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**About the Authors** .................................................................................................................. 155
There is no common definition of Maintenance 4.0 or Industry 4.0. Before considering solutions or engaging with external vendors, senior management must define its strategic vision for Maintenance 4.0. This vision must align with overall business goals.

When it comes to devising strategy, every organization has its own preference. Whether you chose to rely on BOGSAT (bunch of guys/gals sitting around a table) or to hire consultants, the results must be the same: The strategy must be easy to understand and communicable throughout the organization, and the results must be measurable.

"So companies have to be very schizophrenic. On one hand, they have to maintain continuity of strategy. But they also have to be good at continuously improving."

~ Michael Porter, author and educator
This chapter covers the following topics:

- The definition and guiding principles of Maintenance 4.0;
- The difference between Maintenance 3.0 and Maintenance 4.0;
- How to select the right Maintenance 4.0 approach for your organization;
- Planning tools to define how your organization defines Maintenance 4.0.

1.1 The Definition of Maintenance 4.0

Before diving into the details, let’s start with a definition of Maintenance 4.0 that is broad enough to cover your industrial assets.

Maintenance 4.0 is the application of Industry 4.0 to operations and maintenance (O&M) activities. The goal is simple: To maximize production uptime by eliminating unplanned, reactive maintenance.

Let’s look at a simplistic depiction of common O&M work streams. Figure 1-1 shows a graph depicting the activities that occur after an industrial asset unexpectedly fails.

![Figure 1-1: O&M work streams in Industry 3.0 vs Industry 4.0](image-url)
Once the failure event occurs and is reported, a series of activities occurs. First, repair crews are assigned and then travel to the worksite where they receive repair instructions. Parts must be ordered and transported to the site.

Typically, root cause analysis (RCA) is performed and valuable time expended on identifying it. Working under pressure to resume production, work crews engage in trial and error activities to identify the cause of the failure. After repairs and an inspection, production resumes.

Maintenance 4.0 brings artificial intelligence (AI) and machine learning (ML) to the production line. Instead of waiting for the equipment to fail, sophisticated algorithms are applied to big data from embedded sensors in the equipment. The algorithms are trained to identify correlated patterns of anomalous machine behavior and warn of evolving machine failure.

![Figure 1-2: Core elements of Maintenance 4.0 (Source: Presenso)](image)
Within Maintenance 4.0, AI-driven industrial analytics is the game changer.

Until recently, machine learning was a study confined mostly to academia. A confluence of multiple factors has lowered the cost of data transportation, bandwidth, storage and analysis. For example, data storage has fallen from five hundred and sixty-nine dollars per gigabyte in the early 1990s to less than one cent today.

**Figure 1-3:** Cost comparison for storage, bandwidth and computing from 1991 to 2019 *(Source: Deloitte Consulting)*

Within Maintenance 4.0, AI-driven industrial analytics is the game changer.

Until recently, machine learning was a study confined mostly to academia. A confluence of multiple factors has lowered the cost of data transportation, bandwidth, storage and analysis. For example, data storage has fallen from five hundred and sixty-nine dollars per gigabyte in the early 1990s to less than one cent today.

**Figure 1-4:** Detection of evolving failures using machine learning *(Source: Presenso)*
As a result of the cost decline, machine learning can now be applied to vast amounts of sensor-generated big data that can be analyzed in real time.

The first component of Maintenance 4.0 is that while the failure is evolving, repairs can be scheduled and parts ordered. Tracing the failure to the original root cause eliminates guesswork and trial and error.

With Maintenance 4.0, machine uptime can be maintained while all non-repair activities are executed.

The second component of Maintenance 4.0 is the adoption of a computerized maintenance management system (CMMS) and automated workflows. Although a CMMS is not new, until now, its implementation has not been considered of strategic importance.

The third element of Maintenance 4.0 is the use of robotics and drones for inspections and repair activities.

In 2018, research was conducted to gain insight into industrial plants’ plans for the adoption of Maintenance 4.0. Figure 1-6 shows the results of that study.

**1.2 The Guiding Principles of a Maintenance 4.0 Strategy**

It is not uncommon for organizations to struggle with many issues related to implementation. With the hype around digitalization at
fever pitch, it is easy to become overwhelmed by the multitude of options available in the marketplace. But the strongest contributing factor to implementation challenges is a failure to devise a strategy for an extensive period of uncertainty.

Formulating a Maintenance 4.0 strategy is not easy. An aggressive strategy based on overinvesting in unproven technologies or a conservative strategy of waiting on the sidelines for absolute certainty are both unrealistic options.

Rather, the seven guiding principles for a Maintenance 4.0 strategic plan are:

1. **Investments Based on Business Case**: The primary obligation to shareholders does not change just because of the changes occurring within the manufacturing arena. What does this mean from

---

### FUTURE ADOPTION OF MAINTENANCE 4.0 TECHNOLOGIES

To what extent will these maintenance solutions be adopted in the next five years (five-point scale)?

<table>
<thead>
<tr>
<th>Technology</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerated adoption of CMMS &amp; automated workflows</td>
<td></td>
</tr>
<tr>
<td>Automated Failure Reporting</td>
<td>4.0</td>
</tr>
<tr>
<td>Automated Repair Scheduling</td>
<td>3.9</td>
</tr>
<tr>
<td>Automated Tool and Parts Inventory Management</td>
<td>3.7</td>
</tr>
<tr>
<td>Delayed adoption of drone &amp; robotics maintenance activities</td>
<td></td>
</tr>
<tr>
<td>Machine Learning for Predictive Analytics</td>
<td>3.5</td>
</tr>
<tr>
<td>Drone and Robotics Assisted Inspection</td>
<td>3.2</td>
</tr>
<tr>
<td>Robotics Assisted Repair</td>
<td>2.6</td>
</tr>
</tbody>
</table>

*Figure 1-6: Survey results regarding industrial plants’ plans for Maintenance 4.0 (Source: Emory University and Presenso)*
a practical perspective? Strategic choices require due diligence and investments must be made based on expected returns to the business. If you cannot justify the investment to your shareholders, it should not be made.

2. **Incrementalism**: Adopting Maintenance 4.0 does not mean eliminating existing maintenance processes and technologies. Yes, there are legacy systems that are no longer effective, but the default should be to adopt existing practices. In fact, it is most likely that part of your organization already implements certain so-called Maintenance 4.0 practices. Big bets on new, still evolving solution categories should be minimized.

3. **Upgrade Existing Maintenance Practices**: In support of incrementalism, industrial plants should evaluate maintenance best practices that can be adopted in parallel to Maintenance 4.0.

4. **Adaptability**: The fast pace of innovation has significant implications for industrial plants adopting a new strategy. Will a solutions breakthrough that occurs in 2020 be redundant by 2025? An accelerated speed of change is the new normal and companies must adjust their mind-sets and identify opportunistic ways to incorporate new Maintenance 4.0 solutions while minimizing disruptions to operations.

5. **Data as an Asset**: Big data is the oxygen of Maintenance 4.0. Although vast amounts of data are generated by sensors embedded within industrial machinery, most of the data is not yet used today. A guiding principle for a Maintenance 4.0 strategy is that data governance practices must be instituted and the underlying value of operational data should be captured.

6. **O&M Collaboration**: Successful implementation of Maintenance 4.0 cannot happen unless the views of plant-level employees are considered as part of the requirements process. Without allocating resources to training and onboarding, Maintenance 4.0 will be stuck in the planning phase.
7. **Share Risk with External Vendors:** Industrial players are unable to keep up with the rapid pace of change. Fortunately, OEMs and other service providers are finding ways to address market opportunities and overcome challenges to their own underlying businesses. Industrial plants should spend the time understanding the strategic roadmap of their most important OEM suppliers and consider mutually beneficial ways to align investments and plans.

<table>
<thead>
<tr>
<th>PRACTITIONERS’ WARNING: THE BIGGEST STRATEGIC MISTAKE TO AVOID</th>
</tr>
</thead>
<tbody>
<tr>
<td>In <em>Understanding Michael Porter: The Essential Guide to Competition and Strategy</em> by Joan Magretta, Michael Porter argues that the lack of a strategy is the biggest strategic mistake an organization can make.</td>
</tr>
<tr>
<td>Our definition of Maintenance 4.0 is a starting point, but not a substitute for the heavy lifting of defining a Maintenance 4.0 strategy for your organization. Of equal importance is how to fit this Maintenance 4.0 strategy into existing processes.</td>
</tr>
</tbody>
</table>

### 1.3 Strategy Under Uncertainty Model

In this section, the S curve of technology innovation model is applied to the Maintenance 4.0 strategy. The S curve refers to the stages of a new technology’s performance as it matures. In the first phase, it evolves slowly. However, after a breakthrough occurs, performance improves rapidly. In the third phase, the pace of performance improvement declines. Finally, as the technology matures, additional performance is difficult to achieve.

It should be noted that the S curve is not an exact model and not all technologies follow the curve. Given the pace of innovation, even if Maintenance 4.0 follows the S curve, there is no way of knowing the duration of Rapid Improvement 4.0 (Stage 2). In fact, one can look back at this period as merely the beginning of emergence. This can be attributed to the existence of new areas of innovation in the data science discipline, specifically automated machine learning (AutoML).

Three strategic postures can be adopted:

1. **Shape the Future** – Shapers are organizations that drive their industry toward new structures.

![Figure 1-7: The S curve of technology evolution](image)

![Figure 1-8: Strategic postures adapted from the Harvard Business Review article, “Strategy Under Uncertainty”](image)
2. **Adapt to the Future** – Adapters choose where and how to compete within the given structure.

3. **Reserve the Right to Play** – Organizations invest incrementally to “stay in the game” without committing to new strategies.

How is this relevant for Maintenance 4.0? With Maintenance 4.0 in its infancy, industrial plants may be tempted to wait on the sidelines until the solution winners and losers can be easily identified. This is a bad idea. The average industrial plant misses seventeen days in production every year, costing billions of dollars in lost revenue. If the cost of downtime for one minute of production in the automotive industry can reach fifty thousand dollars, the risk of not pursuing Maintenance 4.0 is far greater than the risk of waiting.

Let’s review each approach separately.

With “reserve the right to play,” industrial players build intelligence around new solution offerings without altering current practices. Although this option seems to be the safest approach, it may be the riskiest. Plants that wait and expect to catch up at a later date may miss the financial and competitive advantages of adopting Maintenance 4.0. Sometimes, strategic patience is a virtue; other times, it is a mistake.

Similarly, there is an obvious downside for industrial plants that pursue “shape the future.” Industrial plants that have built their own internal machine learning capabilities fit into this category. It requires significant investment in recruiting big data scientists and building out Maintenance 4.0 competencies. At the same time, the level of investment and risk may not justify the potential reward, especially because newer solutions may provide the same value at a lower cost.

“Adapting to the future” is the middle path for industrial plants. These organizations recognize the uncertainty associated with disruptive technologies and position themselves to react when opportunities emerge.
DISCUSSION TOPIC:  
Where Does Your Organization Fit In?
Where does your organization view its Maintenance 4.0 strategy within the S curve continuum? Does it have the resources for “shape the future?” Can it wait for “reserve the right to play?”
1.4 Audit the Current State / Maintenance 3.0 and 4.0

For starters, ignore the marketing collateral from Industrial IoT vendors. Only in a make-believe world will Maintenance 4.0 replace Maintenance 3.0 practices overnight. Significant investments have been made in current systems and tools. Most importantly, O&M employees are already trained on processes that are delivering results.

<table>
<thead>
<tr>
<th>TABLE 1.1 – CURRENT MAINTENANCE SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
</tbody>
</table>
| Acoustic Monitoring | Ultrasonic sensors detect sound related to behavioral anomalies. The solution can process multiple, simultaneous acoustic streams and compare them to previously labeled sounds. This is done to predict upcoming failure. | - Sensor is wireless and can detect ultrasounds that humans cannot perceive (up to 100 kHz)
- Can compute multiple concurrent sounds |
| Vibration Monitoring | The system uses sensors to detect vibrations, compares the sensor data to previous vibration patterns, and identifies unusual vibration patterns as potential anomalies. Algorithms are developed by vibration analysts, machine diagnostic expert developers and big data experts to detect changes indicative of upcoming failure. | - Combination of vibration/sound data and expert knowledge for thorough analytics
- Real-time analysis with automated alerts
- Interface with live status of monitored devices displayed |
<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Solution Highlights</th>
</tr>
</thead>
</table>
| Network Listeners         | The solution “listens” to the plant's machine to machine (M2M) network, more specifically, to M2M communications using network hubs. It detects all anomalies and gives plant managers the opportunity to react before failure or to identify the origin of each machine failure. This technology works autonomously. Once installed, it functions independently of human intervention or customization. | • Rapid connection to existing systems with no disruption of production  
• Factory-wide visibility                                                                                                                                  |
<p>| Thermal Imaging           | The thermal imager captures an object's entire temperature profile as a two-dimensional image. The thermal image can then be compared to a baseline thermal image of a healthy machine for detection of an anomaly. This allows technicians to predict an upcoming failure. | • Does not disrupt production, as thermal imaging is measured from a distance that does not affect the machine's actual state                                                                                           |
| AI-Driven Industrial Analytics | Advanced algorithms analyze data generated from sensors embedded in industrial assets. Emerging signs of failure are identified through the detection of anomalous machine behavior.                                                                                                     | • No need for manual intervention or installation of additional hardware within the industrial plant                                                                                                                    |</p>
<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
<th>Solution Highlights</th>
</tr>
</thead>
</table>
| Digital Twin    | The virtual clone of a piece of machinery, it collects data from the whole asset, including all the parts, components and systems, to create a simulated clone. The collected data is filtered based on the requirements for analysis. To complete the analysis, it may be combined with other sources of data, such as the weather or the humidity level. This exact representation of an asset on a virtual platform enables simulations to determine the best way to optimize the use of assets, predicts upcoming asset failure and provides visibility of the current asset’s health status. | • Data is extracted from the servers in all parts of the asset and is transmitted to the digital twin  
• A cloud-based infrastructure and platform is used |
**EXERCISE #1:** Use the Maintenance Audit template to list the current maintenance practices within your organization and identify the owner(s) of the different solutions.

<table>
<thead>
<tr>
<th>Solution</th>
<th>What is the current state of this solution within your organization (e.g., nonexistent, defined, planned, partially deployed, mostly deployed)?</th>
<th>Who within the organization is responsible for the solution?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acoustic Monitoring</td>
<td></td>
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<tr>
<td>Vibration Monitoring</td>
<td></td>
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<tr>
<td>Network Listeners</td>
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</tr>
<tr>
<td>Thermal Imaging</td>
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<tr>
<td>Digital Twin</td>
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<tr>
<td>AI-Driven Industrial Analytics</td>
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<tr>
<td>Automated Failure Reporting</td>
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<td>Automated Repair Scheduling</td>
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<td>Automated Tools &amp; Parts Inventory Management</td>
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<tr>
<td>Robotics Assisted Repairs</td>
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<tr>
<td>Drone &amp; Robotics Inspection</td>
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<td></td>
</tr>
</tbody>
</table>
EXERCISE #2: Use what you filled out in the Maintenance Audit to complete the Maintenance 4.0 Audit Worksheet on the current state of each element of Maintenance 4.0. What are the implementation goals in three and five years? Figure 1-9 is an example of a completed worksheet. A blank template is provided in Section 1.8.

<table>
<thead>
<tr>
<th>Category</th>
<th>Nonexistent</th>
<th>Defined</th>
<th>Planned</th>
<th>Partially Deployed</th>
<th>Mostly Deployed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Learning</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Predictive Maintenance</td>
<td><img src="#" alt="Nonexistent" /></td>
<td><img src="#" alt="Defined" /></td>
<td><img src="#" alt="Planned" /></td>
<td><img src="#" alt="Partially Deployed" /></td>
<td><img src="#" alt="Mostly Deployed" /></td>
</tr>
<tr>
<td>Automated Failure Reporting</td>
<td><img src="#" alt="Nonexistent" /></td>
<td><img src="#" alt="Defined" /></td>
<td><img src="#" alt="Planned" /></td>
<td><img src="#" alt="Partially Deployed" /></td>
<td><img src="#" alt="Mostly Deployed" /></td>
</tr>
<tr>
<td>Automated Repair Scheduling</td>
<td><img src="#" alt="Nonexistent" /></td>
<td><img src="#" alt="Defined" /></td>
<td><img src="#" alt="Planned" /></td>
<td><img src="#" alt="Partially Deployed" /></td>
<td><img src="#" alt="Mostly Deployed" /></td>
</tr>
<tr>
<td>Automated Tools &amp; Parts Inventory Management</td>
<td><img src="#" alt="Nonexistent" /></td>
<td><img src="#" alt="Defined" /></td>
<td><img src="#" alt="Planned" /></td>
<td><img src="#" alt="Partially Deployed" /></td>
<td><img src="#" alt="Mostly Deployed" /></td>
</tr>
<tr>
<td>Robotics Assisted Repairs</td>
<td><img src="#" alt="Nonexistent" /></td>
<td><img src="#" alt="Defined" /></td>
<td><img src="#" alt="Planned" /></td>
<td><img src="#" alt="Partially Deployed" /></td>
<td><img src="#" alt="Mostly Deployed" /></td>
</tr>
<tr>
<td>Robotics and Drone Assisted Inspections</td>
<td><img src="#" alt="Nonexistent" /></td>
<td><img src="#" alt="Defined" /></td>
<td><img src="#" alt="Planned" /></td>
<td><img src="#" alt="Partially Deployed" /></td>
<td><img src="#" alt="Mostly Deployed" /></td>
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<tr>
<td>Digital Twin</td>
<td><img src="#" alt="Nonexistent" /></td>
<td><img src="#" alt="Defined" /></td>
<td><img src="#" alt="Planned" /></td>
<td><img src="#" alt="Partially Deployed" /></td>
<td><img src="#" alt="Mostly Deployed" /></td>
</tr>
</tbody>
</table>

Figure 1-9: An example of a completed Maintenance 4.0 audit worksheet
FOCUS TOPIC: Where Does Your Current CMMS Fit Into Maintenance 4.0?

Computerized maintenance management systems contain detailed operational information, including asset performance data and work order management. Given the disruptive nature of Industry 4.0, does a CMMS that dates back to the mid-1990s belong in the smart factory of the future?

Ideally, a CMMS contains root cause analysis (RCA), including failed component, component problem and cause code. In many cases, it is not possible to extract consistent RCA data from the CMMS. These are challenges that are typically identified:

- The CMMS often competes with other tools. Very often, RCA data is stored by technicians in a spreadsheet, but is not inputted into the CMMS.
- When RCA data is inputted, it is often mislabeled. Mandatory fields are used inconsistently and business rules are not applied. We have seen anything ranging from a two word cryptic code to a mini encyclopedia. Neither of these can be used systemically.
- RCA data within the CMMS is not considered accurate and, therefore, is not used operationally.

The result is that valuable information that can be used to predict the likelihood of machine failure is wasted. Not surprisingly, the culprits are obvious – either there are no consistent processes and rules for inputting RCA data or O&M employees are not trained on them.

Even without an industrial analytics solution, existing computerized maintenance management systems are simply not being used optimally. The remedy is not technical and does not require an investment in new software. First, the problem will not be addressed until the importance of RCA is understood and prioritized by plant management. Second, O&M employees need to understand the benefit of inputting RCA
information: how learning from one failure can be applied broadly with the plant(s) and improve overall equipment effectiveness (OEE). Finally, change does not happen without formalizing the process, job performance metrics and ongoing training.

Ironically, the most forward-thinking industrial plants apply a completely nontechnical approach to RCA by relying on human intelligence. This includes interviewing repair crews, photographing damages, reviewing previous incident reports and performing physical assessments, including raw materials analysis. Although this level of inquiry is not always necessary or feasible, its application is indicative of a culture that prioritizes a systematic understanding of RCA.

Without advocating a specific CMMS solution, those industrial plants with legacy computerized maintenance management systems that are decades old may wish to update them in parallel to other solution upgrades. Without advocating for or against upgrading a plant’s CMMS, there are best practices that can be implemented today that are independent of the Maintenance 4.0 adoption.

**PRACTITIONERS’ WARNING**

Don’t Allow Vendors to Frame the Strategic Vision

Because industrial plants lack experience with Industry 4.0, the temptation may arise to rely on large vendors’ expertise. This is a mistake. A strategy should be developed independently of outside influence, especially that of third parties whose agendas (and incentives) do not align with those of the plant.

**1.5 Benchmark Research on Maintenance 4.0 Strategy**

With all the hype associated with Maintenance 4.0, it is understandable that some organizations are concerned that they are lagging their competitors. But don’t panic. When asked about whether industrial plants have clearly communicated Maintenance 4.0 strategies, forty-three percent of O&M employees surveyed claim their organization has no
formal Maintenance 4.0 strategy. Although they may not be personally aware of the strategy, this is a significant percentage. Furthermore, thirty-seven percent state that senior management has devised a strategy, but has not articulated it.

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11%</td>
<td>To the best of my knowledge, there is no formal Maintenance 4.0 strategy</td>
</tr>
<tr>
<td>9%</td>
<td>Senior management has developed a strategy, but it has not been clearly articulated</td>
</tr>
<tr>
<td>37%</td>
<td>A Maintenance 4.0 strategy has been communicated throughout the organization, but there is NO employee buy-in</td>
</tr>
<tr>
<td>43%</td>
<td>A Maintenance 4.0 strategy has been communicated throughout the organization and there IS employee buy-in</td>
</tr>
</tbody>
</table>

![Figure 1-10: O&M survey responses on maturity of Maintenance 4.0 strategy](Source: Emory University and Presenso)

What does this indicate? It can be argued that Maintenance 4.0 is still in its infancy and that most O&M professionals are either unaware of the strategy or do not believe it has been communicated to the organization. The good news is that other industrial plants are figuring this out at the same time.

### 1.6 The Future of Maintenance 4.0

“There are known knowns. These are things we know we know. We also know there are known unknowns; that is to say, we know there are some things we do not know. But there are also unknown unknowns – the ones we don’t know we don’t know.”

~ Donald Rumsfeld, former U.S. Secretary of Defense
How do you adopt Maintenance 4.0 when there are so many moving parts? For instance, although 3-D printing of spare parts is still in the beginning phase, do you incorporate this into your planning?

This handbook references current practices in Maintenance 4.0, but let’s consider for a bit the direction it is heading.

First, let’s consider trends in data science. The future of Maintenance 4.0 will track innovations in artificial intelligence (AI) and how it is applied to root cause analysis. Access to big data relating to machine failure will deepen organizations’ understanding of the underlying contributing failure factors, which will further improve the ability to remediate failure proactively – even before evolving failure. The next wave of Maintenance 4.0 is a prescriptive model based on a coalescence of AI and automated repair processes.

Second, OEMs will most likely assume some of the maintenance responsibilities currently performed by O&M groups. This is not a new concept. Rolls-Royce adopted the Power-by-the Hour™ service agreement model in the 1960s. The model is based on charging a fixed hourly rate for jet engines without the need to purchase the engine itself.

This model is increasingly referred to as hardware-as-a-service (HaaS). More OEMs will seize the opportunity to analyze the big data generated by the sensors embedded in the industrial equipment they manufacture. By applying machine learning to this data, an OEM can monitor its industrial equipment remotely and dispatch technicians to fix evolving failure before occurrence.

Although HaaS is still in its infancy, research indicates a growing recognition that OEMs will likely adopt a service model.
No manufacturer can survive the Industry 4.0 tsunami with a business as usual mentality. Big data is more than the new oil of the twenty-first century. For OEMs, it is the gateway to long-term, sustainable growth.
1.7 Expert Practitioner Perspective

For this handbook, we asked a seasoned industry practitioner to share his insights into Maintenance 4.0 maturity. The questions we posed to him:

**To what extent has Maintenance 4.0 become an integral part of the strategy of the industrial plants with which you are familiar? How are plants integrating Maintenance 4.0 into their overall strategy?**

Here are his responses:

**Jack R. Nicholas, Jr., P.E., CMRP, CRL, IAMC:** “Current literature on big data, advanced analytics, cloud computing technology, and related subjects spells out the need for the merger of OT [operational technology] and IT [information technology], tying the mill deck to the boardroom. While this is desirable in many ways, it often requires a significant change in culture in organizations with a large, if not dominant, IT influence on digital transition. Many C-level executives (if not all by this time) are scared to death of a career ending data breach.

“Cybersecurity in most companies is assigned to IT personnel as a collateral duty and may be based on just a week or two of training – totally inadequate in today’s cyberspace climate. While methodologies, such as reliability-centered maintenance and total productive maintenance have been around for decades, they still haven’t been adopted to the degree needed for personnel in plants to have a firm knowledge of failure modes being experienced and to link them to data needed to provide advance warning of onset at stages where economic mitigation can be planned and executed in an orderly fashion. Thus, there is no way for them to justify the adoption of AI-driven industrial analytics.”
1.8 Chapter Template

As referenced in Section 1.4, you can copy this Maintenance 4.0 Audit Worksheet template and use it for conducting your own audit.

### MAINTENANCE 4.0 AUDIT WORKSHEET

<table>
<thead>
<tr>
<th>Category</th>
<th>Nonexistent</th>
<th>Defined</th>
<th>Planned</th>
<th>Partially Deployed</th>
<th>Mostly Deployed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine Learning Predictive Maintenance</td>
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<td>Automated Failure Reporting</td>
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<td>Automated Repair Scheduling</td>
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<td>Automated Tools &amp; Parts Inventory Management</td>
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<td>Robotics Assisted Repairs</td>
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<td>Robotics and Drone Assisted Inspections</td>
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<td>Digital Twin</td>
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</tr>
</tbody>
</table>

- Current State
- 2 Year Plan
- 3 Year Plan
Please answer the following questions before moving on to the next chapter.

- What are the key differences between Maintenance 3.0 and 4.0?
- How does the S curve apply to your strategy?
- Can you define the future state of Maintenance 4.0 for your organization?
As the industrial world embarks on a path toward Maintenance 4.0 – a core foundation of Industry 4.0 – many plants seem stuck in neutral and are not moving beyond the pilot phase. Embracing innovation while discarding legacy know-how creates a risk to an organization’s competitive strengths. While there are theoretical frameworks to address this risk, the chasm between strategy and implementation cannot be crossed unless organizations can progress through all stages of the journey.

The Maintenance 4.0 Implementation Handbook provides a step-by-step guide for the entire Maintenance 4.0 implementation team. It covers a range of issues, including how to prioritize assets for deployment, the specific elements to include when forecasting investment returns and how to scale solutions across an organization. The Handbook contains practical tools and exercises for both senior managers planning for Maintenance 4.0 and plant-level employees responsible for deployment.

Written by the cofounding team of Presenso, the Handbook includes best practices from deploying artificial intelligence-driven industrial analytics at some of the world’s largest industrial plants. In addition, it provides insights from leading industry-recognized operations and maintenance practitioners. In this way, the implementation team can learn from the contributors’ successes and failures, avoiding some of the inevitable implementation roadblocks. If executed correctly, Maintenance 4.0 will reshape the industrial domain. In an era of disruptive innovation, it is discipline, conservative investments and old-fashioned executional excellence that will separate the winners from the losers.

Order your copy today through the MRO-Zone Bookstore: www.mro-zone.com