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# INTRODUCTION

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# Introduction & Overview

## THE IMS CENTER

The IMS Center is a leading NSF Industry/University Cooperative Research Center (I/UCRC) in the area of Prognostics and Health Management (PHM). The Center has over twelve years of experience in developing and delivering PHM solutions for a wide-range of applications. IMS Center's mission is to enable products and systems to achieve and sustain near-zero breakdown performance, and transform maintenance data into useful information for improved productivity and asset life-cycle utilization. Since its inception, the Center has conducted over 100 successful industry and NSF supported projects, and has attracted over 80 members from all across the globe. The IMS Center was recently identified as the most economically impactful I/UCRC in NSF's recent study titled *Measuring the Economic Impacts of the NSF Industry/University Cooperative Research Centers Program: A Feasibility Study*. According to this study, the Center delivered its members \$846.7 Million in combined benefits over the last ten years.

## 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. All members enjoy over a 30 to 1 leveraging ratio, and the opportunity to develop specific research projects with the center, based on their interests. Membership is the highest level of collaboration.

## SELECTED MEMBERSHIP BENEFITS

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

- All IMS members will have non-exclusive and royalty free licensing rights in using all technologies and information developed by the Center.
- The university will waive the overhead for the membership as the contribution to the Center.
- Company members can receive the leveraged research results (at least 15:1 ratio) from its membership investment.
- All projects funded through membership funds and federal sponsors will be shared among companies.
- Company members can share the best practices and experiences gained from the IMS Center's testbeds and develop partnerships.
- The Center will work with the Company to develop a separate research contract and IP agreement based on company's interests.
- Company members mentor the IMS testbed projects and can hire and recruit experienced IMS researchers with great impacts.
- The Center can work with company members to develop company specific projects. In addition, these projects can be executed by either a research team at the Center or with dedicated full-time on-site researchers working at company site and assist companies to implement IMS technologies.



## 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 PHM. Listed below are opportunities for collaboration that the Center pursues.

**Core Membership Research Projects** - These projects target areas that are central 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 IMS researchers and the Center's members. Core Research Projects are presented to the members at the Industrial Advisory Board (IAB) Meetings, held every six months. 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.

**Technical Assistance Agreement** - A Technical Assistance Agreement (TAA) can be generated for situations in which a member has a specific issue that can be addressed using existing technologies. For such projects, no new IP will be created, though some customization work may be required. TAAs work well for projects involving consultation, training, test-bed validation, existing tool deployment, and any other project involving the application of existing core technologies.

**Internships** - As an alternative to developing a member-specific project or technical assistance agreement, 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. The work conducted by an IMS researcher while on internship is owned solely by the host member.

**Technical Training** - The IMS Center offers training courses for engineers from member organizations in the use of its prognostics methods and its Watchdog Agent Toolbox. These courses can be tailored to the interests and level of experience of the attendees. Such courses can run from 3 days to 3 weeks, depending on the level of detail required.

**Corporate Training** - The IMS Center provides training for engineers and executives in Dominant Innovation: a tool for helping organizations to identify and develop value-added services to achieve improved productivity and performance. Participation in this training can transform an existing business into a smart product service business.

**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.



#### 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.

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.

#### WATCHDOG AGENT® TOOLS

SIGNAL PROCESSING & FEATURE EXTRACTION		HEALTH ASSESSMENT	
Time Domain Analysis	Wavelet Analysis	Logistic Regression	Neural Networks
Frequency Domain Analysis	Principal Component Analysis	Statistical Pattern Recognition	Gaussian Mixture Model
Time-frequency Analysis	Expert Extracted Features	Self-organizing Maps	Auto-Associative NN
PERFORMANCE PREDICTION		HEALTH DIAGNOSIS	
ARMA	Match Matrix	Support Vector Machine	Bayesian Belief Network
Recurrent Neural Network	Trajectory Similarity-based	Self-organizing Maps	Hidden Markov Model

## IMS CENTER PATENTS

PATENT TITLE	PATENT NUMBER & INDUSTRY
<p><b>Methods for Prognosing Mechanical Systems</b></p> <p>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.</p>	<p>US – 8,301,406</p> <p>Manufacturing and Industrial Assets and Systems</p>
<p><b>Turbine-to-Turbine Prognostics Technique for Wind Farms</b></p> <p>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.</p>	<p>US – 13/674,200</p> <p>Wind Turbine Farms and other Mechanical Fleet Systems</p>
<p><b>Methods and Systems for Energy Prognosis</b></p> <p>This patent was awarded for novel methods for determining and predicting the health condition and operating performance of a system based on non-intrusive power consumption measurements.</p>	<p>US – 20110066391</p> <p>Manufacturing and Industrial Assets and Systems</p>
<p><b>Method and System for Electric Vehicle Battery Prognostics and Health Management</b></p> <p>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.</p>	<p>US – 20120296512 INT – PCT/US12/35136</p> <p>Electric Vehicles and Autonomously Guided Vehicles</p>
<p><b>Method and System for Prognostics &amp; Health Management Based on Cloud Computing</b></p> <p>This provisional patent was filed based on a novel method for assessing and predicting health and performance of a system utilizing advances in cloud computing, cyber-physical systems, modeling and prognostics.</p>	<p>US – 61/509,945 (Provisional)</p> <p>Manufacturing and Industrial Assets and Systems</p>
<p><b>Quick-test Method for Battery State of Charge Estimation</b></p> <p>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.</p>	<p>Provisional Patent</p> <p>Battery Manufacturing and Electric Vehicles</p>



## CONTACT US

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

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