User Manual

1. Document Information

1.1 Document Control Information

- **Document Title:** Smart Maintenance Platform for Aero Engine Industrial Equipment - User Manual

- **Version:** 1.0 (Initial Draft)

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- **Status:** In Progress

- **Document Owner:** Project Team

1.2 Revision History

Version	Date	Description	Author
0.1	April 2, 2025	Initial structure	Tong Li
0.5	April 4, 2025	Core functionality overview	Jingxiao Han
1.0	April 6, 2025	Completed initial draft	Project Team

1.3 Approvals

 Name Role Signature Date

1.4 Document Scope

This user manual provides comprehensive guidance for operators, maintenance personnel, and administrators of the Smart Maintenance Platform for Aero Engine Industrial Equipment. It covers detailed descriptions, operational procedures, and best practices for all functional modules of the system, aimed at helping users fully utilize the platform's predictive maintenance capabilities.

2. Introduction

2.1 System Overview

The Smart Maintenance Platform for Aero Engine Industrial Equipment is a deep learning-based predictive maintenance system designed to improve aero engine reliability, reduce unexpected downtime, and optimize maintenance schedules. The system works by collecting and analyzing sensor data to detect potential anomalies and predict the remaining useful life (RUL) of critical components.

The platform integrates advanced anomaly detection algorithms (such as Skip-GANomaly, PHOT) and life prediction models (such as CNN-LSTM, CNN-Transformer, DBN-BiGRU) to provide data-driven support for maintenance decisions. The system presents complex analytical results through an intuitive user interface, enabling technicians to make informed maintenance decisions.

2.2 Target Audience

This user manual is intended for the following user groups:

- **Operators**: Technical personnel responsible for daily monitoring and basic system operations

- **Maintenance Engineers**: Professionals responsible for analyzing diagnostic results and performing maintenance tasks

- **Managers**: Decision-makers who need access to reports and performance metrics

- **System Administrators**: IT personnel responsible for system configuration, user management, and permission settings

2.3 System Requirements

2.3.1 Hardware Requirements

- **Server Requirements**: [To be detailed after system implementation]

- **Client Requirements**: Any computer or mobile device supporting modern web browsers

- **Recommended Configuration**: [To be detailed after system implementation]

2.3.2 Software Requirements

- **Supported Operating Systems**: Windows 10/11, macOS, Linux

- **Supported Browsers**: Google Chrome (latest), Mozilla Firefox (latest), Microsoft Edge (latest), Safari (latest)

- **Other Dependencies**: [To be detailed after system implementation]

2.3.3 Network Requirements

- **Minimum Bandwidth**: [To be detailed after system implementation]

- **Network Configuration**: [To be detailed after system implementation]

2.4 Conventions and Terminology

2.4.1 Document Conventions

This manual uses the following formatting conventions:

- **Bold text**: Indicates menus, buttons, or interface elements

- *Italic text*: Indicates specially emphasized information

- Code font: Indicates system messages or input values

- Warnings and notes are highlighted in special formatted boxes

2.4.2 Glossary

- **RUL**: Remaining Useful Life, the estimated time a component can continue to operate before failure

- **PdM**: Predictive Maintenance, using data analytics and machine learning to predict when equipment will need maintenance

- **Anomaly Detection**: Identifying behaviors or states that deviate from normal operation patterns

- **Threshold**: A predefined value that triggers an alert or notification

- **Alert**: A system-generated reminder indicating a condition that requires attention

- **Deep Learning**: A branch of artificial intelligence that uses multi-layered neural networks for pattern recognition and prediction

- **KPI**: Key Performance Indicator, used to measure the performance of a system or component

- **CNN**: Convolutional Neural Network, a deep learning algorithm suitable for image and pattern recognition

- **LSTM**: Long Short-Term Memory, a type of recurrent neural network suitable for time-series data

- **GAN**: Generative Adversarial Network, a deep learning technique used for anomaly detection

- **Transformer**: A neural network architecture based on self-attention mechanisms

3. Getting Started

3.1 Accessing the System

To access the Smart Maintenance Platform for Aero Engine Industrial Equipment:

1. Open a supported web browser

2. Navigate to the system URL: [System URL will be provided after deployment]

3. Enter your username and password on the login page

4. Click the **Login** button

Note: On first login, you may be required to change your default password and set up security questions.

3.2 User Interface Overview

Based on the system architecture designed by Fubin Chen and modules mentioned in the project plan, the user interface includes the following main areas:

3.2.1 Navigation Menu

Located on the left side of the interface, providing access to all main functions of the system:

- **Dashboard**: System overview and key metrics

- **Device Center**: Manage and monitor all engine equipment

- **Monitoring Center**: Real-time data and trend monitoring

- **Alert Center**: View and manage system alerts

- **Data Analysis**: In-depth analysis and reporting

- **Data Simulation**: Simulate different operational scenarios

- **System Administration**: Configure and manage system settings

3.2.2 Main Content Area

Occupies the central part of the interface, displaying the content of the currently selected function. Content changes dynamically based on the selected menu item.

3.2.3 Top Toolbar

Contains:

- User information and account settings

- Notification indicators

- Help and support options

- System status indicators

- Global search functionality

3.2.4 Status Bar

Located at the bottom of the interface, displays:

- Current system status

- Last update time

- Connection status

- Version information

3.3 Login and Logout

3.3.1 Logging Into the System

1. Navigate to the system login page

2. Enter your username and password

3. (Optional) Check the "Remember me" option to save your login information

4. Click the **Login** button

3.3.2 Logging Out of the System

1. Click on the user icon in the top toolbar

2. Select **Logout** from the dropdown menu

3. Confirm the logout operation

3.3.3 Password Reset

If you've forgotten your password:

1. Click the **Forgot Password** link on the login page

2. Enter your username or registered email

3. Follow the instructions sent by the system to reset your password

3.4 User Preferences

You can customize the system interface according to your personal needs:

1. Click on the user icon in the top toolbar

2. Select **Preferences**

3. Adjust the following options:

   o Interface language

- Time zone settings

- Notification preferences

- Dashboard layout

- Data display units

- Color theme

4. Core Functionality

4.1 Device Center

4.1.1 Overview

The Device Center is the central location for managing all monitored aero engines and components. It provides device registration, configuration, grouping, and status monitoring capabilities, enabling users to manage the entire device lifecycle.

4.1.2 Feature List

- Device registration and configuration

- Device status monitoring

- Device grouping and categorization

- Device details viewing

- Device maintenance history

- Device documentation management

4.1.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

4.2 Monitoring Center

4.2.1 Overview

The Monitoring Center provides real-time and historical monitoring of engine performance. Users can view key parameters, analyze performance trends, and identify potential issues. This module utilizes advanced visualization techniques to make complex data easy to understand and interpret.

4.2.2 Feature List

- Real-time data monitoring

- Historical trend analysis

- Multi-parameter correlation analysis

- Custom dashboards

- Threshold configuration and monitoring

- Data export and reporting

4.2.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

4.3 Data Simulation

4.3.1 Overview

The Data Simulation module allows users to simulate engine performance under various operating conditions. This is valuable for training purposes, predictive scenario analysis, and hypothesis testing. Users can configure different parameters and observe the simulated results.

4.3.2 Feature List

- Simulation scenario creation

- Parameter configuration

- Simulation run control

- Results visualization

- Comparison with historical data

- Scenario saving and sharing

4.3.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

4.4 Alert System

4.4.1 Overview

The Alert System monitors engine performance and system predictions, generating notifications when anomalies are detected or potential issues are predicted. Users can configure alert rules, manage alerts, and track resolution processes.

4.4.2 Feature List

- Alert rule configuration

- Real-time alert monitoring

- Alert notifications (email, SMS, system notifications)

- Alert acknowledgment and handling

- Alert history recording

- Alert statistics and trend analysis

4.4.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

4.5 Reporting System

4.5.1 Overview

The Reporting System provides comprehensive reporting and analysis capabilities to help users understand equipment performance, track maintenance activities, and support decision-making processes. The system includes predefined reports and custom reporting options.

4.5.2 Feature List

- Predefined reports (operational status, maintenance history, performance trends)

- Custom report building

- Report scheduling and distribution

- Export to multiple formats (PDF, Excel, CSV)

- Report history and version control

- Interactive data visualizations

4.5.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

5. Advanced Functionality

5.1 Anomaly Detection

5.1.1 Overview

The Anomaly Detection functionality utilizes advanced deep learning algorithms (such as Skip-GANomaly and PHOT selected by Xuanhe Yang) to identify non-normal patterns in engine operation. These anomalies may indicate potential failures or situations requiring

maintenance.

5.1.2 Feature List

- Real-time anomaly detection

- Historical anomaly analysis

- Anomaly type classification

- Anomaly severity assessment

- Root cause analysis support

- Anomaly detection settings configuration

5.1.3 Algorithm Description

- **Skip-GANomaly**: A Generative Adversarial Network-based anomaly detection method that identifies deviations by learning normal operation patterns

- **PHOT (Phase-Only Transform)**: Utilizes frequency domain analysis to identify anomalies in time-series data

5.1.4 Key Operations

[Detailed operation steps will be added after user interface design is completed]

5.2 Remaining Useful Life Prediction

5.2.1 Overview

The Remaining Useful Life (RUL) prediction functionality uses multiple deep learning models (such as CNN-LSTM, CNN-Transformer, DBN-BiGRU) to predict the remaining useful life of critical engine components. These predictions help maintenance teams plan maintenance activities at optimal times.

5.2.2 Feature List

- Component life prediction

- Prediction confidence intervals

- Multi-model prediction comparison

- Prediction trend analysis

- Maintenance window recommendations

- Prediction influencing factor analysis

5.2.3 Algorithm Description

- **CNN-LSTM**: Combines Convolutional Neural Networks and Long Short-Term Memory Networks, suitable for data with both temporal and spatial characteristics

- **CNN-Transformer**: Combines Convolutional Neural Networks and Transformer architecture, utilizing self-attention mechanisms to capture long-distance dependencies

- **DBN-BiGRU**: Combines Deep Belief Networks and Bidirectional Gated Recurrent Units for bidirectional analysis of time-series data

5.2.4 Key Operations

[Detailed operation steps will be added after user interface design is completed]

5.3 Maintenance Schedule Optimization

5.3.1 Overview

The Maintenance Schedule Optimization functionality combines anomaly detection and life prediction results to help users develop optimal maintenance schedules. It considers multiple factors, including predicted failure risk, maintenance costs, downtime impact, and resource availability.

5.3.2 Feature List

- Maintenance task recommendations

- Maintenance window identification

- Maintenance resource allocation

- Scenario analysis ("what-if" simulations)

- Maintenance schedule conflict detection

- Cost-benefit analysis

5.3.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

6. System Administration

6.1 User Management

6.1.1 Overview

The User Management functionality allows administrators to create and manage system user

accounts, assign roles and permissions, and monitor user activity. This ensures proper access control and system security.

6.1.2 Feature List

- User creation and management

- Role definition and assignment

- Permission configuration

- Password policy management

- Access logs and auditing

- User activity reporting

6.1.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

6.2 System Configuration

6.2.1 Overview

The System Configuration functionality allows administrators to customize system settings, including notification parameters, data retention policies, system integration settings, and global thresholds.

6.2.2 Feature List

- Global system settings

- Notification configuration

- Data management settings

- Integration settings

- Performance tuning

- Logging configuration

6.2.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

6.3 Data Management

6.3.1 Overview

The Data Management functionality provides tools for data storage, backup, archiving, and

cleanup. It helps administrators maintain system performance and ensure data integrity and availability.

6.3.2 Feature List

- Data backup and recovery

- Data archiving and cleanup

- Data import and export

- Data quality monitoring

- Storage capacity management

- Data access control

6.3.3 Key Operations

[Detailed operation steps will be added after user interface design is completed]

7. Best Practices

7.1 System Usage Recommendations

- Regularly check the dashboard for system overview

- Configure custom alert thresholds for critical equipment

- Use multiple models for prediction comparison

- Regularly review and analyze anomaly detection results

- Compare system predictions with actual maintenance findings to optimize models

- Use the data simulation feature to test the impact of different scenarios

7.2 Data Interpretation Guidelines

- Understand prediction confidence intervals

- Focus on trends rather than individual data points

- Associate anomaly patterns with known issue types

- Consider the impact of operating conditions on predictions

- Use correlation analysis to identify influencing factors

- Compare prediction results with historical patterns

7.3 Troubleshooting Tips

- Ensure sensor data quality and connectivity

- Verify input parameters and configuration settings

- Check system notification and alert configurations

- Use data simulation to validate issues

- Review system logs for error messages

- Contact the technical support team for advanced assistance

8. Appendices

8.1 Keyboard Shortcuts

[Will be added after user interface design is completed]

8.2 Frequently Asked Questions

[Will be added after collecting common questions during system implementation and testing]

8.3 Error Message Reference

[Will be added after system implementation]

8.4 Support Contact Information

- **Technical Support Email**: [Will be added after system deployment]

- **Support Hotline**: [Will be added after system deployment]

- **Help Desk Hours**: [Will be added after system deployment]

- **Emergency Contacts**: [Will be added after system deployment]

8.5 Related Documentation

- System Design Document

- Installation and Configuration Guide

- API Reference Manual

- Data Dictionary

- Training Materials

- Maintenance Manual

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