

Industrial Problem-Solving Handbook: Practical Tools and AI-Driven Methods for Engineers and Managers

Lean Foundations & Advanced AI Applications Series

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INDUSTRIAL PROBLEM-SOLVING HANDBOOK: PRACTICAL TOOLS AND AI-DRIVEN METHODS FOR ENGINEERS AND MANAGERS

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Industrial Problem-Solving Handbook

Practical Tools and AI-Driven Methods for Engineers and Managers



Preface



IN TODAY'S FAST-PACED industrial environment, engineers and managers face increasingly complex challenges—from process inefficiencies and equipment failures to quality issues and operational bottlenecks. Traditional problem-solving methods, while effective, are no longer sufficient on their own. Modern industry demands approaches that are **structured, data-driven, and augmented by emerging AI technologies**.

This handbook was written to bridge that gap. It consolidates **practical tools, proven methodologies, and AI-driven techniques** into a single, accessible guide. Readers will find actionable strategies they can immediately apply to improve processes, reduce waste, optimize production, and drive continuous improvement.

Whether you are a production manager, process engineer, industrial consultant, or operations leader, this book provides a **step-by-step roadmap** for tackling real-world industrial problems. It emphasizes clarity, practicality, and measurable results, supported by case studies and examples from diverse industrial settings.

The goal is simple: empower professionals to **solve problems smarter, faster, and more effectively**, turning

challenges into opportunities and fostering a culture of continuous improvement across their organizations.



Author Notes



ABOUT THE AUTHOR:

Dr. Mohammed Hamed Ahmed Soliman is an industrial engineering professor, consultant, and author with extensive experience in manufacturing, operations, and process optimization. Over his career, he has helped engineers and managers across multiple industries implement structured problem-solving approaches, Lean and Six Sigma methodologies, and AI-driven process improvements.

Dr. Soliman is passionate about making complex industrial methods **practical and accessible** for professionals at every level. His work combines academic rigor with real-world insights, ensuring that readers not only understand the theory but can also apply it effectively in their workplaces.

Why This Book:

This handbook was born from the need for a **comprehensive, practical guide** that blends classical industrial problem-solving techniques with modern AI-supported methods. It aims to serve as both a reference and a practical toolkit, helping professionals transform challenges into measurable improvements.

A Note to Readers:

While this book presents structured approaches and tools, the **true power lies in application**. I encourage you to

experiment, adapt, and continuously refine these methods to suit your unique industrial environment. Continuous improvement is not just a methodology—it is a mindset.



Chapter 1. Introduction to Industrial Problem-Solving



1.1 WHY PROBLEM-SOLVING is the #1 Skill in Industry

Every industrial organization — whether a factory, a power plant, or a logistics hub — is a constant problem-solving arena. Machines break down, quality defects appear, supply chains get disrupted, and customer expectations rise.

In this environment, **problem-solving is not just a skill, it is the survival mechanism of industry.** A company's competitiveness depends on how quickly and effectively it can detect, analyze, and resolve problems.

- In **manufacturing**, problem-solving means identifying the root cause of a defect on a production line before thousands of parts are wasted.
- In **maintenance**, it means diagnosing why a pump failed and preventing the same failure from shutting down operations again.
- In **management**, it means analyzing why costs are rising and deciding on the best corrective actions.

A common saying in operations is:

“Problems are treasures — if you solve them systematically, they reveal the path to improvement.”

Companies that excel in problem-solving reduce downtime, improve quality, and innovate faster than competitors. On the other hand, poor problem-solving leads to recurring failures, wasted resources, and frustrated teams.

1.2 Traditional vs. Modern Methods

Industrial problem-solving has evolved significantly over the last century.

Traditional methods:

- Rely heavily on **human intuition, experience, and observation**.
- Examples: walking the shop floor, brainstorming with teams, simple tools like check sheets and Pareto charts.
- Strength: practical, quick, and low-cost.
- Limitation: depends strongly on expertise of individuals and may overlook hidden patterns.

Modern methods:

- Combine **structured frameworks** with **data-driven analysis and AI**.
- Use sensors, digital twins, machine learning, and advanced analytics.
- Strength: detect hidden patterns, predict failures before they occur, and optimize decisions.
- Limitation: require data infrastructure, investment, and technical skills.

The most effective organizations today do not choose one or the other — they integrate **classical structured approaches** with **modern AI-powered tools**, creating a hybrid system of problem-solving.

1.3 Overview of Structured Frameworks

Before diving into tools, it is essential to understand the **frameworks** that guide problem-solving. These frameworks provide the “roadmap” — the steps to follow so teams don’t jump to conclusions or miss critical details.

1.3.1 PDCA (Plan–Do–Check–Act)

One of the earliest systematic methods introduced by W. Edwards Deming.

- **Plan** – Define the problem, collect data, and plan a solution.
- **Do** – Implement the solution on a small scale.
- **Check** – Evaluate results against expectations.
- **Act** – Standardize if successful, or restart cycle if not.

PDCA emphasizes **continuous improvement** and small cycles of learning.

1.3.2

DMAIC

(Define–Measure–Analyze–Improve–Control)

The backbone of Six Sigma problem-solving.

- **Define** – Clearly state the problem and objectives.
- **Measure** – Collect data to understand the current state.
- **Analyze** – Identify root causes using data analysis tools.

- **Improve** – Implement solutions targeting root causes.
- **Control** – Put controls in place to sustain improvements.

DMAIC is **data-intensive**, ideal for reducing variation and defects.

1.3.3 A3 Problem-Solving (Toyota Method)

A lean approach named after the **A3 paper size**, where the entire problem-solving story is captured on one page.

- **Background** – Why this problem matters.
- **Current state** – What is happening now (data, diagrams).
- **Goal** – What we want to achieve.
- **Root cause analysis** – Why the problem exists.
- **Countermeasures** – Actions to address causes.
- **Implementation plan** – Who, when, how.
- **Follow-up** – Checking results and standardizing.

A3 emphasizes **visual thinking, storytelling, and teamwork**.

1.4 Where This Book Fits In

This handbook combines the **best of both worlds**:

1. **Classical tools** (5 Whys, Pareto, FMEA, Control Charts) that are proven and practical.
2. **Modern AI methods** (machine learning, digital twins, generative AI) that open new frontiers in efficiency and innovation.

3. **Hybrid approaches** that merge both, enabling engineers and managers to solve today's problems while preparing for tomorrow's challenges.

The goal is to make you a **future-proof problem solver**:

- Able to define problems clearly.
- Skilled in using structured frameworks.
- Equipped to leverage AI and data science when appropriate.
- Capable of leading teams through effective problem-solving journeys.

1.5 Key Takeaways from Chapter 1

- Problem-solving is the **most critical skill in industry** — it drives survival, competitiveness, and innovation.
- Traditional methods rely on intuition and experience, while modern methods leverage **data and AI**.
- Frameworks like **PDCA, DMAIC, and A3** provide structure and discipline, preventing teams from skipping steps.
- The future of problem-solving lies in **combining classical discipline with AI-driven insights**.

Figure 1.1 – Evolution of Industrial Problem-Solving
(A simple timeline/arrow diagram)

Traditional → Structured → AI-Driven

Observation & Intuition → PDCA, DMAIC, A3 →
Predictive Analytics, Digital Twins, Generative AI

(Experience-based)

(Framework-based)

(Data- & AI-driven)

- Message: Industry moved from intuition → structured → AI-powered hybrid problem-solving.

Table 1.1 – Comparison of Structured Frameworks				
Framework Steps		Strengths	Limitations	Best Use Case
PDCA	Plan → Do →	Simple,	May oversimplify complex issues	Daily shop-floor improvements
	Check → Act	iterative, continuous improvement		
DMAIC	Define →	Data-driven,	Requires strong data and statistics	Quality and process variation
	Measure →	structured,		
	Analyze →	excellent for defect		
	Improve →	Control		
A3	Background →	Visual, collaborative, storytelling tool	Needs discipline to avoid oversimplification	Lean manufacturing & teamwork
	Current State →			
	Goals → Root Cause →			
	Countermeasures			
	→ Plan → Follow-up			