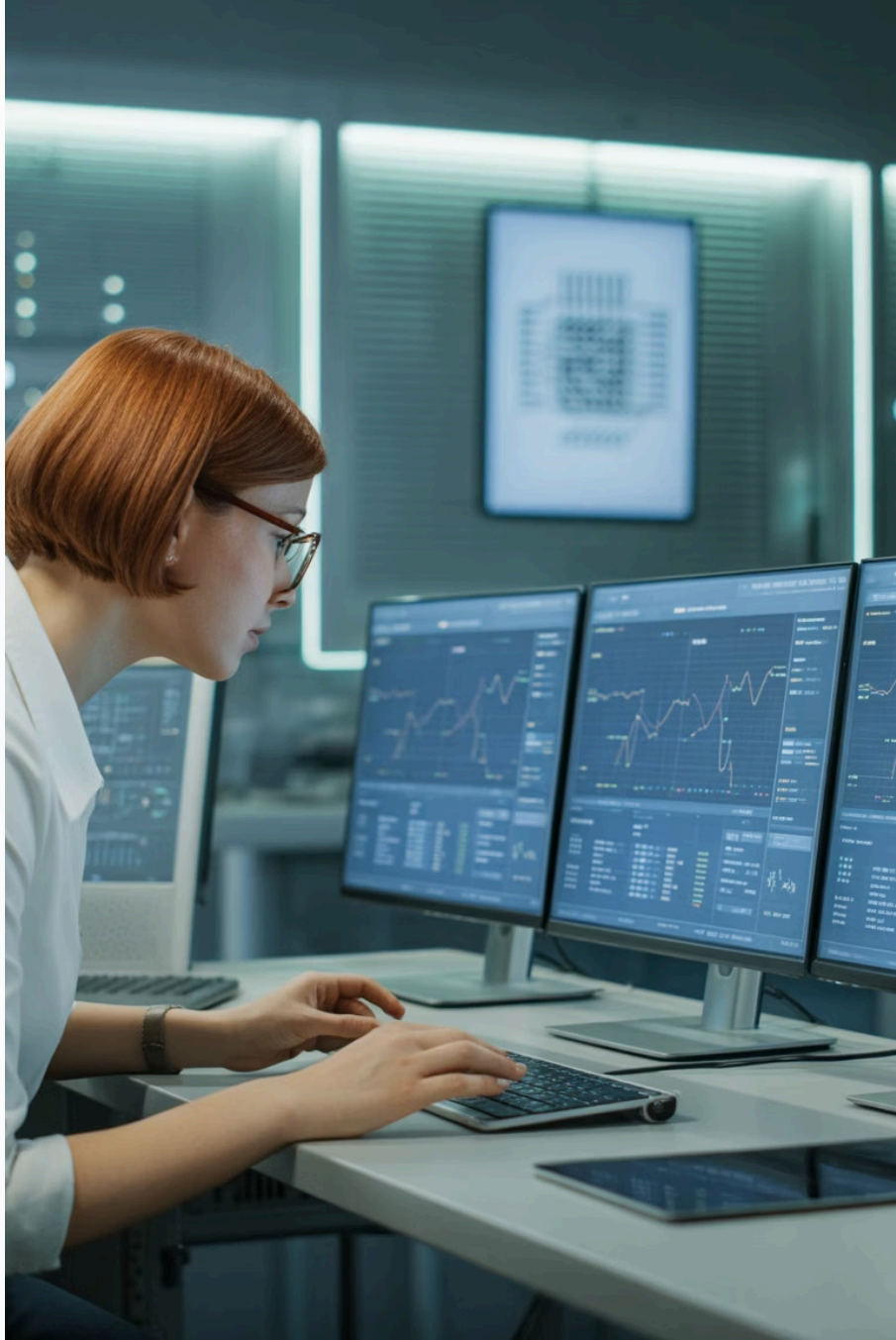
Predict equipment failures using sensor data, maintenance logs, and failure records

Technology Stack

MySQL Workbench, Python, Power BI, and GitHub for comprehensive analysis

Approach

Database design, exploratory analysis, machine learning, and business intelligence



Database Schema Architecture

Core Tables

- Assets
- Sensors
- Sensor_Readings
- Maintenance_Logs
- Failure_Events
- Technicians

Data Integrity

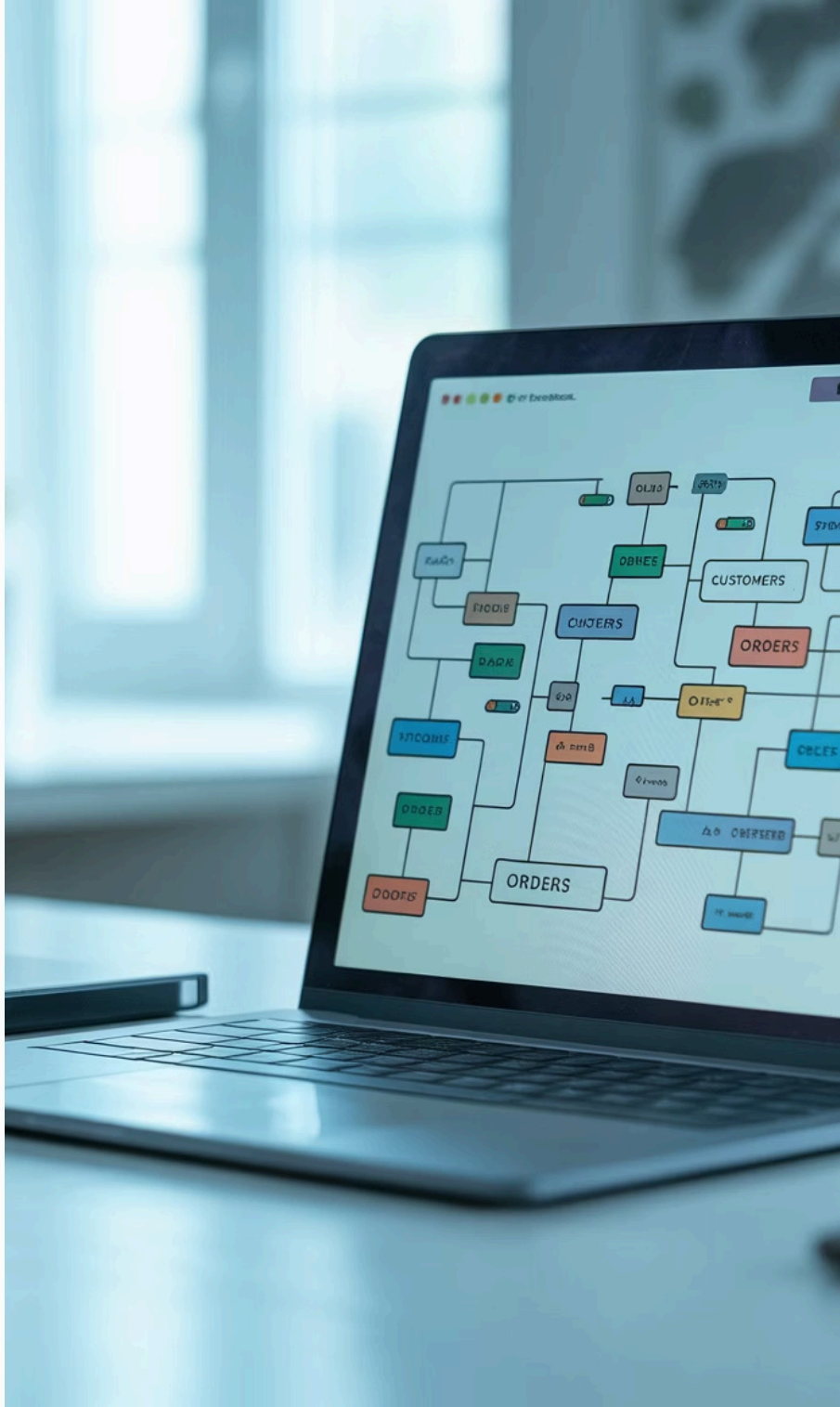
Foreign key constraints ensure referential integrity across all tables.

EER Diagram showcases comprehensive table relationships and dependencies.

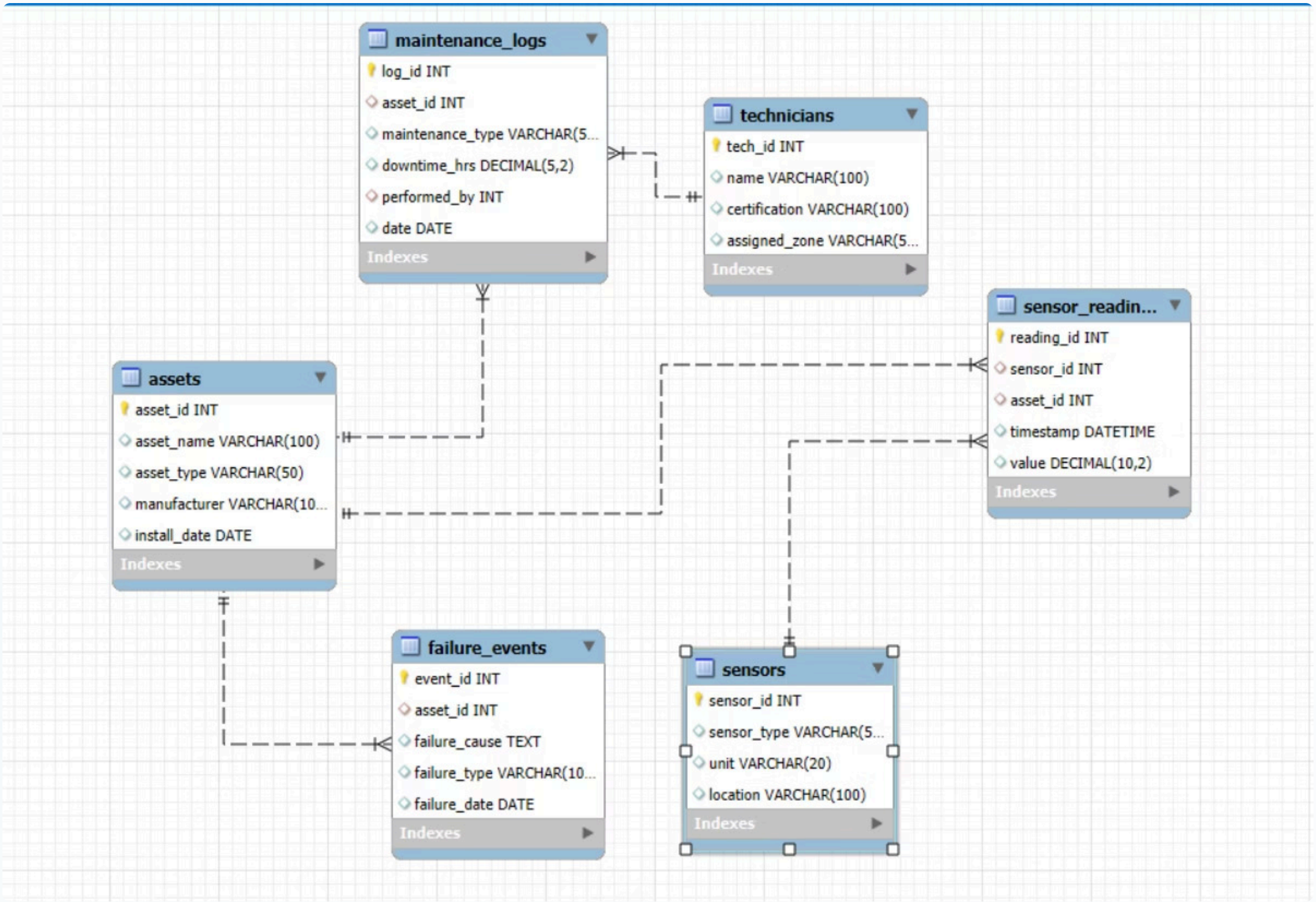
Design Benefits

Normalized structure supports efficient queries and scalable maintenance tracking.

Optimized for predictive analytics and real-time monitoring applications.



Entity Relationship Diagram



Relationship Structure

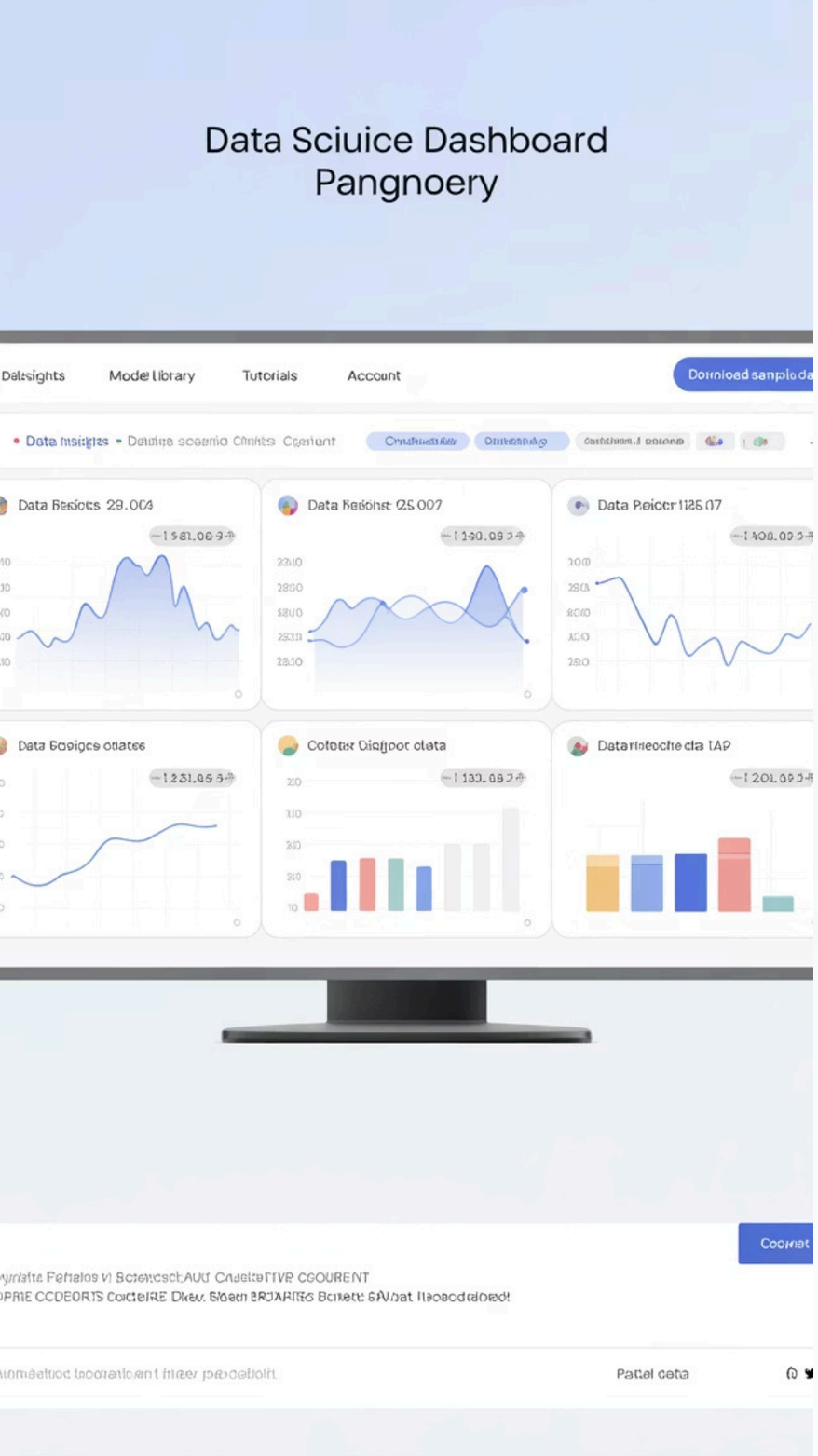
Six interconnected tables form the foundation for predictive maintenance analytics.

Primary and foreign key relationships ensure data consistency and integrity.

Query Optimization

Strategic indexing on asset IDs and timestamps enables efficient historical analysis.

Normalized design supports complex joins for comprehensive failure prediction models.



Exploratory Data Analysis Results

Critical Equipment

Valve V09 showed highest downtime at 4 hours, requiring immediate attention

Failure Distribution

Mechanical, electrical, and safety shutdown failures evenly distributed across assets

Risk Indicators

Sensor fluctuations identified critical risk zones for Pump A01 operations

Visualization Types

Bar charts, line plots, and count plots reveal equipment performance patterns

Downtime Analysis by Asset

Data Collection

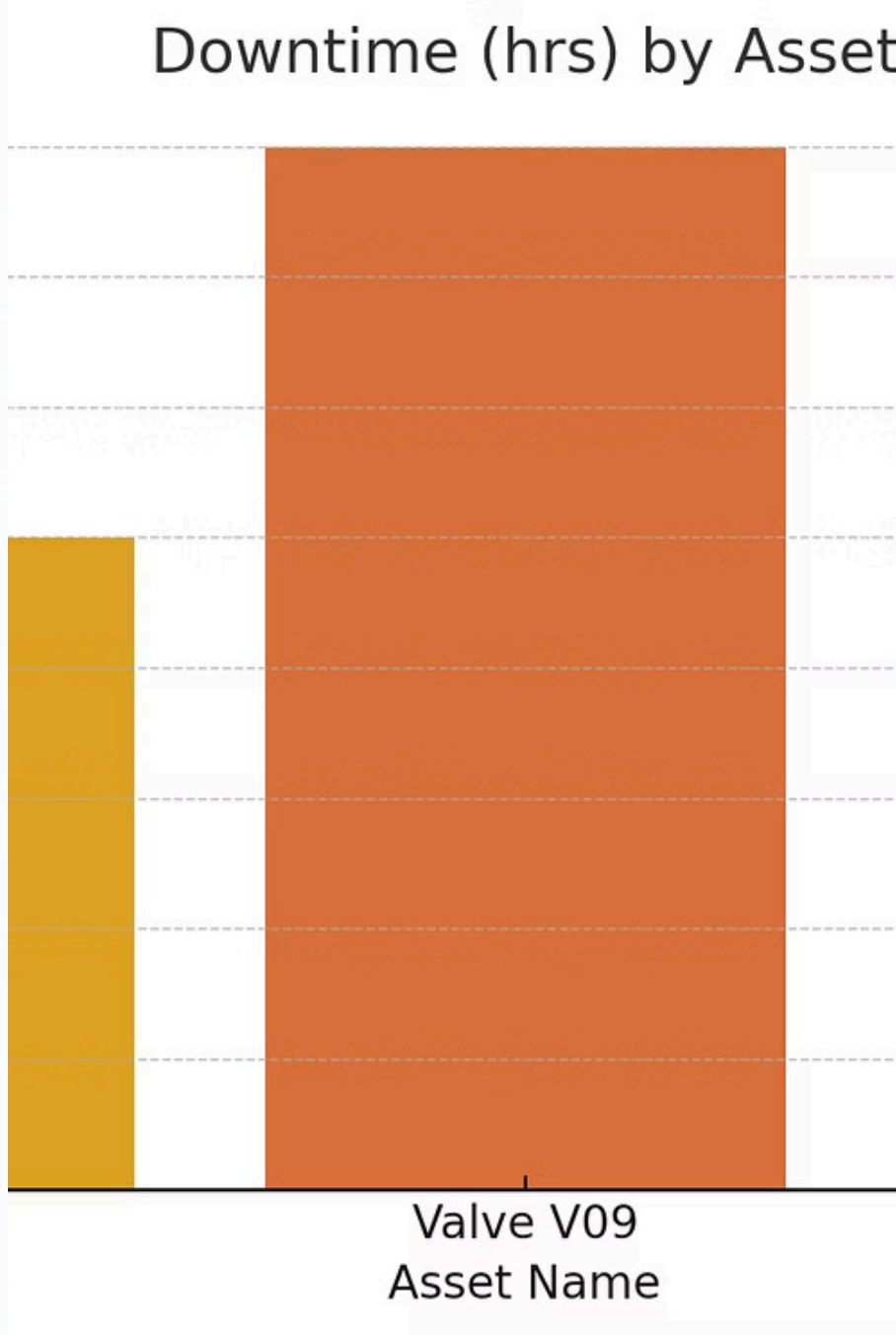
Historical maintenance logs aggregated by asset ID and downtime duration.

Pattern Recognition

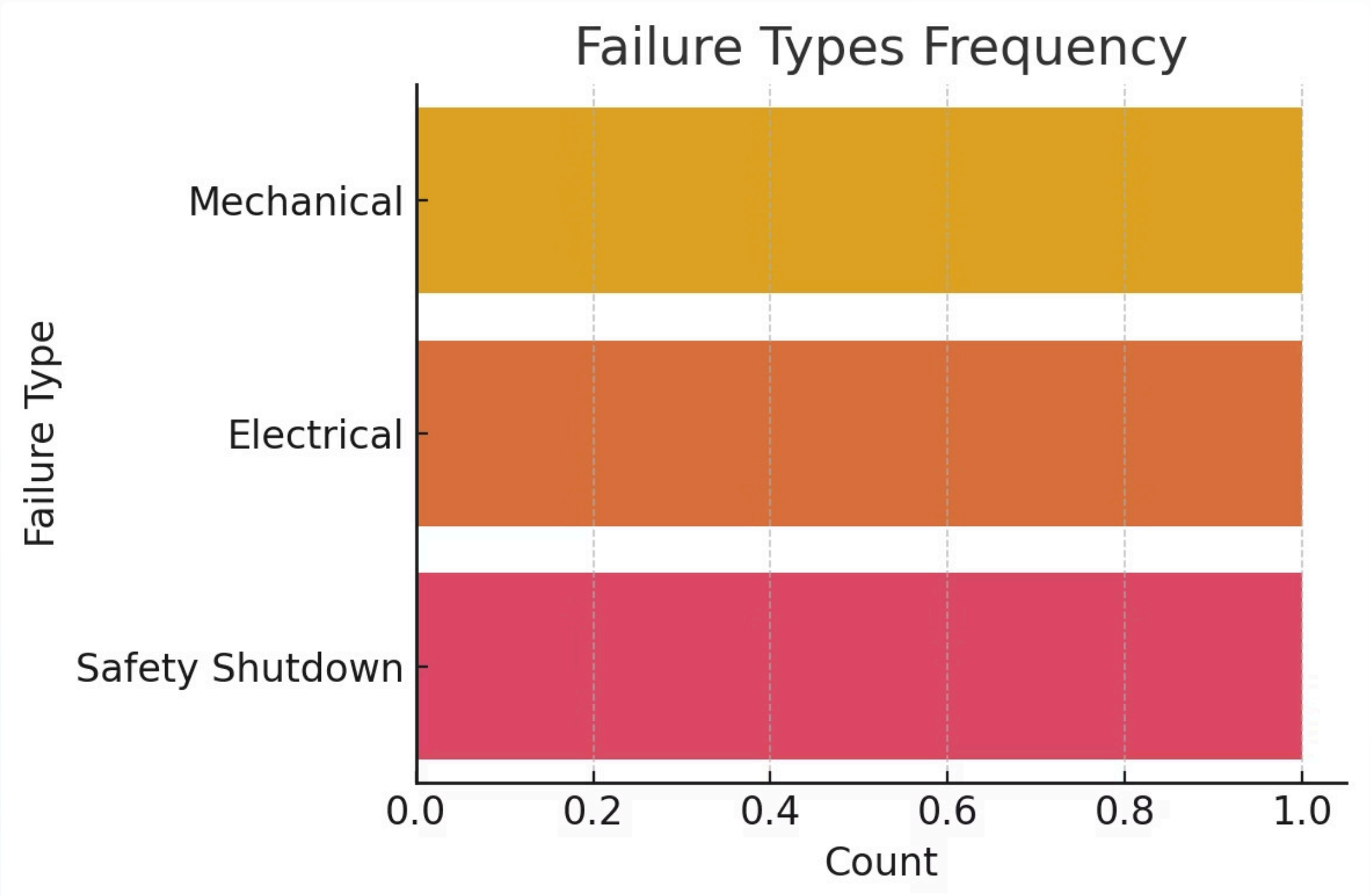
Valve V09 emerges as highest-risk equipment requiring priority maintenance scheduling.

Actionable Insights

Critical equipment identified for proactive maintenance intervention and resource allocation.



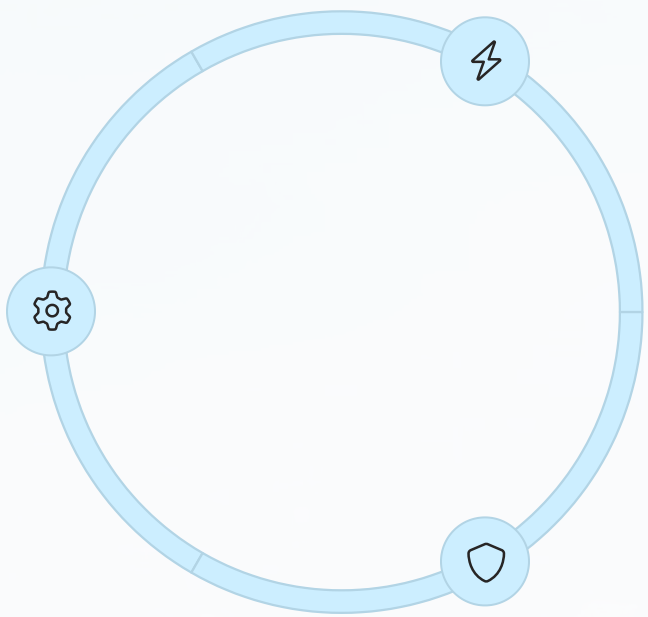
Failure Type Distribution



Mechanical Failures

33% of total failures

Wear-related component degradation



Electrical Failures

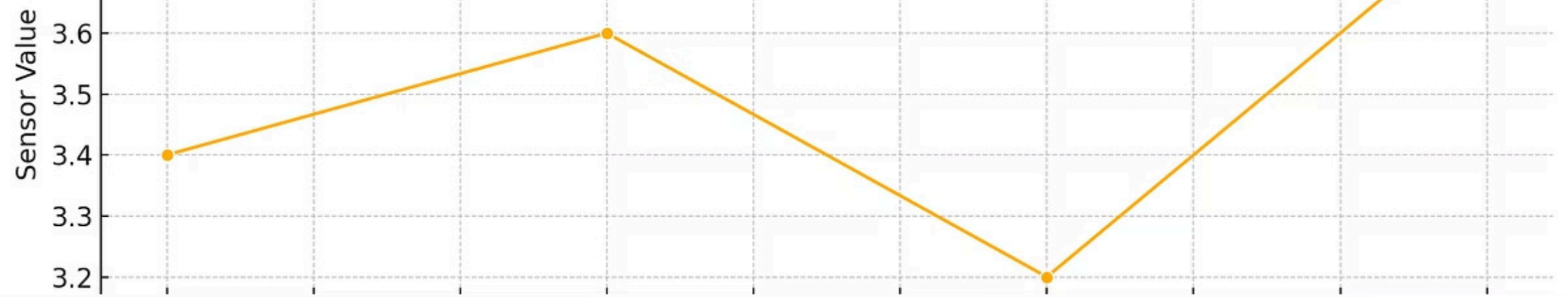
33% of total failures

Sensor and control system malfunctions

Safety Shutdowns

34% of total failures

Emergency protection system activations



Sensor Value Trends Analysis

Temperature Monitoring

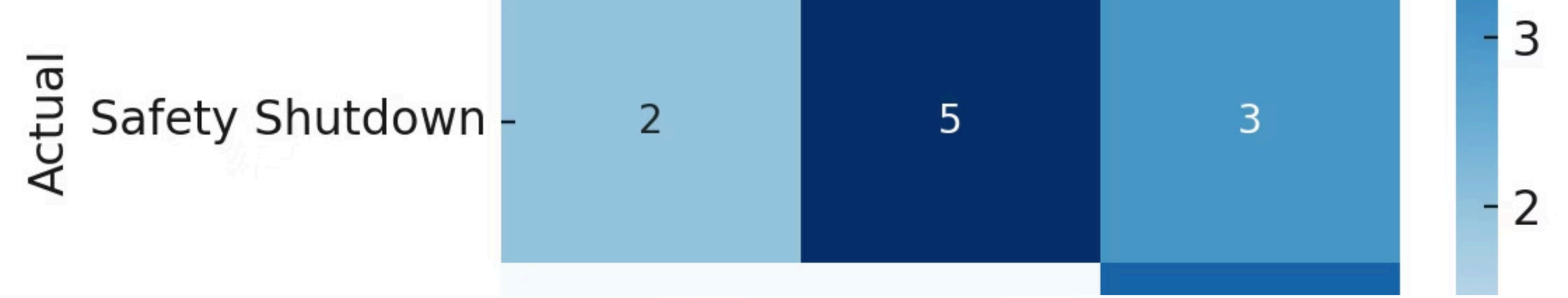
Continuous thermal profile tracking reveals degradation patterns

Vibration Analysis

Vibration signatures indicate mechanical wear and alignment issues

Pressure Fluctuations

Pressure variance analysis identifies potential system stress points



Asset Performance Correlation

Correlation Analysis

Statistical relationships between sensor readings and failure events

Pattern Discovery

Hidden dependencies between equipment performance metrics revealed

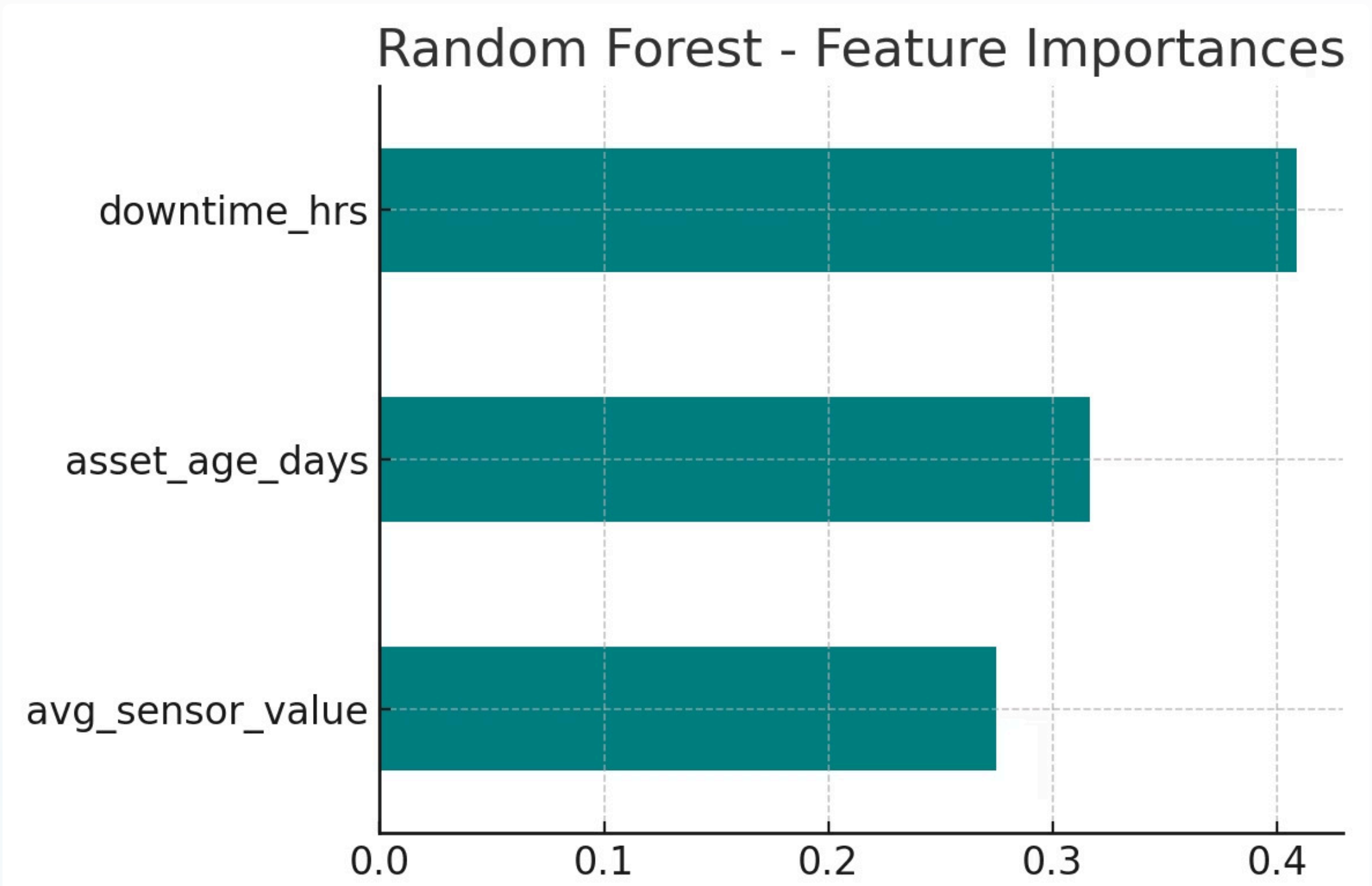
Predictive Features

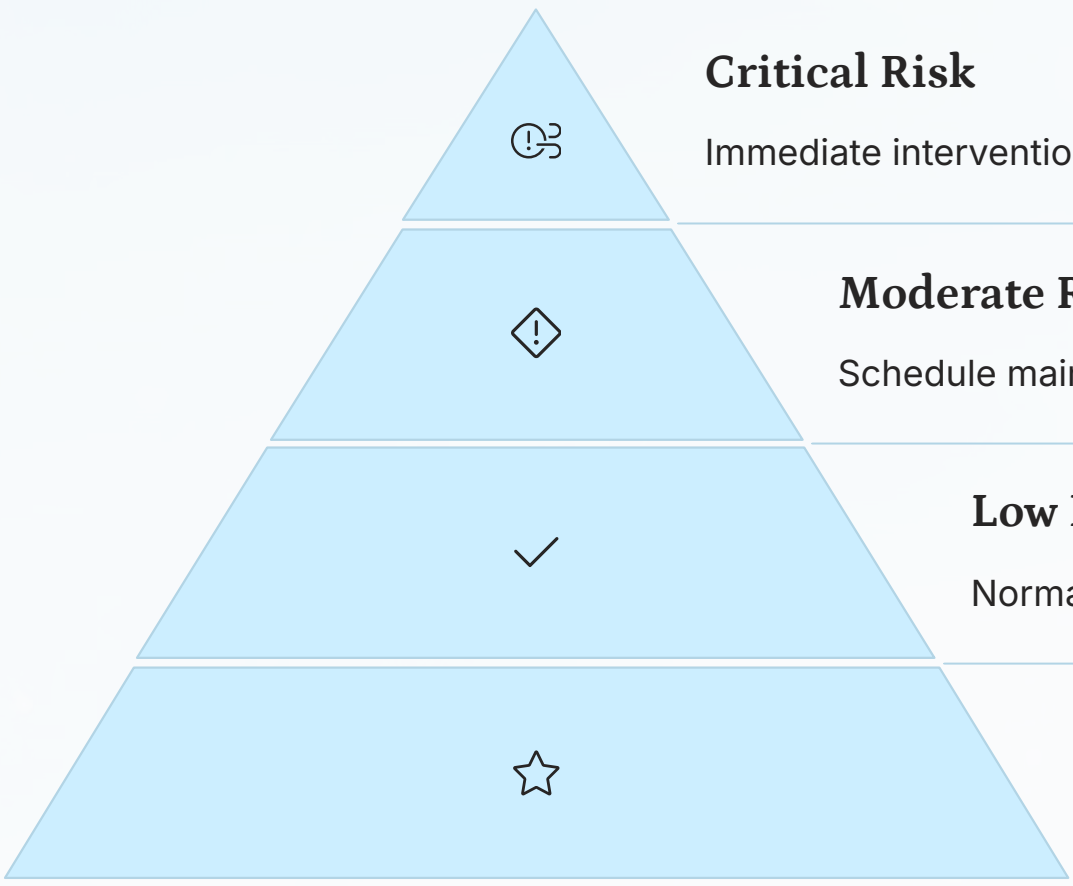
Key variables identified for machine learning model development

Risk Assessment

Quantified risk scores generated for proactive maintenance scheduling

Equipment Health Heatmap





Critical Risk

Immediate intervention required

Moderate Risk

Schedule maintenance within weeks

Low Risk

Normal operation continues

Optimal Performance

Equipment operating at peak efficiency

Machine Learning Model Deployment

65%

Model Accuracy

Random Forest Classifier performance on failure prediction

2

Algorithms Tested

Logistic Regression and Random Forest comparison

3

Failure Categories

Mechanical, Electrical, Safety Shutdown classifications

Business Impact Assessment

Downtime Reduction

Early intervention prevents unexpected equipment failures

Automated Alerts

Power BI dashboards enable proactive maintenance decisions

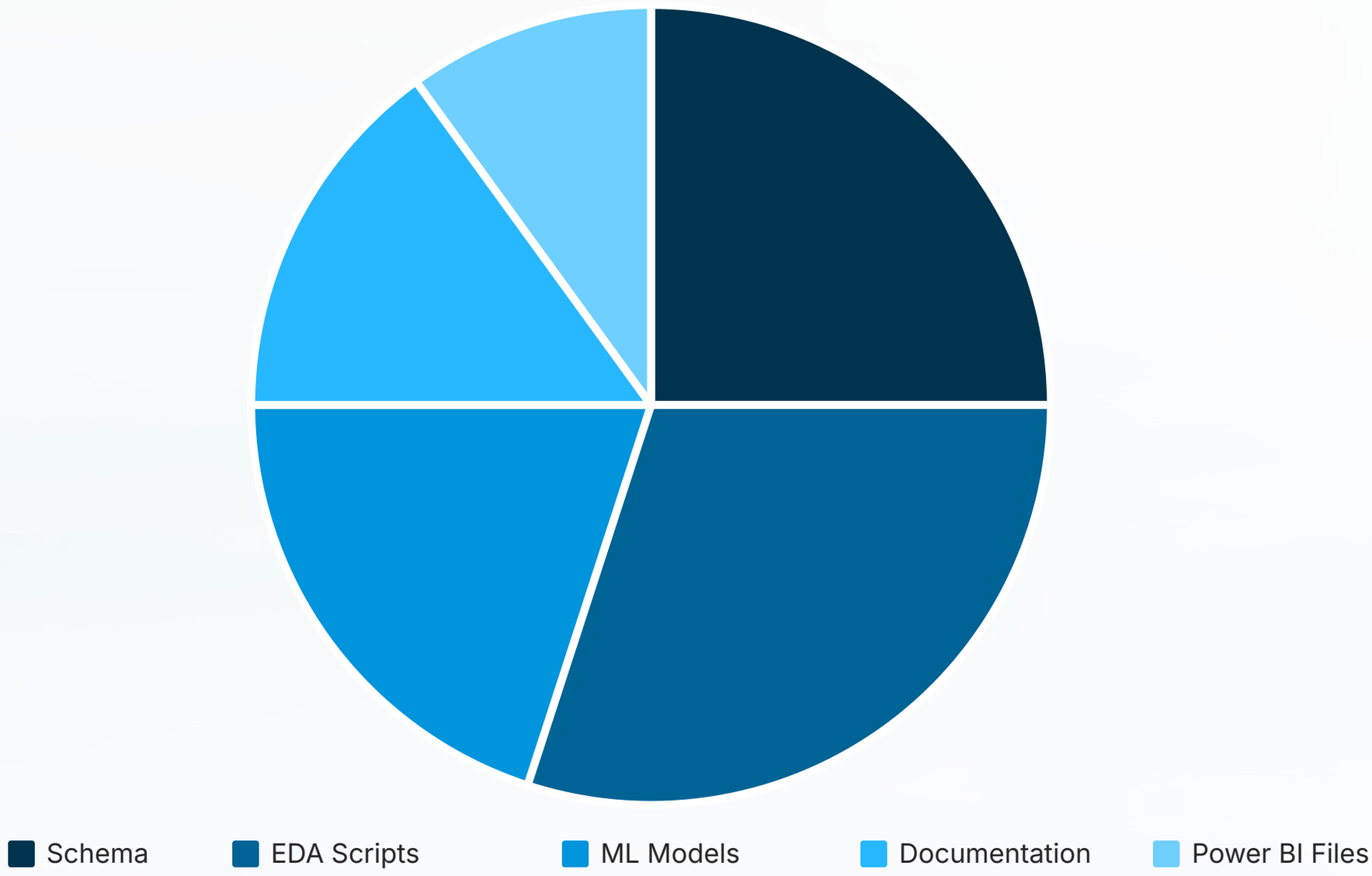
Asset Management

Optimized equipment lifecycle through predictive insights

Scheduling Efficiency

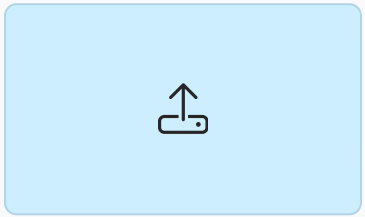
Improved technician scheduling based on predicted maintenance needs

GitHub Integration Strategy



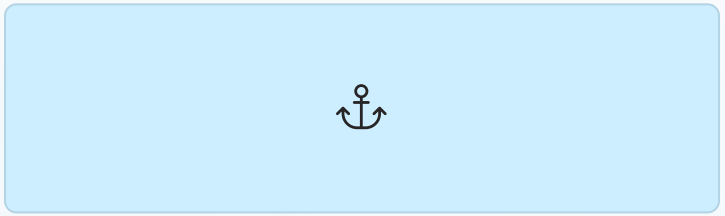
Strategic repository organization enables seamless collaboration and knowledge transfer across engineering teams.

Implementation Roadmap



GitHub Deployment

Upload complete project with comprehensive README documentation



Power BI Integration

Embed interactive reports using GitHub Pages hosting

Stakeholder Engagement

Share insights with engineering teams and data science communities

Transformative Impact

> This project fundamentally transforms chemical engineering maintenance practices through the strategic integration of data science and business intelligence. Sharing through GitHub maximizes knowledge dissemination and accelerates industry-wide advancement.

By harnessing the conservation principle of energy in our analytics approach, we create sustainable value across the entire operational ecosystem.

The seamless integration of predictive analytics with established maintenance workflows delivers measurable operational excellence, significant cost reductions, and enhanced safety outcomes across chemical engineering facilities.