Aberdeen *Group*

The Asset Management Benchmark Report

Moving Toward Zero Downtime

April 2006

Executive Summary

External market forces, Lean manufacturing strategies, and ever lower tolerances for late deliveries are putting pressure on manufacturers to ensure that facilities and equipment are not only available, but also operating at peak performance. While some companies are still struggling to organize and execute preventive and predictive maintenance procedures, better performers have implemented holistic asset management strategies that enable them to proactively ensure the health and fitness of plants, factories, and equipment across an increasingly dynamic global manufacturing network.

Key Business Value Findings

By taking a holistic approach to asset management, best-in-class companies are better able to optimize the performance of their plants and equipment, thus avoiding unplanned downtime and unneeded maintenance. Comprehensive asset management programs require the simultaneous pursuit of multiple maintenance management programs to not only improve daily performance, but also to ensure the ongoing health and longevity of mission critical equipment. This study includes perspectives from 156 manufacturers and demonstrates a strong link between OEE (overall equipment efficiency) performance and the formalization of processes, the ability to share knowledge, and the appropriate deployment of process automation and emerging technologies.

Implications & Analysis

In addition to looking for opportunities to optimize investments in existing assets, best-in-class companies are also pursuing strategies to improve the ROI delivered by existing computer systems, including CMMS (computerized maintenance management systems), EAM (enterprise asset management), PDM (product data management), and document management systems. One strategy that is being pursued by one third of better performing companies (vs. 14% other categories) involves rationalizing data across all asset-related systems and databases both by improving interoperability and building data models to unify operational data. Forward thinking companies are also leveraging information contained in these existing systems to empower their decision makers 55% more frequently with web-based performance analytic tools than their poorer performing competitors. Finally, best-in-class companies are extending core systems by leveraging emerging technologies such as smart devices six times more frequently than industry average and laggard organizations.

Recommendations for Action

Based on survey participants' responses, Aberdeen has divided manufacturers into three categories according to our competitive framework: *best in class* (those who have mature asset management strategies and operations), *industry average* (companies that have implemented formalized asset management programs in some areas), and *laggard* (those companies that are just embarking on asset management and/or are meeting with some resistance). Here are our recommendations for each group:

- ***Best in class:*** Unify core systems around a single 'version of the truth'; deliver real-time information directly to decision-makers; develop optimized asset management lifecycle strategy.
- ***Industry average****:* Integrate asset management processes with engineering and other enterprise systems; leverage analytic tools to empower decision-makers; sustain performance with continuous improvement programs, supported by integrated and automated processes.
- ***Laggard:*** Break down departmental silos; use key performance measurements to drive change based on facts; standardize asset-oriented tasks and activities; automate core functions and processes.

Competitive Framework Key

The Aberdeen Competitive Framework defines enterprises as falling into one of the three following levels of practices and performance:

Laggards (30%) —practices that are significantly behind the average of the industry

Industry norm (50%) —practices that represent the average or norm

Best in class (20%) —practices that are the best currently being employed and significantly superior to the industry norm

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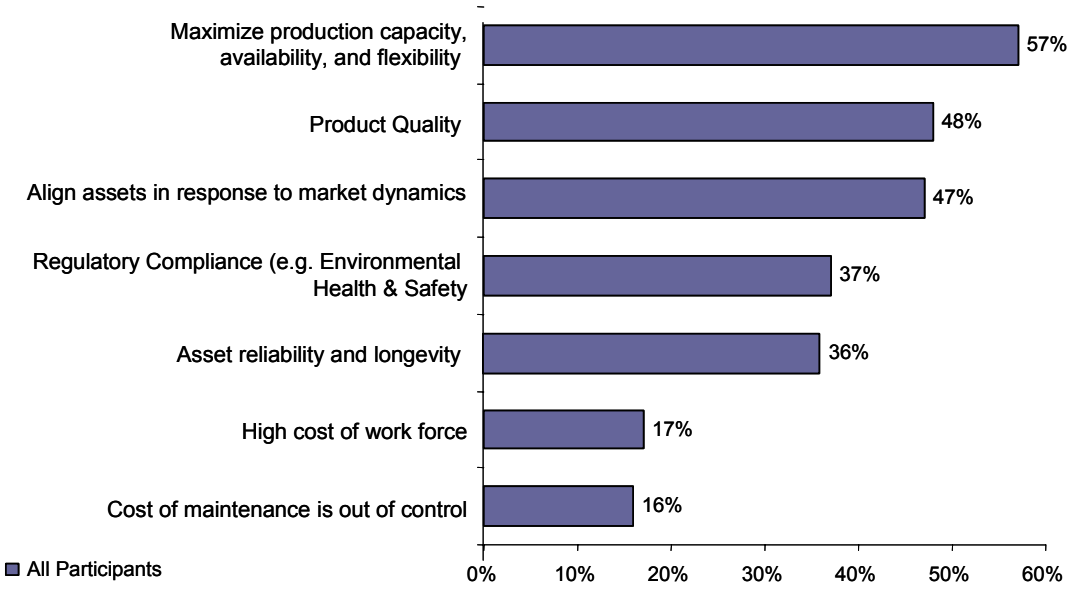
Chapter One:
Issue at Hand

Key Takeaways

- External factors are putting manufacturers under pressure to maximize production capacity, improve product quality, and better align assets to market dynamics.
- Responding to these pressures will require a holistic asset management strategy focused on asset health and fitness.
- Implementation challenges include the ability to manage change, the lack of skilled and unskilled resources, and little coordination between departments.

Demanding customers and dynamic market requirements are putting pressure on companies to respond more rapidly, with more options, and at a lower cost than the competition. For manufacturers, this requires plants and factories that are available and running at peak performance 24 hours a day, potentially in facilities around the globe. Recognizing that these challenges are being compounded by increasingly stringent regulatory compliance requirements, forward thinking companies are taking strides toward developing holistic and long term asset management strategies to ensure optimal manufacturing response in the short term and in the years to come.

Figure 1: Factors Driving Asset Management



Source: AberdeenGroup, April 2006

When asked to identify those factors that were driving the focus on asset management (Figure 1), 57% of survey respondents ranked the need to *maximize production capacity, increase availability, and improve flexibility* among their top three priorities. Over the past several years, many companies have downsized production capacity as part of overall cost cutting initiatives. However, recent up ticks in demand are leaving many manufacturers looking for ways to increase the performance of existing assets, basically "doing more with less" and doing it "faster and smarter".

PACE Key — For more detailed description see Appendix A

Aberdeen applies a methodology to benchmark research that evaluates the business pressures, actions, capabilities, and enablers (PACE) that indicate corporate behavior in specific business processes. These terms are defined as follows:

Pressures **—** external forces that impact an organization's market position, competitiveness, or business operations

→ ***Actions*** **—** the strategic approaches that an organization takes in response to industry pressures

→ ***Capabilities*** **—** the business process competencies required to execute corporate strategy

→ ***Enablers*** — the key functionality of technology solutions required to support the organization's enabling business practices

More rigorous customer-defined quality thresholds and stricter regulatory requirements are driving manufacturers to focus more on *product quality* as indicated by 48% of respondents. Achieving product quality goals requires that not only will equipment continue to operate at peak performance, but there will also be ongoing efforts to improve the quality of both products and processes.

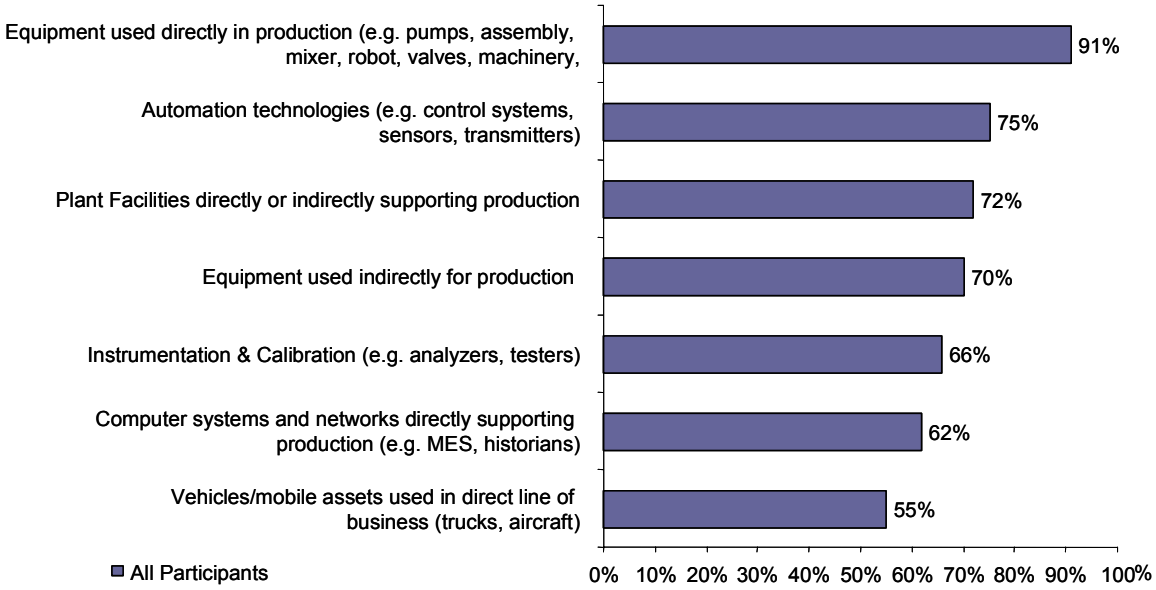
Also cited as a top challenge by 47% of respondents, *aligning assets in response to market dynamics* indicates that managers and directors in engineering, manufacturing, and maintenance are well aware of external market dynamics as well as corporate pressure to remain competitive.

Regulatory compliance was sited as the fourth most important driver of asset management at 37%. Companies operating in regulated industries must meet a wide range of expectations from environmental health and safety, while maintaining reliability and operational excellence. For example, in utilities, the Clean Air Act imposes compliance and emissions controls that govern how utilities must manage their assets.

Defining Asset Management

Asset management focuses on achieving the lowest total life-cycle cost to provide products or services. The goal is to produce at a cost lower than the competition while delivering a higher ROFA (return on fixed assets) to the shareholders. It is the responsibility of all departments to measure and control associated costs; only when resources and knowledge are shared across departments, can this be achieved. For the purpose of this study, *asset management is defined from the perspective of an owner/operator* and refers to equipment used directly or indirectly in production or logistics. By and large, study respondents concurred with this definition as shown in Figure 2; they include not only equipment, but also automation technologies, plant facilities, and the other technologies in their definition of asset management. The management of assets also can be viewed relative to the lifecycle of the overall facility and the parts that are used to repair and maintain.

Figure 2: Components Driving Asset Management



Source: **Aberdeen***Group*, April 2006

Achieving Asset Health and Fitness

All assets should be well maintained to avoid unplanned outages and unneeded maintenance. Looking at asset health and fitness, Aberdeen recognizes four levels of maturity:

- *Level 1:* Reactive maintenance is a break-fix strategy generally reserved for non-mission critical and simple equipment. The philosophy is that until a piece of equipment actually breaks, there is no need to work on it.
- *Level 2:* Preventative maintenance is a strategy used by companies that are trying to stay one step ahead of breakdowns; typically involves mission-critical equipment, or more complex, or higher capacity. The goal is to actively schedule times to do maintenance work and inspect for problems before a failure occurs.
- *Level 3:* Predictive maintenance is about anticipating problems before they happen. Its first priority is to prevent breakdowns and work stoppages by looking at things such as vibration sensors, quality degradation, and the constant monitoring of run times, which are typically compared to reference models.
- *Level 4:* Holistic asset management encompasses the previous concepts and applies each in a constant effort to continuously optimize, improve, and evolve its asset management processes.

Many companies languish when it comes to asset health and fitness. What challenges must these companies overcome to achieve these goals? According to this study, 49% of respondents (Figure 3), creating a *culture of change* is among their three top challenges.

All too many companies are passively managing equipment, generally by relegating maintenance to lower levels within the manufacturing organization.

Figure 3: Implementation Challenges

Source: **Aberdeen***Group*, April 2006

Identified as the second most important challenge at 39% was the *lack of sufficient resources coupled with the lack of necessary skills and experience*. Historically, having resident mechanical and electronics skills to maintain equipment was sufficient; however, over time, computer skills have become an increasingly important part of the equation. Furthermore as some emerging technologies introduce more sophisticated methods of diagnostics and analysis, more specialized skills are required to operate instruments and interpret results; analogous to the transformation in the medical profession from country doctor to medical specialist. Acquiring newer required skills necessitates investments in training employees and/or outsourcing maintenance all together.

In third place, 34% report that *maintenance functions are managed by individual departments and there is no incentive to combine forces*. However, we will later show a link between an organization's performance improvement capabilities with the ability of its people and systems to work across departmental boundaries (for example engineering and maintenance). Finally, while *developing and sustaining an optimized asset maintenance strategy* is tied for fourth place, if companies achieved this goal, many of the challenges with higher ratings would be resolved.

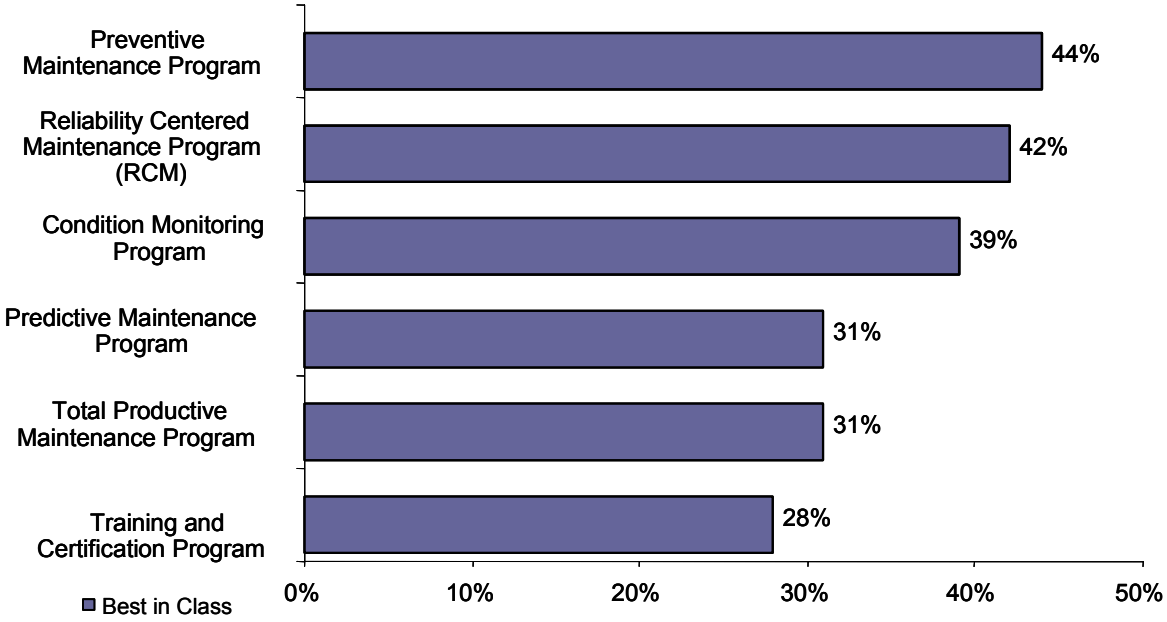
Chapter Two:
Key Business Value Finding

Key Takeaways

- Best in Class companies are taking a holistic approach to asset management by pursuing multiple techniques to orchestrate both strategic and tactical activities.
- This study shows a strong link between a strong OEE (overall equipment efficiency) and the Best in Class operational characteristics identified in this study.
- As a technology market, asset management boasts a relatively high adoption rate of applications: 90% of companies are using core solutions, 68% emerging technologies, and 61% outsource services.

A well executed asset management strategy should improve manufacturing performance by assuring the availability of equipment and plant capacity that may have been previously unavailable (due to underperformance or downtime for planned maintenance). Best in Class manufacturers are guaranteeing asset availability by proactively focusing on the health and fitness of equipment and facilities before they fail to sustain optimal performance. During the course of this study, we asked participants to identify those strategic actions that were vital to achieving their asset management goals; Figure 4 shows how representatives from Best in Class companies responded.

Figure 4: Best in Class Strategic Actions



Source: AberdeenGroup, April 2006

Strategic Actions of the Best in Class

As shown in Figure 4, Best in Class companies are pursuing key strategies:

- *Preventative Maintenance* actions (44% of respondents) are time-based, condition-based, or usage-based. Time-based activities take place at regular time intervals such as weekly or monthly; condition-based actions happen when product quality is slipping or a machine is operating below output standards. Usage based maintenance occurs at the end of a series of batches (warranting refurbishment or clean-out for example) or a certain number of units were produced (for example 30,000 components).
- *Reliability Centered Maintenance* or RCM programs (selected by 42% of respondents) focus on measuring equipment availability, uptime, and asset reliability. This can be either for specific pieces of equipment, across the plant, or across an entire manufacturing network. RCM considers how assets could fail to perform a required function and what decisions must be taken when reduction in performance takes place. RCM also involves production people determining from day one what the future maintenance asset strategy should be for individual pieces of equipment and their components.
- *Condition Monitoring* focuses on a specific indicator to detect the onset of deterioration and to provide a measure of the extent and rate of deterioration towards failure. In this context, failure of a unit may be caused by actual failure of an item or by deterioration in performance to a level which is unacceptable for safety, product quality, or other reason. For example, inspectors will monitor for progressive signs of degradation, such as corrosion, cracks or wear.
- *Predictive Maintenance* relies on the development of an asset strategy which determines the level of downtime necessary to maintain an asset, along with the resource structure required for organizing and controlling the work. Predictive maintenance analyzes and compares sampled data to reference models to assess the potential for failure. Examples of methods used include vibration monitoring on moving equipment and infrared sensors for detection of hot spots in electrical systems.
- *Total Productive Maintenance* operates with the goal of maximizing the effective utilization of maintenance resources. It addresses the challenge of evaluating all resources in terms of money, people, and time, and then allocating them in such a way that puts them to their best use. In other words, how to get the best ROI.

Asset Management Maturity and Performance

To determine Best in Class, we asked participants to characterize their maturity in key areas: process standardization, data and knowledge management, and process automation. Results are summarized in Table 1.

Table 1: Asset Management Maturity

Process Standardization	All Respondents
Breakdown maintenance is the approach, driven by economic pressures; running assets until they break is common	25%
Preventative maintenance is currently the widespread approach to maintaining equipment and machines	57%
Low tolerance for failures, risk, and adverse business impact drives proactive processes, root cause analysis, audits, planning	18%
Data and Knowledge Management	**All Respondents**
Each functional area has its own understanding of basic asset requirements and is Responsible for data retention	48%
Formal policies and procedures exist at the local level. Data about assets are shared Across company-wide, on a reactive basis	35%
Comprehensive lifecycle information (i.e. as-built/maintained configuration, performance & documentation readily available	17%
Process Automation	**All Respondents**
Manual processes, paper documents, and spreadsheets are used	28%
Information and process automation centered on maintenance work and materials and costs (i.e. CMMS/EAM) with limited integration to real-time ship floor systems	64%
Fully automated and holistic management system supporting tactical and strategy decision making within the plant & externally	8%

Source: **Aberdeen*Group***, April 2006

To determine which performance category each research study participant fell into, all respondents were scored and ranked based on maturity. The top 20% were designated Best in Class, the middle 50% industry norm, and the bottom 30% laggards.

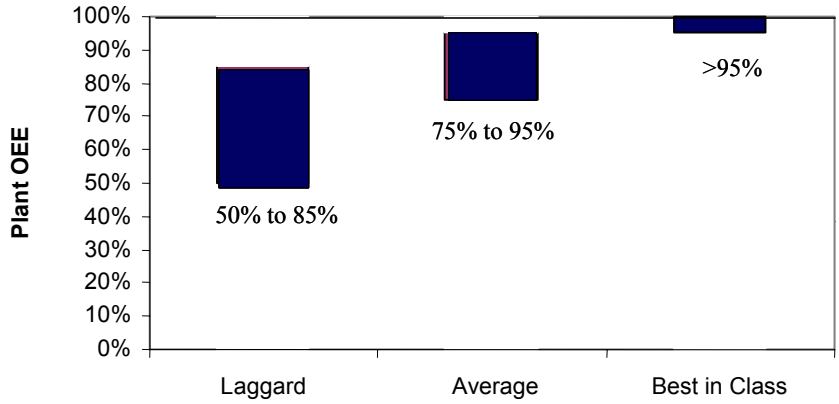
Additionally, to further validate performance designations, relative rankings were pegged against reported plant level OEE (overall equipment effectiveness) based on:

- Units used to describe annual production (e.g. barrels, tons, units, megawatts)
- Total rated/planned production capacity (units per year)
- Total available production capacity (units per year)
- Good saleable units produced (units per year)

The findings from Figure 5 show that Best in Class companies report an OEE of greater than 95%. This is in comparison to industry average companies who report between 75% and 95% and laggards that report an OEE between 50% and 85%.

OEE calculated by multiplying three ratios: availability ratio (time available/calendar period), quality ratio (total quality product produced /total product produced), performance ratio (rate of production divided by capacity of machine to produced).

Figure 5: Plant Level OEE Performance Ranges by Competitive Group in Study



Source: AberdeenGroup, April 2006

While OEE is an important KPI and used in many organizations, it is worth noting that some companies, such as Rexam, instead choose to focus on OE, or operational efficiency. Rexam is the world's largest beverage can maker, producing over 50 billion cans per year across its 40 global manufacturing plants.

Focused on its limited capacity, growing business, and zero tolerance for equipment failure, Rexam launched a major effort to achieve world-class OE (Operational Efficiency) which it defines as a formula:

OE = QM & PM & OM / WCM

(OE-operational efficiency, QM-quality management, PM-plant maintenance, OM-operations monitoring, WCM-world class manufacturing)

To support this effort, Rexam established tougher standards for quality, committed to providing real-time visibility to decision-makers, and focused on keeping its high speed lines up and running around the globe. To accomplish these goals, the company initiated a bottom up integration plan which involved capturing real-time performance data, synchronizing the management of production processes, and delivering operator instructions via an intelligent technology platform. Today, Rexam is using the Acumence Plant Analytic Server to compare real-time production data to predetermined operational KPIs (e.g. production efficiency, spoilage) and if anomalies are detected, messages are immediately transmitted to SAP which in turn dispatches a maintenance worker for immediate review.

Technology-Enabling Asset Management

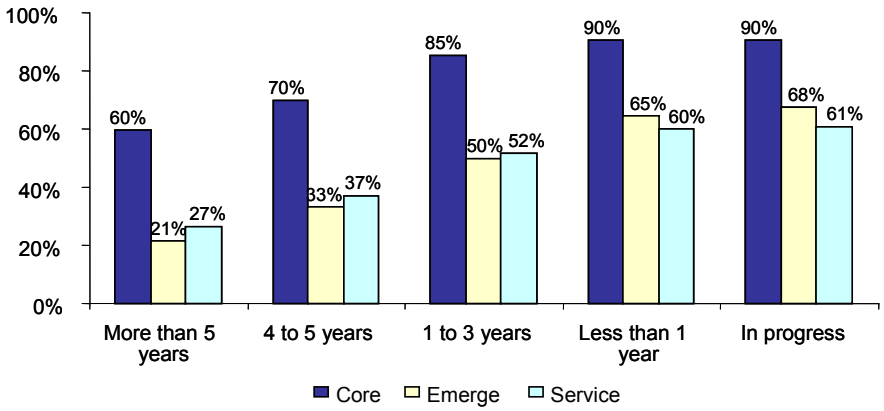
Technology solutions can provide a solid foundation for managing assets and the information that supports them. Technology solutions are divided into three major categories:

- *Core systems* manage major maintenance functions and work processes associated with asset management. Prior to computers, maintenance was handled by people with toolboxes and clipboards. Technicians repaired machines that were not working, and subsequently logged the time and spare parts used to complete

the task. Two to three decades ago, computer systems that automated rudimentary maintenance tasks by printing work orders were introduced. Over time, these maintenance management systems evolved and matured into CMMS (computerized maintenance management systems) and in a few instances, to more sophisticated EAM (enterprise asset management) systems. Simultaneously, the simple word processing systems of yesteryear have evolved into todays more sophisticated and intelligent document management systems that effectively deploy SOPs (standard operating procedures), manage engineering change orders, and a host of other critical operational processes. From an engineering perspective, simplistic CAD drawings and equipment related information made the jump from paper-based drawings to EDM (engineering document management systems) in the same timeframe, making this information readily available to maintenance workers via integrated computer systems. Today, many of the core maintenance systems are used by engineers and planners, not directly by the operators that are directly responsible for maintaining and operating production equipment. However, improved interoperability of systems and the use of emerging SOA (service oriented architectures) will enable these systems to be more broadly deployed, delivering key information and decision making capabilities to operators and decision makers alike.

- *Emerging technologies* used in the asset management area include diagnostic tools for predictive and condition monitoring, smart devices, analytic tools, and unified data model solutions. Smart devices may be incorporated directly into equipment to deliver real-time data so that results can be analyzed relative to parameters and appropriate action taken. Most companies use some form of vibration analysis to do predictive maintenance; other technologies include infrared scanning, spectrographic, lubricant, and wear particle analysis. As technologies have matured, more computer skills are needed by maintenance technicians; for charting, trending, and data interpretation.
- *Outsourced services* are provided by a number of firms in response to an insufficient level of specialized knowledge on staff in manufacturing companies. *There is a growing need to fill this knowledge gap and opportunity to infuse new methods as an experienced workforce retires, draining companies of experience and intimate knowledge of their asset base.* Like medical specialists, asset management service companies offer particular expertise; for instance, some companies offer training and certification services to help manufacturers sustain regulatory compliance and develop specialized in-house workforce skills. To better leverage performance measurement and analytic tools, remote monitoring service providers are emerging that operate globally 24x7 to detect anomalies in equipment and processes, and advise manufacturers of potential actions. One of the benefits of using such services is that many service contracts are based on achieving certain performance goals, which helps both parties to set and manage mutual goals that may be hard to adopt internally. Additionally, manufacturers of capital equipment are beginning to offer services to manage the assets they sell. Taken to the ultimate level, companies are now marketing multi-vendor support and even total plant asset management services.

Figure 6: Relative Adoption Rates by Technology Category



Source: AberdeenGroup, April 2006

For instance, an engineering manager for a major consumer goods manufacturer shared with us how his company's Lean program is continuing to drive positive changes into its asset management program. About a year ago as part of its RCM (reliability centered maintenance) program, responsibility for inspecting, cleaning and performing normal maintenance was switched from the maintenance department to (workcell) production operators responsible for the operations performed on a single piece of equipment. Because new equipment requirements tend to be multi-purpose and company-specific, each piece ultimately is custom designed by the company's engineering department. Additionally, this more sophisticated equipment demands more sophisticated maintenance; as a result, the company elected to outsource maintenance services to ATS (Advanced Technology Services). "Our decision to outsource enables us to focus on what we do as a manufacturer, rather than on becoming maintenance experts". As a result of the continuous monitoring of KPIs (e.g. proactive vs. reactive maintenance, the availability of critical assets, preventative maintenance schedule compliance) provided by ATS, the company has achieved measurable improvements in product quality, scrap reduction, and increased factory throughput.

Pressures, Actions, Capabilities, Enablers (PACE)

There's a clear relationship between the pressures companies identify, the actions they take, and their subsequent competitive performance. All participants should examine their prioritized PACE selections and determine whether they can glean valuable perspectives by comparing their PACE selections with those of Best in Class companies. Table 2 shows the pressures and prioritized actions, capabilities, and enablers companies must embrace to move from industry norm to best in class.

Table 2: PACE (Pressures, Actions, Capabilities, Enablers)

Priority	Pressures	Actions	Capabilities	Enablers
1	Maximize production capacity, availability, flexibility	Preventive and preventative maintenance programs	Real-time monitoring, calculation and alerts of KPIs (i.e. OEE), anomalies and failures	CMMS with integrated analytic tools and the ability to monitor equipment in real-time.
2	Product Quality	Implement continuous improvement programs and conditioning monitoring technologies	Technological capability to collect and monitor SPC and other data; alarms and facilitate root cause analysis.	CMMS integrated to MES and/or SPC; ability to detect And diagnose issues in real time.
3	Align assets in response to market dynamics	RCM (Reliability Centered Maintenance Program)	Monitor equipment performance; develop plans to avoid potential failures and loss of performance	Condition monitoring and diagnostic solutions such as analytical services, diagnostic instruments
4	Knowledge retention & retiring workforce	Build an electronic framework for capturing knowledge (SOPs, equipment history, etc.)	Collect relevant data and instructions relevant to equipment and facilities	Standardized data model that that maintains critical product and equipment related data across systems and enables 'drill downs' as required
5	Asset reliability and longevity	Develop long term asset strategy focused on health, reliability, and lifecycle needs	Accurate as-built and as maintained asset history, configuration and documentation	EDM (engineering document management) Configuration and Data Exchange for Capital Projects
6	High Cost of Workforce	Determine maintenance requirements across plants and facilities; organize and standardize findings, look for efficiencies	Empower operators by providing appropriate training and technology tools.	Deliver actionable information to decision makers (e.g. operators, quality, engineering, maintenance, management)
7	Cost of maintenance is out of control	Proactively remove waste and streamline processes related to maintenance	Standardized identifications, data, processes; well defined and understood procedures	Automated operating procedures, standardized equipment and repair parts data, maintain data on a single system

Source: **Aberdeen*Group***, April 2006

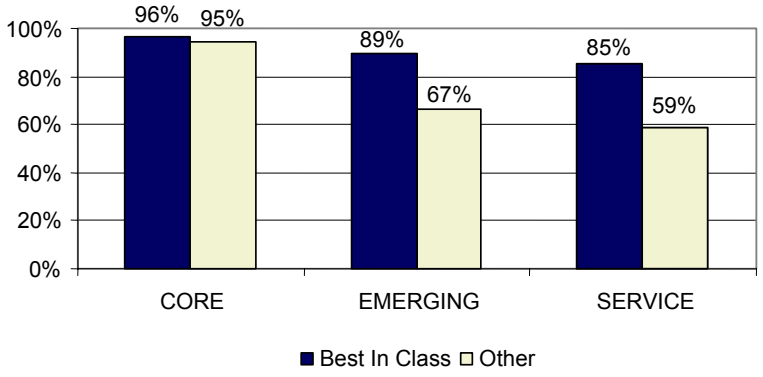
Chapter Three:
Implications & Analysis

Key Takeaways

- 75% of survey respondents reported they are enhancing and/or replacing core asset management capabilities
- Best in Class companies use performance management analytics 55% more frequently than others and predictive technologies 40% more frequently
- Best in Class companies are six time more likely to use smart devices for asset health greater than others (39% vs. 6% others)
- Unified Asset Data Framework is used by twice as many Best in Class companies than others (33% vs. 14% others)
- 85% of Best in Class companies use third party services, 44% more than others

Manufacturers that are implementing holistic asset management programs are better positioned to proactively respond to dynamic markets, demanding shareholders, and increasingly stringent regulatory pressures. In a soon to be released Aberdeen ***Industrial Control Platform Benchmark*** report, about half of the respondents indicated that one of their top three strategic actions is to increase production asset performance (availability, quality and lifecycle). According to that study, continually improving the performance of assets, processes, and product quality are key characteristics that set the Best in Class companies apart from their lower performing counterparts. From a market perspective, the use of technology to support the management of assets is widespread (Figure 7) with approximately 95% indicating that they have automated core processes.

Figure 7: Current Use of Technologies & Services (Best in Class vs. Other)



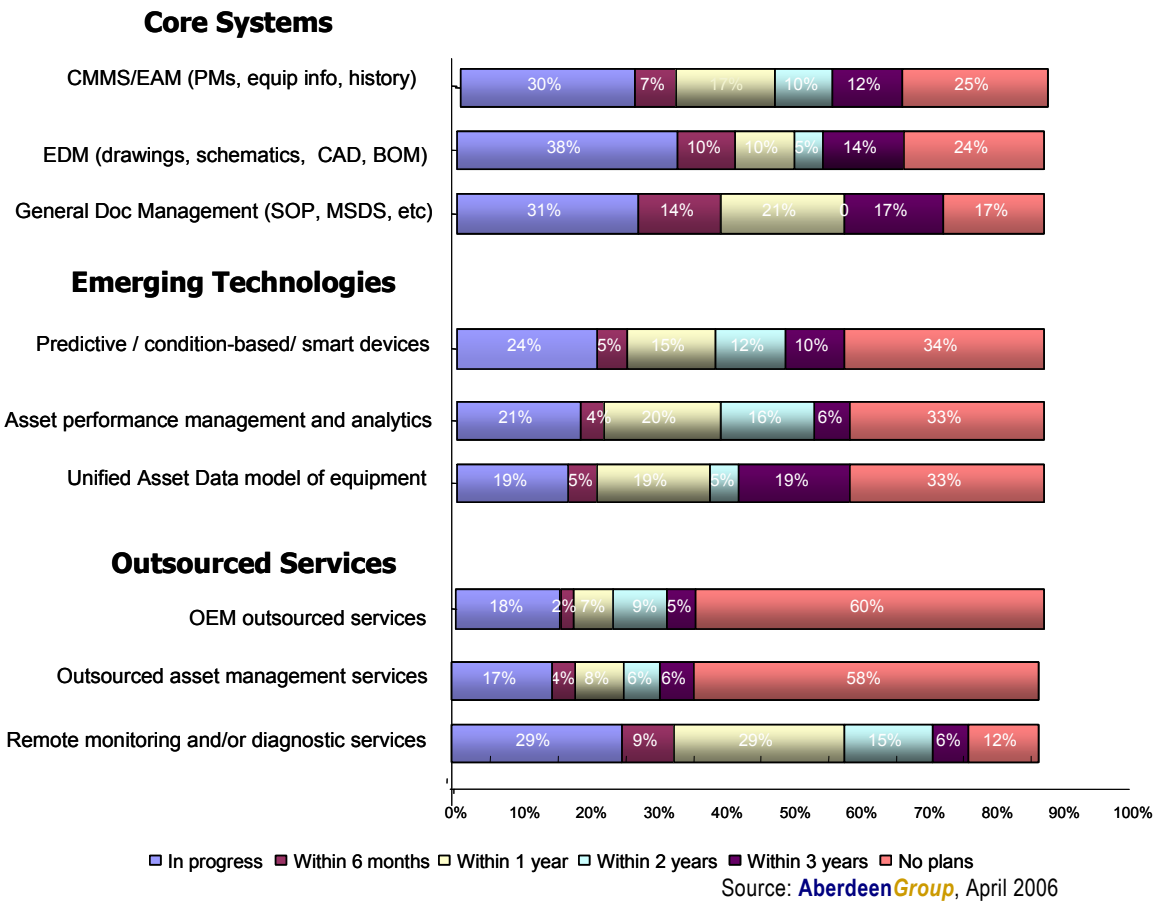
Source: AberdeenGroup, April 2006

The use of non-core technologies and services is not quite as high with 89% of Best in Class companies employing emerging technologies and 85% using third party services. In comparison, the use of technology is less widespread among the lower performing companies represented in the survey; 67% are using emerging technologies and 59% using services. Figure 8 further supports Chapter 2 findings which stated that the majority of Best in Class and many other manufacturers are leveraging and combining the power of core applications, emerging technologies, and outsourced diagnostics services to better manage assets locally and around the globe.

Core Applications

Companies will continue to strengthen their critical asset management processes applications by bringing together core applications, emerging technologies, and outsourced services into an integrated technology foundation. Although most core systems have been in place for well over five years, many no longer meet current needs. As a result, approximately 75% of survey respondents reported that they are either enhancing and/or replacing capabilities or intend to do so within the next three years. (see Figure 8)

Figure 8: Planned Change in the Asset Management Technology Landscape



Source: AberdeenGroup, April 2006

Traditionally manufacturers have relied on core applications to support basic maintenance functions, streamline processes and, to enable timely decision making. However, today's manufacturer must be more responsive, Leaner, and more collaborative. Many earlier generation core systems were not designed or implemented to meet these needs. Their primary purpose was to be a *system-of-record*, capturing data after the fact for future reference and accounting; most often they existed in isolation or with limited integration, such as the ability to pull up a document from a maintenance work plan. Key considerations relative to replacing, updating or extending core applications include the ability to support cross-functional processes, including maintenance, operations, engineering and supply chain. Newer generation solutions are leveraging SOA and web services to accomplish this.

As companies invest in core systems, they should consider simultaneously streamlining business processes across all related systems and functions. This is particularly true for the many companies that plan changes for two or all three core system during the next three year period. As Six Sigma and other continuous improvement programs determine new ways to increase performance, it is critical that the core systems are sufficiently flexible to facilitate the reconfiguration and introduction of new integrated and automated processes.

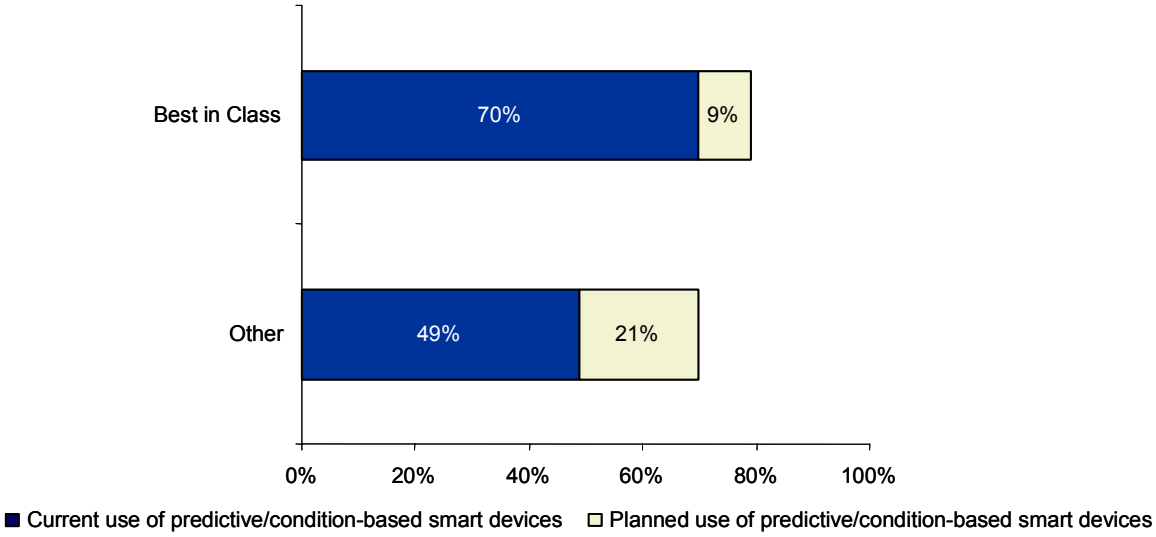
Predictive Technologies

Forward thinking companies are making a strategic shift from reactive to more proactive asset performance management. This shift is driven by the principle that unplanned downtime, (resulting from the break/fit approach), is more costly than early detection, corrective action, and planned intervention. The simplest and most common proactive approach is scheduled preventative maintenance and overhauls. This approach helps companies get maintenance costs under control, by planning materials and resources, thereby allowing operations to schedule around planned work, rather than suffering the uncertainty of breakdowns. However, this approach can lead to unnecessary or premature maintenance, resulting in unnecessary expense and loss of equipment availability. To address this problem, companies are incorporating predictive and condition-based technologies and paying more attention to equipment reliability. The choice and mix of proactive methods a company uses depends on the plant specific asset types and their criticality to process, asset, and quality performance objectives. Companies looking to reduce costs and increase asset availability will continue the shift toward proactive and apply technology to better optimize asset health and fitness.

Over the next three years, 70% (Figure 8) of the Best in Class companies indicated plans to invest in predictive/condition-based and smart devices technologies. Current and planned use of these technologies was cited by 79% of the Best in Class (Figure 9) compared to 60% of the other respondents.

Despite investment strategy, it is important to keep abreast of emerging technologies in this area as new sensing, diagnostics and analysis methods are continually coming to market. For example, technology vendors have recently introduced on-line vibration sensors and some are marketing instruments that plants can operate themselves instead of sending samples to a professional lab.

Figure 9: Use of Predictive/ Condition-based and Smart Device Technologies



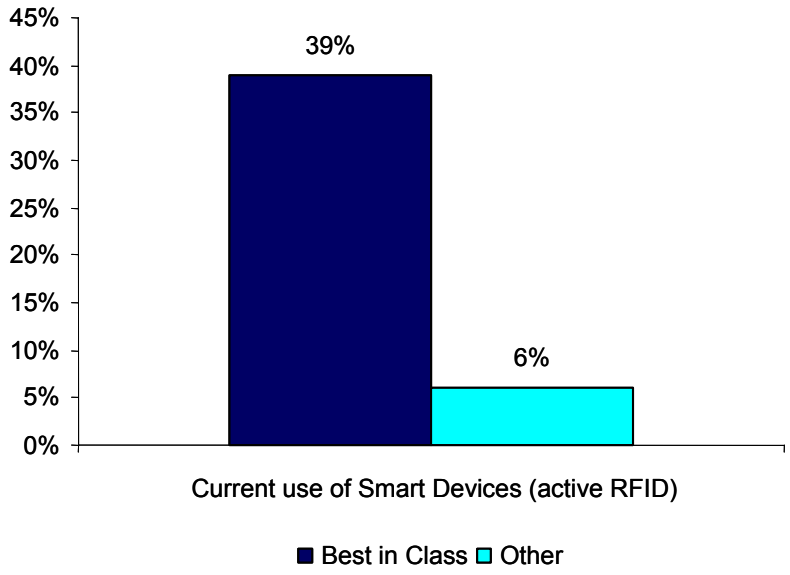
Source: AberdeenGroup, April 2006

Smart Devices

As manufacturers plan future technology investments, considering smart devices in the mix will help drive improvements into the ability to proactively manage assets. Best in Class companies represented in our survey are more aggressively utilizing smart devices as part of their asset management program. Figure 10 shows that 39% of Best in Class respondents cited the use of smart devices, as among their top-three approaches to managing health, operations and minimizing downtime; as compared to only 6% of all other companies surveyed.

With the need to focus resources on value-added activities, manufacturers should view smart devices as an opportunity to reduce the wasted effort associated with preventing and predicting product failures. Smart devices have the intelligence to determine and communicate information about the asset's health status, in addition to whatever else is communicated in their operational role. This is an example of how proactive asset management is being driven down into the asset hierarchy and how vendors in the market are responding with emerging technologies. The embedded intelligence is available from a wide range of products such as smart transmitters, smart valves, smart pumps, on up to million dollar production equipment. Communication options (e.g. wireless, Ethernet and fieldbus) and industry standards allow multi-vendor alternatives to be compatible with most industrial control platforms and asset management systems..

Figure 10: Smart Devices a Top 3 Approach to Improve Health/ Lower Downtime



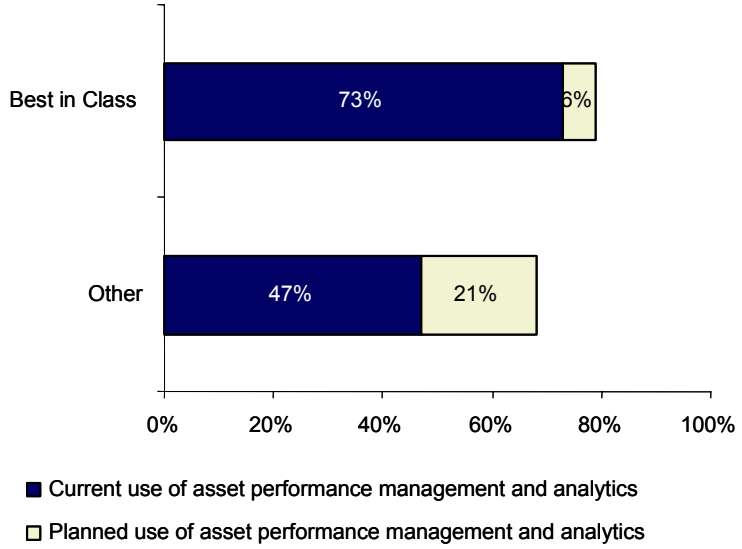
Source: AberdeenGroup, April 2006

Analytics for Proactive Decision Making

Preparing to proactively manage assets requires that accurate real-time information be delivered to decision-makers. However, with increasing amounts of data also comes the risk that people may become overwhelmed and potentially overlook early indications of problems. Performance management and analytic tools help to make sense of this information and present it to decision-makers in a useful form.

As shown in Figure 11, performance management and analytic tools are technologies that Best in Class companies (86%) use more than other manufacturers (52%). Decision-makers are better prepared to make timelier decisions when presented with performance indicators they trust and when aided by analytic tools that help them understand the implication of performance metrics. For example, a maintenance engineer notified of a high motor-temperature can better diagnose the alarm, by having the ability to access historical trends and drill-down on related indicators. On-line analytic tools support decision making with the automated and continuous monitoring of real -time data which can detect infrequent and subtle trends that would be impossible for humans to catch.

Figure 11: Current and Planned Use of Asset Performance Analytics



Source: **Aberdeen***Group*, April 2006

Analytic tools can help present opportunities to improve performance by triggering events For example, an asset performance degradation event could spawn a cascade of processes such as a quality non-conformance notification, quarantine of product, and quality inspection, just to name a few. The market is responding to manufacturers' needs for analytic tools, both general purpose and application specific. The simplest forms of analytics are often spreadsheets populated with plant floor data. The next level, general purpose analytic tools allow companies to define (often by means of models or configuration) their own analytic rules, triggers and actions. These provide ease-of-use and structure, whereas spreadsheets can become cumbersome and difficult to maintain. Application specific products are also being marketed by companies that have specific domain knowledge to perform specific functions such as:

- Analyze control loop performance to detect a lag in responsiveness
- Identify valves that are sticking or not performing well
- Prioritize the important alarms to focus on
- Equipment performance (e.g. pumps)

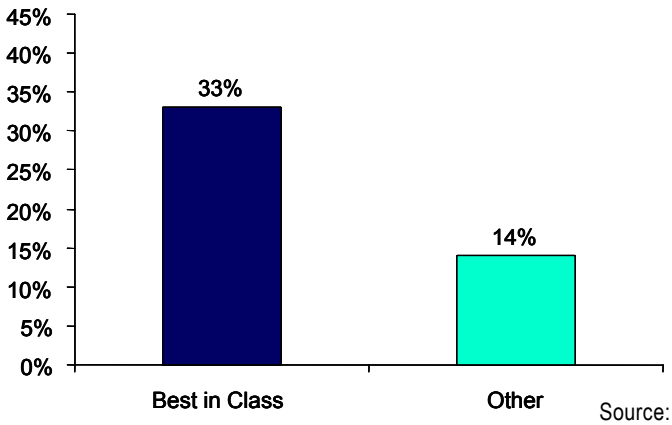
To get more return on capital investments in plant and equipment, manufacturers should better understand the relationship of asset performance to overall manufacturing performance goals. Analytics can be useful as a basis for intelligently optimizing asset performance. While it can be overwhelming to correlate raw real-time data to performance indicators manually, analytics help to translate this raw data into a reference model so that the bigger picture can be understood. Such models can also be used as a basis for more informed decision making relative to extending the life of current assets and investing in new ones. Leading companies are now using plant floor data in simulations to predict the ROI of process and equipment changes.

During the course of this study, we spoke with Meridian Energy, the largest provider of electricity in New Zealand; the company owns $800M worth of assets, 80% of which is critical equipment. The company is proactively managing these assets and applying more science to the strategic asset planning process using the Matrikon solution. Concerned about the impending retirement of much of its workforce, Meridian began capturing knowledge and streamlining processes in 2000. Over time, the company developed predictive models for transformers (based on IEEE standards) and other equipment (e.g. turbines, generators, governors) based on supplier data, maintenance history, subject matter expert knowledge, rules, statistical models, etc. Today these models are used to trigger alerts and manage workflows; they also predict end-of-life, calculate MTBF (mean time between failures), diagnose conditions, and recommend action and maintenance schedules. The Matrikon system analyzes combinations of factors such as vibration, oil and temperatures, condition monitoring information, real-time data from an IT system that gathers historical data from remote site PLCs. Data quality is also enhanced by recommending corrective actions based outlier data that conflicts with the defined models. Finally, for future strategic asset planning, these predictive models provide the basis to justify refurbishment, make capital investments and pursue other opportunities to improve asset performance.

Unified Asset Data Framework

Overall, the proactive approach will be of limited success if decision-makers working as cross-functional teams have a different view of the truth. There is substantial value in developing a comprehensive data model that unifies core systems and enables the introduction of emerging technologies. For example, let's say a smart device alerts a decision maker of an impending problem. The negative impact on the business will not be avoided if decision-makers lose precious time piecing together information from isolated or marginally integrated systems. This is the case in most manufacturing environments now, where decision-makers are running in reactive mode, solving the immediate problem at hand. Too often their response time is too slow to prevent the negative impact on manufacturing performance.

Figure 12: Current Use of Unified Asset Data Model



Source: AberdeenGroup, April 2006

Best in Class companies recognize the need for a cohesive framework to bring together in context all information regarding assets, production data, engineering documents, plant/equipment master data and business information. According to our survey, the Best in Class lead other companies almost two to one (33% vs. 14%) in deploying a unified asset data model of equipment and operations in context (Figure 12). Forward thinking companies are implementing a unified data model and integrating systems into a comprehensive foundation that provides a "single version of the truth". This combines assets and operational history, as well as incorporating supplier, engineering and asset documents with equipment configuration and history. As companies run leaner and seek to manage knowledge more actively, the process of figuring what version of the truth is right will be identified as another non-value-added activity to eliminate.

Unified asset data models can also be instrumental in getting new plants up and running quickly. As an example, Conectiv Energy a regional power generation company, recently built a new generating facility in Bethlehem Pennsylvania. It was a major challenge to collect and rationalize all the data associated with operating and maintaining the new facility and its mission critical equipment. The company used the NRX Asset Hub to collect and aggregate information directly from 'hard book' libraries, paper manuals, OEMs, and best practice procedures into a single database. Once this task was complete, the company was able to get maintenance up and running quickly and simultaneously populate the corporate SAP maintenance system with critical information.

A unified asset data model serves a tactical purpose in daily operations and, from a strategic perspective, will enable companies to adapt and manage change. Operationally, such a foundation should increase the ability and capacity for operations and support teams to interpret and act on critical indicators and anomalies. Strategically, this single version of truth should put historical performance indicators into context -- allowing that the context may change over time (e.g. change in product mix, production volume, assets in use). Provided with more complete and accurate information, decision-makers can make better decisions when, for example, studying long range effects to improve future performance, or making business decisions such as plant upgrades or process changes.

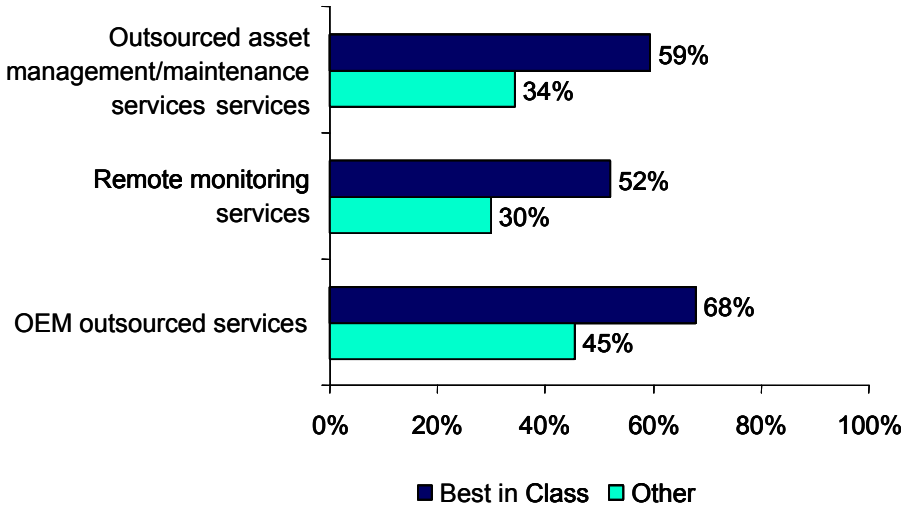
Conectiv Energy is also using the SAP/NRX VIP solution in more established facilities to deliver role-based asset management functionality to key personnel including operators and mechanics. From an operations perspective, this solution enables maintenance workers to 'point and click' to create and view asset and work information; eliminating the need for in depth training on SAP. The goal was to streamline maintenance processes and simplify the tasks and functions for 'casual users'.

Outsourced Services

Many manufacturing companies are outsourcing portions of maintenance management in order to focus on building their own internal manufacturing competencies. Here again (Figure 13) the Best in Class are more aggressively taking advantage of such services than their counterparts in the survey; using nearly double the amount of outsourced asset management/maintenance services, (59% versus 34%). Consistent with their preference for vendor value-added capabilities in smart devices, 68% of the Best in Class employ OEM outsourced services. And over half of best- in-class use remote monitoring services, which is 40% greater than other companies (30%). Further analysis reveals that among these type services, OEM outsourcing ranked first (50% overall), followed by

asset management/maintenance services (40% overall) and then remote monitoring (35% overall).

Figure 13: Current Use of Outsourced Services



Source: AberdeenGroup, April 2006

Stacking Up Against the Competition

Aberdeen has developed a competitive framework that helps determine success factors for laggard, industry average, and Best in Class performers. Survey respondents were evaluated on five criteria: process, organization, knowledge, technology, and performance metrics. Table 1 allows companies to review how their organization stacks up.

Table 3: Aberdeen Competitive Framework

	Laggards	Industry Average	Best in Class
Process	Breakdown maintenance is the approach, driven by economic pressures, running assets until it breaks common.	Preventive maintenance is currently the most widely accepted approach to maintaining equipment and machines.	Low tolerance for failures, risk and adverse business impact drives proactive processes, root cause analysis, audits and planning.
Organization	No corporate level goals, strategy or metrics in place. Maintenance department essentially functions independently and reactively.	Limited interdisciplinary team activity (i.e. operators, quality, maintenance and engineering). Driven to departmental metrics and goals.	A cross-functional team is responsible for strategic asset management, integrating asset, production and corporate metrics and goals.
Knowledge	Each functional area has its own understanding of basic asset requirements and is responsible for data retention.	Formal policies and procedures exist at the local level. Data about assets are shared across company-wide, on a reactive basis.	Comprehensive asset lifecycle information, (i.e. As-built/As Maintained configuration, documentation, compliance issues) is managed and readily and securely available.
Technology	Manual processes, paper documents, and spreadsheets are used.	Information and automation centered on maintenance work and materials and costs. Isolated or limited integration to real-time shop floor systems or external departments or service providers.	Information organized around assets with relations to operations supports tactical and strategic decisions. Secure access and process automation extends to partners in the asset value chain.
Performance Metrics	Focused on maintenance labor costs and completion of work orders asset availability is significantly reduced by maintenance activities	Audit ratings are satisfactory, non compliance costs are rarely incurred.	Recognized by customers and trading partners as an industry leader who exceeds at regulatory compliance and sustains consistent and reliable production and asset high performance.

Source: **Aberdeen***Group*, April 2006

Chapter Four: Recommendations for Action

Key Takeaways

- Laggard: Break down departmental silos; standardize asset-oriented tasks and activities; automate core functions and processes.
- Industry average: Integrate asset management processes with engineering and other enterprise systems; leverage analytic tools to empower decision-makers; sustain performance with continuous improvement programs.
- Best in class: Unify core systems around a 'single version of the truth'; deliver real-time information directly to decision-makers; develop optimized asset management lifecycle strategy.

Driven by demanding customers, regulatory agencies, and shareholders, along with the availability of emerging technologies, a new era of asset management solutions is being ushered in. The following actions should help spur necessary performance improvements.

Laggard Steps to Success

Companies that are behind in terms of operational performance have a large opportunity for improvement.

1. *Break down departmental silos.*

   To capitalize on assets including tools, spare parts, and maintenance related materials, provide visibility and enable sharing of resources and capabilities. Take on a more holistic definition of assets under management. Elevate asset management core systems to an enterprise level to identify commonalities, enable internal performance benchmarking.

2. *Standardize asset oriented tasks and activities.*

   Establish standard operating procedures, inspection standards, and failure codes. Expand this to the enterprise.

3. *Automate core functions and activities.*

   Identify low hanging fruit for process improvements to eliminate time wasted looking up information and re-entering data. Integrate and automate processes between core applications, enterprise and plant floor systems.

Industry Norm Steps to Success

Companies reporting average performance results also have an opportunity to improve the management of their assets.

1. *Integrate asset management processes with engineering and other enterprise systems.*

   Use engineering and general document management solutions to establish version control and ensure that current and accurate engineering and vendor information is readily available for any activity involving an asset, (e.g. maintenance, operations, engineering, procurement). Integrate engineering and enterprise with asset management systems to ensure consistency of procedures, design and vendor information, and provide procurement and accounting information to plant level decision-makers.

2. *Leverage analytic tools to empower decision-makers.*

   Support decision-makers with analytic tools that help reduce the overwhelming load of real-time events and automate the monitoring and analysis of critical indicators impacting performance. Leverage email and text messaging capabilities to proactively notify decision-makers. Consider remote monitoring and outsourcing options as a way to increase critical asset performance by leveraging specialists who will layout well defined objectives.

3. *Sustainable performance with continuous improvement programs*

   Empower continuous improvement teams with automated data collection and dashboards for greater visibility to performance. Use performance and analytic tools to make the connection between process, asset and quality. Consider smart devices and lower cost communication options (wireless or Ethernet-based) as a way to enable real time measurement of critical equipment.

Best in Class Next Steps

Companies that have achieved competitive differentiation through operational excellence still have the opportunity to continue to improve and extend their lead even further.

1. *Unify core systems around a 'single version of the truth'.*

   Proactively bring together EDM, document management, and CMMS data and processes into a holistic framework that provides uniform visibility and consistency across systems.

2 *Deliver real-time information in context directly to decision-makers, on-demand or event-driven.*

   Leverage integrated systems to present comprehensive asset information in real-time direct to appropriate decision-makers. Deploy a role based program that helps to reduce the information overload, and use integration to automate the process of gathering relevant information so decision maker spend more time making decisions and less time on gathering information.

3. *Develop optimized asset management lifecycle strategy.*

   Optimize short and long term tradeoff between investment capital, operations and maintenance. Periodically reassess mix of preventative and predictive approached maintenance. Consider whether asset downtime actually impacts pro-

duction, based on production schedule. Associate asset performance with quality performance and monetize its contribution to the cost of good quality (prevention) or cost of bad quality (failure).

Author Profile

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Jane Biddle leads Aberdeen research efforts in the global manufacturing sector. Through benchmarking studies, best practice reports, and tailored research projects, she remains focused on helping clients understand and anticipate the impact of business and technology on their organizations. Jane has been at the forefront of technology since implementing MRP systems for Hewlett-Packard customers. This experience led her to become MRP/ERP product manager and industry solution manager for Digital Equipment's CIM marketing organization. In the mid-1990s, she established the manufacturing practice for Benchmarking Partners before she joined SAP to initiate and manage its Industry Centers of Expertise for the Americas.

Just prior to joining Aberdeen, Jane was an independent consultant providing strategic advisory services to technology and service providers in the supply chain and manufacturing sectors. Jane is a frequent speaker at industry conferences and has published a number of articles. She is currently serving as APICS West Jersey president. Jane received her BS in Computer Science and MBA from Rivier College in Nashua, N.H. and maintains her APICS CPIM certification status.

Appendix A:
Research Methodology

During the month of February 2006, **Aberdeen***Group* with *Control Engineering,* aided by the *Society for Maintenance & Reliability Professionals (SMRP)* and *Plant Services,* examined asset management philosophies, techniques, and technologies of 156 enterprises across a number of industry sectors.

The drive for improved financial results, product quality, safety, and the ability to operate 24 hours conspire to make the management of manufacturing assets an important objective for all manufacturers in 2006 and beyond. This benchmark study investigates how companies are overcoming traditional performance boundaries to ensure that assets are meeting operational and performance objectives by asking the following:

- What opportunities do manufacturers have today to proactively manage their plant and equipment availability?
- What business capabilities and technology enablers are leading manufacturers deploying to predict failures so that action can be taken to minimize their impact on operations?
- How are decision-makers being empowered with actionable and timely information? And, what are their future plans for the use of technology?

Aberdeen supplemented this online survey effort with telephone interviews with select survey respondents, gathering additional information on Lean strategies, experiences, and results.

The study aimed to identify emerging best practices for Lean and provide a framework by which readers could assess their Lean capabilities.

Responding enterprises included the following:

- ***Job title/function****:* The research sample included respondents with the following job titles: maintenance services (26%), engineering projects (18%), manufacturing operations or engineering (13%), and reliability engineering (11%).
- ***Industry****:* The research sample included respondents from manufacturing industries including food & beverage (13%), chemicals (11%), automotive (10%), and industrial equipment (8%).
- ***Geography****:* Nearly all study respondents were from North America; remaining respondents were from the United Kingdom and the Asia-Pacific region.
- ***Company size****:* About 43% of respondents were from large enterprises (annual revenues above US$1 billion); 27% were from mid-sized enterprises (annual revenues between $50 million and $1 billion); and 30% of respondents were from small businesses (annual revenues of $50 million or less).

Solution providers recognized as sponsors of this report were solicited after the fact and had no substantive influence on the direction of the *Asset Management Benchmark Report*. Their sponsorship has made it possible for **Aberdeen***Group*, *Control Engineering , SMRP and Plant Services* to make these findings available to readers at no charge.

Table 4: PACE Framework

PACE Key
Aberdeen applies a methodology to benchmark research that evaluates the business pressures, actions, capabilities, and enablers (PACE) that indicate corporate behavior in specific business processes. These terms are defined as follows: *Pressures* — external forces that impact an organization's market position, competitiveness, or business operations (e.g., economic, political and regulatory, technology, changing customer preferences, competitive) *Actions* — the strategic approaches that an organization takes in response to industry pressures (e.g., align the corporate business model to leverage industry opportunities, such as product/service strategy, target markets, financial strategy, go-to-market, and sales strategy) *Capabilities* — the business process competencies required to execute corporate strategy (e.g., skilled people, brand, market positioning, viable products/services, ecosystem partners, financing) *Enablers* — the key functionality of technology solutions required to support the organization's enabling business practices (e.g., development platform, applications, network connectivity, user interface, training and support, partner interfaces, data cleansing, and management)

Source: **Aberdeen***Group*, April 2006

Table 5: Relationship between PACE and Competitive Framework

PACE and Competitive Framework: How They Interact
Aberdeen research indicates that companies that identify the most impactful pressures and take the most transformational and effective actions are most likely to achieve superior performance. The level of competitive performance that a company achieves is strongly determined by the PACE choices that they make and how well they execute.

Source: **Aberdeen***Group*, April 2006

Table 6: Competitive Framework

Competitive Framework Key
The Aberdeen Competitive Framework defines enterprises as falling into one of the three following levels of FIELD SERVICES practices and performance: *Laggards (30%)* — Asset Management practices that are significantly behind the average of the industry, and result in below average performance *Industry norm (50%)* — Asset Management practices that represent the average or norm, and result in average industry performance. *Best in class (20%)* — Asset Management practices that are the best currently being employed and significantly superior to the industry norm, and result in the top industry performance.

Source: **Aberdeen***Group*, April 2006

Appendix B:
Related Aberdeen Research & Tools

Related Aberdeen research that forms a companion or reference to this report include:

- *The Product Quality Benchmark Report,* December 2005
- *Manufacturing Transparency,* December 2005
- *Winning with Global Manufacturing Networks,* September 2005
- *Best Practices in Lean: The Momentum Builds,* July 2005

Information on these and any other Aberdeen publications can be found at www.Aberdeen.com.

About AberdeenGroup

Our Mission

To be the trusted advisor and business value research destination of choice for the Global Business Executive.

Our Approach

Aberdeen delivers unbiased, primary research that helps enterprises derive tangible business value from technology-enabled solutions. Through continuous benchmarking and analysis of value chain practices, Aberdeen offers a unique mix of research, tools, and services to help Global Business Executives accomplish the following:

- IMPROVE the financial and competitive position of their business now
- PRIORITIZE operational improvement areas to drive immediate, tangible value to their business
- LEVERAGE information technology for tangible business value.

Aberdeen also offers selected solution providers fact-based tools and services to empower and equip them to accomplish the following:

- CREATE DEMAND, by reaching the right level of executives in companies where their solutions can deliver differentiated results
- ACCELERATE SALES, by accessing executive decision-makers who need a solution and arming the sales team with fact-based differentiation around business impact
- EXPAND CUSTOMERS, by fortifying their value proposition with independent fact-based research and demonstrating installed base proof points

Our History of Integrity

Aberdeen was founded in 1988 to conduct fact-based, unbiased research that delivers tangible value to executives trying to advance their businesses with technology-enabled solutions.

Aberdeen's integrity has always been and always will be beyond reproach. We provide independent research and analysis of the dynamics underlying specific technology-enabled business strategies, market trends, and technology solutions. While some reports or portions of reports may be underwritten by corporate sponsors, Aberdeen's research findings are never influenced by any of these sponsors.

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Founded in 1988, Aberdeen*Group* is the technology-driven research destination of choice for the global business executive. Aberdeen*Group* has over 100,000 research members in over 36 countries around the world that both participate in and direct the most comprehensive technology-driven value chain research in the market. Through its continued fact-based research, benchmarking, and actionable analysis, Aberdeen*Group* offers global business and technology executives a unique mix of actionable research, KPIs, tools, and services.