Smart Information: Data Make Maintenance Intelligent

From Repair to the Predictive Maintenance of Entire Machine Fleets

A revolution is underway in the field of maintenance and servicing. The feedback that IoT technologies enable machines to provide back to the upstream processes not only brings valuable information to these processes, but also makes completely new servicing and business models possible. On the path to this new world of servicing there are many intermediate objectives and advantages – if you know where you want to go.

Every machine is equipped with dozens of sensors, and the data flow seamlessly into a data lake where artificial intelligence fishes for anomalies and sounds the alarm long before the failure actually happens. The service technician will find the right spare parts and detailed descriptions of how to replace the parts on-site. In the meantime, the digital model of the machine has been updated and the machine is immediately fitted with modifications during maintenance, which bring the machine up to date.

Many visions of maintenance and digitalization sound like this or remarkably similar. But implementing such a complete vision requires a lot of groundwork and upheaval throughout a company. Significant improvements can also be achieved with much less effort and the advantages of digitalization exploited. Once a foundation has been laid, further steps can be implemented according to need and resources.

The individual levels of digital maintenance range from simple reactive maintenance to financially optimized maintenance, which contributes strategically to the creation of value within a company. The effort required for implementation increases with each level, but so do the advantages and possibilities offered by the maintenance.

Operational Maintenance: From Repair to Prevention

Reactive maintenance has been the norm up to now. If a machine was broken, someone repaired it. Depending on the time required to carry out the repair and the availability of spare parts, this means interrupting the production process for anywhere between a few minutes and several days. Even at this level, a little forethought can save a lot of time and money. If you make sure that the machine documentation is up to date, the purchasing department can order spare parts based on the documentation instead of waiting until the service technician has removed and identified the parts.

It also pays to stockpile certain parts, such as those that break more often, as well as those that are very cheap or very hard to get hold of. At this point, a somewhat deeper consideration is recommended. Some components are relatively expensive and rarely break, but they have a high strategic value, for example, if they paralyze the entire production line when there is a defect. In this case, it might be worth stocking up on them after all. Not only do you need to take into account the storage space and the capital tied up in them, but also the costs in the event of a failure.

A good example can be found in the engine room of cargo ships, where a complete engine piston, including connecting rod, often hangs on the wall. It doesn't really make any economic or technical sense to sail such an expensive, large, and heavy part around for many years. But if an engine failure occurs, it is often extremely costly to transport this huge spare part to a remote location in the world and lift it into the engine room, so in the end it is worth having it on board at all times.

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Preventive maintenance occupies the first level of the maintenance pyramid. In the simplest case, this requires virtually no effort to implement, just some planning – maintenance and precautionary replacement of parts is scheduled based on operating periods or usage.

Image 1: Operational Maintenance

Preventive maintenance is what you do on a car, for example. The timing belt must be replaced every 75,000 miles or 6 years – the manufacturer has found out in tests and calculations that practically all timing belts reach these intervals without breaking. So the timing belt is replaced at a time when it is still functional in virtually all cases. If you just keep driving, the risk of a broken timing belt and thus engine damage increases more and more. Replacement by interval can be scheduled so that downtime is kept to a minimum and costs are very moderate compared to those incurred in the event of a belt failure.

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Tactical Maintenance: Looking into the Future with Sensors

In the next step, **condition-based maintenance**, technical equipment is used for the first time. Sensors built into the machine sound an alarm when a parameter deviates from its usual range of values. So it reacts when the defect is happening, so to speak, or when a rule is violated – a bearing must not become hotter than X degrees, a pressure drop must not rise above value Y. If this value is exceeded, maintenance is due.

For example, you could constantly check the precision of the timing belt drive on an engine. If the timing belt starts to tear, the fabric layers inside the belt will probably tear first, making the belt longer and the valve timing less accurate. A technical device could now stop the engine before the belt breaks. You accept an unplanned defect, but avoid the subsequent costs of the damage.

As for operational maintenance, tactical maintenance can also be improved through planning. With condition-based maintenance, you wait with your eyes open, so to speak, until a threshold is exceeded – but you could also react with foresight if the measured values move in the direction of the limit.

This is known as **predictive maintenance**. The sensor data are continuously evaluated and interpolated into the future. This allows you to recognize an incipient defect and try to calculate when the component will eventually fail. The maintenance date is then scheduled at a convenient time within this period. Data analytics technologies are used here to identify anomalies and assign them to a defect and a component. A time prediction can then be made based on the rate of change.

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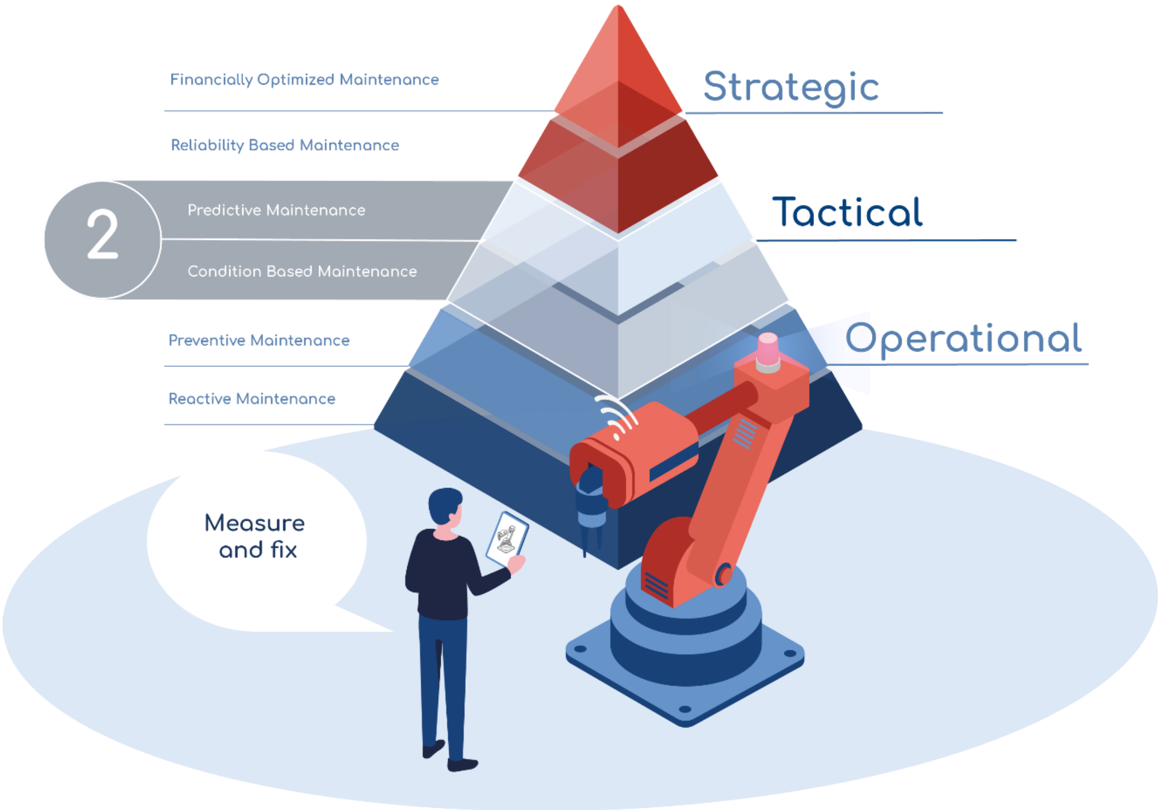

Image 2: Tactical Maintenance

Strategic Maintenance: Improve Instead of Repair

At the previous levels, maintenance tended to be centered on individual parts or assemblies: a defect in a machine is imminent or occurs and maintenance is performed in response to the individual event. If you approach maintenance strategically, you consider entire systems, an entire production line, or a complete portfolio of machines in the field. This is also where the domain of "as-a-service" concepts begins: if a company operates machines at a customer's site and supplies the customer with the output of these machines, a strategic consideration is essential. If you enter into a service contract to supply a certain quantity of parts, it makes a

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lot of sense to use the experience gained on one machine to optimize all the other machines before the same defect occurs on them.

Reliability-based maintenance has the reliability of an entire machine fleet at its heart. For this, in addition to the real-time sensor data of all the machinery, current data on all machines are required at all times – the operator must know the exact status of each machine. If a defect occurs, the system analyzes which "sister machines" – those with the same components – exist and how high the probability is that the same defect will occur on these machines. In addition, a new component is being developed that avoids this defect. For example, components that are perfectly fine may be updated on several machines, as they have been identified as a reliability risk.

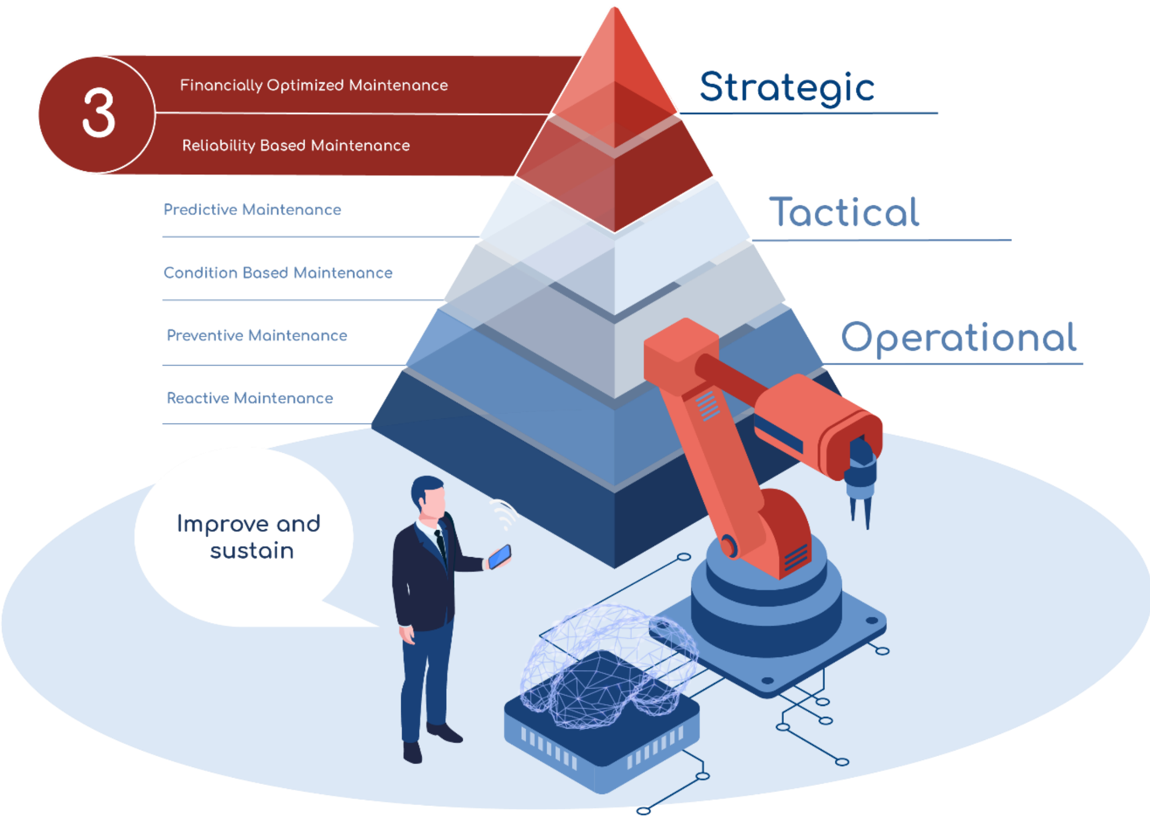

Image 3: Strategic Maintenance

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Since this of course does not necessarily make economic sense, **financially optimized maintenance** applies the technology of predictive maintenance to the entire machine fleet. The sister machines are therefore identified, but they are not replaced as a matter of course, rather the components of these machines are put under closer observation. If the values start to deviate as expected, the component can be replaced with its improved version.

Intelligence in Maintenance: Increasing Reliability, Maintaining Efficiency

Digitalization is changing maintenance. Instead of repairing or replacing parts at specific points in time as a matter of course, sensors, data analytics, and other technologies make it possible to operate machines or entire machine fleets at maximum efficiency and reliability levels.

As complexity rises, this requires increasingly complex and far-reaching holistic IT tools as more and more data are integrated and used in the process. Documentation, spare parts catalogs, CAD data, and other electronic information provide the overall picture of a machine or a machine fleet, which is needed to approach the topic of maintenance in an equally holistic manner.

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