Condition-Based Maintenance (CBM)
Model-aware methods for effective system management solutions

The reliability of fielded infrastructure systems is increasingly becoming a major concern as they age and operational budgets to maintain them get stretched. PARC’s CBM technology suite empowers engineers, operators, and maintenance personnel to improve the reliability and maintainability of critical systems. It can enable the transition from conventional schedule-driven inspections to effective CBM using fundamental model-aware algorithms that yield insights about system health, safety, and performance. It can offer significant operational benefits from increased uptime and savings in resources invested for unnecessary periodic inspections without compromising safety or customer satisfaction. Over time, this can enable the aggregation of actionable insights for improved productivity and planning. Building on a strong foundation of model-aware methods that facilitate potent first-principle representations of systems, PARC’s technologies can eventually help realize the bigger vision of self-aware, self-adapting systems.

Illustration of PARC’s CBM suite enabling enhanced system life-cycle management

The Challenge: Traditional Maintenance
Schedule-driven maintenance practices can result in an undue number of expensive and unnecessary inspections early in system life while being insufficient as systems age and deteriorate. There is a strong need to transition to condition-based maintenance (CBM) that can allow adaptive maintenance planning and safely maximize system operational life and performance. Traditional data-driven approaches for CBM have been limited in accuracy, need massive training data sets, and often result in too many false alarms. Thus, they are usually insufficient to reliably make this transition.

The Solution: PARC’s CBM Suite
We augment data-driven methods with powerful model-aware techniques that enable a deeper system understanding. These require much smaller training data sets and can offer high-accuracy diagnostic sensitivity (90% and higher) for soft faults and detect them early before they escalate into hard failures that cause system downtime or accidents. Prognostics then estimate remaining useful life or time to failure for informed maintenance/operations. This can allow operators to reliably transition to CBM while also yielding valuable insights for longer-term planning.

The Business of Breakthroughs®
CBM Technology Enablers
PARC’s unique combination of world-class, cross-disciplinary skills and cutting-edge IP portfolio is central to our CBM solution. It uses these key enablers:

- **Sensing**: Integrating PARC’s low-cost, compact, high-res, and robust sensing solutions yields accurate system data.
- **Modeling**: Customized first-principles models that can simulate failures are then built for the system.
- **Fault detection**: Deviations and anomalies from expected system behavior are reliably monitored.
- **Diagnostics**: Efficient reasoning engines then isolate and infer root cause of faults within a sub-system.
- **Prognostics**: Remaining useful system life is then probabilistically predicted using the system model and data.
- **Action recommendations**: Finally, decision-theoretic algorithms offer smart recommendations for planning.

Benefits
Our solution not only helps to identify issues in real-time as they happen, but also provides predictive insights about what will happen in the future. This can yield several enterprise-level benefits:

- **Smoothen operations**: by significantly reducing operations labor with reduced number of manual system inspections.
- **Increase uptime**: by avoiding unneeded checks and detecting faults early before they become hard failures.
- **Maximize system life**: by running the system to its true capacity from real-time accurate condition estimation.
- **Enable safer usage**: by detecting soft faults early, thus avoiding catastrophic failure events.
- **Facilitate scheduling maintenance**: by anticipating failures well in advance, operations are adequately prepared.
- **Improve longer-term planning**: by boosting the learned system behavior with recommender algorithms.

Proven in Many Sectors
Typically after an initial customization program, our technologies are matured for testing in real-world environments, and eventually adapted for commercialization by our clients. PARC researchers have completed successful CBM projects and transitioned prototypes to industry for various manufacturing, transportation, energy, defense, and aerospace systems.

Engage
Companies interested in this technology should contact PARC to discuss customization, our pilot partner program or other opportunities for collaboration and/or licensing.
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