The machines that predict the future

The time when flights were cancelled, trains were delayed and elevators broke down may soon be over. Today, products are able to predict their own future. Thanks to predictive maintenance, they can forecast failures before they occur.

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While it may not get much attention as recycling, remanufacturing or refurbishing, maintenance is an important 'loop' of the circular economy. What's more, it's one of the 'tighter loops' of the circular economy framework, which means there's a chance for businesses to better preserve the value of products, components and materials. Unfortunately, because of challenging and sometimes costly implementation, the benefits from proper maintenance often remain uncaptured.

However, in recent years, maintenance capabilities have drastically improved through predictive maintenance, driven by a combination of technologies such as sensors, cloud computing, big data and machine learning.

Sensors are used to collect data on the condition of the equipment such as temperature, pressure, vibration or speed. For example, Rolls Royce uses 25 sensors to monitor the health of its Trent aircraft engine. Then the data is sent to remote cloud platforms using technologies such as Wi-Fi, cellular networks or satellite telecommunication.

These **cloud platforms** manage large amounts of data. When thousands of assets equipped with dozens of sensors are collecting data every second, volumes increase very quickly. Modern offshore drilling platforms have about 80,000 sensors, which are forecast to generate approximately 15 petabytes (or 15 million gigabytes) of data during their lifetime. As a result, cloud platforms usually rely on **big data** technologies to handle such volumes.

Once it's collected and stored, the data is analysed using **predictive algorithms** that detect fault patterns by comparing real-time data with pre-identified failure patterns. For example, the company Komatsu compares real-time data from its mining equipment against predesigned models to determine if maintenance is necessary. Recently, **machine learning** has enabled algorithms to analyse and store machine failure patterns that iteratively learn from data, allowing systems to find hidden signs without any explicit conditions.

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Companies that manage costly assets, especially in the aerospace, oil & gas and rail industries, have been early adopters of predictive maintenance. Rolls-Royce monitors 4,500 in-service engines in its Aircraft Availability Centre, whilst aircraft manufacturers and maintenance, repair & operations companies use predictive maintenance to monitor a plane's condition from nose to tail. Using ultrasonic sensors and advanced analytics, GE is able to predict piping failures due to corrosion and erosion in refineries. Alstom uses a "scanner" to collect train data that will be analysed by its "HealthHub" data analytics platform, and Deutsche Bahn uses sensors to look for abnormal vibrations of its switch equipment and detect anomalies that can lead to problems with different components of train tracks.

Improving maintenance, at last

The maintenance process hasn't changed much since its adoption by industries in the 1950's. Until now, most companies rely on a regular maintenance schedule (preventive maintenance) or repair equipment only when they break down (corrective maintenance). Preventive maintenance is not always efficient, as precautionary component replacements can be done unnecessarily or at a wrong time, while corrective maintenance can be costly when the failure leads to a long downtime.

Predictive maintenance, on the other hand, offers a much better solution. Unlike preventive maintenance, it replaces only the required part at the required time. Not only does it detect machine conditions that will lead to failure, but it also estimates the amount of time before that failure occurs, allowing maintenance to be planned. Unlike corrective maintenance, it also avoids costly downtime. For instance, it reduced downtime due to breakdowns of Hitachi magnetic resonance imaging systems by 16.3%.

Many industries could take advantage of predictive maintenance. Airbus and Boeing could increase fleet availability by up to 35% by reducing time-consuming routine maintenance. Predictive maintenance would allow a 10-40% cost saving in factories, according to McKinsey &

Company. Train manufacturers could reduce material-related costs by up to 15%.

Beyond predictive maintenance

Once collected and stored, equipment data enables the improvement not only of maintenance efficiency but also operations and energy efficiencies.

For instance, using this data can lead to better remanufacturing. In the past, when GE remanufactured locomotive diesel engines, upon arrival they had to tear down each engine into component parts, search for what needed to be corrected, then rebuild it. Today, GE already know the wear and tear on each component in each engine based on historical data analysis. They know which ones need intensive work and really serious repair, which ones need just a little brushing up and which ones don't need any repair at all.

Equipment data can also help maximise the use of equipment by optimising working parameters. Caterpillar works with their customers to reduce vessel fuel consumption based on the analysis of nearly 40 million hours of marine engine data.

Opportunities to improve equipment efficiency are significant: most equipment data remains unused. For example, on an oil rig, only 1% of the data collected by sensors is examined.

Choosing the right data analytics platform

Predictive maintenance adoption faces various challenges. Acquiring advanced capabilities in data analytics, Internet of Things infrastructure or data security, are a few examples.

To help fill the capability gap, technology companies such as Microsoft, IBM, and SAP and industrial ones like GE, Siemens, and Airbus offer data analytics platforms. These platforms help to store and secure data, to

create and manage applications and to run analytics. Like an operating system for a laptop or a smartphone, a platform does a lot of things in the background that makes life easier and less expensive for developers, managers, and users.

Unfortunately, selecting a data analytics platform is not like choosing between MacOS and Windows for a PC or between iOS and Android for a smartphone. There are hundreds of solutions available and some years may be required for the market to consolidate.

Rather than implementing a data analytics platform, it is also possible to buy predictive maintenance services. Various vendors are indeed bundling their equipment with maintenance services, such as SKF for its bearings or Thyssenkrupp for its elevators. The more customers they get, the more equipment data they are able to analyse and the more powerful their predictive algorithms become. Over time, these vendors may transition to new business models where they sell services instead of products. For instance, Rolls-Royce has leveraged its predictive maintenance capabilities to implement its TotalCare business model, where its aircraft engines are charged on a fixed pay-per-flying hour basis. With these new business models, vendors are incentivised not only to design durable products but also to extend their product life.

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If maintenance doesn't get a lot of hype, it often has more impact on people's daily lives than the vast majority of technological innovations. Hopefully, it is becoming not only more efficient but also more accessible. Initially used for trains or planes, predictive maintenance is now used for compressors, air conditioning systems, bridges or roads. Tomorrow it will likely be used for washing machines, vacuum cleaners or fridges, improving material and product longevity as well as the energy efficiency of billions of different types of equipment.