Prescriptive Maintenance: Transforming Asset Performance Management

Robert Golightly, Senior Product Marketing Manager, Aspen Technology, Inc.

Introduction

Asset maintenance has historically been thought of as something preventive — and in many cases reactive, unpredictable and done out of pure necessity. Maintenance in this mindset is a cost center, and not something that creates measurable value. However, with the ever-increasing need for overall asset reliability and optimization, all businesses should be looking to proactively address asset maintenance. The ability to digitize and proactively monitor assets via sensors has steadily evolved to where technology is now ready to revolutionize asset maintenance.

Leveraging that capability, today's asset performance management (APM) technology can **deliver advanced warning of failures through a combination of predictive and prescriptive analytics, enabled by integrated software that incorporates artificial intelligence (AI) and machine learning.**

This type of solution provides the time to plan around predicted downtime and provides a holistic view of the operation; plant personnel can see exactly how downtime financially affects the entire organization. The ability to see wide and deep creates value by enabling the development of new ways of running the business. Digital transformation is knocking down the data silos and delivering the tools necessary to make sense of the data that is readily available.

Predictive and prescriptive maintenance have moved from the early focus on proof-of-concept pilots to broader rollouts. The market has learned over the last few years that, while everyone claims to be using machine learning and AI, not all APM solutions are created equal. Success is ultimately defined by the ability to rapidly deliver at enterprise scale.

The Objectives of Asset Performance Management

Equipment failures and process disruptions are the main drivers of unplanned downtime that costs the process industries billions of dollars in lost revenue and profit every year. For oil and gas companies, forced shutdowns cost an average of $38 million a year — and up to $88 million a year in the worst-case scenarios. At chemical plants, the cost of unplanned downtime ranges between $10,000 to $250,000 per hour.

This is an area where we commonly see corporate initiatives cropping up around APM and risk management. What these companies are searching for are ways to improve the accuracy of detection and increase the notification period of these asset downtime events. With more warning, more options become available — and with options comes the opportunity to mitigate the negative impact of those events.

Safety and Environmental Benefits

APM solutions are delivering improved levels of asset availability and reliability, but there are other important benefits as well. It's well-documented that the rate of accidents increases significantly during transitory operations like shutdowns and startups. By avoiding unexpected failures, safety is improved — especially for maintenance workers — as companies gain the ability to move from emergency maintenance to planned maintenance made possible by earlier warnings.

Those transitory operational periods can also produce excessive levels of greenhouse gas emissions, particularly from flaring, or the combustion of excess product that is typically released when a plant experiences over-pressuring operation. So reducing unexpected failures can have a significant environmental impact, as flared natural gas alone produces more than 300 million tons of CO_2 emissions globally every year (the equivalent of approximately 77 million cars).[1] Much of that could be avoided by eliminating unplanned shutdowns.

New Technologies and a New Approach

Traditional preventive maintenance alone cannot solve the problems of unexpected breakdowns. With asset performance management powered by low-touch machine learning, it's now possible to extract value from decades of design and operations data to perform prescriptive maintenance and optimize asset performance.

This technology deploys precise failure pattern recognition with very high accuracy to predict equipment breakdowns weeks or even months in advance.

Here are just a few examples of it in action:

- A European petrochemicals producer has used a predictive analytics solution to develop a data driven approach to maintenance planning. With the new plan in place, they eliminated two days of shutdown per year on each piece of equipment and **saved $1.8 million in downtime costs.**

- A refinery with 300,000 barrels per day of capacity has been able to predict failures with significant lead time — and has done so without false positives. These capabilities are expected to reduce unplanned shutdowns by up to 10 days, **increase revenue by 1-3%**, reduce refinery maintenance costs and cut operating expenses by 1-5%

- A refinery has implemented solutions to **predict failures with nearly 30 days of lead time** enabling the staff to schedule maintenance, shift production where necessary and improve the way they look at root cause analysis.

- A leading pulp and paper manufacturer has seen how advanced technology improves safety, as their predictive analytics solution **alerted to a major fire with nine days of advance warning.**

- A metals and mining company has deployed a leading-edge predictive analytics solution across more than 300 of its assets. It is managed by essentially one person, and the company has improved availability enough to **get full return on investment in less than six months**.

Earlier Warnings — Finding the Subtle Patterns Humans Can't See

This new approach to asset performance management and predictive analytics has two important capabilities: it finds problems sooner than competing technologies, and it takes faster action to correct the problems.

That improvement highlights another significant difference: the accuracy of failure signatures over anomaly detection. For example, a major oil and gas company was experiencing recurring, unexplained breakdowns of compressors at one of its refineries. The staff was a mature implementer of reliability-centered maintenance methodologies and used state-of-the- art vibration systems, but still the breakdowns occurred.

Frustrated, the company turned to Aspen Mtell®. In a rapid implementation spanning just five days, Aspen Mtell autonomous agents were deployed to protect three major compressors and pumps. On the third day of implementation, one anomaly agent alerted and **exposed the cause of a compressor failure that had plagued the refinery for over a decade**.

In a similar "save," one agent alerted, with eight weeks' warning, to a failure in the third-stage valve of a multi-stage compressor. The operations staff chose to continue unheeded. Seven weeks later, the vibration system announced excursions, and the condition deteriorated rapidly. In three days, the compressor was shut down for maintenance. The tear-down proved that Aspen Mtell had correctly announced the impending failure a full seven weeks before the state-of-the-art vibration system.
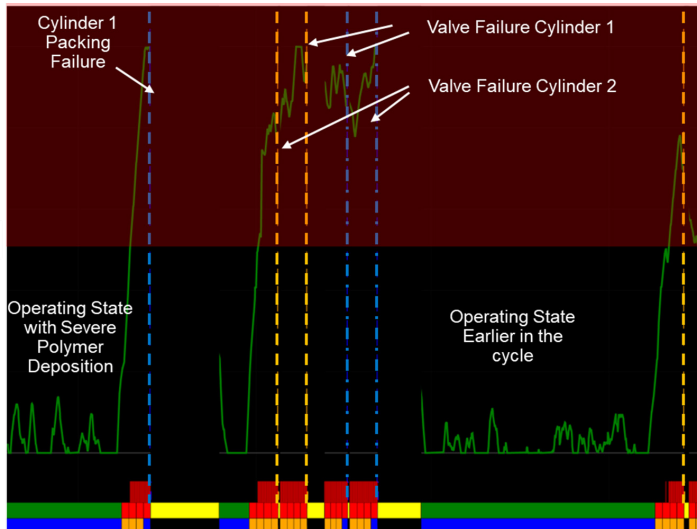
Automating the Data Science: Better Data Beats Fancier Algorithms

One of the most time-intensive tasks associated with any analysis is preparing the data. Aspen Mtell provides a low-touch machine learning approach that eliminates much of the manual effort involved in "data cleaning." Users report that identifying, selecting and preparing data can consume a significant fraction of the time spent analyzing a problem. Aspen Mtell tackles that challenge, automating much of the data preparation workflow by:

- Determining the minimum important set of sensors
- Defining the key derived transforms of the sensors
- Identifying data regions for machine learning training and testing
- Automating the tuning of most parameters
- Determining the frequency of data needed for analysis

The second major area of automation is in "feature engineering," or creating new input features from your existing ones. In general, you can think of data cleaning as a process of subtraction and feature engineering as a process of addition.

This is often one of the most valuable tasks one can do to improve model performance, for three important reasons:

1. You can isolate and highlight key information, which helps your algorithms "focus" on what's important.
2. You can bring in your own domain expertise.
3. You can bring in other people's domain expertise.

Asset performance management enables improved availability that unlocks the tremendous value and productivity lying uncaptured in assets.

Together, these capabilities result in the creation of **predictive agents** that can tackle a range of difficult problems, such as:

- Multiple failure modes that share causes
- Multiple operating states that result in similar outcomes
- Cascading failure modes (i.e., one failure causes other failures)
- Failure modes that can be explained using domain expertise
- Failures that take months to evolve (no sudden onset)

The competence embedded in the autonomous agents of Aspen Mtell represents a breakthrough in automating data collection, cleansing and analysis to provide prescriptive maintenance protection for equipment.

In one real-world application, the solution was built by an engineer with less than five years of experience. With just a few hours of instruction, he completed the development of a new Aspen Mtell agent — including the work to access, extract, clean, organize and prepare data for analysis. Aspen Mtell was designed not for the data scientist, but for the process engineer.
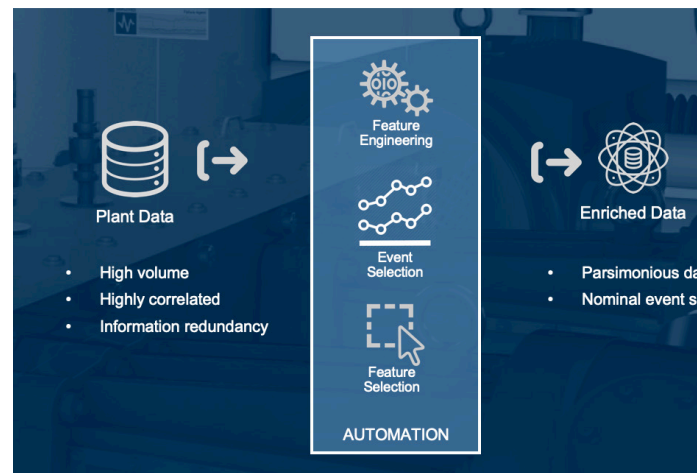
Successful Applications of Prescriptive Analytics

The low-touch machine learning approach of Aspen Mtell is proving itself every day in projects across the energy, chemicals, mining and food and beverage industries, among others. By modeling asset failures rather than asset behavior, Aspen Mtell provides a more scalable approach. And unlike other approaches, failure signatures developed on one asset can often be used to inoculate identical assets.

Here are some examples of other recent applications:

• In a drilling operation, autonomous agents correctly detected calibration errors on drilling joystick operations that had gone unnoticed. Aspen Mtell **provided two to four weeks' warning of impending failures** on top-drive, mud pump and draw works components.

• A multinational mining company implemented Aspen Mtell machine learning and significantly improved production uptime. This customer makes extensive use of autonomous agents for early, heads-up warning of degradation in metals refining processes and equipment, and agents regularly **advise a time-to-failure of 40 days** on a pump.

• In another industrial facility, Aspen Mtell agents have detected vibrations in pumps that led to the replacement of mechanical seals before failure, and they also identified signatures that led to the replacement of a high-pressure pump with 39 days of lead time. In the same plant, problems with a wash oil pump were **detected 48 days in advance.**

• A large, global chemicals company had been seeking better notification of fouling in a quench oil tower. Drawing on fouling data from the previous year, and Aspen Mtell agents **provided an alert with a 125-day lead time** of fouling. Unfortunately, the company took no action and eventually had to shut down the quench oil tower due to fouling.

• In a European refinery, vacuum bottom pumps had been affected by repeated seal and bearing failures. Aspen Mtell learned the failure history, which included more than a dozen different failure signatures. The agents **provided lead times of 28 and 31 days** for future seal failures on the pumps, as well as lead times of 10 and 28 days for future bearing failures. The refinery ignored the warnings and was later forced to replace seals and bearings after the failures occurred.

Solution Scalability: an Asset per Day

With customers commonly having thousands of assets on a single site, success ultimately becomes a question of how fast the solution can be rolled out. If the solution doesn't scale appropriately, a plan could take several years to complete. Two big constraints on scaling predictive analytics solutions are preparing good data and developing the underlying models.

The Aspen Mtell solution utilizes machine learning, AI and automation to prepare data and to create the failure signature models. The ability to assist in cleaning and preparing data and the cloud-based automation to build agents combine to deliver the scalability needed to support enterprise-level rollouts. Another key feature for scalability is that Aspen

Mtell can often transfer failure signatures across assets. With other model types, they are generally not transferable across similar assets, so the work to create and maintain the models must be repeated for each asset. As an example, the oil driller referenced earlier **transferred failure signatures for key assets to over 200 drilling rigs** around the world. And in another facility, agents that were trained to identify casing leaks on electric submersible pumps in one facility have been **transferred to 18 other pumps.**

The adoption of Aspen Mtell is now at a point where companies are rolling it out across facilities. In recent months, several have implemented expansion programs, including:

- A mining facility that now has Aspen Mtell deployed on all major assets across three sites

- An energy company that has Aspen Mtell deployed in six refineries and on multiple pipelines

- An energy company that has extended its initial refinery rollout to include its wind farms

- A pharmaceutical company that has rolled Aspen Mtell out across 10 key assets at three sites

Conclusion

These results illustrate the ability of Aspen Mtell to provide earlier prediction of asset failures while reducing or eliminating false positives. The companies adopting this technology have demonstrated the speed at which the solution can be developed using available resources, and they have proven the ability to inoculate similar assets with failure signatures to achieve incredible scalability.

1. The IoT Transformation of Gas Flaring Operations, Lana Ginns, Flow Control, Oct. 4, 2016

About Aspen Technology

Aspen Technology (AspenTech) is a leading software supplier for optimizing asset performance. Our products thrive in complex, industrial environments where it is critical to optimize the asset design, operation and maintenance lifecycle. AspenTech uniquely combines decades of process modeling expertise with machine learning. Our purpose-built software platform automates knowledge work and builds sustainable competitive advantage by delivering high returns over the entire asset lifecycle. As a result, companies in capital-intensive industries can maximize uptime and push the limits of performance, running their assets faster, safer, longer and greener.

Visit www.AspenTech.com to find out more.