eIMS

CENTER FOR INTELLIGENT MAINTENANCE SYSTEMS

Introduction & Overview

THE IMS CENTER

The IMS Center is a leading research center in the areas of Industrial AI, Prognostics and Health Management (PHM), and Industrial Big Data Analytics. The IMS Center's mission is to enable products and systems to achieve and sustain near-zero breakdown performance, and transform maintenance data to useful information for improved productivity and asset life-cycle utilization for worry-free uptime. Since its inception, the Center has conducted over 120 successful industry and NSF supported projects, and has attracted over 80 members from all across the globe. Formerly an NSF Industry/University Cooperative Research Center (I/UCRC), the IMS Center was identified as the most economically impactful I/UCRC in an NSF commissioned study titled *Measuring the Economic Impacts of the NSF Industry/University Cooperative Research Centers Program: A Feasibility Study*. According to this study, as of 2012 the Center had delivered its members a $855.4 Million at a 238:1 leveraging ratio.

IMS CENTER MEMBERSHIP

There are two types of IMS Membership: full and affiliate. Full members are companies or organizations with more than 500 employees and pay a membership fee of $40,000 annually; affiliate members have less than 500 employees and pay $12,000 annually.

SELECTED MEMBERSHIP BENEFITS

The following represent some of the many benefits of being a member of the IMS Center:

- All IMS members will have the right to obtain a non-exclusive, royalty free license to use, internally, all technologies and information produced by the Center.
- Members have the right to negotiate a non-exclusive, commercial use license for IMS Center technologies.
- All efforts funded through membership funds and federal sponsors will be shared among all members.
- Members can share the best practices and experiences gained from the IMS Center's test beds.
- Company members can send their personnel to the Center as visiting scholars to learn from Center researchers (some additional funding may be required based on the scope of such a program).
- Members host and mentor IMS test bed projects and can hire and recruit experienced IMS researchers.
- Only IMS Center Members can host IMS researchers as interns.

- Company members are able to request a short (1-3 months) feasibility study. The goals of this study can include: criticality analysis, data acquisition consulting, data quality assessment, and initial analysis. The final deliverable will be the development of a company specific research project proposal based on the findings of this study.
- The Center can work with company members to develop company specific projects to address a specific issue or goal of the funding member.
- Two (2) free registrations for all IMS Center Industry Advisory Board Meetings.
- 100% of the funds provided by members go towards IMS Center projects—the University of Cincinnati does not claim overhead on these funds.

![eIMS Center for Intelligent Maintenance Systems logo]

MISSION

Since being established in 2001, the IMS Center's mission has been to enable products and systems to achieve and sustain near-zero breakdown performance, and transform maintenance data to useful information for improved productivity and asset life-cycle utilization.

iMS TECHNOLOGIES

FAIL & FIX »»» »»» **PREDICT & PREVENT** »»» **NEAR-ZERO BREAKDOWN PRODUCTS & SYSTEMS**

INDUSTRIES

Since 2001, the IMS Center has conducted over 150 projects with over 80 member companies. Center has developed methodologies, tools and solutions in a wide range of industries, including, but not limited to, Manufacturing, Energy, Transportation and Healthcare.

Smart Manufacturing

Machine Tools   Industrial Robots
Semiconductor   Production Quality

Energy

Wind Turbine   Power Supplies
Battery   Oil & Gas

Transportation

Automotive   High-speed Trains
Aviation   Marine Vessels

Healthcare

Rehabilitation   Neurocritical Care
Sports Medicine

CORE TECHNOLOGY: THE WATCHDOG AGENT®

The Watchdog Agent® is a collection of intelligent software tools developed by the IMS Center that can be customized for monitoring equipment and systems in many diverse applications. Monitoring in this regard can refer to health or condition assessment, fault detection and performance prediction, among others. Monitoring results can be used in an enterprise resource planning system to ensure the appropriate preventative actions are taken before failures can occur, optimizing maintenance scheduling and resulting in extensive cost savings.

WATCHDOG AGENT® TOOLS

SIGNAL PROCESSING & FEATURE EXTRACTION	
Time Domain Analysis	Wavelet Analysis
Frequency Domain Analysis	Principal Component Analysis
Time-frequency Analysis	Expert Extracted Features

PERFORMANCE PREDICTION	
ARMA	Match Matrix
Recurrent Neural Network	Trajectory Similarity-based

HEALTH ASSESSMENT	
Logistic Regression	Neural Networks
Statistical Pattern Recognition	Gaussian Mixture Model
Self-organizing Maps	Auto-Associative NN

| HEALTH DIAGNOSIS	
Support Vector Machine	Bayesian Belief Network
Self-organizing Maps	Hidden Markov Model

The Watchdog Agent®-enabled monitoring process begins with the identification of critical equipment. Sensors and data acquisition systems accumulate raw performance data from this equipment. Features are then extracted using signal processing tools. These features are then analyzed using appropriate tools specialized for health and performance assessment. When the performance of the monitored equipment falls below a defined threshold, fault diagnosis tools can determine the specific fault type and location. If data from previous operations exists, performance degradation can be further analyzed by prediction tools to determine when potential failures will occur, thus making the Watchdog Agent® a transformational technology for predicting and preventing failures for worry-free uptime.

The Watchdog Agent® toolbox can ensure that the correct preventative actions are taken before failures can occur, resulting in significant cost savings, via improved process reliability, uptime and throughput.
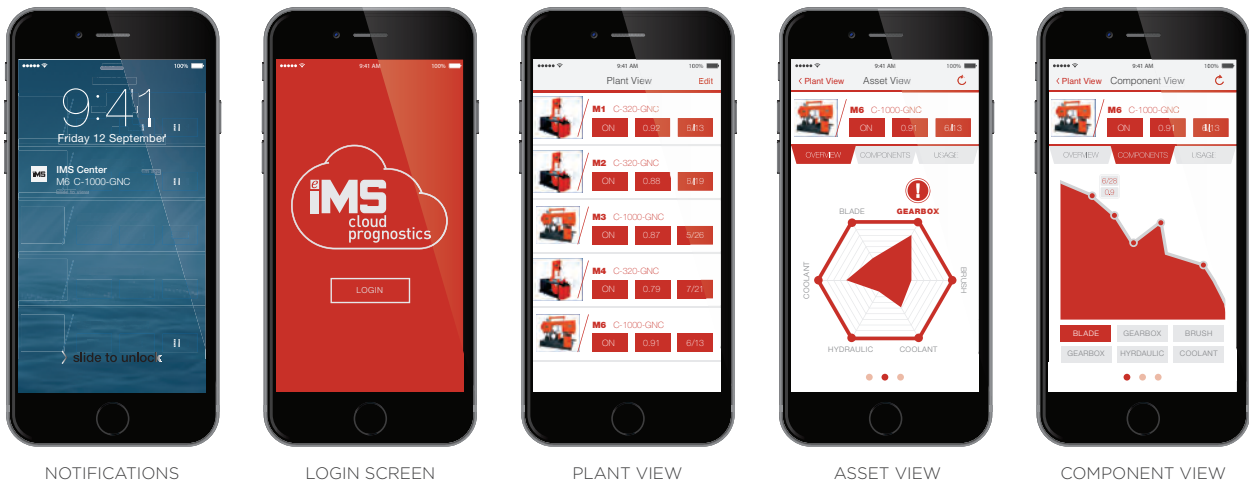
DEPLOYMENT DEMONSTRATION • CLOUD-BASED PROGNOSTICS

The IMS Center has developed a cloud-based solution to monitor the health of industrial robots using torque signals. This system is designed to be scalable, and to require little to no additional instrumentation. Beyond industrial robots, this solution could be deployed for many applications that involve a large number and/or widely distributed assets. A similar solution for bearing health monitoring has also been developed that integrates the Center's virtual bearing concept.
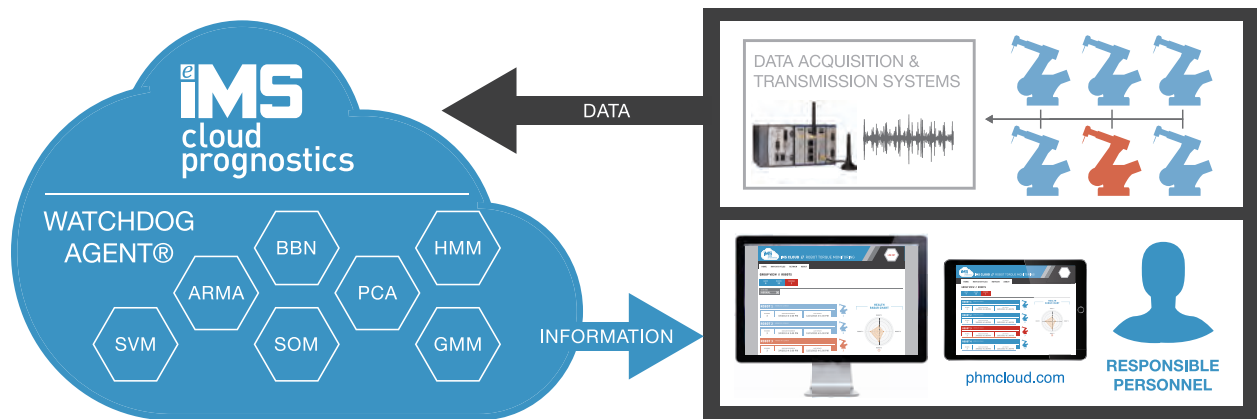
DEPLOYMENT DEMONSTRATION • MOBILE HEALTH MONITORING APPLICATIONS

The development of the Center's cloud-based prognostics platform has enabled the creation of the Center's first mobile app-based health monitoring solution. This App presents a global view of the user's facility or production line while also allowing the user to drill down to see the health status of each individual machine and each component being monitored.

NOTIFICATIONS   LOGIN SCREEN   PLANT VIEW   ASSET VIEW   COMPONENT VIEW

DEPLOYMENT DEMONSTRATION • MOBILE APPS FOR SPECIFIC APPLICATIONS

The Center's cloud-based platform and mobile applications can be adapted to work with a variety of applications. The Center recently developed a ball screw health monitoring application for member company HIWIN that utilized both the cloud-based platform and prior successes in mobile application development.

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IMS CENTER PATENTS

PATENT TITLE	PATENT NUMBER & INDUSTRY
Methods for Prognosing Mechanical Systems This Patent was awarded for novel methods for predicting when a failure will occur in a mechanical system based on extracting features from measurement data and selecting a prediction model based on the degradation status of the mechanical system and a reinforcement learning model.	US – 8,301,406 Manufacturing and Industrial Assets and Systems
Turbine-to-Turbine Prognostics Technique for Wind Farms This patent was awarded for novel methods for predicting the remaining-useful-life of a wind turbine or turbine component based on the performance of wind turbines within a cluster of turbines. These clusters are established based on performance metrics within a turbine farm, as well as environmental conditions, age, historical information, etc.	US – 13/674,200 Wind Turbine Farms and other Mechanical Fleet Systems
Method and System for Electric Vehicle Battery Prognostics and Health Management This patent was awarded for a novel system for managing the mobility of an electrically-powered vehicle. This system is based upon inputs from a network of sensors that provide details about the operating condition of the vehicle as well as the ambient and environmental conditions. The estimates and prediction of mobility is displayed for the user for improved decision making.	US – 20120296512 INT – PCT/US12/35136 Electric Vehicles and Autonomously Guided Vehicles
Method and System for Prognostics & Health Management Based on Cloud Computing This provisional patent was filed based on a novel method for assessing and pre-dicting health and performance of a system utilizing advances in cloud computing, cyber-physical systems, modeling and prognostics.	US – 61/509,945 (Provisional) Manufacturing and Industrial Assets and Systems
Quick-test Method for Battery State of Charge Estimation A provisional patent application has been submitted for a novel method for rapidly testing and determining the initial quality and potential life-cycle of a battery.	Provisional Patent Battery Manufacturing and Electric Vehicles

IMS GLOBAL PARTNERS

During the past 10 years, the IMS Center has been working closely with more than 30 research institutions and over 120 industry partners, worldwide.

AMERICAS

21st Century Systems	EDAptive	LAM Research
Abbott Laboratories	Emerson / Fisher	Mathworks
Advantech	ETAS	Mazak
Allied Telesis	Festo	McKinsey & Co.
AMD	Ford	Montronix
American Axel	FTI	National Instruments
AMP Electric Vehicles	GE Aviation	P&G
AmpliSine Labs	Genex	Parker Hannifin
API	GM	Pratt Whitney
Applied Materials	Goodyear	Prometec
ARL	GCWW	Rockwell
Avetec	Harley-Davidson	SCK
Boeing	Honeywell	Siemens TTB
BorgWarner	HRL	Spirit Aero
Bosch Rexroth	Idaho Natl Lab	Technical Data Analysis
Caterpillar	Ingersoll Rand	TechSolve
Chevron	Intel	Texas Instruments
Cisco	Inteligistics	Toyota
Coherix	ITW	United Technologies
D-Simlab	Johnson Controls	USPS
Daimler-Chrysler	Kalscott	We Energies
DC Water	Kistler	Woodward
Eaton		

EUROPE

Alstom Transport
Bosch
FMTC
FORCAM
KONE
Plastic Omnium
Preh, Inc.
Tekniker

ASIA

AITRI	HIWIN	ServTech
Allied Circuit Co., Ltd.	Huazhong NC	Shaanxi Auto
Avary Holding	III - IDEAS	Shanghai Electric
Baoshan Steel	III - SSI	Sinovel
Beijing Shenzhou	iRootech	Tongtai
CEI	ITRI	Toshiba
CEPREI	Janus	UMC
Coretech	Kinpo Group	Zhejiang Yunsha Group
Cosen Saws	Komatsu	
CRRC	Korea Aerospace Univ.	
CSD Taiwan	Lippo Group	
CSSC Electronics Co Ltd	Merit Data	
Cyberinsight	MHCC	
Daikin	MIRDC	
Dekam Software Co., Ltd.	Mitsubishi	
Delta Electronics	National Taiwan Univ.	
DENSO	Nissan	
Dongling	OMRON	
Feng Chia University	PMC	
Fire Safe	Ringod	
Foxconn	Samsung	
Hitachi	SANY	

MAXIMIZING IMS MEMBERSHIP

The IMS Center actively engages with member companies, satellite centers and partner institutions to advance research and broaden the knowledge in the area of Prognostics and Health Management (PHM) and Industrial AI. Listed below are opportunities for collaboration with the IMS Center as an IMS member.

Core Membership Research Projects - These projects target areas that are central to furthering the IMS Center's overall mission and that are of interest to the majority of the Center's members. These areas are identified by Center directors, IMS researchers and the Center's members. Core Research Projects are presented to the members at the Center's Industrial Advisory Board (IAB) Meetings. Members at these meetings have the opportunity to indicate their interest or support for these projects, and can give targeted feedback to researchers to help guide these projects to mutually beneficial results.

Feasibility Studies - Prior to a sponsored project, a feasibility study may need to be conducted, the purpose of which is to determine the specific needs of the member, as well as the technologies required to meet those needs. Such studies are funded by membership funds, with the ultimate result being a member-specific sponsored project.

Member-specific Sponsored Project - When a member company has a specific research goal, or its needs go beyond existing technologies, a member-specific sponsored project is generated. Specific intellectual property terms can be decided upon based on the sponsors input, and in keeping with the terms of the IMS membership agreement, and the policies of the IMS Center site's host institution.

Internships - As an alternative to developing a member-specific project, an IMS member has the opportunity to host a researcher from the Center at their facility. Such internships are common, and serve as an excellent way to promote collaboration, as well as to share information, experiences, technologies, etc. Any new technologies developed by an IMS researcher while on internship can be the sole property of the host member.

Technical Training - The IMS Center offers training courses for engineers from member organizations in the use of its prognostics methodologies. These courses can be tailored to the interests and level of experience of the attendees. Such courses can run from 3 days to 3 months, depending on the level of detail required. Additional costs may apply.

Visiting Scholar Program - The IMS Center can host personnel from a member company as a visiting scholar. During this program, the visiting scholar can receive extended training and can collaborate directly with IMS Center researchers on their own projects.

Joint Proposal Writing - Many opportunities exist for IMS members for joint proposal writing; this is especially true for small companies (SBIRs, STTRs, etc.) and research institutes.

CONTACT US

For more information on becoming a member and for updates on exciting new developments at the IMS Center.

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