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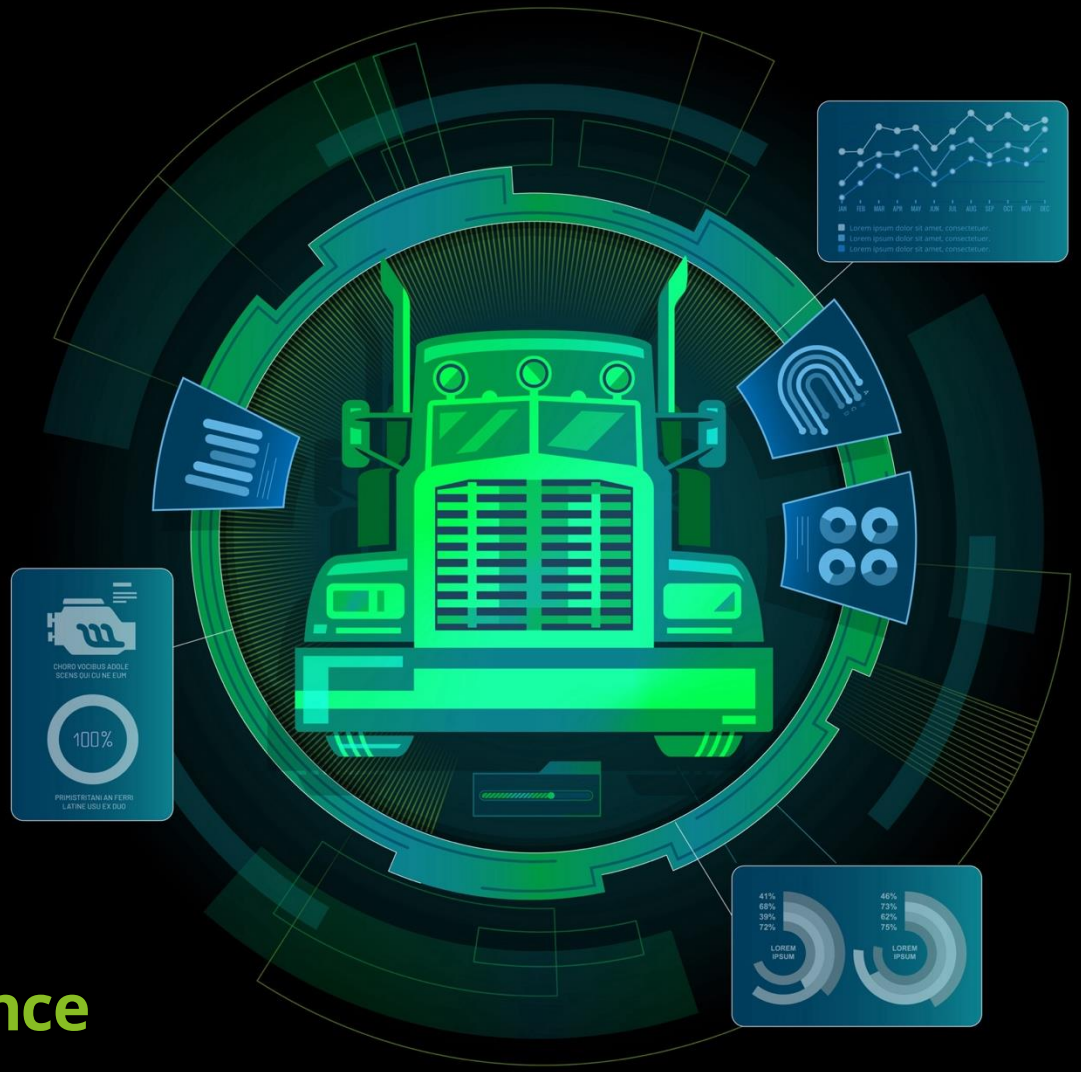

Predictive Maintenance for Mobile Assets

Deloitte's approach

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Imperative for maintenance transformation

Overview of mobile assets and key challenges

Mobile assets refer to movable equipment and vehicles crucial for the operations across multiple industries, enhancing mobility and operational efficiency

Types of Mobile Assets

Commercial Vehicles

Vehicles used for transportation and logistics, including **trucks, buses,** and **vans**

Construction Equipment

Heavy machinery used in construction projects such as **excavators, cranes** and **bulldozers**

Agriculture Vehicles

Equipment used in farming and crop production such as **tractors** and **combine harvesters**

Railway Locomotives

Vehicles used for the transportation of goods and passengers via **railways**

Managing Mobile Assets: Key Challenges

Maintenance Challenges

Regular wear and tear, the need for periodic repairs and overhauls

Operational Efficiency

Ensuring assets are running at optimal efficiency

Asset Tracking

Monitoring the location and usage of mobile assets

Cost Management

Balancing maintenance costs with asset performance

Why predictive maintenance?

The advancement of Telematics and 5G, availability of limitless data storage/computing power, and advanced analytical capabilities (in edge and cloud) have unlocked the power to predict asset failure, reduce maintenance cost, and increase asset life.

Salient benefits of predictive maintenance (PdM) include:

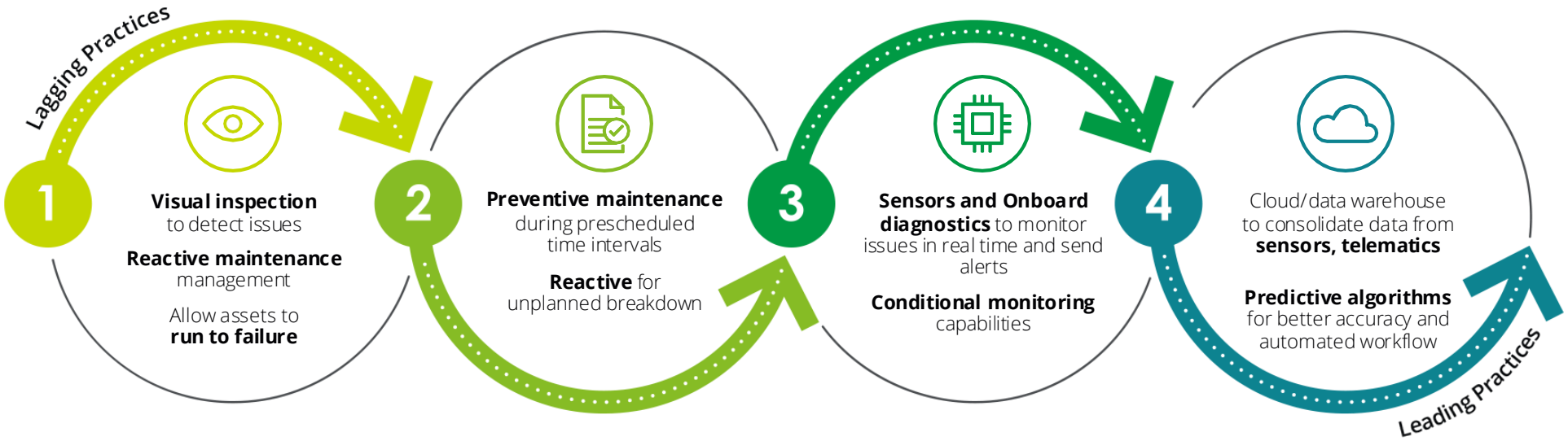
- Improved asset-life expectancy leading to reduced capital outlay for asset replacement
- Reduced overtime costs due to reduction of unplanned repairs
- Reduced repair costs and times due to performing maintenance on site locations
- Optimal availability of skilled maintenance technicians and operators in times of labor shortages
- Better parts management and predictability
- Better control over fleet operations planning
- Improved safety due to reduced failures
- Meeting Service Level Agreements for better customer service

Some additional benefits with PDM include enhanced "Track & Trace" capability leading to improved delivery estimation accuracy

Source: 1: Benefits of Predictive Maintenance for the Logistics Industry | 2: 10 ways predictive maintenance with telematics data can boost fuel efficiency | 3: Based on Deloitte Experience | 4: Position Paper-Deloitte Analytics Institute

Evolution of mobile asset management

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



Success Stories

The European division of a large global automobile manufacturer is implementing a smart vehicle data collection and monitoring system to enable enhanced **vehicle repair**, **recovery**, and **smarter insurance** management.

A large fleet management company's clients with a need based predictive maintenance (PdM) program had ~20% fewer days down per service repair as compared to their clients without a PM program2

A large fleet management company leverages onboard diagnostics, tire pressure monitoring systems, and **advanced data analytics** on **real time data** to predict potential tire issues, reporting a **20% reduction in unplanned downtime** and **15% decrease in roadside assistance calls**[3].

A leading global mining company collected and analyzed train and rail infrastructure data using AI to predict and prevent rail car failures in its iron ore transport network, resulting in a **50% reduction in single-car unscheduled maintenance events**, and in **$34M in savings** over a 5-year period[4]

Sources: 1: Ford Connected Vehicle Data Collection | 2: Preventative Maintenance Study | 3: Michelin Connected Fleet | 4: Global Mining Company Case Study

Reasons behind failure of predictive maintenance implementation

Despite of advancement in technology, fleet management organizations have not been able to harness the power of these technologies beyond pilots.

NON-STANDARDIZED PRACTICES

Each function or fleet group tends to adopt distinct technologies. This results in a lack of standardization across processes and impedes the transfer of learning, resulting in extended timeframe development and rollout.

POORLY DEFINED BUSINESS CASE

The absence of clear guidelines for formulating a comprehensive business case, defining success metrics, and calculating benefits poses challenges in securing project approval from executives and restricts the visibility provided by the program.

INCREASING TECH COMPLEXITY

Insufficient expertise in identifying the right vendors is a challenge. Additionally, resources to foster collaboration between business and technical aspects are limited.

INADEQUATE CHANGE MANAGEMENT

Reluctance to move away from legacy processes, tools, and technologies, combined with fear of adoption, diminishes the realized benefits from the program and risks losing corporate-level support.

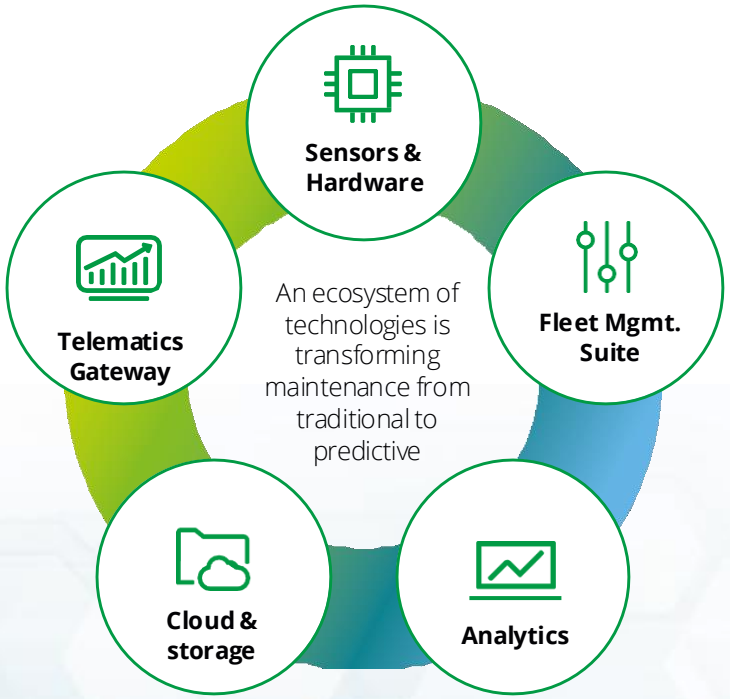
Maintenance transformation: An ongoing challenge

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 asset failure
- Low fleet utilization
- High spare parts inventory and maintenance costs
- Risk to safety and environmental impacts
- Increased Mean Time To Repair (MTTR) due to lack of documentation and diagnostics history

Leading practice/future vision



Key challenges associated with mobile assets

Mobile assets require a differentiated approach due to nature of usage, to effectively enable predictive capabilities

Mobile Asset PdM Nuances

- **Dynamic Operating Conditions:** Mobile assets encounter shifting, often unpredictable environmental conditions
- **Connectivity Limitations:** Remote or hard-to-reach areas challenge consistent connectivity for mobile assets
- **Usage Pattern Diversity:** Geographic, demand, and seasonal factors lead to broad variability in mobile asset usage
- **Transport Stress Impact:** Mobile assets are subject to vibrations, shocks, and other stresses from variable surface conditions
- **Maintenance Accessibility Issues:** The mobility and diverse locations of assets complicate routine and critical maintenance access

Key Challenges in Mobile Assets PdM

Data Accessibility: Connectivity constraints hinder real-time data collection, essential for timely maintenance

Data Privacy: Ensuring security and privacy of transmitted predictive maintenance data poses significant challenges

Sensor Integration: Integrating diverse sensors complicates creating a unified analytical approach

Sensor Allocation: Ensuring the right sensor is installed in the vehicle to fetch required data

Predictive Modeling Complexity: Analyzing disparate variables and handling often discontinuous data adds complexity

Resource Allocation & Schedule Optimization: Vehicle availability and external factors constrain maintenance scheduling

Deloitte's experience

Deloitte's approach to Predictive Maintenance is grounded in 10+ projects in the predictive analytics domains

	Predictive Analytics based Safety Alerting for a global automotive OEM	Predictive maintenance for a package delivery corporation	Transforming Maintenance with Predictive AI and part positioning for a Global Airlines Company
Issue	A global automotive OEM received a consent order from NHTSA for safety act violations including early warning reporting. OEM agreed with NHTSA to invest in SDAI capability for improving early detection & reporting	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 global airlines company was experiencing delays and cancellations due to maintenance events in which the required part was unavailable to complete the required fix. This in turn was resulting in increased spend on expedites to meet short turnaround times, part borrowing from other airlines, and increasingly complex network of inventory across their many global repair stations.
Solution	Developed a predictive analytics ML model to estimate likelihood of a specific type of safety issue occurring. This model used onboard telematics sensor (e.g., vibration sensors) & diagnostics data (e.g., battery health sensor short circuit). Developed fleet impact estimation ML model on top of predictive ML model to estimate % of fleet impacted with a specific type of safety issue. Periodic notification of fleet impact pushed to front-end screens for downstream governance & investigation prioritization	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 developed an AI solution to predict part requirements based on initial maintenance comments and previous repair history. This information was integrated with maintenance planning, allowing the Supply Chain team to proactively position required parts across the repair station network as soon as maintenance events occurred. The model also helped reduced repair times by predicting parts requirement prior to conducting complete diagnostics.
Impact	The novel predictive analytics & fleet impact estimation ML models for predicting safety issues and estimating fleet impact, represented a significant upgrade in early issue detection & reporting capability. This contributed to resolving the consent order with NHTSA	Program is estimated to drive $100M+ in annual benefits by unlocking capacity across 150+ facilities amounting to ~4%+ overall capacity unlock.	The AI solution helped predict parts required for maintenance in the first attempt and mitigated 60-75% of deferrals, which could potentially lead to a $2.0-2.8M annual savings. The team reduced 37% of expedites resulting in expected reduction of ~8650 man-hours. The model provides guidance to users to influence where to direct diagnostic attention which aided in reducing tail swaps and expensive delays/cancellations.

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

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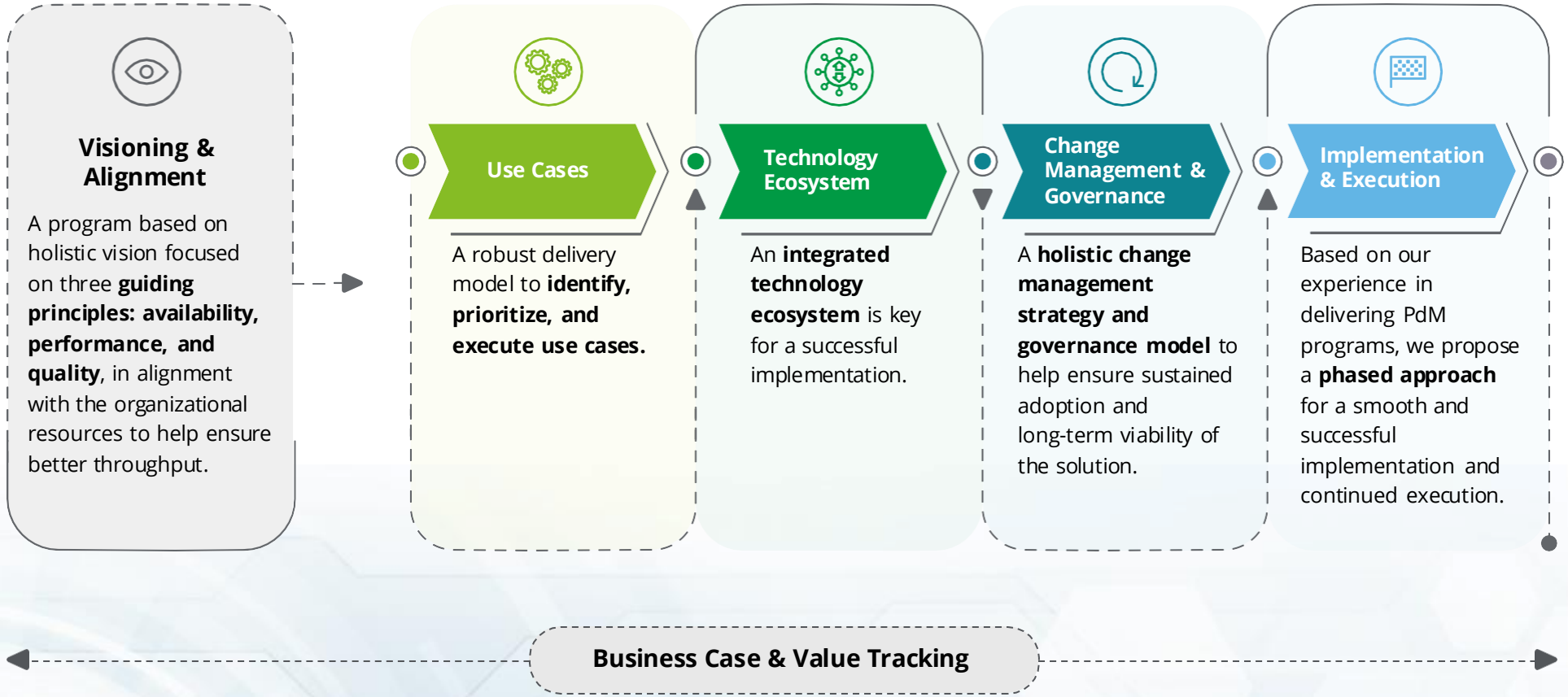
Our approach to predictive maintenance transformation

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.

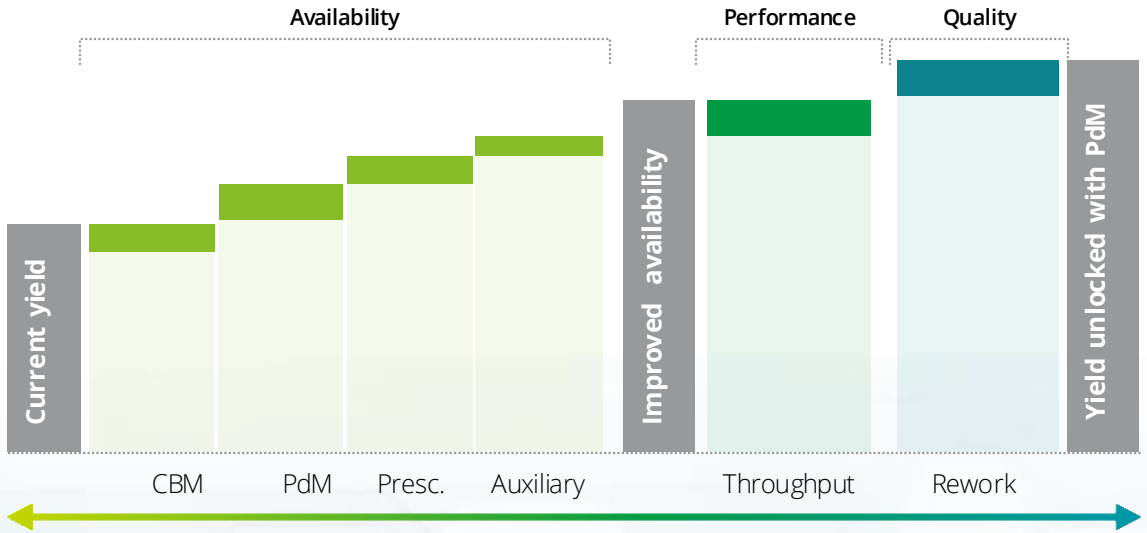
PREDICTIVE MAINTENANCE VISIONING

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 enhance the operational time of mobile assets by incorporating both conditional monitoring and predictive analytics. This ensures that vehicles and equipment are operational and available when needed

Performance: These use cases aim to boost the productivity and efficiency of mobile assets. While focusing on predictive maintenance, they also extend to related areas, broadening the business case for PdM in mobile contexts

Quality: By implementing predictive maintenance strategies for mobile assets, these use cases minimize the need for repairs and maintenance rework. This leads to improved operational efficiency and reduces costs associated with 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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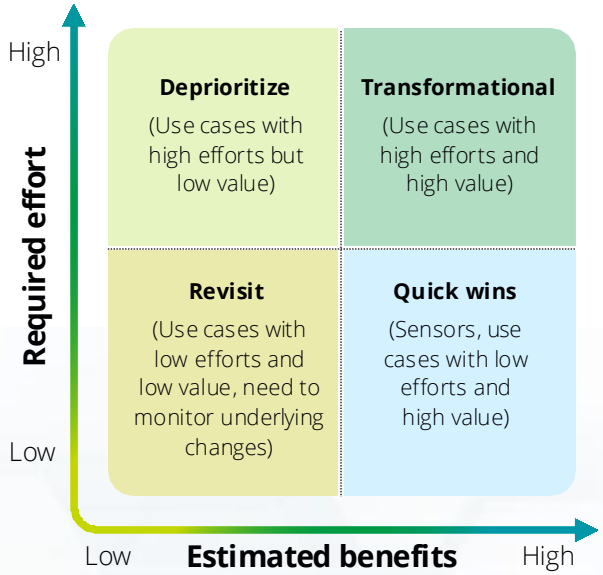
Prioritization



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

Need for a Robust Tech Ecosystem

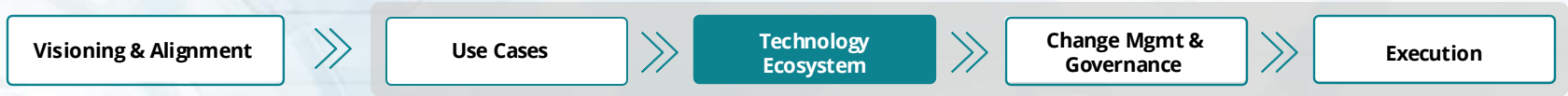
Tech ecosystem is important for predictive maintenance because it provides the infrastructure, tools, and capabilities necessary to collect, process, analyze, and act upon data effectively

Data Acquisition	Data Transport & Gateway	Data Storage & Processing	Data Analytics	Fleet Management
Sensor Hardware Collection or measurement of data from various assets. Devices and sensors are used to gather parameters such as location, speed, fuel consumption, and engine diagnostics	**Telematic Gateway** Transmission of the collected data via cellular networks or other communication protocols to a central system or cloud service for further processing and analysis	**Hyper-scaler Platform** Cloud storage and IoT Application Enablement Platforms that support Predictive Maintenance applications	**Analytics** Data engineering, data science, integration of machine learning and other analytical capabilities on client's data	**Fleet Management Suite** FMS acts as a managing layer for the IoT platform enabling governance & control it helps optimize fleet operations by tracking vehicle health and increasing overall productivity
On-Prem Storage A local server/drive used to store data temporarily before it's transmitted to a central server	**Data Protocols** These are standard procedures for transmitting data between devices. Protocols like MQTT, CoAP are commonly used in IoT applications	**Cloud Services** Cloud services such as data storage, database management and data warehousing enable storing and processing large volume of data efficiently		

Need for Integrator, Deloitte

Deloitte's experience in the implementing predictive maintenance solution enables them to play the role of an Integrator, which is essential to:

1. Ensure seamless connectivity and communication between various components of the system
2. Help in combining hardware & software from different vendors, aligning them with the business processes, and ensuring data flows accurately for real-time analysis
3. Enhance the overall efficiency, enable accurate predictive analysis, and ensure a smoother implementation of the maintenance strategy



Essential Ecosystem Capabilities

An effective predictive maintenance solution should have some fundamental capabilities for successful execution

Scalability and Flexibility

The underlying architecture supporting PdM should be scalable and flexible to accommodate changing business needs and growing data volumes

Accuracy and ERP Integration

Data & models should be accurate to avoid excessive maintenance and integrate with organization's existing process management systems

Data Security and Compliance

Data security and compliance are crucial, especially when dealing with sensitive information such as equipment performance data or maintenance schedules

Regulatory Compliance

To ensure meeting regulatory standards and avoiding penalties, it's crucial to have robust systems for predicting and preventing potential failures

Resource Allocation & Schedule Optimization

Effective PdM relies on advanced scheduling capabilities. These systems must account for vehicle availability and potential delays, ensuring maintenance resources are optimally allocated

Structured Predictive Modeling

For PdM to be successful, a structured approach to data collection, analysis, and decision-making is essential. This reduces the complexity of modeling and supports effective maintenance strategies

Sensor Integration

To enhance PdM, integrating diverse sensors onto mobile assets is key. This requires a comprehensive framework that addresses challenges such as power usage, compatibility, and the diversity of vehicle makes and models within a fleet

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

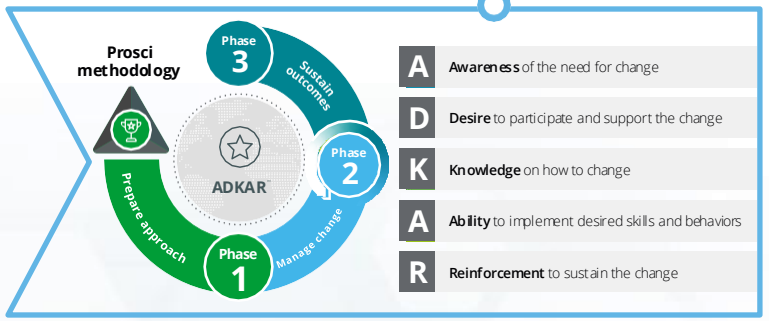
Impact/risks

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

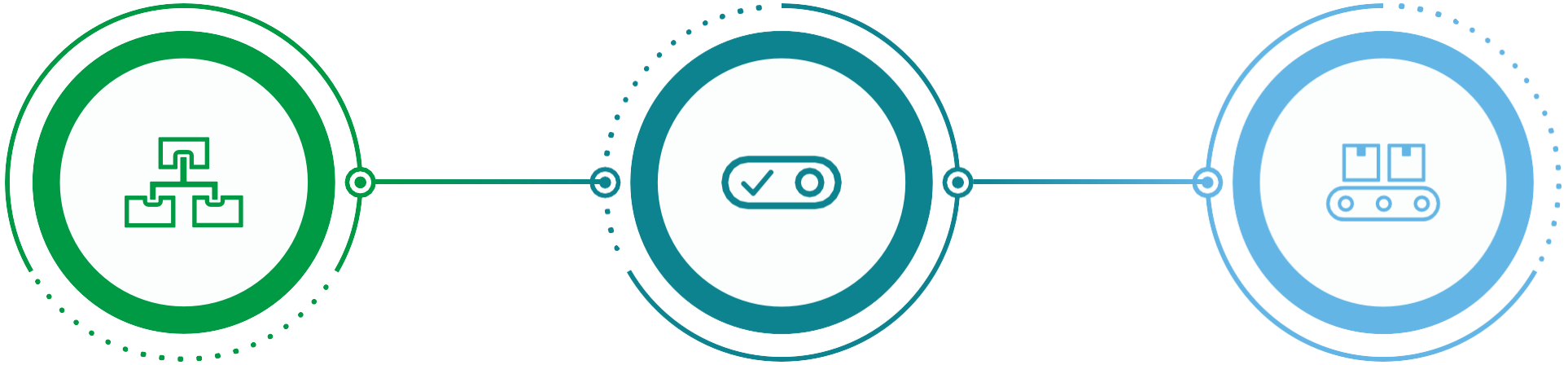
Mitigation plans are developed using lessons learned and proven models, such as the Prosci and ADKAR frameworks, to help ensure both organizational and individual change are made and sustained



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 a pilot fleet

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 more fleets

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 a pilot fleet (established data integrations)
- AI/ML algorithm development and use case launch

Pilot evaluation

- Evaluation of solution performance on the pilot fleet
- Technology/capability preparation at addl. fleet
- 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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