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2025

Smart Maintenance, Repair, & Overhaul

Point of View

How to use this deck

Purpose

Establish an overarching perspective on increasing the efficiency and effectiveness of MRO using Industry 4.0 technologies—creating Smart MRO

Use

For external or internal use, please contact the team on the next slide with questions

What to expect

- *What is Smart MRO?*
- *Why Smart MRO?*
- *Smart MRO capabilities*
- *Deloitte's approach; why us?*

Contact us for your Smart MRO needs

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Terms alignment for this POV

Concept		*Terminology Used*
Worker, mechanic, repair specialist, etc.		**Shop floor personnel**
End item		**Asset (aircraft, tank, etc.)**
Machine		**Equipment**
Group or audience		**MRO organization**

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01

What is Smart MRO?

What is maintenance, repair, & overhaul (MRO)?

MRO encompasses actions performed on shop floor equipment or assets throughout their lifecycle across industries like aviation, automotive, construction, healthcare, and energy; while used interchangeably, maintenance, repair, and overhaul have distinct nuances

Maintenance

Routine, basic activities to ensure equipment or assets remain in good working condition; typically scheduled and performed at regular intervals

Repair

More invasive and corrective action as needed to restore functionality quickly; often includes fixing or replacing parts

Overhaul

POV focus

Most comprehensive process; involves restoring equipment or assets to operating condition by disassembling, evaluating, fixing, and reassembling

MRO can be conducted on both...

Shop floor equipment (SFE)

- Maintaining shop floor equipment primarily involves maintenance and repair, overhaul is less of a focus
- Ensuring shop floor equipment remains in operational condition directly supports production
- Performing routine maintenance prevents unexpected downtime which can impact production
- Maintaining SFE health is key to extending the working life and performance of equipment

End item assets

Effective MRO prevents costly failures and/or extends serviceable life by ensuring end item assets are safe, compliant, and operationally ready.

Location of repair activities depend on the severity of the repair:

- Minor operations typically are performed in the field
- More complex operations often require relocating the asset to a specialized facility equipped to perform the repair or overhaul

How does manufacturing differ from MRO?

Manufacturing and MRO complement and depend on each other, but differ in primary objectives, focus, and operations, and are most effective when designed with the needs of both in mind

Manufacturing is production-oriented, focused on initial production and assembly, while **MRO is readiness-oriented**, focused on maintaining, repairing, or overhauling

Manufacturing	MRO
Focused on building a new asset from a set list of raw materials and standardized workflows or instructions	Focused on maintaining, repairing, overhauling, and upgrading of an existing asset
One time activity to build an asset from scratch	Ongoing over the life span of an asset to ensure continued functionality and reliability
Predictable product outputs since product conditions are expected to be the same, similar	Unpredictable nature of asset conditions causes higher variability for MRO
Higher predictability allows for better anticipation of potential failures, smaller subset of possible problems	Unpredictable nature of MRO uncovers unforeseen issues, hindering effective planning of parts and resources

Common market trends and challenges in deploying Smart MRO

Overcoming obstacles to governance, change management, talent, and technical infrastructure is required for a successful transformation

Creating and enforcing a governance model

System of rules, practices, and processes that direct an organization

- Poorly defined metrics, ambiguous goals, lack of common understanding of requirements; institutional personnel actions that limit operational expertise
- No clear sponsorship or enterprise-wide support for deployment strategy
- Fragmented implementation approaches
- Competing priorities and lack of clear criteria for piloting, scaling, or discontinuing initiatives

Facilitating change management successfully

Transitioning individuals and organizations into a new state of existence

- Cultural resistance to change and inadequate communication on the purpose and benefits of the project
- Resistance to adopting ideas/solutions from other sites
- Lack of focus on user buy-in and failure to adapt promptly to user feedback
- Difficulty managing change load, implementing too many changes at once

Retaining and training the workforce

Aging workforce, growing skills gap, and inadequate training programs

- Misunderstanding the impact of workforce trends on the organization and not planning accordingly
- Skills and training gap results in personnel lacking necessary expertise to operate and maintain smart machinery and leverage emerging technologies
- Loss of Subject Matter Expert (SME) expertise

Accessing and supporting tech infrastructure and hardware

Overhauling or modifying existing technology and infrastructure to meet new requirements

- Underestimating the level of effort required to coordinate all the technology in a Smart MRO
- Deploying OT networks and new devices in old infrastructure and brownfield sites.
- Inability to address the operational technology (OT) and informational technology (IT) convergence strategy and manage cybersecurity considerations

A Smart MRO facility enables a digitally connected ecosystem

Integrated advanced technologies and data-driven approaches link the field to the facility, anticipate maintenance needs, and optimize resource allocation to maximize repair effectiveness and quality without compromising safety

A Smart MRO's goal is to improve readiness by systematically reducing variability and risk. Smart MROs aim to help your MRO organization be **reliably prepared** when needed most.

Connected

Exchange data seamlessly across assets, equipment, people, and systems

Proactive

Monitor material, labor, and facilities continuously to maximize quality while mitigating risks and constraints

Safe

Augment strenuous work with robotics for worker safety; cybersecure networks and systems for safe connectivity

Flexible

Tailor solutions to align with your organization's unique philosophy

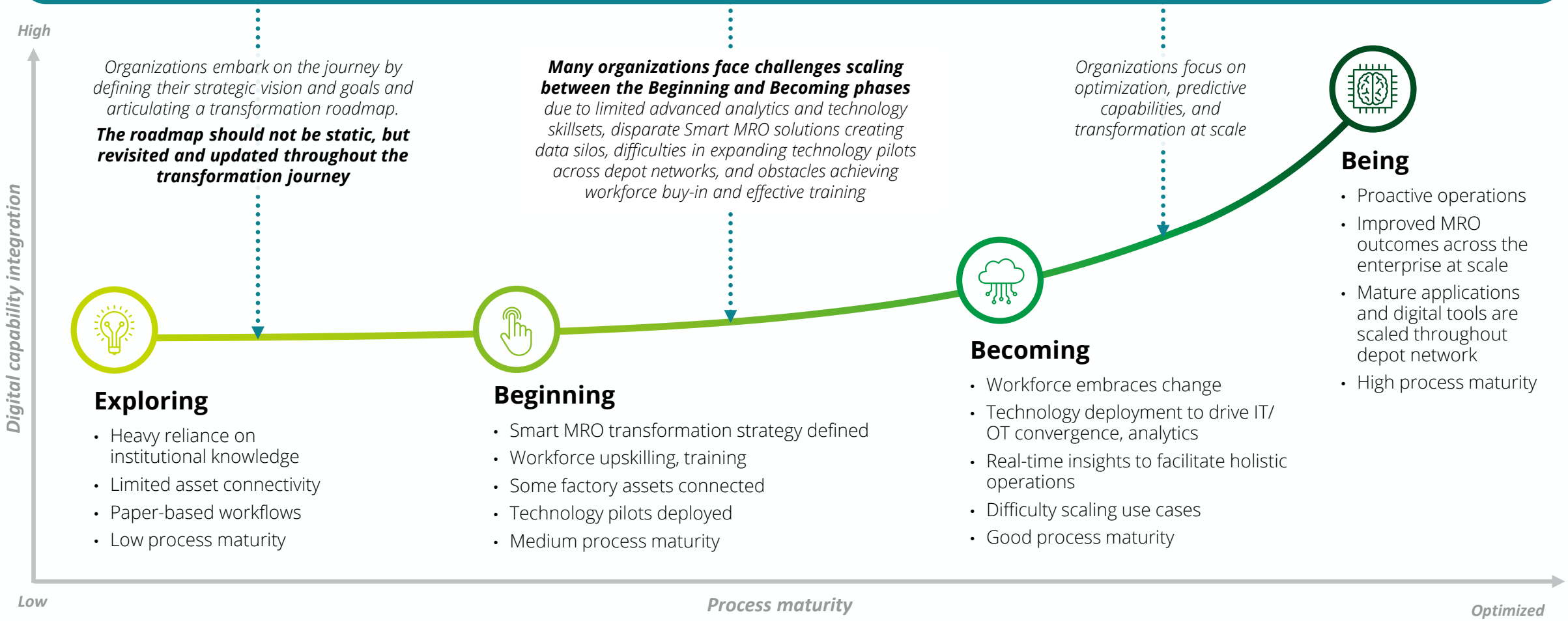
Optimized

Adjust resource allocations dynamically to streamline operations and reduce costs

The Smart MRO journey can begin anywhere on the maturity curve

Organizations require a holistic approach—orchestrating advanced technology, enabling the workforce, and synchronizing operations

Maturity curve represents an organization's current capabilities and future possibilities



Organizations embark on the journey by defining their strategic vision and goals and articulating a transformation roadmap.

The roadmap should not be static, but revisited and updated throughout the transformation journey

Many organizations face challenges scaling between the Beginning and Becoming phases *due to limited advanced analytics and technology skillsets, disparate Smart MRO solutions creating data silos, difficulties in expanding technology pilots across depot networks, and obstacles achieving workforce buy-in and effective training*

Organizations focus on optimization, predictive capabilities, and transformation at scale

Exploring

- Heavy reliance on institutional knowledge
- Limited asset connectivity
- Paper-based workflows
- Low process maturity

Beginning

- Smart MRO transformation strategy defined
- Workforce upskilling, training
- Some factory assets connected
- Technology pilots deployed
- Medium process maturity

Becoming

- Workforce embraces change
- Technology deployment to drive IT/ OT convergence, analytics
- Real-time insights to facilitate holistic operations
- Difficulty scaling use cases
- Good process maturity

Being

- Proactive operations
- Improved MRO outcomes across the enterprise at scale
- Mature applications and digital tools are scaled throughout depot network
- High process maturity

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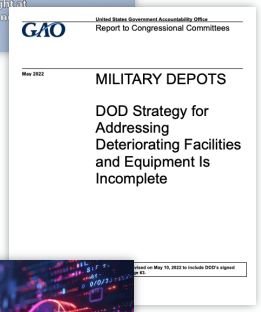
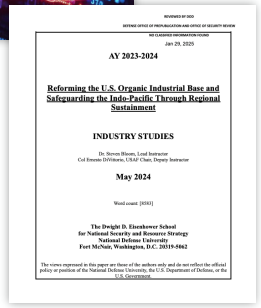
Why Smart MRO?

Evolving technology and warfighter landscape is demanding

Meeting current day MRO demands require not only new technology and processes, but a new way of thinking





*"**Digital Transformation is no longer a buzzword, it's a business imperative** for MROs seeking to remain competitive and resilient in a rapidly changing environment."*

MRO Outlook 2024

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*"Since fiscal year 2016, the condition of the depots' infrastructure - **their facilities and equipment - generally has remained in the fair-to-poor range and has not improved**."*

DOD Strategy for Addressing Deteriorating Facilities and Equipment Is Incomplete

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*"The **ever-present skills gap in defense MRO continues** apace in 2025. The defense industry is seeing an influx of next-gen platforms… bringing the need for an entirely new maintenance knowledge base."*

The year digitalization and heightened cybersecurity change the course of defense operations

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*"**OIB infrastructure challenges are summarized by three factors: aging facilities and equipment, geographical centralization in CONUS, and cyber vulnerabilities.** Regardless of the nature of the threat, poor facilities and equipment will serve as constraints to the level of productivity in the OIB."*

Reforming the U.S. Organic Industrial Base and Safeguarding the Indo-Pacific Through Regional Sustainment

1. **Doing more with less**
2. **Mission readiness & gearing up for conflict**
3. **Keeping pace with Industry 4.0 market and competition**

Transform from current to future state for Smart MRO results

Utilize current state pain points with equipment, people, operations, and systems to inspire future state vision and outcomes

	Aging equipment and infrastructure	Talent management challenges	Efficiency & effectiveness challenges	Disjointed systems & data
Current State	• High maintenance costs • Extended TAT from frequent breakdowns • Unexpected failures disrupt shop floor performance	• Knowledge loss from aging and retiring workforce • Inability to attract and retain tech savvy talent • Workforce skills not keeping up with modern MRO needs	• Unanticipated demand forces constant reassessment of labor, parts, and equipment planning • Constant juggling of capacity constraints	• Manual and time-consuming data collection prone to human error • Siloed or outdated data across engineering, planning, and production • Incompatible systems with data leak vulnerabilities
Future State	**Advanced tech** • Data-driven, proactive approach to equipment maintenance • IoT connected systems that communicate and adapt • Timely, critical interventions before failures occur	**Enabled workforce** • Centralized knowledge management • Personalized training materials for talent upskilling • Cross-trained, empowered workforce	**Optimized operations** • Seamlessly and automatically adapt resource allocation to new constraints • Upstream and downstream supply visibility	**Integrated, secure enterprise solutions** • Sensor-driven autonomous data collection • Single source of truth, enterprise-wide data repository • Cybersecure systems with automated monitoring and risk mitigation

Desired outcomes

Effective assets *(TAT / readiness)*

Optimized costs

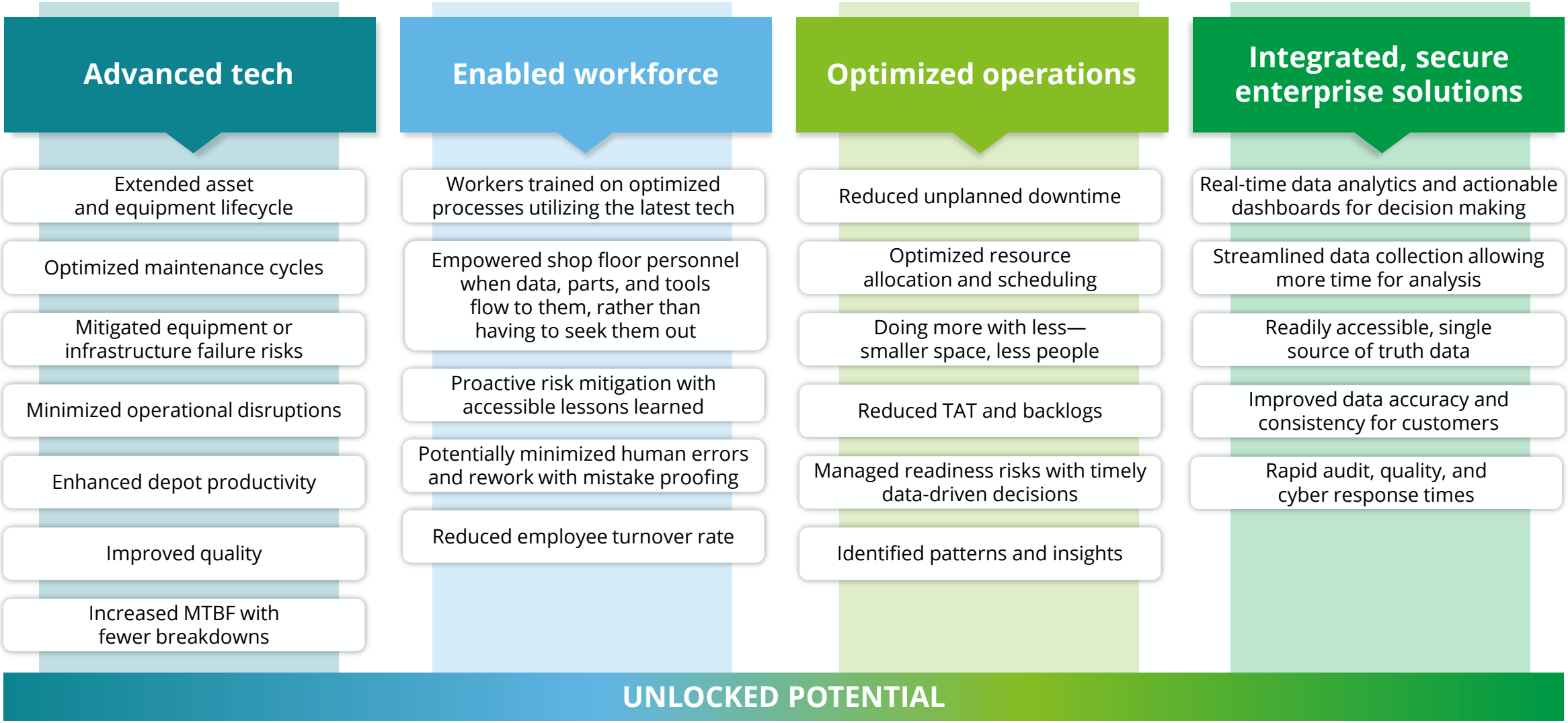
Efficient processes

Agility *(flexibility / ability to manage risk)*

Safety and security

Smart MRO can unlock benefits across the organization

Deriving from the four capabilities that form the foundation of Smart MRO, an organization can realize potential in a multitude of ways



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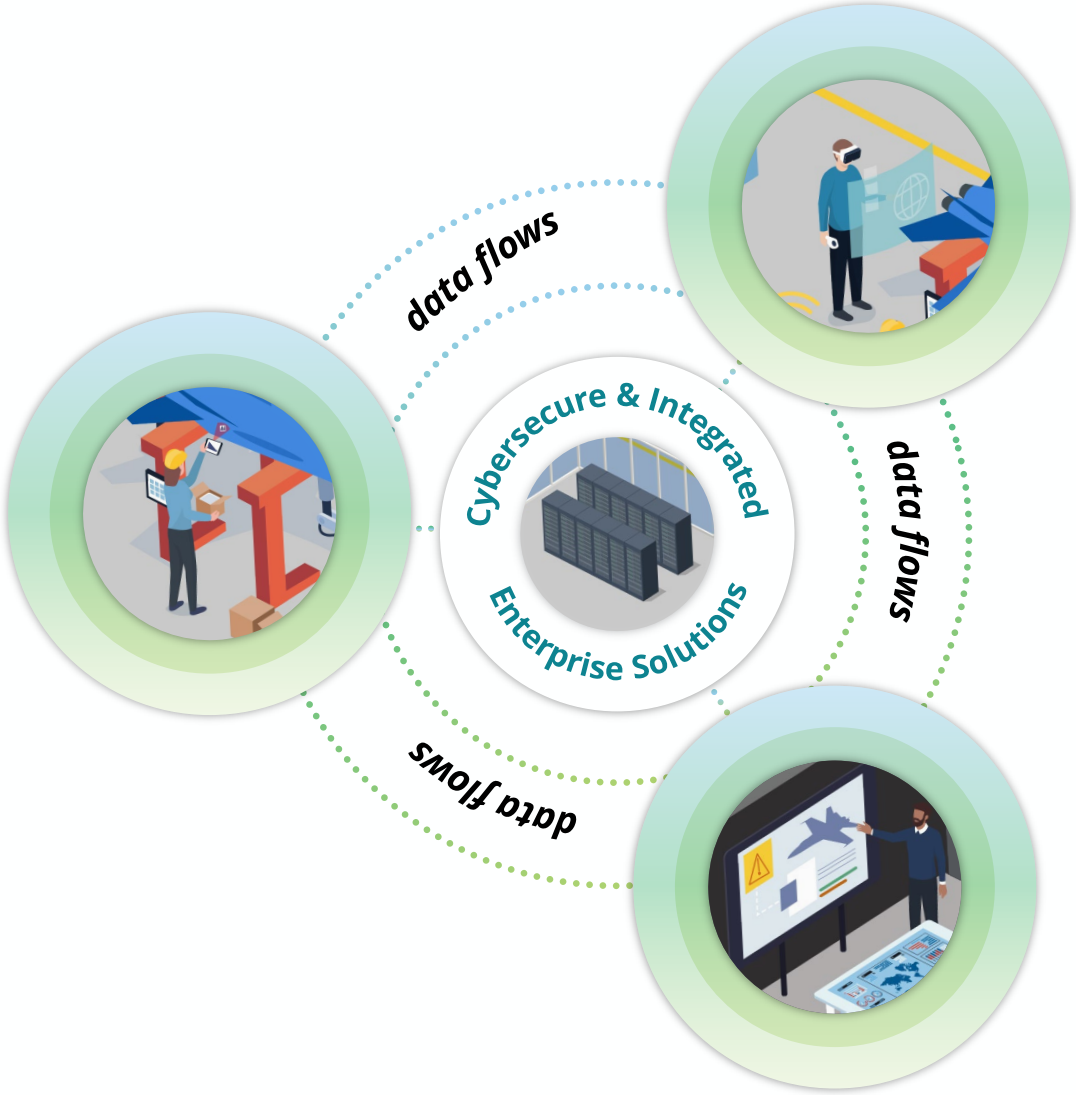
Smart MRO vision & capabilities

What capabilities form the foundation of a Smart MRO?

The integration of technology, workforce, and operations data across cybersecure enterprise solutions

Enabled Workforce

Workers rapidly trained *(in a safe, simulated environment)* on improved maintenance practices utilizing the latest tech.
This allows for significant improvements to digital knowledge management, and mitigates turnover impacts



Advanced Technology

Workforce, equipment, and facilities equipped with latest Industry 4.0 digital capabilities fully integrated into systems network infrastructure

Optimized Decision Making

Insights from rich, integrated data spanning assets, equipment, people, and systems facilitate resource allocation at the optimal place and time to maximize throughput

What does a Smart MRO ecosystem look like?

Digital capabilities span the full asset lifecycle from in-field deployment to in-depot maintenance

Induct

Review assets' digital BOMs, CADs, processes, and upcoming work. **Dynamically schedule** workload and personnel, while simultaneously matching skills and qualifications to workload.

Disassemble & evaluate

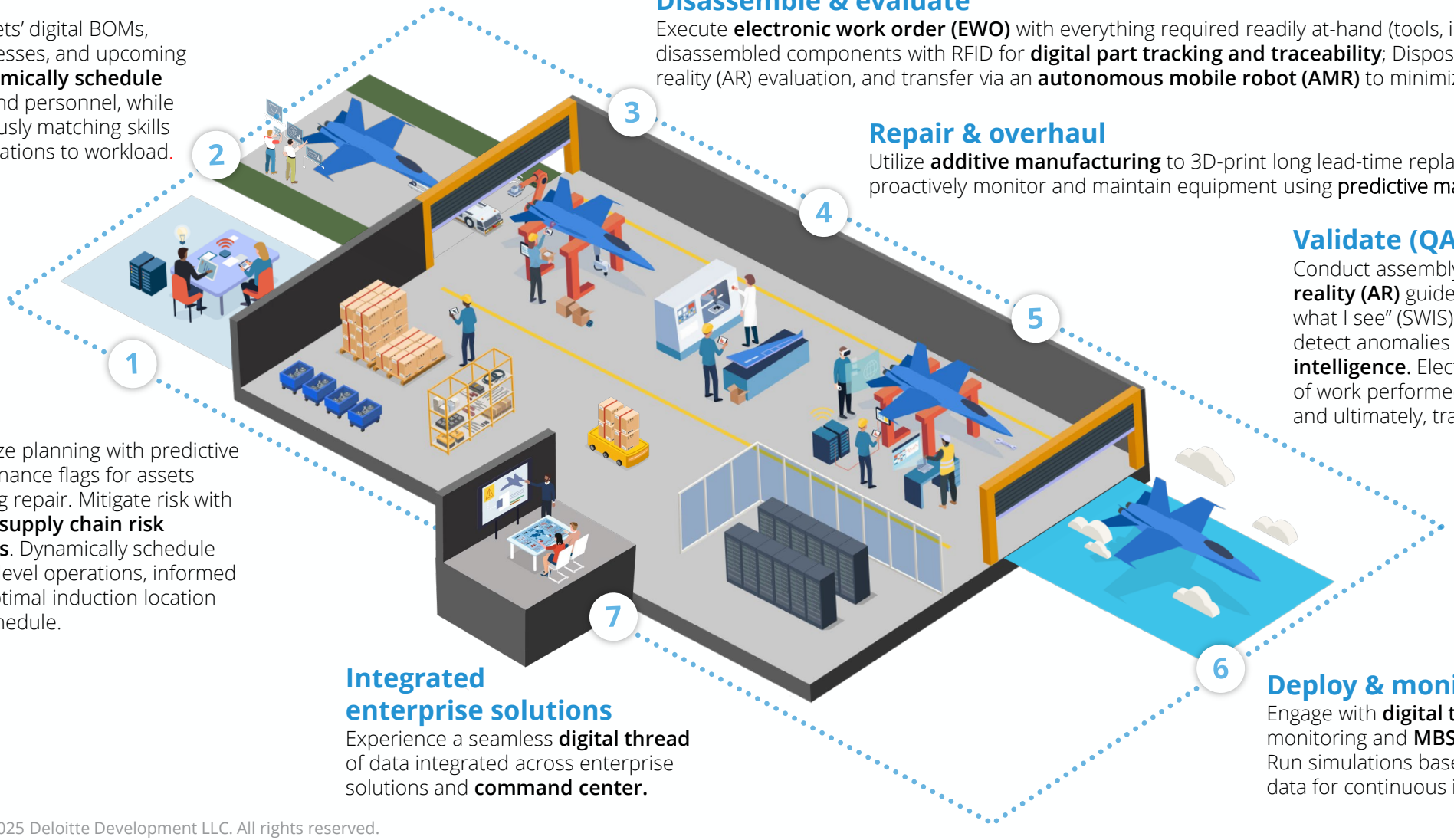
Execute **electronic work order (EWO)** with everything required readily at-hand (tools, instructions, etc.) Tag disassembled components with RFID for **digital part tracking and traceability**; Disposition parts via augmented reality (AR) evaluation, and transfer via an **autonomous mobile robot (AMR)** to minimize worker strain.

Repair & overhaul

Utilize **additive manufacturing** to 3D-print long lead-time replacement items; proactively monitor and maintain equipment using **predictive maintenance.**

Validate (QA) & reassemble

Conduct assembly utilizing **augmented reality (AR)** guided instructions and "see what I see" (SWIS) remote expert validation; detect anomalies real-time using **artificial intelligence.** Electronically capture summary of work performed, authentication signature, and ultimately, traceability.



Plan

Optimize planning with predictive maintenance flags for assets needing repair. Mitigate risk with **global supply chain risk reviews**. Dynamically schedule facility-level operations, informed with optimal induction location and schedule.

Integrated enterprise solutions

Experience a seamless **digital thread** of data integrated across enterprise solutions and **command center.**

Deploy & monitor

Engage with **digital twin** for part condition monitoring and **MBSE** for scenario analysis. Run simulations based on asset performance data for continuous improvement.

Smart MROs excel with advanced technology

Advanced technology use cases allow an MRO organization to operate at the next level of maturity

Model based systems engineering (MBSE)
manages the complexity of integrations across different systems

Digital thread
integrates enterprise systems to create a single source of truth for effective decision making

Advanced connectivity and network security
provides a secure private network connecting OT devices on the shop floor

Artificial intelligence
independently performs or augments tasks traditionally requiring human intelligence

Monitoring & mitigating

- **Condition-based monitoring & predictive maintenance**
  monitors industrial equipment performance parameters (e.g., temperature, vibration, etc.) using sensors and triggers alerts for failures and proactive maintenance; provides real-time monitoring and predictive insights
- **Supply chain risk**
  illuminates multi-tiered, geographically disaggregated supplier networks and potential risks for source planning

Data & connectivity

- **Digital location tracking**
  leverages advanced tracking to locate shop floor parts, tools, and personnel, for real-time operations visibility & safety
- **Digital twin**
  represents parts, equipment, etc. for configuration management and "what if" scenario planning (e.g., shop floor layout optimization, new equipment ROI)
- **3D scanning**
  captures precise digital models of physical objects for PLM, CAD/CAM, and manufacturing

Automation & robotics

- **Autonomous mobile robot (AMR)**
  allows seamless asset flow in MRO by transporting components autonomously, reducing manual movement and lost items
- **Additive manufacturing**
  facilitates flexible, low-volume production and customization, streamlining supply chains with digital inventories and distributed manufacturing
- **Augmented reality (AR)**
  allows subject matter experts (or different departments) to see through the eyes of shop floor workers in real time to facilitate faster part testing, hands-free training, and guided workflows

Planning & scheduling

- **Dynamic scheduling**
  optimizes work-in-progress (WIP) maintenance by synchronizing labor, equipment, and material availability to maximize efficiency
- **Command center**
  aggregates multisystem data for informed decision making
- **Electronic work order (EWO)**
  describes the scope of work to be completed and replaces traditional paper-based work orders

Smart MROs should promote an enabled workforce

Emerging technologies, change management, and data literacy are crucial to reskill and upskill workers in industrial organizations, including those with MRO operations

Workforce development

Next generation tools can empower the workforce. **Artificial Intelligence** can provide personalized training materials and relevant information from maintenance manuals quickly to new employees. For example, organizations can record legacy SMEs describing critical processes and use AI to translate it into electronic work instructions for new employees, facilitating key knowledge transfer from retiring workers. New staff can acquire skills on the job with **Augmented Reality (AR)** or in a safe, virtual setting with **Virtual Reality (VR)** headsets and even access guided work instructions from a **remote expert**.

Change management

Successful digital transformation hinges on effective **change management** throughout the organization as well as on top-down and bottom-up idea generation. It's helpful when stakeholders lead by example, embracing new technologies themselves, holding their teams accountable, and employing incentives or rewards. **Empowering front-line workers** to offer ideas for innovation and implementing successful **pilots across the organization**, is beneficial to workforce buy-in to change. Supervisors can help shift organizational culture by incorporating new tools into their team's routine, like reviewing dashboards during meetings.

Data literacy

Fluency in the **new language of data** is key for workers as systems become interconnected, and more data is created. To ensure successful **data governance**, leaders need to **define key metrics** for the organization, communicate how those metrics are calculated to the workforce, and train employees on any new roles. To help facilitate these changes, technical experts and data analysts can create dashboards reflecting shop floor realities. **Centers of Excellence** also can certify departments' data sets for dissemination throughout the organization.

Worker safety

MRO environments are dynamic, making worker safety challenging. Sensors and cameras with **AI-vision models** can identify safety hazards, such as spills, air quality issues, or prolonged noise exposure, and detect proper PPE usage while maintaining user data anonymity. **Machine Learning Models** can analyze weather data to predict the likelihood of lightning strikes in naval environments. In addition, **drones or autonomous vehicles** can conduct inspections in difficult to reach or hazardous areas.

Smart MROs can optimize decisions: org operations

Leadership can enhance dynamic management for depot operations

Optimized Decision Making

Asset management

Work order status, equipment performance and reliability (uptime / downtime, availability, mean time between failures, repair turnaround time, repair time), critical actions

EHS and compliance adherence?

Optimal staffing count?

Critical KPIs and actions?

Equipment performance and reliability?

Work order status?

Planned vs. actual performance and demand?

Workforce

Availability, capacity forecasts, safety incidents, compliance score, training needs, critical actions

Process

Work order status, delivery trends, throughput, order lead-times, critical actions

Network performance and demand?

Critical cyber vulnerabilities and incidents?

Root cause for performance deviations?

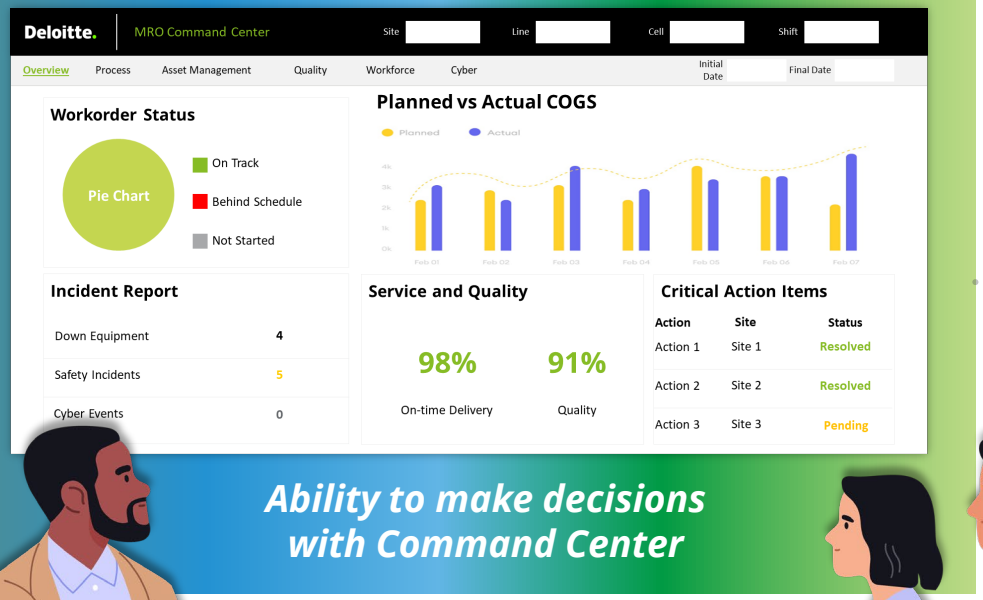
Quality improvement protocols and investments?

Cyber

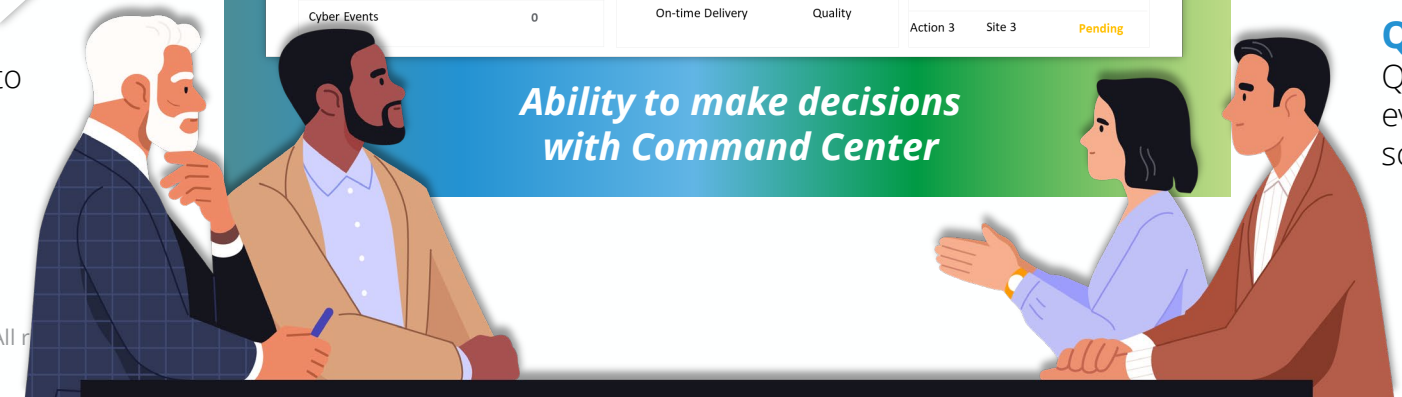
Incident status, mean time to detect and resolve, incident details, critical actions

Quality

Quality trends, non-conformance events, defect rate, first pass yield, scrap / repair / rework costs



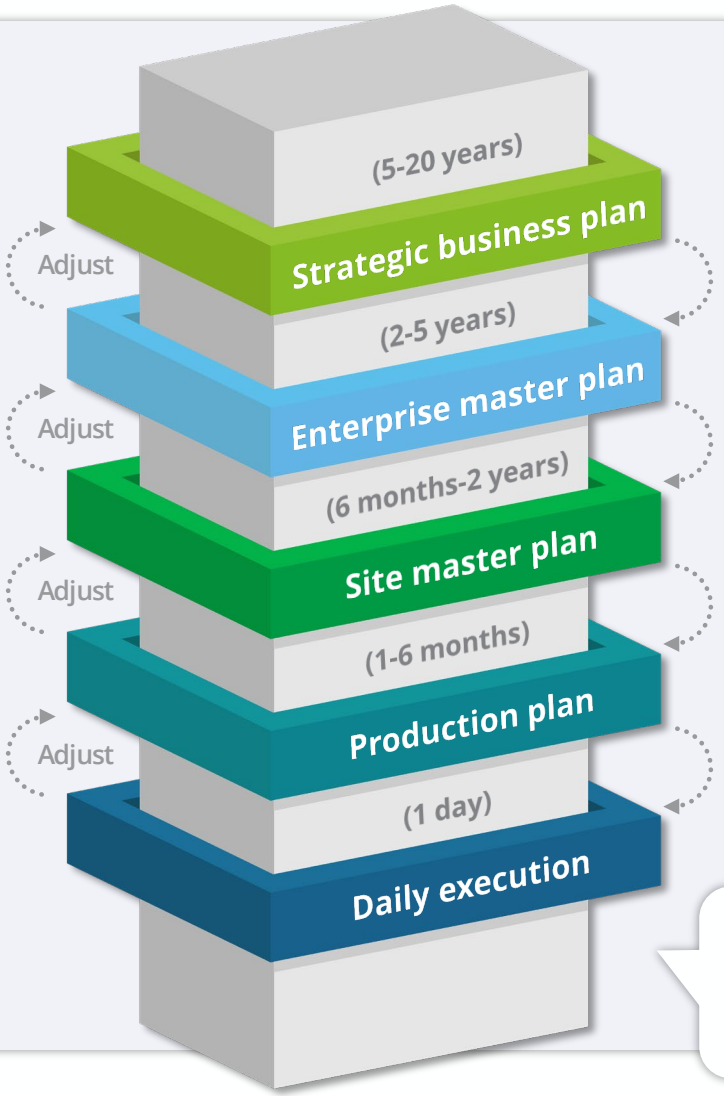
Ability to make decisions with Command Center



Optimized Decision Making

Smart MROs can optimize decisions: enterprise planning

Feed forward and back loop of data drives continuous improvements and strategic alignment



Execution feedback loop
Data from daily execution drives continuous improvement

Strategic business plan: Organization's cohesive strategy guides all plans and is informed by execution feedback loop

Enterprise master plan: Regional / global capital investments and long-term resources planned based on collective facility needs

Site master plan: Mid-term facility capacity and infrastructure updates planned based on fleet forecasted utilization and daily constraints

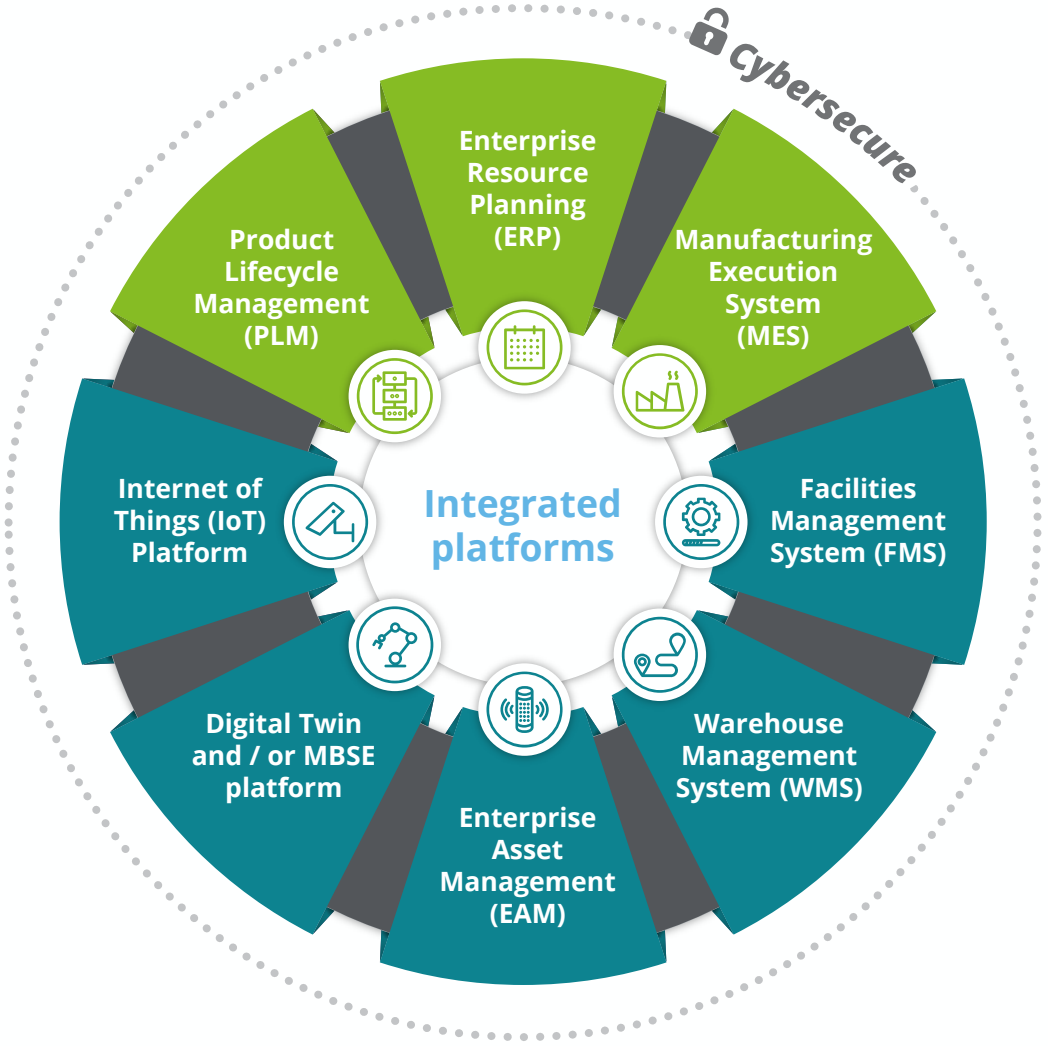
Production plan: Major asset overhaul scheduled based on forecasted demand and daily trends in material, equipment, and labor supply

Daily execution: Real-time status of depot planned and unplanned operations using asset, equipment, and labor performance data

Strategic alignment
Enterprise-wide data integration empowers depot managers in daily execution decisions to align to strategic KPIs and allows organization leaders to set realistic long-term strategies based on current capabilities and constraints

Smart MROs need cybersecure and integrated enterprise solutions

Enterprise solutions manage data variation and information siloes, allowing integrated data flow to facilitate timely, informed decisions



- Integrated enterprise solutions provide a **digital thread** that is a single source of truth for all maintenance activities across the organization
- Data collected and stored across these platforms is leveraged as the backbone for **advanced technologies**
- Well integrated enterprise solutions with accessible data and analytics enable organizations to have **optimized operations and processes**
- An **enabled workforce** allows organizations to use enterprise solutions successfully to their full potential
- **Cybersecurity** is critical to maintain the reliability and availability of enterprise systems, supporting a secure and resilient smart MRO environment

Foundational solutions *Enhancing solutions*

04

Deloitte’s approach; why us?

Deloitte's approach – leveraging our methodology and tools

Our approach to implementation can meet MRO organizations where they are on the maturity curve

Activities

Assessment

Understand current state process

- Identify gaps or pain points through a series of activities
- Conduct onsite plant visits to view the end-to-end repair process, understand the value stream map and material flow, and identify challenges
- Hold interviews across different functions
- Perform a tech assessment to understand existing systems, data flows, and tech gaps to highlight areas for enhancement
- Analyze repair data to understand current metrics and establish a baseline for the future

Strategy & governance

Define overarching organizational strategy for transformation

- Identify present and future organizational needs
- Support leadership development, and buy-in, clear goals, and metrics tied to business results
- Foster solution sponsorship from leadership to shop floor personnel, and gain cross-enterprise acceptance
- Adopt a holistic strategy for integration and solutioning; avoid a fragmented or "random acts of digital" approach

Roadmap

Create a detailed roadmap with actionable initiatives

- Develop a transformation roadmap to serve as the guidepost for the journey
- Review, consult, and update consistently for alignment to the overall strategy
- Outline phased implementation steps, timelines, and key milestones
- Allocate necessary resources such as budget, personnel, and technology to support the steps of the roadmap

Pilots

Select transformation initiatives from the roadmap

- Prioritize and plan select pilots that align to the roadmap and vision
- Validate, refine, and improve solutioning before beginning full-scale implementation
- Design with future scaling and sustainment plan in mind; plan a production-ready solution

Scale & sustain

Turn pilots into production-ready scaling and sustainment plans

- Execute the crawl-walk-run phased-approach across the organization, starting with small, manageable steps and gradually increasing scope
- Monitor and adjust carefully at each stage
- Determine ways to scale systematically, once successful
- Implement practices to sustain the transformation, including ongoing training, tech enhancements, and regular reviews to assess delivery value

…with the help of our showcase accelerator, the SMRF

Deloitte’s approach – the Smart Maintenance & Repair Facility (SMRF)

We are committed to supporting clients in their Smart MRO journey and invested in a new facility to help them discover what’s possible

Industry 4.0 brought to MRO

Deloitte’s Smart Maintenance and Repair Facility is located at The Smart Factory by Deloitte @ Wichita. The facility **showcases the application of Industry 4.0 technologies** in a Maintenance, Repair, and Overhaul (MRO) environment.

Tailored MRO experience

The Smart Maintenance and Repair Facility provides an **immersive, hands-on experience** that will demonstrate the advantages of a tailored MRO solution. Your organization will **gain valuable insights into the latest MRO trends and technologies**, while Deloitte's experts identify opportunities to optimize your MRO operations, leading to **increased productivity, performance, and cost savings**.

Interested? Contact us

To **learn more**, scan the QR code or contact Deloitte’s Smart Maintenance leaders at **smartmaintenanceandrepair@deloitte.com**

Deloitte's approach – Why us?

We have the subject matter experience and holistic delivery approach to take your organization into the future of Smart MRO

Our experience

Our experience in MRO end-to-end processes

- Deloitte has SMAs with over 30 years of experience supporting transformations within MRO environments.
- Our experience spans different asset types (aircraft, ships, automative), industries (commercial, Department of Defense), and levels of repair complexity.
- Our SMAs know your processes and operations and bring mature knowledge across a wide range of transformation projects to support your specific Smart MRO journey.

Our skilled workforce in key related areas

Outside of MRO knowledge and improvements, there are parallel functions required to become a Smart MRO facility. Our skilled workforce excels in these areas:

- Cybersecurity and considerations
- Network infrastructure and capability
- Data science, flow, and mapping
- Lean Six Sigma and processes improvement
- Transformation and change management

Our delivery

Demonstrated emerging tech in our MRO environment

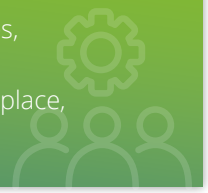
- We built a Smart MRO Facility (SMRF) with co-located collaborators and know what it takes to maintain the future.
- We focus on innovating and engineering solutions with countless successful client engagements across industries.
- Deloitte's specialists in digital thread, dynamic scheduling, predictive analytics, and machine-conditioned monitoring facilitate MRO success, scalability, and long-term results.

We build an approach and solution that works for you

- Our teams align technology with requirements, facilitating an agnostic approach while considering current system investments.
- With a wide spectrum of technology and maturity levels with associated costs, we cater to your specific stage in the process. Just as your pressing issues are unique, so are our solutions.
- Our specialists have extensive experience in delivering mature and cost-effective solutions.
- We provide tailored solutions within each engagement, understanding and addressing your unique pain points.

We bring the right ecosystem and alliance partners for holistic solutions

- It takes an ecosystem to create and deliver innovative solutions custom-designed for you. Deloitte's alliance ecosystem includes more than 60 of the world's leading companies, collaborating and investing to bring you innovative, scalable, complete, and best-in-class solutions.
- It is crucial to develop clear leadership, well-defined processes, and robust policies to facilitate successful scaling. Our approach enables these foundational elements to be in place, facilitating smooth implementation and long-term success.



Deloitte.

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Thank you.

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