

AI in Maintenance & Reliability:
Predictive and Prescriptive
Maintenance with Artificial
Intelligence

Mohammed Hamed Ahmed Soliman

Published by personal-lean.org, 2025.

Publisher: Personal Lean Publications
For inquiries: info@personal-lean.org
Website: www.personal-lean.org

No AI-generated text, translation, or images were used in the production of this work.

All trademarks and brand names belong to their respective owners and are used for identification and educational purposes only.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, including text, photographs, illustrations, tables, and diagrams, without prior written permission from the copyright holder.

While every precaution has been taken in the preparation of this book, the publisher assumes no responsibility for errors or omissions, or for damages resulting from the use of the information contained herein.

AI IN MAINTENANCE & RELIABILITY:
PREDICTIVE AND PRESCRIPTIVE MAINTENANCE
WITH ARTIFICIAL INTELLIGENCE

First edition. August 9, 2025.

Copyright © 2025 Mohammed Hamed Ahmed Soliman.

All rights reserved.

Written by Mohammed Hamed Ahmed Soliman.

Table of Contents

AI in Maintenance & Reliability Predictive and Prescriptive Maintenance with Artificial Intelligence	1
Preface	9
Part 1 Chapter 1 – Introduction to AI in Industrial Maintenance	11
Chapter 2 – The Evolution from Reactive to Prescriptive Maintenance	15
Chapter 3 – Understanding Data Sources: Vibration, Thermal, Acoustic, Oil, and Operational Data.....	21
Chapter 4 – Fundamentals of Predictive Maintenance (PdM).....	26
Part 2 Chapter 5 – Machine Learning Basics for Maintenance Engineers	32
Chapter 6 – Using AI to Detect Anomalies in Equipment...39	
Chapter 7 – Case Studies: Predicting Failures in Pumps, Motors, and Gearboxes.....	45
Part3 Chapter 8 – What is Prescriptive Maintenance?	51
Chapter 9 – Optimization Algorithms for Maintenance Scheduling.....	57
Chapter 10 – Decision Support Systems with AI.....	63

Chapter 11 – Case Studies: AI Recommending Maintenance Actions 69

Part 4 | Chapter 12 – Building an AI-Driven Maintenance Strategy 73

Chapter 13 – Integrating AI with CMMS/EAM Systems.... 79

Chapter 14 – ROI and Cost-Benefit Analysis of AI in Maintenance 84

Chapter 15 – Roadmap for Industry 4.0 Readiness 90

Appendix A – IoT Sensors for Maintenance & Reliability.... 95

AI in Maintenance & Reliability

Predictive and Prescriptive Maintenance with Artificial Intelligence



Contents

Preface

Part 1

Chapter 1 – Introduction to AI in Industrial Maintenance

1.1 The Changing Landscape of Industrial Maintenance

1.2 The Maintenance Spectrum

1.3 Why AI is a Game-Changer

1.4 Real-World Impact

1.5 Challenges and Misconceptions

Key Takeaways

Practical Checklist – Before Starting with AI in Maintenance

Chapter 2 – The Evolution from Reactive to Prescriptive Maintenance

2.1 The Four Generations of Maintenance

2.2 The Maintenance “Maturity Curve”

2.3 From Data Collection to Data-Driven Decisions

2.4 Enabling Technologies

2.5 Benefits of Moving Up the Curve

2.6 Barriers to Adoption

Key Takeaways

Practical Checklist – Is Your Organization Ready for Prescriptive Maintenance?

Chapter 3 – Understanding Data Sources: Vibration, Thermal, Acoustic, Oil, and Operational Data

3.1 Why Data is the Lifeblood of AI in Maintenance

3.2 The Main Data Categories for AI-Driven Maintenance

3.3 The Power of Data Fusion

3.4 Data Quality Challenges

3.5 Data Governance for Maintenance AI

Key Takeaways

Practical Checklist – Data Readiness for AI

Chapter 4 – Fundamentals of Predictive Maintenance (PdM)

4.1 What is Predictive Maintenance?

4.2 How PdM Differs from Other Strategies

4.3 Core Workflow of Predictive Maintenance

4.4 Key Technologies in PdM

4.5 PdM Algorithms and Methods

4.6 Industrial Examples of PdM in Action

4.7 Benefits of PdM

4.8 Limitations of PdM

Key Takeaways

Practical Checklist – Before Starting PdM

Part 2

Chapter 5 – Machine Learning Basics for Maintenance Engineers

5.1 Why Maintenance Engineers Need Machine Learning (ML)

5.2 What is Machine Learning?

5.3 Types of Machine Learning in Maintenance

5.4 The Machine Learning Workflow for Maintenance

5.5 Key ML Concepts for Maintenance Engineers

5.6 Common ML Algorithms in Maintenance Applications

5.7 Example: ML Predicting Pump Bearing Failure

5.8 Common Pitfalls

Key Takeaways

Practical Checklist – ML Readiness for Maintenance

Chapter 6 – Using AI to Detect Anomalies in Equipment

6.1 What is Anomaly Detection?

6.2 Why AI Outperforms Traditional Thresholds

6.3 Types of Anomaly Detection in Maintenance

6.4 The AI Anomaly Detection Workflow

6.5 Case Study – Pump Cavitation Detection

6.6 Challenges in AI-Based Anomaly Detection

6.7 Best Practices

Key Takeaways

Practical Checklist – AI Anomaly Detection Readiness

Chapter 7 – Case Studies: Predicting Failures in Pumps, Motors, and Gearboxes

7.1 Why Case Studies Matter

7.2 Case Study 1 – Predicting Pump Bearing Failure

7.3 Case Study 2 – Detecting Motor Overheating in a Manufacturing Plant

7.4 Case Study 3 – Gearbox Tooth Wear in a Cement Plant

7.5 Cross-Case Insights

Key Takeaways

Practical Checklist – Building Your Own Case Studies

Part3

Chapter 8 – What is Prescriptive Maintenance?

8.1 From Prediction to Prescription

8.2 The Core Components of Prescriptive Maintenance

8.3 Data and AI in Prescriptive Maintenance

8.4 Benefits of Prescriptive Maintenance

8.5 Example Scenarios

8.6 Challenges in Implementing Prescriptive Maintenance

8.7 The Future of Prescriptive Maintenance

Chapter 9 – Optimization Algorithms for Maintenance Scheduling

9.1 Why Optimization is Critical in Maintenance

9.2 Types of Optimization Approaches

9.3 Multi-Objective Optimization

9.4 Integration with Predictive and Prescriptive Maintenance

9.5 Example Scenario

9.6 Challenges in AI Maintenance Optimization

9.7 Best Practices

Chapter 10 – Decision Support Systems with AI

10.1 Introduction

10.2 The Role of DSS in Maintenance

10.3 AI Capabilities in DSS

10.4 AI Models Used in Maintenance DSS

10.5 Integration with CMMS/EAM Systems

10.6 Human-in-the-Loop Decision Making

10.7 Benefits of AI-Driven DSS in Maintenance

10.8 Challenges and Considerations

10.9 Case Example – AI DSS for a Power Plant

10.10 Key Takeaways

Chapter 11 – Case Studies: AI Recommending Maintenance Actions

11.1 Case Study 1 – AI-Driven Maintenance on a Petrochemical Pump System

11.2 Case Study 2 – AI-Guided Gearbox Maintenance in a Steel Mill

11.3 Case Study 3 – Wind Turbine Blade Maintenance Optimization

11.4 Key Takeaways

Chapter 12 – Building an AI-Driven Maintenance Strategy

12.1 Defining the Vision and Objectives

12.2 Assessing Current Maintenance Maturity

12.3 Building the Data Foundation

12.4 Selecting the Right AI Approach

12.5 Organizational Readiness and Skills Development

12.6 Pilot Projects and Scaling

12.7 Integration with Decision-Making Processes

12.8 Continuous Improvement and Feedback Loops

12.9 Governance and Cybersecurity

12.10 Strategic Roadmap for AI in Maintenance

Chapter 13 – Integrating AI with CMMS/EAM Systems

13.1 Why Integrate AI with CMMS/EAM?

13.2 Integration Architecture

13.3 Practical Integration Approaches

13.4 Example Workflow

13.5 Data Challenges in Integration

13.6 Benefits of AI-CMMS/EAM Integration

13.7 Looking Ahead

Chapter 14 – ROI and Cost-Benefit Analysis of AI in Maintenance

14.1 Introduction

14.2 Understanding ROI in AI Maintenance