

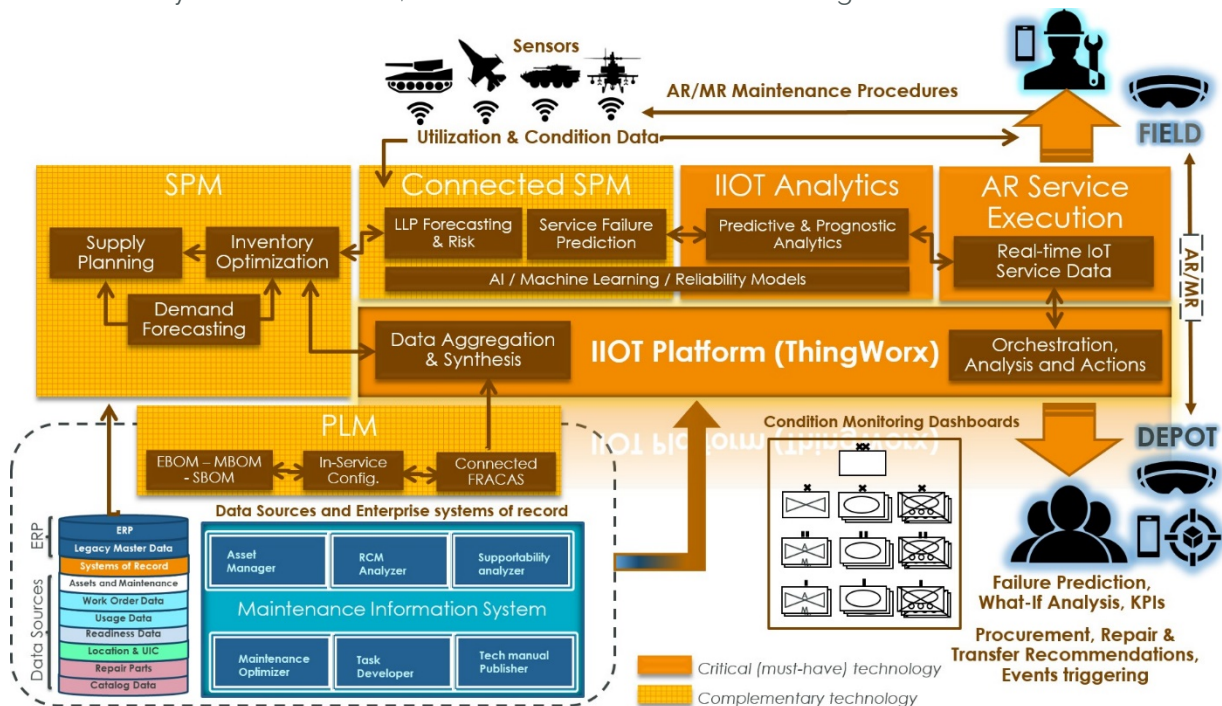
# Condition-Based, Predictive and Prognostic Maintenance (CBM+ PPMx) for Weapon System Support

PTC solution is built on an integrated suite of Commercial Off the Shelf (COTS) software tools and will address the customers desire to improve availability and fleet readiness across the operations. Through a predictive and prognostic maintenance capability the solution will reduce associated equipment down time and improve readiness

**PTC CBM+ PPMx Solution** is modular, it allows organizations to integrate a suite of technology, or to deploy technology components individually. The value of combining surpasses that of any of the tools individually by creating a **true digital thread** that delivers the desired outcomes of data availability and analytics envisioned for the outcome of the real CBM+ implementation. The solution open framework can also be deployed on premise or in secure Cloud.

PTC CBM+ PPMx solution offering is based on an **open framework technology architecture** and systems of record agnostic. The solution enables **connectedness, connectivity, data exchange and interoperability** between various systems of record, vendor-based and legacy systems, such as:

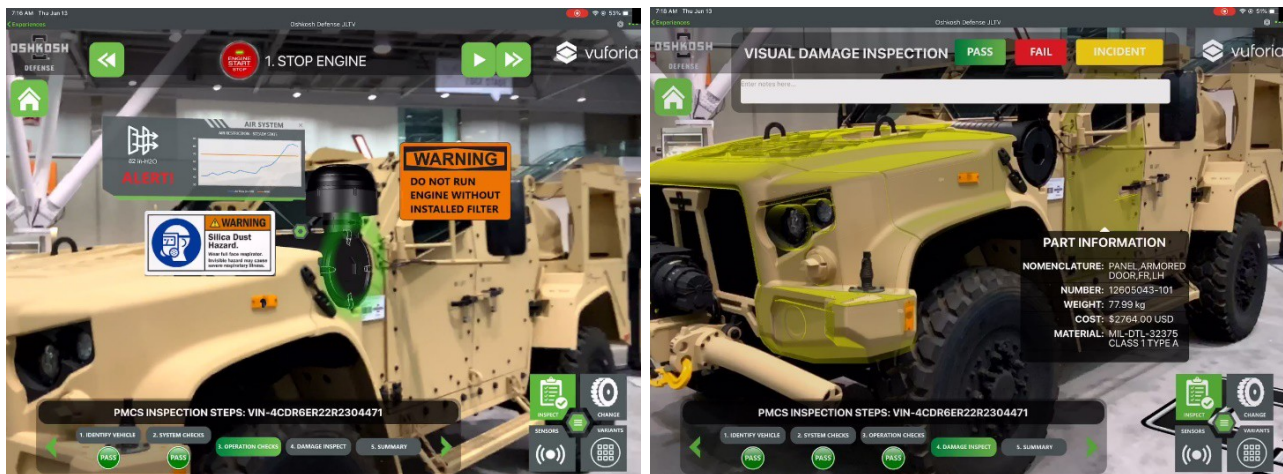
- Logistics Data Management and Analysis Systems
- Maintenance Information and Planning Systems
- Materials and Supplies Management Systems
- Reliability, Quality, FRACAS and Risk Management Systems
- Depot, Repair and Stock Management Systems
- Warehouse, Warranty and Freight Management Systems
- Procurement, Order Management, Financial and ERP Systems
- PLM Systems for E-BOM, M-BOM and In-Service BOM management



The PTC solution will not only provide a state-of-the-art predictive maintenance capability, but it will also integrate with the wider sustainment engineering ecosystem that creates a true “decision support system” that enables modelling and simulation of scenarios to plan for a certain level of readiness within varying budgetary conditions, as well as other “what if?” scenarios, such as surges in op-tempo, causal factors, changes in MTBF parameters etc. This solution will enable key members of your organization to make strategic decisions on investments for weapon systems in a way that maximizes the operational readiness of that system in a budget constrained environment.

PTC CBM+ PPMx solution offering is based on ThingWorx IIoT Platform, which enables seamless connectivity between the systems, with the PTC mission-critical solution of Service Parts Management (SPM) for Supply-chain planning, Availability-based Inventory Optimization and Demand Forecasting. ThingWorx IIoT Platform enables capability to aggregate and synthesize data from various sources – legacy and vendors- supported systems and applications. It is an open integration framework, with out-of-the-box plug-ins (connectors) and open API, which enables integration with existing maintenance and service information systems, like LM&R, PBL, RCM, Quality, and others.

PTC Augmented Reality (AR) capabilities, (Visual enhancement capabilities) connected into the CBM+ PPMx architecture will boost maintenance procedures and training with interactive Inspection procedures and AR-based work instructions:



*PTC CBM+ PPMx Solution with AR-driven inspection and service procedure*

In the core of the solution is powerful ThingWorx Analytics, AI, and ML capability, which provides unprecedented data analytics for **preventive and prognostics maintenance (PPMx)**. This capability will provide root cause analysis of unscheduled and sequential maintenance events while enabling overall improvements of maintenance scheduling.

ThingWorx IIoT Platform eliminates complex connectivity, programming, and deployment tasks for developers while delivering powerful end user solutions that drive high levels of return on investment. Using the ThingWorx Platform we will integrate data analytics and Machine Learning into daily operations with smart, connected applications, operations, and software.

PTC CBM+ PPMx solution offering will deliver the following outcomes

- Wrap and Extend existing data sources to make data available to decision makers.
- Connect historically siloed data sources, systems, and data repositories.
- Close the Gap of functional silos at all levels of the enterprise.
- Enable connected enterprise of maintenance, supply, and engineering.

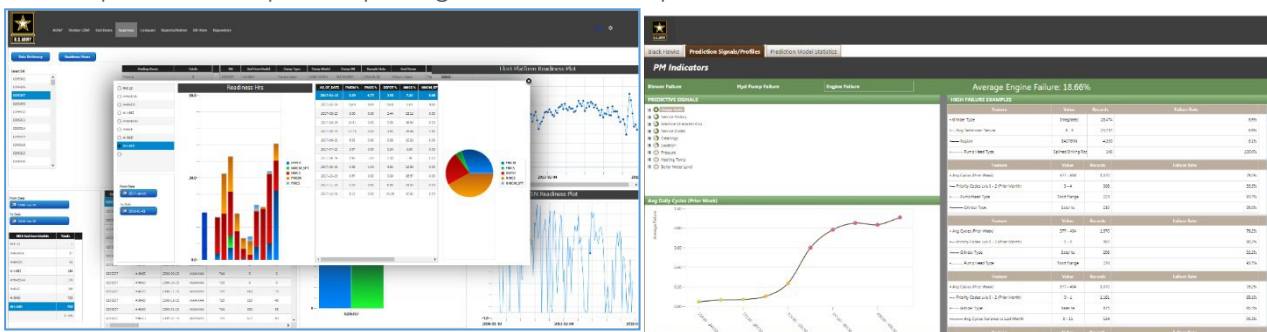


**ThingWorx Analytics** can also be used on its own to perform advanced analytics functions or in conjunction with complementary tools: ETL, custom modeling, etc.

ThingWorx Predictive Analytics capability, based on condition data from design, configuration, historical reliability, maintenance data, equipment sensors and statistical models, will provide you with the capability to get an advanced signal of poor quality, reliability, and impending failure of a part, which provides a more accurate forecast than any traditional forecasting methods for spare parts.

Features Include:

- **Descriptive Analytics** - ThingWorx Analytics provides advanced descriptive capabilities such as statistical calculation and statistical monitoring services. Statistical calculation services transform raw data and individual sensor readings into useful, meaningful data to be used for monitoring or as inputs for predictions. Raw data is often not directly useful for monitoring, and common data transformation requires additional coding for application developers. ThingWorx Analytics provides a standard library of pre-written statistical calculation services that make it easier and faster for developers to perform many common data transformations.
- **Diagnostic Analytics** - Diagnostic analytics involves finding relationships and patterns within data to figure out: why did this happen? This includes searching through large data sets for insights that might otherwise be missed. Diagnostic insights can often identify rules, patterns and scenarios that can be used for monitoring of the performance of an asset or process without requiring a predictive model. ThingWorx Analytics provides features called signals and profiles to generate diagnostic analytic insights using a variety of advanced algorithms.
- **Predictive and Prescriptive Analytics** - The ThingWorx Analytics automates or extends data science practice with predictive modeling and prescriptive analytics with no need to manually build algorithms. Predictive Analytics applies machine learning to historical or real-time data to make predictions about future outcomes. ThingWorx analytics provides this functionality by learning from data to create predictive models using supervised machine learning techniques and algorithms contained within the platform. After a model is trained, it is validated against a set of data held out from the training process to provide insight on how the model will perform when put into practice. Relevant accuracy measures for the type of goal being predicted are captured and available to enable customers to assess model performance prior to putting the model into operation.



*Illustrations: Readiness Analytics Dashboarding and Predictive Maintenance Indicators*

- ✓ Support seamless, end-to-end information flow and connectivity across Failure Analysis, Reliability and Maintainability which results in Reliability Centered Maintenance and Level of Repair Analysis
- ✓ Enable an enterprise, edge deployable approach to designing, deploying, and operating Predictive Maintenance and Prognostic and Health Management solutions
- ✓ Conduct root cause analysis and insights to continuously monitor performance against required/predicted mission and design outcomes, conduct root cause analysis, and improve performance, agility, responsiveness, and scale of supply chain, maintenance, and support operations.

The proposed CBM+ PPMx solution can help answer strategic questions and address the following use cases:

- Failure/Data Reporting and Root Cause Analysis
- Optimizing the Effectiveness of Existing Maintenance Schedules
- Assist decision making regarding the prediction of mechanical and structural failures.
- Assist decisions to replace or exchange items, and recommendations to optimize the equipment readiness and fleet readiness rate.
- Leverage statistically based predictions to improve supply availability.
- Leverage prototype solution for financial planning, forecasted Budget Planning scenarios and PBL.
- Supply Chain impacts due to changes and Budget Constrains.
- What if Scenarios of Risk-based allocation of limited inventory
- Forward looking alerts to zero balance, critical shortages, need for expedites.
- Impact of Fleet size changes, configuration changes, retrofits, movement/redeployment
- Changes in reliability characterizes of subsystems or parts.
- Order planning of new buys and repairs
- Supersessions and upgrades of equipment
- Impact of changes in service level goals

PTC customers have been gaining benefits from implementing the PTC CBM+ PPMx Solution Offer and reported the following outcomes:

- Reduced unplanned downtime by **86%**
- Predicted impending alarms with **91% accuracy.**
- Predicted likelihood of part rework with greater than **95% accuracy.**
- Reduced maintenance costs by **41%**
- Improved first time fix rates by **20%**
- Predict Common source of unplanned downtime with **90% accuracy.**
- Predicted impending failures by **89%**
- Reduced Unnecessary parts exchanges by **35%**

AR-enabled solution and visual enhancement outcomes:

- **25%** faster wiring harness install with AR-driven assembly procedure.
- **47%** faster training instruction comprehension.
- **34%** faster wiring a turbine control box.
- **20-30%** Increase in training rates.



#### Resources:

- PTC's Federal, Aerospace and Defense: <https://www.ptc.com/en/industries/aerospace-and-defense>
- PTC's Internet of Things (IoT) Technology: <https://www.ptc.com/en/products/iot>
- Unlocking the Potential of Industrie 4.0: <https://www.ptc.com/en/industries/manufacturing/industry-4-0>