CONDITION BASED MAINTENANCE (CBM) IN DOD: ARE WE THERE YET?

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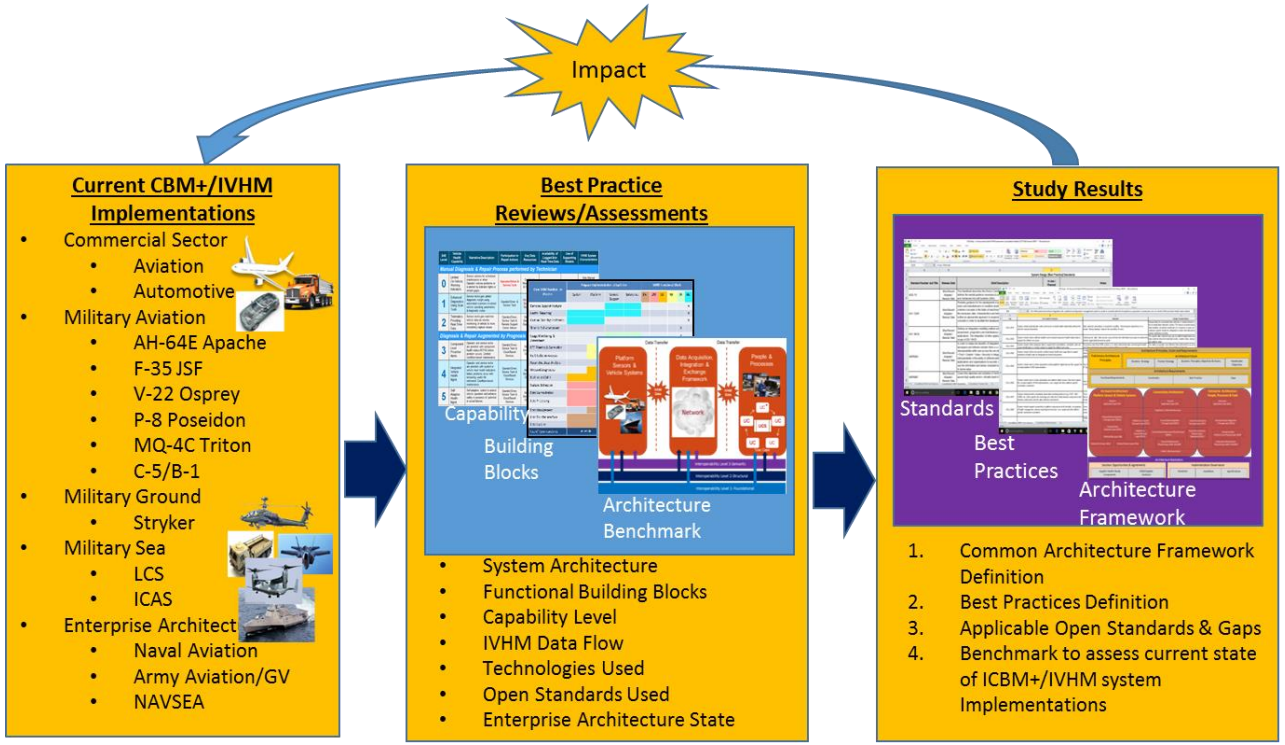
DoD Case Study Overview



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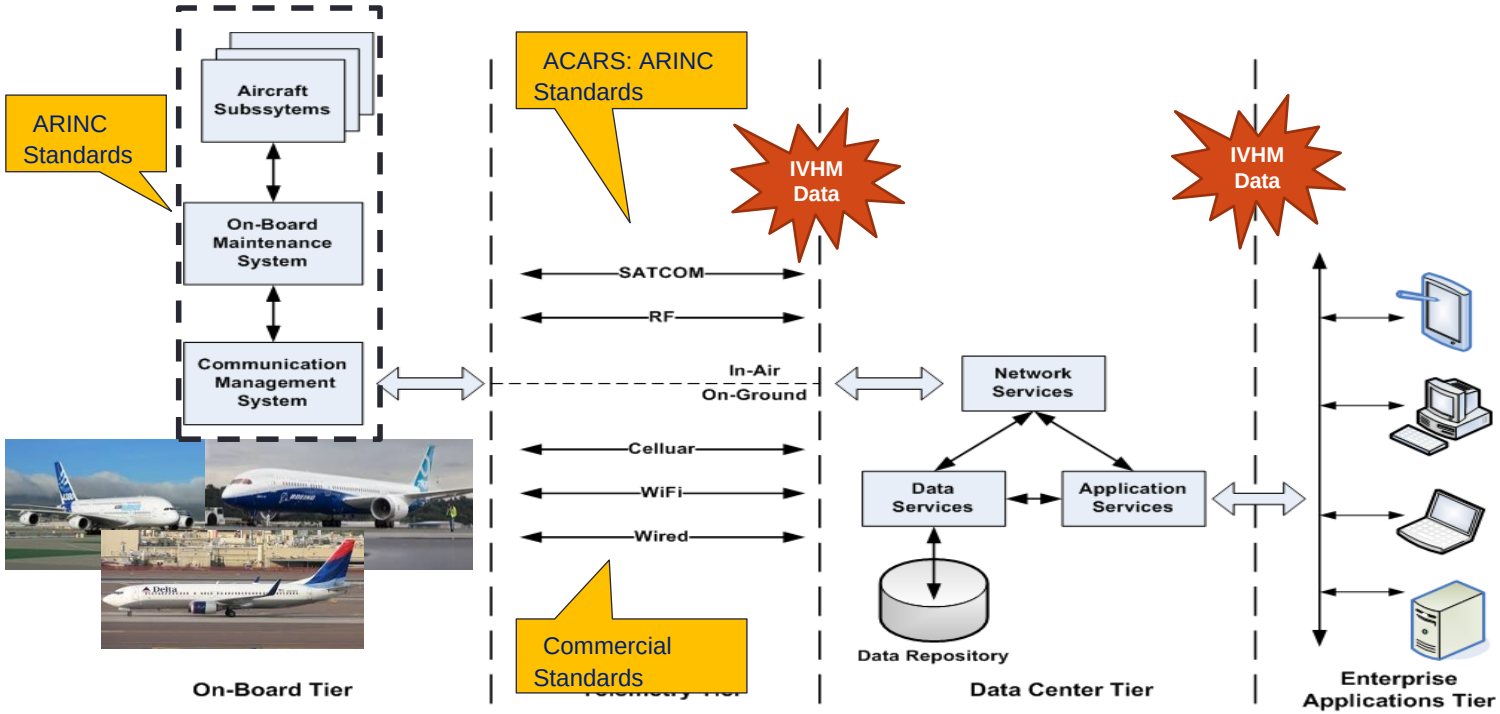
Best Practice in Commercial Aviation



- ✓ Standards-based centralized systems gather health and status data from several subsystems and perform fault consolidation and root-cause analysis, directing the mechanic to the offending subsystem that requires repair or replacement.
- ✓ Data collected; BIT, FOQA, aircraft performance, (e.g., hard landings, engine, performance, tail strikes, etc.).
- ✓ Some OEMs offer health monitoring/advisory services for their equipment as part of their product support package.

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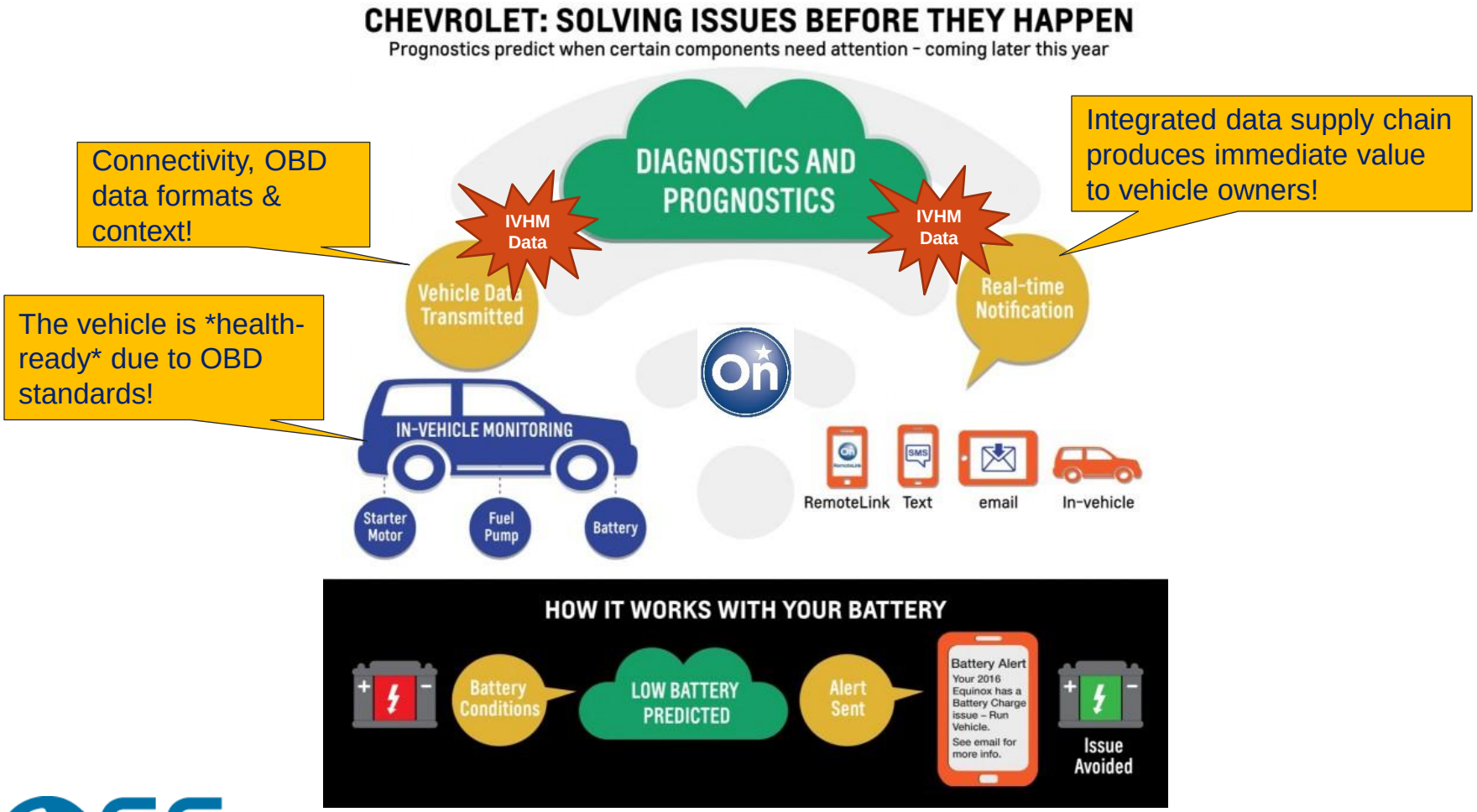
Best Practice in the Automotive Industry



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SAE IVHM Capability Levels (JA6268)

SURFACE VEHICLE AND AEROSPACE RECOMMENDED PRACTICE

JA6268: DESIGN & RUN-TIME INFORMATION EXCHANGE FOR HEALTH-READY COMPONENTS

- **"Health-ready components"** are supplier-provided components or subsystems which have been augmented to monitor and report their own health or, alternatively, those where the supplier provides the integrator sufficient information to accurately assess the component's health via a higher-level system already on the vehicle.

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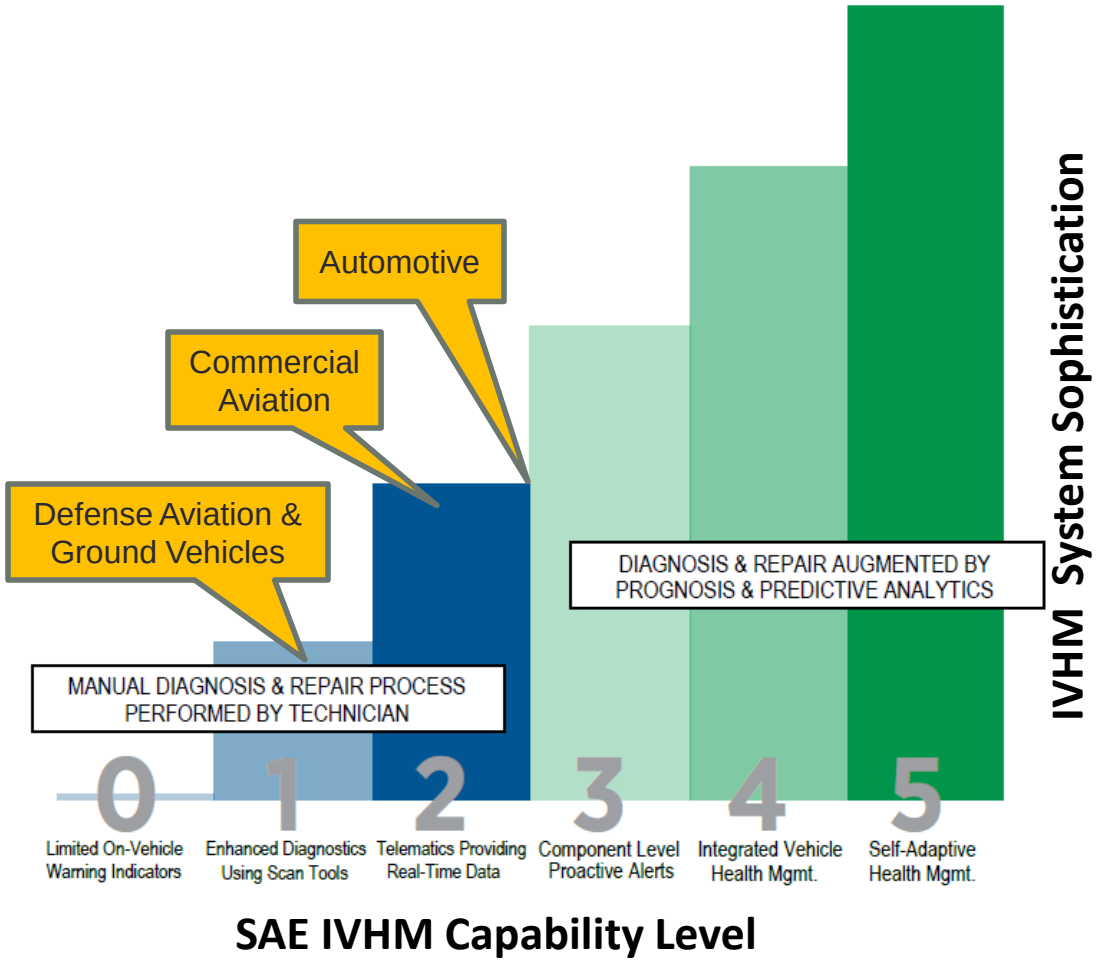
Where we are today…



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SAE JA6268 Health-Ready Levels

(Tailored for manufacturing assets)

Level 0: Limited On-Asset Warning Indicators : Asset maintenance actions are prompted by either scheduled maintenance intervals or when the asset operator is alerted by indicator lights, simple gauges or observes a performance issue.

Level 1: Enhanced Diagnostics using Portable Maintenance Aids: Asset is equipped with on-asset diagnostic software. Maintenance technician gains added diagnostic insight using portable maintenance aids or scan tools to extract operating parameters and/or diagnostic codes that were calculated and retained specifically to enhance the diagnostic process.

Level 2: Remote Health Monitoring : Asset is equipped with data link to transmit diagnostic health indicators and operating parameters to maintenance technicians or to a central support center. Maintenance technician gains added diagnostic insight (in advance) without having to physically be there. In addition, the data can be used to monitor real-time performance or to capture performance history over time for subsequent analysis.

Level 3: Component Level Proactive Alerts : Asset operator and maintenance technician are provided with component Proactive Alert Identifiers (PAI) as alerts of impending problems, possibly listing severity (Red/Yellow/Green), along with estimated component Performance Life Remaining (PLR) or Remaining Useful Life (RUL) and recommended remediation actions.

Level 4: Asset Level Health Management: Operator and maintenance technician are provided with cross-system or asset-level health indictors before problems occur, along with estimated critical function Performance Life Remaining (PLR) or Remaining Useful Life (RUL) and recommended remediation actions.

Level 5: Self-adaptive Health Management: Health Management capability is integrated with asset control functions to provide autonomous**,** real-time, self-adaptive control and optimization to extend asset operation and enhance production lot completion and/or safety, in the presence of component or system degradation.

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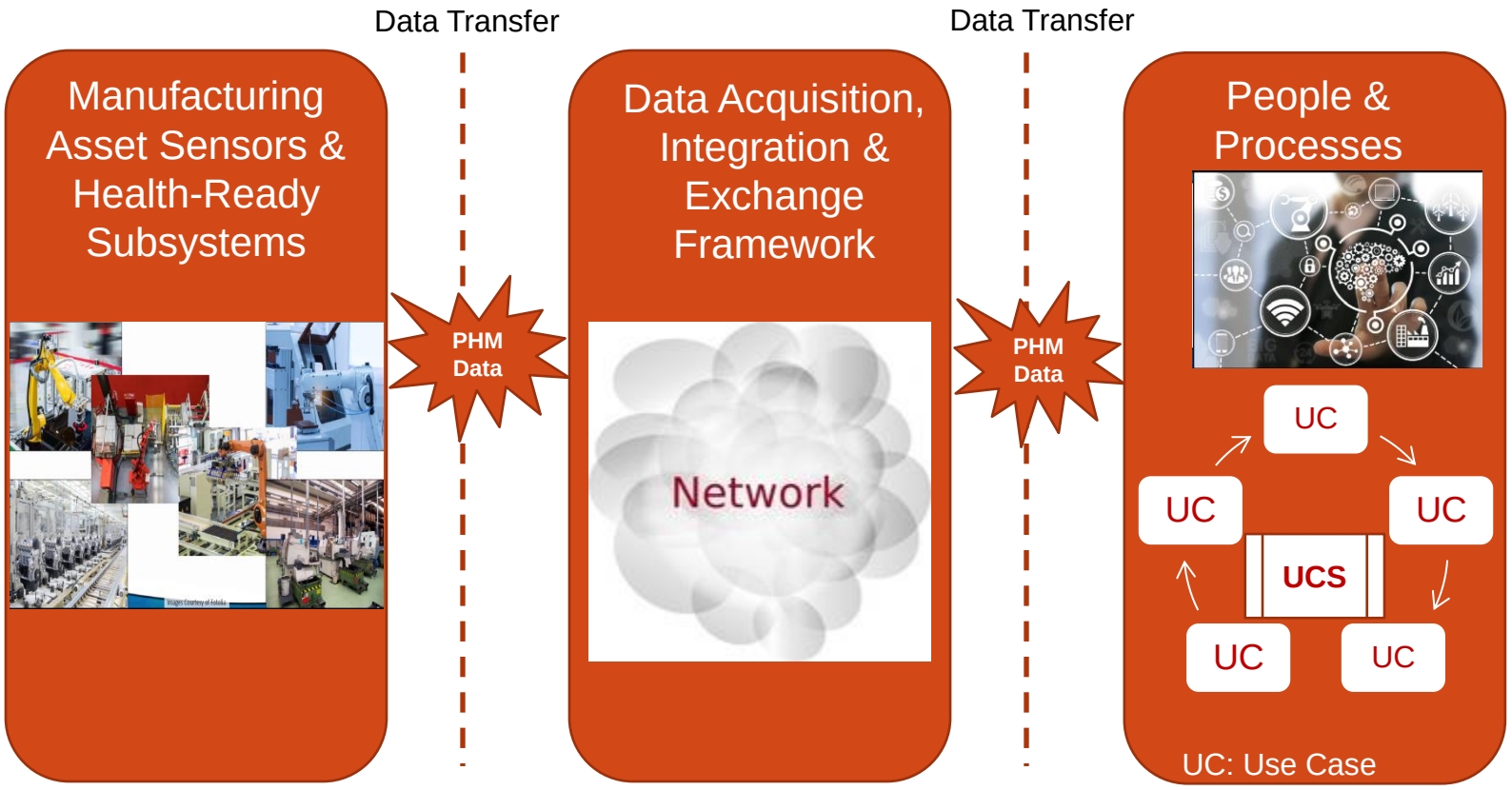
Manufacturing System View



- **Note**: the system architecture encompasses the asset health monitoring/PHM function inherent within the health-ready subsystems; the asset context functions ; the data acquisition, integration , connectivity and exchange framework; and the tools and processes used to manage and restore the asset's health.

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Common Challenges/Opportunities

- Data Ownership:
  - Equipment OEM dependence & data ownership issues.
  - Maintenance and Logistics organizations limit access to their data.
  - “Perceived value” and “classification” of raw asset data and maintenance information limit rapid dissemination across the enterprise.

- Connectivity:
  - Non-integrated data supply chain.
  - At/off-platform test and maintenance information is still captured into paper records or within isolated databases.
  - Maintenance and logistics information systems may limit the ability of users to extract relevant data in a form that can be communicated to other such system.
- Data Quality:
  - Inconsistent/non-continuous data collection
  - Dissimilar preservation of data source context (Values, Meta Data)
  - The data collected across operations and maintenance activities is in numerous non-standard formats.

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What we have learned to date…

- **Delivering on the promise** of Condition/Predictive Based Maintenance requires a systematic maturity model of Capability Levels (SAE JA6268)…there is no silver bullet!
- **Use of Standards** (OMS, OBD) has enabled advances in PHM capability in the commercial aviation/automotive industries.
- **"Health-Ready Assets"** and use of **Standards** are the Key to unlocking the potential of PHM in any domain.
- **PHM system implementations** should be based on specific stakeholder operational use cases; asset maintenance, manufacturing operations planning, etc.
- **Investments in IT infrastructure/analytics/AI tools** without having a consistent collection, transformation, exchange and quality of asset data deliver limited value to stakeholders.
- **Collection of the "right data"** and derivation of the right asset health indicators are essential to supporting reliable analytics.
- **Without completed fields**, **properly modeled or validated data**, reliable and efficient analysis is not possible.

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Discussion

Condition Based Maintenance (CBM) in DoD: Are we there yet?

Not yet!

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