



The 23rd International Asset Facility and Maintenance Management Conference

Research on the Construction and Implementation Path of a New TPM-Based Preventive Maintenance Model in Lights-out Factories

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Today's Workshop Agenda (60 Minutes)

- ❑ Part 1 (15 min): Opening & the New Challenges
- ❑ Part 2 (30 min): The New TPM Framework & How to Implement It
- ❑ Part 3 (15 min): Expected Benefits, Critical Issues & Closing



Workshop Guidelines & House Rules



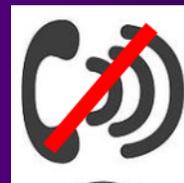
Participate Actively

Share your views



Listen Respectfully

**One speaker at a
time**



Silence Your Devices

For everyone's focus



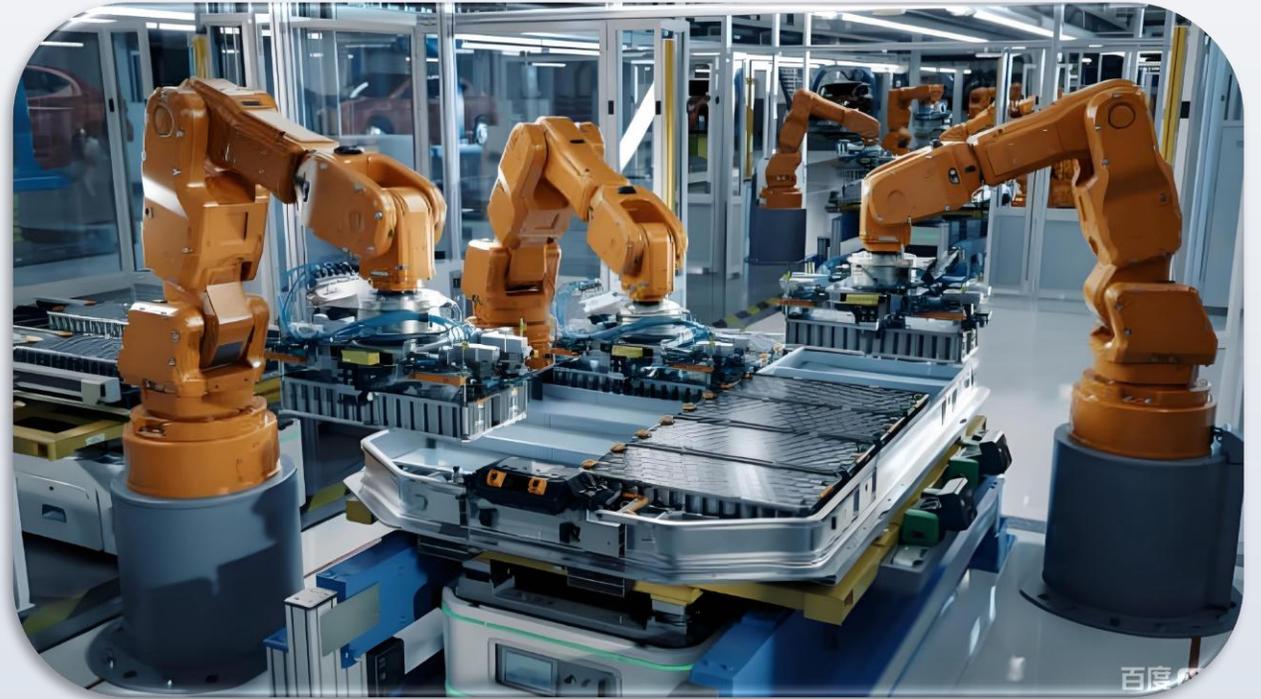
Think Solutions

**Constructive
mindsets welcome**

Agenda

PART 1

Opening & the New Challenges



See the Future of Car Making : The Reality of Lights-out Manufacturing

A Glimpse into the Future: SAIC-GM-Wuling Smart Factory



The Wuling Hongguang, a compact van widely used in rural and urban China for both cargo and passengers.

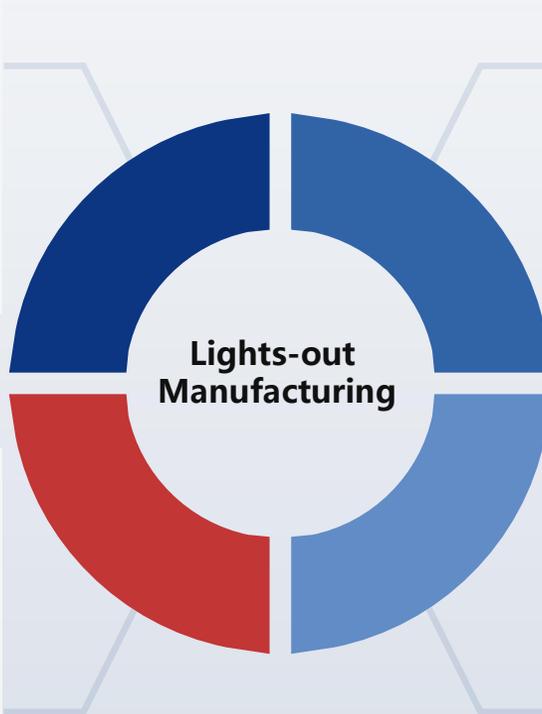
Typical Characteristics of Lights-out Manufacturing

End-to-End Automation

The complete production value chain—from material handling and processing to assembly, inspection, and logistics—is executed by integrated robotic and automated systems without the need for human operators on the production line.

The human role shifts from direct operation to remote monitoring and exception management. Personnel oversee the factory from central control rooms using MES or digital twin platforms, intervening only for high-level decision-making or unforeseen issues.

Remote Supervision & Control



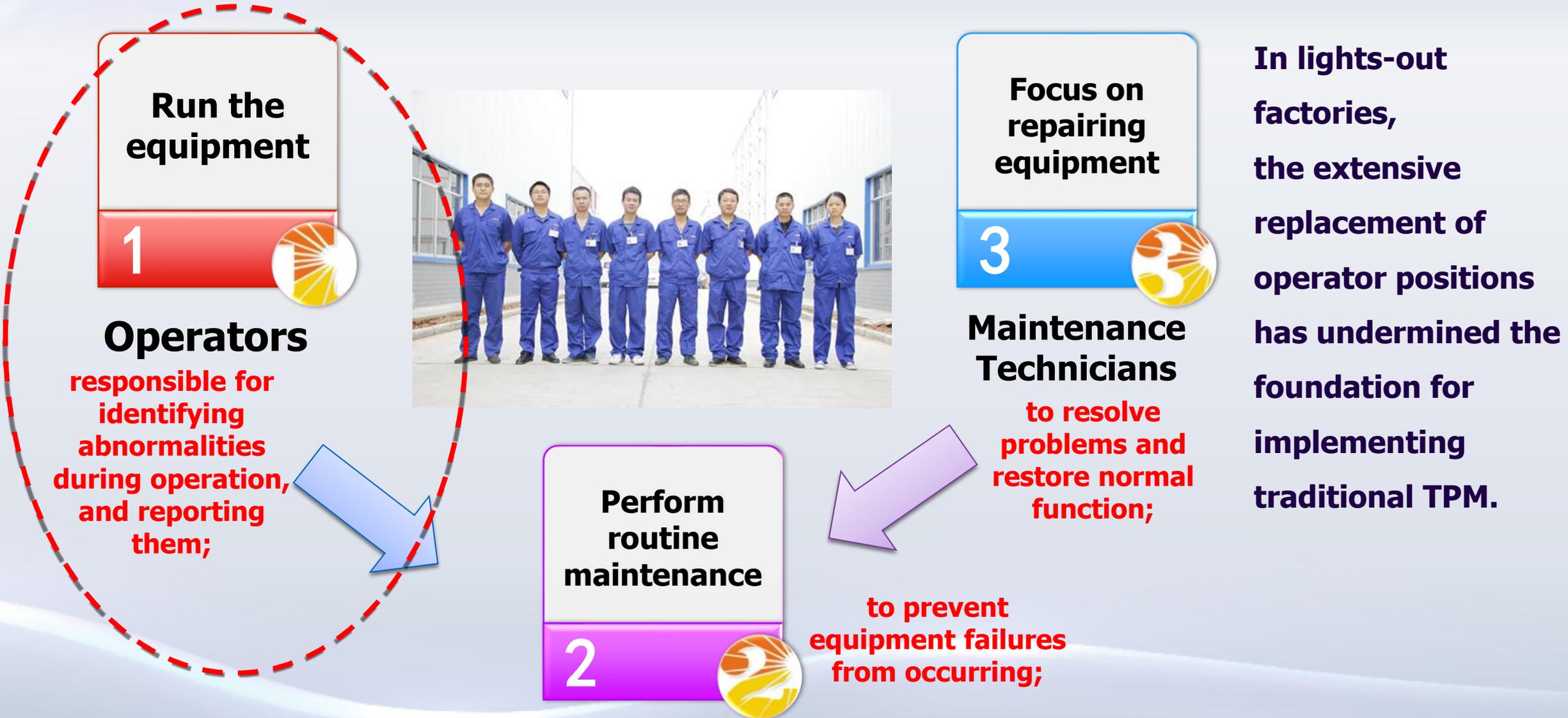
Autonomy & Data-Driven

Operations are governed by interconnected systems (IIoT, CPS) that enable self-optimization. Processes are controlled by real-time data analytics, AI, and predictive algorithms (e.g., for maintenance or quality control), ensuring adaptive and resilient production.

The factory design eliminates or drastically reduces traditional facilities for on-floor personnel (e.g., lighting, walkways, safety signage). The physical environment is optimized for machine operation, maintenance access, and energy efficiency.

Minimal Human-Centric Infrastructure

Implementing traditional Total Productive Maintenance (TPM)



Discuss:

With the move towards unmanned or minimally staffed production floors, several critical questions emerge:



How can we monitor and assess equipment degradation promptly and accurately?



Can routine cleaning and basic maintenance tasks--essential for restoring equipment condition, be eliminated or automated?



If these tasks remain necessary, who should be responsible for performing them?

Why Traditional TPM Falls Short?

The Three Core Challenges We Identified

Failure of Problem Discovery

No operators as the "first line of defense."

Sky-High Maintenance Pressure

Unplanned downtime is extremely costly.

Extreme Demand for Speed

Repairs must be ultra-fast and accurate.

From "Human-Centric" to "Data-Driven & Collaborative"

Old Model

Relies on people's senses and routine checks.



New Model

Built on:

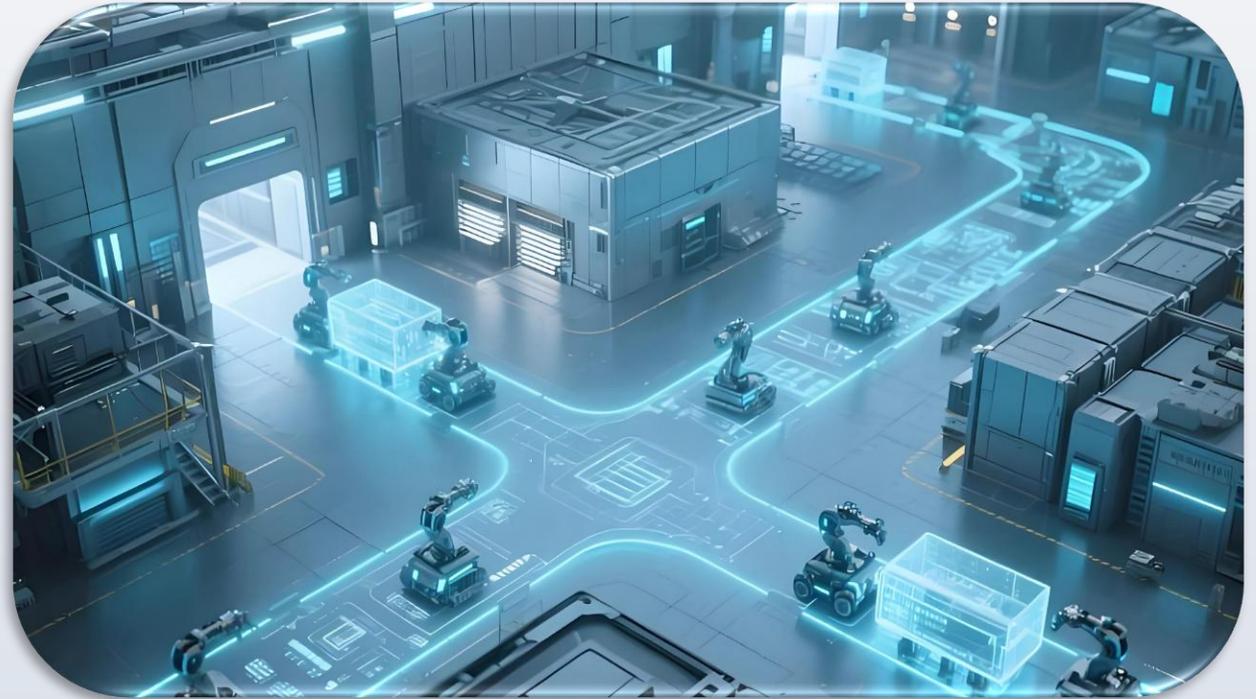
- ❑ **data-driven,**
- ❑ **collaboration between humans and machines,**
- ❑ **and prevention before failure.**

Our Proposed Solution: A New TPM Framework

**To address these challenges,
we propose a new TPM framework...**

PART 2

The New TPM Framework
& How to Implement It

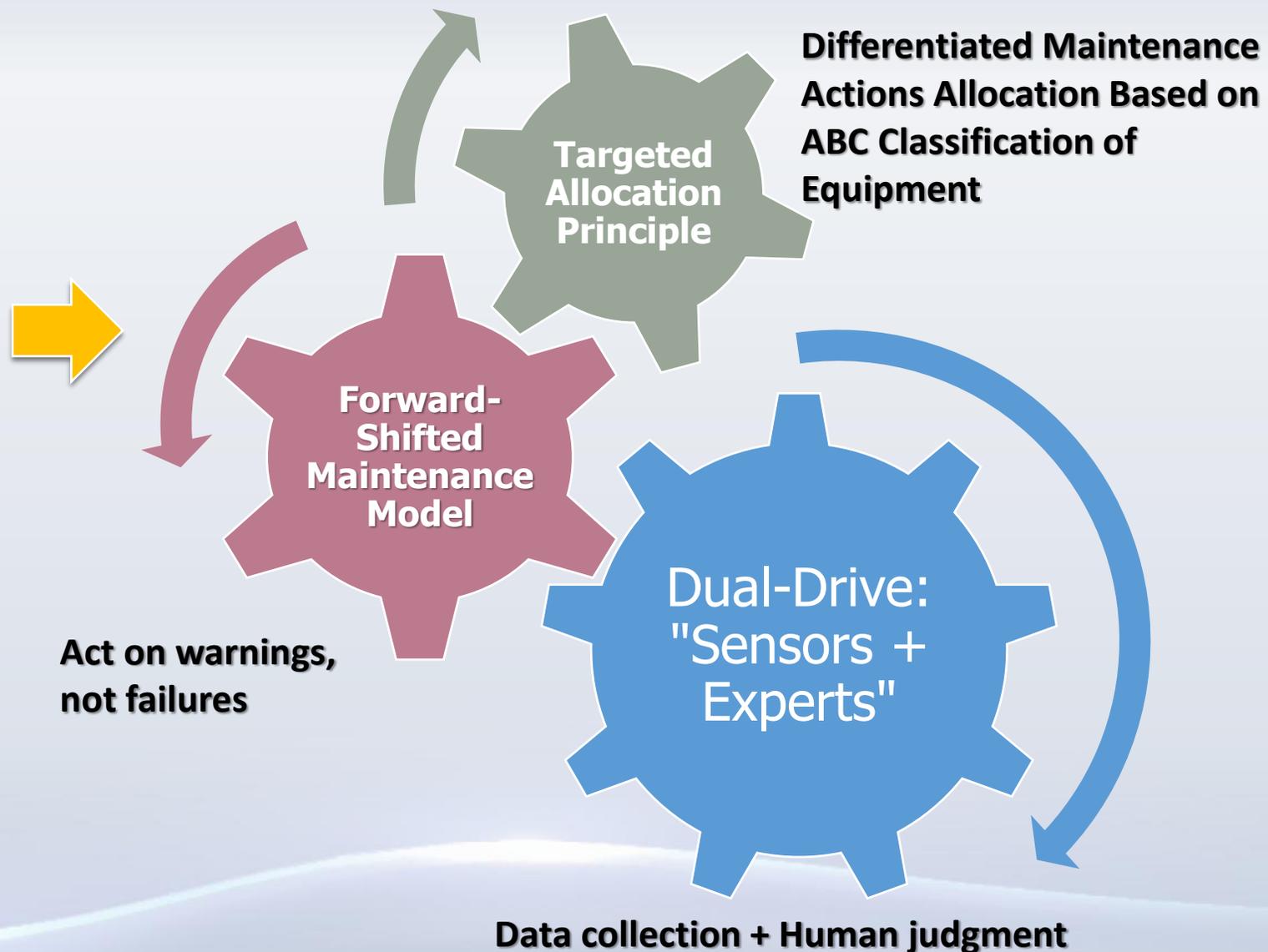


The Pillars of the New TPM Framework

The Core of the New Model--

3 Key Elements:

- **Data-Driven Operations**
- **Human-Machine Collaboration**
- **Forward-Shifted Maintenance**



Element 1: "Sensors + Experts" in Action

How It Works: The Dual-Drive Mechanism

Sensors:

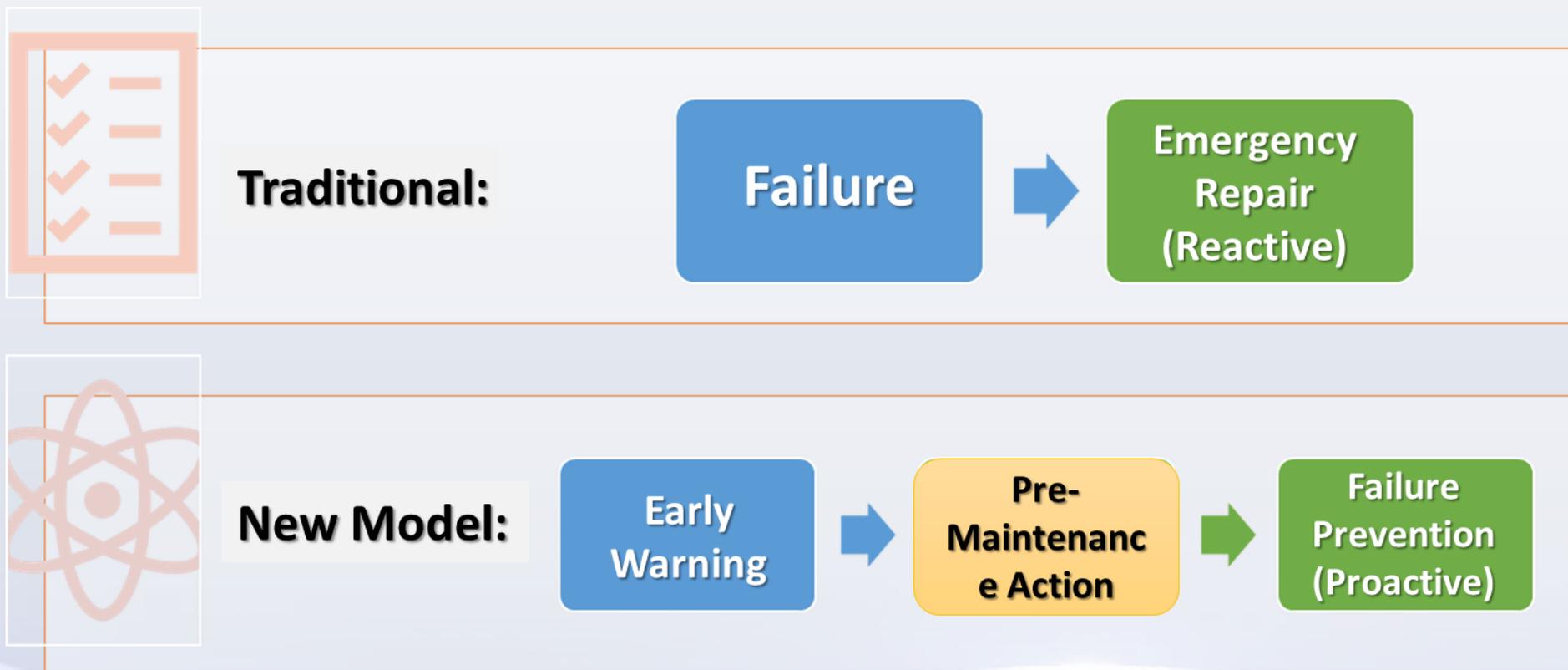
- 24/7 monitoring (vibration, temperature, current...).
- They are the new "eyes and ears."

Experts (Maintenance Staff):

- Focus on root cause analysis and precise intervention.

Element 2: Shift Your Maintenance Forward

Change the Timeline of Maintenance activities



Element 3: Maintenance Smartly with ABC Classification

Not All Equipment is Equal: The ABC Principle

Under the lights-out factory model, maintenance resources and strategies should be differentially configured and designed based on equipment criticality (ABC classification):

- ❑ **Class A (Critical):** Deploy real-time condition monitoring combined with on-call expert support.
- ❑ **Class B (Important):** Implement periodic precision inspections along with specialized patrol checks.
- ❑ **Class C (Normal):** Adopt floor video monitoring paired with an anomaly alert response mechanism.

Interactive Exercise 2: Your Thoughts on This Framework?

Quick Feedback Round: Write down your good ideas

Questions:

1. What is the most practical idea here for your context?
2. What would be the biggest obstacle to implementing this?

Case Study: Implementing ABC Equipment Classification – a Factory in Nanchang city, China

- Based on defined rating criteria, engineers evaluate different equipment types/models within the Enterprise Asset Management (EAM) system. The system then automatically assigns an A, B, or C classification level according to the calculated score.

设备型号: 安全阀-A48Y-16C

因素	故障后果影响	权重	分值	评分
生产因素	a.停产, 直接影响产品质量	0.3	10	<input type="radio"/>
	b.造成生产不稳定, 对产品质量有影响或影响连续生产		5	<input type="radio"/>
	c.影响不大, 对工艺质量没有影响或影响较少		1	<input type="radio"/>
安全环保因素	a.有爆炸或火灾危险, 或有有毒有害物质外溢, 或存在重要环境因素/重要危险源	0.3	10	<input type="radio"/>
	b.有局部伤害危险, 或存在一般环境因素/危险源		5	<input type="radio"/>
	c.影响不大		1	<input type="radio"/>
精密因素	a.结构特别复杂、精密, 不易修复或故障频繁	0.1	10	<input type="radio"/>
	b.结构比较复杂, 修理工时/故障率一般		5	<input type="radio"/>
	c.一般结构, 故障率低		1	<input type="radio"/>
经济因素	a.设备重置价值很高, 或年修理费用很高	0.1	10	<input type="radio"/>
	b.设备重置价值较高, 或年修理费用较高		5	<input type="radio"/>
	c.一般		1	<input type="radio"/>
备用因素	a.无备用设备	0.1	10	<input type="radio"/>
	b.有一备用设备		5	<input type="radio"/>
	c.有多备用设备		1	<input type="radio"/>
备件因素	a.配件供应不畅, 购买困难	0.1	10	<input type="radio"/>
	b.基本能满足生产, 被专业供应商垄断供应的		5	<input type="radio"/>
	c.能满足生产, 能进行普通采购或定做的		1	<input type="radio"/>

* 审批人:

序号	设备名称	设备分类号	型号名称	型号编码	当前定与等级	当前分值	分值状态	审批状态	审批人	最后更新时间	操作
21	安全阀	0701	SHOX-A1012	0701001	A类	8	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
22	加压机	0901	SJ2141C	0901000	A类	8	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
23	加压机	0901	SJ411E	0901001	A类	8	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
24	加压机	0901	SJ2141E	0901002	A类	8	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
25	加压机	0902	SJ2141D	0902000	A类	8	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
26	压缩机	1001	SRM12	1001000	A类	8	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
27	压缩机	1201	LT122-20P-12	1201000	B类	5.2	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
28	压缩机	1201	WCL12	1201001	B类	5.2	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
29	压缩机	1201	WPL12	1201002	B类	5.2	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
30	压缩机	1201	WPL08	1201003	B类	5.2	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
31	压缩机	1201	WPL10	1201004	B类	5.2	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
32	压缩机	1202	GP22	1202000	B类	3.1	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
33	压缩机	1202	gashuo	1202001	B类	3.1	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备
34	压缩机	1303	CGK01-20	1303000	A类	8.1	已评分	审批通过	余皓	2025-04-29	重新评分 历史记录 查看设备

将根据以下分值范围, 自动计算设备等级。

* A类分值范围	7.51	至	10.00
* B类分值范围	3.01	至	7.50
* C类分值范围	0.00	至	3.00

Case in Point: At the Bosch Suzhou plant

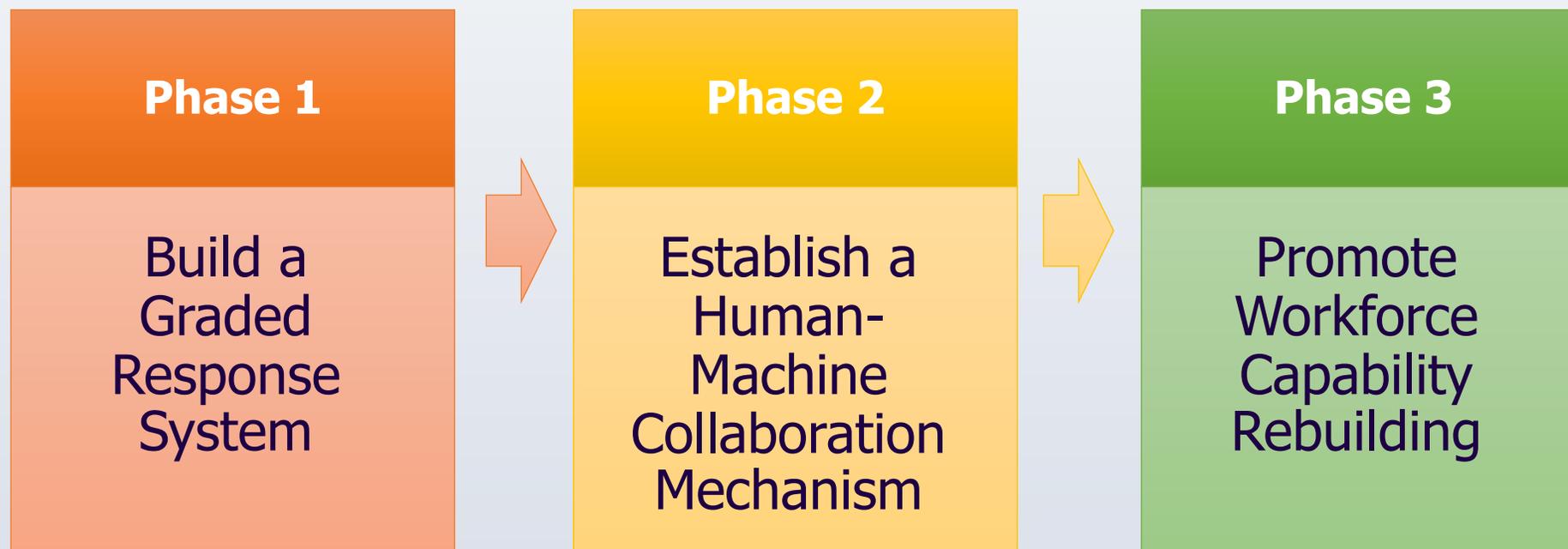


Bosch Suzhou plant

- ❑ Critical equipment is equipped with an "Equipment Health Dashboard."
- ❑ A green light indicates that maintenance personnel should analyze historical data for trends,
- ❑ while a yellow light signals them to proceed immediately to the site with their toolkit.

How to Make It Happen: A "Three-Phase" Path

Our Proposed Implementation Strategy



Phase 1: Build a Graded Response System

First, Manage Alerts, Avoid "Alert Fatigue"

Overview table of the graded response rules

Level	Color	Lights-out Factory
Level I	Blue	Minor fluctuation. Log & analyze weekly.
Level II	Yellow	Persistent abnormality (>2h). On-site check within 4 hours
Level III	Red	Nearing safety limit. Immediate shutdown to repair

Case in Point: At BOE's Fuzhou facility



BOE's Fuzhou facility

- After implementing the graded response rules to guide maintenance tasks on their Gen 8.6 LCD panel production line, the on-time response rate for Level II equipment alerts reached 98.7%.

Phase 1: Build a Graded Response System

Second, Frontline deployment: The "Three Forward Shifts"



Three Forward Shifts

01-Physical Shift (frontline deployment of tools)

"Equipment First Aid Stations" or mobile carts near lines.

02-Temporal Shift

"Golden Hour" inspection during preparation time(7:00am~9:00am).

03-Technological Shift

Mobile AR guides & SOPs of Rapid Response to Equipment Micro-defects in maintenance personnel pocket.

Case in Point: At SANY's No. 18 Workshop in Changsha city

Designated as a Lighthouse Factory, has reduced the average response time for equipment maintenance tasks to 11 minutes by deploying mobile maintenance vehicles.



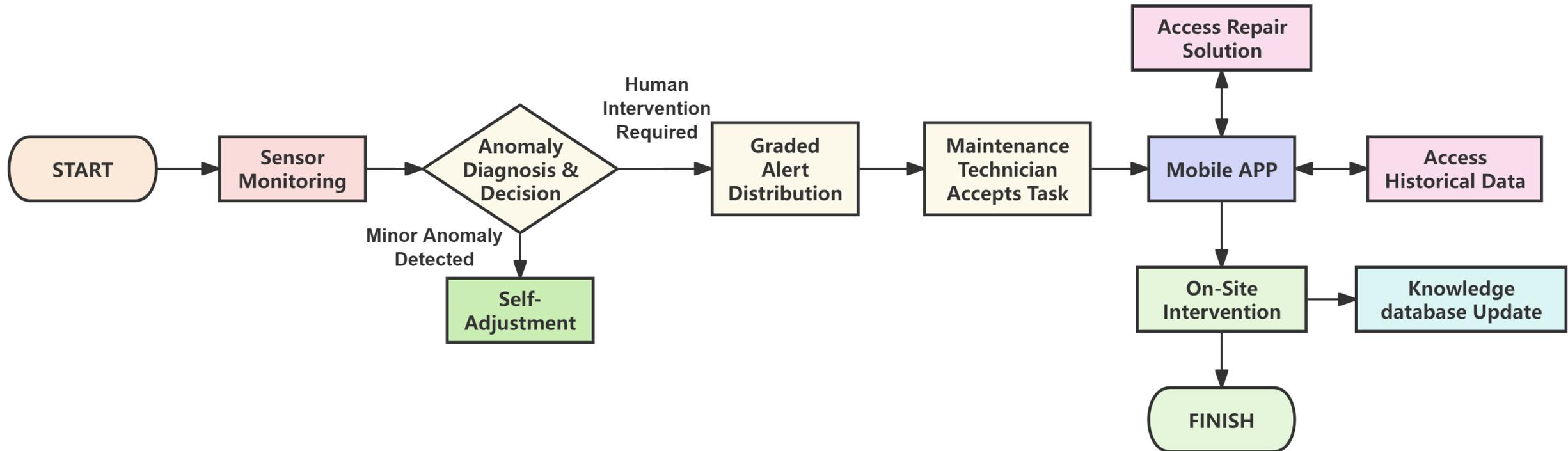
SANY's No. 18 Workshop in Changsha city



mobile maintenance vehicles

Phase 2: Establish Human-Machine Collaboration

Optimize the "Human-Machine Collaboration" in the Loop



Case in Point: At SAIC VOLKSWAGEN's Anting Plant



SAIC VOLKSWAGEN's Anting Plant

- ❑ SAIC VOLKSWAGEN's Anting Plant, a recognized smart factory in China, has increased its maintenance intervention efficiency by 40% by implementing human-machine collaborative workflows.

Case in Point: Proactive Maintenance at a Dongguan Printing Factory

A data-driven equipment health model



- ❑ The MES system syncs key operational data—like equipment start/stop times, quality defects, and minor stoppages—to the EAM system.
- ❑ This integration supports a data-driven equipment health model, which generates a weekly **Equipment Health Index (0~100)**.
- ❑ Using this score, maintenance teams can proactively identify and prioritize the most degraded equipment for early intervention.

Phase 3: Rebuild Your Workforce Capability

First, Maintenance Team Needs New Skills

Ultimately, the roles and capabilities of personnel must be transformed and upgraded.

A New Maintenance Personnel Competency Matrix

Competency	Training Content (Example)	Certification Method
Data Analysis	Minitab/SPC trend analysis, Vibration spectrum analysis	Submit diagnostic reports for blind review
Rapid Response	5-minute handling method for typical failures, Standardized operations	Practical timed assessment
Preventive Optimization	FMEA (Failure Mode and Effects Analysis), RCM (Reliability-Centered Maintenance)	Submit improvement proposals and defend them

Case in Point: At a Factory in Nanchang City, China



□ The facility has established a performance evaluation framework for maintenance personnel within its Enterprise Asset Management (EAM) system, assessing both their operational practices and technical skills.

Phase 3: Rebuild Your Workforce Capability

Second, Concurrently, implement an *Equipment Chief Physician System*

- where each senior maintenance personnel are deeply responsible for the ***full lifecycle health*** of 15-20 pieces of critical equipment, much like a doctor responsible for patients.
- They must issue monthly ***Equipment Health Reports***, including KPI trends, failure analysis, and improvement suggestions.



A senior maintenance technician is inspecting the critical equipment under his responsibility

Case in Point: At a Factory in Yulin City, China

检维修大数据分析-设备健康盖点

首页 语言 您好,管理员

首页 设备管理 预警监测管理 专家库管理 系统管理

设备一览 实时监测一览 历史数据回放 评估报告

请选择流水线号 输入设备名称或设备编号 [搜索] 按设备名称

20区反应气压缩机-20区反应气压缩机 (1160C401)

数据: 37469, 27, admin01, admin01
模型状态: 提取完成, 580, 0.14
监测状态: 监测中

净化装置-净化装置冷冻站丙烷压缩机 (1142C201)

数据: 37469, 27, admin01, admin01
模型状态: 提取完成, 580, 0.14
监测状态: 监测中

空分装置-氮气压缩系统A2氮气压缩机 (1110C501A2)

数据: 37469, 27, admin01, admin01
模型状态: 提取完成, 580, 0.14
监测状态: 监测中

空分装置-DaDa (内部测试)

数据: 37469, 27, admin01, admin01
模型状态: 提取完成, 580, 0.14
监测状态: 监测中

检维修大数据分析-设备健康盖点

实时监测

异常状态分析

稳定性趋势分析

设备状态评估报告

Equipment Health Reports

设备状态评估报告

稳定性趋势分析

Q&A: What Changes in Maintenance Work Time Allocation When Factories Go "Lights-Out"?

A Comparative Overview of the Shift in Time Distribution

Maintenance Work	Traditional Factory	Lights-out Factory
Breakdown Maintenance+TBM		
Predictive Maintenance (P _d M)		
Maintenance Strategy Optimization		

PART 3

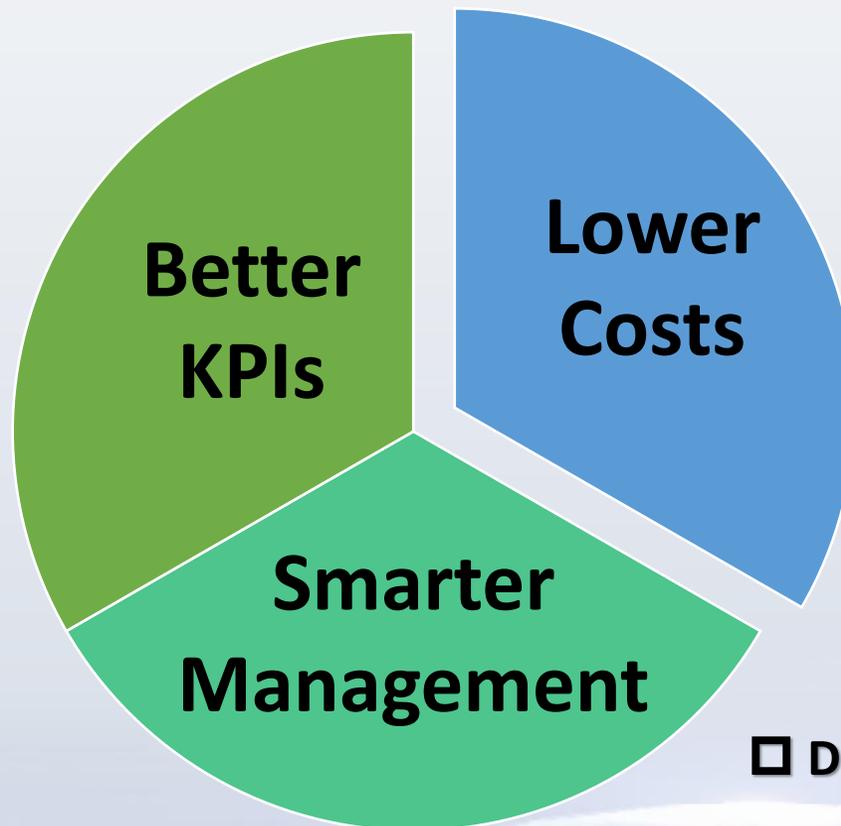
Expected Benefits,
Critical Issues & Closing



What You Gain: The Benefits

Expected Outcomes of Implementation

- ❑ Higher OEE (Overall Equipment Effectiveness),
- ❑ Higher MTBF (Mean Time Between Failures),
- ❑ Lower MTTR (Mean Time To Repair).
- ❑ etc.

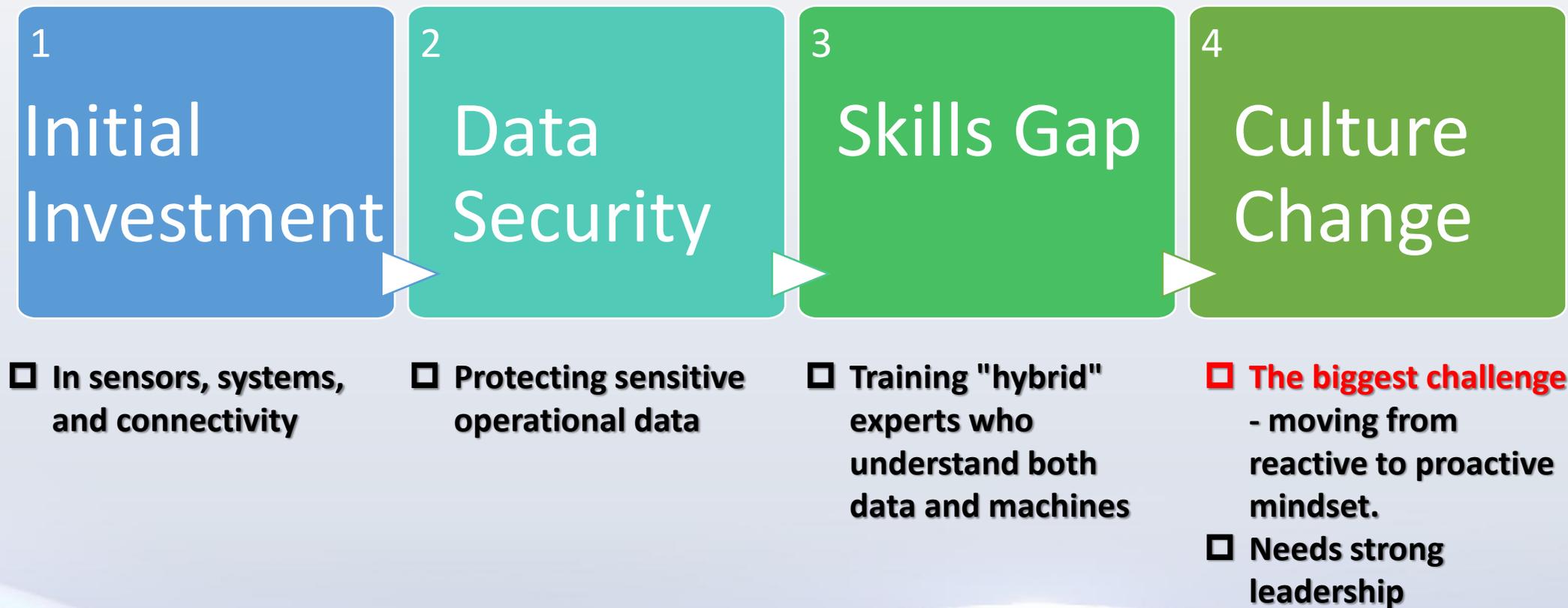


- ❑ Less unplanned downtime,
- ❑ optimized spare parts inventory.

- ❑ Data-driven decisions,
- ❑ transparent lifecycle management.

What You Must Solve: Critical Issues

Key Challenges to Address for Success



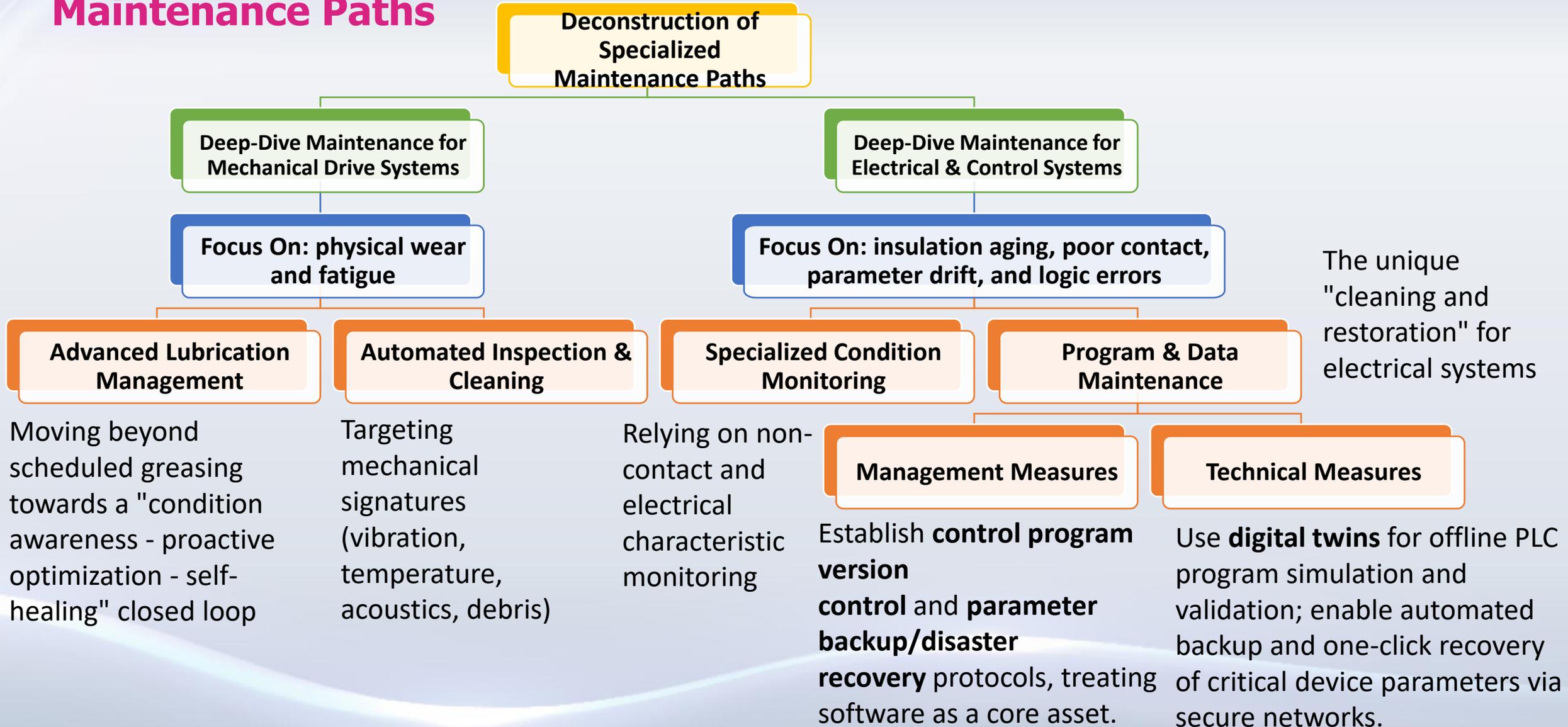
Interactive Exercise 3: Your Key Takeaway

Final Reflection & Sharing

Questions:

"What is your single biggest takeaway or 'aha!' moment from today's workshop?"

Specialized Deep-Dive: Deconstruction of Specialized Maintenance Paths



Specialized Deep-Dive: Integrated Implementation within the New TPM Framework

Phase 1-In the Graded Response System

Define differentiated alert thresholds and grading criteria for mechanical (e.g., vibration severity, oil contamination) and electrical (e.g., temperature anomaly, insulation index) parameters.



Phase 2-In the Human-Machine Collaboration Mechanism

Develop targeted AR assistance—mechanics view disassembly steps and torque specs via AR glasses; electrical engineers overlay circuit diagrams and PLC ladder logic for troubleshooting.



Phase 3- In the Workforce Capability Rebuilding

Build specialized competency matrices. Mechanical experts master vibration analysis and oil data interpretation; electrical experts master thermogram analysis and control system diagnostics. Implement "Mechatronics Expert" training programs for system-level issues.

Summary & The Road Ahead

Conclusion: The Journey to Intelligent Maintenance

- ❑ The new TPM model is essential for lights-out factories.
- ❑ Start with the framework (Sensors+Experts, Forward-Shift, Targeted Allocation Principle), follow the three-phase path.
- ❑ Future: Integration with **Digital Twin** and **AI** for "Autonomous Maintenance."



The 23rd International Asset Facility and Maintenance Management Conference

THANK YOU!

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