

ARC BEST PRACTICES

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Plant Asset Management Best Practices for the Process Industries

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	People	Processes	Technology	Information
Ground breakers	<i>Executive sponsorship</i> <i>Cultural change program completed</i> <i>Use of 3rd party outsource</i> <i>Value-oriented decision making</i>	Strategy executed enterprise-wide Broad set of KPIs validated Cost and value orientated maintenance strategies deployed <i>All asset classes managed through single process</i>	<i>Integrated ERP, EAM, PAM, MES/CPM executed</i> Short return periods <i>Returns monitored</i> Comprehensive asset monitoring technologies deployed	Open standard integration <i>Global access to real-time PAM information</i> <i>Actionable contextual information</i>
Leader	Management and Workforce acceptance <i>Training and cultural change program developed</i> Generalized, cost reduction oriented business case	Plant-wide predictive maintenance strategy Broad set of KPIs applied Maintenance strategies focus on decreasing cost-oriented and increasing value Large set of asset classes managed in single process	Integrated EAM and PAM being deployed with returns <i>Mobile solutions deployed</i> Intelligent monitoring software deployed	<i>Consistent data management</i> <i>Single unified data model</i> <i>Increasing information flow between maintenance and operations</i>
Competitor	Maintenance management acceptance and workforce awareness Training and cultural change planned Awareness of need to balance cost and benefit	Local deployment strategies KPIs defined Various strategies heterogeneously implemented On-line and off-line asset management in separate processes	EAM and/or PAM deployed with variable returns Inconsistent deployment of technologies	Limited information transparency <i>Inconsistent data models and granularity</i>
Follower	Maintenance management awareness Skills awareness Cost orientated thinking	Time-based preventative maintenance Various cost-oriented strategies Little process awareness	Little awareness of asset monitoring methodologies and PAM	Manual processes and data entry <i>Islands of information</i>

Plant Asset Management Maturity Model

Note: Practices based on additional comments by respondents or from prior ARC research are in italics.

Executive Overview

The NAMUR Working Group 4.13 on Plant Asset Management (PAM) in cooperation with ARC Advisory Group created and distributed a survey to NAMUR members, to determine their perceptions and expectations of plant asset management systems (PAM). ARC presented preliminary results at the NAMUR General Assembly in November 2006. ARC and NAMUR made the survey public to general process industry users in December 2006. Overall, the survey had over 110 respondents.

Survey results show that PAM has the potential to deliver significant benefits to manufacturers. For now, awareness of and experience with PAM are low, but satisfaction is high among current PAM users surveyed. Few companies

Main Conclusions from the ARC-NAMUR PAM Survey

- There is a very large potential for PAM both in number of companies and in the extent of usage, in terms of methods and asset classes.
- Companies should invest in evaluating PAM solutions, and establish corporate strategies, including business process integration with other corporate processes.
- The technical basis for PAM is well established for field devices. There is a wide array of needs for further development of methods for asset classes outside of automation.
- Methods, standards, and integration (Interoperability) must improve to improve ROI on PAM solutions.

have PAM strategies, while many are interested in managing asset classes for which an automated PAM solution is not yet available. Users are mainly focused on operational and maintenance cost and timesaving, and despite the perception of benefit, many encounter difficulties in quantifying returns on PAM systems to justify the investment. Improved integration, data standards, interoperability, and availability of

monitoring methods improves benefits by lowering engineering and maintenance costs, and thus enhance the potential of PAM to offer additional economic profit to manufacturers.

This study examines the benefits and challenges reported by current users of PAM, as well as the perceived potential of PAM. It also analyzes the needs and expectations of users in terms of asset classes managed, monitoring methodologies, system functionality, engineering, and implementation perspectives.

PAM in the Landscape of Processes and Solutions

Asset Management and Maintenance Processes

Asset Management and Maintenance are intertwined and overlapping processes, and the differences and similarities between the two depend on the user’s perspective. Both have an effect on an organization’s cost structure and profit.

Calendar Time			
Available Time			Planned Downtime
Operating Time		Unplanned Downtime	
Net Operating Time		Speed Losses	
Valuable Operating Time	Quality Losses		

TEEP = Valuable Operating Time / Calendar Time

OEE = Valuable Operating Time / Available Time

Production Asset Availability

Maintenance is an activity associated with availability of production assets. Several key performance indicators (KPIs) for availability are in use today, including Overall Equipment Effectiveness (OEE) and Total Effective Equipment Productivity (TEEP). Maintenance is often seen from a cost perspective, consistent with an annual accounting view of the enterprise, rather than as a source of profit. Economic

profit, a measure of benefit, is the operating profit minus the cost of capital. The cost of capital includes interest for loans for investment in capital goods and the difference in actual value of the goods over the reported period.

If maintenance focuses on lengthening the effective life of assets while guaranteeing availability, this lowers the cost of capital by improving returns on existing capital goods. This reduces that amount of capital tied up in goods, by eliminating unnecessary assets and delaying capital investment. These financial mechanisms help to increase the added value of assets and

Economic Profit

Economic profit is a better measure for wealth creation, shareholder value or added value than profit, by taking the total cost of capital, including interests and depreciation into account.

enhance the company’s profits, contradicting the perception that maintenance activities only contribute to an organization’s costs. These mechanisms will realize their potential only then when the corresponding approaches and processes are put in practice.

Asset Management is associated with managing the life cycle of assets. This implies optimizing net value by maximizing utilization, minimizing cost and maximizing useful life. This broad view of asset management can include maintenance and the sourcing

of supplies and replacements. The definition in the NAMUR recommendation NE091 is “measures taken to conserve or enhance the value of a plant”, confirming the impact of asset management on value and economic profit.

The best long-term strategy for manufacturers is to optimize the value of the asset life cycle. However, this must not happen at the expense of production. The value an asset creates through production should be taken into account in this optimization. Asset Management should seek to ensure that the availability of plant resources just satisfies production requirements and constraints. A more narrow view of Asset Management sometimes encountered is:

- Asset health monitoring
- Diagnosis of health issues and decision support for remediation
- Predictions of remaining useful life before maintenance
- Proposing remediation
- Communication of the above

Viewed in this light, maintenance is seen as a complementary process to direct the strategy, planning and execution of maintenance intervention, and management of maintenance supplies. The sourcing of supplies can be regarded as an enterprise system task.

ARC’s view is that Plant Asset Management is restricted to the productive phase of the asset. Within the life of a plant, automation and IT solutions go through different cycles of installation, productive use, and decommissioning that require parallel management to accommodate the varying life cycles of the solutions. At times, enterprise solutions or processes operate autonomously using a single set of best practices and one software solution.

The opposite approach deploys a strong corporate Asset Management (AM) function, setting middle and long-term business-oriented PAM strategies, providing directives, tools and support, analyzing performances and setting standards and objectives, incorporating feedback and strategy updates, designing collaboration among plant asset managers, and with other functions, as sourcing, manufacturing and business units. This is the ideal steering or business process management required to optimize the performance of corporate plant asset management. This is a simplification, since PAM can attempt to find local economic optima consistent with corporate directives. A corporate Asset Management function would also

deal with the enterprise aspects of Asset Management, which are not discussed here.

Asset Management Systems and Solutions

PAM systems deploy analysis software that collects asset information and characteristics to identify potential asset problems. PAM systems use intelligence embedded in the assets and use various technologies (vibration, ultrasonic, IR thermography, modeling software, and others) to protect and predict health of assets. This information is used to optimize maintenance, plant operation, increase production availability, and enable a predictive maintenance and operations strategy. PAM solutions categorize criticality of problems as related to the operation of the plant, while linking operators to supplier, engineering, and quality control documentation to empower them with the necessary knowledge to manage assets effectively. PAM has two asset categories: Automation Assets and Production Assets.

Asset Class	Electrical	Mechanical
Production	Motors, Switchgear, Transformers, Drives, Wiring	Turbines, Compressors, Fans, Gear Boxes, Conveyors, Grinding Mills, Extruders, Dryers, Pumps, Pipes, Heat Exchangers, Tanks, Boilers, Furnaces
Automation	Pressure, Temperature Flowmeters, Level Meters, Miscellaneous Sensors, Analytical, Switches	Control Valves, Positioners, Associated Equipment

PAM systems are typically integrated with higher-level systems, such as EAM, for maintenance management activities and manufacturing operations. Manufacturers are increasingly using EAM software applications to help schedule and manage their maintenance functions. EAM systems manage and optimize scheduling, workflow, inventory, purchasing, and other related maintenance activities.

Study Methodology

Asset Management was the theme of the NAMUR general assembly in November 2006. To prepare, the NAMUR Working Group 4.13 on PAM

decided to conduct a survey of NAMUR members on their perceptions and expectations of Plant Asset Management, and the PAM systems designed to facilitate that process. The goal was to present the results at the general assembly. ARC Advisory Group, a member of the PAM working group, helped to develop the survey and make it available on-line. The survey was advertised among NAMUR member companies, and received approximately 60 responses before the general assembly. After that, NAMUR and ARC opened up the survey to all process industry users, and received another 50 responses. We estimate that the respondents to the survey include 70 NAMUR members, 30 process industry professionals, and about 10 suppliers, many of whom are PAM implementation consultants.

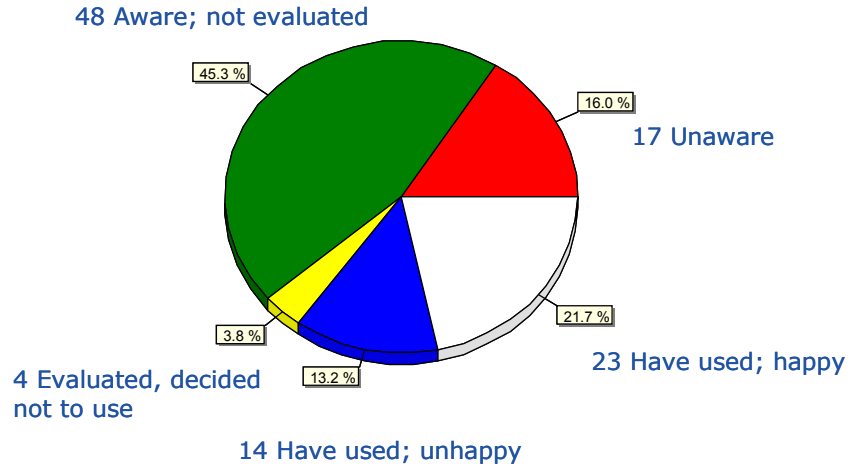
Practices and strategies have been ranked against the respondents' assessment of the benefits perceived and a performance metric of the of a PAM implementation. We report behavior, opinions and practices when more than two thirds of respondents agree, or distributions of practices that shows clear trends. These calibrated, best practices are summarized together with the other survey results and are presented as a PAM maturity model on page 2.

Study Results

Awareness

Are You Aware of Plant Asset Management?

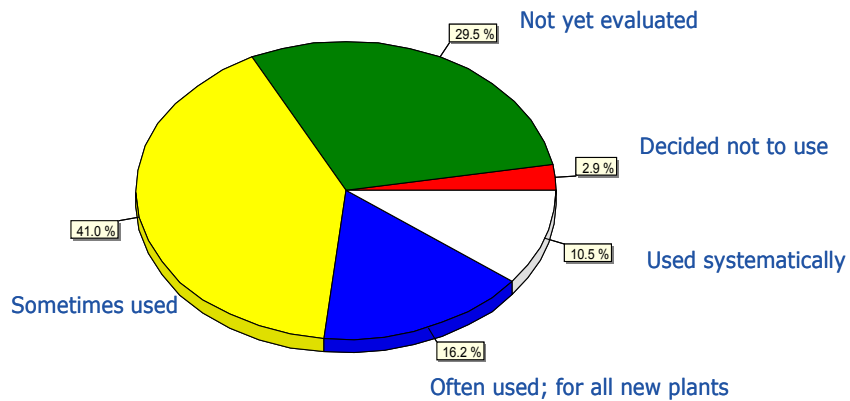
Over 85% of respondents are aware of PAM, but almost half of them have not evaluated a PAM solution. About a third of respondents have used PAM, and among those, a little less than two thirds are satisfied. If we assume that the same proportion of the respondents, who have not evaluated a solution yet, would be satisfied if they did, this leaves a great potential for future satisfied users.



Are You Aware of Plant Asset Management?

Is PAM Used in Your Company?

This question refers to the company of the respondent, and not to his personal experience, as was the case in the preceding question. Apparently, respondents' companies use PAM much more than respondents themselves: over 65 % use PAM to some degree.

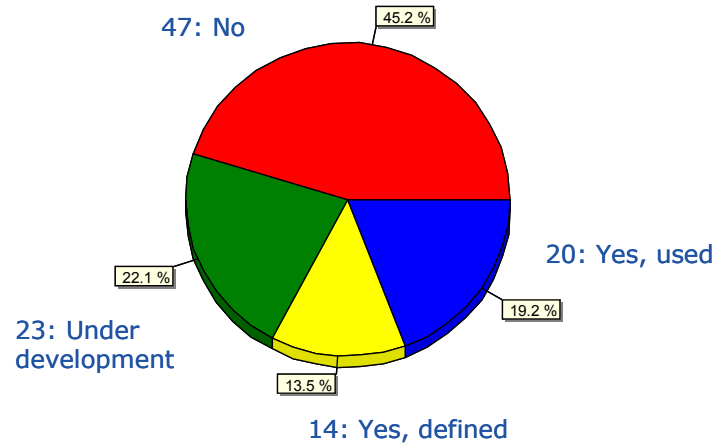


Is PAM Used in Your Company?

Does Your Company Have a Formal Asset Management Strategy?

About half of respondents' companies have a strategy for PAM. This is significantly smaller than the 70% using an Enterprise Asset Management (EAM) solution. It would appear therefore that EAM is not always chosen for strategic reasons. With more than 45% of the companies having no strategy for PAM, it is not surprising to find important proportions of professionals who are unaware or have not had the opportunity to evaluate

these solutions. The question remains open if this cause and effect relationship were taken in the right direction: if professionals demonstrated clear support for PAM solutions, enterprise management may be inspired to develop strategies for PAM. For those companies using PAM, but without a strategy, this may be an opportunity to support the practice with an effective strategy to improve ROI from these solutions.



Does Your Company Have a Formal Asset Management Strategy?

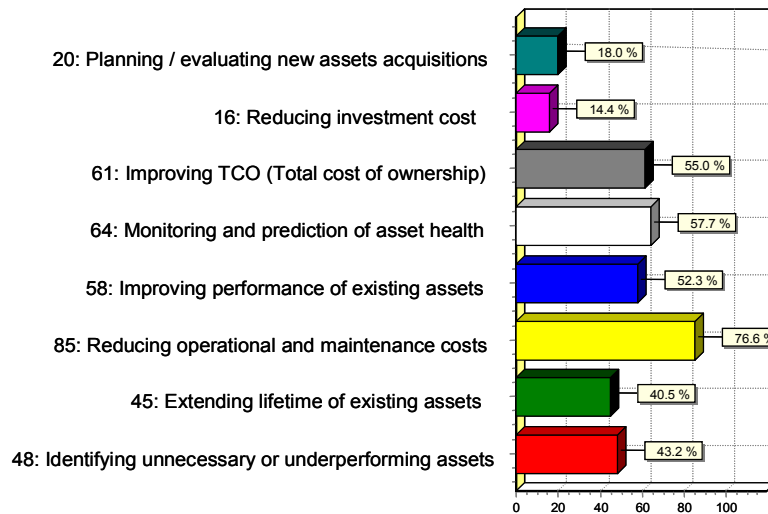
Needs and Expectations of Users

Which Aspects within Plant Asset Management Are of Special Importance to You?

'Reducing operational and maintenance cost' is by far the most important aspect of PAM to respondents, followed by:

- Improving TCO
- Monitoring and prediction of asset health
- Improving performance of existing assets

Our interpretation is that the strategy in operations is focused on controlling operational and maintenance cost because of their effects on a company's profit. Apparently, less attention is paid to the longer-term life cycle cost/benefit of assets (planning capital investment, extending asset lifetime) that could be supported by an EAM/PAM strategy, although the financial rewards from this approach could be very significant. This is likely related to incentives for operations and maintenance professionals, which may be calibrated to meeting asset availability objectives over the short term. It is also important for maintenance and production to identify asset health and underperformance and improving performance of existing assets.



How Important Is On-line Plant Condition Information to You?

On-line PAM information is considered very important. This should be seen in the context of the asset classes considered, the limited availability of asset monitoring methods for some of those classes, and the hurdles that respondents report in applying PAM, such as a lack of integration, standardization, and interoperability.

Importance	Number of Responses	Percentage of Responses
Extremely important	41	39%
Very important	46	43%
Important	18	17%
Somewhat important	1	1%
Not important	0	0%

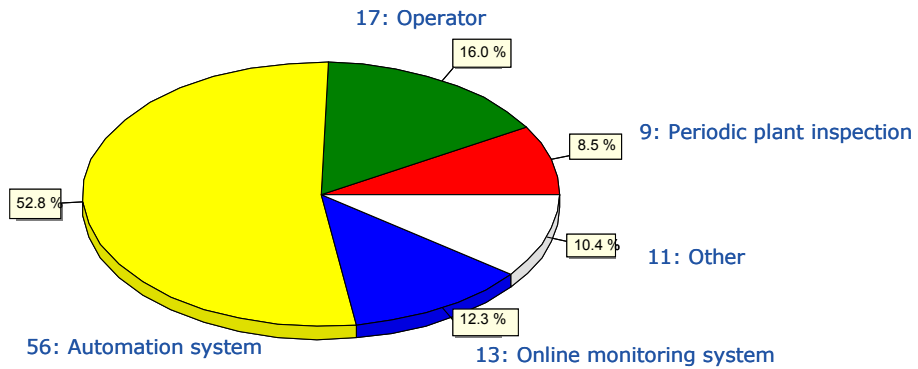
Importance of On-line Plant Condition Information

Status of Plant Information

What Is Your Primary Source for Plant Condition Information?

The vast majority of plant condition information stems from control systems or on-line monitoring systems. This is consistent with the large importance respondents placed on having access to on-line information. At the same time, it means that the asset classes, for which no on-line monitoring methods are yet available, that is, the majority, will be less monitored than the others will. This is likely due to the high cost of on-line systems and low

levels of staffing in maintenance, automation, and operations to implement new monitoring infrastructure.



What Is Your Primary Source for Plant Condition Information?

Are You Satisfied with the Quality and the Relevance of Plant Information?

Respondents were somewhat satisfied with both relevance and quality of the information. However, there is room for improvement, given that many respondents are neutral regarding the importance of the information.

Satisfaction Level	Quality (Amounts)	Quality (Percent)	Relevance (Amounts)	Relevance (Percent)
Very satisfied	6	6%	5	5%
Satisfied	36	35%	39	37%
Neutral	45	43%	36	35%
Not satisfied	16	15%	19	18%
Not satisfied at all	1	1%	5	5%

Importance of On-line Plant Condition Information

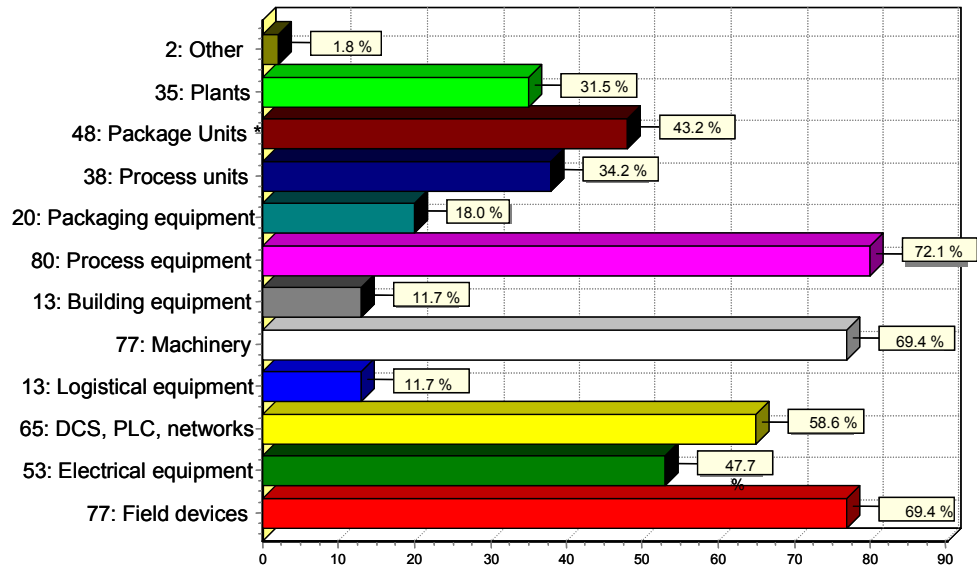
Asset Classes

Which Asset Classes Would You Consider for PAM?

For the respondents the most important asset classes are:

- Process equipment
- Machinery
- Field devices
- DCS, PLC and networks
- Electrical equipment

It is interesting to note that machinery and process equipment are mentioned here, given that PAM solutions for these assets are limited. Surprisingly enough, these asset classes scored higher than DCSs and PLCs. These answers are even more surprising as plant engineers and managers are a minority among the respondents (see “Profile”).



For the above categories, PAM solutions are only available for field devices and rotating and reciprocating machinery. Solutions for networks, DCS, PLC, and electrical equipment are not widely available, but are available from a few select suppliers. In addition, information standards only exist for field devices. That implies that PAM can only partially satisfy user needs, and implies that there are additional costs to engineer and maintain these asset classes. For PAM implementations to be more effective, information standards are needed for these equipment classes. Until then, successful PAM implementations may face significant hurdles.

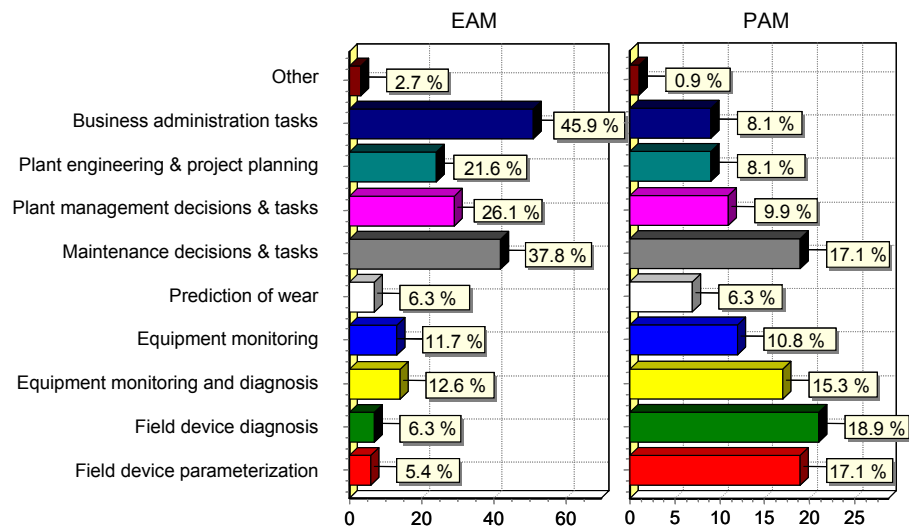
Enterprise and Plant Asset Management Experience

Do You Use an EAM or a PAM System?

About 70 percent of respondents use an EAM system for high-level asset management and maintenance activities. The inverse is true for PAM. Only about 30 percent reported using an IT system specifically dedicated to PAM purposes.

What Functions Do Those Systems Support?

Those who reported using an EAM or PAM system also answered which functions their EAM or PAM systems support. The EAM systems largely support management functions, while PAM systems are primarily used for plant support functions. Interestingly, responses for individual functions limit at about 50% of the respondents, which indicates there is not one single function that is supported by all applications. It is also interesting to note that both types of systems cover all functions, although in different proportions. For larger enterprises, this opens up possibilities for interoperation between PAM and EAM systems, collaboration between users and cascaded business processes. If aggregated PAM information can be synchronized with the EAM system, this would make the EAM more valuable and create savings for the organization. This raises further questions: is collaboration and interoperation feasible from a users' perspective? To which degree is it used? What is the degree of success was obtained?



Which Functions Do Your EAM and PAM Systems Support?

Do You Capture, Manage, and Evaluate Information About Plant Conditions Centrally?

Many users capture, manage, and evaluate information about plant conditions centrally in EAM or PAM systems. In their comments, many also mention using ERP and CPM systems, and capturing test results and other data for analysis. Some exploit the data for preventative maintenance programs, while others archive all maintenance activities.

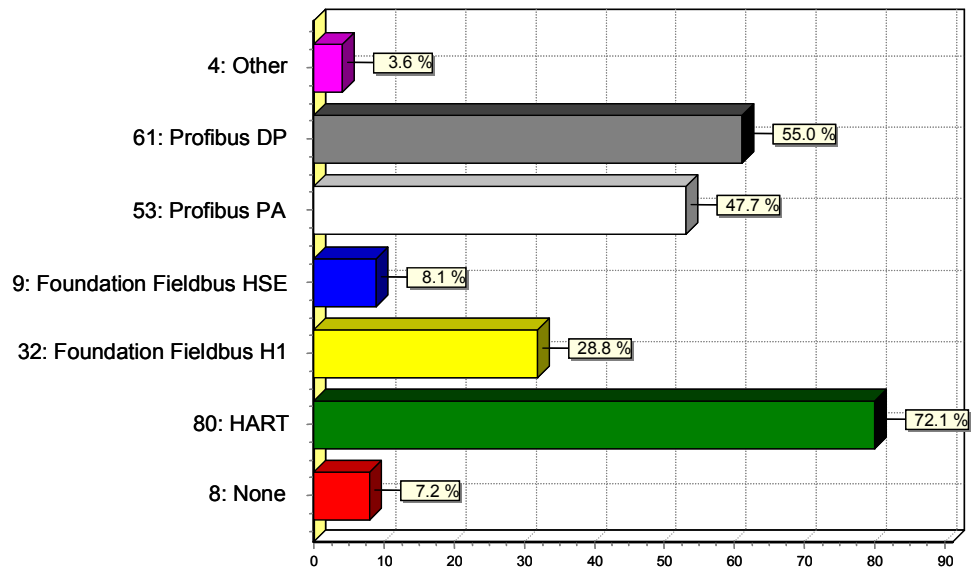
Centralized Management	Number of responses	Percentage of responses
Yes	41	41%
In Part	33	33%
No	17	27%

Central Management of Plant Condition Information

Technical Basis for PAM and Obstacles Perceived

Do You Have Field Devices with Communication Capabilities?

Responses show a clear dominance of HART (80) and PROFIBUS PA (61) Technology. This is not surprising, given that the majority of respondents are European. In absolute terms, the penetration of communicative devices is high, so the infrastructure required to manage field devices is largely present. However, for other types of equipment, particularly the rotating equipment considered as critical for the process industry, such as the majority of pumps, no communication capabilities are currently available.

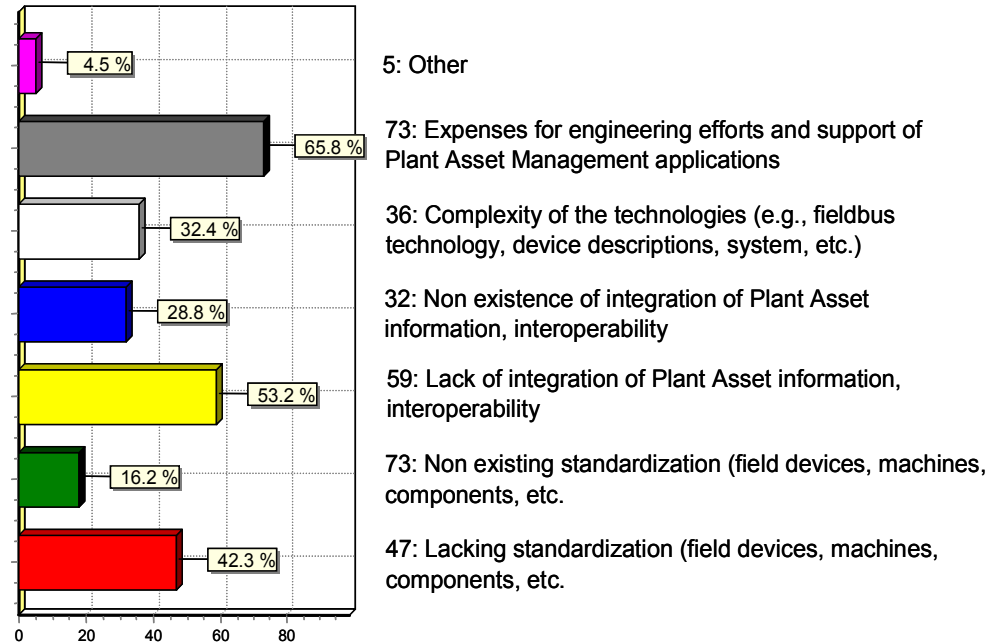


Most Respondents Used Profibus and HART for Field Device Communication

What Obstacles Do You See for the Technical Realization of Plant Asset Management Functions in Your Plant?

The main obstacles mentioned for implementing PAM were:

- Expenses for engineering efforts and support of PAM applications
- Lack of integration of Plant Asset information, interoperability
- Lack of standardization (field devices, machines, components, etc.)



What Obstacles Do You See for the Technical Realization of Plant Asset Management Functions in Your Plant?

Do These Obstacles Prevent the Further Application of Plant Asset Management Solutions?

Apparently, the obstacles that professionals perceive could limit further penetration of PAM, even if many of them recognize the potential benefits and attach high importance to on-line asset and condition information. About 80 percent of respondents feel that these technical obstacles prevent the further application of PAM solutions. The effort to engineer and maintain a PAM system is seen as the most significant obstacle. This concern about cost likely makes it difficult for middle and lower level managers to make a credible business case for implementing PAM at their companies. This is attributed to the scarcity of automation and maintenance personnel that the industry often mentions. Many also see building business cases for PAM as difficult. Professionals may not have sufficient expertise and resource availability to do business cases altogether. ARC believes both points relate to the singular focus on operational and maintenance cost that respondents mentioned. The current business case only considers operational cost saving and does not sufficiently consider the impact on

capital cost resulting in less convincing returns. This in turn explains low awareness at executive levels and lagging progress on Asset Management strategies.

Category	Obstacles
Complexity	Engineering, implementation, and maintenance of PAM (#1) Infrastructure required Too many interfaces
Infrastructure	Lacking equipment/technology Lacking integration (#2) Historically grown, heterogeneous structure difficult to deal with
People	Lacking knowledge/training Lacking resources Maintenance strategy is rigid
Standards	Too many fieldbus standards (#3) Missing PAM standards / lack of seamless integration (#3) Too many proprietary solutions Too many information formats
Cost/Benefit	Cost too high Benefits not supported / not easy to prove / not known Investment justified on price instead of benefit
Miscellaneous	Missing modularity / difficult to build up step by step Maintenance strategy is rigid

Additional Obstacles Mentioned by Respondents

When respondents mention a lack of standardization and interfacing capabilities, as well as excessive complexity of technology, they probably indirectly refer to the expense of engineering and maintenance. Providers can exploit these levers to lower the threshold for PAM.

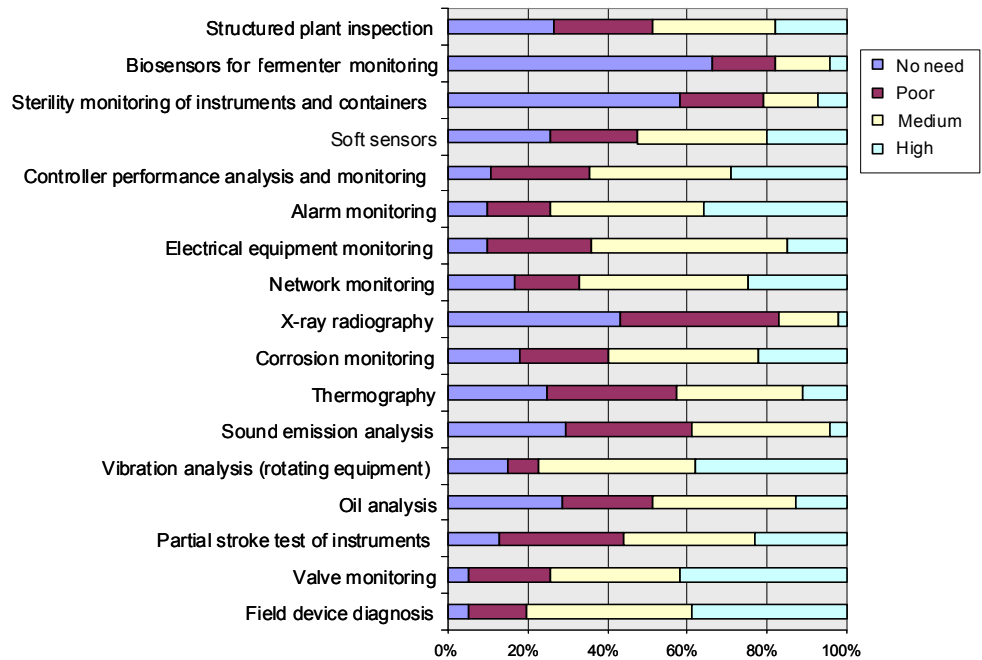
Asset Monitoring Methods

What Potential Would You Attribute to the Following Asset Monitoring Methods in Your Domain?

Monitoring methods that have high potential according to respondents are:

- Field device diagnostics
- Valve monitoring

- Vibration analysis
- Alarm monitoring



These are on-line methods existing today, and their potential and value to the organization are not difficult to recognize. Monitoring methods given a “medium”

- Partial stroke test
- Oil analysis
- Sound emission
- Thermography
- Corrosion monitoring
- Electrical equipment monitoring
- Controller performance
- Soft sensors
- Structured plant inspection

Low potential is attributed to:

- X-ray radiography
- Biotechnology methods

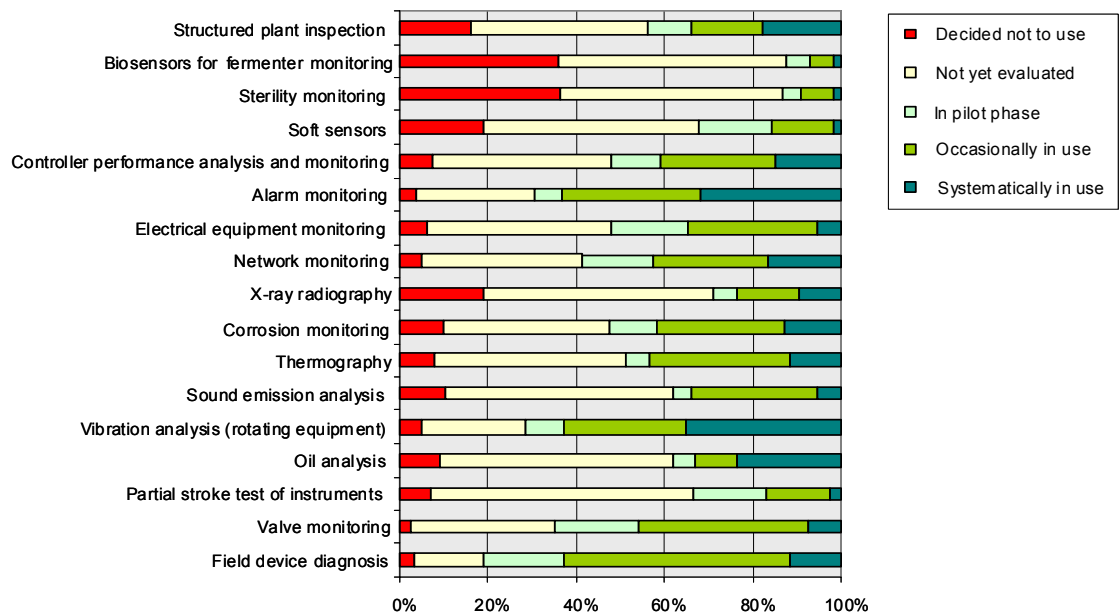
That the biological methods do not score high is understandable based on the low representation of biotechnology operations in the survey. X-ray and

corrosion monitoring are seen as having low potential, probably within the context of the current PAM systems.

What Is Your Experience with These Methods?

Many monitoring methods still need to be evaluated by users. The methods that are most often used, and thus more familiar to respondents, are also identified as having the highest potential:

- Field device diagnostics
- Vibration analysis
- Structure plant inspection



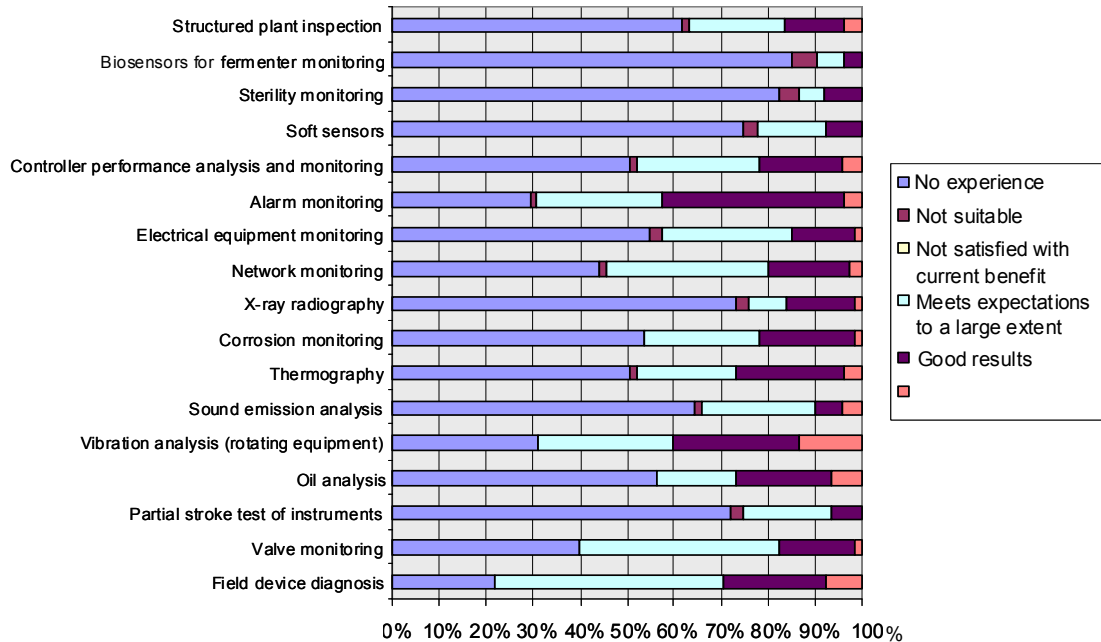
Methods believed to have high potential but less used in practice include:

- Valve monitoring
- Network monitoring
- Electrical equipment monitoring
- Alarm monitoring
- Controller performance

Based on Your Experience, Please Evaluate These Methods for Benefit and Adequacy

Many respondents reported having “no experience” with most methods, and this result corresponds to the group who have not yet evaluated these functions. Good and reasonable results were obtained with:

- Field device diagnosis
- Valve monitoring
- Vibration analysis
- Network monitoring
- Alarm monitoring
- Controller performance monitoring
- Structured plant inspection



Poor results are obtained with:

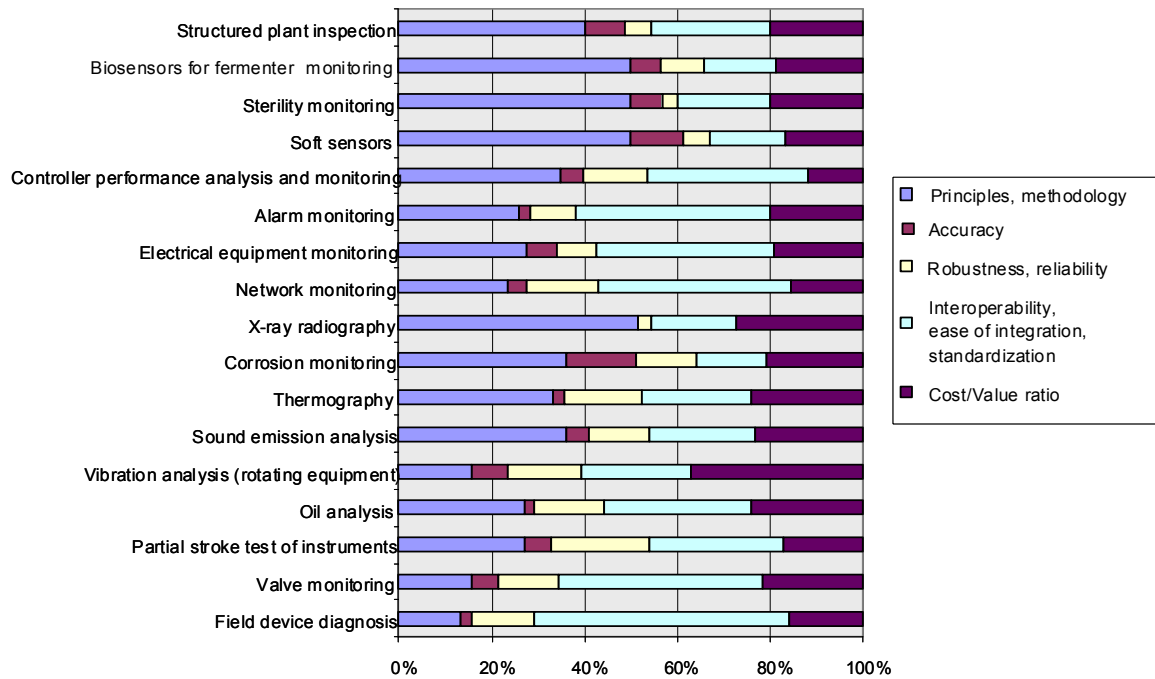
- Oil analysis (cited for medium-high potential)
- Partial stroke testing (cited for medium-high potential)
- X-ray radiography
- Biological methods

This is consistent with the potential identified for those methods and indicates a prudent approach on the part of respondents, who may need more experience or knowledge about these functions.

Which PAM Monitoring Methods Require Improvement?

When asked about possible improvements to monitoring methods, respondents voiced clear needs for improved interoperability and integration for methods that yield reasonable or good results today. For all methods, respondents cited a need to improve the cost/value ratio, most likely related

to the concern of cost of engineering and maintenance for PAM applications. Given their high scores for “principles and methodology” improvements, it is clear that X-ray radiography and soft sensors may not be well understood as monitoring methods by respondents. Soft sensors are a well-documented and proven technology in process engineering. This knowledge needs to be better communicated. Respondents see vibration analysis as costly.

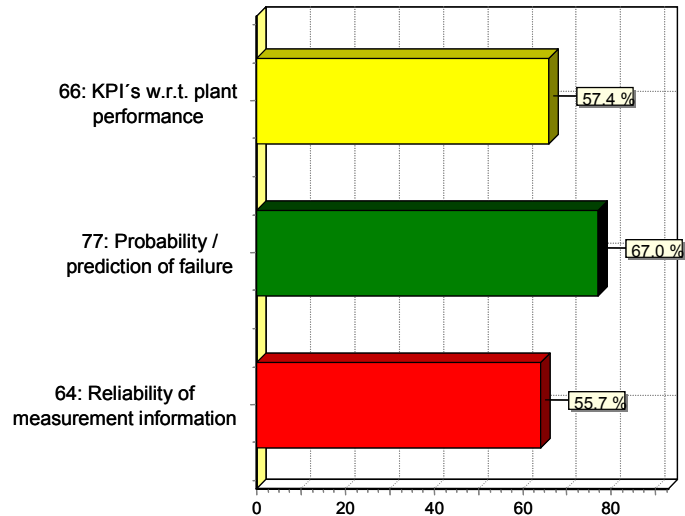


Plant Asset Management Functions

Which of the Following Functions Should a PAM System Support?

Plant Operations

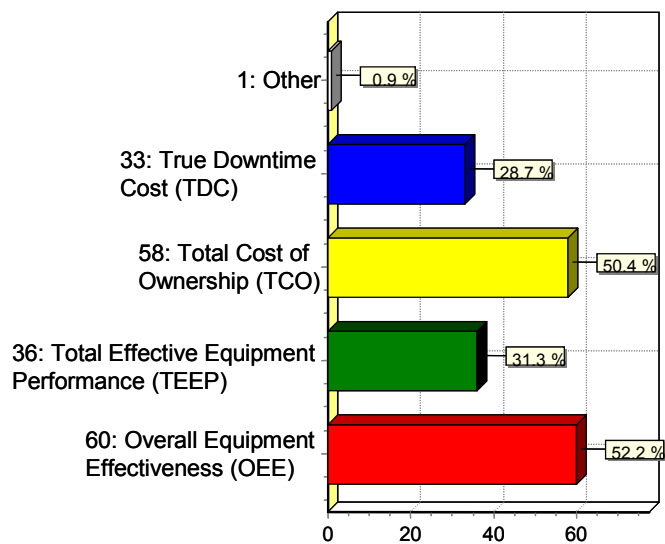
Prediction and probability of failure are most important. Plant performance KPIs score highly too. Apparently, this is not an aspect of interest exclusively to managers, since the majority of participants are professionals without management roles. The interest in KPIs is encouraging, since plant performance is a measure that has a strong effect on the bottom line. PAM should therefore include management functionality for use in the plant. It can play a role in collaboration with corporate functions and across business units when EAM and PAM are well integrated.



The reliability of measurement information also scores well. ARC believes this is required to be able to judge its relevance and precision, in order to improve the quality of decisions made based on measurements.

Asset Performance Management

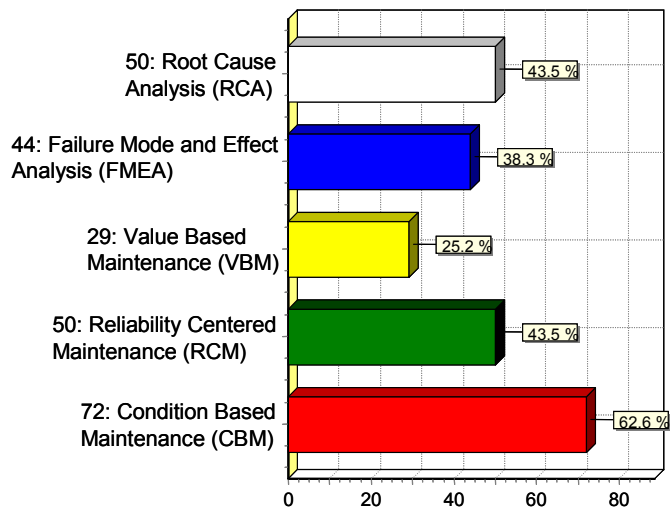
Respondents attach more importance to Overall Equipment Efficiency (OEE) and Total cost of ownership (TCO) than to Total Effective Equipment Performance (TEEP) and True Downtime Cost (TDC). ARC believes that the difference in meaning between OEE and TEEP is not enough to explain the difference in scores. Likely, OEE is simply better known among respondents. For TCO and TDC the answers may be influenced by a similar effect. TCO concerns the full asset life cycle, where TDC focuses on the non-productive time only. No other functions were mentioned.



Asset Maintenance Strategies

Condition Based Maintenance (CBM) has the highest score, followed by RCA and Reliability Centered Maintenance (RCM), where Value Based Maintenance (VBM) scores lowest. This indicates that professionals are more in reactive (CBM) than in proactive mode Failure Mode and Effect Analysis (FMEA) and Root Cause Analysis (RCA). ARC believes that some of these strategies can be explained based on industry needs and process economics:

- RCM could make more sense in a sold-out situation where maximizing production volumes is more important than anything else (as is true in refining currently),
- CBM would correspond more to a maintenance and operational cost reduction strategy, which most respondents appear to attach great importance to, and may indicate that their production equipment may be operating at less than full capacity.

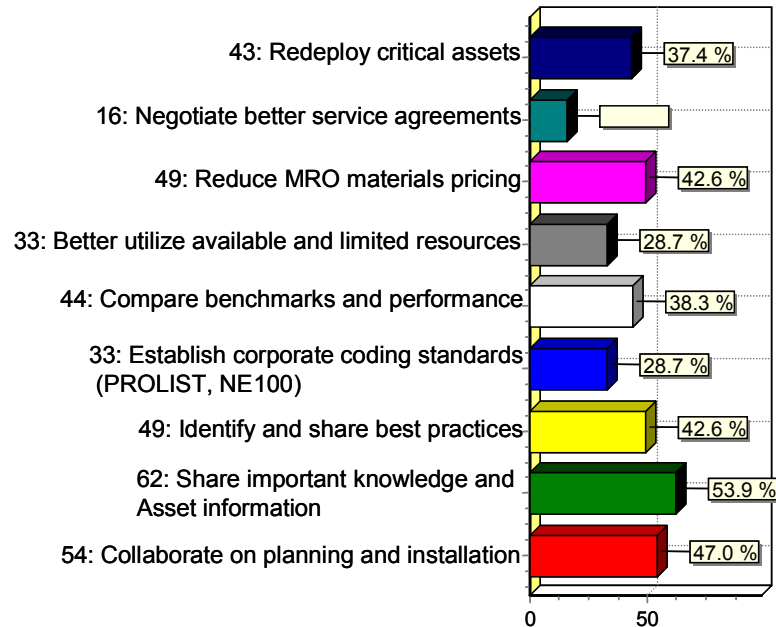


The more proactive strategies, such as RCA and FMEA, should give better results long term. To determine the results from each more objectively, Value Based Analysis would be a valuable tool. ARC recommends that manufacturers shift their attention to these strategies, and to shift from condition-based to predictive maintenance practices.

Asset Lifecycle Management

Survey respondents generally mention three or four of the functions proposed, but seem to be divided as shown from the spread of responses. The highest rated functions include:

- Redeploy Critical Assets
- Reduce MRO materials pricing
- Share knowledge and asset information

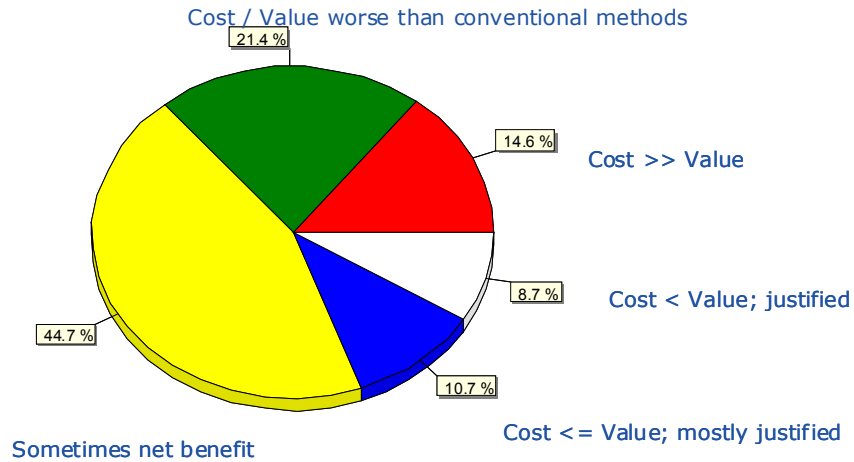


Redeploying Critical Assets and MRO pricing are cost driven; this is consistent with the importance users place on reducing operational and maintenance costs. “Sharing knowledge and asset information” and “collaboration on planning and installation” are time and resource driven.

Benefit Expectations

What Is Your Valuation of the Cost/Benefit Ratio for PAM?

Respondents are divided among those who believe the cost of PAM is justified, and those who believe there is a net cost. It cannot be concluded from the data if a majority of the cases there is net benefit or not: it depends how the response “sometimes net benefit” is interpreted. In any case, a fair number of companies appear to have realized net benefits, where others have yet to see a payback. In the report section “PAM Maturity Model”, these benefit perceptions are correlated with a company’s practices, to provide opportunities for users to improve perceived benefits.



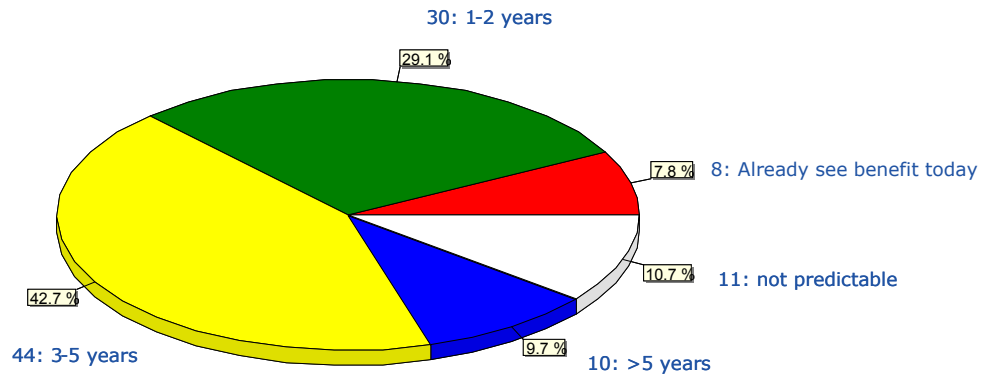
In Which Areas Do You See Most Benefits from PAM Systems?

Most respondents emphasize the optimization of asset use, by improving reliability and efficiency, followed by “value enhancement”. Interestingly, the reduction in demand for new assets is not seen as very important. In our view, however, this overlaps with “Value enhancement” in the sense of diminishing capital tied up in assets. Users probably underestimate the importance of reducing capital requirements for economic profit.

Areas of Benefit	Percent Response
Providing all time and asset-dependent information for decision support.	21.2%
Value enhancement by evaluating asset options and reducing maintenance costs	23.2%
Reducing the demand for new assets by using demand management and maintaining current assets	7.1%
Optimize asset use and manage all maintenance efforts involved by making assets as reliable and efficient as possible	44.4%
Administration of assets	4.0%

When Do You Expect to Realize a Reasonable Benefit from PAM Applications?

Among respondents, there is a clear expectation of receiving a net benefit from PAM applications over the short and middle term. It cannot be concluded if users’ expectations are based on current or future PAM capabilities.

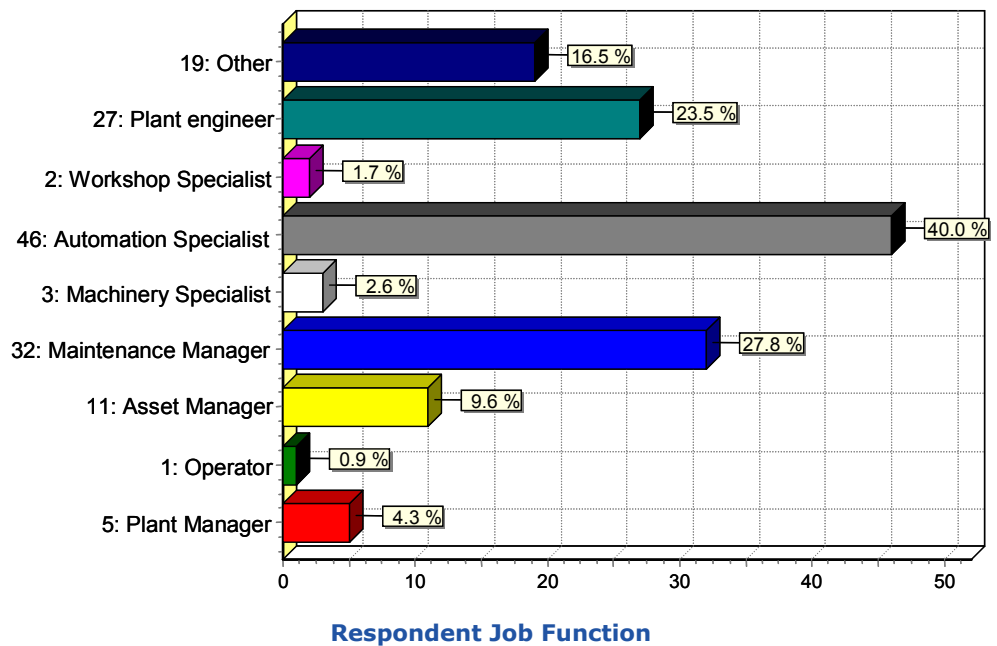


Respondent Profile

Function

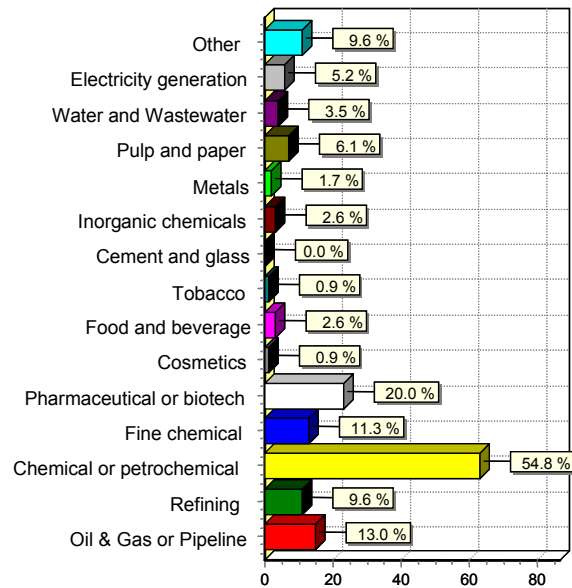
The majority of respondents were Automation Specialists (40%), Maintenance Managers (28%), or Plant Engineers (24%).

Among respondents, it appears that Asset Manager is probably yet a widespread function. However, with more plant managers and operators participating in the survey, a comparison of practices and opinions between maintenance, automation, and production is possible.



Industry

About half of the respondents on the survey belong to member companies of NAMUR. The majority of respondents were in the chemical or pharmaceutical industries, but there is a broad representation from almost all process industries, particularly oil & gas and refining.



Respondents by Industry

Survey Conclusions

From the results of the survey, it is clear that there is a very large untapped potential for PAM solutions.

- Many are either unaware or have not evaluated PAM solutions.
- About half of the users perceive net benefits.
- There is an important need for on-line plant asset information for a wider array of asset classes.
- There is pressure to reduce the engineering and maintenance effort for PAM systems, as well as operations and production costs.
- PAM strategies can become more proactive and more value-oriented.
- Both management and maintenance functions are required in PAM. There is great potential for business process and application integration between PAM and EAM.

- The technical basis for PAM is well established for field devices. Users are demanding further development of a wide array of monitoring methods for asset classes outside of automation and electrical equipment.
- Methods, standardization, and integration must improve in order to lower engineering and maintenance cost of systems. This will lower the threshold for further usage and boost benefits for the industry.

Plant Asset Management Maturity Model

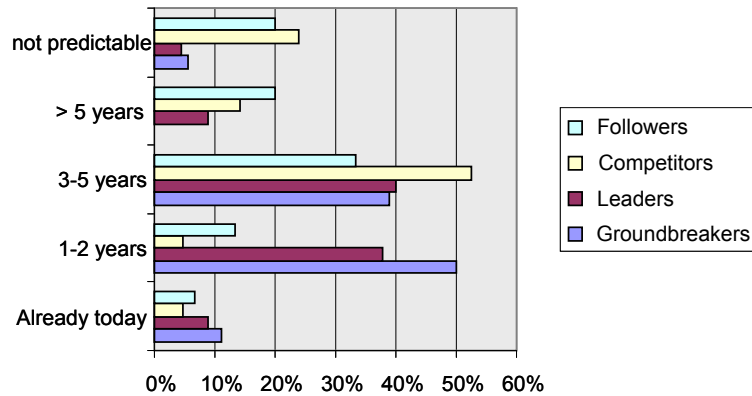
The main performance indicator for PAM in the survey is the cost/benefit valuation. The first two categories are too small to yield significant results when studying their practices, so they have been grouped together in a single category “Groundbreakers”; the others are “Leaders”, “Competitors”, and “Followers” in the order of benefits perceived.

Expected Return Period for PAM

Respondents’ expectations about the period for a return on their PAM investment are more or less consistent with the benefits they perceive today. Groundbreakers have shortest expectations for a return period, while Followers have the longest. Competitors and Leaders fall somewhere in between. Competitors and followers seem to have more difficulty in estimating returns from PAM investments than do Leaders and Groundbreakers. Interestingly there is a small group across all ranks of 5-10% that already perceives a benefit from PAM. Respondents who expect to see a return on PAM in 3-5 years are well represented in most categories, although less so among Groundbreakers and Leaders.

Cost / Benefit Valuation	Ranking	Number of Responses	Percentage of Responses
Benefit predominates, costs are justified	Groundbreakers	9	9%
Benefits greater than or equal to costs	Groundbreakers	9	9%
Benefits may or may not be equal to costs	Leaders	45	45%
Cost/benefit ratio is worse than that of classical methods	Competitors	21	21%
Costs are much higher than the total value of benefits	Followers	15	15%

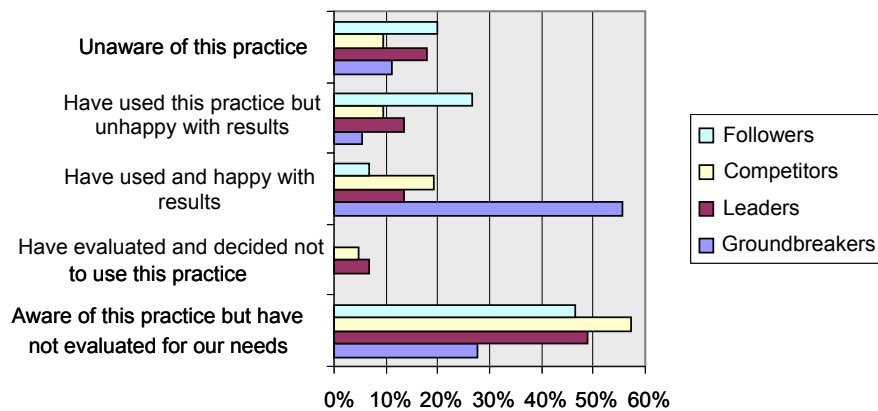
Cost/Benefit Ratios for PAM



Expected Return Period by User Ranking

Awareness

Groundbreakers have significantly more happy experiences with PAM. Lower ranking enterprises have lower usage of PAM solutions and lower level of satisfaction. The total awareness of PAM does not vary much by their rank. It may seem contradictory that some Groundbreakers have not evaluated PAM; however, individual respondents of Groundbreaker enterprises may not have had hands-on experience with PAM, while many of their peers are using it successfully.

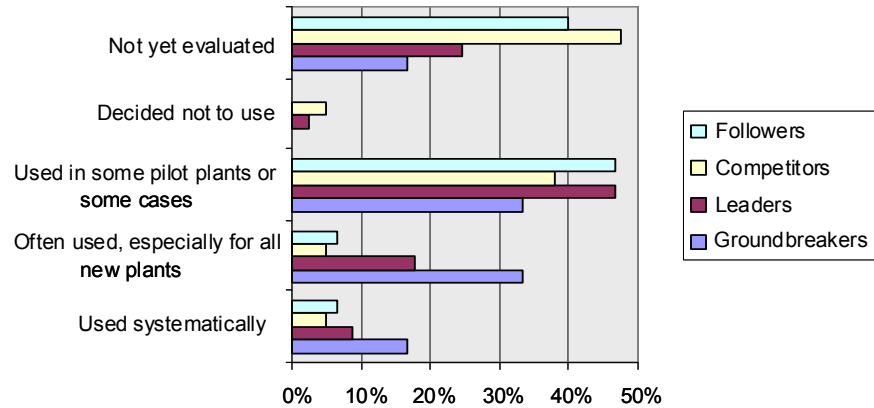


Awareness of PAM by User Ranking

Usage and Obstacles

Groundbreakers also use PAM more systematically, and more often in new plants. For Leaders the trend is similar but less pronounced. Followers and Competitors tend to have not evaluated PAM yet, or are significantly less systematic in their use of PAM.

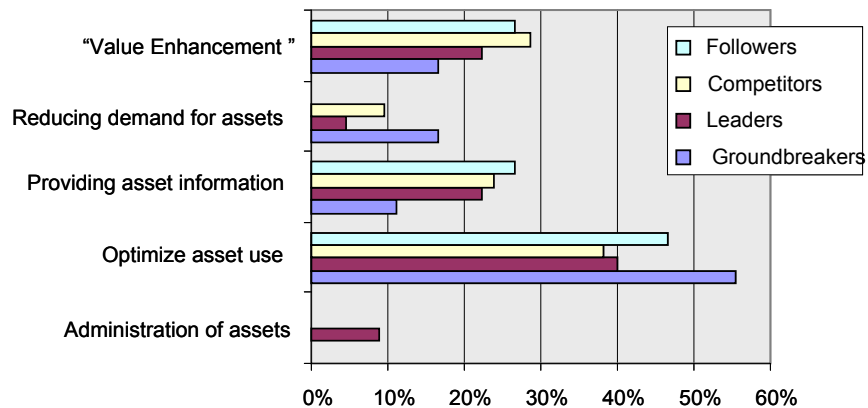
All user categories felt that the expense for engineering and support is a significant obstacle for PAM implementation. Groundbreakers and Leaders see lacking interoperability of PAM as an integration obstacle, where Followers mention lack of standardization. Apparently Groundbreakers and Leaders have can perceive the benefits from having integrated systems, where Followers are more focused on the connectivity of the PAM system with plant equipment.



Usage of PAM by User Ranking

Benefit Areas and Important Aspects of PAM

With increasing rank, respondents have less of a short-term, cost-reduction focus (“Value Enhancement”) and see slightly less value in providing asset information. Instead, they attach more importance to value generated by reducing capital investments in new assets and to increasing the reliability and efficiency of assets. Administration of assets shows up only in the category of leaders.

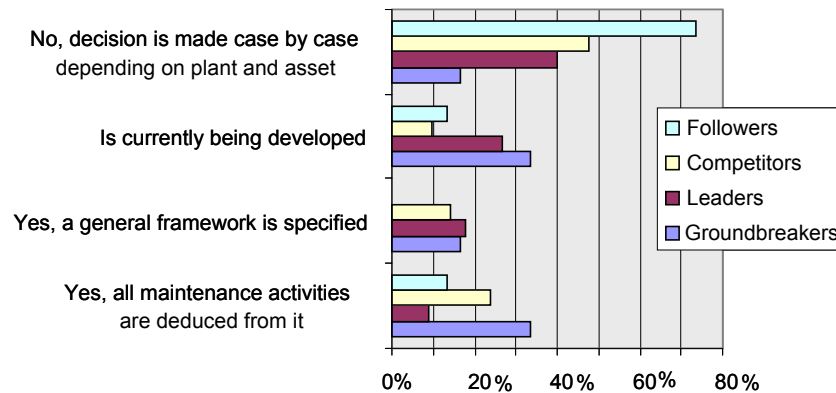


PAM Benefit Areas by User Ranking

All categories mention in significant proportions that “Reducing operational and maintenance cost” is an important aspect of PAM for them. Groundbreakers and Leaders, indicating their interest in predictive and preventive maintenance, mention “Monitoring and predicting asset health”. Competitors mention “improving performance of assets”.

PAM Implementation Strategy

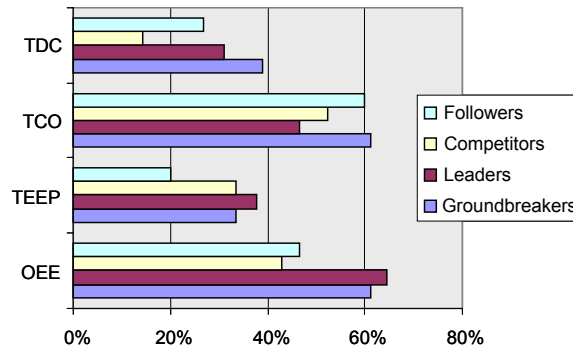
The lower the ranking, the less uniformity companies have in implementing PAM and the less well defined their asset management strategy tends to be. Among Groundbreakers, we find over 30% of respondents have corporate strategy from which all maintenance activities are derived, including PAM implementation. Groundbreakers also have the most respondents reporting that a strategy is being developed. In the Followers, asset management strategies are least developed, as indicated by the highest rate of “case-by-case” decisions on PAM implementation. This result is consistent with the global trend of using strategies and business process as uniformly as possible throughout the enterprise for a maximum of benefits.



PAM Implementation Strategy by User Ranking

Asset Performance Management (KPIs)

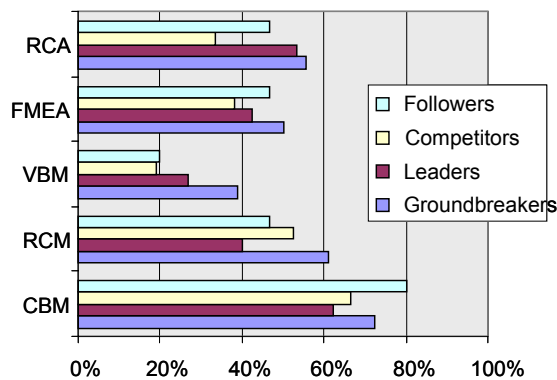
OEE and TDC are clearly used more as Asset Performance Management metrics by Groundbreakers and Leaders than by Competitors and Followers. Followers use TEEP much less than other categories. The general trend is that the higher the rank, the more balanced the use of KPIs in terms of cost and benefit orientation, and the greater number of KPIs are being used in parallel.



Asset Performance Management (KPIs) by User Ranking

Asset Maintenance Strategies

Groundbreakers and Leaders are more likely to use Root Cause Analysis and Value Based Maintenance. In Reliability Centered Maintenance, a similar trend seems apparent, although Leaders are an outlier in the series. Failure Mode & Effect Analysis and Condition Based Maintenance are in use throughout the sample of respondents. The higher the rank, the more balanced the use of strategies and the more strategies in use simultaneously.



Asset Maintenance Strategies by User Ranking

PAM Maturity Model

From the analysis of practices ranked by the benefits they bring to users, a maturity model of has been constructed (see inside cover). Those practices that have been calibrated to the ranking by the analysis above are printed in black. Practices based on additional comments by respondents or from prior ARC research are in italics.

Recommendations for Best Practices

1. Audit the enterprise to determine the status of previous asset management initiatives, identify critical assets, deployed business and process communication standards. Use this information to define a corporate asset management strategy. Identify asset management critical goals & objectives, scope of solution by type of plant. Inform and train personnel to create an Asset Management culture and deploy the strategy throughout the enterprise.
2. Consider value creation and cost reduction in business cases for implementing asset management. Include intangibles such as cultural change and the “buy-in” of all stakeholders. Prioritize projects, and approve projects based on business cases. Monitor the value delivered by these projects.
3. PAM and EAM solutions are complementary and both should be adopted. Consider deploying a PAM solution first since PAM will help to maximize the productivity of an EAM system. By including both in the implementation plan, interoperability will be ensured with minimal customization.
4. In implementing PAM, focus activities on key asset classes: Process Equipment, Field Devices, Machinery, and automation networks. Include new classes as asset monitoring methods become available. Consider PAM solutions that reduce the cost and labor of maintaining a separate AM network.
5. Adopt FDT/EDDL to improve flow of information from assets to AM solutions, and transition to FDD UA as soon as available.
6. Transition from a preventative maintenance culture to a reliability-based predictive maintenance culture. This effort includes workforce and management training, new work processes, and performance management.

7. Collaborate with suppliers to
 - Improve standardization of data formats and interfaces
 - Improve the level of self-configuration, self-maintenance and self-healing of PAM systems to reduce the cost of engineering and support.
 - Obtain modular solutions that can be implemented without production disruption or upsets.
 - Increase the number of available asset monitoring methods for an increasing set of asset classes.
8. End users should join standards committee to support the creation and approval of asset management standards

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Acronym Reference: For a complete list of industry acronyms, refer to our web page at www.arcweb.com/C13/IndustryTerms/

AM Asset Management	PAM Plant Asset Management
CBM Condition Based Maintenance	PLC Programmable Logic Controller
CPM Collaborative Production Management	PLM Product (Process) Lifecycle Management
CPS Collaborative Planning and Scheduling	OEE Overall Equipment Efficiency
DCS Distributed Control System	RCA Root Cause Analysis
EAM Enterprise Asset Management	RCM Reliability Centered Maintenance
ERP Enterprise Resource Planning	ROI Return on Investment
FMEA Failure Mode and Effect Analysis	TDC True Downtime Cost
KPI Key Performance Indicator	TCO Total Cost of Ownership
MES Manufacturing Execution System	TEEP Total Effective Equipment Performance
MRO Maintenance, Repair & Operations	VBM Value-Based Maintenance

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