Improving Operational Profitability with Automation Asset Performance Management (APM)

by Manoj Chandrasekharan

Executive summary

Plant automation assets are not only fundamental building blocks of any industrial plant but also represent significant capital and operations and maintenance (O&M) expenses. Plant productivity can be dramatically improved by implementing solutions which provide actionable early insight into abnormal asset conditions so that maintenance teams can make more informed decisions and act on them efficiently from anywhere.

Introduction

As businesses strive to improve the bottom line and gain competitive advantage, improving operational efficiency is one of the key objectives for manufacturing plants. This requires plant assets to run at peak productivity levels, producing high-quality products at the right time while also ensuring compliance with health and safety regulations.

Plant operators have long considered increased availability and utilization, coupled with minimized downtime (both planned and unplanned), to be the most effective levers to maximize productivity. Traditionally, operators have adopted preventive maintenance practices to minimize unscheduled downtime. While these may help avert some potential issues, studies have found that most of these periodic maintenance checks can actually be avoided. Preventive maintenance is not only labor-intensive, but it also does not eliminate the possibility of catastrophic failures.

While preventive practices cannot be completely eliminated, there is a growing need to gradually evolve to proactive and predictive maintenance programs that leverage plant-wide asset management solutions. Work done by the US Department of Energy has estimated an 8-12% cost savings over traditional preventive maintenance programs.

This paper proposes a new groundbreaking Automation Asset Performance Management (APM) solution which will deliver higher plant productivity at lower risk. It first briefly discusses industry concerns and trends, focusing on those related to asset reliability and performance. The following sections contain:

1. an analysis of how asset failures occur
2. a definition of Asset Management and the characteristics of a plant APM solution
3. a description of a new solution which is comprehensive, scalable, and modular
4. data on typical reliability measures and benchmarks for assessing the quality of a company's asset management program
5. a discussion on the value of implementing an effective asset management solution

Industry challenges and trends

It is no secret that industrial productivity and profitability are severely affected by the current business environment and market uncertainty. Today's situation is characterized by:

1. Fragile and rapidly changing economic and geopolitical conditions coupled with significant supply-demand imbalances that are forcing companies to limit growth by constraining their capital and operating expenditures
2. A growing shortage of expertise which is adversely impacting the operations and maintenance (O&M) programs of companies in the hydrocarbon processing industry
3. An increasing focus on compliance, requiring companies to devote more time and effort to managing EHS and regulatory risks

ARC Advisory Group

"The global process industry loses $20 billion, or 5%, of annual production due to unscheduled downtime, with an average hourly cost of about $12,500."

In addition to the tough business environment, plant O&M teams face several operational challenges, as well. Understanding these unique O&M challenges is critical to developing solutions that maximize long-term asset value:

1. Complex technical environment with multiple protocols, multiple asset types from multiple vendors
2. Poor decision support due to data overload and information islands. This results in an inability to differentiate and prioritize asset health data automatically and in real time.
3. Knowledge management challenges driven by an aging work force. Significant amounts of tacit knowledge regarding the safe and efficient operation of assets are lost when workers retire or leave.
4. Satisfying the needs of a wide range of stakeholders, ranging from the plant manager to the maintenance supervisor/technician to the plant operators
5. The ability to access information on the go and act on it (e.g., raise a work order) using handheld devices like smart phones, tablets, etc., is emerging as a critical need for maintenance staff.

To a large extent, most of these concerns are directly or indirectly associated with topics related to Automation APM.

Challenge: Reducing downtime

Plant downtime is one of the biggest causes of lost productivity. Many plants operate below their maximum production or throughput potential, often because of inadequate availability. Improving availability can significantly improve plant productivity and the resulting financial performance.

Table 1

Availability benchmark in various industries

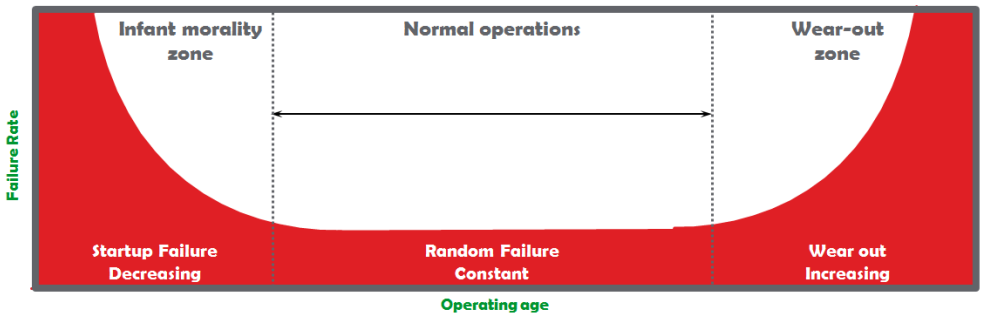
Process Type	Worst	3rd quartile	2nd quartile	Best
Continuous	< 78%	78 - 84%	85 -91%	> 91%
Batch	< 72%	85 - 90%	91 -95%	> 90%
Chemical, Refining, Power	< 85%	85 - 90%	91 -95%	> 95%
Paper	< 83%	83 - 86%	87 -94%	> 94%

Fluor Global Services – Benchmark Study – NA, AP, EU, 1996

Understanding how asset failures occur is the first step towards defining strategies to improve their reliability and availability. Most reliability engineers are familiar with traditional view of Asset Wear represented by the bathtub curve as shown in Figure 1.

Figure 1

The bathtub curve plots the failure rate over time.



According to this view, an asset's life cycle can be divided into three distinct stages: High infant mortality, characterized by a high but rapidly decreasing failure rate, followed by a low and constant level of random failure, then a wear-out zone, characterized by a rapidly increasing failure rate.

While the bathtub curve is a useful way to illustrate the age-related failure rate of an asset throughout its operational life cycle, recent studies have shown that age-related failures only account for about 20% of all failures. Instead, random failure patterns for assets and components were found to be much more prevalent, accounting for roughly 80% of all failures.

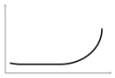
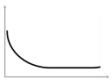
With age-related failures, the amount of time an asset is in operation (in-service duration) contributes to its eventual failure. Other factors include stress fatigue, erosion/corrosion, wear out etc. With random failures, as their name suggests, the failures occur randomly and are not influenced by the length of time the asset is in operation.

For a time-based preventative maintenance task to be applicable, two conditions should exist: (1) the failure mode must be wear or age related, (2) the probability of failure must increase at an identifiable age. As we've established that most failures are not age related, time-based preventative maintenance is not the most effective strategy to prevent failures. In such a situation, the most effective approach would be a predictive maintenance strategy that is based on condition monitoring to detect potential failure conditions and allow a known and sufficient time period for adequate correction. The advantages of predictive maintenance are many. A well-executed predictive maintenance program will all but eliminate catastrophic equipment failures, reduce O&M costs, and minimize or erase overtime costs.

Table 2 below illustrates the typical failure patterns, of which type D was found to be the most common:

Table 2

The asset failure pattern

Profile	Failure profiles	Failure	Characteristics	Examples
A		Age related	Mechanical assets initial wear in period	Bearings
B		Age related	Mechanical devices	Reciprocating engine cylinders, compres-sor blades etc.
C		Age related	Structures	Pressure vessels, etc.
D		Random	Electronic components, complex components after corrective mainte-nance	Computers, PLCs, etc.
E		Random	Complex devices with high stress work conditions	High pressure relief valves
F		Random	Complex devices or machinery with a well-balanced design	Multiple sealing high pressure centrifugal pump

The majority of current intelligent automation assets are designed to power predictive maintenance strategies. A comprehensive Automation APM program should leverage this in-built predictive intelligence to monitor asset health status in real time, detect abnormal conditions, and automatically deliver health status, along with the potential causes and possible maintenance actions, in an easy-to-understand way. Mobility and decision support tools like workflow functionality can further improve the productivity of the team managing the O&M of a plant.

Automation assets

ISO 55000 defines Asset Management as the "coordinated activity of an organization to realize value from assets." An asset is defined as "an item, thing or entity that has potential or actual value to an organization."

A well-executed APM solution will empower the people who run and operate a plant to answer the following three questions anytime, anywhere:

1. Will my plant continue to produce efficiently?
2. Do we understand what could go wrong and when?
3. What actions are needed to prevent an unplanned shutdown or achieve a faster turnaround time?

As such, there is no “one size fits all” APM solution. Every plant has its own unique approach, depending on its business and O&M goals. However, adopting a modular yet integrated solution approach will enable each facility to implement different components of a plant-wide Automation APM solution in a time frame that fits their operational needs, budget constraints, and manpower constraints.

The functionality required for effective asset management depends to a large extent on the types of automation assets in the plant. ARC divides a plant’s assets into two categories:

- Automation assets
- Production assets

Table 3 lists the various types of plant assets in a typical plant.

Table 3

Assets in a typical plant

Asset type	Electrical	Mechanical
Automation assets	Pressure, Temperature, Flow, Level, Misc. Sensors, Analytical, Switches, Networks	Control Valves, Positioners, and Associated Equipment
Production assets	Motors, Switchgear, Transformers, Drives, Wiring	Turbines, Compressors, Fans, Gear Boxes, Conveyors, Grinding Mills, Extruders, Dryers, Pumps, Pipes, Heat Exchangers, Tanks, Boilers, Furnaces, Production Units

The prioritization of assets to be included in an APM solution can be done by failure rate. An example is shown in Table 4. This data is available from a variety of sources:

1. Site/company specific: Failure rate data which has been collected from similar equipment being used for very similar applications
2. Industry specific: E.g. OREDA offshore failure rate data
3. Generic: A generic data source that combines a large number of applications and sources

Table 4

Assets failure rate

Asset type	Faults per year
Instruments in contact with process fluid	
Pressure measurement	0.97
Flow measurement	1.09
Instruments not in contact with process fluid	
Valve positioner	0.41
Controller	0.26

Source: Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control

Automation APM solution

A comprehensive Automation APM solution which delivers business objectives requires a much more holistic approach, going well beyond the traditional approach narrowly focused on configuration and diagnostics functionalities. This necessitates collaboration between equipment, control, business, and people facilitated by the three functional layers, namely Monitor, Decide, and Act, as illustrated in Figure 2.

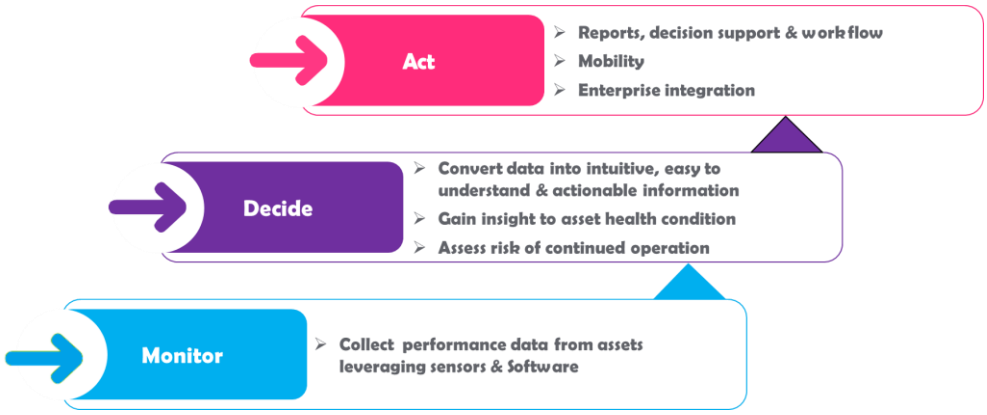


Figure 2

The three functional layers of an Automation APM solution

Monitor

As discussed earlier, any typical plant consists of a wide variety of automation assets, ranging from instruments and valves to drives etc., and production assets like pumps, fans, motors etc. Different condition monitoring technologies are needed to monitor and detect impending failure in these assets. The monitor layer of Automation APM leverages multiple built-in condition monitoring engines to automatically monitor the health of various automation assets in real time, and presents the information in a common and unified dashboard environment, enabling faster and more effective responses to abnormal conditions.

In the case of intelligent automation assets, this condition monitoring capability may be achieved leveraging intelligent communication protocols like HART, Profibus, etc. For non-intelligent automation assets, condition monitoring technologies may vary from a simple rule engine application to more advanced pattern recognition software.

Examples of built-in condition monitoring engines

Condition monitoring engines for intelligent automation assets like instruments, valves, drives, etc., scan intelligent automation assets in real time for new/updated diagnostic data, interpret diagnostic data against known conditions, and transform it to user-friendly language. Extra information like location data, plant area, NUMAR 107, etc. can be added to support maintenance prioritization.

Generic condition monitoring engines for non-intelligent assets can be based on industry standards which enable data collection from a wide range of sources, including plant historians, and basic monitoring offerings such as fluid and vibration systems, as well as more complex condition sources such as model-based equipment health, advanced process control, and loop tuning solutions. The data can be real-time, near-time or offline/ historical.

Once data is collected, the analysis can be based on a rules-based engine which can use pre-defined or customer-defined algorithms or models to take advantage of the condition information and tools already available in the customer's organization.

With these condition monitoring capabilities, the vast majority of assets in a plant can be monitored, whether automation or production related.

In a nutshell, this layer helps converge health alerts from a broad range of assets, allowing operations and maintenance personnel to quickly focus their attention on a particular asset — from amongst the thousands of assets in a plant — which needs immediate corrective action to prevent a plant upset or unplanned downtime.

Figure 3 shows an example of a unified workspace that helps improve asset reliability by providing increased awareness of asset health, asset performance alerts, and the status of maintenance work orders.

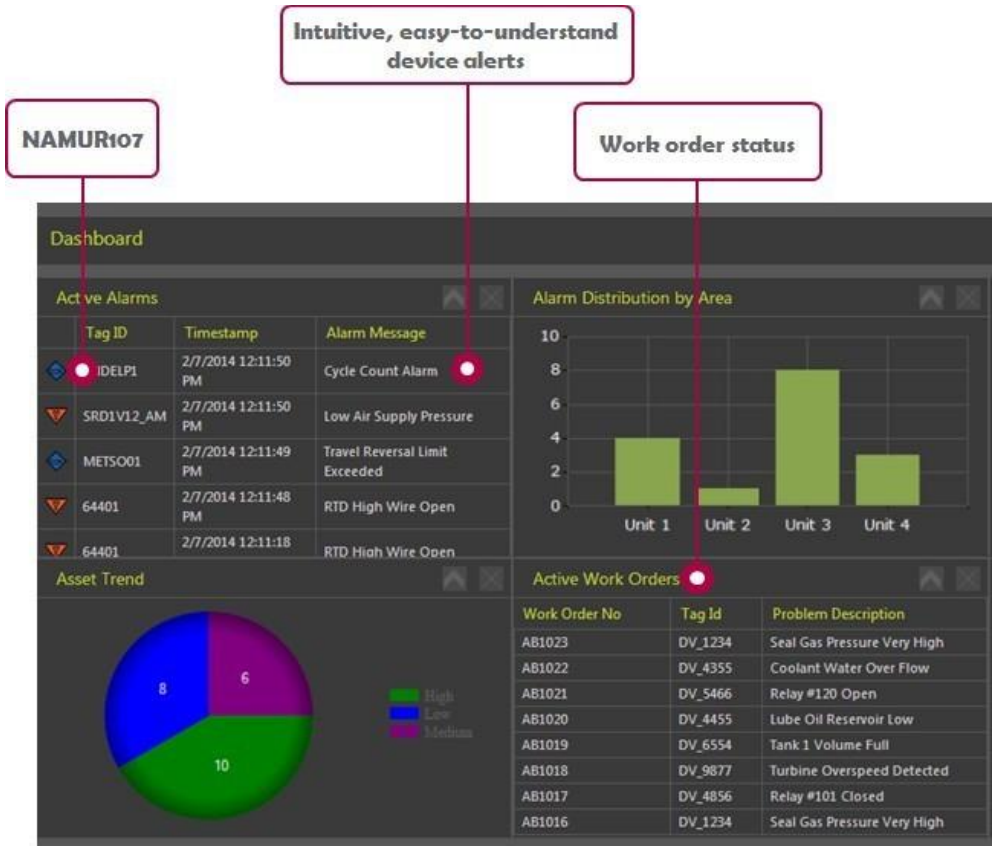


Figure 3

A unified workspace provides a holistic view of asset health, performance, and status of work orders.

Decide

One of the primary operational challenges associated with implementing an APM solution is data overload. This results in an inability to differentiate the relative significance of asset health data in real time so that asset maintenance priorities can be correctly established.

This functional layer provides asset health alerts in an intuitive, easy-to-understand way, with the actionable information. Context is added to alerts to indicate criticality levels, for example by using standard NAMUR 107 categories. Smart analytics and comparison with historical data help identify failure modes, quality trends, and process issues to reduce time to repair and eliminate unnecessary trips to the field. Comprehensive reporting enables improved shift handovers and status reporting. All of this information empowers maintenance to make more informed decisions in real time.

Figure 4 shows an example of a unified workspace that provides clear and concise asset performance alerts and recommended corrective actions.

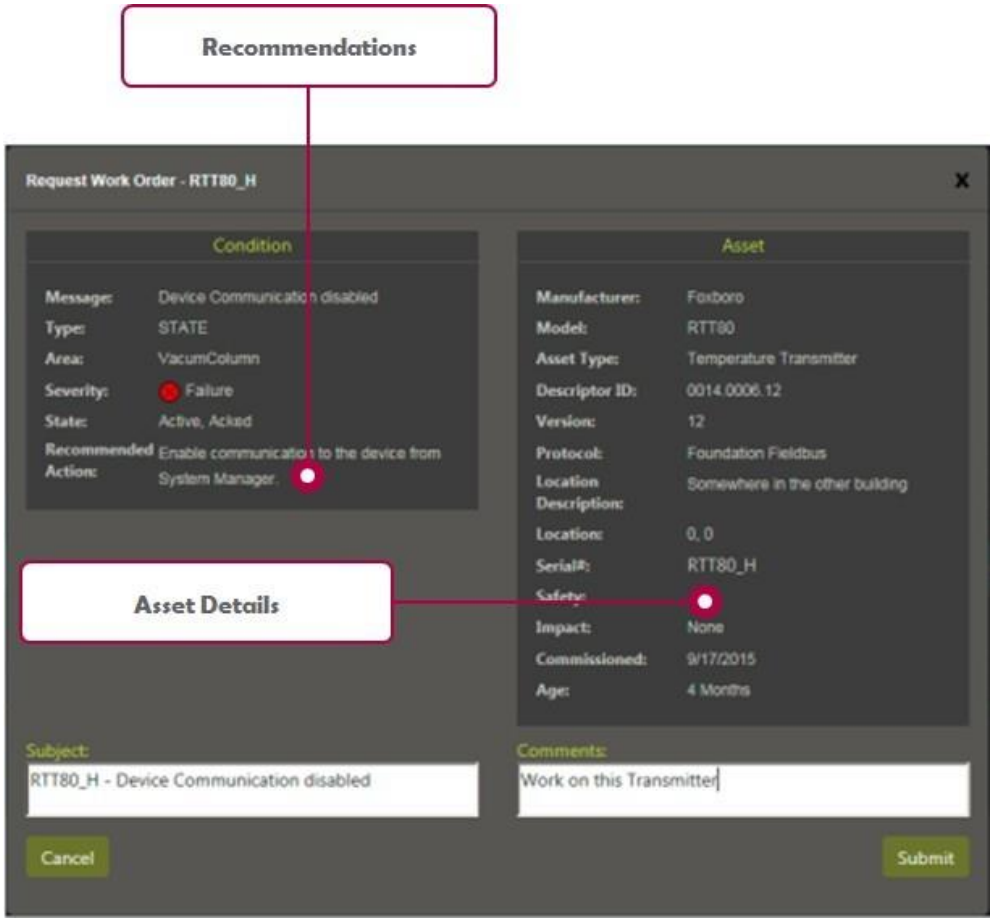


Figure 4

A unified workspace provides clear and concise asset performance alerts and recommended corrective actions.

Act

This layer provides tools to support action on maintenance-related decisions. It includes:

1. Mobility to allow quick response from anywhere in the plant
2. Workflow options to streamline maintenance processes and eliminate paperwork
3. ERP integration for work order creation and tracking

The combination of the above three functional layers provides a modular yet integrated APM solution which is compatible with a wide range of plant assets. The advantage of the modular approach is that components can be implemented and integrated into the overall system as needed, as long as the basic infrastructure to support it is in place and has the capability to support integration. The modular design allows solutions to be tailored according to specific needs and budget.

If you can't measure it, you can't improve it

Traditionally, reliability engineers responsible for implementing an asset management solution focused on a single KPI such as “availability” in order to evaluate the success of the program. However, this metric alone is not enough to assess the effectiveness of the solution.

Beyond availability, reliability engineers should also take responsibility for controlling costs, evaluating and implementing new technologies, tracking and reporting on EHS and compliance issues, etc. To support these activities, the reliability engineers must be aware of the various indicators that can be used to measure the quality or effectiveness of the asset management program. Not only are these metrics useful in assessing asset management effectiveness, but they can also be used to provide justification for investments required to implement an asset management program.

Table 5 displays a selection of KPIs that can be used to evaluate an asset management program. Not all of these measures may be useful in all situations. However, a program should use as many of these KPIs as possible to identify shortcomings and, more importantly, to measure where your company stacks up against the best performers in the industry.

Table 5

Typical benchmarks

KPI	Benchmark
Equipment Availability	> 95%
Schedule Compliance	> 90%
Emergency Maintenance Percentage	< 10%
Maintenance Overtime Percentage	< 5%
Preventive Maintenance Completion Percentage	> 90%
Preventive Maintenance Budget/Cost	>15%–18%
Predictive Maintenance Budget/Cost	>10%–12%

Some other KPIs which may also be applicable are:

- Work orders generated/closed, to better understand changes in staff workloads
- Safety incidents, to get an overall safety picture (commonly tracked either by the number of lost time incidents or the total number of reportable incidents)
- Energy consumption, to track equipment performance
- Spare parts consumption, as a measure of changes in maintenance costs

Results are repeatable, over and over

It has been shown in practice that asset management delivers higher productivity at lower risk. The top three benefits from asset management are:

1. Maximized asset operational uptime
   - Detection and avoidance of asset failures
   - Shortened time of scheduled shutdowns
2. Minimized O&M cost
   - Elimination of wasted effort
   - Reduced overtime
3. Maximized workforce productivity and improved safety
   - Improved efficiency with effective, fast response times
   - Improved collaboration among team members
   - Improved safety with fewer visits to the field

Work done by the US Department of Energy has quantified the benefits of predictive maintenance and the numbers are indeed compelling. For example:

- Reduction in maintenance costs = 25%-30%
- Elimination of breakdowns = 70%-75%
- Reduction in downtime = 35%-45%
- Increase in production = 20%-25%

Conclusion

As companies strive to improve profitability, an APM solution empowers organizations to improve plant productivity by maximizing uptime, reducing O&M costs and enabling safe and efficient operations. An effective APM solution encompasses the capabilities to monitor the condition of assets, ideally automatically in real time; provide analytics and predictive forecasting for better maintenance decision support; and the tools to execute the decisions from anywhere.

About the author

Manoj Chandrasekharan is Asset Management Offer Director in Schneider Electric's Process Automation Business. He holds a bachelor's degree in Mechanical Engineering and an MBA from the University of Strathclyde, UK. He is also an active member of ISA 108. He has published multiple articles in global journals on the subject of Asset Management.