Brightlayer Industrial suite
Whitepaper

Condition-based maintenance

The impact of increasingly proactive maintenance programs

Powering Business Worldwide

Data collection and analysis by
451 Research
S&P Global
Market Intelligence

Introduction

Technology impact evaluation

For industrial manufacturers with thousands of industrial assets across hundreds of production lines and operations in dozens of facilities, maintenance operations entail a massive cost footprint. Taking a proactive approach to maintenance operations can have a substantial impact compared to reactive and time-based approaches.

Leveraging real-time data regarding asset conditions to inform maintenance represents an important shift away from reactive operations and can significantly reduce costs and improve business outcomes such as safety and sustainability. Shrinking the interval between awareness of and reaction to changes in equipment condition and performance can exponentially improve cost-reduction efforts (for repairs, replacement, labor, etc.) across the enterprise. Condition-based maintenance is an essential step to implementing proactive programs and realizing significant benefits. Manufacturers can use conditionbased maintenance to augment existing preventive maintenance approaches when it makes economic sense based on asset cost, inventory issues, criticality and other criteria.

Wherever they are in their maintenance program maturity, manufacturers must address challenges across their workforce, technology systems and partners to achieve success. For many, the move toward predictive maintenance presents challenges, including cultural discomfort, concerns about model biases and faulty conclusions. To minimize those concerns, manufacturers can align with technology providers knowledgeable in navigating these maintenance program challenges.

Figure 1: The top five challenges for manufacturers' maturing maintanance programs

Q. What are your most significant challenges to maturing your approach to maintenance?
MRO = maintenance, repair and operations; ERP = enterprise resource planning.
Base: All respondents (n=345).
Source: S&P Global Market Intelligence 451 Research and Eaton custom condition-based maintenance study.

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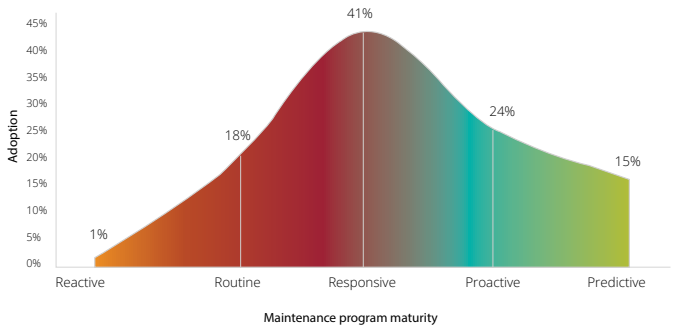
Adoption

Manufacturers should view maintenance as a continuum such that one program does not immediately or entirely supersede another; it is common to have a mix of maintenance approaches depending on asset criticality and cost. Manufacturers implement emerging technologies and use cases (e.g., condition-based monitoring, predictive maintenance) to varying degrees, based on business criticality and other factors.

Figure 2: Current adoption of maintenance in manufacturing



Q. How would you best categorize the maturity of your maintenance program?
Base: All respondents (n=345).
Source: S&P Global Market Intelligence 451 Research and Eaton custom condition-based maintenance study.

In the study, we asked manufacturers to categorize their maintenance program's maturity across the following stages (see Figure 2):

Reactive (1%): Very few respondent organizations wait to fix equipment when it breaks or have a "break/fix" maintenance model due to the substantial inefficiencies, costs, exposure to risks and other business impacts.

Routine (18%): These respondents are in the first phase of preventive maintenance but lack condition monitoring insights into deteriorating asset condition or performance. This lack of insight results in frequent and surprise repairs and outages, as well as inefficiencies from excessive scheduled maintenance.

Responsive (41%): The largest proportion of manufacturing respondents sometimes leverage conditionbased monitoring that identifies some machine/equipment failures and reduces some unplanned outages. Adjusting some planned maintenance processes based on reporting of actual asset conditions reduces the risk and cost of asset failures.

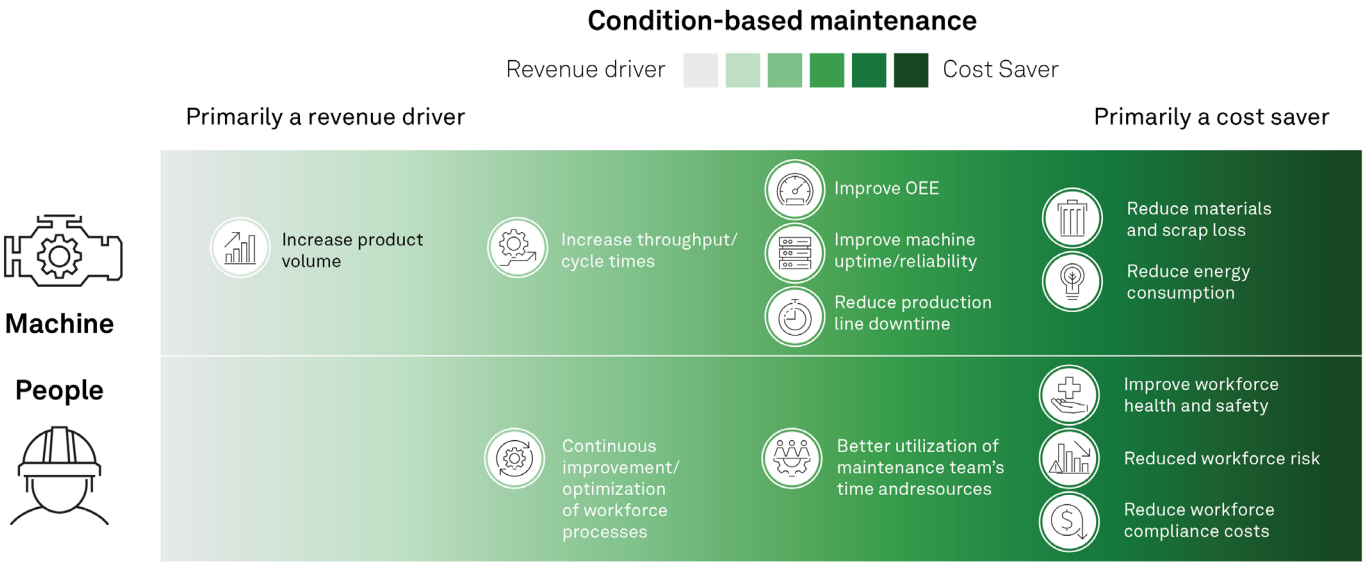
Proactive (24%): Nearly one-quarter of respondent manufacturers frequently leverage asset monitoring to better understand equipment condition and identify potential failures. Real-time visibility and insights from industrial internet of things (IIoT) sensor data (e.g., voltage, vibrations, etc.) enables maintenance teams to optimize processes and prioritize tasks, repairs and dispatches based on urgency, business impact, proximity of spare parts, skill set of technicians and other key factors. Asset monitoring drives efficiencies, lowers costs and yields higher returns on net assets.

Predictive (15%): Manufacturers with the most technologically mature maintenance programs leverage condition-based and AI/ML-driven insights to more precisely predict machine/equipment failures and reduce unplanned outages to nearly zero. Manufacturers can continuously improve the maintenance process by leveraging predictive AI/ML models that harness vast sums of historical and IIoT sensor data captured through asset monitoring beyond a single deployment. These AI/ML models can improve over time and collectively learn from installments at the organization and industry peers. Despite the potential upside, adoption challenges to predictive operations include cultural discomfort, model biases, time to train models, supporting AI/ML-architected development efforts, and IIoT sensor collection frequency and associated costs.

We focused our analysis on the business impact of condition-based maintenance — the foundational, more immediate and less fraught ingredient in maturing maintenance programs.

Impact on business outcomes

The bulk of financial impacts attainable today from condition-based maintenance are cost savings driven by operational efficiencies, reduced downtime and workforce-related business outcomes. However, increasing revenue via more proactive maintenance is an increasingly frequent benefit (i.e., by increasing production volume) from operating more efficiently.



Customer scenario: Oil and gas

Hypothetical: An oil and gas organization's downstream refineries transform raw materials into finished products (gasolines, liquids, etc.) through continuous manufacturing.

Before condition-based maintenance

- Older refinery assets are subject to failure (i.e., electrical outages), costly to remove/replace and present a significant safety risk because they frequently operate in hazardous environments.
- The maintenance workforce uses planned maintenance scheduling, resulting in substantial inefficiencies and productivity loss when unexpected issues occur.
- Workforce faces greater exposure to safety hazards from a lack of insights into industrial assets' real-time operating conditions.

Business impacts of condition-based maintenance

- Improved refinery/machine uptime.
- Increased refinery throughput/yield.
- Better utilization of maintenance team's time and resources.
- Reduced workforce compliance costs.
- Improved workforce health and safety.
- Reduced workforce risk.

Increased asset efficiencies

The quantity, diversity and complexity of assets operating in hazardous environments where manual monitoring or planned maintenance is often impractical presents special challenges for maintenance. Running machines to failure means that every repair is unexpected. Failures also shorten the equipment's life span, subsequently costing more in replacements and upkeep. Condition-based maintenance, informed by asset monitoring, helps ensure optimal maintenance planning for continuous productivity.

Greater operational resiliency and reliability

Downtime is a major contributor to costs in 24/7 operations, which can't use overtime to make up lost production. Asset maintenance and repair in hazardous environments can require "hot work" ermits and complex safety precautions — all while the downtime clock continues to run and costs compound. Condition-based maintenance involves constantly monitoring for anomalies in asset health and informs maintenance priorities, which improves operational resiliency and asset reliability, especially in 24/7 manufacturing facilities.

Improved workforce safety and productivity

Global workforce shortages and skills gaps have positioned the workforce as the most important asset of industrial organizations. Ensuring workforce safety while improving productivity is paramount. Industrial operations are inherently dangerous with heavy machinery making complex movements and exposure to hazardous materials and environments causing safety and health risks. Using condition-based maintenance practices to monitor for performance or condition changes that lead to downtime can help minimize the time workers spend in the field since they will already know the situation and, therefore, the parts, tools, protective equipment and permits they will need to maintain or repair the asset. Asset monitoring reduces risk to workers while also alleviating compliance concerns for electrical equipment owners (e.g., 2023 revision of NFPA 70B Standard for Electrical Equipment maintenance).

Customer scenario: Automotive manufacturer

Hypothetical: A global automotive manufacturer with hundreds of production lines in factories across the globe requires operations and maintenance teams to react rapidly to daily shifts in market fluctuations and customer demands.

Before condition-based maintenance

- Operational outage from breakdowns results in costly halts to production and reduced product volume.
- Machinery that is malfunctioning or operating suboptimally jeopardizes product quality and cycle times.
- Excessive Scope 1 and 2 carbon emissions lead to higher costs, hefty compliance fines and increasing pressure from board members, investors and customers.

Business impacts of condition-based maintenance

- Improved overall equipment effectiveness.
- Reduced production line downtime.
- Reduced material and scrap loss.
- Increased throughput and cycle times.
- Increased automobile volume.
- Reduced energy consumption.
- Improved sustainability compliance reporting.

Reduced operational costs

The bottom line is always under scrutiny from investors, the board of directors and executives. Key cost factors across production lines include machinery, materials and workers, as well as the interactions between them. Condition-based maintenance improves cost-centric manufacturing metrics such as overall equipment effectiveness, where identifying potential machine breakdowns and suboptimal performance improves equipment availability and performance. Condition-based maintenance helps ensure product quality while limiting materials and scrap loss by minimizing the opportunity for a malfunctioning asset to produce non-conforming product that requires rework or must be scrapped.

Increased revenue

The automotive industry (as well as many others) is heavily measured by production volume. Missing production targets by a few percentage points can swing a discrete manufacturer's market capitalization drastically. Condition-based maintenance is a critical revenue driver in high-volume industries where outages can cost thousands of dollars in overtime costs and rework. Alerts based on asset monitoring inform condition-based maintenance planning, which is critical in industries that prioritize production speed, quick responses to (and prevention of) bottlenecks, and the continuous improvement of processes and correlating metrics such as throughput and cycle times.

Improved sustainability

Sustainability has become a high-profile trend, and discrete manufacturers' decisions impact stakeholders across investors, partners, workforce and customers. Reducing Scope 1, 2 and 3 emissions is at the top of the list of most manufacturers' strategic initiatives now and will be for the foreseeable future. The first step generally is to establish a baseline by measuring energy consumption for Scope 1 (direct emissions from buildings, equipment, etc.) and Scope 2 (indirect emissions from electricity, heat, etc.) across operations. Condition-based maintenance supports this by compiling vast amounts of typically disparate, siloed or inaccessible data (e.g., voltage, electrical usage) that can be used to address changes as they emerge and reduce or eliminate issues that contribute to excess emissions. Having accurate data and demonstrating ongoing efforts to maintain compliance across a variety of metrics is useful for reporting to regulatory bodies and lessening exposure to fines. Additionally, improving asset performance can reduce energy consumption and wasted materials.

Outlook

Manufacturers will continue to revamp and shift their maintenance programs away from being reactive and toward proactive metods. Being proactive enables greater visibility into complex and sometimes unpredictable industrial environments. Condition-based maintenance significantly impacts multiple business outcomes that extend across the manufacturing value chain. This maintenance-maturity shift may not happen overnight, and some aspects of reactive maintenance will likely remain intact as organizations combine methods to best suit their business and financial priorities. Despite traditionally having limited budget, resources and access to innovative technologies, maintenance teams can make a major impact on the top and bottom line. Aligning with the right technology partner(s) is fundamental given maintenance programs' elevated status based on cost avoidance and revenue impact. Manufacturers that view maintenance as a strategic pillar will find opportunities for significant cost savings and differentiation in their competitive landscape.

Methodology

This report is based on data from a custom survey commissioned by Eaton and conducted by S&P Global Market Intelligence 451 Research. The survey was fielded in Q2 2024 among 345 manufacturing/industrial respondents.

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David Immerman is a consulting analyst at S&P Global Market Intelligence. He is responsible for executing on a range of custom research initiatives and development of thought leadership across technology sectors including industrial IoT, digital transformation, edge computing, AI/machine learning and fintech, among others, and verticals such as manufacturing and automotive.

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Printed in USA
Publication No. WP090004EN
August 2024