Digitization of Condition Monitoring:
Shift from Asset-Functional Strategies to Enterprise Performance Optimization

A Frost & Sullivan White Paper

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50 Years of Growth, Innovation and Leadership
Chapter 1: Importance of Condition Monitoring — Making the Most of CM Solutions to Reduce Asset Performance Variability .................................................. 3

1.1 Critical Pressure Points in Today’s Operation Activities ............................................. 3

1.2 Evolving Industrial Maintenance Dynamics ............................................................. 5

1.3 Importance of Condition Monitoring and Business Benefits ..................................... 8
CHAPTER 1: IMPORTANCE OF CONDITION MONITORING — MAKING THE MOST OF CM SOLUTIONS TO REDUCE ASSET PERFORMANCE VARIABILITY

CM solutions have been used for several decades to maximize asset performance, positioning customers to attain productivity, asset reliability, and savings. The industries that have traditionally adopted CM, such as oil and gas and power generation, remain the largest CM market revenue contributors today.

Exhibit 1 - CM Market: Market Share Revenues by End-Industries, Global, 2017

Both industries rely on asset classes that require a combination of CM technologies to ensure reliable asset operations. Many other industries are expanding the adoption of CM for the same underlying benefits of higher productivity, reliability, and predictability to optimize cash flow. Technology advancements are enabling plant-wide deployment at an exponential rate.

Complemented by Industry 4.0, plants are changing the way CM and maintenance strategies are managed. Plants of the future will have assets that seamlessly communicate with each other, are self-aware, and are intrinsically intelligent as technology continues to advance, disrupt, and transform. In essence, a digital fabric will drive an integrated view of the operational landscape by connecting every piece of equipment with intelligent algorithms and informing decision-making. These are exciting times as CM continues the journey.

1.1 Critical Pressure Points in Today’s Operation Activities

Top Pressure Points in Operation Activities

Frost & Sullivan has confirmed with survey participants a set of six critical pressure points faced in operation activities through the journey to transformation.

Plant operators will need this understanding to consider further CM technology adoption as they start the journey to Industry 4.0 and align internal practices and processes.
Industries must be prudent in implementing new technology assets to ensure that immediate needs are met while also providing a pillar to expand upon. Industry 4.0 is a step change advancement in CM to improve operational efficiency. A common challenge is the variety of available assets, vendors, maintenance strategies, and technologies. To stay competitive, many plant owners are applying resources to modernize aging assets, maintaining reliability, and delivering improvements on process and equipment safety. A second challenge is the trade-off and ROI decision making when optimizing CM deployment. And last but not least, how does one employ this within one common system.

The following outline highlights the top pressure points affecting operational activities across industries. The top priority for survey participants is to maintain asset reliability.

### Exhibit 2 - Industrial Process Control: Top Pressure Points affecting Operational Activities, Global, 2017

<table>
<thead>
<tr>
<th>Pressure Point</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintaining asset reliability</td>
<td>57.1%</td>
</tr>
<tr>
<td>Improving process safety</td>
<td>42.9%</td>
</tr>
<tr>
<td>Lack of skilled workforce availability</td>
<td>28.6%</td>
</tr>
<tr>
<td>Efficient management of planned downtime</td>
<td>14.3%</td>
</tr>
<tr>
<td>Managing cost pressures while driving plant availability</td>
<td>28.6%</td>
</tr>
<tr>
<td>Reducing maintenance expenditures</td>
<td>42.9%</td>
</tr>
<tr>
<td>Modernizing/replacing aging infrastructure or equipment</td>
<td>14.3%</td>
</tr>
<tr>
<td>Unplanned downtime</td>
<td>14.3%</td>
</tr>
<tr>
<td>Integrating technology improvements with existing systems</td>
<td>42.9%</td>
</tr>
<tr>
<td>Change management implementing new operational models</td>
<td>28.6%</td>
</tr>
<tr>
<td>Need to standardize processes and digitally transform</td>
<td>42.9%</td>
</tr>
<tr>
<td>Access dark data for strategic insights (e.g., from siloed assets, business units)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Ensure high-speed data flow and real-time control for critical applications</td>
<td>14.3%</td>
</tr>
<tr>
<td>Improve operational visibility by centralizing information and decision-making</td>
<td>28.6%</td>
</tr>
<tr>
<td>Optimize asset performance management</td>
<td>14.3%</td>
</tr>
<tr>
<td>Real-time optimization integrated with planning</td>
<td>28.6%</td>
</tr>
<tr>
<td>Energy optimization</td>
<td>42.9%</td>
</tr>
<tr>
<td>Reducing mean time between failures</td>
<td>14.3%</td>
</tr>
<tr>
<td>Other</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

No one would argue the need to address problems before they become bigger. These pressure points, plus the need to optimize ROI, only reinforce the value Condition Monitoring can enable.
1.2 Evolving Industrial Maintenance Dynamics

Productivity via operational efficiency and optimization continually drives the demand for CM solutions leveraging sensors, hardware, and software. The global CM market generated $1.6 billion in revenue in 2016; vibration CM segment revenue stood at $1.04 billion, as shown in exhibit 3—3.8% higher than the previous year. All indicators point to this positive trend will continue.


In the past five years, CM technology has rapidly advanced, driven primarily by technology convergence and customers shifting to more intelligent monitoring systems. A paradigm shift from schedule- to condition-based maintenance is happening, with strategies changing from reactive to preventive — and, in line with Industry 4.0, moving toward predictive and prescriptive.

Exhibit 4 illustrates the evolution of strategies between 2005 and 2020.

Exhibit 4 - Evolution of Maintenance and Condition Monitoring Applications

Source: Frost & Sullivan
Currently, a majority of the maintenance analytics remains in phases 1 and 2, which involve simple evaluation of data using descriptive analytics to provide a comprehensive view of current asset status. Each phase is explained below:

- **Reactive maintenance** is all too common and is used to find equipment maintenance. It is used to find out why a failure occurred after the actual breakdown, using simple statistical tools to pinpoint the cause of failure. This common approach is popular with low-probability-of-failure and non-critical assets. Run to failure falls in the mode and is acceptable in some cases.

- **Preventive maintenance** is a time-based approach. This is a recommended practice when failures are determined by the number of cycles and run times.

- **Predictive maintenance** is a proactive CM approach that identifies when and how seemingly random failures will occur, prior to the actual breakdown. Improved and advanced technology has made predictive maintenance more widely accepted with greater diagnostic capability using machine-learning techniques, predictive model simulation, and pattern recognition to benchmark historical data with real-time sensor data. A predictive maintenance (i.e., CM) approach has clear operational benefits over preventive maintenance, such as unexpected failures reduced by over 55%, with optimization of asset performance, reliability, and life expectancy.

- **Proactive maintenance** is an integrated CM approach focused on the “What should happen?” question instead of “Why did it happen?” by analyzing predictive and descriptive data. Prescriptive analytics recommends actions that mitigate risk by analyzing a wide variety of data using complex mathematical models.
We are seeing a disruption to the CM landscape. Integrated and collaborative technology will be employed to monitor and manage widespread asset classes anchored by predictive and prescriptive maintenance strategies, a transformation that will drive operational and business decisions to ensure improved performance and safety. The changes within the asset monitoring landscape that are forcing the shift to CM solutions are illustrated in the following graphic.

Exhibit 5 - Asset Monitoring and Management: Changing Landscaping

The industry is realizing the value of integrated enterprises with an end-to-end view of operations. The capability to analyze data remotely is an ongoing phenomenon converting Big Data into smart data. Big Data’s success will require collaboration across different organizational functions including manufacturing, design, information technology, and aftermarket services. This will require comprehensive data visibility on potential interruptions, tracking, cybersecurity, data storage and data integrity.

Plant operators are expanding from asset-specific monitoring to fleets including all plant-wide assets. The paradigm in the manufacturing landscape can scale from site-specific to enterprise-wide efficiency improvements. The further adoption of CM technologies will drive the shift from traditional reactive maintenance operational models to predictive maintenance and from siloed enterprises to connected enterprises. The biggest opportunity lies in integrating siloed systems to work harmoniously, providing holistic and proactive health information for the entire enterprise.
Connected plants at the enterprise level integrate the manufacturer’s value chain, offering greater visibility and control at various stages of product development, engineering, production, and delivery to the end user. Plants worldwide are likely to be connected through industrial cloud technologies, Big Data, mobility, sensors 4.0, analytics, and cognitive intelligence while enabling asset reliability. This will require increased investment in CM technologies, advanced automation, and communication systems that seamlessly integrate data from legacy systems and other equipment.

It is often challenging for manufacturing companies to work across a complex ecosystem from reactive and preventive maintenance to predictive and prescriptive maintenance and achieve digitization. There is still a lack of understanding about business benefits, customer value, and ROI, but market leadership opportunities lie in the ability to structure scalable enterprises and prioritize machinery issues.

### 1.3 Importance of Condition Monitoring and Business Benefits

As maintenance strategies shift from reactive to preventive, predictive, and prescriptive, key operating benefits are expected for asset management. The major benefits of CM are:

- Maximizing asset uptime
- Enhancing yield
- Lowering costs
- Minimizing unplanned downtime
- Extending asset life
- Improving safety
- Making more informed decisions

Condition monitoring could achieve a 50% reduction in maintenance costs.
The market continues to value the benefits of continuous monitoring and analysis of assets, as condition monitoring enables further informed decisions, rather than just arbitrarily replacing asset components over a predetermined period of time. Exhibit 7 illustrates the proven operational benefits of adopting a CM strategy:

Exhibit 7 - A Condition Monitoring Strategy Enables

- **50% Reduction in maintenance cost**
- **55% Reduction in unplanned machine failures**
- **30% Increase in machinery availability**
- **60% Reduction in Mean time to repair**
- **30% Reduction in spare parts cost**
- **30% Increase in plant machinery life**
- **70% Reduction in maintenance breakdowns**
- **90% Reduction when process data was combined with predictive maintenance data**
- **25% Increase in production**
- **40% Reduction in downtime**

These benefits strongly suggest that use of predictive/prescriptive CM will increase in the coming years. A scheduled reactive and preventive maintenance approach can be more costly. The cost of adopting this maintenance occurs when equipment is run to failure from the familiar P-F curve below.

Exhibit 8 - P-F Interval Through CM

For example, a reactive maintenance approach could cost between $17,000 and $19,000 a year for a pump and motors used in a power generation plant, and amount to millions of dollars for all plant assets. Today, advanced maintenance and technologies are most often reserved for only the most critical assets. Often, plant managers and operators feel they do not have the resources or the information for a more proactive maintenance approach. The practice of implementing a limited number of diagnostic tools and separate monitoring systems is a problem for maintenance approaches. Following is a review and evaluation of a holistic prescriptive maintenance strategy implementing an assortment of varying condition monitoring tools.
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