White Paper

The Trend Toward Fully Integrated Maintenance

How the Internet of Things Will Dramatically Affect Maintenance Operations

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"If we had computers that knew everything there was to know about things—using data they gathered without any help from us—we would be able to track and count everything, and greatly reduce waste, loss and cost. **We would know when things needed replacing, repairing or recalling,** and whether they were fresh or past their best."

– Kevin Ashton in coining the term Internet of Things, 2009

The Internet of Things is now a reality, and expert consensus is that it will fundamentally change the way we live and interact. Beyond common social media examples, many aspects of business life will fundamentally change as machine data is gathered, understood, and integrated into daily decisions. In particular, maintenance professionals can set their sights on fully integrated maintenance. Fully integrated maintenance entails looking beyond a single machine or machine-oriented KPIs that focus on availability. Continuous communication among machines, maintenance operations, and lines of business will enable informed adjustment of daily maintenance and business operations as they work toward common goals.

The Digital Disruption

Today, almost all industries are facing disruptive competitors and business models. These disruptions are driven largely by the availability of data, increased connectivity in business and society, and the commoditization of physical things. Differentiation is increasingly moving to services provided, rather than features of physical products. Servitization of products, the emergence of the smart grid and connected vehicles, and the deployment of cyber-physical systems are all children of disruption. With organizations increasingly judged by the level of service they provide, maintenance moves from a back-office activity to a front-office differentiator. This in itself could disrupt maintenance practice. And maintenance operations are not isolated from global trends, which make change inevitable:

- **Future generations will be digital natives.** Previously, maintenance professionals developed a "feel" for their equipment. Maintenance decisions were often made based on personal experience or manufacturer recommendations in the absence of operational data. Younger employees are more comfortable with technology, expect to have data at their fingertips, and are comfortable relying on analytics for decisions.
- **High expectations of communication and information.** In our private lives, we have a high, and increasing, expectation that we will be able to find information when and where we need it. Influenced by consumer-oriented companies, we now expect to be informed of personally significant events (e.g., flight delays and grid outages). As this trend moves into our professional lives, maintenance professionals will be expected to provide frequent and accurate updates of outages and other relevant events to all interested parties.
- **Organizational agility.** Adaptability and agility are key to fending off disruptive challenges, both from established competitors and new market entrants. Maintenance professionals must mirror this agility as they are required to support new business models, including servitization of products, localized electrical generation, and live tracking of customer orders in production. In many cases, new business models make availability of equipment transparent to customers, and availability will have a more direct influence on profitability.
- **Integration of the Internet of Things.** As the hype around big data and the Internet of Things subsides, organizations will look at all data as "just data." Real innovation will arise when they support business decisions or enhance services based on integrated data and not on the silos of data that seemed acceptable only a few years ago. Maintenance innovation in particular will benefit from an integrated approach, as sensor data is integrated with business data. Maintenance decisions can be made in the context of business activities and calculated equipment profitability.

The Case for Fully Integrated Maintenance

Maintenance practice continues to mature, with predictive maintenance and the rise of condition-based maintenance increasingly prevalent. The benefits of improved practice are clear: Productivity and availability increase, while maintenance cost and industrial accidents decrease. However, these benefits are limited because these maintenance practices typically focus only on the equipment itself. Maintenance decisions based on a wider range of data points can ensure that limited maintenance budgets and resources support business goals beyond narrow machine-oriented KPIs. Like all other resources, maintenance resources must be optimized within the broad context of an organization's business goals.

Treating asset management (aka "maintenance") as an expense to be minimized—rather than as a contributor to be optimized—is a serious (maybe fatal) mistake for asset-intensive companies.

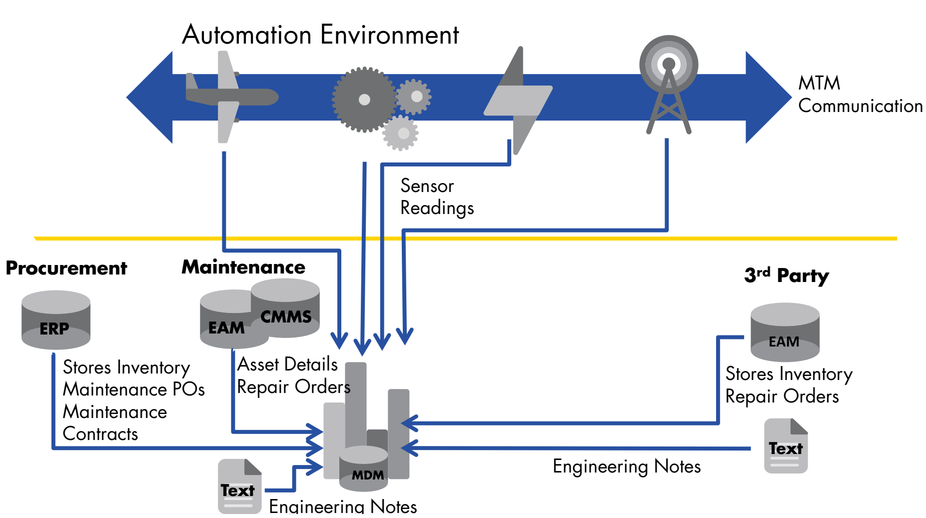
– Dale Blann, The Marshall Institute

Some industry examples include:

- **Servitization of products.** Weighing the probability of failure versus its cost. Cost of failure includes missed service level agreements on availability contracts.
- **Utilities and telcos.** Prioritizing maintenance based on equipment profitability. Calculation of infrastructure profitability is based on the profitability of the customer base it supports.
- **Manufacturing.** Monitoring the relationship between machine wear and product quality. Such monitoring potentially increases maintenance costs but reduces overall cost when the cost of scrapped or returned product is considered.

Embracing Global Trends

With the current level of sensors already deployed on vital equipment, most organizations are ready to embrace the global trends that are steering them toward fully integrated maintenance. This will be a long journey, with three key stages.



Stage 1: Understanding

Goal: Identify a "failure signature."

Sensor data from machines is collected centrally and placed into context along with additional business data. This includes records of maintenance activities, spare parts, and consumables used. Activities may be performed by internal or external teams which imply a variety of data sources. All data is analyzed to identify patterns in the sensor data that indicate failure of a component.

Tools Required for Stage 1

- **Master data management.** Create an asset master to ensure all records can be associated with the correct asset, regardless of data source. Include maintenance hierarchies that capture install dates and positions for rotables and other serialized components.
- **Flexible data integration and data quality tools.** Complexity is certain to increase as the practice matures. Data integration must be easily adjustable and extensible as new data sources or fields are added and/or source and target systems change. Data quality is vital to ensure that data and, by extension, analyses are trusted despite multiple source systems.
- **Scalable analytics environment.** This environment makes it possible to explore all types of data and their interrelationships. It may comprise a packaged solution, a data warehouse, or a number of integrated systems performing specialized analytical tasks.

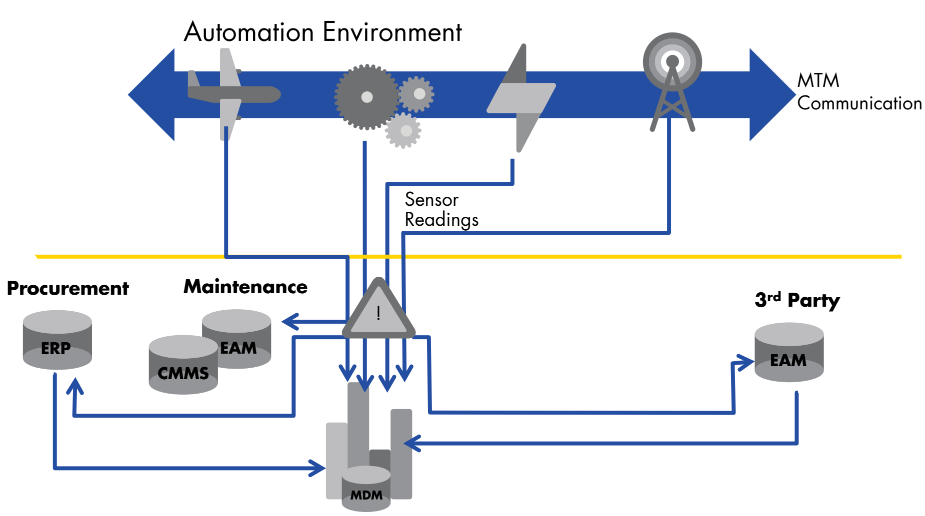
Stage 2: Alerting/Condition Based Maintenance

Goal: Proactively detect failure signatures based on current activities.

Once failure signatures have been determined, a complex event processing (CEP) tool can be programmed to detect these signatures in sensor readings. On detection of a known failure signature, the CEP tool triggers an event. Events can range in complexity both in detection and action. Failure signatures may start out fairly simple, but complexity will increase as understanding of the data and analytical capabilities matures. Similarly, action complexity will mature from simple alerts to the launching of automated business processes as trust in event detection rises.

Tools required for Stage 2:

- **Data streaming.** Collecting, filtering, and routing sensor data as it is produced. Filtering is important because of the sheer quantity of sensor readings. As a rule, only readings that indicate a change in state of a machine are of interest.
- **CEP.** The ability to detect either simple or complex events based on both streaming sensor data and data held in other systems for implementing advanced event logic.

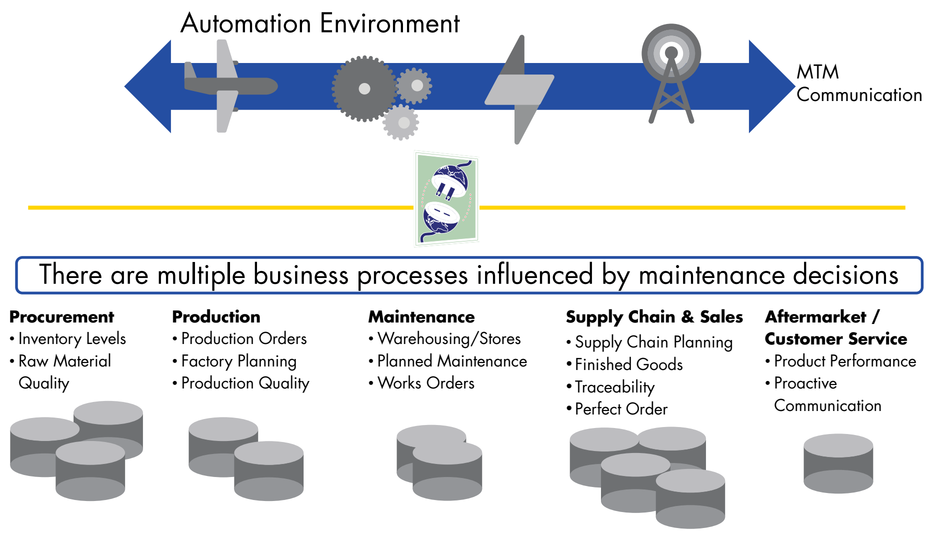


Stage 3: Fully Integrated Maintenance

Goal: Align maintenance decisions with business goals.

Once failure signatures and responses are established, the processes can be enhanced by including additional data sources in the analytics engine(s). As earlier discussed, doing so enables maintenance decisions to be made in a broader business context. Event processing becomes more complex, either through the addition of more advanced logic, or the broadening of the "customer base" that needs to be alerted upon event detection.

No additional tools are required at this stage. However, the scalability and flexibility features of tools implemented during Stages 1 and 2 become important.



The Maintenance Continuum

It is clear that fully integrated maintenance will not be implemented as a single project across an entire organization. Nor will it be commercially viable to implement on all equipment. Individual organizations are likely to have machinery on different maintenance programs, forming a maintenance continuum. Reactive maintenance is appropriate for cheap or unimportant equipment. Condition-based and fully integrated maintenance should be prioritized for the most critical or profitable machines. Determining the appropriate maintenance program for each machine should be based on its calculated value.
The data required to calculate a machine's value is broadly similar to the data required to execute a fully integrated maintenance program. Thus, deciding where a machine resides on the maintenance continuum can be considered a task within the fully integrated maintenance program.

Selecting a pilot for advanced maintenance practices also requires understanding a machine's value. Ideally, advanced maintenance programs should be piloted on equipment that can immediately demonstrate value. However, some equipment may be deemed too risky to include in advanced maintenance programs before the organization has reached a level of maturity in maintenance analytics.

GE is Leading the Way

Informatica customer GE is helping its customers harness the power of intelligent machines across facilities and fleets using software and analytics in industries such as aviation, healthcare, transportation, oil and gas, energy management, and power and water.

Industrial-strength big data may be collected, managed, and analyzed to gain actionable insight into improving machine performance and inevitably the efficiency of the systems and networks that link them.

Leveraging the Intelligent Data Platform

The building blocks for deploying integrated maintenance overlap significantly with the Informatica® Intelligent Data Platform. This platform is a "data highway" that connects people, places, and things in an increasingly data-centric world to unleash the potential of information. The Informatica Intelligent Data Platform ensures that trusted data flows freely in many directions, integrating sensor data and maintenance decisions into core business activities. The data that the platform manages is broadly available to all operations within an organization—allowing the expense of sourcing and storing sensor data to be balanced against multiple benefits as data is reused to drive value across various business processes. Product quality, indirect (spare part) spend, customer profitability, and omnichannel customer interaction are areas that could be early movers in incorporating sensor data into their analytics and business processes.

The trend that will be instrumental in the journey toward fully integrated maintenance is the normalization of big data. In the near future, all data sources (big and small) will be actively integrated and analyzed to support daily decisions and to inform medium- and long term strategy. This requires data to be managed as a valuable asset using tools such as the Informatica Intelligent Data Platform. In the data-centric business environment of the future, it will be natural—and inevitable—to make maintenance decisions in the broader context of business goals.

About Informatica

Informatica Corporation (Nasdaq:INFA) is the world's number one independent provider of data integration software. Organizations around the world rely on Informatica to realize their information potential and drive top business imperatives. Informatica Vibe, the industry's first and only embeddable virtual data machine (VDM), powers the unique "Map Once. Deploy Anywhere." capabilities of the Informatica Platform. Worldwide, over 5,000 enterprises depend on Informatica to fully leverage their information assets from devices to mobile to social to big data residing on-premise, in the Cloud and across social networks.

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