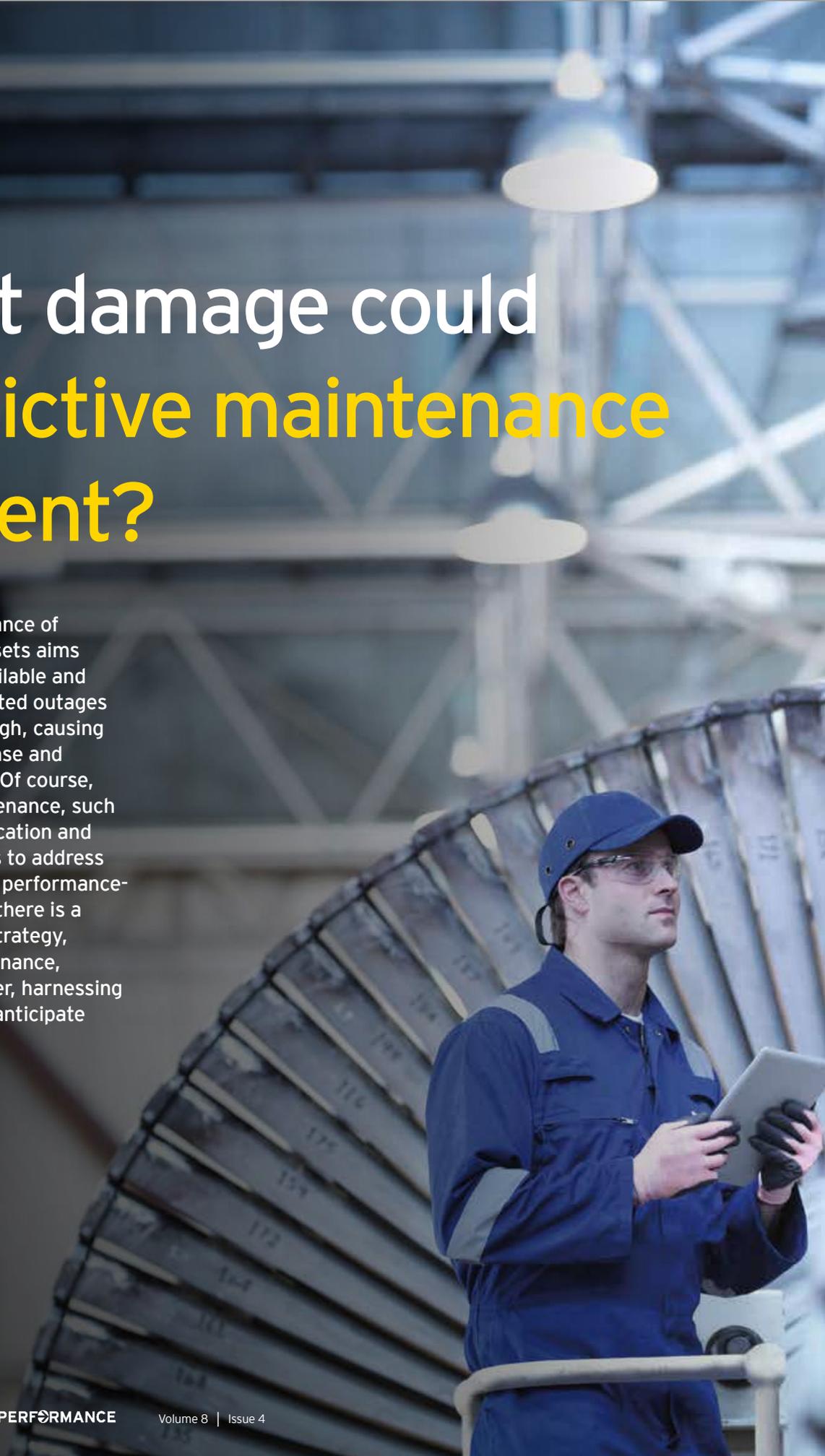# What damage could predictive maintenance prevent?

Regular maintenance of machines and assets aims to keep them available and reliable. Unexpected outages still happen, though, causing unforeseen expense and lost productivity. Of course, preventive maintenance, such as cleaning, lubrication and overhauling, aims to address this on a time- or performance-based cycle. But there is a future-oriented strategy, predictive maintenance, which goes further, harnessing machine data to anticipate and avert issues.

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What damage could predictive maintenance prevent?

Technical equipment used to produce goods inevitably suffers abrasion and fatigue of material and components. The result is incidents and damage that often lead to unplanned downtime of machines or production lines. The knock-on effect of this is higher costs: for labor and materials to fix the machines and, indirectly via rescheduling production plans, missed delivery timelines or reduced income due to lower output.

Of course, scheduled maintenance is designed to reduce these impacts and increase the efficiency and reliability of assets. But there is a future-oriented strategy in which the probability of defects is forecasted using data from sensors and technical guidelines: it's called predictive maintenance. The aim is to detect possible and imminent breakdowns at the right time to help prevent these events by planned maintenance activities.[1]

Whatever sector an organization operates in, and whatever its size, implementing a predictive maintenance strategy indicates a big change. Topics such as Industry 4.0, the internet of things and big data are becoming increasingly important and, as technology advances, companies will be able to collect, manage and harness large amounts of data, some of which will help drive maintenance processes efficiently.

But implementing a predictive maintenance strategy means more than just using data-collecting technology. Organizations have to define which data should be collected and how to analyze it automatically, and decide how and when to follow findings with actions. So predictive maintenance requires technical prerequisites as well as changes to the organization, processes and personnel skills.

Considerations for a predictive maintenance strategy

The process of setting up predictive maintenance starts with identifying an upcoming issue that will cause a breakdown in the near future. To begin, reasonable parameters have to be determined that allow the target state of the equipment or part to be defined.

These parameters are the reference values with which the current status can be compared. It is essential that they are as accurate as possible, because they will be the indicators for determining what maintenance measures will be necessary. When we use the term as "accurate as possible," we mean that the parameter can comprise either a single value or a range before it represents a deviation from the target value.

Monitoring the predefined parameter means that the current status of the equipment has to be measured constantly – for example, pressure, temperature or vibration have to be detected to describe and document the current status.

The frequency of measurements also determines the accuracy of the collected data. While it may cost more to store the greater volumes of data created by more frequent measurement, if the frequency chosen is too small, there is a greater risk of missing information that could forecast problems. Bear in mind too that, as the frequency and complexity increases, the higher the number of dependencies between single sensor values there will be.

> Implementing a predictive maintenance strategy means more than just using data-collecting technology.

1. H. Weiss, "Predictive Maintenance: Vorhersagemodelle krempeln die Wartung um," http://www.ingenieur.de/Themen/Forschung/Predictive-Maintenance-Vorhersagemodelle-krempeln-Wartung-um, accessed September 2016.
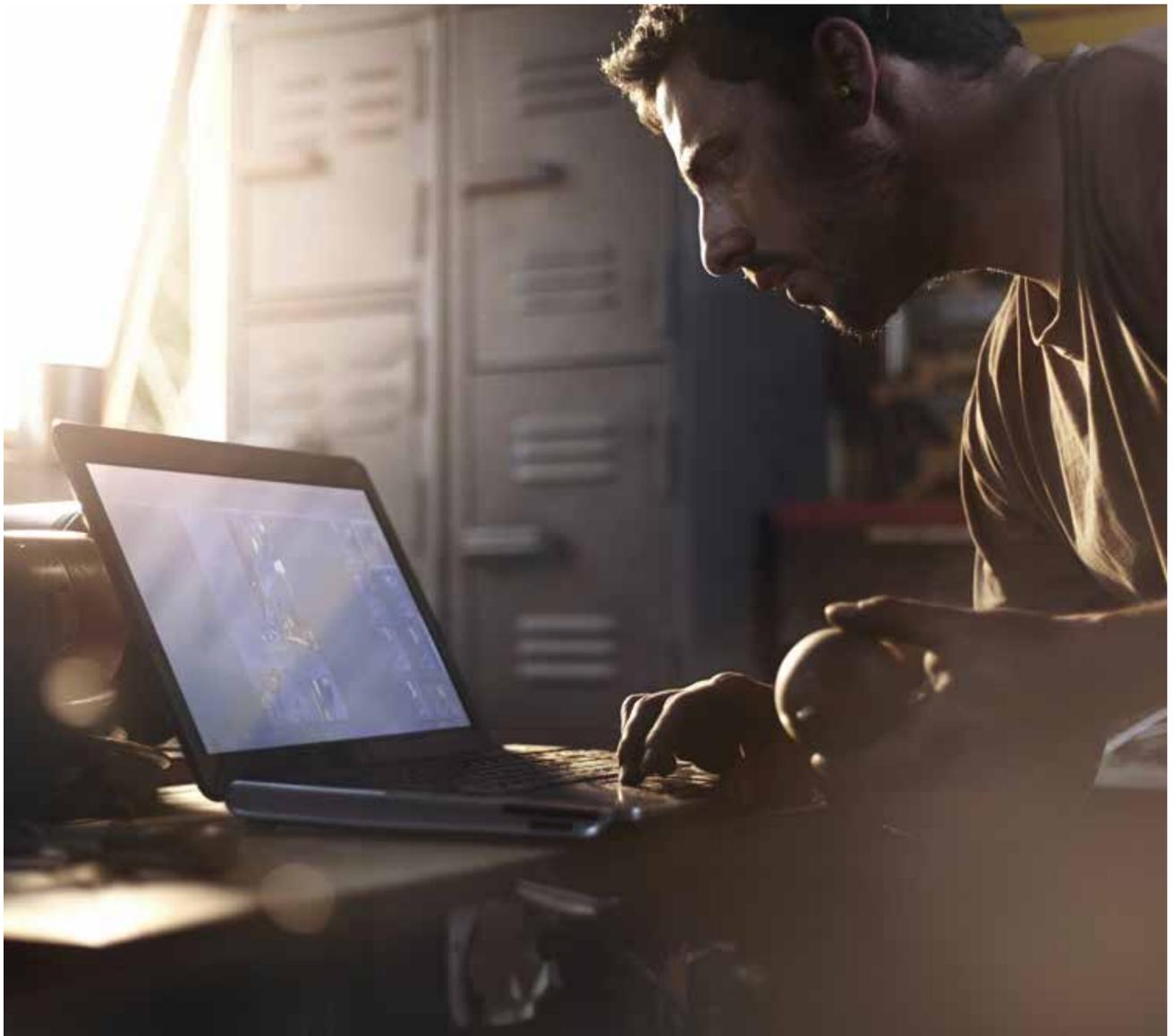
What damage could predictive maintenance prevent?

> Issues should be detected soon enough to plan maintenance activities, but not so far in advance that needless maintenance is performed.

It's also necessary to define how the data will be used for prediction, so a systematic basic rule has to be developed to monitor the asset's condition, with algorithms to analyze trends and better forecast equipment status and possible breakdowns. These rules could help interpret information to gauge whether the gap between the current- and the target-state value can be considered a deviation, or if the trend of values should initiate measures to prevent an imminent breakdown.

These issues should be detected soon enough to plan maintenance activities, but not so far in advance that needless maintenance is performed. Finding the right point in time for maintenance work is essential if a good balance is to be struck between effective and cost-efficient maintenance, greater reliability and a lower risk of unplanned downtimes. Defining these rules is very important when implementing a predictive maintenance strategy, and requires specialist technological and methodical knowledge.

The next step is to decide on the measures and maintenance activities to prevent issues from happening, and catalogs are commonly used to connect measurements such as inspection, service activities and part changes to the maintenance notifications.

With so much data stored in the cloud, data security also has to be considered. Information such as performance KPIs, measurement values and master data must be stored as securely as possible to avoid misuse.

In some cases, the collection of machine data might be connected with employee data. Or it could be that the company wants to monitor the behavior and performance of individual employees. When it comes to employee data, it's important to consider individuals' rights and engage with the works council to prevent possible issues arising on the project.[2]
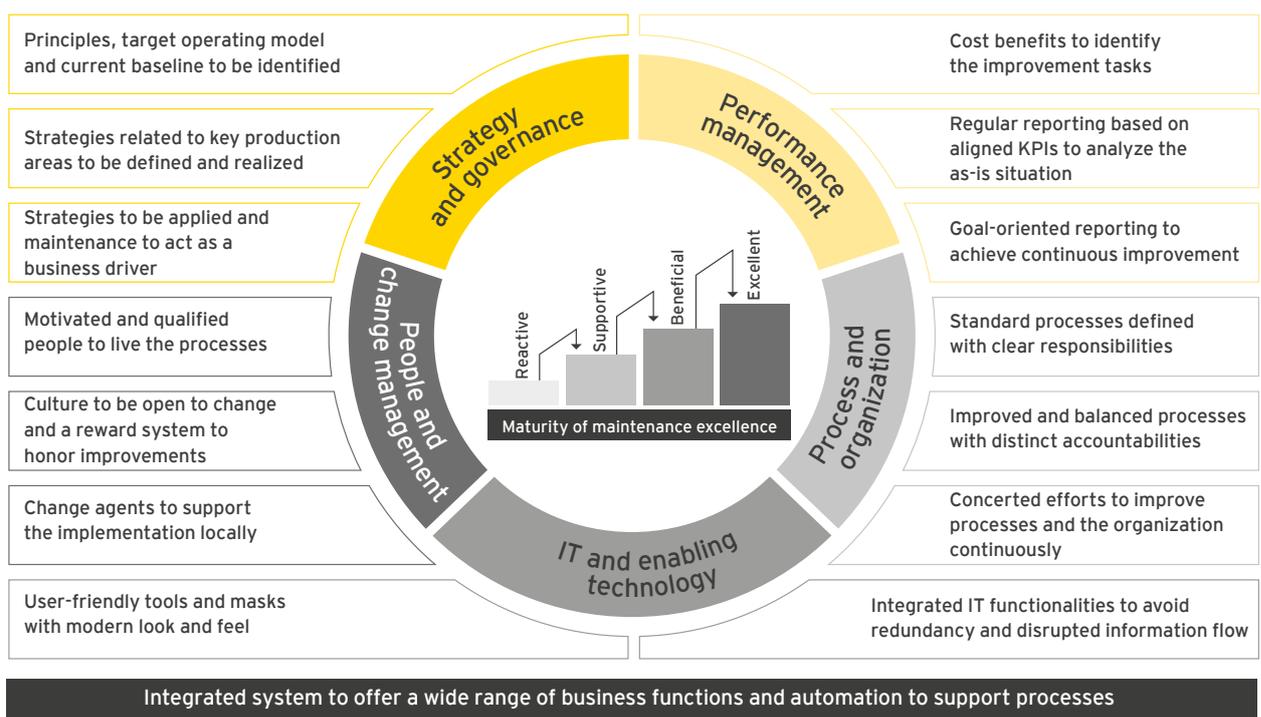
Predictive maintenance as part of an integrated approach

To realize the benefits of predictive maintenance, it should be part of a balanced maintenance strategy and follow governance guidelines in the same way as, for example, data security. Clearly defined processes, including roles and responsibilities, support all of the preparations and operations during setup and performance of predictive maintenance. Meaningful KPIs can be used to measure the effects on reliability, efficiency and costs.

And, last but not least, opportunities for development should be made available to anyone involved to enable them to develop methodical and analytical skills, as well as the self-motivation to gain a deeper understanding of cause and effect within technical systems.

With so many aspects to take into account, we recommend that predictive maintenance is considered as part of an integrated approach. Our methodology to support this is based on our maintenance excellence model.

Figure 1. An integrated approach for maintenance excellence

Strategy and governance	**Performance management**
Principles, target operating model and current baseline to be identified	Cost benefits to identify the improvement tasks
Strategies related to key production areas to be defined and realized	Regular reporting based on aligned KPIs to analyze the as-is situation
Strategies to be applied and maintenance to act as a business driver	Goal-oriented reporting to achieve continuous improvement
People and change management	**Process and organization**
Motivated and qualified people to live the processes	Standard processes defined with clear responsibilities
Culture to be open to change and a reward system to honor improvements	Improved and balanced processes with distinct accountabilities
Change agents to support the implementation locally	Concerted efforts to improve processes and the organization continuously
IT and enabling technology	
User-friendly tools and masks with modern look and feel	Integrated IT functionalities to avoid redundancy and disrupted information flow

Maturity of maintenance excellence: Reactive, Supportive, Beneficial, Excellent

Integrated system to offer a wide range of business functions and automation to support processes

2. G. Knüpffer, "Predictive Maintenance: Vorhersage mit Hürden," http://www.produktion.de/technik/it/predictive-maintenance-vorhersage-mit-huerden-102.html, accessed September 2016.

What damage could predictive maintenance prevent?

Introducing the maintenance excellence model

The model comprises two dimensions. The first considers maintenance from the following perspectives:

► Strategy and governance

► Process and organization

► Performance management

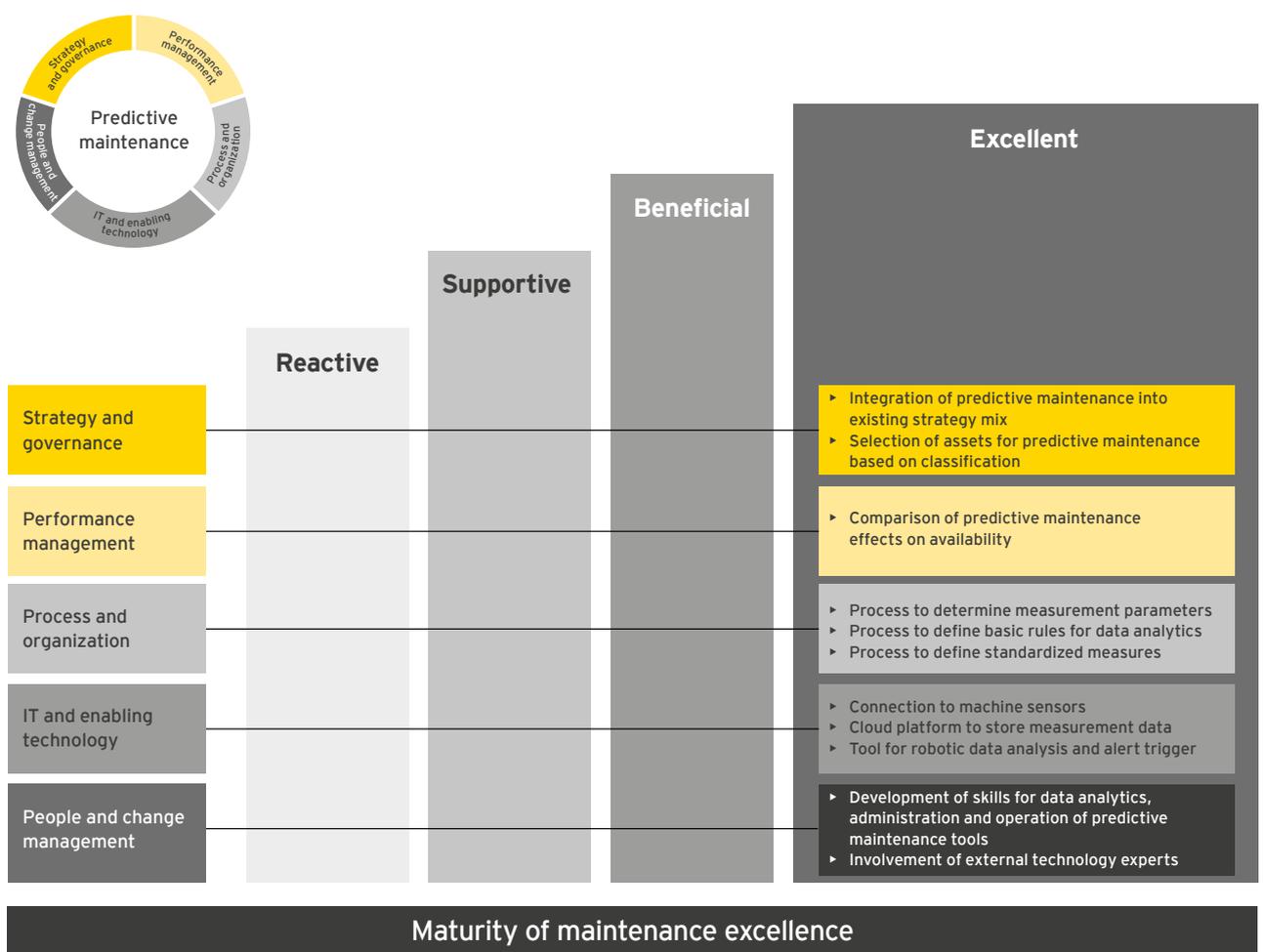► IT and enabling technology

► People and change management

The second dimension highlights the maturity of maintenance as a comprehensive system, and aims to classify the as-is situation and devise concrete measures to reach the next level of excellence.

To guide the maintenance organization from level to level, several key elements are embedded into the model. One of these is predictive maintenance, which sits on the fourth, and effectively highest, maturity level.
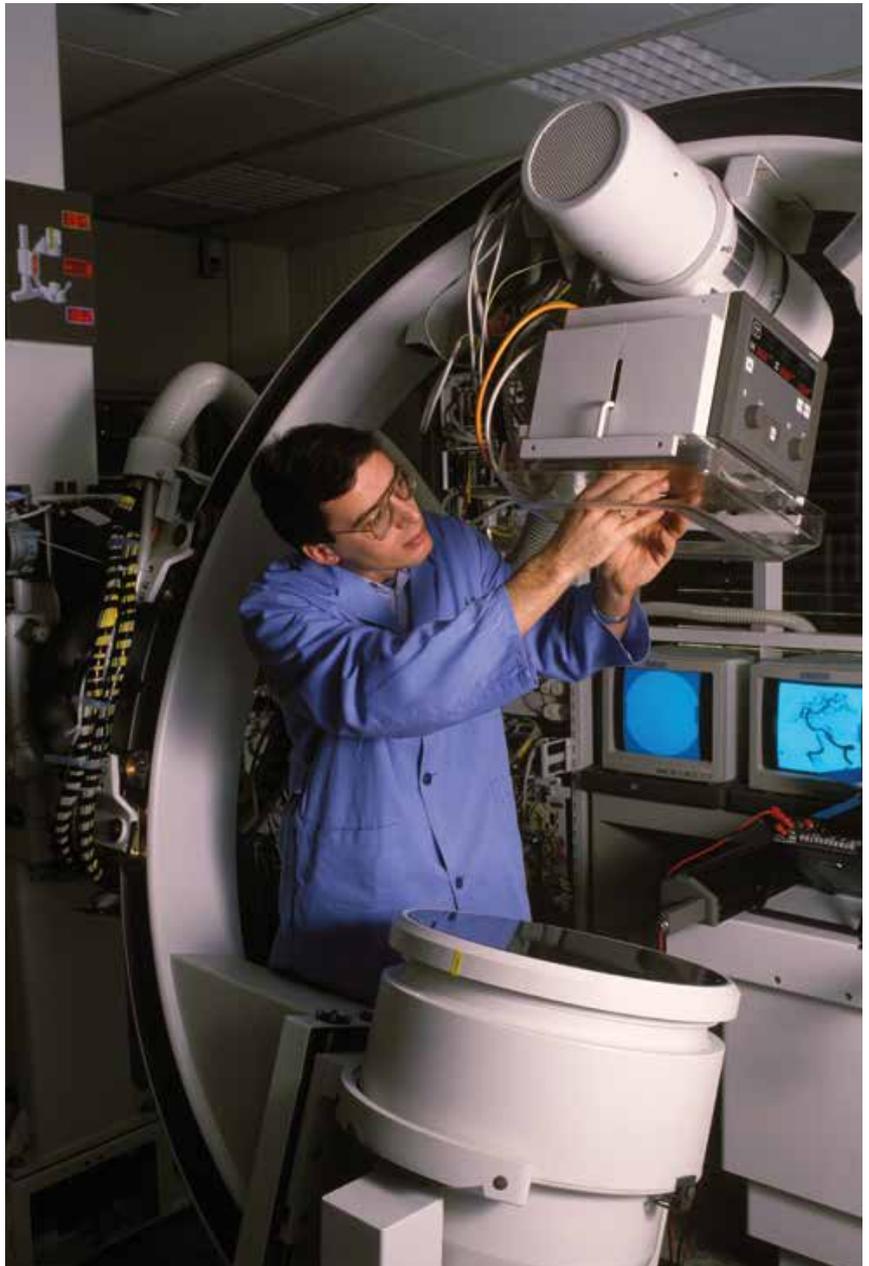
Predictive maintenance needs to be part of a balanced maintenance strategy and follow governance guidelines in the same way as, for example, data security.

Figure 2. How predictive maintenance sits within the maintenance excellence model

- Strategy and governance
  - ▸ Integration of predictive maintenance into existing strategy mix
  - ▸ Selection of assets for predictive maintenance based on classification
- Performance management
  - ▸ Comparison of predictive maintenance effects on availability
- Process and organization
  - ▸ Process to determine measurement parameters
  - ▸ Process to define basic rules for data analytics
  - ▸ Process to define standardized measures
- IT and enabling technology
  - ▸ Connection to machine sensors
  - ▸ Cloud platform to store measurement data
  - ▸ Tool for robotic data analysis and alert trigger
- People and change management
  - ▸ Development of skills for data analytics, administration and operation of predictive maintenance tools
  - ▸ Involvement of external technology experts

Maturity of maintenance excellence

What damage could predictive maintenance prevent?

As the key elements are designed to be based on each other, the position of predictive maintenance within the model is based on some prerequisites:

► A balanced mix of corrective and planned maintenance is in place.

► Condition-based maintenance is also part of the mix, as this can help facilitate knowledge about critical components and their weak spots.

► Management's focus on investing in reliability means maintenance staff can rely on the commitment of the leadership team.

► Dedicated responsibilities for planning, preparation, performing and control of tasks are all part of the organizational setup.

► Operational staff are organized in mixed-skill teams, and daily cleaning and lubrication is conducted by machinery personnel.

► Spare parts storage and supply is linked to a risk-based classification of the assets.

► Primary planned activities are well prepared, coordinated with the production plan, and performed efficiently and without interruptions.

► Processes are supported by an integrated maintenance management system that provides structured real-time and on-demand information, including a complete history of disturbances and their causes, planned and unplanned measures, exchanges of spare parts, and costs of internal and external labor and material consumption.

► Administrative effort is lowered by user-friendly input masks and mobile devices. Lean processes are enabled by automated processes resulting in high data quality.

► A key driver for continuous improvement is the use of target-oriented KPIs that build the basis for regular reporting, which is deeply anchored within the maintenance organization.

► Besides technical skills, staff are well grounded in methods and tools for cause and effect analysis and deriving measures for sustainable optimization.

► Campaigns to accomplish the next level of excellence are accompanied by active change management and coaching, to gain buy-in from the maintenance staff and motivate them to drive change on their own terms.

With these prerequisites in place and part of daily operations, predictive maintenance can be employed in the following ways (shown here in the context of the five perspectives of the maintenance excellence model).

What damage could predictive maintenance prevent?

Strategy and governance

▶ Predictive maintenance should be integrated into the mix of maintenance strategies.

▶ Not every machine needs failure prediction based on real-time sensor data, so the portfolio of assets should be classified on the basis of which equipment items need to be managed by predictive maintenance, using criteria such as probability of occurrence and extent of loss or predictability.

Process and organization

▶ New technical guidelines should be implemented that define how to interpret mass data to enable automatic deduction of predictions.

▶ If not already in place, the process to define measures related to specific alerts or notifications must also be defined.

▶ These processes should be allocated to a specialized team, staff unit or global business unit.

Performance management

▶ Initially, it may be a challenge to measure whether the prediction works efficiently, because it is difficult to differentiate the effects of preventive, condition-based and predictive maintenance. But, with predictive maintenance, there should be an overall increase in the equipment's availability, and this KPI should eventually stabilize at a high level.

▶ In contrast to the above technical KPI, the costs related to predictive maintenance should also be monitored and compared with any detected effects.

IT and enabling technology

▶ The maintenance management system should be fully integrated into any IT infrastructure-related initiatives, such as moving to the cloud or implementing a system to analyze big data.

▶ If available, apps can run on tablets to help visualize and anticipate potential problems.

People and change management

▶ Staff involved in setting up and running predictive maintenance should be provided with help to develop skills in data analytics, sensor techniques, and the administration and operation of the predictive maintenance system.

▶ Some skills will need to be brought in from outside the organization: for example, when defining the right measurement points, prediction rules, sensors and failure measures. These all demand a very deep understanding of the construction, plugged components and its characteristics in relation to changing operational conditions. But because these tasks are effectively temporary and, therefore, don't require a full-time specialist within the organization, typically, companies buy in this knowledge from external experts.

Conclusion

With every step an organization takes on the journey to maintenance excellence, the complexity of the entire system increases. Although disruptive innovations in sensor technology, IT infrastructure and data processing applications are key enablers to implementing predictive maintenance, there should be a methodical step-by-step approach to help realize the benefits that can be derived from it.

A solid and stable foundation that incorporates these key elements can harness the potential of new technology. And, when brought together in this way, these elements can produce a synchronized approach that is similar to the smooth workings of an engine. ∎

With predictive maintenance, there should be an overall increase in the equipment's availability, and this KPI should eventually stabilize at a high level.