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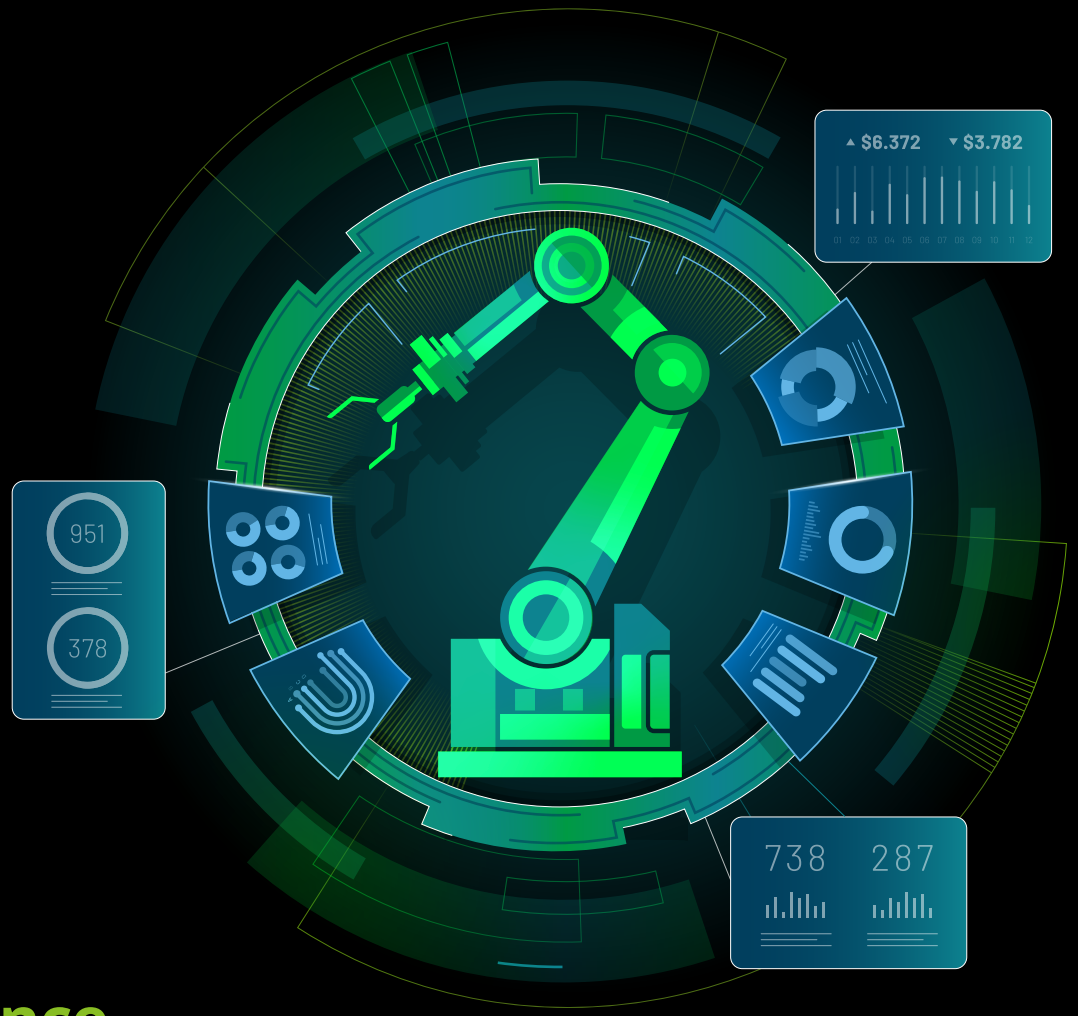

Predictive maintenance

Deloitte's approach

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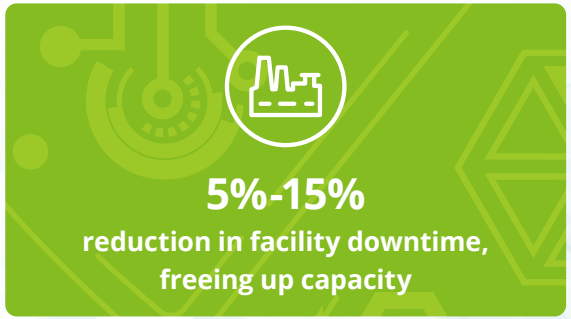
Imperative for maintenance transformation

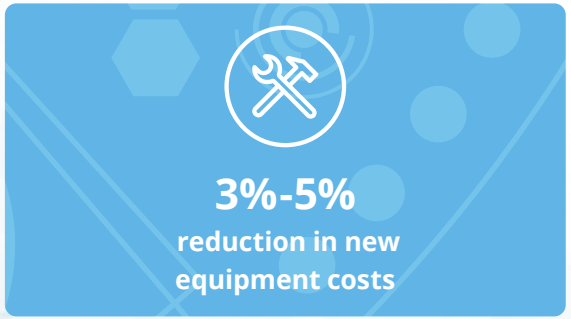
Why predictive maintenance?

The advent of Industrial 4.0 technology, availability of limitless data storage/computing power, and advanced analytical capabilities have unlocked the power to predict equipment failure, reduce maintenance cost, and increase asset life.

Salient benefits of predictive maintenance (PdM) include:

- Improved asset-life expectancy leading to reduced capital outlay for asset replacement
- Reduced overtime costs due to reduction of unplanned repairs
- Optimal availability of skilled maintenance technicians and operators in times of labor shortages
- Better parts management and predictability
- Better control over production/operations planning
- Improved work/life balance for maintenance team
- Improved safety of workforce due to reduced asset failures





Source: Internal Deloitte analysis derived from work with clients.

Deloitte's experience

Deloitte's approach to Predictive Maintenance is grounded in 15+ projects in the smart factory and predictive analytics domains.

	Predictive maintenance for a package delivery corporation	Connected vehicle analytics of a global automotive oem	Reliability engineering techniques for a food packaging company
Issue	A global package delivery company was seeing an increase in downtime at its sortation facilities, due to increased asset utilization and increased package inflow, leading to maintenance window shrinkage. Deloitte was engaged to identify and implement relevant use cases to optimize maintenance of assets across the sortation network.	A leading global truck manufacturer was developing its first fully connected truck ecosystem and needed help assessing use cases for applying sensor data to reduce costs, improve uptime, find new sources of revenue, and meet regulatory requirements.	A manufacturer of zippered plastic bags was experiencing downtime and waste due to plastic residue reducing the effectiveness of a cutting blade. They needed to know how often to perform blade cleaning in order to minimize downtime.
Solution	Deloitte partnered with the client to develop a well-integrated Predictive Maintenance framework consisting of IoT technologies (e.g., ultrasonic inspection devices, vibration/ temperature sensors) and advanced analytics to predict and prevent imminent asset failures. This unlocked 30+ predictive and functional use cases (e.g., gearbox failure, belt damage) and was supported by a robust change management program to ensure end-user adaptation.	Deloitte worked with the client to develop IoT-driven fleet management dashboards to track and enhance previously paper-based operations. Deloitte identified seven use cases that addressed the OEM's four priority outcomes including telediagnosis capability to remotely diagnosis issues to reduce downtime and warranty costs associated with large failures and connected vehicle analytics that used connected vehicle data to predict quality issues and prevent recalls.	Deloitte data scientists applied their knowledge of reliability engineering techniques from the automotive industry to calculate probability distributions of failure patterns. Running simulations revealed that letting the machine continue to run until the next scheduled downtime was more efficient.
Impact	Program is estimated to drive $100M+ in annual benefits by unlocking capacity across 150+ facilities amounting to ~4%+ overall capacity unlock.	Enabled development of an internal capability to securely store, analyze, and interpret machine vehicle data leading to reduction of critical component failures and engine replacements.	Implementation of the recommendation is expected to yield an increase in overall equipment effectiveness (OEE) by 10% on the manufacturing line and a projected increase in annual profit of $200K per line.

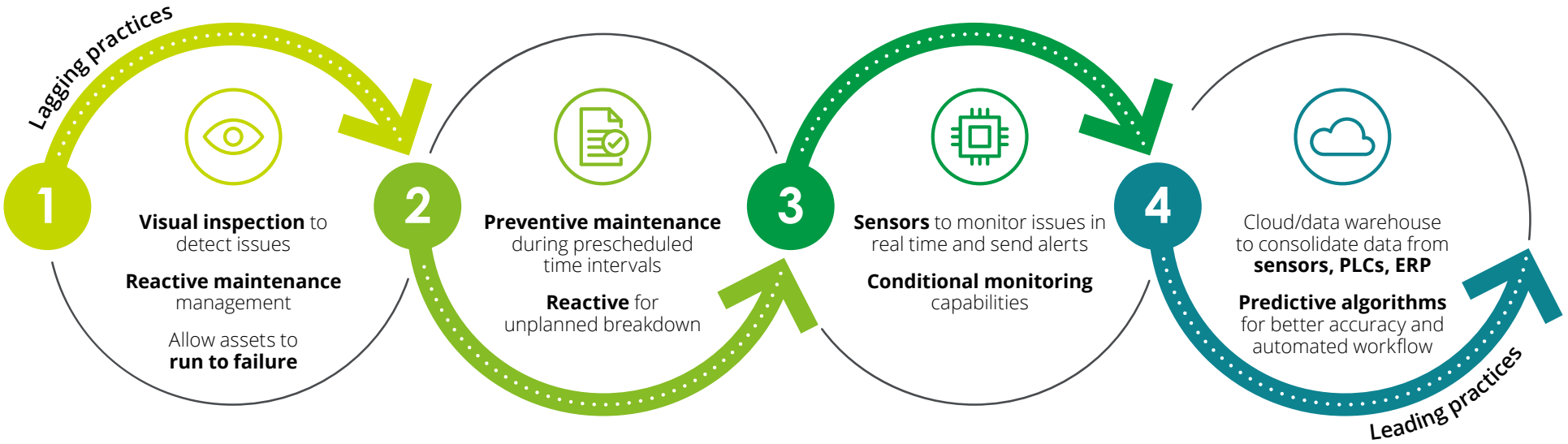
Lessons learned

Deloitte's insights from past PdM programs.

- Start small and scale
- Plan the future-state architecture approach and strategy
- Develop the solution in collaboration with end users
- Ensure support from leadership
- Maintain systems integrations and investment in enabling technology
- Train end users on tools and processes
- Express the value and incentivize adoption
- Leverage lessons from other organizations

Evolution of asset management

Based on our experience, well-executed predictive maintenance solutions drive substantial downtime reduction, increase productivity, and reduce overall costs



An aluminum-producing company following **reactive maintenance practices** struggled with **downtime, equipment failure, limited production,** and **maintenance costs***

A UK-based oil company following **preventive maintenance practices** incurred losses of more than **$300,000** when its oil production went down by **7,500 barrels** as a result of **prolonged maintenance shutdowns**

A large US logistics company began rolling out conditional monitoring with **sensors** with an aim to **reduce downtime by 12%–15%, but due to increased volume, saw downtime go up**

A US multinational energy and oil company began implementing **PdM across its refineries by using sensors to predict when equipment will need to be serviced, thereby reducing maintenance cost, eliminating breakdowns, and reducing downtime**

*Industry examples to illustrate respective use cases.

Reasons behind failure of predictive maintenance implementation

Industrial automation is growing rapidly with the development of IoT technologies, reduced cost of data storage/ computing, and advancements in AI/ML capabilities. Yet, based on our experience, maintenance organizations have not been able to harness the power of these technologies beyond pilots.

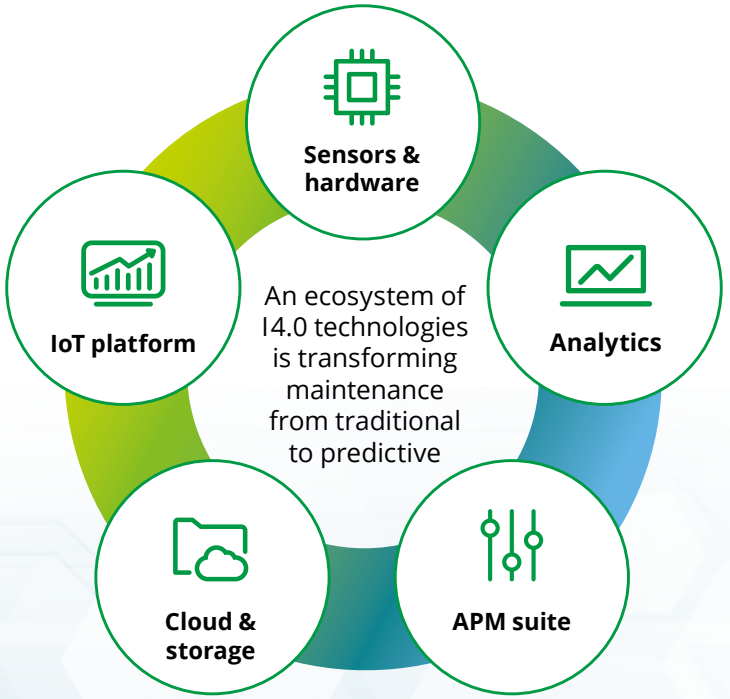
Maintenance transformation: An ongoing challenge

Traditionally, companies followed either reactive or preventive methods for maintenance. Striking a balance between them is critical, and often companies fail to get it right.

Challenges with traditional maintenance

- Unplanned downtime and equipment failure
- Low equipment availability
- High spare parts inventory and maintenance costs
- Risk to employee/public safety and environmental impacts
- Increased Mean Time To Repair (MTTR) due to lack of documentation and diagnostics history

Leading practice/future vision



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Our approach to predictive maintenance transformation

PdM is at the heart of Deloitte's smart factory offering

Predictive maintenance is a critical use case for companies undergoing smart operations and factory or facility transformations. It involves the capture of real-time and historical machine health data over its life cycle to diagnose specific issues before they cause downtime.

Facility consumption and energy management

Using energy management software is like giving our planet a hug. It applies AI, ML, and motion sensors to optimize energy levels in real time, reducing consumption and overhead costs.

Smart warehousing solutions

Tackle constant pressure from both ends of the supply chain with smart warehousing solutions: AR picking, automated conveyance, and real-time process visibility. This holistic approach equals smarter planning and leaner processes.

Quality sensing and detection

Humans doing quality inspections get a helping hand from automated vision systems and real-time analytics. Smart sensors identify potential issues faster, minimizing interruptions and maximizing productivity.

Asset intelligence/ performance mgmt. (predictive maintenance)

Scheduled maintenance? Not anymore, thanks to IoT, AR, and sensor-enabled monitoring. These innovations predict equipment issues before they happen, reducing unplanned downtime, unnecessary work, costs, and safety risks.

Facility synchronization and dynamic scheduling

It's the age of now, and customer expectations are high. Deliver customized products and services by using cloud computing, AI, IoT, and robotics to create highly responsive, continuously collaborative networks.

Smart conveyance

Inefficient transfer systems equals stagnant warehouse performance. Autonomously guided vehicles (AGVs), cameras, sensors, and ML/AI can optimize travel paths to deliver materials to the production line more quickly and accurately, in a saleable way.

Engineering collaboration/digital twin

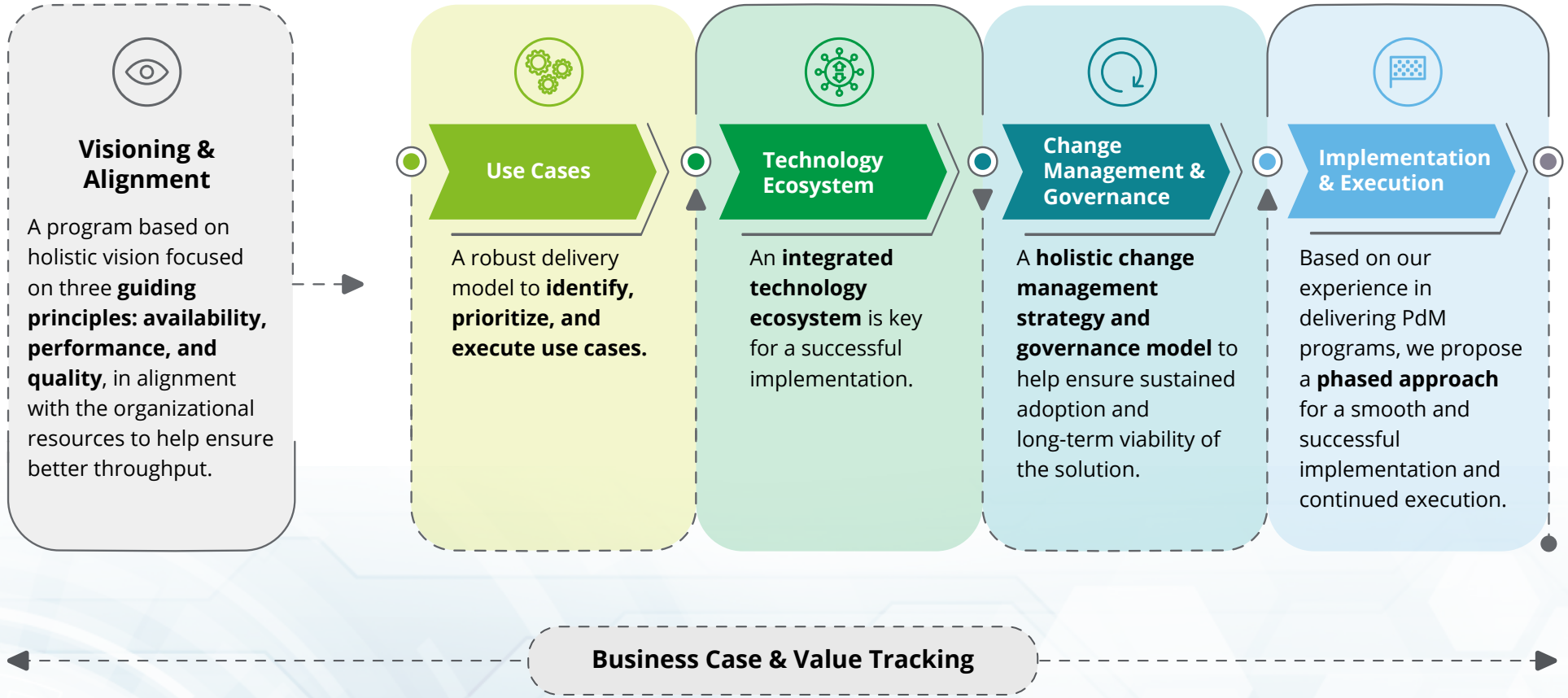
Physical prototypes? Those are so 2020. Turn to digital twins for multi-physics simulations, data analytics, and ML capabilities that virtually show the impact of all variables in real-word scenarios.

Augmented workforce efficiency

It's no longer humans vs. machines—it's humans *with* machines. Employ an augmented workforce that integrates robotics, computer vision and IoT alongside human employees to drive better outcomes, enhance productivity, and increase safety.

Proposed PdM framework

Deloitte's Predictive Maintenance framework is designed to drive a successful maintenance operations transformation



Visioning and alignment

A program based on holistic vision focused on three guiding principles: availability, performance, and quality, in alignment with the organizational resources to ensure better throughput.

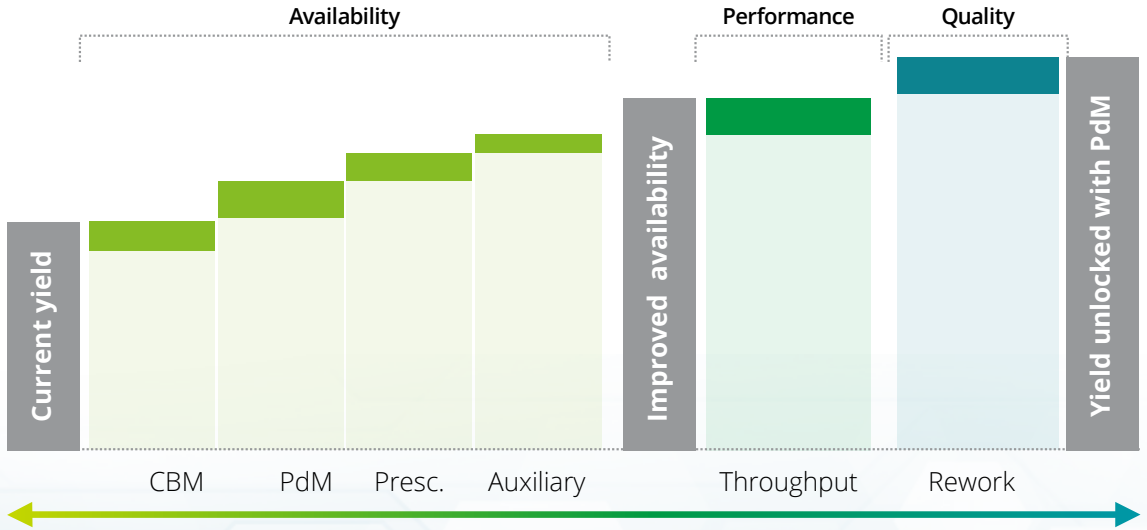
PREDICTIVE MAINTENANCE VISIONING

Visioning involves communication with stakeholders in developing a shared vision of the future. With a growing business outlook, the goal should be to create a holistic, long-term vision and develop a program that can scale and adapt. At this tangent, it is imperative and profitable to reduce maintenance downtime and cost and to improve capacity utilization.

Availability: These use cases increase the amount of time that the systems are up and running. These encompass both conditional monitoring and predictive analytics use cases.

These use cases can increase the overall throughput of products. They can expand to areas that are tangential to pure predictive maintenance but will help expand the overall business case for PdM.

These use cases can reduce the amount of rework involved. They increase efficiency and reduce surcharges due to quality issues.



End-to-end **improvement** which can lead to **improved efficiency and identification of possible increase in yield.**

Visioning & Alignment » **Use Cases** » **Technology Ecosystem** » **Change Mgmt & Governance** » **Execution**

Use case sequencing recommendations

We propose a robust prioritization method based on benefits and level of effort to identify, prioritize, and execute use cases.

Sequencing considerations:

Benefit potential
Use cases with high benefit potential (esp. quick wins) show up early on road map

Data availability
Use case sequencing reflects data source activation and cloud integration timeline

Maturity of analytics
Early use cases are more conditional/predictive, while later use cases get more prescriptive

Required lead time
Transformational use cases that require a high lead time (e.g., lots of historical data) are prioritized to start in Tranche 1

Benefit

Commonality: Measure the extent to which the use case spans across the organization

Time to realize benefits: Duration measure to assess the time required before benefits are achieved

Impact: Measures the relevance of use case to the organization's strategic objectives and vision

Net financial benefit: Estimation of expected ROI and financial benefit

+

Effort

Cost: Estimate of the level of investment needed to implement the desired use case

Resource and skills: Measures the availability of resource and skills to achieve the desired goals

Time to execute: Duration measure to assess the time required to roll out and implement the use case at hand

Data source and technology: Measure of data source readiness for PdM (based on prior data source evaluation scoring)

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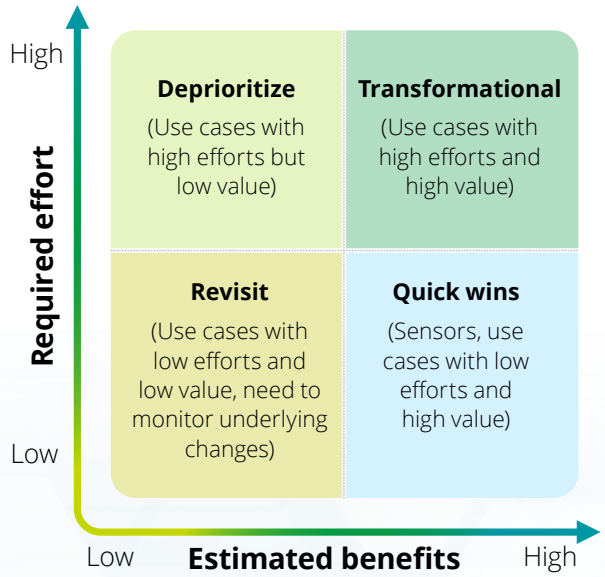
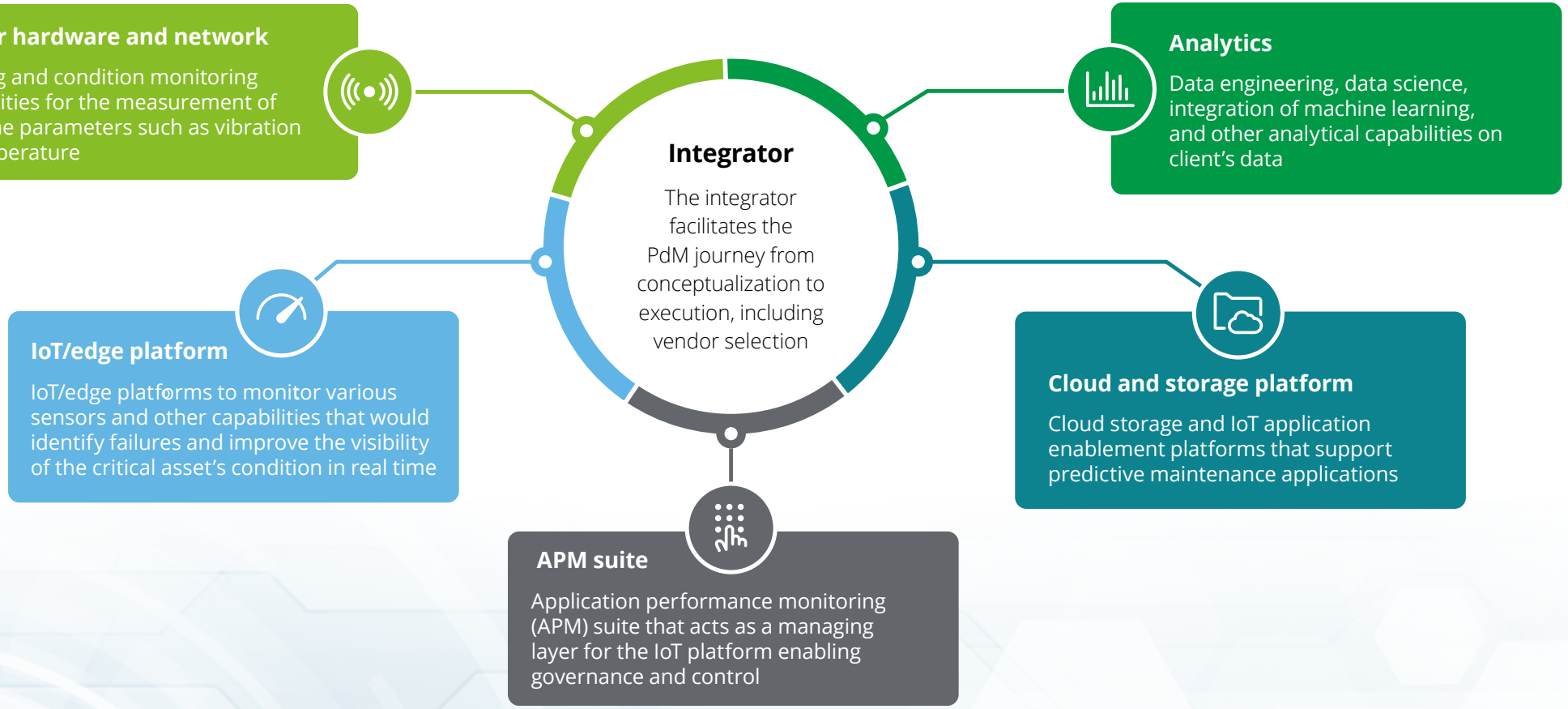
Prioritization



Visioning & Alignment » Use Cases » Technology Ecosystem » Change Mgmt & Governance » Execution

Technology ecosystem

An integrated technology ecosystem is key to successful implementation.



Visioning & Alignment » Use Cases » **Technology Ecosystem** » Change Mgmt & Governance » Execution

Change management

A holistic change management strategy is required to help ensure sustained adoption.

Changes

New technology, processes, operating model, and governance will require substantial changes across an organization's maintenance operating procedures and groups

- Implemented future state architecture
- Updated maintenance processes
- Updated operating model
- Defined PdM governance

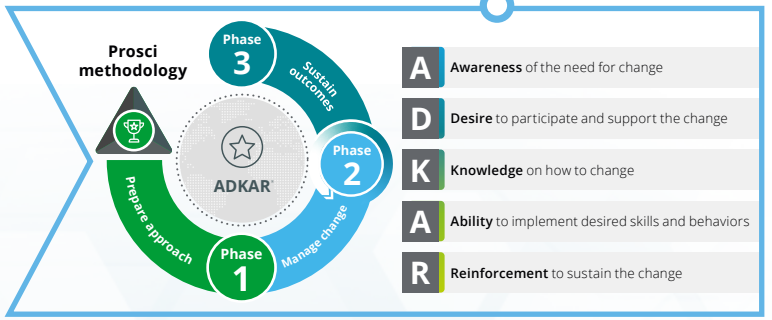
Impact/risks

These new changes will likely impact existing organizations and individuals, creating potential new and unforeseen risks, especially around adoption

- Implemented future state architecture
- Updated maintenance processes
- Updated operating model
- Defined PdM governance

Mitigation plans

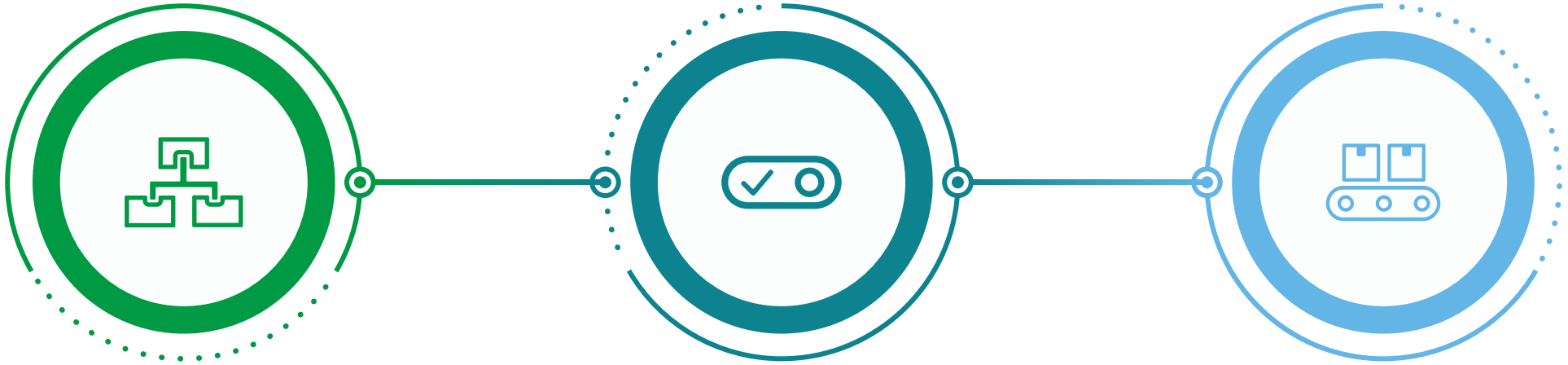
Mitigation plans are developed using lessons learned and proven models, such as the Prosci and ADKAR frameworks, to help ensure both organizational and individual change are made and sustained



Visioning & Alignment » Use Cases » Technology Ecosystem » **Change Mgmt & Governance** » Execution

Governance structure

A holistic governance model led by a program manager can help ensure long-term viability of the solution.



Data and architecture

The data and architecture governance model can help ensure **integrations** are established and maintained, owners are identified and aligned, and data is **secure and reliable.**

Use case enablement

Leveraging a standardized use case delivery model and inputs from the field to **source, prioritize, execute, and evolve** use cases. As use cases are rolled out, value should be tracked and reported. This also includes liaisoning with the product owners to provide guidance and creating a bridge between Deloitte and project stakeholders.

Field

The success of the PdM program will be dependent on **adoption and support** from the **field** maintenance crews. Their input is critical to the evolution of the PdM program.

Visioning & Alignment » **Use Cases** » **Technology Ecosystem** » **Change Mgmt & Governance** » **Execution**

Our PdM execution approach

Our approach is "action-oriented" with a focus on quickly identifying relevant use cases, building a robust business case, executing a pilot to prove architecture, and scaling the solution broadly.

Strategy and pilot

Strategy and vision alignment
Develop prioritized use case portfolio

Identify stakeholders and conduct visioning sessions

Design road map and business case
Build out road map/ business case

Compare solution design alternatives

Pilot implementation
Launch predictive use cases

Deploy solution at lighthouse facility

Pilot evaluation
Continually track adoption levels and assess program success against business case

Evaluate solution performance

Scale

Scaled Deployment
Continually track adoption levels and assess program success against business case

Roll out solution and remaining facilities

Illustrative activities and deliverables

Strategy and vision alignment
- Visioning workshops
- Current-state assessment
- Data source and vendor evaluation
- Use case portfolio and prioritization matrix

Design, road map, and business case
- Client-specific architecture (based on design decision workshops) pilot implementation road map
- Governance structure
- Business case

Pilot implementation
- Solution deployment at 'lighthouse' facility (established data integrations)
- AI/ML algorithm development and use case launch

Pilot evaluation
- Evaluation of solution performance at pilot facility
- Technology/capability preparation at addl. facilities
- Change management 'roadshow' for scaled deployment

Scaling
- Scaled solution throughout the organization
- Governance and solution maintenance
- Ongoing value tracking
- Integration of underlying predictive maintenance technology architecture with other edge/cloud initiatives (as desired by client)

Visioning & Alignment » **Use Cases** » **Technology Ecosystem** » **Change Mgmt & Governance** » **Execution**

03

Why Deloitte

Why Deloitte?

Deloitte brings best-in-class capabilities and solutions that illuminate the supply network; sense risks in real time; and align people, processes, technology, and governance to develop resilience and agility.

Team: Our talent model revolves around "bilingual" teams that bridge the gap between traditional business issues and cutting-edge data science. Our technical experience helped us carve out a niche in the smart factory space, catering to all our client needs.

Advanced analytics: Advanced analytics have evolved exponentially over the past few years, with problems that previously required significant effort to "solve" being addressed by these advanced techniques (such as AI optimization and machine learning, data science, CIO architecture, and architects to drive conversation with vendors and implementation of solutions).

Speed and scale: Through experience across a broad range of projects with clients we have developed a library of 30+ use cases for predictive maintenance and own a smart factory testing ground that helps us compete with industry standards. This allows us to identify the opportunities that matter most to your vision and provide insights that translate into action.

Implementation: With our prior experience, we have developed an implementation approach that starts with defining vision and strategy for the program, followed by a pilot to demonstrate feasibility and finally scaling the solution—all the while tracking benefits to help ensure speed to value.

Unique skills: We have a unique set of skills that we bring to activate the architecture, such as OT architects, cloud developers, data scientists, change management and maintenance domain specialists.

Assets and accelerators: We help client time to value using a portfolio of IoT and smart factory-specific assets, including pre-built solutions, reference architectures, custom widgets, and code repositories, which provides Agile tools and assets and embeds leading practices/standards into our implementation projects.

Tailored approach: We have alliances with leading organizations to ensure you can build a modular solution tailored to your needs.

Change management: We prioritize change management efforts because we know that people and processes are critical for ensuring adoption and long-term sustainability of the solution.

Ready to unlock the power of predictive maintenance? Contact us.

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