PEMAC

A GUIDE TO LATEST MAINTENANCE STRATEGIES USING PREDICTIVE SYSTEMS

How Predictive Maintenance using hybrid Artificial Intelligence and Analysis Intelligence is disrupting the global manufacturing sector

Contact PEMAC today to discuss your maintenance management needs.

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INTRODUCTION

The concept of preventative maintenance is driven by the desire to prevent rather than experience asset failure. The benefits of preventing a machine failure can have significant benefits in terms of machine repair costs, lost production time and disruption to the customer.

Imagine a production facility where all breakdowns are predicted far enough in advance that engineering teams can alter the maintenance strategy to avoid the outcome. Interested? In this educational guide, we look at the guiding principles and research behind the science of predictive maintenance.

We will also provide an outline of how you can get started with the PEMAC solution to deliver successful predictive maintenance planning across your business operation.

5 Essentials for a Successful Predictive Maintenance System

How can you possibly build certainty around a future asset breakdown that justifies the replacement of a component that's working fine now, but which will fail soon? To prevent an event occurring we need to understand something about the system we want to monitor, and we need time to prevent the failure. For predictions to be useful, we need 5 things:

- A Stable System
- A Leading Indicator
- Sufficient Data
- Analysis Intelligence
- Time to Act

1
THE SYSTEM

The Cynefin Framework describes four kinds of systems – Complex, Ordered, Simple and Chaotic. (Bonne & Snowden, 2019)[1]. The framework suggests what the correct response mechanism is for dealing in that environment and how to learn to predict. In an engineering sense, that translates to determining what correct maintenance strategy will deliver the best outcome.

Complex	Ordered
Simple	Chaotic

[1]*Bonne, M. E., & Snowden, D. J. (2019, May 7). Retrieved from A Leader's Framework for Decision Making: https://hbr.org/2007/11/a-leaders-framework-for-decision-making*

Simple System

Cause and effect relationships exist. They are predictable and repeatable.

Way to Interact: Sense-Categorise-Respond.

Correct Approach: Deploy Best Practice.

Chaotic

No Cause and effect can be determined.

Way to Interact: Act-Sense-Respond.

Correct Approach: Try to establish order or move to Complex.

Complicated System

Cause and effect relationships exist but are not self-evident. So here we need expertise to come up with a suitable approach.

Way to Interact: Sense-Analyse Respond.

Correct Approach: Deploy Good Practice

Complex

No Cause and Effect. Experimentation to learn is required.

Way to Interact: Probe-Sense-Respond.

Correct Approach: No singular best approach. Constantly learn. Constantly evolve.

1
THE SYSTEM

You might recognise that most manufacturing companies sit in the '**Simple**' or '**Complicated**' categories. So, the rules of the system are either obvious (i.e. replacing oil regularly extends engine life) or can be learned over time provided there are ways to learn. So, understanding the stability of your environment and then being able to experiment are key ingredients to making prediction useful.

Production systems may be typically considered 'static' and by and large when certain failure events occur, engineering teams would be reasonably confident of predicting the likely follow-through and outcome of such failures and their resolution. There are, however, multiple types of production systems and identifying the most relevant is the first step towards building an effective predictive solution for any facility. Factories can be extremely busy working environments, but they are rarely '**Chaotic**'.

2

LEADING INDICATOR

For prediction to be valuable we need to be able to see something coming down the line before it occurs. We need an indicator alert that the system is going to fail at a point that gives us sufficient time to do something about it.

Identifying leading indicators like increased vibration or excessive heat being generated are two examples. But the leading indicator also needs to be identifiable and measurable against some baseline. How far in advance do we see the symptom before we see the outcome? To draw a conclusion, we need data.

3

SUFFICIENT DATA

The vulnerability with making predictions with too little data or information is called bias. In statistics there are many tests to see if your sample size is too small to use and likely to create a bias in your conclusions. **Bias is a real issue that needs to be understood and addressed.**

There are lots of different types of bias.

- **Confirmation Bias**: drawing a conclusion and then ignoring new information/data that challenges the opinion. This is commonly known as ‘jumping to conclusions’!
- **Recency**: giving too much weight to recent events and assuming that, because an event happened some time ago it’s less likely to occur now.
- **Anchoring**: giving too much weight to the first event. ‘That machine always breaks because…’

3

SUFFICIENT DATA

In a factory setting you may not experience a problem often enough to generate sufficient data to make a useful prediction. Leveraging data in different locations for the same or similar equipment is one way around this problem and some manufacturers share this data with their customers. This substitution approach is actually a common human decision-making approach used in everyday life.

However, if unplanned jobs or breakdowns are not recorded systematically on your computerised maintenance management system (CMMS) the true performance of the machine is not known, exposing gaps in equipment behaviour. This limits the useful data generated and prevents a useful model being created that might help generate insights into equipment failure (like performing Root Cause Analysis at the end of each breakdown). This also means that you can't benefit from Artificial Intelligence (AI) because you don't have the model or the data to help the machine learn.

3
SUFFICIENT DATA

The benefit of full data capture helps reduce the impacts of these errors, but the data needs to be analysed in a certain way. Collecting any data requires effort and typically expense. The evolution in the Internet of Things (IOT) and the relative ease around interfacing different systems and hardware has made both the cost of acquiring data and its availability less of an issue.

It also helps reduce the problem of machine breakdowns not being recorded by people. So, the prediction error associated with insufficient data is less of a problem today but understanding the value of that data is a different matter.

4

ANALYSIS INTELLIGENCE VS ARTIFICIAL INTELLIGENCE

The risk of collecting the wrong data is really caused by not understanding the system being observed and the actual data being collected. According to Ajay Agrawal in his book Prediction Machines 'Prediction facilitates decisions by reducing uncertainty, while judgement assigns value' (Argawal, Gans, & Goldfarb, 2018)[2].

While the first problem might look like having sufficient data in order to reduce error in decisions, the key issue is deciding what data is worth collecting? It's this data that leads to consistent or high probability predictions. The 'what data to collect?' decision is down to the model of the machine under review and how this is created. (The concept in AI is called 'deep learning' and is related to a concept called 'neural net methods'). This brings us to a key concept – **how do machines learn?**

[2] *Argawal, A., Gans, J., & Goldfarb, A. (2018). Prediction Machines. Boston: Harvard Business Review.*

4

ANALYSIS INTELLIGENCE VS ARTIFICIAL INTELLIGENCE

One of the issues with Artificial Intelligence (AI) is that initially it underperforms other approaches until the system has been ‘trained’ and to get ‘trained’ it needs data and feedback just like us.

However, AI’s learn faster than humans and they are also better at analysing more complex data where humans tend to be poor.

There are three ways to learn something.

- **Supervised Learning**
- **Reinforcement Learning**
- **Unsupervised Learning**

4

ANALYSIS INTELLIGENCE VS ARTIFICIAL INTELLIGENCE

'**Supervised Learning**' is useful when you know how something already works and generally you know how something works because you've a lot of experience (data) to support the learning. For example, I know that the quality of the oil impacts on engine life and so changing the oil at the 'correct' interval will extend the engine's life by reducing wear and tear or friction on components.

'**Reinforcement Learning**' is more trial and error. I do something and when I get a good outcome or a bad one, I do more or less of it. This is an expensive way to learn as there's an element of experimentation built into the approach and there's a probability, I might be wrong. We see this occurring sometimes when intervention maintenance checks sometimes cause more problems than the original piece of work was meant to prevent.

4

ANALYSIS INTELLIGENCE VS ARTIFICIAL INTELLIGENCE

Here we might decide that 'run to failure' is a better strategy or changing the interval of maintenance based on some feedback measure like Mean Time Between Failure (MTBF) might be more valuable. What happens if, as the machine ages, new problems manifest themselves? Or what happens if you use the machine in an environment different than it was designed for?

To train a new employee or a new AI we need to allow them to learn from mistakes and successes on the job. 'Without a pathway to learning, the machine will neither play well nor improve over time' (Argawal, Gans, & Goldfarb, 2018, p. 2526). The tolerance for error will depend on the impact of making a decision based on the data and the insights generated. For example, our acceptance of the wrong result from a google search versus a mistake by a pilot or onboard computer in an aircraft is very different. AI's learn better in the 'wild' where they get more data but the danger here is that a decision is made that has a detrimental impact. This is one of the key issues with the release of Automated Driving.

4

ANALYSIS INTELLIGENCE VS ARTIFICIAL INTELLIGENCE

One way to deal with the 'tolerance of error' issue is to do what airlines have done to reduce errors – simulation. Before the pilot gets to fly the plane, he or she learns on a simulator. This reduces the cost of an error.

Another example of this concept called 'digital twins' involves building virtual models of physical equipment. General Electric (GE) builds software models for its turbines and then collects data of its machines in the field. The software application called 'Predix' uses machine-learning algorithms to predict what machine is likely to fail. It can then suggest a course of action given the current condition of the machine, its operating environment and compare this against the aggregated data being passively collected from similar equipment. (Wilson & Daugherty, 2019)[3]. Predix also supplies the confidence level of its prediction along with the financial costs of acting versus not acting.

[3] *Wilson, J. H., & Daugherty, P. R. (2019, May 7). Collaborative Intelligence: Humans and AI Are Joining Forces. Retrieved from Harvard Business Review: https://hbr.org/2018/07/collaborative-intelligence-humans-and-ai-are-joining-forces*

4

ANALYSIS INTELLIGENCE VS ARTIFICIAL INTELLIGENCE

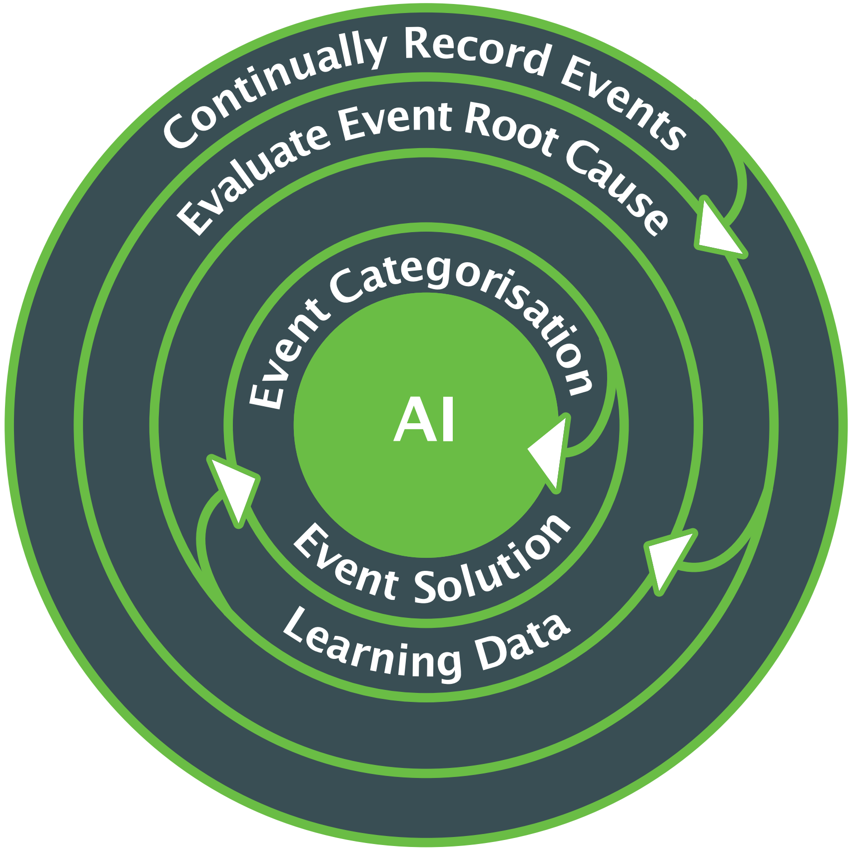
The idea of '**Collaborative Intelligence**' where humans and AI work together to gather, analyse, understand and then act on data to create superior outcomes holds the key to reducing machine failures, costs and driving efficiency.

'**Humans and AI actively enhance each other's complementary strengths: the leadership, teamwork, creativity, and social skills of the former, and the speed, scalability, and quantitative capabilities of the latter**'. (Wilson & Daugherty, 2019).

5

TIME TO ACT

So now all that's needed is **Time to Act**: Time for the AI to learn by collecting the data, feedback from the real world provided by the engineer and time to learn from mistakes in choosing the best course of action by an 'augmented' human engineer.



Next Steps

So, what does all this mean to you the owner of a maintenance system? For AI to be useful to you it needs to learn and for that it needs data. Your maintenance system is one source of data provided you are using it correctly and by correctly, I mean, not just for Preventative Maintenance.

The unplanned work being generated in your business is a valuable learning opportunity if it's approached a certain way. Recording events and then understanding the underlying root cause of the problem is key to generating data that you and your AI can use to create better prediction outcomes and implement superior maintenance strategies in terms of timing and response. Better data must be consistent so you will need to spend time in identifying the failure modes that different types of equipment are likely to experience.

Alternatively, over time you need to review how your engineers are describing problems and solutions in order to categorise those problems and their solutions into common terms. Viewing AI as another useful tool in your toolkit to lower costs by improving machine availability and hence profitability allows you to embrace the potential benefits.

AI, in terms of both artificial intelligence and analysis intelligence, are powerful, collaborative resources that, used to optimum effect will lead your production facility towards the 'future of work'.

The Results

If you are the owner of a CMMS system – then results should be at your fingertips! Your maintenance system is a core source of data, provided you are using it correctly. PEMAC Clients have experienced substantial improvements in their Maintenance Operations with the Maintenance Intelligence delivered by PEMAC Assets – our core CMMS.

Client Improvement reports are quoted to us delivering averages such as –

- **Up to 80% reduction in maintenance costs**
- **70% of planned continuous improvement change initiatives achieved within 6 months of PEMAC Installation**
- **Achieving an average of 99% improvement in operation/production uptime**
- **Reducing all manual administration and fulfilling 100% paperless activity**

About PEMAC

PEMAC is a leading provider of Maintenance Management and Health & Safety Software – enabling safer working environments with significantly improved production performance and substantially lower maintenance costs. Using our strong history and experience with a wide client base from multiple sectors, we have launched our 6th generation CMMS – PEMAC Assets.

Tracking all equipment and stock, maintenance tasks and routines, plus Contractor and Permit management are core to PEMAC Assets. Added to these basic product attributes, PEMAC Assets also supports compliance of 21CFR, on-site validations, enables calibrations and has a dynamic paperless approval system which can be used across your entire organisation – and all then backed up with live reporting supporting LEAN and AMIS operations. PEMAC Assets is web-based, works across multiple sites in multiple languages and can easily integrate with existing ERP, OEE or financial platforms.

PEMAC

ABOUT

With more than 200 features, PEMAC Assets is a fully customisable solution enabling full Predictive Maintenance planning using IOT technology. Our customers can select, combine and integrate multiple PEMAC Assets modules into one intuitive platform - meaning you no longer need to look to separate products on different platforms to address your maintenance management and planning needs, protect the health & safety of your staff and contractors, or manage change approval in a 100% paperless environment.

PEMAC Assets is available as SAAS or as an on-premise solution and implemented with support by the PEMAC team. Whether you are a large enterprise with a global footprint or just taking the first steps in implementing a CMMS, PEMAC has solution for you.

To find out more about PEMAC and PEMAC Assets, contact sales@pemac.com.

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