NSF Industry/University Cooperative Center (I/UCRC) on Intelligent Maintenance Systems (IMS)

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The IMS Consortium

UNIVERSITY OF CINCINNATI

TOSHIBA

MISSOURI S&T

Honeywell

Chevron

BorgWarner

Boeing

Motorola

National Instruments

CATERPILLAR

EDAPAIVE COMPTING, INC.

IC
develop Center for Environmental, Safety and Health Technology Development

21CSI

21ST CENTURY SYSTEMS, INC.

FESTO

KISTLER

GM

AVETEC

Daimler Chrysler

FORCAMO

OMRON

TechSolve

Syncrude

P&G

PMC

BOSCH

Intellogistics

BOSCH 100 Years in USA 2006

FESTO

CONSULTORIA E FORMACAO

NSF

中心主任 Systems Maintenance Intelligent

AMD

Smarter Choice

CISCO

SEMATECH

TOYOTA

Parker

GE Aircraft Engines

UNIVERSITY OF MICHIGAN

1817
New IMS Members in 2009/2010

- ALSTOM
- Ingersoll Rand
- HRL Laboratories
- ARL
- Delta
- Forcam
“Intelligent prognostics consists of continuously tracking health degradation and extrapolating temporal behavior of health indicators to predict risks of unacceptable behavior over time as well as pinpointing exactly which components of a machine are likely to fail.”

IMS Vision and Mission

Vision:

Mission:

“To enable products and systems to achieve and sustain near-zero breakdown performance, and ultimately transform maintenance data to useful information for improved productivity and asset utilization.”
Five-Level Productivity Model

Level 1: 5S and Kaizen Model (Hands-on Level)

Level 2: Lean Manufacturing Systems and Six-Sigma (Data Level)

Level 3: E-enabled Predictive Tools (Information Level)

Level 4: Decision-Making and Optimization Tools (Knowledge Level)

Level 5: Synchronization Tools (Autonomous Level)
  Data Transformation → Prediction → Optimization → Synchronization
Maintenance of the Future

Closed-Loop Life Cycle Design

Design for Reliability and Serviceability

Product Center → Product Redesign

Smart Design

Enhanced Six-Sigma Design

Health Monitoring Sensors & Embedded Intelligence

Watchdog Agent®
Degradation Assessment (Feature Monitoring)

Self-Maintenance
• Redundancy
• Active
• Passive

Communications
• Tether-free
• Internet
• TCP/IP

Health Information

Just-in-Time Service

Near-Zero Downtime

• Web-enabled Monitoring & Prognostics
• Decision Support Tools for Maintenance Scheduling
• Synchronization Service
• Asset Optimization

Watchdog Agent® is a registered trademark of IMS Center.
IMS Methodology: 5S Approach

- **Streamline**
  - Sort, Filtering, Prioritize Data
  - Reduce Sensor Data Sets & PCA
  - Correlate and Digest Relevant Data

- **Smart Processing**
  - Assess Health Degradation
  - Predict Performance Trends
  - Diagnose Potential Failure (Prognostics)
  - Embedded Agent (hierarchical system)
  - Tether-free Communication
  - Only Handle Information Once (OHIO)
  - Decision Support Tools

- **Synchronize**
  - Systematic Prognostics Implementation
  - Reconfigurable Hardware and Software Platform

- **Standardize**
  - Maintenance Information Standardization
  - Embedded Knowledge Mgt. for Self-Learning
  - Closed-Loop Product Life Cycle Design
  - User-Friendly Prognostics Deployment

- **Sustain**
  - Embedded Agent (hierarchical system)
  - Tether-free Communication
  - Only Handle Information Once (OHIO)
  - Decision Support Tools
### Signal Processing & Feature Extraction
- Time Domain Analysis
- Frequency Domain Analysis
- Time-frequency Analysis
- Wavelet/wavelet Packet Analysis
- Principle Component Analysis (PCA)

### Health Assessment
- Logistic Regression
- Statistical Pattern Recognition
- Feature Map Pattern Matching (Self-organizing Maps)
- Neural Network
- Gaussian Mixture Model (GMM)

### Performance Prediction
- Autoregressive Moving Average (ARMA)
- Elman Recurrent Neural Network
- Fuzzy Logic
- Match Matrix

### Health Diagnosis
- Support Vector Machine (SVM)
- Feature Map Pattern Matching (Self-organizing Maps)
- Bayesian Belief Network (BBN)
- Hidden Markov Model (HMM)
Results of Smart Prognostics Tools for Asset Health Information

**Confidence Value**
for performance degradation assessment
(CV ~ 0-1)

**Health Radar Chart**
for multiple components degradation monitoring

**Health Map**
for potential issues and pattern classification

**Risk Radar Chart**
to prioritize maintenance decision
## Snapshot of IMS Project Portfolio

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<td>Health Assessment Platform for Robots</td>
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