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Digital Trends in Maintenance & Asset Management

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Digital Trends in Maintenance & Asset Management

Contents

Foreword

Digitalisation, or digital transformation, is all around us. In our day-to-day lives we find our way using online navigation apps, use home automation, scan groceries at the supermarket, talk with chat-bots or even humanoid robots. But what about the implementation of digital solutions in the industry? Or even more specific: in the field of Maintenance & Asset Management? Are we already using the full potential?

After executing surveys on predictive maintenance (PdM) in 2017 and 2018, we, PwC and Mainnovation, were curious to see whether the initial enthusiasm for PdM is still there in 2023. But we were also interested to see if maintenance is adopting other digital solutions, such as mobile maintenance, augmented reality, digital twin and 3D printing.

To gain this insight, we surveyed 127 companies in Belgium, Germany, the Netherlands, Norway and South Africa and we interviewed four leaders based on their best practices. We would like to thank all participants for their openness and valuable input, particularly Port of Rotterdam, Shell, PepsiCo and the South African Mining Company. They shared with us why they feel digitalisation is beneficial… or not. Because we also asked why companies are not (yet) implementing. Very interesting!

And maybe, in some cases, this 'not yet' can be turned into a 'yes, we are implementing' in the near future, as this report also provides a Roadmap to Digitalisation. We even dare to call it 'a Blueprint for (digital) success'. Because, at PwC and Mainnovation, we do believe in the benefits of digitalisation. We feel that implementing one or more of the solutions covered in this report, enables you to start utilising the full potential and create value for your company. But, of course, make up your own mind. Digitalisation is a journey every company needs to make for themselves. We hope this report will help you. And we wish you happy reading.

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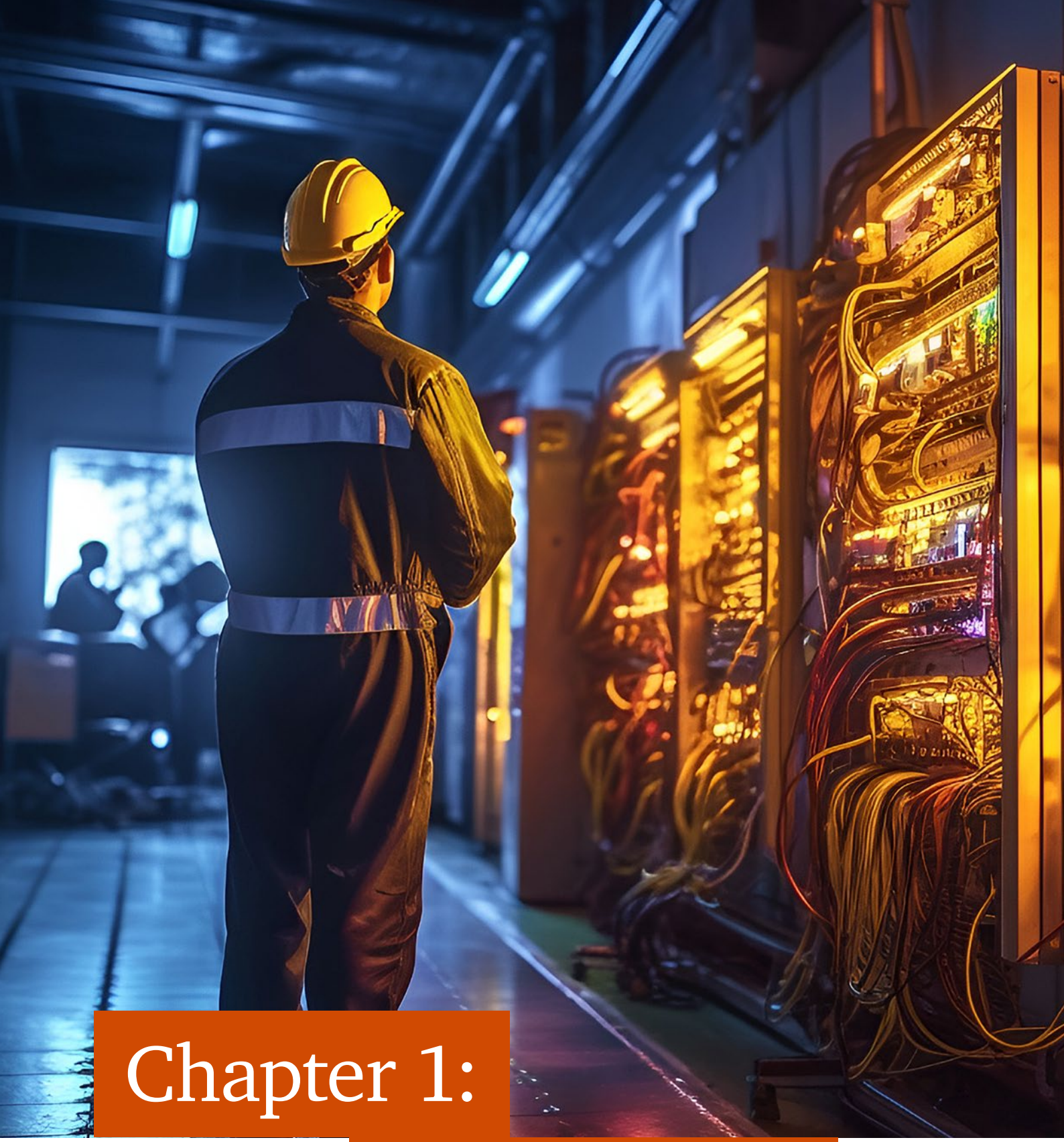
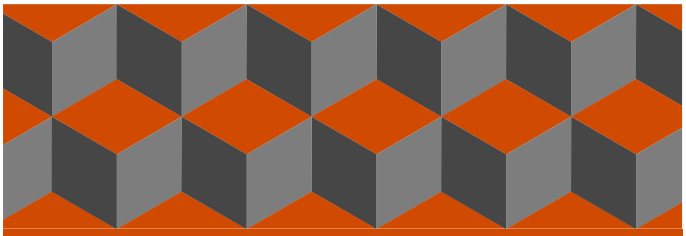


Chapter 1: Introduction

Are we using the full potential of digital transformation?

Digitalisation of Maintenance & Asset Management organisations has gained momentum in recent years. The way we execute our work has changed drastically. Or has it? Do we still rely on old techniques and are we hesitant to implement modern, digital solutions? And if we did decide to digitalise our work, are we really using the full potential or are we still in a pilot phase?



The year is 1985. Introducing Tom: Tom is a young but experienced maintenance engineer at a large chemical plant. On his weekly inspection of five large pumps he uses mainly his senses to check the status of the installation. His nose tells him the oil being used is getting old now. He lifts a cover plate to see that the rubber seals show some tiny deterioration. He puts his hand on the side of the pump and concludes that the temperature is a little higher compared to last week. Conclusion: revision of this pump is required. He mentions this on his paper work order, double checks if the number on the machine is the same as the number on his form and he moves on to the next pump.

The year is 2023. Introducing Michael: Michael is a data analyst at a large chemical plant with a background in mechanical engineering. His mobile phone tells him that he has an event scheduled for this afternoon: Tom's retirement party. But first he has to check pump number 64883-S1 because KPI's showed there was an anomaly in the dates. He scans the QR-code with his phone, puts on his AR glasses and immediately Maryam, an expert on these types of pumps, located in India, pops up. She tells Michael what to check and they both dive into the data of the pump. It was installed in 1985 and it appears it may break down in the next three months. They both decide the last weekend of April would be appropriate to refurbish the pump. More than enough time to 3D print new rotating impellers.

Science fiction

The way of working by Michael (see border), could have been an episode in the science fiction film 'Back to the Future' from 1985. But indeed, this is how it works in 2023. Or at least, this is how it could work. We have the opportunities and possibilities in terms of sensitive sensors, better Wi-Fi, augmented reality layers, digital twins, big data analytics, improved EAM/ERP software et cetera. But what about the skills to use them? Do we have the IT-infrastructure in place? Do we already have enough valuable data to extract the right conclusions? And will the investment pay off?

Important questions to answer because new techniques are only implemented if there are clear benefits for the Maintenance & Asset Management and/or the company as a whole. And it's true, some techniques (such as the digital twin or virtual reality) are still not completely developed for efficient and profitable use in practice. Are they still considered to be science fiction, or are they real applications – with benefits! – for certain tasks or sectors? Let's find out.

Background

Five digital trends

After two decades of mainly focussing on the implementation and the use of Enterprise Asset Management (EAM) or Enterprise Resource Planning (ERP) systems, the digital revolution in Maintenance & Asset Management can be reflected in five digital trends: mobile maintenance, predictive maintenance (PdM), digital twins, augmented reality (AR) and 3D printing.

Let's define the meaning of these digital innovations. Good to know: the explanation we provide is focussed on the world of Maintenance & Asset Management. Of course AR is used in the gaming industry and we know that you can use your mobile phone for so much more than just maintenance, but those use cases will not be our focus in this report.

Mobile maintenance

The power of mobile solutions is endless. The use of mobile solutions contributes to better efficiency, a higher Hands on Tool Time (HoTT) and improvement of the technicians' safety. Mobile maintenance enables companies to provide the information where it is needed because the Enterprise Asset Management system is always close at hand. This means the technician is always provided with the right digital work order and all need-to-know and nice-to-know asset information. The mobile device is also a tool for communication: sharing information about failures in text, with pictures or via an old fashioned phone call with the supervisor. In addition, the mobile device can proactively give safety warnings.

To execute mobile maintenance, technicians are provided with a phone, tablet or another device to register their maintenance activities. This device is connected to or part of the EAM/ERP system and, in specific industrial sectors, with GIS, DMS and other business applications. For plants working with hazardous materials the mobile devices are ATEX-safe.

Predictive maintenance

Predictive maintenance techniques are designed to find patterns in the failure behaviour and help determine the condition of equipment in order to predict when maintenance should be performed. PdM enables companies to execute maintenance 'just in time'; on the one hand exploiting the full potential of the installation and preventing accelerated deterioration, while on the other hand avoiding unforeseen downtime. In other words: the main promise of predictive maintenance is to allow convenient and timely scheduling of corrective and preventive maintenance, and to prevent unexpected equipment failures.

Based on big data and statistics, predictive maintenance enables you to improve the reliability and uptime of the assets. Comprehensive analytics of the data is key for success. Not just through assembling data via periodic visual and instrument inspections and continuous real-time monitoring, but also through understanding and combining the data with other process data to be able to make realistic predictions. In some cases, this information can help to describe the actions to be taken (prescriptive maintenance), that contribute to improving Maintenance and Asset Management processes.

Digital twin

A digital twin is a virtual replica of a physical object, system or process. The concept and model of the digital twin was publicly introduced in 2002 by Michael Grieves. NASA was one of the first to use this technology for space exploration missions. The aerospace and automotive industries have more recently been utilising digital twins for simulation, testing and design optimisation purposes.

In the context of factories, fleets and infrastructure, a digital twin represents the entire lifecycle of these assets, capturing real-time data and simulating their behaviour. It gives companies the opportunity to test new maintenance methods or see what the effects of new production methods are on the actual asset. It enables you to first simulate a scenario, before you actually bring it into practice on the real asset. In addition, it enables employees to efficiently access up-to-date configuration data for their daily activities. Instead of looking for paper documentation, the necessary data is one click away. A digital twin can also be used for training the maintenance personnel. In the realistic and interactive environment technicians gain hands-on experience without the risks and costs associated with working on real assets.

To build a digital twin for maintenance purposes, you need accurate and up-to-date static and dynamic data about the asset's function and design characteristics, performance, condition and operational parameters. This data can be collected through sensors, IoT devices and other monitoring systems. The digital twin then uses this data to create a virtual model that can simulate scenarios for better decision-making and optimise maintenance schedules.

Augmented reality

Augmented reality (AR) is a technology that overlays digital information, such as images, text, and 3D models, onto the real-world environment. In the context of maintenance tasks, AR can be used to improve processes by providing technicians with real-time guidance and support and additional asset information.

By using AR devices like smart glasses or by using mobile applications, maintenance technicians can access relevant information, step-by-step instructions, and virtual objects that are superimposed onto the physical equipment they are working on. This technology enables technicians to visualise complex systems, identify components, and perform tasks with greater accuracy and efficiency. By providing detailed instructions in this manner, AR solutions can bridge the experience gap of junior technicians. Also, it provides flexibility for specialists who are scarcely available. By calling in through an AR device, a technician can show and discuss a problem with a specialist from a distance.

3D printing

3D printing, also known as additive manufacturing, is a process of creating three-dimensional objects by adding successive layers of material. Traditionally, companies rely on a supply chain to source and deliver spare parts, which can be time consuming and costly. With 3D printing, companies can produce spare parts on-demand, directly at the maintenance site, reducing lead times and inventory costs. This technology enables rapid prototyping and customisation of parts, as well as the production of obsolete or hard-to-find components.

The history of 3D printing dates back to the 1980s when the concept was first introduced. It evolved over the years, and in 1986 the first commercial 3D printing process was invented. Since then, advancements in materials, technologies and affordability have led to an increased adoption of 3D printing across industries, including its valuable application in maintenance and spare part management.

Key questions of this survey

These digital trends are often topics for keynotes and they are covered in maintenance magazines articles. So we talk the talk, but do we walk the walk? Are these digital trends already applied in practice? If so, to what extent? And what do companies want to achieve with this? What are the critical success factors? Also interesting: if they are not being applied, what is stopping companies from implementing and using these techniques?

Across all these questions, we also wanted to know what the differences are between northwestern European countries (participating countries are: Belgium, Germany, the Netherlands and Norway) and South Africa, an upcoming, emerging country from a digital perspective.

Approach of this survey

With this survey we searched for answers to the key questions. What is the current state of affairs regarding the five digital trends? What are the major developments across various industries? And what can we learn from top performers?

We sent out an online survey and received 127 replies from companies in Belgium, Germany, the Netherlands, Norway and – for comparison – South Africa. We asked about the implementation level to find out if digital solutions had been applied, but also sought to understand the reasons why the digital solutions had or had not been applied in practice.

The responses came from many different sectors. To be able to compare and contrast and to draw conclusions, we clustered the companies into five industrial sectors.

- Discrete manufacturing
- Food & Pharma
- Heavy process industry
- Infrastructure & Fleet
- Service providers

The survey outcome, combined with various case studies, our own knowledge and experience, was used to develop a Digitalisation Roadmap, which will help companies to take the next step in digitalisation. How to build a solid foundation for successful implementation?

Article 1

Data is key at Port of Rotterdam

One of Port of Rotterdam's most critical assets, is an incredibly elusive asset. They also have no control over a multitude of equally elusive factors that affect this asset. And yet they do everything they can to optimally maintain this asset, because it is very important for the existence of the company. For this: data is key!

The elusive asset Giel Jurgens, asset owner at Port of Rotterdam, is talking about, is the bottom of the port. 'Yes, the bottom of the water. Silt, soil and on top of that a lot of salty sea water. Affected by the elements, fluctuating shipping traffic and even by the melting of the snow in Austrian mountains. You can't see it, it's constantly changing and yet we have to manage it.'

Continuous optimisation

The Asset Management department of Port of Rotterdam has two important goals. 'We manage the port industrial complex and we make sure we enable safe, smooth and clean shipping traffic. These goals are aligned and very important for the good reputation of Port of Rotterdam.' As the largest seaport in Europe, Port of Rotterdam has a great responsibility for global trade activities. Jurgens: 'We operate with a very broad perspective. Developments from all over the world have to be taken into account. This means we are continuously optimising the port in order to meet the wishes and requirements of our customers. We do this based on data.'

Digital transformation

For this task Jurgens uses the term 'digital transformation'. He explains: 'Internet of Things, where everything is connected with everything, helps us to fulfil our missions. For instance: we are striving for 'Just in Time Sailing'. If a ship has to wait three days before she can unload, this costs time, money and emissions. We use data to avoid this. Data on time of arrival of

this particular ship but also other ships, data of the weather, water level and the soil conditions. And also on the availability of an appropriate terminal.' Even data on the amount of salt in the water is relevant. 'The saltier the water, the more carrying capacity. So with a higher salt concentration, the draught of a ship is less. This tells us something about the necessary depth of the bottom of the water.'

Asset management

Not all elements are asset management related. Therefore cooperation with other departments and other parties that provide data, is crucial. 'Our job is to translate the information to asset management decisions. When we provide a proper water depth and we can assure the customer of this given, this means the trader knows he is able to load extra containers. Every extra container that can be delivered in a safe and smooth way, means extra income.'
So, this 'elusive asset' – the bottom of the water, is monitored closely. 'We echo sound the water depth with survey vessels. If it is below 'Nautically Guaranteed Depth', then we have to dredge.' The data obtained is also used for predictive maintenance analyses. 'The siltation rate differs per part of the port. We try to predict this as best we can, but we always double-check. Also, if the ships never come close to this depth on a specific part of the port, we know we don't have to dredge this part.'

Sacrificial anodes

The water bottom is only one of the 23 different assets considered as critical for the Port. There are around 76 kilometres of quay walls, 123 jetties, 19 vessels, 2 locks, a lot of road infrastructure and so much more. Also on these assets the digital transformation applies.

Most quay walls have a metal sheet pile wall. A very robust material that has to withstand the influences of wind and weather for decades. But constantly surrounded by flowing salt water, degradation and corrosion occurs faster than normal. 'We were curious whether we could predict and prevent this wall thickness decrease. Sacrificial anodes were placed. These corrode, so that the sheet pile wall doesn't degrade anymore. Also, the decrease of these aluminium anodes is measurable. We were able to create a degradation curve to predict the end of life for these anodes.'

Opportunities

Using sensor data from the quay walls, measuring the degradation of steel in the water, analysing samples drilled from the quay walls to gain knowledge on the degradation. 'Data is key', Jurgens emphasises. 'We use it for logistics, to improve service for our clients and for asset management. With data you can extrapolate – use the knowledge from a short period to predict the long term future. With data you can search for anomalies and use them to analyse failures. You can also use data provided by others. By doing this, Port of Rotterdam delivers quick and smooth shipping traffic, reduces costs ('If we don't have to dredge a certain part of the port, that is a significant cost saving') and also has an answer to employee scarcity and the growing shortage of resources and raw materials. Plus, by sharing data there are also benefits for many other parties. So Jurgens is very positive about digital transformation. 'We believe in this progress. The more we digitalise, the more opportunities we see. We are eager to take this to the next level.'

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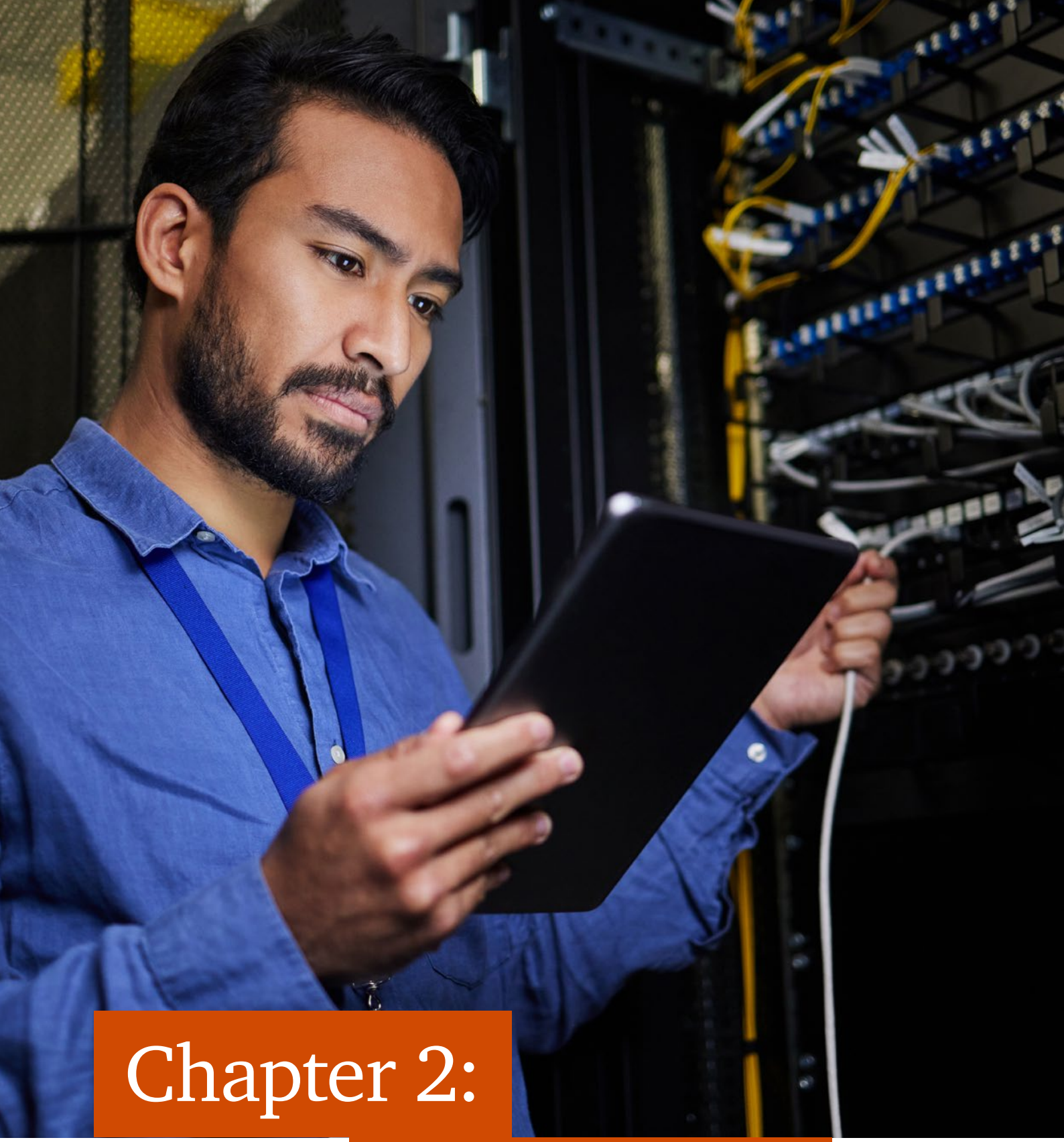
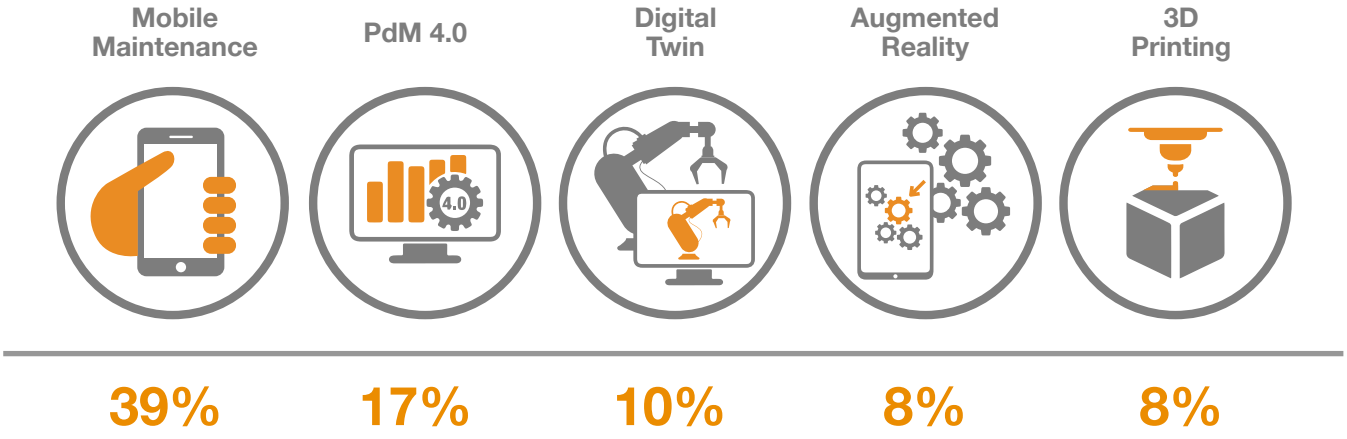


Chapter 2: Key findings

What is the status of digitalisation in Maintenance & Asset Management in northwest Europe?

In this survey we focus on five digital trends in Maintenance & Asset Management. What is the implementation level in the four surveyed European countries? Which software applications are used? What is the primary goal for implementation and what are the critical success factors? And also, what are the reasons for not starting with digitalisation? In this chapter we present the key findings.

Figure 1 Implementation level for participants from northwest Europe



2.1 Implementation level

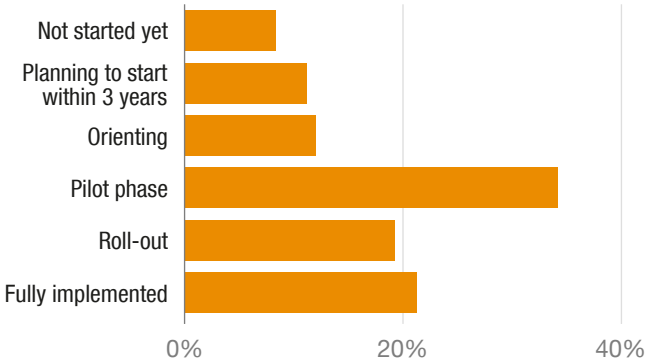
To get a good idea whether the five digital solutions are really being used, we asked companies what their implementation level is. Are they planning to start in the future or are there no plans at all? Are they implementing at this moment, or is the solution already in use and has the technique been fully implemented? This gave insight that mobile maintenance is a mature technique, predictive maintenance is emerging but digital twins, augmented reality and 3D printing are still new and not yet ready to be optimally applied in the field.

Figure 1 shows the implementation level for participants from northwest Europe for the five digital solutions. The percentages reflect the sum of companies that have fully implemented the solution or are currently implementing.

The evolution of mobile maintenance

With a score of 39%, mobile maintenance is the innovation that shows the highest implementation level. So amongst the five solutions, this is the solution that is mostly applied in the field of Maintenance & Asset Management.

Figure 2 What is the level of implementation of mobile maintenance that your company has attained?



This can be explained by the fact that, compared to the other solutions, this innovation was the earliest to have been developed and introduced. Mobile maintenance originated around the turn of the century, so it benefits from 20+ years of evolution. In 2007 the first iPhone was released. Since then mobile has taken off due to the rapid development of apps. We also see mobile maintenance benefitting from these developments. Possibly because the developments of many mobile technologies (such as devices, Wi-Fi, UI, security et cetera) and apps also increased rapidly. Your own mobile phone even became a usable device. This, and the developments and professionalisation of EAM/ERP software suppliers, led to more reliable, safer, user friendly and more valuable applications within the field of maintenance.

The implementation level is the highest in Infrastructure & Fleet (50%) and in Service providers (48%). This is not surprising because in these industrial sectors most employees are in the field and far away from their desks. They are not constantly working at the same location. Therefore the need for mobile solutions is higher.
Surprisingly also Food & Pharma has a high implementation level (50%). This shows that the technology is also perfectly applicable in a factory setting. The industrial sector where implementation is lagging, is the Heavy Process industry (22%). An important criterion here is that a device has to be safe to use in potentially explosive atmospheres (ATEX).

Specifically for mobile maintenance we also asked for what purpose the technique is used. One functionality stands out: work order registrations (70%). Companies also choose to use mobile devices for inspections (42%).

Figure 3 Mobile maintenance; roll-out + fully implemented

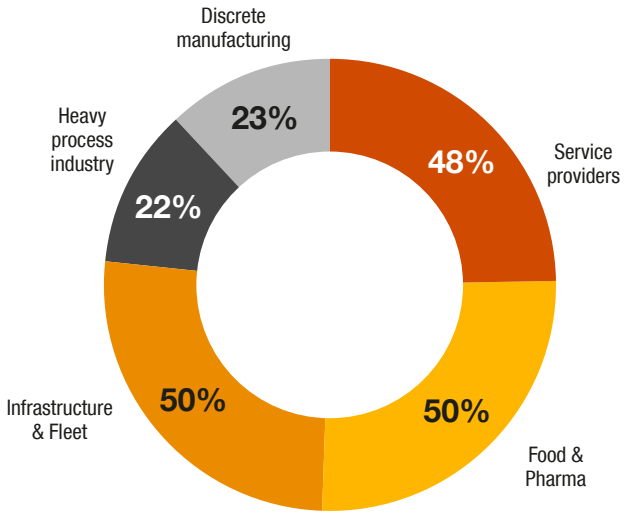
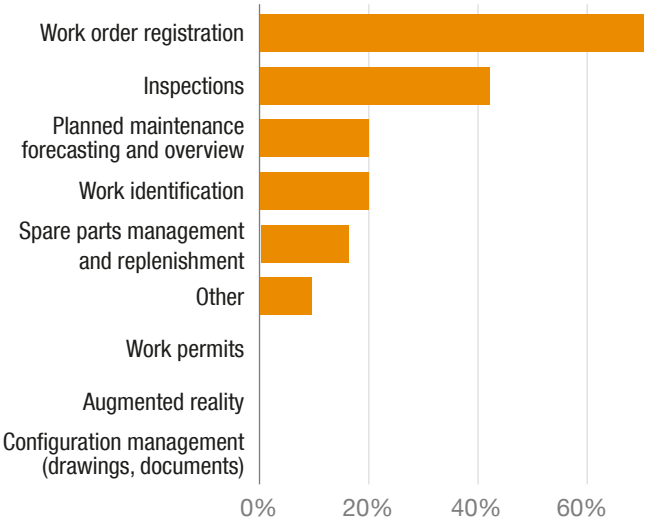


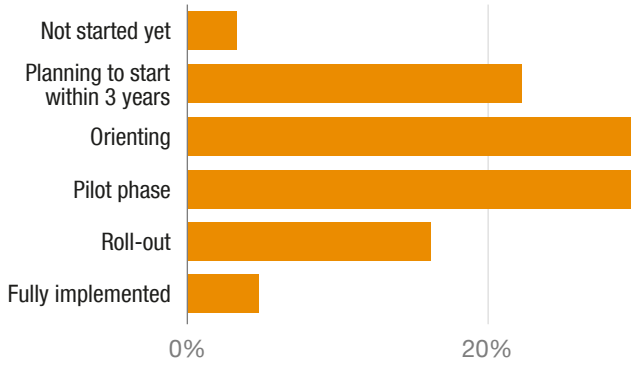
Figure 4 Functionalities



Predictive maintenance is picking up

After mobile maintenance, predictive maintenance has the highest implementation level (17%). This technique is gaining popularity. If we compare the results with previously held surveys on predictive maintenance, we see an enormous growth. Compared to 2018 the implementation level has almost doubled[1].

Figure 5 What is the level of implementation of predictive maintenance that your company has attained?



Also here we see that service providers are in the lead when it comes to applying predictive maintenance (38%). Service providers, mainly Original Equipment Manufacturers (OEMs), focus on a specific group of asset types that exists in high numbers. This makes it easier to offer specific digital solutions related to these assets.
Food & Pharma also shows a relatively high adoption (19%) compared to the other industrial sectors. In this sector many companies use standard equipment. This means they can benefit from the knowledge and services provided by OEMs about predictive maintenance.

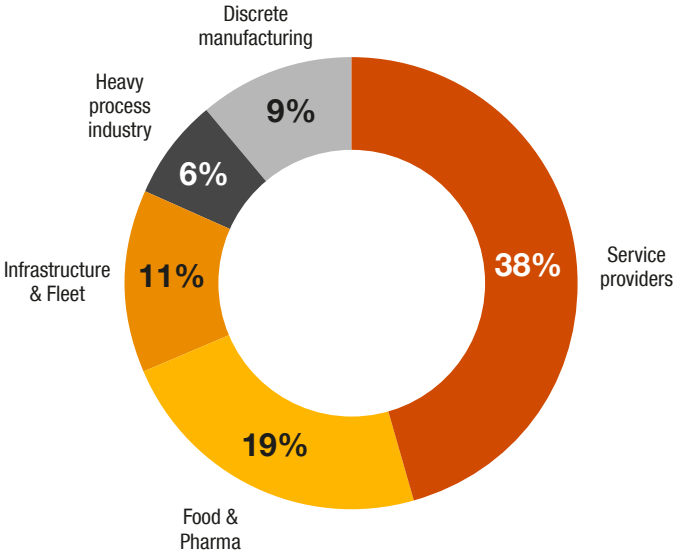
AR, 3D printing and digital twin still in start-up phase

For the other three digital solutions, the implementation level is low. Digital twin is at 10% and augmented reality and 3D printing are both at 8%.

There are different explanations for these low scores. The digital twin was only recently introduced in Maintenance & Asset Management.

Augmented reality is highly dependent on reliable software and hardware (AR glasses) but they are still not entirely fit for maintenance activities. Original Equipment Manufacturers (OEMs) could bring AR to the next level by providing a standard solution including all data references and manuals. Finally, 3D printing is mostly applied at locations that are hard to reach and when there is a clear economy of scale. PepsiCo however proved that it is possible to build a good business case with 3D printing. See page 34 for their interesting case story.

Figure 6 Predictive maintenance; roll-out + fully implemented



From pilot phase to implementation

For the near future we expect the implementation levels of the digital solutions to increase. The results show that many companies are planning to implement a digital solution and they are already exploring the field. On average for all five solutions, 21% of participants indicate that they are at the moment in a pilot phase regarding the implementation of at least one digital solution. This percentage is particularly high because of the major plans in the field of mobile maintenance and predictive maintenance. Here the percentages for pilot phase are 31% and 27% respectively. To be continued...

1 On predictive maintenance PwC and Mainnovation previously executed surveys: *'Predictive Maintenance 4.0 - Predict the unpredictable' (2017) and 'Predictive Maintenance 4.0 - Beyond the hype: PdM 4.0 delivers results'* (2018).

2.2 Software solutions

Digitalisation is all about using smart technology to enable better and/or new business activity. Proper, good functioning software is a must-have. It is hard to present the most popular software solutions for all techniques, because it is a scattered landscape where different companies in different industrial sectors use different tools.

Figure 7 What is the level of implementation of digital twin that your company has attained?

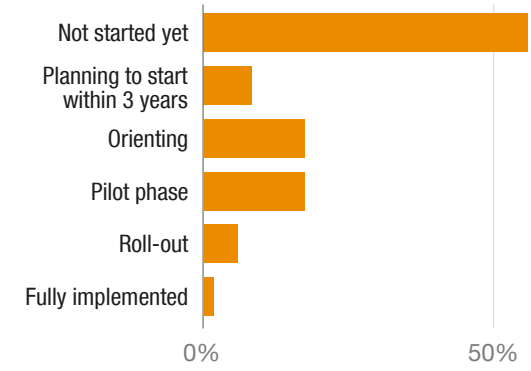


Figure 8 What is the level of implementation of augmented reality that your company has attained?

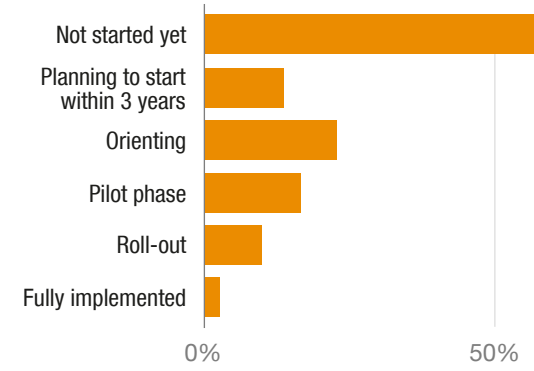
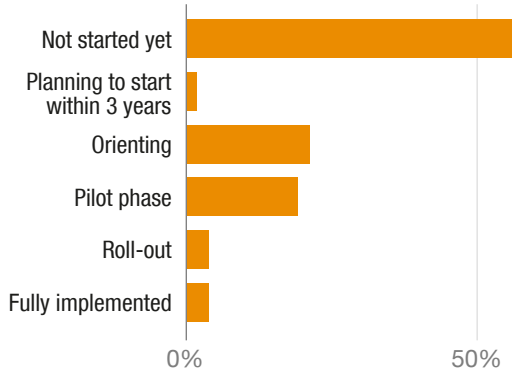


Figure 9 What is the level of implementation of 3D spare parts printing that your company has attained?



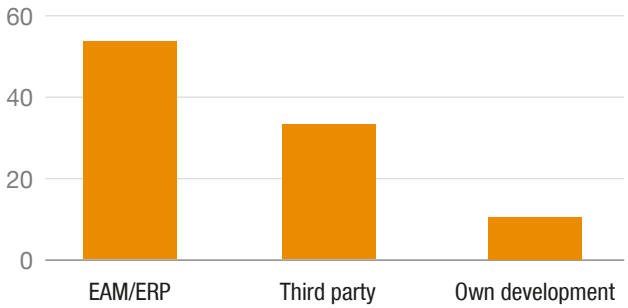
Mobile Maintenance

For the companies that are using mobile solutions, more than 50% is using the mobile app that is provided by the EAM/ERP-supplier. Of these 50%, more than half are using SAP, followed by Maximo and Ultimo. About one-third is using a third-party solution like Mendix, Prometheus or Sigga, whilst 10% created their own mobile solutions.

Predictive Maintenance

For predictive maintenance we see a highly scattered landscape of all types of platforms and software. Almost 30% is using solutions linked to their EAM/ERP-software, 20% use various sorts of condition monitoring tools and almost the same amount use a range of big data platforms and algorithm software. Some IT-system names that were regularly reported included OsisoftPi, Azure, Icare, IBM Watson and Aveva.

Figure 10 Type of mobile solutions



Augmented reality

Although not many companies are using AR-technology yet, we see that among the participating companies that do apply AR, two systems are dominant. About one-third of AR-users mentioned Microsoft Hololens and approximately 20% uses Realware as the tooling for the AR-technology.

3D printing

For 3D printing similar conclusions can be drawn to AR. However, for these companies one system is dominant. More than 50% of all companies are using the Ultimaker platform, with Cura software as the core, for realising their printed spare parts with 3D printing technology.

Digital twin

There is no dominant system that is highlighted by the companies who are using digital twins on a more advanced level. Specific GIS-software is mentioned most, but the majority of companies are still referring to their EAM/ERP-system as the main tooling for (some kind of) digital twin of their assets.

2.3 Primary goals

The implementation of a new technique must be well founded. Why do we do the things we do? The inquiry for the primary goals led to the top 3 findings for the five digital trends as presented in Table 1.

It is interesting to see that there is some similarity in goals. The most important reason for the implementation of mobile maintenance, predictive maintenance and digital twin is 'uptime improvement'. This states that the ambition from the maintenance department to deliver maximum technical availability, is exceedingly high. It also implies that companies see digital solutions contributing to this goal.

'Cost reduction' was also mentioned as a primary goal for digitalisation, but not as often as 'uptime improvement'.

Sustainability?

Despite the enormous challenge hanging over our heads to reduce the carbon footprint, the goal to 'increase sustainability' is not in the top 3 at any of the digital trends. Even though the companies have not established a direct link between their asset management digitalisation and their ESG impact, we expect that the increasing regulatory requirements and industrial "peer pressure" will push companies to prioritise it in the near future.

Other specific goals

The primary goal to start with 3D printing is 'to prevent spare parts obsolescence'. With 3D printing you can reproduce obsolete parts that are no longer available. In some situations a swift supply of spare parts is difficult or even impossible (e.g. international sea freight or long lead time batch manufacturing) and in these cases a printed object "can bring the vessel home". Also, for the implementation of augmented reality, a specific goal was mentioned: 'a solution for employee scarcity'. AR can provide real-time guidance and support to technicians. It enables (scarce) experts to remotely assist on-site personnel, reducing the need for specialised skilled workers at every location.

2.4 Critical success factors

On the matter of the critical success factors for the five digital trends, there is some variety. 'Data availability' was mostly mentioned for predictive maintenance and the digital twin, which is not surprising. These techniques strongly depend on reliable data. PdM and digital twins empower maintenance teams to make data-driven decisions and ensure the reliability and performance of assets.

Also 'support from the workforce' was considered to be a critical success factor. For mobile maintenance 70% of the participants answered 'support from the workforce'. The Shell case story on page 20 emphasises the importance of employee commitment. When Shell implemented mobile maintenance, they found that one of the biggest challenges was to show the team the benefits and create employee commitment.

Table 1 Top 3 findings for primary goals in Europe for implementing a digital solution.

Trend	#1	#2	#3
MM	Uptime improvement	Cost reduction	Solution for employee scarcity
PdM	Uptime improvement	Cost reduction	Lifetime extension of ageing assets
DT	Uptime improvement	Cost reduction	Improve safety level
AR	Solution for employee scarcity	Training and skills development	Uptime improvement
3D	Prevent spare parts obsolescence	Cost reduction	Securing logistic supply of parts

Table 2 Top 3 findings for critical success factors in Europe for implementing a digital solution.

Trend	#1	#2	#3
MM	Support from workforce	Involvement of IT department	Skills within own organisation
PdM	Data availability	Data analytics capabilities	Skills within own organisation
DT	Data availability	Positive business case	Skills within own organisation
AR	Support from workforce	Skills within own organisation	Involvement of IT department
3D	Positive business case	Skills within own organisation	Support from workforce

But taking the next step towards digitalisation also requires skills: data analytics capabilities and technical skills within the own organisation, as well as the availability of a skilled IT department. It is a different way of working and employees must be trained to practise these techniques in a safe and efficient manner.

Furthermore, we noticed 'a positive business case' is especially important for the implementation of 3D printing and also for realising a digital twin.

2.5 Reasons not to start

We started this chapter with insight into the implementation level of the five digital solutions. On page 13 we presented the sum of the percentages of companies that are implementing or have implemented a digital solution. In this section we focus on companies who have not (yet) started with implementing one of the five digital trends (see Table 3).

Taking into account that the overall implementation level is not very high (mobile maintenance as an exception), it is interesting to examine why companies are not implementing digital solutions. What's holding them back?

Companies that have not (yet) started implementing these digitalisations, mention 'lack of skills within the organisation' as an important impediment.
Other reasons not to start using predictive maintenance are 'no data/not enough data' and 'no good business case'. With 'data availability' and 'data analytics capabilities' as critical success factors, you see where the shoe pinches.

The importance of a good business case

The answer 'no good business case' was presented as an important hurdle. Does this mean that the investment is too large, compared to the returns? Besides the investment of the technology itself, there are also costs related to training, adapting to the new way of working, switching to new software et cetera. So, the costs are easy to calculate, but the benefits are often difficult to estimate. However, without a convincing business case, you will not get approval for your project.

Figure 11 Percentage participants who did not start (yet) with implementing. Note: this data contains all 5 countries.

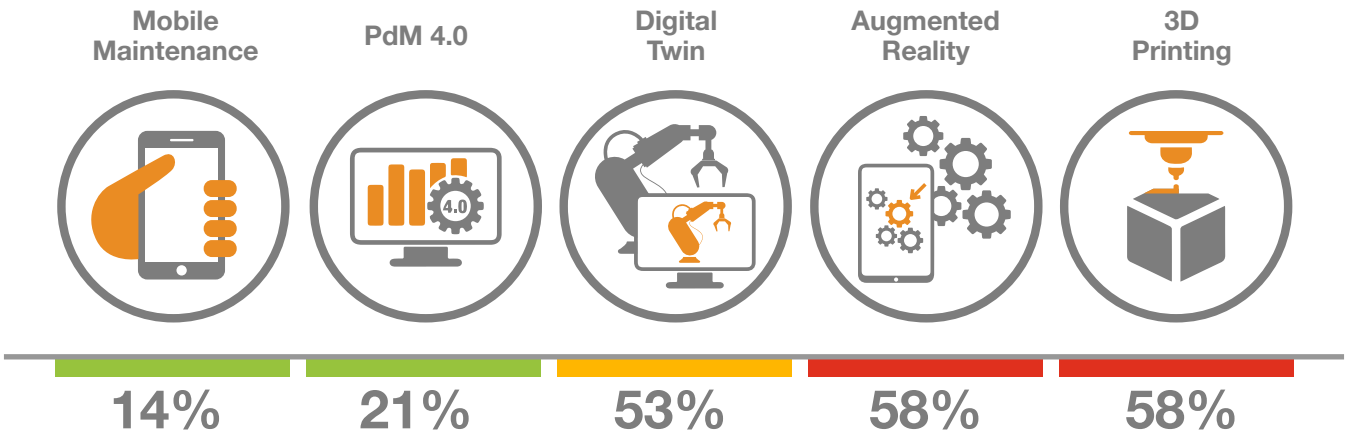


Table 4 Top 3 findings for reasons not to start in Europe for implementing a digital solution.

Trend	#1	#2	#3
MM	Not relevant for our types of assets	Lack of skills within organisation	No good business case
PdM	Lack of skills within organisation	No data/Not enough data	No good business case
DT	No good business case	Lack of skills within organisation	Not relevant for our types of assets
AR	No good business case	No data/Not enough data	Lack of skills within organisation
3D	Not relevant for our types of assets	Lack of skills within organisation	No good business case

2.6 Conclusion

These results from the northwestern European countries show that Maintenance & Asset Management is moving towards digitalisation, but with small steps. Not many of the respondent companies are implementing or have implemented one or more digital solutions.

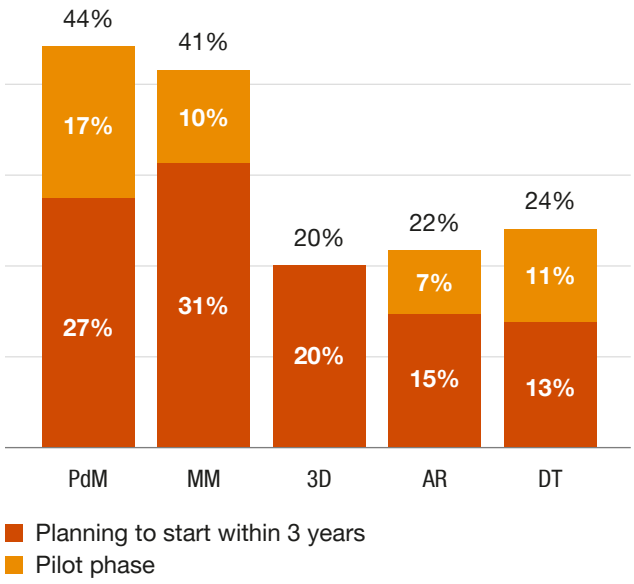
However, mobile maintenance stands out as the digitalisation in which we are really pushing through. This solution is widely used in all industrial sectors. Predictive maintenance is upcoming. Other techniques are only recently introduced and cannot be considered common practice in Maintenance & Asset Management.

We do see Service Providers taking the lead, also because it is likely that they are able to create a new business model with digitalisation. They will drive asset owners to take their digital transformation plans to the next level.

The main reason for digitalisation is to improve uptime. Digitalisation is not seen as a technical IT project, but more as a change project.

> We do see Service Providers taking the lead, also because it is likely that they are able to create a new business model with digitalisation. They will drive asset owners to take their digital transformation plans to the next level.

Figure 12 Participants from northwest Europe in 'pilot phase' + 'planning to start within 3 years'



Positive: we see that many companies have plans to start with digitalisation in the near future. A lot of participants replied that they are undertaking a pilot phase or that they are planning to start within three years. So, for now, we can conclude that we are not yet using the full potential of digital transformation, but we are moving forward.

The benefits and challenges of mobile maintenance

Implementing a new, mobile way of working on the Shell Energy and Chemicals Park Rhineland in Germany, with iPhones for everyone and more insight on the spot where maintenance is executed, sounded really appealing. And yes, it led to significant quality improvements. But the biggest challenge, and also the biggest lesson learned, was the importance of involving the workforce. It is a team effort.

Wolfgang Schuster is Maintenance Execution Manager at Shell Energy and Chemicals Park Rhineland. ‘For me and my team it is really important that we do the right things right. In that regard digitalisation and automating things will be a crucial lever to be able to focus on this and other goals.’

Accelerator

The first steps towards mobile maintenance were taken in the Philippines. ‘By using digital tools we could visualise the plant and remotely work on planning, troubleshooting, et cetera.’ This started before Covid-19. ‘The pandemic worked as an accelerator’, Schuster explains. ‘We were lucky that we, prior to the pandemic, already started the mobile maintenance project. We could respond a little bit faster. So when less people were granted access on site, we were able to make use of the experts all over the world to help our maintenance engineers online, from a distance.’ The pandemic took everyone by surprise. ‘But it made us bolder to try new things and the result of that was that we saw that it worked. We are now integrating this remote team in our maintenance process, making use of all the information available in the field.’

The value of data

The initial goals for implementing mobile maintenance were cost reduction and a quality and reliability improvement. ‘The cost reduction is driven by the fact that there is value in data. The data is important, helps others and helps the organisation to progress.’ As an example Schuster mentions spare parts

‘Using your camera and reaching out via Teams to get back to the supervisor are intuitively done by younger technicians. A skill that was also rapidly developed during the pandemic by the way. The old fashion way, the older technicians prefer, is to rely on a call or step into the office and talk to the person in charge face to face.’

management: ‘When we send out the rotating equipment repair team, they expect the necessary tools to be there and also that the spares are available. Gathering data helps us to efficiently fill up the spares that we know that will be taken out for these specific tasks.’

Next generation

Mobility and availability go hand in hand. Shell provided all employees with iPhones. ‘We figured we needed to provide devices they would take with them anyhow. So if you are called out for an emergency repair, you have the right equipment on you.’ The mobile devices – iPads are also available – are used for work order registration, work preparation and execution. Schuster admits there is a difference in adapting and using this mobile way of working between generations. ‘Using your camera and reaching out via Teams to get back to the supervisor are intuitively done by younger technicians. A skill that was also rapidly developed during the pandemic by the way. The old fashion way, the older technicians prefer, is to rely on a call or step into the office and talk to the person in charge face to face.’

Benefits of mobile

Schuster feels one of the biggest benefits of mobile maintenance is the increased speed of exchanging information. ‘Stepping into an office takes time. Nowadays exchanging information and taking decisions based upon this, is going faster and faster. In that regard, transparent information is paying off every day.’ But it is not only about taking information to management. ‘By taking pictures, connected to the right location, automatically attached to the right work order, this helps the workflow. At the next inspection all the required information is there.’

It also gives technicians access to additional information that sometimes is not visible. Schuster: ‘The installation is not always showing you the underlying piping. But now you can go into the P&ID’s (Piping and instrumentation diagram) to understand what’s happening.’

The human factor

Written out this way, the benefits are obvious, but they were not immediately widely recognised. Schuster explains: ‘The added value was not instantly felt in the field. As a result of a mobile way of working, administrative work needs to be done. So you are not doing less work, you are doing more work. Also because after completing a task, after resolving an issue, the new task immediately pops up.’ In the background it definitely increases efficiency and availability, but this is not visible to the workforce. Schuster emphasises that humanising the experience of mobile maintenance is an important factor. ‘The support from the workforce is one of the most critical success factors. Involve the team, share successes and make sure everyone is aware of the benefits and the gains.’

Quality improvement

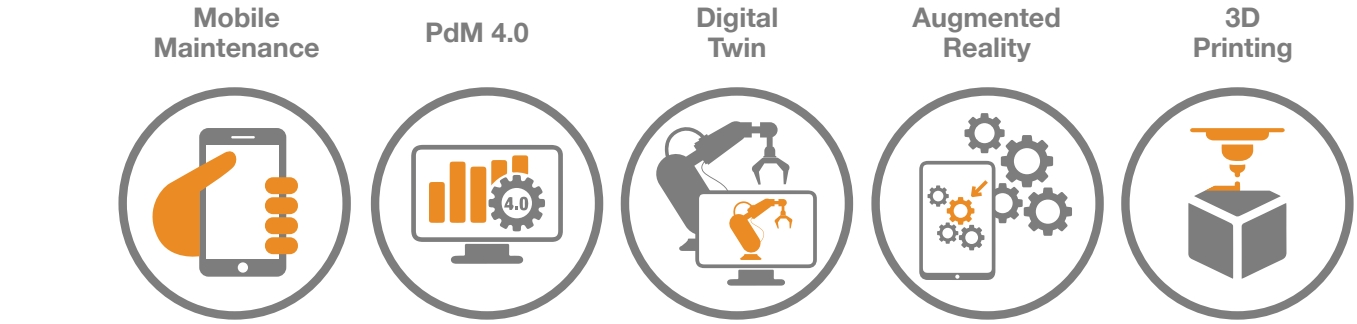
To Schuster and the management the benefits were clear from the beginning. Mobile maintenance definitely led to quality improvement – doing the right things right – increased efficiency and higher technical availability. Schuster: ‘Companies who are hesitant to go in this direction, should try to visualise where the flow of information is not clear. How long does it take before the supervisor or management gets the information out of the field? Too long? Does this mean that the people in the field are also waiting for the information? Quickly sharing information to make sure everyone can do the right things right means efficiency. And this means value.’

Chapter 3: Northwest Europe versus South Africa

Comparison between results gathered in Europe and South Africa

In the previous chapter we presented the key findings from the results we collected in four northwestern European countries. We also received responses from companies in South Africa. In this chapter we will take a closer look at the differences and similarities.

Figure 13 Implementation level for participants from northwest Europe and South Africa



	Mobile Maintenance	PdM 4.0	Digital Twin	Augmented Reality	3D Printing
South Africa	14%	14%	5%	5%	0%
Northwest Europe	39%	17%	10%	8%	8%

Why this comparison? The difference between the countries in Europe on the one hand and South Africa on the other, is not only the geographical location. In terms of digitalisation and modernisation of Maintenance & Asset Management, we consider South Africa as an 'emerging country'. Development and progress starts a bit later compared to European countries. It is therefore interesting to see which way the developments are going. Will South Africa follow the same route or will other choices be made? And what are the reasons for not (yet) implementing a certain technique?

3.1 Implementation level

In South Africa the implementation level – companies that are implementing at the moment or have fully implemented a certain solution – is significantly lower for all five digital solutions. We saw mobile maintenance excelling in European countries. In South Africa this is also the most popular solution, together with predictive maintenance. They both score 14%. The interest in augmented reality and digital twins is lacking (5%) and this also applies to 3D printing: none of the participants is currently rolling out 3D printing (0%).

Figure 14 Mobile maintenance; roll-out + fully implemented

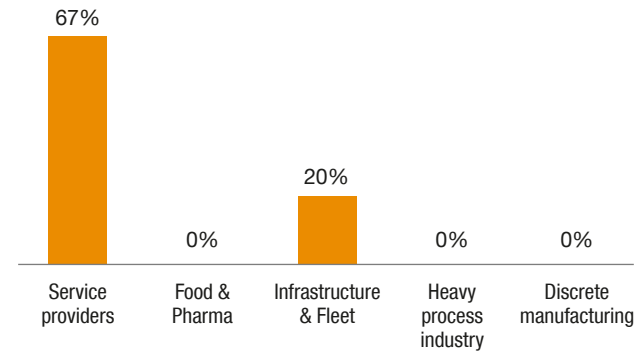
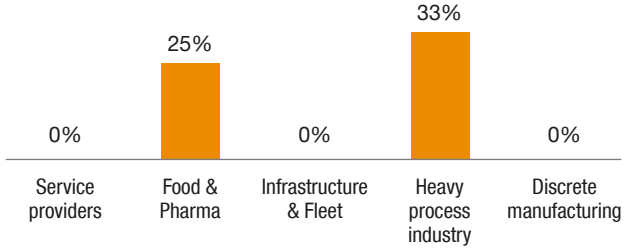


Figure 15 Predictive maintenance; roll-out + fully implemented



3.2 Primary goals

If we look at the primary goals, we see a lot of similarity between Europe and South Africa. In Europe we see 'uptime improvement' was mentioned more often than 'cost reduction' and in South Africa it is the other way around. So it appears that South Africa considers digitalisation mainly as a solution for cost control and not so much for uptime improvement.

This resembles the economic situation that South Africa is dealing with at the moment. They are dealing with a serious energy crisis, even more serious than in northwest Europe, which is leading to extreme high energy costs and this forces companies to reduce their operational costs. This means that there is a limited budget for innovation and digitalisation, unless there is a foolproof business case to achieve cost reduction.

3.3 Critical success factors

The critical success factors are moderately scattered. We see 'data availability' as an important factor and this matches the results from Europe. Also the 'involvement of the IT department' was mentioned multiple times by participants in various countries.

One critical success factor that stands out, compared to Europe, is the availability of a 'long term digitisation plan'. This factor is in this list three times but in Europe this answer was barely chosen.

Another difference between Europe and South Africa is the fact that 'support from workforce' was hardly mentioned by South African participants, while in Europe this was the most important answer for mobile maintenance and augmented reality. This shows that digitisation projects in Maintenance and Asset Management in South Africa are seen more as an IT project than a change project.

Table 5 Top 3 findings for primary goals in South Africa for implementing a digital solution.

Trend	#1	#2	#3
MM	Cost reduction	Uptime improvement	Improve safety level
PdM	Cost reduction	Uptime improvement	Lifetime extension of ageing assets
DT	Uptime improvement	Cost reduction	Increase sustainability
AR	Training and skills development	Uptime improvement	Cost reduction
3D	Cost reduction	Prevent spare parts obsolescence	Lifetime extension of ageing assets

Table 6 Top 3 findings for critical success factors in South Africa for implementing a digital solution.

Trend	#1	#2	#3
MM	Involvement of IT department	Data availability	Support from workforce
PdM	Data availability	Reliability engineering capabilities	Data analytics capabilities
DT	Long term digitalisation plan	Involvement of IT department	Skills within own organisation
AR	Involvement of IT department	Data availability	Long term digitalisation plan
3D	Skills within own organisation	Long term digitalisation plan	Data availability

Table 7 Top 3 findings for reasons not to start in South Africa for implementing a digital solution.

Trend	#1	#2	#3
MM	No long term digitalisation strategy	Digital innovation is too expensive	Not relevant for our types of assets
PdM	Lack of data anlytics capabilities	Digital innovation is too expensive	Lack of skills within organisation
DT	No good business case	Digital innovation is too expensive	Lack of skills within organisation
AR	No good business case	No long term digitalisation strategy	Not relevant for our types of assets
3D	No good business case	Not relevant for our types of assets	No data/Not enough data

3.4 Reasons not to start

In South Africa, not having a good business case is also one of the reasons not to start with digital implementation. This is often due to the fact that the innovation entails an expensive investment. For many digitisation projects, the expected cost savings are not easy to calculate, because there is little benchmark data available. As a result, many projects do not progress beyond the pilot phase.

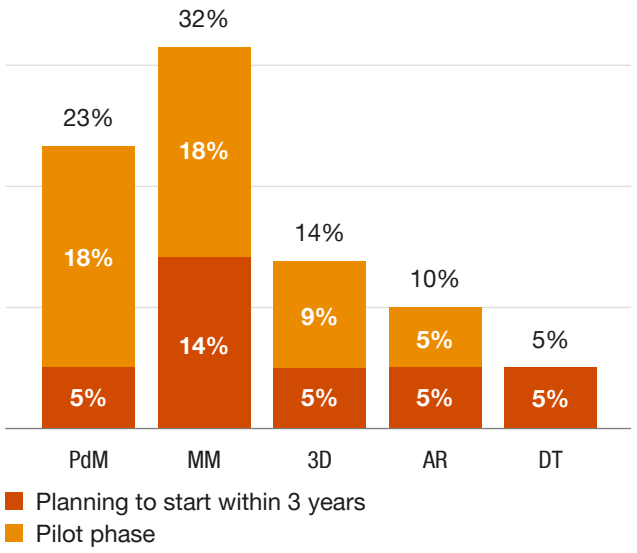
An important hurdle for implementing predictive maintenance is ‘a lack of data analytics capabilities’. Also, a ‘lack of skill’ was mentioned several times. As a result of the economic situation in the industry, many (young) highly educated professionals are leaving for other sectors with growth potential. The industry in South Africa is dealing with a serious brain drain.

3.5 Conclusion

This outcome emphasises that South Africa is an emerging country, from a digital perspective. There is a strong focus on cost reduction due to the weaker economic situation and challenges like the energy crises, brain drain and limited budget for innovation.

> In South Africa, not having a good business case is also one of the reasons not to start with digital implementation.

Figure 16 Participants from South Africa in ‘pilot phase’ + ‘planning to start within 3 years’



The country is following developments in Europe with great interest, as they aim to increase the current maturity and implementation levels in the future. In Europe we increasingly see that Maintenance & Asset Management has a voice in the boardroom. It could definitely help South African companies if they approach Maintenance & Asset Management from an added value point of view instead of considering it ‘just a technical necessity’.

Article 3

Digitalising the mining industry

Mining is ‘the extraction of valuable geological materials’. At one of the largest platinum mining complexes of the world, located in South Africa, this involves underground extraction of metals, primarily platinum, but also palladium, nickel and gold. Mining is a very capital intensive industry with very high safety standards. How can digitalisation be of valuable use? Kearabetswe Mabe explains how using robots and drones makes his tasks much easier.

The operation comprises a ten-shaft mining complex and concentrating and smelting plants. The underground infrastructure relies on associated infrastructure above the ground, such as trains, pipelines, compressors, refrigeration and ventilation equipment.

Pipelines

As Operations Engineer, Kearabetswe Mabe is responsible for overseeing the maintenance of critical assets. He is leading a team of about 127 in-house maintenance personnel and also managing the work of a large number of permanent and ad hoc contractors. Mabe explains: ‘At this location in the north of South Africa we house the concentrator and the smelters. We have rock drills powered by compressed air and of course proper ventilation and refrigeration to make sure the workforce is able to operate at a certain depth. Another important asset is a 65 kilometre network of pipelines, mainly used to transport compressed air from the network of interconnected compressor houses. It is quite a task to inspect and maintain these pipes.’

Robots

For example, at the tailings dam, most pipes are underground. This comes with a challenge for maintenance. In the past. Mabe sent out a maintenance technician and assistant on a special, hand pedalled cycle to do physical inspections inside the pipeline. ‘We did visual inspections to measure the quality of the pipelines on spaced out point along the network.

But now we use a robot with cameras and sensors mounted on it. Obviously, this is a lot safer and we get richer data because every inch is measured. With the visual inspection we've had a few pipeline failures, that were not foreseen. Now we look for anomalies in the data and we know where maintenance is required.'

Drones

The tailing dam is an earth-fill embankment dam used to store byproducts of mining operations. It is very important to manage the water levels of these dams. 'For this we currently use drones', Mabe explains. 'There are rules we need to follow as required by the Water Use License. The Department of Water Affairs audits us to check how well we use our water resources. We need to prevent being wasteful in our water usage and we have to manage the run-off and seepage from the tailing dams. In the past this was analysed by a guy in a helicopter with a high-definition camera on board. Now the drones do these inspections.'

But drones are used for other tasks as well. 'We use them for surveying stockpiles. So when you have a problem in the plant you want to use the buffer you build up. Drones are used to measure the amount of tonnage in the stockpiles.' And finally drones are used for security reasons. 'It is 'the eye in the sky'.'

The road to modernisation

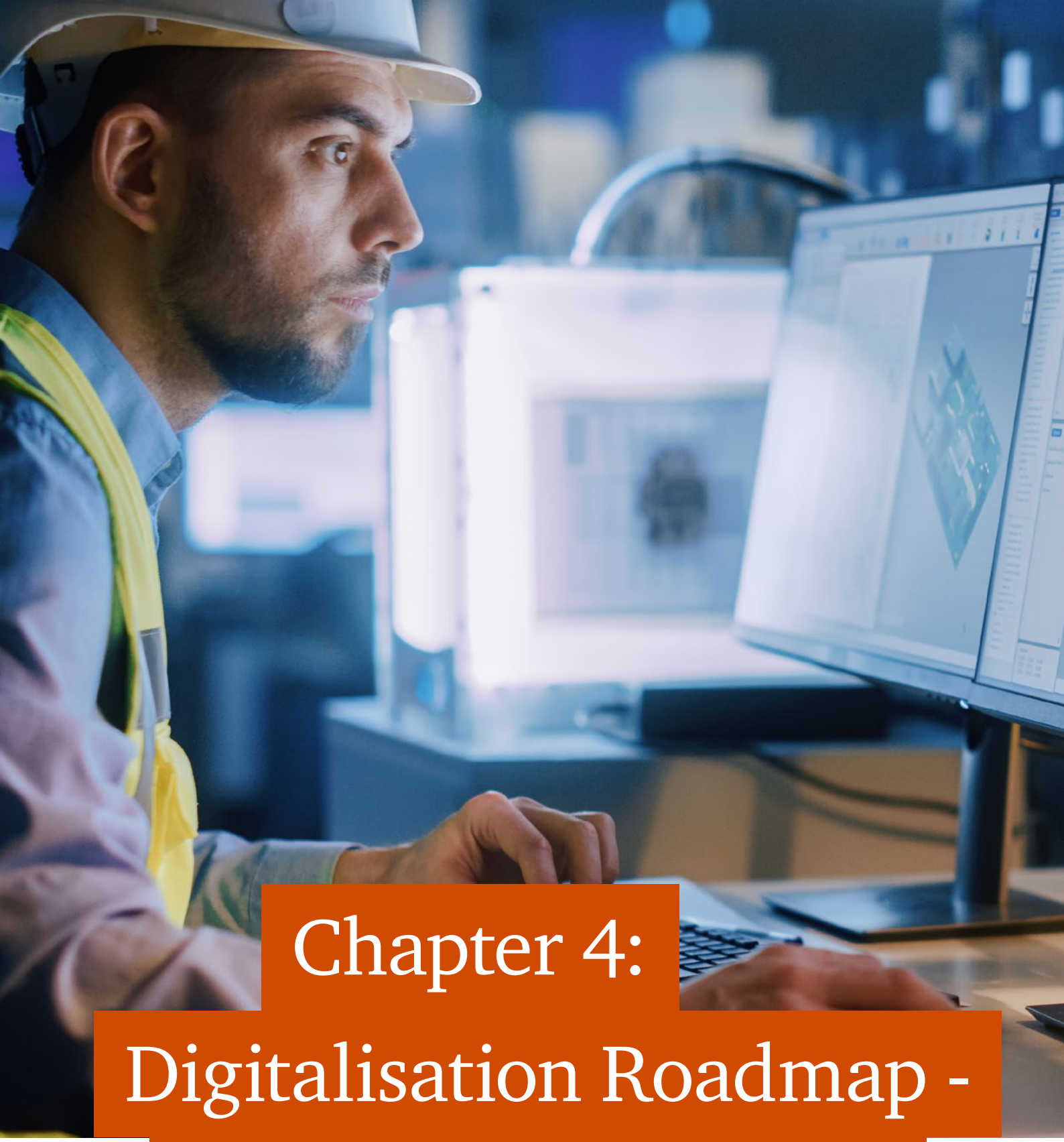
The mining company introduced special forums to encourage innovation and adoption of new technologies. 'On a forum you write down the requirements for a new technology you want to bring into the organisation. You register it formally, do risk assessments, cost analyses and you list out the benefits. If the benefits are recognised, you get the licence to try this new technology.' Mabe thinks this forum works both ways: 'It helps the formal implementation process. Procurement is a big thing in the South-African mining industry. We have a social responsibility to take local unemployment into account. This means we need to give the local suppliers an opportunity to tender on the process. By using the forum it helps us to establish: why this vendor? Are there other players in the market that could offer a better and cheaper service? Do they have the relevant ownership criteria?' This sounds complicated but according to Mabe this enables a swift and smooth implementation of the technique.

Benefits

In the case of the robots and drones implementation, the benefits were clear. Mabe: 'It's faster, cheaper and more detailed.' Also, to find licensed drone pilots in the existing workforce was not a problem. 'It is a very nice capability to have. Many people signed up to go for the licence. I actually wanted to do it myself.'

Mabe considers this technology to be an augmentor: it enhances what you are already doing. And to start working with these kinds of techniques, the only impediment would be the willingness to try out new technology, is Mabe's opinion: 'We thought it would be very expensive, but in relative terms, it really isn't. Obviously, you have to select it in relation to the size of the organisation, the types of assets and the frequency that you need to do certain inspections – definitely do that analysis! – but sitting where I am sitting, I can't imagine it wouldn't be a benefit. The use of these techniques is making my life much easier.'

'We did visual inspections to measure the quality of the pipelines on spaced out point along the network. But now we use a robot with camera's and sensors mounted on it. Obviously, this is a lot safer and we get richer data because every inch is measured.'

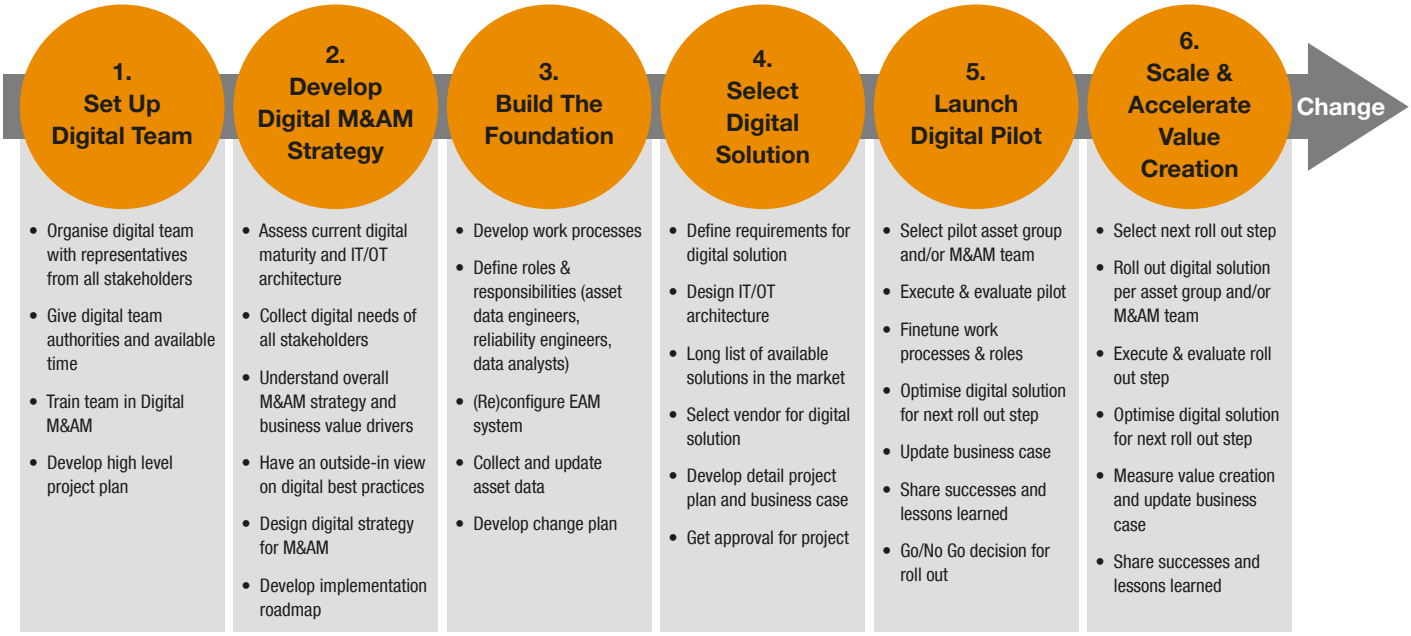


Chapter 4: Digitalisation Roadmap - Making digital work!

Digitalisation Roadmap for Maintenance & Asset Management

Based on the insights from the previous chapters, PwC and Mainnovation developed a Digitalisation Roadmap for successful implementation of digital solutions in Maintenance & Asset Management. This roadmap consists of 6 steps, which are briefly described in this chapter.

Figure 17 Digitalisation Roadmap for Maintenance & Asset Management



4.1 Set Up Digital Team

The first step in the Roadmap is to appoint a Digital Team. This team will take the lead in the digital transformation of the Maintenance & Asset Management department with representatives from all layers across the department. Members could typically comprise of an asset manager, reliability engineer, mechanic, IT/OT engineer, project engineer, work planner and a management team member. The team should be supplemented with representatives from adjacent departments such as IT, Procurement, HR and Operations so that all interests are covered.

Make sure the team is big enough to represent all functions but 'small' enough to be actionable. Give the team responsibility and rights needed to make decisions. Organise back fill so that the team members can free up their agenda to lead the digital journey. The team should be provided with training in Digital Maintenance & Asset Management so that members gain knowledge of the latest developments in this area.

Step 1 of the roadmap concludes with the creation of a high-level project plan for the 5 steps to follow.

4.2 Develop Digital M&AM Strategy

Once the team is assembled, we can start analysing the current situation with step 2: Develop Digital Maintenance & Asset Management Strategy. What are we currently doing in terms of digitalisation and which pilots are we running? What does our IT/OT architecture look like, and which problems are we facing? What is our overall Maintenance & Asset Management Strategy and how can digitalisation contribute to the company's value creation? But perhaps most important, what are the needs and requirements of the end users who will have to work with the new digital solutions? Often the 'gold' can be found on the shop floor. This can be researched by doing surveys, in-person interviews, assigning test groups and visiting more experienced colleagues for inspiration.

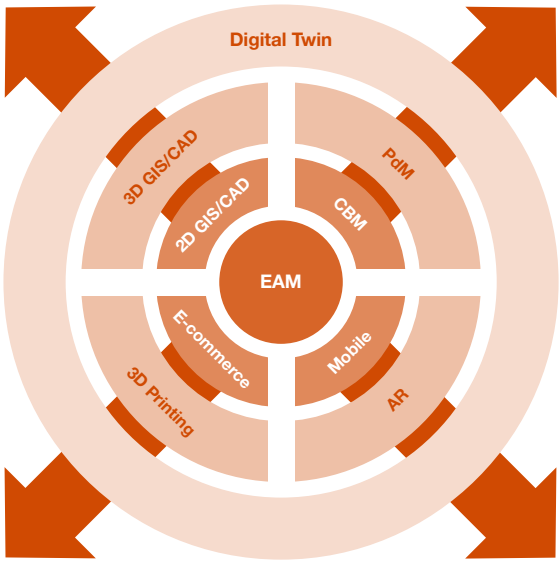
The insights from this internal analysis can be used when starting the strategy sessions, especially when they are linked to external best practices. The cases in this report could be used as inspiring examples of companies that have made a successful digitalisation step on their identified needs and ideas. This provides a good basis for drawing up the Digital Maintenance & Asset Management Strategy and the development of an implementation roadmap. It should be noted that digitalisation should always serve the overall Maintenance & Asset Management Strategy. Too often, companies start digitalisation projects because it is technically possible (and sexy!) and not because it contributes to the company's mission.

Step 2 will be completed with the Implementation Roadmap, setting out the various strategic digitalisation initiatives over time.

4.3 Build The Foundation

The third step in the Roadmap is one that is often skipped in practice. It is a step that lays the foundation for successful digitalisation. This foundation consists of a number of elements and begins with the work processes. It is often underestimated how the introduction of predictive maintenance, augmented reality, 3D printing, mobile maintenance and digital twin changes the ways of working within the Maintenance & Asset Management organisation. It is important to draw out these new ways of working in advance so that changes can be implemented in the right time. This can possibly lead to new roles and modified responsibilities within the organisation. For example, the roles of Reliability Engineer and Data Analyst are crucial for Predictive Maintenance. The project will be doomed to fail if these roles are not filed timely.

Figure 18 Growth Model for Next Generation EAM Systems



Another element within the foundation is the EAM system. A well-configured EAM system is the basis for successful digitalisation. The solutions for predictive maintenance, augmented reality, 3D printing, mobile maintenance and digital twin will need to be linked to the EAM system in a way that new work processes are secured within it. From this perspective, it is therefore not surprising that more and more EAM systems are offering functionalities for the new digital solutions (see figure 18).

A final element within the foundation is asset data. Many of the digital solutions use asset data. This data is managed in the EAM system (asset and maintenance data), GIS (geographical maps), CAD (design specifications and drawings) and DMS (documents). It is important to have this data available and up to date before starting the Digitalisation Roadmap. 3D Printing of Spare Parts only works if the design specifications are correctly stored in the CAD system. Predictive Maintenance only works if the assets are correctly registered and classified in the EAM system. Mobile Maintenance for mechanics in the field only works if the assets are properly plotted in the GIS.

Step 3 is completed with the creation of a change plan. The description of the new work processes and roles shows what changes need to be made within the organisation in order for the digital solutions to be received properly. The change plan includes all necessary activities in the areas of training, communication, reorganisation, recruitment, culture and leadership.

4.4 Select Digital Solution

Step 4 of the Roadmap concerns the selection of the Digital Solution. Based on the process descriptions from step 3, it is easy to determine the functional requirements for the application to be purchased or developed. For example, for mobile maintenance it can be determined whether we may work only with notification and work orders or may include digital inspections, work permits and/or inventory control. For predictive maintenance, the process description will indicate whether the digital solution only needs to issue early warnings (Condition Based Maintenance), predict future failures (Predictive Maintenance) or even suggest which preventive measure to be carried out (Prescriptive Maintenance).

We found in the survey that a scattered landscape of software solutions and suppliers is shared across the five different areas. It is important to clearly identify what best suits your company and, especially for the pilot phase, make sure to balance the effort (develop or use what already exists) versus the goal (understanding the business case) in the first stages of a new solution.

With the list of functional requirements, a normal IT procurement process can be started, in which a long list is consolidated and a preferred vendor is finally selected. Parallel to this process, the Digital Team designs the future IT/OT architecture.

Now that it is clear which solutions will be purchased and which changes need to be made, the Digital Team can create a detailed project plan for the pilot and roll out phase. Also, a specified cost and benefit analysis can be performed for the business case. The costs are derived from step 3 (change activities) and step 4 (IT solutions), while the benefits have already been estimated in step 2. In the business case, a final check is made on whether the project contributes to the overall Maintenance & Asset Management Strategy. In that case and if the business case is positive, approval will be requested for the entire project, including a Go/No Go decision after the pilot (step 5).

4.5 Launch Digital Pilot

After approval, the Digital Team can start the pilot implementation. This pilot serves as a Proof of Concept, demonstrating that the new digital solution works as envisioned in the design of the new ways of working.

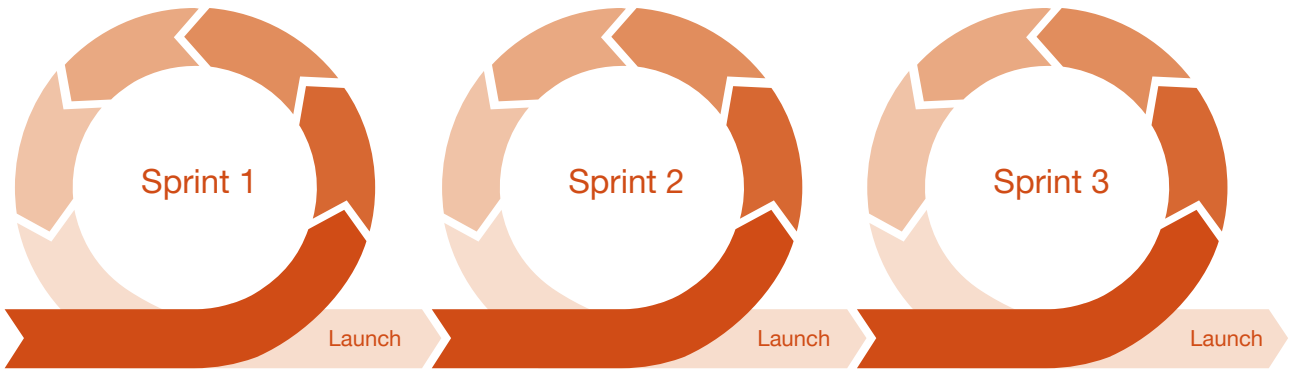
It is therefore important to select the pilot phase carefully. In doing so, keep the scope limited. For example, choose only one or two asset types and for Mobile Maintenance only one or two maintenance teams when looking at Predictive Maintenance or Augmented Reality. Also look for a pilot with a high change readiness factor: a department that is willing and able to change at all levels, from the top floor to the shop floor.

It is important during a piloting phase to accept failure, learn from it and adapt. In the change plan, clearly position this step as a learning phase and not the deliverable itself. Give the digital team time and space to find the best solutions for your company. A methodology that suits this need well is the agile scrum methodology. This entails working through short development cycles in a safe (sandbox) environment and constantly embedding the feedback from users and test-panels.

After the implementation of the pilot, there will be a thorough evaluation of the functionality of the new tool, the functionality of the new ways of working (including roles) and the outcome against the business case. This can lead to possible adjustments of the tool, the work processes and/or the business case. Of course, it can also lead to stopping the project or choosing another supplier.

In the case of a positive evaluation, approval is requested for the roll out phase (step 6) and the success of the pilot, as well as the lessons learned, are shared within the organisation.

Figure 19 Graphic representation of sprints in an agile scrum approach



4.6 Scale & Accelerate Value Creation

The last step of the Roadmap is the roll out phase. The roll out can take place across the axis of asset types (e.g., if deploying Predictive Maintenance and/or Augmented Reality) and/or across the axis of the organisation (e.g., if deploying Mobile Maintenance). Again, it is recommended to take small manageable steps, evaluate the result, optimise the solution and continue the roll out.

An important point of attention within the roll out is measuring and monitoring the business case. After all, this determines the success of the Digitalisation Roadmap. It is therefore important to show after each roll out step whether there is an increase in asset availability or uptime, cost reduction, safety improvements or other benefits. By continuously reporting and managing against the business case, the project maintains maximum alignment with the overall Maintenance & Asset Management Strategy.

4.7 In conclusion

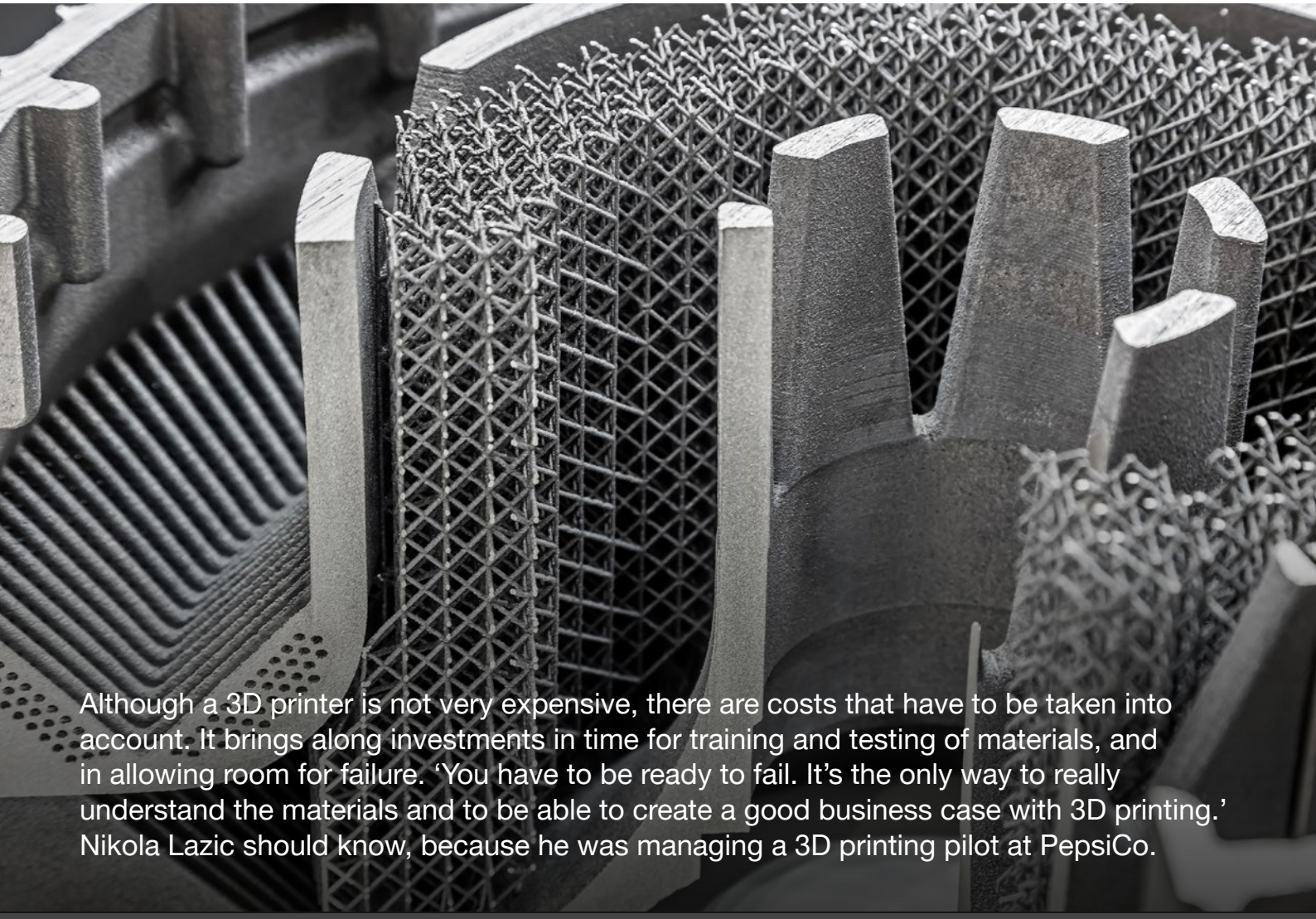
In the survey, we saw that many companies are struggling to implement the new digital solutions. They don't start with them or they get stuck in the pilot phase. With the Digitalisation Roadmap for Maintenance & Asset Management, we have established an approach that removes the most important hurdles. We like to characterize the roadmap as:

- An implementation approach that is not IT driven but contributes to the business value drivers of the company
- An implementation approach that can gradually grow in use and maturity of the solution
- An implementation approach that first works on the foundation (processes, roles, EAM and data) before starting with digitalisation
- An implementation approach that realises that it is a change project in which people must make the difference

> An important point of attention within the roll out is measuring and monitoring the business case. After all, this determines the success of the Digitalisation Roadmap.

Article 4

3D printing - a trial-and-error approach



Although a 3D printer is not very expensive, there are costs that have to be taken into account. It brings along investments in time for training and testing of materials, and in allowing room for failure. ‘You have to be ready to fail. It’s the only way to really understand the materials and to be able to create a good business case with 3D printing.’ Nikola Lazic should know, because he was managing a 3D printing pilot at PepsiCo.

PepsiCo – one of the largest food and beverage companies in the world – started experimenting with 3D printing in 2017. In a specific plant in Europe a cheap printer was installed. It indeed was not able to produce reliable parts. The team disappointedly concluded there were no benefits and decided to stop testing. But this was not the end of it.

Tests with plastic parts

In 2018 PepsiCo went for a more professional approach. An official request was sent out to explore this technology. Nikola Lazic: ‘Back then I worked as maintenance programme manager for the beverages category. But also in snacks we wanted to know more about the possibilities of 3D printing. We started with tests in plants in Russia and the UK. An important demand was to really have a good business case.’ Lazic was aware of the previous results. ‘But in my opinion this was mainly caused by a lack of knowledge in materials.’ Lazic and the PepsiCo Maintenance Team dived into the concept of 3D printing.

The right material

An important realisation was that there are more than 100 types of plastics. ‘People think plastic is plastic, but this is not true’, Lazic explains. ‘Knowledge of the material is definitely a critical success factor. For example, you need to know the specifications like the resistance of the plastic for temperature, wear or chemicals. Is there a high stiffness or a lot of flexibility? Is it flame retardant, recycled and is it safe for food contact?

So if you need high temperature resistant materials, you can choose from a list of suitable printing materials. If you need it to be UV resistant, again there is a list. And so on.' The project managers concluded it takes time to discover what the right material is for a specific part, depending on the functionality.

Be ready to fail

Striving for first-time-right on 3D printing, is a utopia. 'Be ready to fail', is Lazic's advice, because there are many factors that influence the result. 'The thickness of the layer, the speed of the printing, temperature, the type of printer. Sometimes where you even use the correct material, but not the right parameters, you will still fail.' Is this considered a waste of time? 'Definitely not. It took time to discover what the best material was for specific parts, but in this process we gained so much knowledge.' This trial and error approach gave PepsiCo a lot of information about materials and their usability. 'We consider it a 'proven technology' now.'

Business case

This also means it meets up to an important demand: a good business case. PepsiCo has factories all over the world. 'The UK team designed a 3D model of a gripper, based upon the original part. This gripper is used to place plastic bags with snacks from a conveyor belt to the packing box. They bought a basic printer for 1.000 euros. The part was designed, printed, tested and after one or two reruns we concluded it worked without issues.' Now let's do the maths: the printed part costs less than 5 pounds. The original part cost almost 400 pounds. The stock usage of this specific part is 15 pieces per year… Lazic: 'So yes, the financial benefits are quite large. A similar part was used on a different machine and here the savings were around 14.000 pounds per year. And this was only in the UK plant.'

In the Russian factory the total investment was 13.000 dollars – a more professional printer was installed and also part of the investment consisted of training about the technique and knowledge of the printing materials – and 4 months after implementation, they already delivered more than 9.000 dollars.

(Dis)advantages

The low costs for production is definitely a big advantage. Another big plus would be the availability of selective spare parts 'on demand'. 'They can be produced and delivered in hours, instead of weeks. This lowers the costs of spares, the total inventory value.'
But there are also a few disadvantages. 'There is a limited availability of materials. It is still mostly plastics. You also have to be aware of the fact the part consists of layers and sometimes this makes the part a little weaker, so the parts are less reliable.'
But in the end the benefits are bigger than the disadvantages. Lazic: 'Most PepsiCo plants use the Markforged printer. It comes with a cloud database and we have already put more than 100 parts in there. This means not everybody needs the skills to design and draw a part in AutoCAD, I can simply download it and send it to the printer.'

PepsiCo is still at the first phase of implementation. 'We haven't implemented it to all sites yet, but I do believe this is the future. We proved the technique is profitable for us.' Lazic recommends the technique but emphasises that you need a few enthusiastic driving forces who will not give up in the face of adversity. 'The trial-and-error approach will give you a lot of valuable knowledge. You will benefit from this later.'

'So yes, the financial benefits are quite large. A similar part was used on a different machine and here the savings were around 14.000 pounds per year. And this was only in the UK plant.'

About the survey

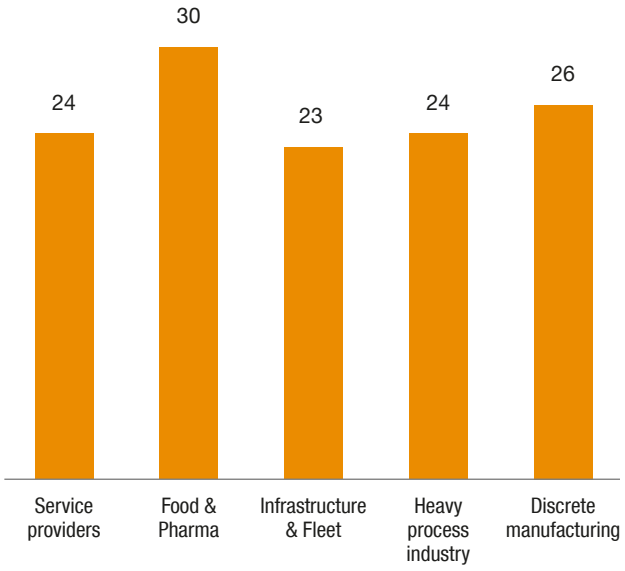
About the survey

This survey on digitalisation was executed by PwC and Mainnovation. We sent out more than 250 online surveys to companies in four northwest European countries (Belgium, Germany, the Netherlands, Norway) and in South Africa. In most cases, the maintenance manager was approached. We received 127 responses from various industrial sectors in various countries.

The outcome of the survey was analysed by a core team, consisting of PwC and Mainnovation experts, and by an international PwC advisory board.

With the results from the survey we were able to acquire the insights, stated in this report. Based on these insights, combined with information we gathered by interviewing companies that can be regarded as top-performers and also combined with our own knowledge and experience in the field of Maintenance & Asset Management, the Roadmap to Digitalisation was designed (Chapter 4).

Figure 20 Number of participants per industrial sector



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Space for personal notes

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Mainnovation is a leading Maintenance & Asset Management consultancy company. We help capital-intensive companies to professionalise their maintenance departments. In our projects, we rely on our innovative VDM^{XL} methodology (Value Driven Maintenance & Asset Management). Companies all over the world have implemented VDM^{XL} with impressive results in terms of increased uptime, cost reduction, safety improvement and/or asset lifetime extension. Find out more on www.mainnovation.com.

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