Intelligent Asset Management Strategy
Meeting the ever-changing needs and expectations of our stakeholders and delivering best-in-class products that add business value for our customers make SAP the thought leader in the supply chain area. This document describes our strategy for SAP® Intelligent Asset Management solutions, which help our customers transform asset management in their enterprise.

1 Executive Summary
Presents our vision to connect digitally to perfect reality along with technology enablers and architecture.

2 Market and Industry Dynamics
Highlights market dynamics and competitor strategies.

3 Intelligent Enterprise
Defines the principles for evolving our solutions and discusses the need to become an intelligent enterprise. We address the design-to-operate (D2O) scenario in the intelligent suite, building the foundation for the digital thread throughout the supply chain.

4 Intelligent Asset Management Strategy
Highlights our way forward for each solution within the wider asset management portfolio and looks at topics on the horizon.

5 Customer Adoption
Outlines our go-to-market priorities and solution marketing approach.

6 Partner Engagement
Describes our partner strategy and complementary partner solutions.
# Table of Contents

2 About This Document

4 Executive Summary

6 Market And Industry Dynamics

7 Main Technology Enaglers

8 Industry And International Standards

8 Customer Expectations

9 Demand For Cloud Solutions

10 Intelligent Enterprise

11 Design-To-Operate Scenario

13 Interconnection

14 Intelligent Asset Management Strategy

15 Building A Next-Generation Asset Management Suite

17 Business Capabilities

31 Intelligence Capabilities

32 Migration To Intelligent Asset Management

34 Customer Adoption

37 Partner Engagement

38 Partner Enablement

38 Complementary Partner Solutions

39 Outlook And Summary

40 Summary
Executive Summary

The Intelligent Enterprise brings incremental value to customers through agility, better-informed decisions, automation, and business process innovation. To enable our customers to become an intelligent enterprise, SAP offers a suite of applications for all aspects of a customer’s business. This includes asset management, which, for many of our customers, is a mission-critical contributor in keeping the world’s assets healthy. This strategy paper outlines SAP’s vision for how we will further improve the health, performance, sustainability, and total value realization of our customers’ assets (see Figure 1).

Figure 1: Vision and Objectives of Intelligent Asset Management

Define, execute, and monitor the optimal asset maintenance and service strategy by providing real-time collaboration, integration, and analytical insights.

Drive safe operations

Maximize asset productivity

Reduce cost
One key enabler is the application of intelligence and automation to maintenance management processes to provide a more dynamic and agile environment. Maintenance jobs will be driven directly by the asset, connected through IoT technology and facilitated by predictive algorithms to preempt failure. Goal- and risk-based planning will optimize the best maintenance strategy for each asset type, which, in turn, will drive maintenance demands. This enables a shift from reactive to proactive maintenance with better planning and less downtime.

Take a step further to prescriptive maintenance by overlaying increased asset intelligence around root cause analysis, failure modes, and corrective action and by including machine learning. Work will be planned and scheduled in detail in a world-leading maintenance execution system. That work will then be supported by mobile devices with the right documentation, knowledge support, and augmented technology to help the technician execute flawlessly. And traditional inhibitors, such as disconnected asset performance management systems and the lack of accurate and complete master data, will be overcome.

Our portfolio of enterprise asset management solutions has evolved from a rich heritage of plant maintenance used by thousands of customers in asset-intensive industries. We will continue to develop next-generation capabilities for maintenance execution with SAP S/4HANA® and provide amazing usability for the front office, powered by innovations such as machine learning and Industry 4.0.

This evolution from enterprise asset management to intelligent asset management is complemented by our new cloud solutions for asset performance management. Customers will be able to eliminate the gap between planning and execution as the solutions share the same data foundation and processes are integrated on a common SAP platform, including real-time insights from Industry 4.0 IoT. Through SAP Asset Intelligence Network, we want to help customers extend this digital transformation to new, collaborative business processes for internal maintenance shared services and network partners, suppliers, and operators.

SAP will continue to offer flexible cloud and on-premise solution adoption. SAP S/4HANA can be deployed in a full public cloud mode, or customers can choose a hybrid of SAP S/4HANA running on premise with the new cloud applications. SAP Cloud Platform provides innovation, extensibility, and integration options for your SAP S/4HANA, legacy, and third-party systems.

With these approaches, SAP is ready to deliver the future of dynamic, real-time asset operations and maintenance and asset performance management together as one unified solution. You can choose where to begin your digital transformation based on business priorities and value, and can scope value delivery projects in weeks, not months.
MARKET AND INDUSTRY DYNAMICS
CEOs in asset-intensive organizations must use new information from the IoT together with enhanced knowledge to open up new, disruptive possibilities for better planning and management of assets. CEOs look to their maintenance and operations managers to weigh investments in asset performance management solutions against returns. In addition, new business models are better enabled, resulting in improvements in other connected areas of the supply chain.

### MAIN TECHNOLOGY ENABLERS

In addition to the market and industry dynamics outlined above, we see eight technology trends and innovations that impact asset-intensive organizations (see Figure 2). The adoption of these trends can present a range of opportunities, such as reducing operational and maintenance costs while increasing overall asset performance.

**Figure 2: Technology Innovations for Intelligent Asset Management**

<table>
<thead>
<tr>
<th>The Internet of Things</th>
<th>Big Data and analytics</th>
<th>Cloud computing</th>
<th>Mobile solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide sensor-enabled condition monitoring for real-time insights and new value-added services</td>
<td>Enable real-time analysis of data streaming from assets that are getting smarter and can communicate status and performance data</td>
<td>Reduce IT operations and maintenance effort while providing scalability to support changing business needs and growth</td>
<td>Provide workers in the field with easy access to necessary information they would otherwise need to access in the office</td>
</tr>
</tbody>
</table>

**Augmented reality and virtual reality**
Provide unmatched situational awareness and enhanced perception for better decision-making

**Artificial intelligence and machine learning**
Bring unprecedented insights and automation of knowledge work across the enterprise

**Business networks**
Simplify collaboration and sharing of information among asset management stakeholders and their equipment and service providers

**Real-time engineering simulation**
Use physics-based digital twins for predictive engineering analysis in product development and operations

With the rise of Industrial Internet of Things (IIoT) technology and the increased use of machine learning, business applications have a greater capability to enable more-precise and better-informed decision-making. At the same time, the assets within a company (whether owned, leased, or in a service relationship) are becoming increasingly complex. For example, look at how complex today’s automobile has become over the last 30 years. While the exponential increase in the number of onboard systems has enhanced performance and safety, it has put pressure on asset management practices to become modern. This includes management of onboard software (firmware) and specialized tools and knowledge for diagnosis and awareness of the “voice of the asset,” that is, the asset is able to self-diagnose and self-report automatically.
INDUSTRY AND INTERNATIONAL STANDARDS

Standards formalize the know-how and best practices for a domain or industry. A number of standards exist, each with its own lifecycle and legal and technical requirements. Where possible and logical, SAP seeks to adopt standards to complement and enhance our solutions.

For example, SAP has developed new solutions in SAP Intelligent Asset Management based on ISO 14224, an international standard relating to the collection of data, including reliability data, relevant for the management of equipment maintenance. This standard covers both the methodology for data collection and details of the data to be collected. In this case, the standard helps accelerate the adoption of solutions that reduce complexity and exploit data across company boundaries in a network-centric environment.

In addition, both SAP and our partners now deliver solutions that support standards for the classification of assets in various industries, such as EN 15380, for railway vehicles and their assemblies, and eCl@ss, a cross-industry master-data standard for products and services. Communication to the IoT layer is enabled through multiple industry standards including OPC Unified Architecture (OPC UA), a machine-to-machine communication protocol for industrial automation as well as the emerging Asset Administration Shell initiatives around Industry 4.0. And we fully embrace and deliver the holistic thought leadership as defined in ISO 55000.

CUSTOMER EXPECTATIONS

Companies that rely on their assets for business operations seek to enhance asset management practices that will help them improve their profitability, productivity, environmental, and social outcomes. As a result, business leaders are looking at asset maintenance in a new way, as shown in Figure 3.

Customers want to change their asset management practices through digital transformation in the following areas:

• Proper maintenance of assets to reduce risk to people, society, and the environment
• Optimal assessment of maintenance needs (reliability, risk, or performance) to deliver recommendations that are the basis for all proactive maintenance work
• Collaborative exchange of master data and planning of maintenance work for assets when interacting with third parties such as contractors, engineering companies, or manufacturers
• Integrated planning and optimization of inventory for maintenance spare parts to reduce total purchasing spend and holding costs
• Complete knowledge about all assets to ensure technicians, planners, reliability engineers, and algorithms have the needed information to develop the best maintenance plan and perform the work properly the first time
• Detailed planning and tracking to ensure the best person with the right skills and the correct parts performs a completely prepared job at the optimal time
• Continuous improvement of future asset maintenance and performance plans based on automated feedback and analysis of failures, performance, life span benchmarking, and other insights
Reactive maintenance is too late for efficient planning and optimization.

Calendar-based maintenance results in over-maintaining assets at higher costs and lower availability.

SAP believes cloud-based deployments of asset management systems will increase over the next five years as buyers accept cloud as a viable option and technology misconceptions are addressed. Changing user attitudes and expanding vendor offerings are creating new market dynamics.

By adopting cloud solutions, you can:

- Eliminate the time and expense of managing upgrades
- Reduce the number of resources needed for infrastructure maintenance
- Accelerate time to value and reduce the cost to deploy new innovations

Take advantage of cloud solutions from SAP, which give your organization the flexibility to leverage your IT investments within the framework of an operational budget, thereby eliminating overhead costs and realizing new business processes faster.

SAP will continue to support and, where appropriate, bring many of our cloud innovations to our on-premise solutions to provide flexibility and choice.
Our intelligent, integration-ready solutions can help you manage customers, supply chains, networks, employees, and core processes (see Figure 4). They are easy to extend and offer a consistent and intuitive user experience.

**Figure 4: Intelligent Solutions and Technologies**

Manufacturing and supply chains are key areas that enable an intelligent enterprise. To run a highly responsive digital supply chain for advanced, customer-centric manufacturing, for example, you need to leverage predictive processes and smart automation and have total visibility across your network. The intelligent suite is built on a digital platform that manages data from any source, in any format. You can rapidly develop, integrate, and extend business applications with SAP Cloud Platform.

**DESIGN-TO-OPERATE SCENARIO**

The design-to-operate (D2O) scenario is SAP’s digital supply chain contribution to an intelligent enterprise; it delivers a seamless supply chain that is enriched by intelligent technologies across the entire SAP Digital Supply Chain portfolio, including solutions to design, plan, manufacture, deliver, and operate (see **Figure 5**).

The vision to deliver on the design-to-operate scenario and go beyond the initial design is interoperability across functional areas. For example, users should be able to make informed decisions by accessing required information from another area without leaving the application in which they are working.

SAP Intelligent Asset Management solutions play a major role in the D2O scenario, supporting asset operators, manufacturers, and service providers across the asset lifecycle.
**Figure 5: Design-to-Operate Scenario Overview**

<table>
<thead>
<tr>
<th>Design</th>
<th>Plan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive customer feedback – create concept and requirements or new or changed product</td>
<td>Create product design and maintain master data for new or changed product</td>
</tr>
<tr>
<td>Create product design and maintain master data for new or changed product</td>
<td>Plan supply for new or changed components</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procure</th>
<th>Manufacture (subassemblies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procure components to build subassemblies</td>
<td>Schedule subassembly production</td>
</tr>
<tr>
<td>Manage and track inbound delivery</td>
<td>Produce subassemblies and track progress</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sell</th>
<th>Manufacture (finished product)</th>
<th>Deliver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive customer sales order (assemble to order)</td>
<td>Schedule finished product production</td>
<td>Plan transport, pack, and load product for delivery</td>
</tr>
<tr>
<td>Schedule finished product production</td>
<td>Produce finished product and track progress</td>
<td>Perform and track outbound transportation and receive proof of delivery</td>
</tr>
<tr>
<td>Register serialized finished product</td>
<td>Receive finished product into warehouse</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive asset master data and onboard asset</td>
</tr>
<tr>
<td>Plan asset maintenance</td>
</tr>
</tbody>
</table>
INTERCONNECTION
As a rule, asset management processes are highly interconnected with other business processes of an equipment operator. For example, equipment efficiency and availability have a massive impact on production planning, fulfilling service-level agreements, achieving revenue targets, and executing flawlessly.

The equipment operator’s business is, in turn, connected with that of the equipment design firm, the equipment manufacturer, and the service provider (see Figure 6). This interconnected business process enables production planners, maintenance planners, and plant managers to maximize asset productivity, drive safe operations, and reduce service and maintenance costs.

Figure 6: Interconnected Processes
BUILDING A NEXT-GENERATION ASSET MANAGEMENT SUITE

We offer SAP Intelligent Asset Management, a modern suite of solutions for asset performance management and asset operations and maintenance. These solutions adopt a network-centric approach to connect business processes across the design-to-operate lifecycle. SAP Intelligent Asset Management supports equipment manufacturers and asset operators, enabling them to define, monitor, execute, and optimize asset service and maintenance strategies by providing the level of collaboration, interoperability, and analytical insights they need. Insights are driven by intelligent technologies such as IoT, machine learning, artificial intelligence, and physics-based digital-twin simulations that are applied to reliable asset information gathered from all the interconnected business partners.

SAP delivers an entire suite of asset management solutions as holistically integrated, end-to-end solutions. For functional and packaging reasons, the suite is divided into the following solution capabilities (building blocks), as shown in Figure 7:

Figure 7: Integrated Solutions for Asset Management

Integrated networks from design to operate
- One common equipment data and intelligence repository for design to operate
- Collaborative work orders and failure data
- Value-added services
- OEM suppliers and asset operators
- Ease of integration and onboarding

Industry 4.0 for assets
- Prediction and simulation
- Open IoT architecture
- Asset integrity processes (RCM, FMECA)*
- Open for partner content (RBI, CUI)**
- Closed loop and automated processes between planning, IoT, and execution

Focus 2020
Asset Networks and Collaboration
New collaborative processes between operators, OEM manufacturers, and other third parties require that SAP Intelligent Asset Management solutions work across networks of stakeholders as well as internal teams. SAP Asset Intelligence Network enables this, creating a collaborative shared-service environment for asset management content.

As such, the first building block delivers the collaborative digital representation of all information about an asset in your company. When you have a complete set of asset information, you can plan better, optimize effectively, and execute maintenance efficiently. This is the foundation that brings together a single source of the truth across companies and across all time horizons for master, planning, and execution data.

Asset central foundation provides an open gateway for extensibility, enabling you to build your own capabilities. In addition, it acts as an integration point for third-party content, algorithms, and applications. The foundation is built natively on SAP Cloud Platform, and data objects are exposed through open and flexible cloud APIs.

The capabilities included this building block include:
• Asset central foundation
• SAP Asset Intelligence Network
• Onboarding and integration services

Asset Performance Management
The second building block focuses on providing the intelligence and tools needed to optimize asset performance. Our solutions support best practices such as reliability-centered maintenance as well as failure mode, effects, and criticality analysis (FMECA) to assess risk. Companies can define the optimal maintenance strategy across their entire asset portfolio using the SAP Asset Strategy and Performance Management application.

With Industry 4.0, the SAP Predictive Maintenance and Service solution and the SAP Predictive Engineering Insights solution enable real-time monitoring and simulation for connected assets using IoT sensors. This allows companies to move away from traditional planned maintenance where assets can be over-maintained and to reduce unscheduled tasks by executing maintenance only and exactly when needed.

With the combination of root cause analysis and FMECA, and by applying machine learning to historical and current data, the SAP solutions enable prescriptive maintenance by matching failure characteristics and proposing the best maintenance procedures. Demand is generated, optimized, and then synchronized with SAP S/4HANA, which drives asset operations and maintenance processes.

The solutions for asset performance management include:
• SAP Asset Strategy and Performance Management
• SAP Predictive Maintenance and Service
• SAP Predictive Engineering Insights

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Asset Operations and Maintenance

This final and foundational building block enables customers to run efficient maintenance operations and manage both scheduled and unscheduled work. This includes front-office capabilities to plan and prioritize work, manage resource availability, and schedule and execute jobs. Mobile delivery is important to help ensure engineers have the intelligence they need at their fingertips and to automate dispatching and job recording.

The tight integration of solutions for asset operations and maintenance with those for asset performance management provides a dynamic and automated maintenance environment, and closes the gap between maintenance strategy, planning, and execution.

To further enhance automation and optimization in an intelligent enterprise, asset operations and maintenance is integrated with supply chain and procurement for spare parts availability; with HR for engineer profiles and skills; with accounting for cost and profitability; and with manufacturing for maximizing production throughput and overall equipment effectiveness.

Solutions for asset operations and maintenance include:
• Maintenance execution with SAP S/4HANA
• SAP S/4HANA Asset Management for resource scheduling
• SAP Asset Manager mobile app

BUSINESS CAPABILITIES

SAP Intelligent Asset Management solutions help you achieve operational excellence; access accurate, real-time information about your enterprise; predict potential operational problems before they occur; and empower your workforce with the information they need to run operational processes smoothly (see Figure 8).

SAP Intelligent Asset Management solutions support best-practice capabilities that enable you to:
• Collaborate with partners and suppliers throughout the asset lifecycle
• Gain real-time insights from connected assets
• Use end-to-end visibility on the strategic, tactical, and operational level
• Predict failures, optimize cost and availability, simulate what-if scenarios, and prescribe solutions
• Plan, prioritize, schedule, execute, and close out work with strong integration into financial, project, and procurement processes
• Drive smarter decisions, improve asset reliability, enable prescriptive maintenance, and automate processes with advanced analytics, machine learning, and simulation
• Deliver an amazing, next-generation user experience tailored to your users
• Integrate maintenance strategy, planning, and execution across the enterprise

Figure 8: Asset Management in the Intelligent Enterprise
To realize these next-generation best practices, SAP recommends the following end-to-end process (see Figure 9):

This end-to-end process shows a unified solution suite that enables asset performance management and asset and operations management, synchronized through the shared asset central foundation. Each key enabler in the process is described in the next section.

The term asset is deliberately used and can refer to any type of asset, such as a device, equipment, tool, machine, or vehicle, and excludes only financial assets or instruments, such as bonds or shares.

### Asset Central Foundation

The transformation to a next-generation asset management structure is key to enabling your company to become flexible and agile in the modeling, managing, and updating of your diverse asset base. Asset central foundation provides a digital encyclopedia of all information about an asset to enable this transformation. It is our leading data model for assets and installed-base objects and was developed as an evolution of the legacy equipment structure in the SAP ERP application and installed-base objects in the SAP Customer Relationship Management application. Industry standards like ISO 14224 are at its heart and, based on extensive customer feedback, it actively complements asset master data in SAP S/4HANA.
Technically developed using microservices and cloud-native techniques, asset central foundation brings together information from operational and business systems (IT/OT convergence) with a modern and scalable architecture to support the entire lifecycle of an asset. Integration is provided into various adjacent and complementary SAP components, including product lifecycle management, manufacturing, and asset and service management solutions from SAP.

Key Use Cases
The use cases for asset central foundation include:
• A digital twin for equipment that delivers a real-time virtual model of a company’s assets and related processes
• A rich encyclopedia of information about an asset and its structure to give the business a total consolidated view of asset information
• A single, flexible, and scalable asset register capable of handling both simple and complex assets
• Enhanced data modeling for functions, failure modes, groups, models, systems, and other business objects to better represent modern asset structures and improve service, reliability, and planning outcomes
• A common and reusable user interface to bring commonality and promote reuse of asset information across SAP-, partner-, and customer-built applications
• Simple and easy lookup, search, and retrieval of asset information for users during business processes

Strategic Goals
Our goals for asset central foundation include:
• A modern asset master-data layer that is IoT enabled, collaboration ready, flexible, and ready for the next generations of use cases on a cloud-native architecture. We will continue to extend and improve the data model with collaboration from the industries.
• Back-end agnostic integration capabilities to help ensure connectedness to older SAP ERP as well as third-party ERP systems, while delivering an enhanced and full native experience for customers that have transitioned to SAP S/4HANA
• Continual improvement of asset master data in SAP S/4HANA as well as alignment with and/or use of improvements in asset central foundation
• Integration and adoption of the data model of the asset central foundation across multiple solutions, including the SAP C/4HANA® suite (service management and commerce), SAP S/4HANA, and the SAP Digital Supply Chain portfolio (manufacturing and transportation) as well as partner solutions
• Development of asset management–related customer extensions to SAP S/4HANA in SAP Cloud Platform using services available with asset central foundation
SAP Asset Intelligence Network
This is the central repository that brings the design, manufacture, and operate worlds together through the engineering bill of materials (BoM) (as designed), manufacturing BoM (as manufactured), and service BoM (as serviced or maintained) through collaboration across multiple companies. It helps companies in asset-intensive industries transform the way asset master data is maintained – moving from siloed approaches of today where every party (equipment manufacturer, equipment operator, maintenance provider, and so on) maintains their own asset record to collaborative approaches of tomorrow, with one digital-twin record maintained in the cloud and available for all parties to access based on strict authorizations (see Figure 10). It also helps determine the best maintenance and service strategies based on cost, risk, criticality, impact, and environmental factors.

Every asset should have a known risk and criticality that result in an appropriate performance plan.

Figure 10: Business Network Collaboration Using a Single Version of the Truth
Key Use Cases
Use cases for SAP Asset Intelligence Network include:
• Exchange of asset master and transactional information between business partners along the value chain for all new and existing assets
• Enablement of business models for OEMs and service providers to generate additional revenue from new information services such as enhanced documentation, remote condition monitoring, or advanced diagnostic services
• Sharing of failure and use data from an operator back to the manufacturer to improve current service or future product generations

Strategic Goals
Our goals for SAP Asset Intelligence Network include:
• Collaborative work management processes among business partners to reduce manual processes and improve data accuracy
• Equipment as a service to enable cross-company business models, such as payment on asset performance or usage
• Near-zero master data management for operators who will receive all technical information from manufacturers upon purchase of a new asset with integration in the logistics process of SAP ERP, such as goods receipt

SAP Asset Strategy and Performance Management
The SAP Asset Strategy and Performance Management application (see Figure 11) helps you determine the best maintenance and service strategies based on cost, risk, criticality, impact, and environmental factors. It drives replace-versus-repair decisions and helps your company develop a forward-looking program of activities that includes planned or proactive maintenance as well as investment decisions. This includes supporting best-practice business processes such as reliability-centered maintenance and FMECA. The recommended maintenance approach resulting from the various assessments is consumed during the fourth step of the integrated process shown in Figure 9 and is enabled by SAP Predictive Maintenance and Service.

Figure 11: Asset Methodologies and Strategies

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Key Use Cases
Use cases for SAP Asset Strategy and Performance Management include:
• Risk and criticality management of individual, systems, groups, or fleets of assets
• Performance of detailed failure mode effect analysis and reliability-centered maintenance process
• Generation of recommendations for specific assets on how to adjust and improve generic or manufacturer-provided instructions and strategies to better suit the operating context of the asset
• Continuous assessment of maintenance and performance plans to improve mitigation of known risks and increase availability of an asset
• Detailed assessment of work priorities to decide on deferral versus earlier work
• Continuous assessment of the performance and integrity of an asset using checklists and inspection processes
• Repair-versus-replacement decisions based on total cost, efficiency, and strategy of an asset

Strategic Goals
Our goals for SAP Asset Strategy and Performance Management include:
• Partner-built extensions based on detailed engineering and industry knowledge to cover a wider domain of problems than SAP solutions have traditionally handled
• Delivery of additional functionality in the areas of cost optimization and lifecycle costing

SAP Predictive Maintenance and Service
SAP solutions for sensor-enabled condition monitoring and predictive maintenance cover a wide range of capabilities that have evolved during many years of collaboration with customers and industry teams (see Figure 12).

SAP Predictive Maintenance and Service delivers textual and event analysis from ERP data. To enhance the analysis, machine learning algorithms are applied to time-series data coming from sensors on IoT-enabled assets. With SAP Predictive Engineering Insights, this is taken further by modeling a high-fidelity digital twin of the asset and using mathematical models such as structural dynamics, thermodynamics, and fluid dynamics to simulate behavior.

Figure 12: Evolution of Sensor-Enabled Asset Monitoring
This results in the capability to deliver predictive optimization by using text, statistics, machine learning, and other techniques to forecast and predict health and life indicators. Forecasts for one or more assets allow you to take corrective actions earlier (improve availability) or to avoid unnecessary maintenance (reduce costs). The ultimate goal is to generate and optimize the maintenance backlog (set of work requests) by automating the process of determining when, what, and why a maintenance event should occur. A set of automatically generated and optimized work requests is subsequently handed over to the fifth step of the integrated process shown in Figure 9 and is enabled by maintenance execution with SAP S/4HANA.

Key Use Cases
Use cases for SAP Predictive Maintenance and Service and SAP Predictive Engineering Insights include:
• Condition monitoring during which current and future asset health is continuously assessed with automated generation of notifications
• Prescriptive recommendations through knowledge-based proposals regarding what work should be performed to improve an asset’s health
• Advanced optimization and analysis that provides anomaly and failure-based intelligence from time-series and text data, including use of custom machine-learning algorithms
• Simulation of asset behavior using advanced 3D and engineering techniques

Strategic Goals
Our goals for SAP Predictive Maintenance and Service and SAP Predictive Engineering Insights include:
• Automatic forecast and prediction of health and life indicators from minimal data (text only) for all of a company’s assets to reduce effort in setting up IoT data ingestion and to better handle old assets
• Proactive generation of maintenance demands without manual configuration of machine learning to make intelligence available to all users, not just to data scientists
• Use of simulation as a tool for selecting high-criticality assets to provide what-if scenarios that can improve accuracy of predictions

Maintenance Execution with SAP S/4HANA
Asset operations and maintenance form the heart of maintenance execution. It is where the work is scoped, planned, executed, and confirmed. Maintenance schedulers manage a consolidated backlog of work that combines all demands from sources such as reactive requests (something is broken), preventive maintenance (from a calendar-based plan), and proactive or prescriptive recommendations generated from predictive, machine learning, or simulation algorithms (see Figure 13). For example, much of the work in the maintenance execution step (step 5 in Figure 9) can be generated in the previous step (see SAP Predictive Maintenance and Service).
Automated and continuous bundling of individual work requests into planning buckets based on related efficiencies (such as co-location, outage availability, common competencies, or materials availability) forms a living and dynamic mid- to short-term prioritized plan based on near-real-time physical realities. Material and labor costs are estimated for the work and then approved.

Once the work is executed, actual costs for labor and materials are captured along with details about the cause of the failure and any other observations.

In most complex enterprises, work needs to be scheduled (and rescheduled), and updates from technicians are executed predominately on a mobile device.

Figure 13: Planned Visualization of Work Packaging and Prioritization
Key Use Cases
Use cases for maintenance execution with SAP S/4HANA include:
• Management of various types of work requests and the planning, estimation, approval, confirmation, and analysis of work executed
• Placement of work into planning buckets and final prioritization of work based on various business criteria
• Planning and analysis of estimated and actual labor and materials costs and consumption
• Complete and structured documentation of work performed to meet reliability, financial, and statutory requirements

Strategic Goals
Our goals for maintenance execution with SAP S/4HANA include:
• Delivery of asset operations and maintenance as a key innovation with SAP S/4HANA Cloud and SAP S/4HANA
• Proactive optimization of maintenance windows by pulling together intelligence from SAP Asset Strategy and Performance Management and SAP Predictive Maintenance and Service
• Dispatch of work according to plan to the best available technician with the correct tools, the right skills, and available, prepared parts
• Continuous and detailed dispatch and rescheduling of work based on current availability and work in progress
• Inclusion of planned inspection and checklist processes from SAP Asset Strategy and Performance Management and visibility of machine status and health from SAP Predictive Maintenance and Service

• Performance of business processes with a geospatial map to help ensure work is planned and executed in the right location
• Extension and integration of SAP S/4HANA to benefit from the optional asset performance management and asset network and collaboration solutions and to help ensure a seamless user experience and integrated business processes

SAP S/4HANA Asset Management for Resource Scheduling
As part of asset operations and maintenance, the ability to schedule work and align available resources, including technicians, skills, spare parts, and tools, is critical. Scheduling needs to run over varying time horizons and be closely linked to other planning processes in the business, including supply chain and manufacturing.

Mid- to long-term scheduling is used to plan required resources by location, team, and skill types, and to group work into optimal time periods to minimize downtime. This can include planned maintenance as well as installation and shutdown projects, and feeds other planning processes such as capital investment, recruitment, training, and spare parts procurement.

Short- to mid-term scheduling (and rescheduling) needs to prioritize critical tasks and manage unplanned maintenance, match demand to specific engineering teams or individuals, consider spare parts and tool availability, group tasks intelligently, and drive the dispatching process.
Together with optimization, predictive algorithms provide a significant opportunity to deliver decision support, assistance, and automation of planning by learning:

- What work needs to be done based on machine health and criticality
- How to effectively group work together
- When to prioritize “break-in” or emergency reactive work over proactive work
- How to automate allocation of people, tools, and parts to work orders
- Details of times and routes that help reduce worker “lag,” travel time, or machine downtime
- The optimal balance between production, logistics, and maintenance for business outcomes

Key Use Cases
Use cases for SAP S/4HANA Asset Management for resource scheduling include:

- Resource capacity planning by team, skill, and location
- Spare parts planning and availability
- Grouping of maintenance tasks to optimize work done during downtime, including shutdowns and turnarounds
- Complex projects and installations that require many resources over extended periods
- Continuous rescheduling of work based on predicted machine health

Strategic Goals
Our goals for SAP S/4HANA Asset Management for resource scheduling include:

- Easy-to-adopt scheduling solution that satisfies the needs of both simple use cases such as team assignment and dispatching to complex projects and multitask scheduling and optimization
- Tight integration of scheduling with strategy and performance, predictive maintenance, work management and mobile capabilities for dynamic and real-time asset management

SAP Asset Manager
Enterprise mobility is a key component of SAP Intelligent Asset Management and is the primary user interface for all maintenance technicians. For assets to operate at peak efficiency, companies need to ensure workers are not sitting in an office doing administrative work on their computers but are working on maintenance jobs. To enable maintenance technicians to work efficiently in the field, companies must provide workers with mobile solutions.

SAP Asset Manager is a mobile-native app that is available for both Apple and Android devices (see Figure 14). Developed as part of SAP’s partnership with Apple and benefiting from decades of development experience in mobile work execution, SAP Asset Manager supports both offline and online execution of work for maintenance technicians.
SAP Asset Manager differs from the standard SAP Fiori Web user interface and from custom or third-party solutions by supporting the following success criteria:

- Primary interface for all activities by a maintenance technician with an easier, more intuitive user experience
- Extensibility using a software development kit that enables customers and partners to change, enhance, or develop new functionality that meets their requirements
- Offline support that helps ensure high performance and always-available data regardless of network connectivity

Key Use Cases

Use cases for SAP Asset Manager include:

- Look up asset information from SAP S/4HANA and asset central foundation to support learning and diagnosis before or during execution of work
- View, start, and complete a user-specific list of jobs (work orders) that need to be performed, including all transaction steps for the successful execution of work
- Record time, parts consumption, and other resource-related transactions
Strategic Goals
Our goals for SAP Asset Manager include:
• Ability for all technicians to perform end-to-end maintenance tasks in the field, thereby maximizing time on the job while minimizing administrative work in the office
• Integrated and native experience that exploits Android- and iOS-specific functionality, such as location, video recording, or image processing
• Delivery of next-generation technologies such as augmented reality to enhance the maintenance technician’s experience
• Access to deep engineering content, including data from predictive maintenance and IoT sensors as well as content provided in asset central foundation or from collaboration with OEM partners

TECHNOLOGY CAPABILITIES
Cloud technologies have become a core element of an enterprise’s technology strategy. The following sections describe our technical approach to help customers realize value from cloud technologies in an efficient and scalable way within their enterprise.

Architecture Strategy for SAP Intelligent Asset Management
Our asset performance management suite is a next-generation suite running on SAP Cloud Platform. Shipments of SAP Intelligent Asset Management solutions will be cloud only and deployed in the Cloud Foundry environment and with SAP Cloud Platform services (SAP Fiori launchpad on SAP Cloud Platform).

Cloud architecture goals include the following:
• Continued movement toward an event- and process-driven architecture for scalability and flexibility
• Hyperscaler-agnostic solution delivery for a consistent customer experience, global feature parity and scalability, and choice of data center provisioning
• Integration with extensibility capabilities for partners and customers to simplify and focus the user experience and functionality on their business needs
• Nondegrading performance to support a global network of billions of asset records for the ultimate user experience
• Embedded proactive intelligence (machine learning) across all events and processes

Figure 15 shows the end-to-end flow of data between systems and processes around the SAP Intelligent Asset Management solutions.
Asset Operations and Maintenance
SAP will continue to develop and deliver maintenance execution capabilities with SAP S/4HANA, following the standard delivery process: first SAP S/4HANA Cloud, then SAP S/4HANA.

Integration Strategy
SAP delivers standard bidirectional and near-real-time integration for SAP Intelligent Asset Management with SAP S/4HANA, SAP S/4HANA Cloud, and SAP ERP 6.0. In future, more-advanced process integration will be offered for SAP S/4HANA and SAP S/4HANA Cloud that will not be downported to SAP ERP 6.0, mainly because new user interfaces and processes with SAP S/4HANA will be optimized to work with, but not requiring, the SAP Intelligent Asset Management solutions that support asset performance management.

We drive integration from a true business process point of view, rather than merely focusing on point-to-point connectivity. Our first focus is ERP: maintenance management with SAP S/4HANA or plant maintenance with SAP ERP. In addition, integration with SAP C/4HANA solutions, SAP Leonardo technologies, and the SAP Analytics Cloud solution offers an end-to-end asset and service management suite.

For all asset-relevant integration involving SAP solutions and third-party applications, we recommend using asset central foundation as the integration end point. Asset data is kept current and unified with integration between asset central foundation in the cloud and maintenance management in SAP ERP.
As depicted in Figure 16, standard integration of asset data between asset central foundation and SAP S/4HANA or SAP ERP is supported for on-premise releases. Starting Q2 2019, the integration scenario is also supported for SAP S/4HANA Cloud.

Our integration approach relies on the following building blocks:

- Data model alignment and public APIs from asset central foundation
- Use of message infrastructure based on Kafka events and event bus to publish messages from asset central foundation to external systems
- Triggering of real-time business events using an SAP-developed mobile add-on that handles changes to asset master data and transactional data in SAP ERP
- Open and published REST APIs for end-to-end connectivity (use of SAP Cloud Platform Integration service middleware is currently optional)

**Extensibility**

SAP Intelligent Asset Management offers a rich set of functionality and processes with a high degree of configurability to meet specific customer needs. However, we realize that there are cases where customers and partners may want to enrich the solutions with their own knowledge and experience or link to third-party intellectual property (IP). We will continue to design SAP Intelligent Asset Management solutions as an open, extensible suite, allowing expert users to include their own IP to boost specific parts of the solution, for example, engineering-specific knowledge about failure patterns to be detected in IoT data or company-developed or third-party algorithms for predictive maintenance, application extensions, or UI workflows.

SAP Intelligent Asset Management allows various visualization tools and calculation algorithms to be "plugged in" to the core assessment and execution process. These tools are provided by internal SAP teams or by partners or customers and are registered in a central catalog for consumption (see Figure 17).
Each plug-in can extract information from and feed results into the core asset central foundation, asset strategy and performance, predictive maintenance, and execution processes. Subscription, provisioning, and consumption-based billing for SAP and partners must be enabled for all plug-ins.

**INTELLIGENCE CAPABILITIES**

The last few years has seen a rise in the pairing of predictive and machine learning algorithms with the increased availability of on-demand calculation resources (in the cloud). Customers who deploy intelligent solutions can accelerate their operational processes, reduce the need for human interaction during the processes, increase the accuracy of the operational data being generated, or automate processes completely.

Intelligent technologies have been an essential part of SAP Intelligent Asset Management right from the beginning. From the first release, for example, asset operations has been backed up with strong machine learning capabilities to identify abnormal machine behavior and to predict upcoming failure to improve maintenance planning. As of now, various areas and functionalities, such as the analysis of failure modes or the identification of important sensor data, are supported by different kinds of machine learning and predictive capabilities. In future, many more areas as well as processes will be backed up by intelligent technologies, enabling our customers to speed up their work, be more accurate, draw better conclusions, and make better decisions.

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**Figure 17: Catalog of Extensibility Tools from SAP and Partners**

[Diagram showing Extensibility with analysis tools and algorithms, SAP Predictive Maintenance and Service (alerts, dynamic condition and timer, and so on), SAP Asset Strategy and Performance Mgmt (assessments, recommendations, and so on), Time-series data lake (including abstraction layer), Asset central foundation (equipment, model, systems, indicators, attributes, templates, and so on), Execution with SAP S/4HANA, Partnership with analysis tools and algorithms, Partner Solution commercialized in SAP App Center, SAP Solution commercialized in SAP App Center, SAP standard solution, Planning workbench, Execution workbench, Notification(s), Work orders, Confirmation(s), Vibration analysis, Neural network, Deep learning, RBI algorithm, Image data algorithm, CUI algorithms, Simulation with ANSYS, Orchestration and extension framework, and various technologies such as Map analysis, 3D analysis, Indicator analysis, Alert analysis, Statistical algorithms, Backlog visualization, and Indicator analysis CUI algorithms Statistical algorithms Alert analysis Planning workbench Confirmation(s) Work orders Notification(s)]
Doing this, the infusion of intelligence within SAP Intelligent Asset Management will always be implemented following three paradigms.

**Embedded Intelligence**
When talking about new, intelligent technologies, we always treat them as part of the process and solution. You do not have to acquire additional services or technologies to enable an intelligent functionality; these technologies will be part of the solutions.

**Integrated User Experience**
You should not be faced with additional hurdles when using intelligent technologies and processes. If you need to configure a new machine learning algorithm, for example, the configuration process is tailored to the role and language of the business user, not to that of the data scientist.

**Automation**
Wherever possible, the methods of automated machine learning are included with a solution. The objective is for the initial model to automatically learn from data, continuously improve and update existing underlying assumptions, and automatically react to changes in the system.

**MIGRATION TO INTELLIGENT ASSET MANAGEMENT**
Customers adopting SAP Intelligent Asset Management solutions typically take a stepwise approach, enabling value to be realized quickly based on their business priorities (see Figure 18).

**Customers of ERP Solutions**
SAP Intelligent Asset Management solutions are designed to integrate with both SAP ERP and non-SAP ERP solution deployments. This same integration applies to SAP S/4HANA, providing a smooth migration path with reduced complexity and lower total cost of ownership when customers later migrate to SAP S/4HANA.

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**Figure 18: Value Road Map for Adopting SAP Intelligent Asset Management**

**Value step 1**
- Deploy high-value asset performance management (APM) capabilities, such as predictive and reliability-centered maintenance
- Integrate APM and operations with asset central foundation, creating a single, shared maintenance-data foundation
- Roll out next-generation mobile technology for engineering team management

**Value step 2**
- Add APM value by leveraging common data foundation for collaboration (internal and external)
- Move maintenance operations into a single SAP S/4HANA solution
- Rationalize third-party integration using asset central foundation

**Value step 3**
- Switch system of record for maintenance execution to the cloud. Enable intelligent maintenance execution, merging APM and operational processes
- Orchestrate maintenance with SAP S/4HANA, keeping tightly integrated processes with manufacturing, procurement, supply chain, and finance

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<table>
<thead>
<tr>
<th>Simplification</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value delivery</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

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New Customers and Customers Planning to Deploy SAP S/4HANA

For customers that are new to SAP solutions or for current customers that plan to implement SAP S/4HANA, SAP Intelligent Asset Management solutions, along with asset central foundation, can be implemented at the same time as SAP S/4HANA, with data automatically synchronized across the applications. You can also deploy these solutions before or after SAP S/4HANA – the choice is yours.

During a longer rollout of SAP S/4HANA, you can implement SAP Intelligent Asset Management solutions in fast sprints, thereby accelerating value delivery. Asset central foundation can also be planned as the system of record for data elements where that makes sense, while other data is managed with SAP S/4HANA. To help maintain clean data beyond the standard validations embedded within each application, you can adopt SAP Master Data Governance, enterprise asset management extension by Utopia on SAP S/4HANA.
CUSTOMER ADOPTION
SAP has over 17,000* customers using plant maintenance functionality in SAP ERP. The historical focus has been on efficient asset operations and cost reduction. However, companies are increasingly looking at assets to provide differentiated and new customer experiences and services and to use the digital potential of Industry 4.0 and new technologies such as predictive analytics and simulation.

Companies are turning to asset performance management to extend the life of their assets and to get more value from them. This includes adopting best practices in risk- and reliability-based maintenance and to tightly integrate risk and reliability with asset operations and maintenance, real-time sensor data from smart assets, and Industry 4.0. The result is a move from reactive and planned maintenance to predictive and prescriptive maintenance.

The boundaries between suppliers and operators of assets are also blurring. Companies are differentiating themselves through new, collaborative processes and digital content, enabled by connecting stakeholders involved in the asset lifecycle both internally and across networks.

However, we know that the maintenance market is conservative and is not yet benefitting from the same level of digital transformation maturity seen in areas like supply chain, procurement, or commerce. The time is perfect for a digital transformation in asset management, embracing new technologies to make assets a critical contributor to company growth and profitability.

You can carry out this digital transformation for asset management in one of two adoption modes, both of which can deliver significant value – and you can start today:

- Innovate quickly using our cloud extensions, with either SAP S/4HANA or your current ERP solution (either SAP ERP or a third-party ERP solution).
  - This mode includes the advanced capabilities of SAP Intelligent Asset Management solutions that support asset performance management. You can begin where value is highest and grow over time. For example, you can start by establishing risk- and reliability-based maintenance practices and expand by connecting assets with Industry 4.0 for predictive and prescriptive maintenance. You can then take the next step and improve business processes internally with mobile apps or externally with network collaboration.

*Data source: SAP support data
• Move to SAP S/4HANA (deployed either in the cloud or on premise)
  – You can adopt next-generation asset operations and maintenance, including new capabilities such as resource scheduling, analytics, and the SAP Fiori user experience for the front office, and can align this with a broader digital core strategy, transitioning from your ERP solution (either SAP ERP or a third-party ERP solution) to SAP S/4HANA.

This dual approach enables all SAP customers to benefit, whether you have already adopted SAP S/4HANA or, if that is a longer-term goal, you seeking benefits on top of your current ERP solution. You can further benefit from the simplification and integration of SAP Intelligent Asset Management solutions, which share common data and interoperate natively with SAP Cloud Platform. SAP is uniquely positioned to integrate all aspects of an asset’s lifecycle across design-to-operate processes and time horizons.

One go-to-market objective is to serve the needs of customers for maintenance operations in the context of the broader enterprise. For example, an equipment record may begin life as designed, be updated as manufactured, and later as maintained; the digital twin is not a snapshot but evolves over time. During the lifecycle of an asset, collaborative processes across teams can enable experience feedback that may trigger a redesign or an upgrade of the asset’s components. Execution is streamlined and highly efficient when engineers have access to real-time supply chain data that can trigger procurement.
PARTNER ENABLEMENT
SAP partners deliver exceptional value and are critical to helping our customers adopt SAP Intelligent Asset Management solutions. SAP will continue to invest heavily in enablement of our partner ecosystem.

For example, partners, many of whom have deep knowledge of and experience working with SAP ERP and SAP S/4HANA, are encouraged to set up their own centers of expertise for SAP Intelligent Asset Management solutions so they can work with customers during evaluations and implementations.

We offer content and services to support our partners, including:
• Webinar series
• Partner events, such as partner testing days and workshops
• SAP PartnerEdge® program
• Implementer-level training

• Enablement content released in a timely manner for every solution, including net-change information

COMPLEMENTARY PARTNER SOLUTIONS
By extending current SAP Intelligent Asset Management solutions, new partners, through the SAP Startup Accelerator for Digital Supply Chain program, and established partners, through the SAP PartnerEdge, Build engagement model, for example, can deliver innovations with SAP Cloud Platform that are independent of the customer's release of SAP ERP or SAP S/4HANA. The abstraction layer (including asset central foundation) of SAP Cloud Platform reduces complexity in developing and deploying solutions as the software interfaces with a fixed interface regardless of the customer’s version of SAP ERP or SAP S/4HANA.

Here are some examples of partners whose offerings strategically complement SAP Intelligent Asset Management solutions:

<table>
<thead>
<tr>
<th>SAP® Solution</th>
<th>Partner</th>
<th>Offering</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAP Asset Strategy and Performance Management</td>
<td>AsInt</td>
<td>Applications for the following use cases: corrosion under insulation, inspection data management, and risk-based inspection</td>
</tr>
<tr>
<td>SAP Asset Intelligence Network</td>
<td>Utopia Global Inc.</td>
<td>Content and nameplate recognition processing</td>
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<tr>
<td></td>
<td>DAQRI</td>
<td>Augmented reality glasses</td>
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<tr>
<td></td>
<td>Quadrica</td>
<td>3D scan software [point cloud technology]</td>
</tr>
<tr>
<td>SAP Predictive Maintenance and Service and SAP Predictive Engineering Insights</td>
<td>ANSYS Inc.</td>
<td>Engineering simulation</td>
</tr>
<tr>
<td>SAP Work Manager and SAP Asset Manager</td>
<td>Kinemic GmbH</td>
<td>Gesture control for hands-free use cases</td>
</tr>
<tr>
<td></td>
<td>Visual Mobility Inc.</td>
<td>Remote assisted reality</td>
</tr>
<tr>
<td>SAP S/4HANA®</td>
<td>Utopia Global Inc.</td>
<td>SAP Asset Information Workbench by Utopia for SAP S/4HANA – for governance of asset master data</td>
</tr>
</tbody>
</table>
The goal of SAP Intelligent Asset Management solutions is to help ensure that every physical asset in the world is running at its highest availability, lowest cost, and least environmental, social, and personal risk.

The following solutions help customers achieve this goal for their entire portfolio of assets:

- **SAP Asset Intelligence Network** for collaborative exchange of information with business partners throughout the entire lifecycle of each physical asset.
- **SAP Predictive Maintenance and Service and SAP Predictive Engineering Insights** for intelligently predicting when and what maintenance to perform based on live sensor data and machine learning, including simulation.
- **SAP Asset Strategy and Performance Management** to have a clear performance plan and a well-justified maintenance strategy with a regular review process.
- **Asset central foundation** for a complete “encyclopedia” of master data for the asset from “cradle to grave”.
- **Asset operations and maintenance** capabilities that enable a world-class, integrated environment for planning, performing, and completing work.
- **SAP S/4HANA Asset Management for resource scheduling** for precise allocation of the best people with the right skill set and the correct and available tools and components.
- **SAP Asset Manager**, a mobile app that provides technicians with all the information they need to execute work at the asset’s location.

SAP delivers an integrated set of best-of-breed asset management solutions that can be deployed separately or together. We recommend that you plan an end-to-end strategy covering all SAP Intelligent Asset Management solutions to support asset performance management and asset operations and maintenance. Your strategy should include asset central foundation in your overall architecture to take advantage of data harmonization, integration, and process synchronization.

**SUMMARY**
SAP Intelligent Asset Management solutions bring collaborative asset intelligence, planning, and prediction and simulation to asset maintenance and operations. These solutions enable digital transformation of asset management by using machine learning and real-time data from IoT-enabled smart assets to inform your entire supply chain. You can continuously improve processes and predict outcomes, collaborate across networks, and offer differentiated service, while generating new revenue streams and developing new ways to compete and disrupt your industry.
In addition, consider the following:

- Asset management strategies continue to mature from reactive to proactive (preventive to prescriptive) with a goal to become financially optimized.
- For high-value assets, digital twins can be modeled on operational technology data streams and can, in addition, simulate asset behaviors, enabling you to anticipate potentially risky or critical operating conditions.
- The merger of solutions for asset operations and maintenance and asset performance management into a unified suite that can optimize along all dimensions (cost, availability, and production) is an innovative and disruptive trend. And SAP is leading this trend.
- Cloud-based deployments of asset management applications will increase over the next five years as buyers accept cloud deployment as a solid option and as technology misconceptions are addressed. Many enterprise application markets have witnessed significant adoption of cloud deployments over the last decade. SAP is a strong leader in this market with the choice of a complete, end-to-end cloud approach as well as a hybrid approach.

For more information, access the following Web sites:
- SAP Intelligent Asset Management solutions
- SAP Community blogs about SAP Intelligent Asset Management
- YouTube asset management videos
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