SmartSignal
Predict the unpredictable

# Proactive Use of Vehicle Data in Multi-Modal Commercial Operations

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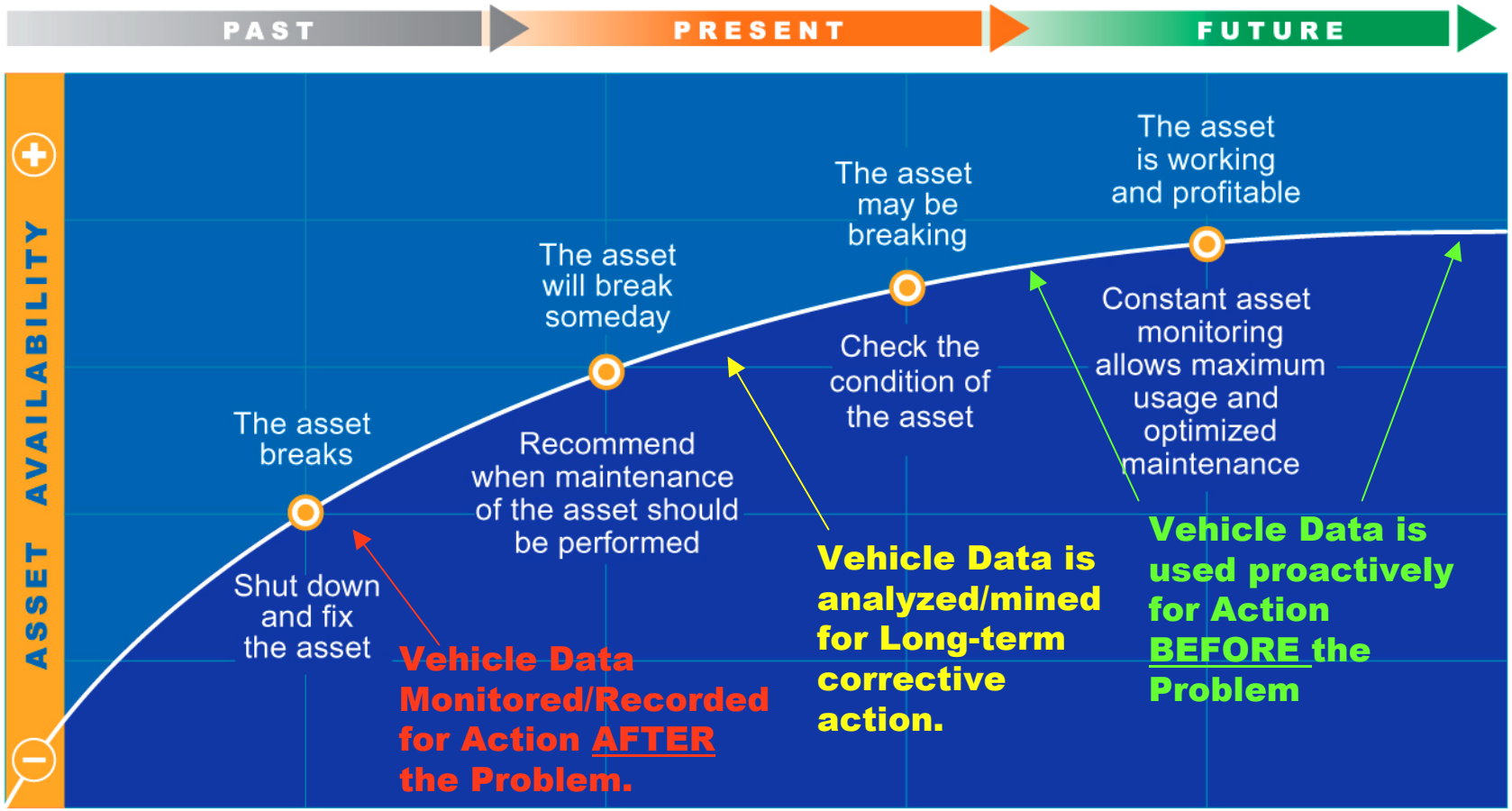
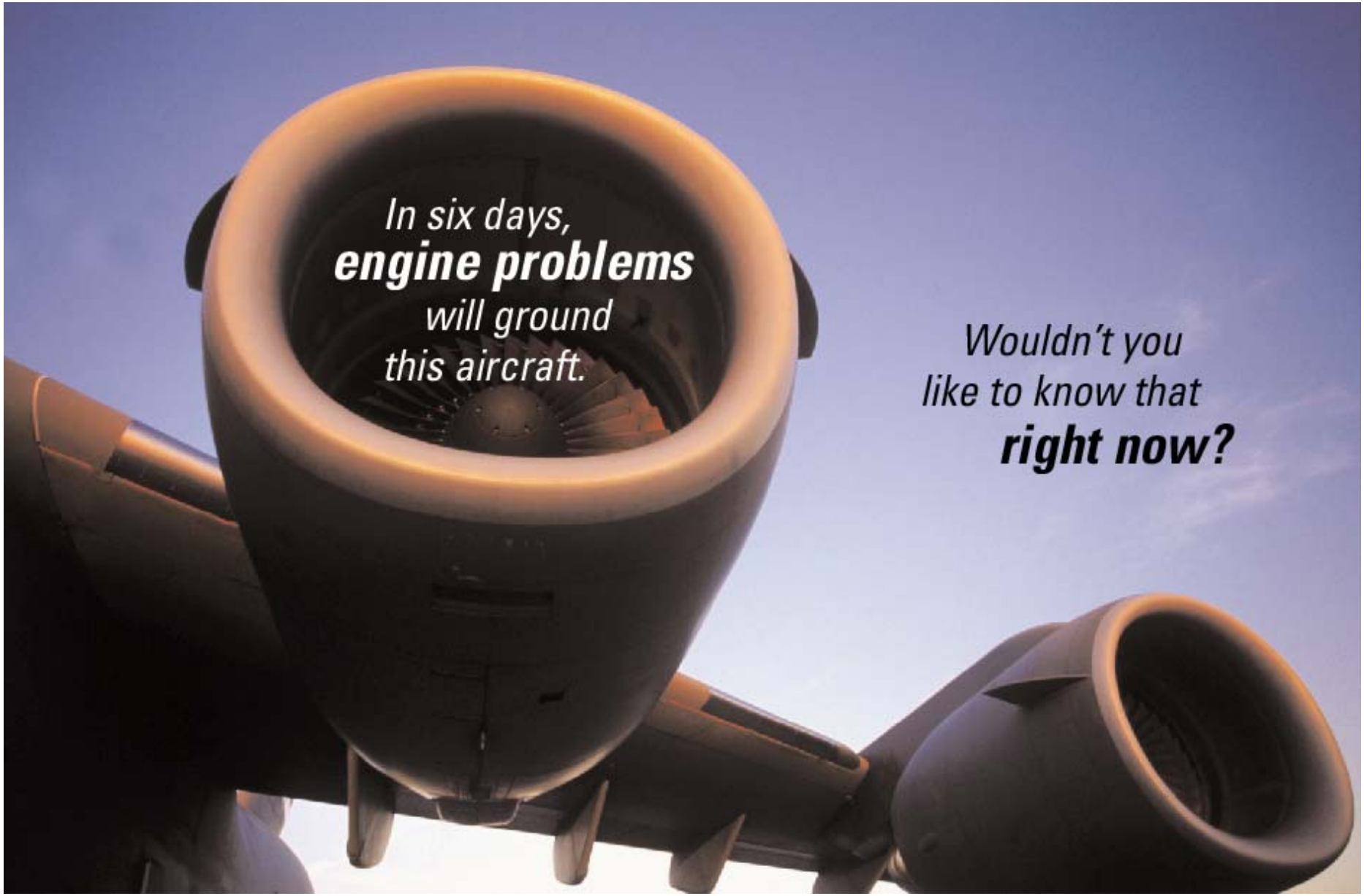
# Paradigm Change: Proactive Use of Vehicle Recorders

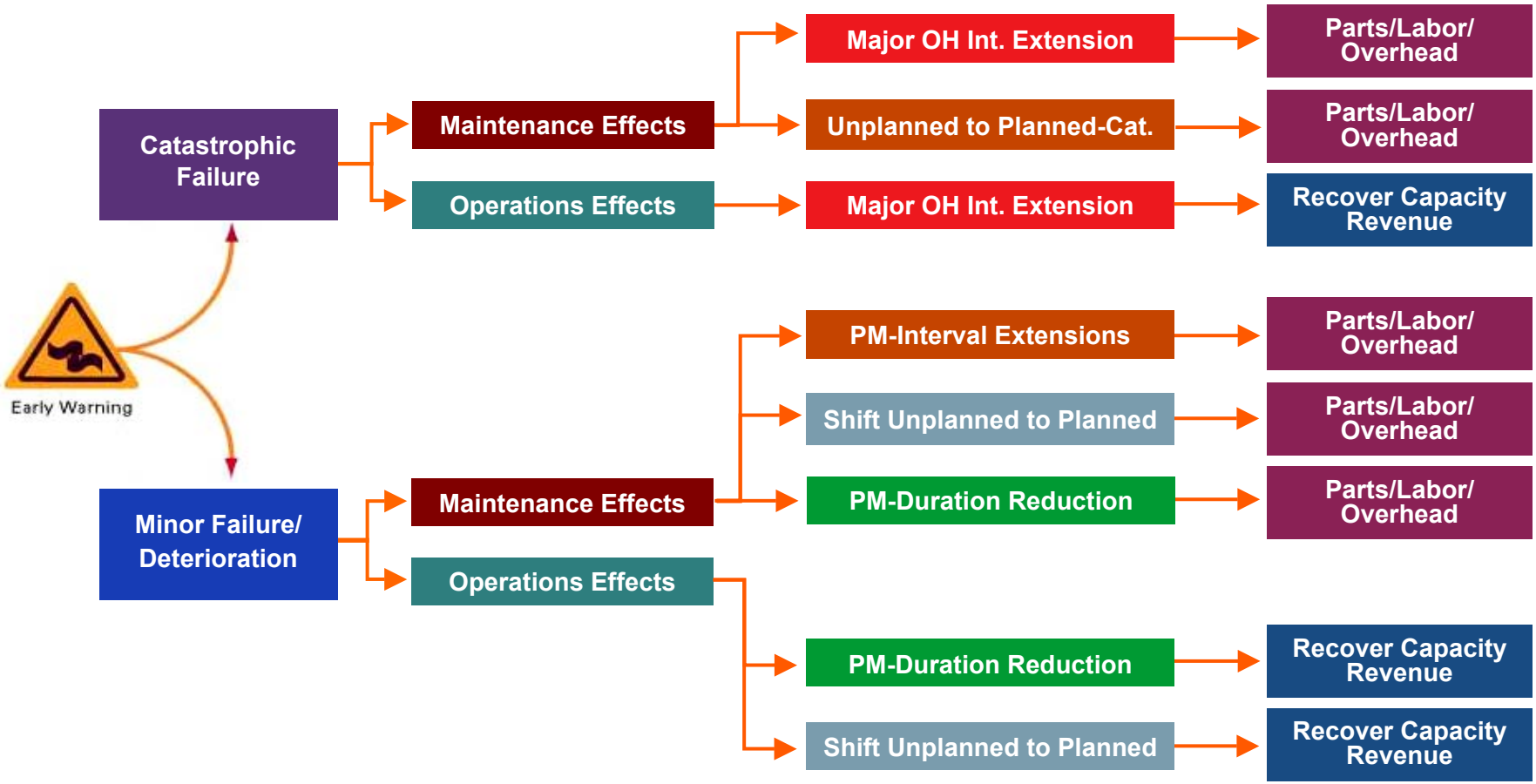


SmartSignal

*Predict the unpredictable*



# Early Warning Value Hierarchy



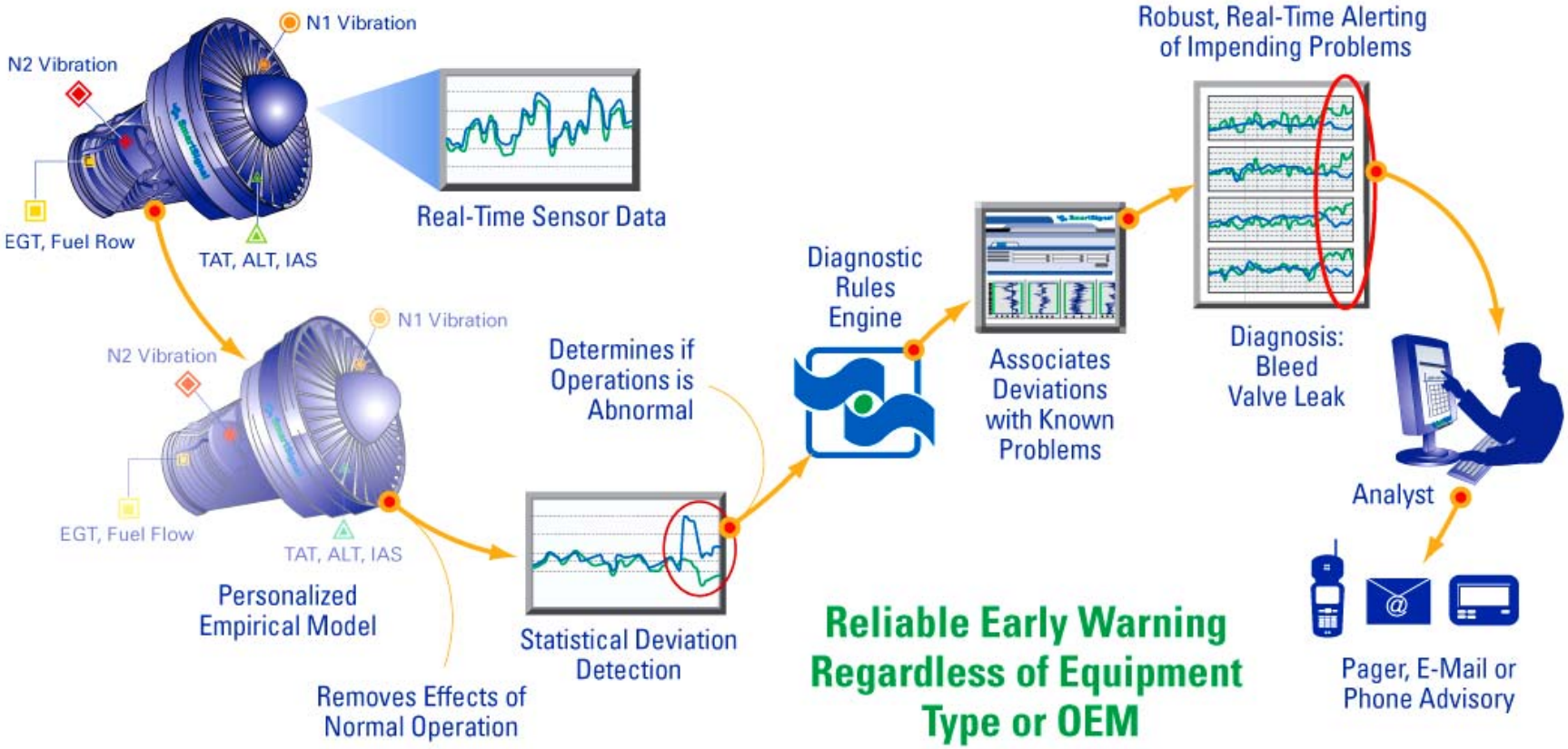
# Leading the Predictive Maintenance Revolution Across Industries:

- **Aviation**
  - Aircraft engine monitoring and prediction
  - Total aircraft health management (airframes, APU's…)

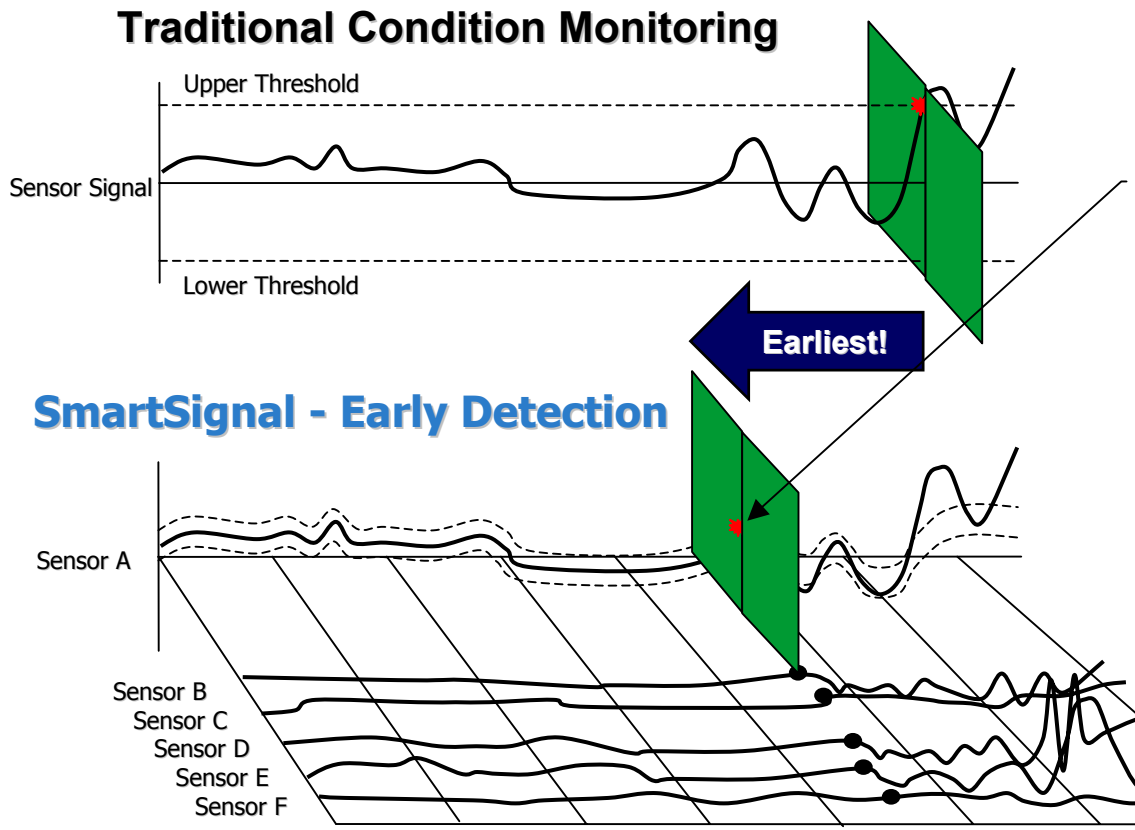
- **Commercial Transportation**
  - Locomotive monitoring and High-Reliability Maintenance
  - Off-road equipment monitoring and prediction
  - Transportation fleet management and monitoring

- **Energy**
  - Remote monitoring and diagnostic center predictive monitoring
  - Pipeline meter monitoring
  - Generation equipment and BOP monitoring and prediction

# How SmartSignal eCM Works

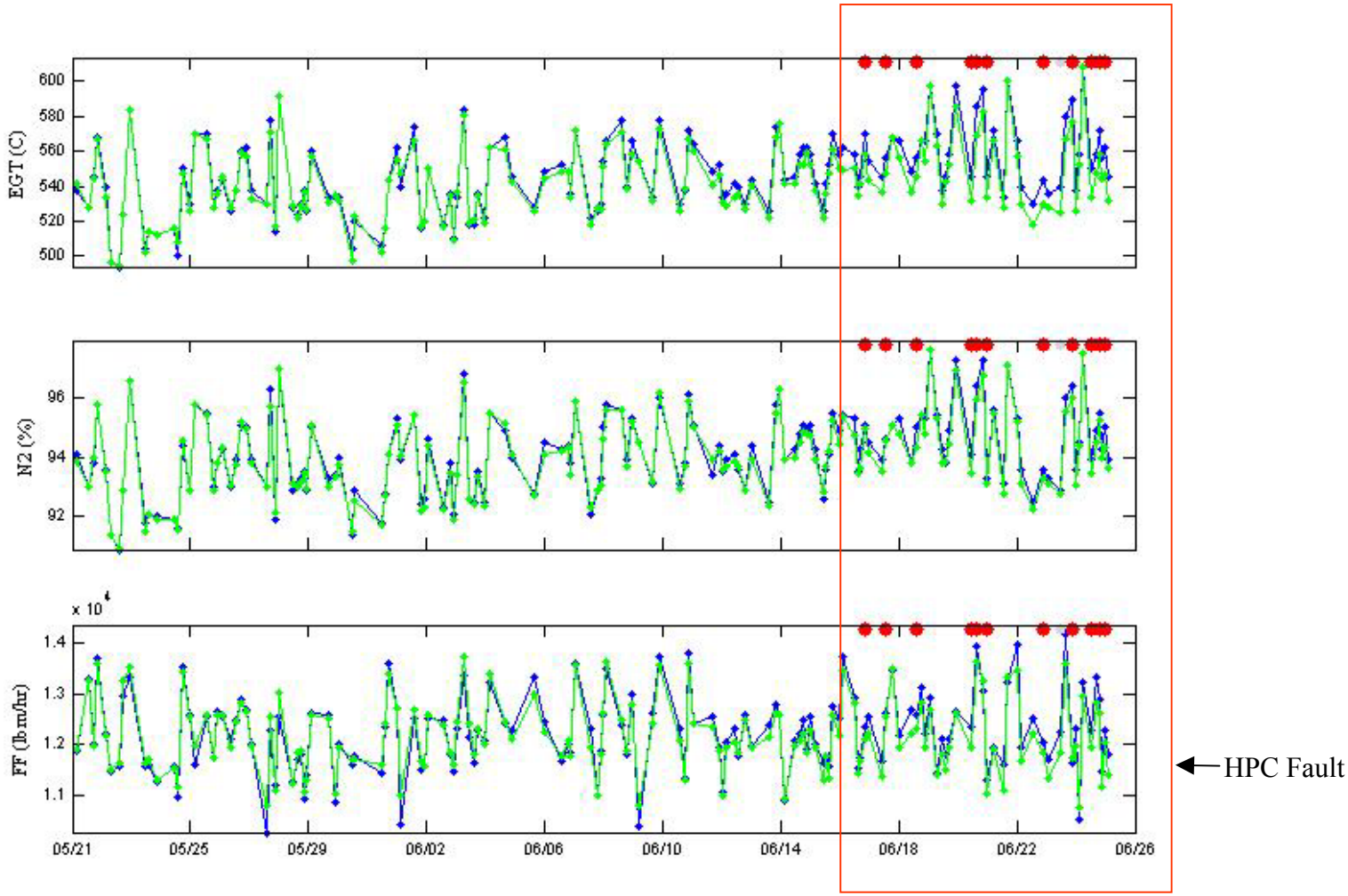


# How SSC Provides Early Warning




- In real-time, eCM generates a *dynamic band* around <u>each</u> signal, using an empirical model to generate an estimate for each sensor based on the value of all other sensors.
- Signal excursions outside of this dynamic band provide the earliest possible warning of trouble – well within the normal operating ranges for each signal.

# Aircraft Engine - TakeOff Data
## Sensor and Estimate Data

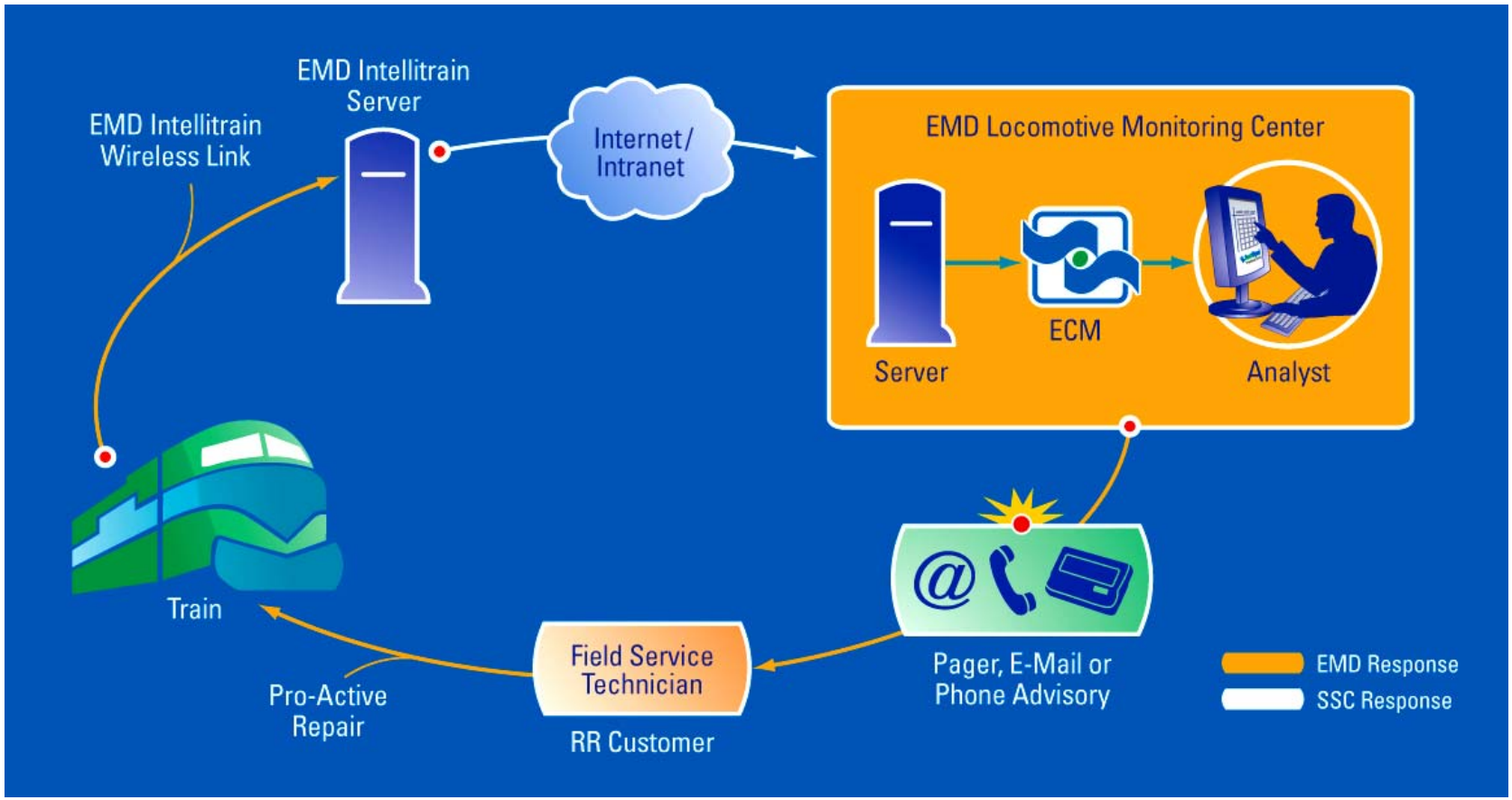


# General Motors EMD Locomotive Group

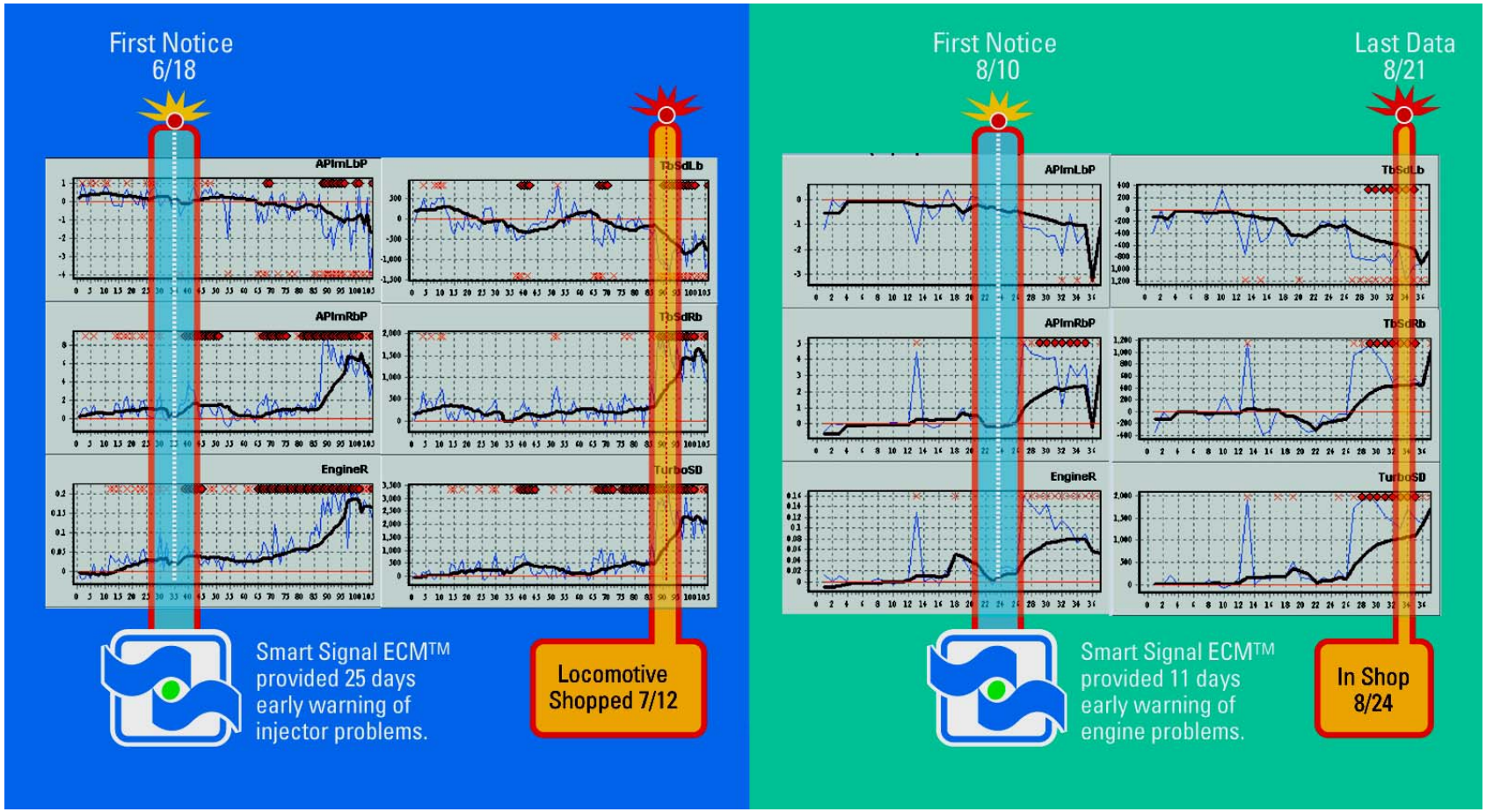
# General Motors EMD Locomotives

- **Business Goals:**
  - Desire for competitive differentiation
  - Increasing customer requirements
  - Current long-term maintenance agreements with railroads
- **SmartSignal solution:**
  - Enhance Intellitrain service offering with predictive condition monitoring
  - Provide key equipment insight necessary for High Reliability Maintenance as a product differentiation
  - Link locomotive performance data back to product design, lifecycle management process
- **Results:**
  - EMD utilizing competitive positioning in rail marketplace due to High Reliability Maintenance
  - EMD also positioning/selling Intellitrain as stand-alone service

# IntelliTrain ECM Infrastructure

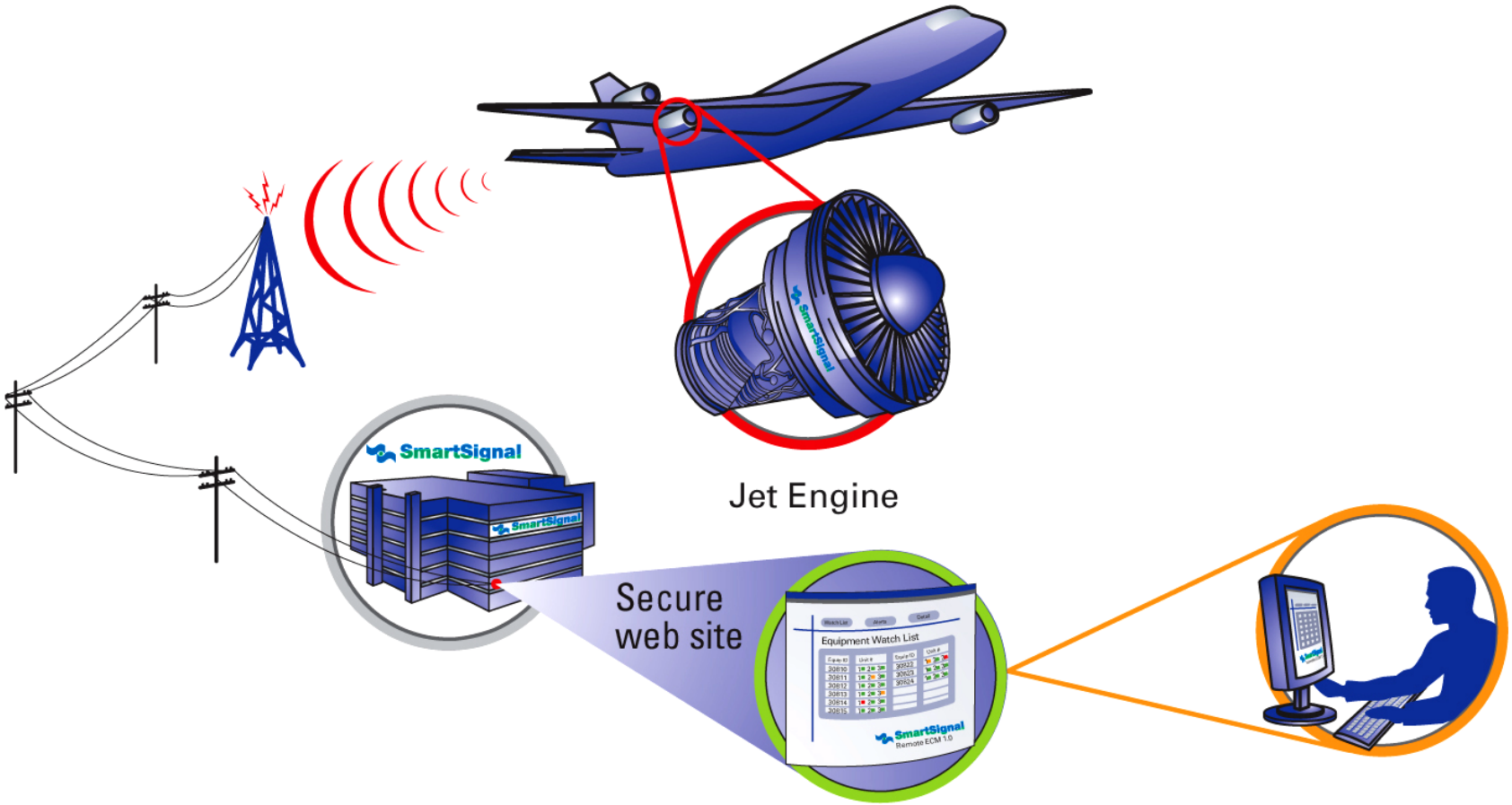


# How Early is “Early Warning”?



# Delta Airlines

# From Aircraft to Analyst



# Delta Airlines

Business Goals:

- Replace existing legacy monitoring system and expand real-time monitoring:
  - All OEM engine types
  - Total aircraft, not just engines
- Significantly reduce unplanned maintenance and move to scheduled/optimal maintenance
- Provide improved management of ETOPS and de-rated takeoff requirements.
- Support maintenance “in-sourcing” opportunities with leading-edge technology.
- Improve customer service and reliability by reducing in-flight shutdowns, air turn-backs, cancellations, and major delays.

# Delta Airlines

- Insight by SmartSignal as a key component of total MRO solution
  - Superior advanced warning of deteriorating engine conditions
  - Superior warning of significant events which fell within OEM-prescribed tolerance limits
  - Proven significant value
  - Link to configuration management, supply chain systems for additional system-wide cost reductions

- Fleet wide rollout Q1 2003; expansion to total aircraft health management

# Caterpillar Mining Trucks

# Caterpillar Mining Truck Monitoring

## Business Goals:

- Improve dealer/end user satisfaction through improved monitoring and maintenance practices
- Provide product differentiation versus competitors
- Improve performance on long-term service agreements

## The Solution:

- Leverage SmartSignal to provide advanced warning on pending equipment issues
- Provide comprehensive monitoring service through dealers to mine operators

## The Results:

- Application as part of Maintenance and Repair contracts for global mining customers